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AVL SIMULATION AND TESTING SOLUTIONS CATALOGUE 2013

AVL SIMULATION AND TESTING SOLUTIONS CATALOGUE 2013

Also available as
iPad App

Dear Valued Customer,

We are pleased to present this new edition of the AVL Solutions Catalog. Since over 60 years, AVL is at the forefront of innovation. With products, solutions and methods designed to help you master the engineering challenges of the automotive world.
Today's industry trends, like tightening CO_2 and emissions limits, shifting consumer markets and buyer expectations as well as a more complex economic environment, put traditional engineering patterns to a test. AVL's comprehensive offerings are providing an answer to this and we strongly believe to have the right tools and services enabling you to create the mobility of tomorrow. Our consistent development platform from simulation to in-vehicle testing helps you to radically shorten development cycles. Our application expertise spanning from advanced research to series production assist you in improving development and test procedures. Our capabilities to deliver a single instrument or a whole testing center support you in your global expansion. Over 5250 AVL employees in more than 40 affiliates share one commitment: to be your preferred partner.
We value your feedback and hope you will choose AVL when looking for innovative solutions helping you to reach your business goals.

Yours sincerely,

Kai U. Voigt
Executive Vice President
Instrumentation & Test Systems

Gotthard P. Rainer
Vice President
Advanced Simulation Technologies

At AVL, we are committed to delivering the most diverse and also the highest caliber simulation, measurement and testing technology available and to provide our customers with outstanding assistance and support.

Fascinating, versatile and individual, like the patterns of a kaleidoscope, this is what AVL's broad product portfolio, leading services and profound application expertise can offer you. Each of the five elements of the ITS kaleidoscope represents a special strength that addresses your requirements and needs:

1. GLOBAL PRESENCE
AVL's worldwide network gives you peace of mind. Wherever your R&D challenges take you, we are always close at hand, ready to provide the service you need.

2. SOLUTIONS FOR THE ENTIRE POWERTRAIN
We offer leading simulation, measurement and testing solutions for the entire powertrain development process, based on a consistent, integrated and open platform.

3. PROFOUND APPLICATION EXPERTISE
AVL is consistently at the forefront of powertrain engineering. This insight enables us to speak your language and to provide you with practical solutions for your engineering challenges.

4. EFFICIENT AND RELIABLE PARTNER
Trust and integrity are the cornerstones of our identity. We are committed to you, our customer, to keeping our promises, to efficiently delivering and making your project a success.

5. DEDICATION TO CUSTOMERS
For us, the customer always comes first. For over 60 years, and in the years to come.

THE AVL PRODUCT NAVIGATOR. ALL CONTENTS AT A GLANCE.

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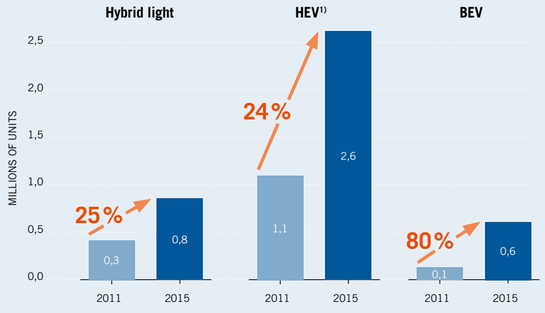
AFFORDABLE CO_2 REDUCTION

SALES OF xEV'S WILL SIGNIFICANTLY INCREASE



xxx CAGR 2011–2015 1) FHEV, PHEV

In the short term global sales of xEV's will significantly increase. Source: Roland Berger, IHS, AVL

THE QUEST FOR SUSTAINABLE MOBILITY

The roadmap to greener vehicles is set. Global legislation will require automotive OEM's to lower fleet CO_2 emissions at an annual rate of 2%-4%, based on today's levels. The EU, for instance, will enforce a limit of 95 grams CO_2/km, effective in 2020. Discussions on a further reduction down to 50 grams CO_2/km have already been started. The achievement of those goals translates into significant challenges for the automobile industry.

GREEN VEHICLES – AT ANY PRICE?

Lowering the carbon footprint of a vehicle fleet, in both production and in-use, is a demanding task. As it turned out, there is no single silver-bullet to cope with that. Meeting CO_2 targets requires changes to the entire vehicle: lightweight construction, reduction of vehicle sizes and an optimization of the whole powertrain. None of those are for free. The electric vehicle saw a renaissance in public opinion and new models made it on the road, promising guilt-free driving. Those "highly-electrified" vehicles all share the burden of high costs for the batteries and a slow progress on the improvement of specific energy storage capacity. As far as we can see today, the majority of consumers are not willing to pay a hefty price premium for a green vehicle. Additionally, drivers are not willing to make sacrifices on driving range, comfort, safety and driveability just for the sake of the environment. That makes the OEM's task even more difficult to find the right balance between meeting legislative requirements and fulfilling customers' expectations while keeping cost under control.

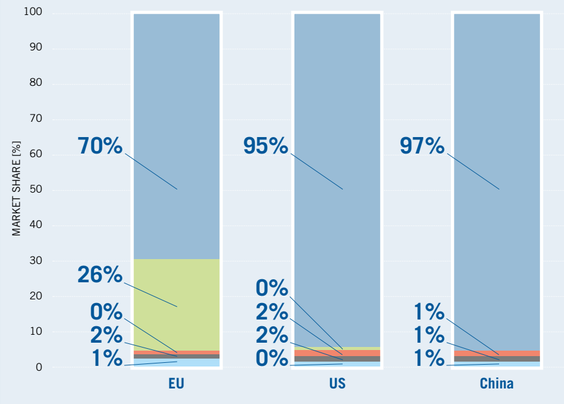
IMPROVING A CLASSIC

Research has shown that there is still significant fuel saving potential in the traditional components of the powertrain – the internal combustion engine, the transmission and its control. Unleashing those potentials with the help of turbocharging, direct injection or other advanced concepts can be comparatively cost effective. But it requires highly accurate and up-to-date simulation and testing tools which allow engineers to imagine, develop and validate new solutions in a rapid development environment. This includes simulation software to explore development alternatives at an early stage, tools to advance the combustion process or instruments to measure and quantify every aspect of the powertrain. AVL's toolchain is the most complete to get this job done.

DEVELOPING THE POWERTRAIN OF TOMORROW

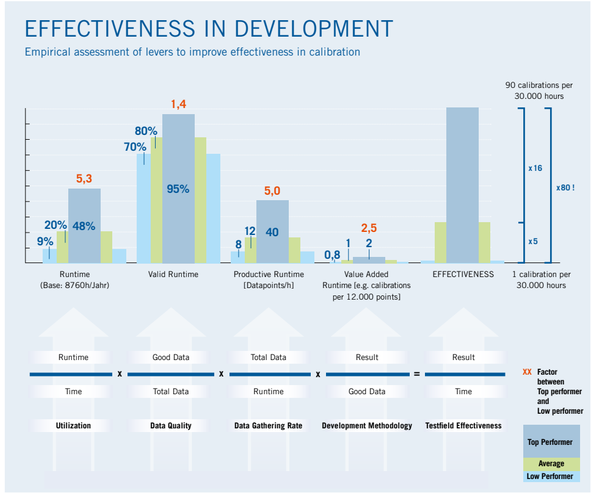
With legislation, customer demand and technical progress on energy storage in mind, it is becoming clear that the powertrain of the future will also contain an electric motor and a battery. The integration of those technologies dramatically increases the complexity of the powertrain. Contemporary approaches to develop, test and validate such an advanced propulsion system will soon touch economic and practical limits. AVL understands that challenge. With the engineers' tasks in mind, we built a comprehensive solution portfolio. Assisting you in predicting CO_2 and exhaust emission levels already at an early development stage through advanced simulation tools. Enabling you to implement and validate CO_2 saving technologies with the help of automated, real-time testing systems and an overarching data management system. Making you able to innovate the development process itself with novel methodologies and model-based approaches. This complete set of tools, processes and methods has one purpose: helping you to build the powertrain of tomorrow.

ELECTRIFICATION NEEDS LEGISLATION



In a scenario for 2020, xEV's will represent a minor share of powertrains. EU CO_2 emission targets will drive electrification in this market. Source: Roland Berger, IHS, AVL

HANDLE COMPLEXITY, MANAGE VARIANTS, INCREASE SPEED



Comparison of various testfields to assess development effectiveness, focus on calibration tasks. Source: AVL Study

COMPLEX WORLD – SIMPLE QUESTION

The automotive industry is experiencing dramatic changes. Tectonic shifts of markets, tougher legislative requirements and highly varying consumer demands are putting unprecedented challenges to automobile manufacturers. Serving to new regions and covering every market niche has become a matter of survival. With this increasing number of variants and today's complex powertrains it is constantly becoming more difficult to meet the development targets of quality, cost and time. Looking at this challenge, powertrain engineers are haunted by one question: how can I find the ideal combination of tools, processes and methodologies that optimally support my development work?

TOOLS UP FOR THE JOB

The first step is to select the right tools for the individual development job. To employ Software which helps to simulate and assess certain development alternatives early, Instruments to measure more accurately what you need to understand better, Systems that automate testing tasks to speed up information gathering. AVL has those tools for you, readily available and carefully engineered together to build the basis of your seamless integrated and open development platform. Products like AVL CRUISE, AVL PUMA™ or our series of instrumentation devices are renowned for setting the industry standards.

DOING THINGS RIGHT

It is a standard approach to automate processes to improve productivity. Today's sophisticated powertrains offer unseen degrees of freedom, making the testing work potentially grow by magnitudes. A linear approach, like plain automation, can't cope with that. It is required to re-invent the process and introduce advanced procedures to achieve the development goal. AVL has a solid track record in supporting customers like you to make this happen. From analyzing the environment, working out an optimized process till the implementation in your test field. Many of the world's top OEM's and Tier 1 suppliers already trust AVL and have sustainably improved their performance.

THE FUTURE OF POWERTRAIN DEVELOPMENT

Leading powertrain experts will agree that a huge potential for increasing the development efficiency lies within the frontloading of development tasks and the networking of development environments. With AVL's tried and tested model-based development approach you are able to seamlessly connect simulation with the physical world to speed up development. Models developed with AVL CRUISE™ to predict a future vehicles performance can be directly used and refined with a real powertrain on an AVL PUMA™ testbed. This validated model of a lead variant can then again be used in the virtual world to already start implementing base calibrations for new and upcoming variants. This dramatically helps to speed-up iterations in the development cycle. On the other hand, AVL is working hard enabling you to shift development task from vehicle to testbed to simulation. To do emission certification on a powertrain testbed – while the real vehicle body is still under development. To shift driveability development work from the road to the chassis dyno, reduce cost, increase development speed and shorten time to market. All this is reality today. And it is called AVL Active Frontloading. When you are developing the powertrain of the future, we are certain you can do it more efficiently with AVL.

LEVERS TO IMPROVE EFFECTIVENESS

Examining the development task calibration

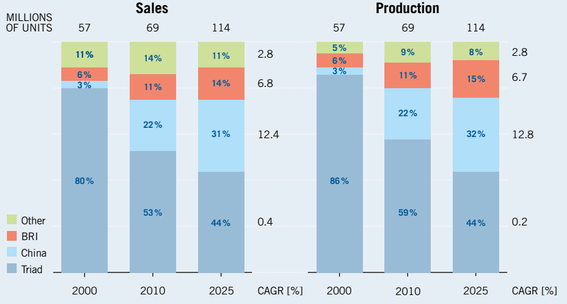
UTILIZATION : (QUALITY, SPEED, ENGINEERING) = 5 : 17

The top testfield is 5.3 times better utilized than the low performer.	However, looking at the factors Data Quality, Data gathering speed and results derived from this data, the best testfield is 17 times better than the worst one.	Methodology has a decisive influence on development effectiveness.

Optimized equipment utilization is just the start. A re-engineered testing approach enables break-through effectiveness.
Source: AVL Study

GLOBAL MARKETS AND GLOBAL OPERATIONS

SALES AND PRODUCTION OF LIGHT VEHICLES 2000-2025 BY REGION, BASE SCENARIO



The BRIC markets will drive growth of the automotive industry. Source: Roland Berger

CONQUERING NEW MARKETS

Looking at the worlds car sales statistics of the past years, one will acknowledge that the BRIC countries and other emerging markets have become the main drivers of growth for the industry. Quite contrary, traditional markets like Western Europe turned out to be much more challenging and most likely will continue to do so in the years ahead. The strategy of many successful car and engine manufacturers to follow those market shifts and re-arrange global production capacity accordingly has paid off. However, those new markets are developing fast with more intense competition and maturing consumers who demand more affordable quality products perfectly suiting their local taste.

ACTING LOCAL

Better understanding the customer needs is paramount for developing better products. Therefore, the relocation of R&D facilities into those promising markets is a logical consequence. From an engineering perspective this undisputedly helps to master the challenge of adapting products to local customer demands and specifics like driving patterns, fuel quality and climatic conditions. AVL understands that challenge, too. With global product availability and own tech centers in all major automotive regions of the world we can help you during that process. Our international presence enables us providing you with proven simulation and testing tools, flexible testing capacity or supporting you with powertrain engineering expertise to solve a specific application problem.

NETWORKING R&D

While optimizing local development operations directly contributes to better local products it most likely might not bring by itself a global optimum in development efficiency. Differences in culture and mindset, hurdles in information exchange and test data difficult to compare are paving the way for parallel developments and other inefficiencies. It is a major task for any distributed R&D organization to overcome such issues and excel with aligned global operations. AVL can help you with that. Our expertise in powertrain development and test operations makes sure we are speaking your language. We are your partner for analyzing existing processes and can help you transforming your individual test facilities into a globally aligned network operation. With solutions that are worldwide available and strongly locally supported. By means of a proven set of tools which is able to reliably generate and handle comparable test data on a global level. Through methodologies designed to speed-up the development of local variants. And by experts that share one dedication: your success.

AVL GLOBAL FOOTPRINT

WHY CHOOSE AVL AS A SIMULATION PARTNER

HIGH FIDELITY SYSTEM SIMULATION MODELS

AVL provides fully interactive and integrated tool chains including AVL's own software tools and third-party software tools. In order to obtain the most benefits throughout the development process, we created consistent simulation models for all of the development phases: fast simulation models together with DOE and optimization for the concept phase, very accurate simulation models for the design and development phase and real-time simulation models parameterized by highly accurate simulation models for engine and powertrain calibration.

POWERTRAIN ENGINEERING INSIDE

AVL's extensive engineering expertise is the strong basis for all of our software tools and methods. By analyzing the powertrain development processes, we have defined software application tasks which cover all of the aspects of powertrain development. In order to hide the complexity of these tasks, we we placed the emphasis on application-focused workflows which guide the user through to practical engineering solutions. Simulation results are displayed in the same easy-to-interpret way as test results.

CLOSE LINK TO TESTING

AVL's software tools are closely linked to and compatible with AVL's instrumentation and measurement tools. More and more, it is becoming a requirement to provide the development engineer with simulation results directly on the test bed based on test results. This leads to more insight into the powertrain, and subsequently a shorter test cycle.

A KALEIDOSCOPE OF SIMULATION POSSIBILITIES

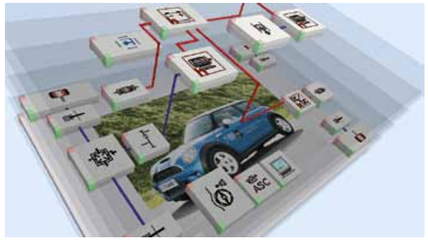
AVL's simulation software development is based on the unique environment available from AVL: powertrain engineering, instrumentation and test systems, and advanced simulation technologies are the three pillars of the company, and provide a huge reservoir of synergies.

AVL's simulation software development is driven by five core values that position AVL Advanced Simulation Technologies as a strong partner for all of your calculation tasks.

- High fidelity system simulation models
- Seamless simulation workflows
- Powertrain engineering inside
- Close link to testing
- Simulation support worldwide

HIGH FIDELITY SYSTEM SIMULATION MODELS SEAMLESS SIMULATION WORKFLOWS

AVL CRUISE



VEHICLE SYSTEM

AVL CRUISE is featured industry-wide as the most mature and advanced system-level vehicle powertrain simulation package. It manages to handle the current and future complexity of powertrain structures with an extremely flexible but nevertheless user-friendly and easy-to-use concept.

FROM CONCEPT STUDIES TO CALIBRATION AND TESTING

AVL CRUISE offers all of the flexibility needed to build up a system model, with the fidelity easily adjusted to all application requirements through the entire powertrain development cycle. It supports everyday tasks in vehicle system and driveline analysis throughout all of the development phases, from concept planning and design in the office to calibration and verification on hardware test systems. Starting with only a few input parameters in the early stages, the maturity of the model grows during the development process according to the continuously increasing simulation needs in calibration. Model reuse in consecutive or iterative development approaches ensures consistent decision processes and saves valuable engineering time by keeping the focus on the target:

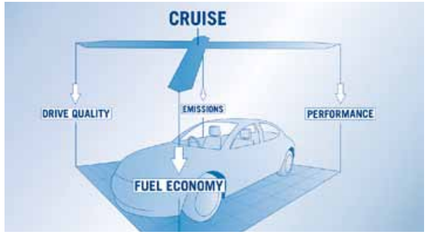
- optimizing vehicle fuel efficiency
- emissions
- driving performance and driveability

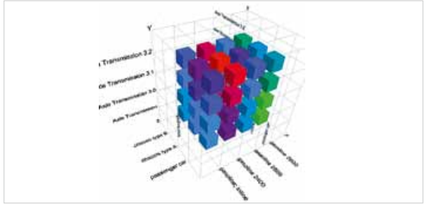
MANAGING CHANGES WITH EFFORTLESS EASE

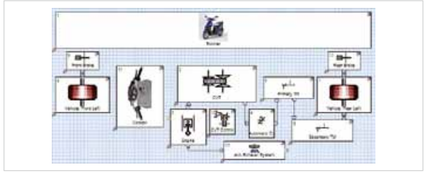
Today's multi-system vehicle powertrain concepts are pushing the complexity of system simulation models to the extreme. The highly adaptable system/sub-system structure of AVL CRUISE literally allows drivetrain concepts to be changed with a mouse click. Vehicle hybridization and morphing of the model to application needs in different phases are carried out within minutes, allowing more time to be spent on the engineering, calibration and testing tasks, without having to dig into mathematical equations and re-program code.

SOLUTION ORIENTED OPEN CONCEPT IN ALL TASKS

AVL CRUISE is more than just a vehicle simulation model. Streamlined workflows are realized for all kinds of parameter optimization, component matching and sub-system integration. The modular structure with its wide range of interfaces to other simulation tools, ready-to-use analysis tasks and data management capabilities are only a few of the key reasons why a growing number of leading OEMs and their suppliers have chosen to establish AVL CRUISE as their powertrain integration platform on a system level.

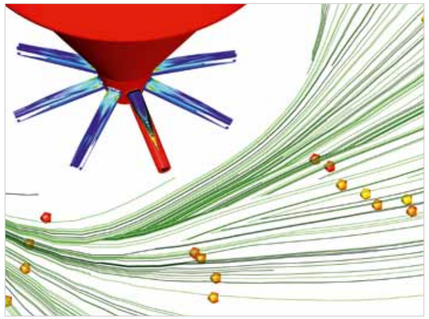


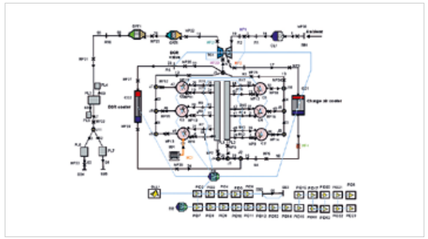




AVL BOOST

AVL FIRE®





COMBUSTION AND EMISSIONS

AVL FIRE® and AVL BOOST are the industry's prime choice when reliable results are needed for engine and combustion development. The intelligent integration of the two software tools facilitates solutions for complex tasks early in the development phase.

SPEEDING UP YOUR PROCESSES

The time required to create moving meshes for complex geometries of modern IC engines is reduced to merely days with AVL FIRE®'s highly specialized and automated pre-processing tool FAME Engine +. This tool combines fast and efficient mesh generation with AVL FIRE®'s state-of-the-art and fully parallelized main program, and provides CFD simulation results that have never been available before.

FEWER EXPERIMENTS, MORE CREATIVITY

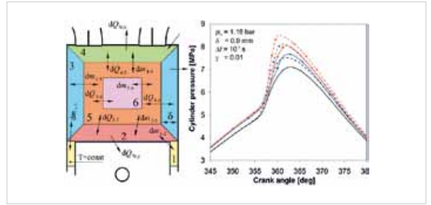
Engine performance and durability are strongly impacted by related fluid flow processes, such as the multiphase flow in injection equipment, in-cylinder gas dynamics, fuel injection, combustion, coolant flows, exhaust gas flows and exhaust gas aftertreatment. The capabilities offered by AVL BOOST and AVL FIRE® enable accurate simulation of all related phenomena, reducing the need for costly and time-consuming experiments.

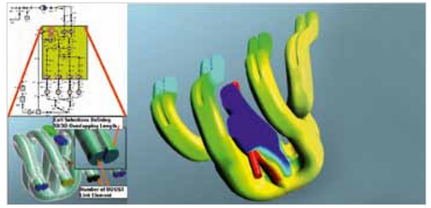
VERIFIED EXHAUST GAS AFTERTREATMENT SOLUTIONS

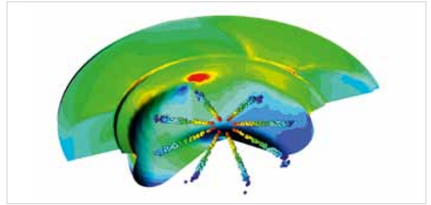
AVL FIRE® and AVL BOOST feature the industry's only seamless integration of 1D, 2D and 3D exhaust gas aftertreatment system simulation tools. This is based on identical mathematical, physical and chemical models which are available to both software tools. These tools are in turn also based on identical mathematical, physical and chemical models. The model is able to grow from one to three dimensions as needed, with consistent results. The highest accuracy is achieved through the implementation of a precise chemical reaction solver, and is proven through continuous verification on AVL's emission test benches.

SYNERGIES BETWEEN SIMULATION AND TESTING

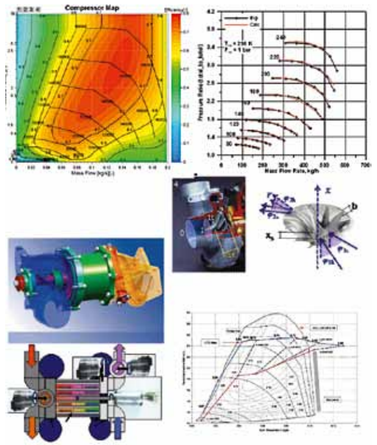
The integration of AVL BOOST directly on the testbed offers the ability to calculate additional results online during the engine test – a tremendous timesaving benefit especially during complex engineering projects, enabled by AVL's unique synergies of testing, simulation and engineering.







AVL BOOST | AVL EXCITE
AVL FIRE®



TURBOCHARGING

AVL BOOST, AVL EXCITE and AVL FIRE® allow advanced compressor and turbine component design and turbocharger matching as part of an overall engine system. This integrated approach accommodates the complex interaction between the system components, in order to create the most effective, low emission engines possible.

ENGINE PERFORMANCE AND EMISSIONS

CO_2 reduction and energy efficiency are the main technology drivers for pressure-charged engines. Turbocharging allows auto manufacturers to reduce their engine sizes and emissions while continuing to deliver the power and performance customers demand.

PRESSURE WAVE SUPERCHARGER

In contrast to standard pressure charging devices, the pressure wave supercharger process is a direct gas-dynamic transfer of exhaust gas energy to the fresh charge in the channels of the rotor via traveling shock and expansion waves. The underlying physics allow highly predictive 1D modeling where the performance is a simulation result and no maps for mass-flow or efficiency characteristics are necessary.

MULTILEVEL SIMULATION DEPTH

Basic thermodynamic matching of the turbocharger is performed for steady-state operation, continued by the optimization of the transient response. The matching calculaton is iterative, based on compressor and turbine maps, as well as the most important engine data. For turbochargers, the engine and pressure charger can be integrated into the vehicle simulation tool AVL CRUISE, in order to consider the overall system of the engine and vehicle within a driving cycle.

REDUCING CO_2-EMISSIONS

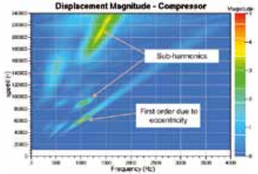
AVL BOOST and AVL FIRE® offer an advanced pressure charging simulation system. Users benefit from the ability to:

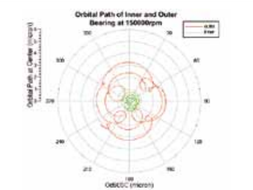
- select a turbocharger to match a given engine
- design new turbochargers with engine matching at every design stage
- readily change compressor and turbine sizes and predict the effect
- rapidly improve the turbocharging system, and determine the impact of wastegates, variable geometry, exhaust gas recirculation and component losses

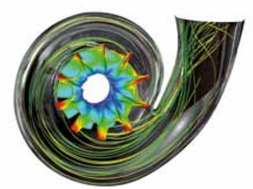
DYNAMICS, STRENGTH AND NVH ANALYSIS OF THE TURBOCHARGER

The investigation of the dynamic stability of the rotor bearing system is an important analysis target in the designing of automotive and industrial turbochargers. This requires a flexible multi-body solution including non-linear models for floating ring slider bearings capable of calculating the dynamic system behavior for rotor speeds over 200,000 rpm. AVL EXCITE can cover all of these effects with different detailing levels.

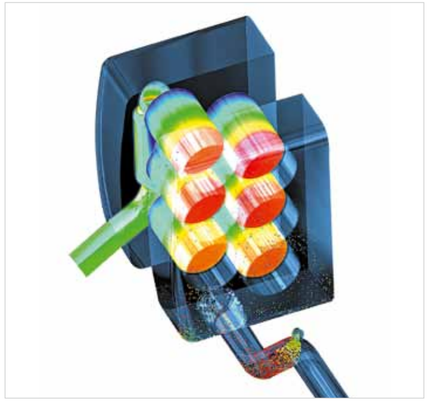
AVL EXCITE is capable of covering all of these effects with different detailing levels. The run-up calculation approach effectively supports the detection of critical speeds caused by torsional and bending resonances. The main analysis targets covered by AVL EXCITE are: unbalanced calculations, bearing forces and displacements, detailed bearing analysis including floating bushing motion, friction and wear, and the excitation of the turbocharger housing for strength and acoustic investigations.

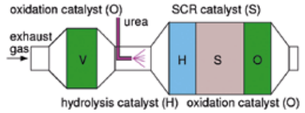






AVL BOOST | AVL CRUISE | AVL FIRE®





AFTERTREATMENT

The AVL Aftertreatment simulation suite, consisting of the capabilities available from AVL BOOST, AVL CRUISE and AVL FIRE®, is a unique solution which enables the consistent modeling of all physics and chemistry relevant to exhaust gas aftertreatment systems.

UNMATCHED PERFORMANCE

Component and system modeling uses AVL BOOST and AVL FIRE®. The AVL Aftertreatment suite enables extremely fast kinetics parameter identification, analysis and optimization for aftertreatment systems. Hundreds of simulations can be performed within hours. Large parameter variations can be investigated easily.

SEAMLESS SOLUTION

AVL BOOST and AVL FIRE® feature the industry's only seamless integration of 1D, 2D and 3D exhaust gas aftertreatment system simulation tools. These are based on identical mathematical, physical and chemical models. The model can grow from one to three dimensions as needed, with consistent results. The highest accuracy is achieved through the implementation of a precise chemical reaction solver. Maps calculated using AVL BOOST can be used in AVL CRUISE vehicle models to predict drive cycle emissions.

EASY HANDLING

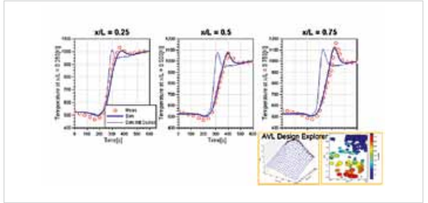
Pre-defined reaction schemes for all common aftertreatment systems are offered in both AVL BOOST and AVL FIRE®. The user also has the freedom to modify or replace the offered schemes by interactively activating / deactivating individual equations or by means of user-defined functions. AVL BOOST model set-up files can be imported into the AVL FIRE® Solver GUI saving users from the time consuming and error prone re-entering of model data when switching from 1D to 2D/3D CFD.

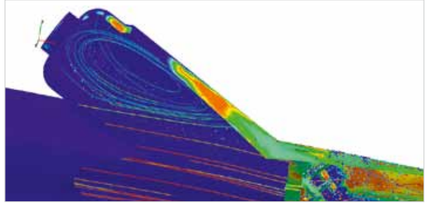
CONTINUOUS DEVELOPMENT, DELIVERING ON DEMAND AND ON TIME

The AVL Aftertreatment suite has been continuously developed for more than 15 years. Close cooperation with leading industrial partners and universities ensures modeling capabilities which match the needs of both developers and researchers working on improving current systems and searching for next generation solutions. New models are implemented without delay or exception.

VERIFIED EXHAUST GAS AFTERTREATMENT SOLUTIONS

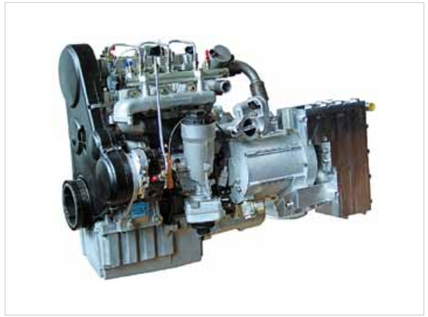
The AVL Aftertreatment suite is not only used by numerous customers around the world, but also by AVL itself. Our engineering division is developing hardware solutions based on simulation results obtained using AVL BOOST and AVL FIRE®. This in turn generates valuable feedback on the software development, and enables continuous verification on AVL's emission test benches.

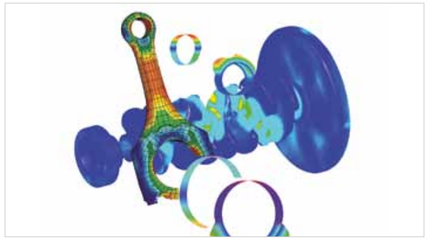




AVL BOOST

AVL EXCITE





DURABILITY AND NVH

AVL EXCITE has been chosen by the majority of engine manufacturers worldwide as their main platform for strength, durability and NVH simulations of power units, making it the leading software on the market for durability analyses of engine components, valve train and timing drive dynamics, tribological analyses of lubricated engine contact points, cylinder kit design and NVH optimization.

REAL LIFE CONDITIONS FOR PRECISE RESULTS

AVL EXCITE calculates complex dynamic models considerably faster than multipurpose tools. Short turnaround times are achieved by robust and optimized solvers even with complex models. The accurate consideration of non-linearities in lubricated engine contact points provides results which are similar to real life. Outstanding elastohydrodynamic (EHD) contact models for slider bearings and piston / piston ring liner contact facilitate detailed investigations of contact behavior, including the calculation of friction and wear. In this way the simulation assists the engineer in making the right design decisions efficiently, and facilitates a significant reduction in costly testing.

POWERTRAIN ORIENTED SOLUTION

Powertrain-analysis-specific workflows and automated model generation and result evaluation capabilities help the engineer to achieve short project lead times. For example, AVL EXCITE AutoSHAFT is a significant time saver for crankshaft model generation. Based on files from CAD, a dynamic crankshaft model can be generated within hours. AVL EXCITE calculates transient engine run-up and in-stationary conditions, without relying on unrealistic speed steps. In this way critical operating conditions can be reliably detected without the time-consuming interpretation of incomplete results.

MULTI-LEVEL SIMULATION MODELS

Different modeling levels for single components as well as for the entire system help the engineer to use an optimum balance of model depth in terms of required accuracy for the application target and the modeling and simulation time. The simulation models can be extended as needed during the development process, saving costs by eliminating the need to rebuild models for each step.

INTEGRATION AND CUSTOMIZATION

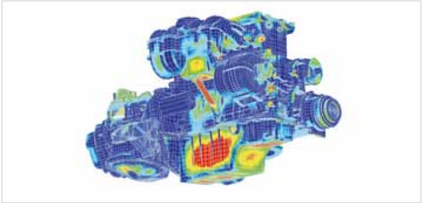
Interfaces for third-party FE and fatigue software enable the seamless integration of AVL EXCITE into the customer CAE environment. With the fe-safe™ based fatigue strength analysis tool AVL EXCITE Fatigue and the integrated finite element solver from Abaqus™ the application workflows for fatigue and NVH analysis can optionally be completely covered by AVL EXCITE. For extensive design variation, parameter identification and optimization tasks, the integrated tool Design Explorer as well as interfaces to commercial optimization software are provided. Furthermore, AVL EXCITE offers customer-definable template models, plot and report generation, workflow descriptions and a customizable GUI.

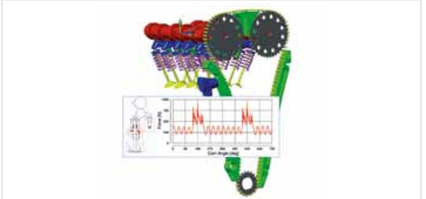
DUCT ACOUSTICS IN TIME AND FREQUENCY DOMAIN

AVL BOOST offers linear and non-linear acoustics modules for the simulation of free field and in-duct acoustics in order to support

- muffler design
- intake and/or exhaust orifice noise reduction
- sound engineering, etc.

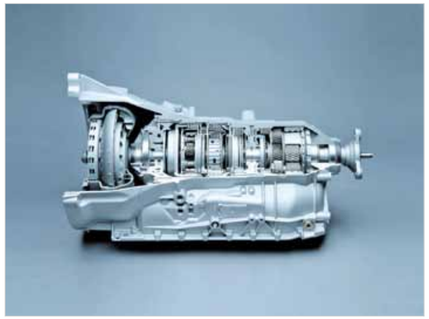
The resulting pressure waves can be used as excitation for shell noise simulation with AVL EXCITE

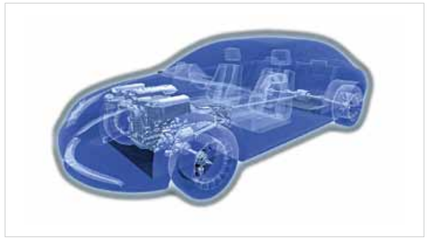




AVL CRUISE

AVL EXCITE





TRANSMISSION AND DRIVELINE

Scalability is a central philosophy of AVL's simulation tool chain. The program portfolio offers transmission and entire driveline modeling capabilities on all of the required levels, matching the needs of diverse applications in component and control development and vehicle integration, from general system behavior to detailed analysis of losses to NVH and durability of single components.

EFFICIENCY ENHANCEMENT – UNDERSTANDING COMPONENTS AND SYSTEMS

When searching for energy saving potential in already extensively optimized drivelines, a primarily component-focused approach, as was standard and normally sufficient in the past, is no longer appropriate. The entire energy flow from drive power generation to the power at the wheel needs to be investigated, taking into account the loss contribution of each component to vehicle CO_2 emissions. This requires a comprehensive systematic approach with an integrated sub-system and detailed component investigation.

Using AVL EXCITE, component and sub-system analyses are performed in order to derive friction maps for each of the loss-contributing parts. These maps are then used in AVL CRUISE for vehicle system investigation, such as the power flow and loss distribution analysis during drive cycle tests. This type of tool interaction makes it possible to understand the impact of each component, as well as its modifications on vehicle fuel consumption (CO_2), which in turn allows one to invest in component improvements with the highest benefit-to-effort ratio.

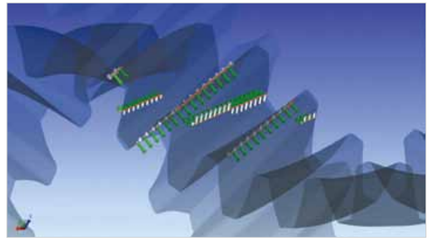
EFFORT REDUCTION IN GEAR SHIFTING PROGRAM DEVELOPMENT

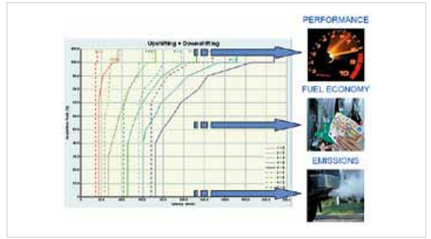
In order to achieve CO_2 targets while still providing a competitive balance in terms of vehicle performance and driveability, automated transmission technologies such as AMT, DCT, AT and CVT are increasingly being introduced in all of the markets. Finding the right gear shifting program for the combination of vehicle type, powertrain technology and component limitations is creating new challenges in the vehicle development process.

AVL CRUISE GSP (Gear Shifting Program) represents the most efficient way to optimize the development of gear shifting programs. In early concept phases, AVL CRUISE GSP enables engineers to automatically generate gear shifting maps for different vehicle powertrain variants within seconds, improving the accuracy of simulated fuel consumption and vehicle performance results. Later on, calibration engineers can start with a gear shifting program which is near-optimized for fuel efficiency, performance and drive quality before having put the real vehicle on the road or testbed. This significantly reduces the development time and in-vehicle testing costs.

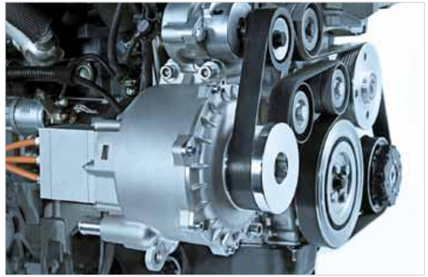
VIBRATION, STRENGTH AND ACOUSTIC OPTIMIZATION

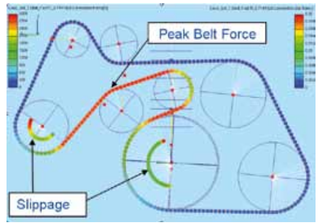
With different modeling levels based on a rigid / flexible multi-body dynamics solution, AVL EXCITE supports the transient vibro-acoustic analysis of conventional and hybrid automotive and non-automotive drivelines up to 3 kHz. One simulation target is the investigation of the dynamic behavior and acoustic noise phenomena in drivelines under stationary and non-stationary operating conditions (e.g. tip-in/back-out, start-stop) such as boom, clonk, rattle, whine, chatter, whoop or shudder. For the analysis of vehicle chassis vibrations, the excitation forces from driveline dynamics are applied to the car body at mounting points such as the power unit mounts. The results are then further used as input through the application of hybrid approaches such as the transfer path method in order to predict interior noise.





AVL CRUISE | AVL EXCITE
AVL FIRE®





ELECTRIFICATION

The simulation of vehicles with different levels of electrification (from HEV to PEV), the optimization of electrical systems and their components (such as electric drives, batteries and fuel cells) under completely new operating conditions, and improvement in the performance of electrical turbochargers are just a few examples of AVL's innovative simulation capabilities in the huge field of new and challenging technology trends.

HIGHLY DETAILED ANALYSIS OF ELECTRIC MACHINE AND HYBRID POWERTRAIN NVH

AVL EXCITE's domain is detailed component and system analysis in terms of the dynamics, strength, durability and acoustics of hybrid powertrain configurations. Analysis targets include the dynamics of front-end belt drives and their interaction with the crank train of belt-driven starter-generator or mild hybrid systems, detailed investigations of crank train bearing behavior under hybrid-drive-specific loading conditions, the dynamics and NVH of transmissions under combined loading, and the effects of non-stationary conditions (such as start-stop, transition, boosting or braking produced by the electric machine) on the powertrain.

OPTIMIZING ENERGY STORAGE AND COOLING SYSTEMS

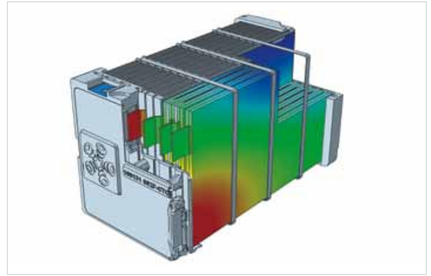
AVL FIRE makes it possible to predict the overall behaviour of a Lilon battery cell, module or complete battery cell, a module or a complete battery during transient charging and discharging processes. Critical conditions can be identified, thereby helping to optimize the system. in terms of electro-chemistry, performance and thermal management. In order to acc-omplish these tasks, AVL FIRE® offers empirical as well as predictive electro-chemical battery models which enable the simulation of electric charge transport in active layers and positive and negative collectors, as well as heat conduction in thermal masses, while considering electric and thermal contact resistance.

UNDERSTANDING THE FUEL CELL

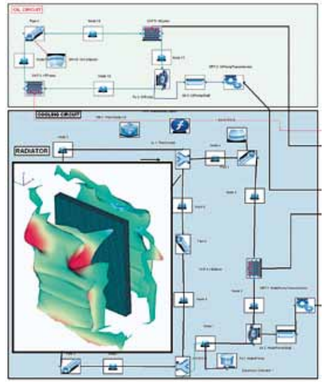
A comprehensive set of electro-chemical and physical models is offered by AVL FIRE® in order to simulate the processes which take place in polymer electrolyte membrane fuel cells (PEM FC). In the catalyst layers AVL FIRE® also solves the electro-chemical reactions in the catalyst layers. Water transport and the transport of hydrogen ions and gas species are calculatedd in the membrane. Phenomena handled in the gas diffusion layer include the capillary flow of liquid water and electron conduction. In addition, phase change due to evaporation and condensation, multi-phase momentum transfer, the multi-component diffusion of gas species and multiphase heat transfer are also modelled. Heat and electron conduction are calculated in the bi-polar plates. Simulation of the cooling channels is also provided in order to measure convective heat transport.

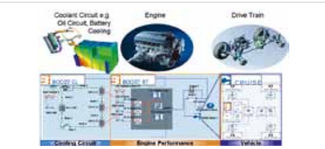
ENERGY EFFICIENCY IS THE FINAL GOAL

Vehicle component and sub-system development cannot be done in isolation if the goal is to improve the fuel economy, performance and drivability. The acceptance and success of a new vehicle is determined by its strategic target definition, the choice of the powertrain configuration and the selection and sizing of the components – early in the first development phase. AVL CRUISE offers a wide range of implemented electric components on a system level, dynamic power flow and energy distribution analysis and an open concept to interface with other tools. These attributes provide an incredible base for all of the hybrid concepts, as well as control function development for all vehicle types from PEV to full HEV and other alternative powertrain solutions.



AVL BOOST
AVL CRUISE
AVL FIRE®





THERMAL MANAGEMENT AND AERODYNAMICS

The component development tasks for the engine and vehicle are distributed over a number of departments. Using consistent simulation models delivers a virtual overall system simulation environment that is consistently detailed during the design process. This enables the sharing of relevant data across the various disciplines required for the study of vehicle thermal management systems (VTMS).

WHY THERMAL MANAGEMENT

A well designed engine cooling system enables fast engine warm-up

- to reduce friction losses
- to allow minimum time for aftertreatment system light-off
- to quickly clear the windshield of ice and condensation
- to ensure adequate cooling of all engine components under all operating and weather conditions
- to allow comfortable cooling or warming of the passenger compartment

SIMULATION ENABLES PERFORMANCE

In order to assist in the optimization of VTMS systems, AVL has established a comprehensive methodology for advanced vehicle simulation, including the simulation of:

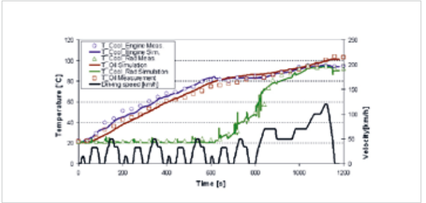
- engine performance
- exhaust gas aftertreatment
- cooling and oil circuits
- engine compartment flow
- heat transfer between fluids and structure

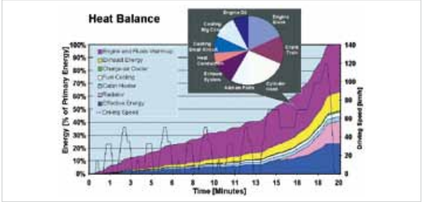
SUPERIOR TOOLS FOR SUPERIOR SOLUTIONS

AVL offers an integrated set of tools consisting of:

- AVL BOOST, for calculating 1D gas dynamics, performance, cooling and oil circuits and exhaust aftertreatment
- AVL CRUISE, the industry standard for integrated vehicle simulations
- and AVL FIRE®, 3D CFD for IC engine and vehicle development

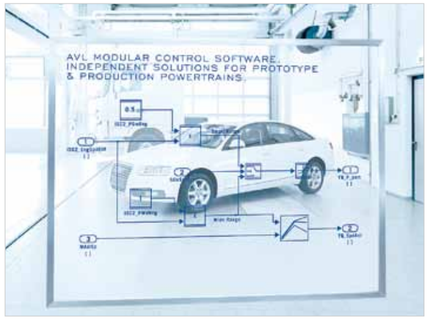
These tools facilitate the seamless development and optimization of vehicle thermal management systems and control strategies.





AVL BOOST

AVL CRUISE



CALIBRATION AND TEST

The growing number of closely interacting components and control systems and the increasing complexity of control functions require the testing of an exhaustive number of new test case combinations. AVL CRUISE and AVL BOOST real-time models add more flexibility and productivity to HiL targets, such as AVL InMotion, IPG CarMaker, dSPACE, ETAS, National Instruments and Opal RT, as well as AVL PUMA Open testbeds.

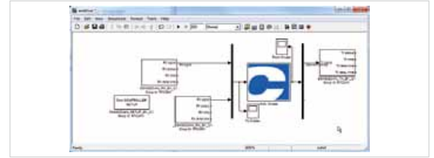
CAE AND TEST WITH THE SAME PLANT MODEL

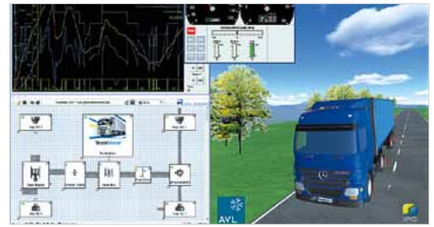
System models, set up in the office for solving powertrain analysis and optimization tasks using AVL CRUISE or AVL BOOST, can be used again in the field of components and control systems testing (engine testbed, hardware in the loop). This is possible thanks to the use of the same system solver, which has been optimized for office as well as real-time applications. In this way the effort required to exchange models in both directions between the office and test systems is kept to a minimum. This consistency between the model and solver forms the basis for achieving comparable high quality results throughout the whole development cycle.

SEAMLESS CONTROL FUNCTION DEVELOPMENT AND CALIBRATION

The modular vehicle drivetrain modeling concept of AVL CRUISE allows one to set up and switch between sub-systems with various levels of detail within a single plant model, which significantly reduces the effort of parameter changes and model maintenance, and which enables one to quickly adjust to specific needs for different working environments. Interfaces to a wide range of modeling and programming tools and control test platforms provide engineers with the openness needed to expand model fidelity in well defined areas, and to incorporate them into a seamless MiL to SiL to HiL development workflow.

AVL BOOST RT is a real-time is a capable real-time engine model dedicated to the investigation of of transient offline operating conditions for CAE applications, and transient online operating conditions which are integrated into the testing environment. This tool supports engine performance, fuel consumption, combustion, emissions, aftertreatment and cooling applications. AVL BOOST RT runs in the time domain through the use of transient and steady-state 0D and quasi-dimensional component models, or alternatively with a crank-angle-resolved or data- driven-surrogate cylinder module.





AVL TEST SYSTEMS – INNOVATIVE SOLUTIONS FOR THE ENTIRE POWERTRAIN

SOLUTION

With decades of experience, AVL provides a wide range of solutions for developing and testing modern powertrain systems, from test beds for optimizing internal combustion engines, to test systems for all components in an electrified powertrain, to roller testbeds for full vehicle development and testing. AVL is the only company in the world to combine competence in powertrain design with competence in state-of-the-art measurement and testing technology.

Many instruments and test systems are already based on the AVL Open Development Platform, which considerably boosts the efficiency of the testing process. Using numerous shared software and hardware technologies, AVL test systems delivers consistent, comparable results that significantly help lower development times and costs. This makes them an ideal, integrated tool chain for developing efficient and environmentally friendly powertrains.

BENEFITS AT A GLANCE

- Great breadth of experience from more than 4,000 test system installations
- High precision of measurement and reproducible measurements results
- Consistency between AVL test systems
- Easy expansion of existing testbed systems for developing hybrid powertrains as upgrades
- Worldwide training by AVL personnel in local language
- Global service & support
- Integrated Open Development Platform leading to consistent results in Development
- XiL Integration ensures highest testing flexibility

TASK

The increasing complexity of modern powertrains is placing increasing demands on the instrumentation and test systems used during development and testing. At the same time, more customers wish to perform development activities at the earliest possible stage. To ensure this, when testing individual components, full systems or even entire vehicles, AVL test systems must precisely emulate reality.

Due to the interaction of several active components in the vehicle, electrified powertrains for hybrid vehicles are becoming particularly complex. The challenge for developers today is to place all components (internal combustion engine, E-motor, battery, inverter, and gears) together into one overall harmonious system. From testing an HV battery in an emulated vehicle environment to testing a full system or entire vehicle with an electrified powertrain, AVL offers all testing systems required to conduct such testing.

Consistency between all the different systems must be guaranteed to keep data acquisition and management as simple and efficient as possible over all test runs. Therefore, all AVL test systems use a common measurement and parameter database.

PORTFOLIO

TEST SYSTEMS FOR INTERNAL COMBUSTION ENGINES AND FOR COMPONENTS

The range spans from combustion development on the single-cylinder testbed, to development testbeds, and performance and emission testbeds. Even turbochargers and injection systems can be tested using special AVL testing systems.

ELECTRIC MOTOR, BATTERY AND INVERTER TESTBEDS

AVL offers testing systems for all components in the electrified powertrain. These are used for testing individual components (e.g. in a virtual vehicle environment) as well as full systems and entire vehicles.

POWERTRAIN AND ROLLER TESTBEDS

The application range of these testbeds is constantly expanding: Alongside endurance, strength, emissions, acoustic and EMC testing, they are increasingly being used in driving maneuver based tests and for optimizing electrified powertrains.

END-OF-LINE TESTING SYSTEMS

AVL end-of-line testing solutions, which integrate perfectly into the production process, cover all functionality verification procedures from subsystems on the assembly line, to hot and cold tests, to quality audit tests.

CONSISTENCY BETWEEN THE VARIOUS AVL TESTING SYSTEMS CONSIDERABLY BOOSTS EFFICIENCY IN DEVELOPMENT.

ELECTRIFICATION – FUTURE-ORIENTED KNOW-HOW FROM AVL

The electrification of the powertrain means developers are faced with many challenges. Electrification not only increases the complexity of the systems, but the number of solutions as well. Therefore, a partner with both comprehensive component know-how and a holistic perspective on the system is critical. AVL provides its customers with exactly this comprehensive expertise.

AVL is equipped to test all components of the electrified powertrain, both as individual components and within the system. Additionally, the customers are provided with the advantage that the electrical assemblies can be tested together with the entire powertrain of a hybrid vehicle (internal combustion engine, transmission, etc.) or with the entire vehicle on the testbed. Furthermore, by using the simulation platform AVL InMotion, realistic performance results (energy optimization, drivability, etc.) can already be achieved on a component and/or system level.

TEST SYSTEMS FOR ALL ELECTRICAL COMPONENTS

AVL offers test systems for development, durabilty testing, and quality assurance for all components of the electrified powertrain, electric engines, high-voltage batteries, and inverters.

AVL inverter test systems emulate the electric engine. All electrical and mechanical conditions can be emulated easily and quickly by means of parameterization. Furthermore, the function of the inverter can be tested with different designs of the electric engine and diverse error scenarios on the basis of emulation, without requiring an electric engine.

Using the AVL electric engine test systems, all types of electric engines (ISG and BSG starter generators and axle engines) can be checked for functionality, reliability, and endurance. AVL battery test systems serve to optimize the service life, safety, performance, and cost-efficiency of energy storage systems.

All AVL measurement and test systems for the electrification of the powertrain can be integrated into an existing AVL test environment in a quick and easy manner (automation, data analysis, host systems, test field management, etc.)

NEW AVL E-STORAGE TEST SYSTEM FAMILY

In order to offer a test system that is as modular as possible and that can be adapted precisely to the respective requirements of the customer, AVL has developed a scalable E-Storage test system family. As a high-end DC source for electric engine and inverter test systems, the AVL E-Storage DC Power Unit is used as a base system. This basic system can be extended with the AVL E-Storage Emulator emulating the behavior of the energy storage with the vehicle (discharge, behavior during acceleration and/or recuperation etc.) in a realistic manner.

As a complete solution for battery tests, the AVL E-Storage Tester is offered as an additional element, including the automation system LYNX. In order to successfully address the new customers' requirements in a quick and resourceful method, all upgrades of the AVL E-Storage system can be implemented on-site in a cost- efficient manner.

The electrically driven AVL EVARE MINI with range extender on the roller testbed.

BENEFITS AT A GLANCE

- Turnkey complete solutions for testing battery cells, modules and battery packs, including battery management system
- Suitable for use in both research and development and in the field of production thanks to the multifunctional layout design
- Reduction of the development time due to consequent application of the “Virtual Proving Ground” approach
- Short delivery and commissioning times
- Global distribution and service network

AVL BATTERY TEST SYSTEMS

Using AVL battery test systems, high-voltage batteries can be tested for use in hybrid and electric vehicles. These tests can be implemented both at cell and module level as well as at the battery pack level. Battery pack tests are possible including or excluding the battery management system (BMS).

Using the AVL battery test systems, all common types of energy storage systems (super capacitors, nickel metal hydride and lithium ion batteries) can be tested and optimized for different fields of application, both passenger and commercial vehicles. From the first prototype creation and pre-production to the final series production, the testbed solutions are suitable for being used within the entire vehicle development process.

The most important development tasks are as follows:

- Durability (calendric service life and cycle stability)
- Safety (during operation and in the event of accidents)
- Performance capability
- Energy storage capability
- Cost reduction

All customized and standardized test procedures (VDA, EUCAR, FreedomCAR, etc.) can be defined easily and implemented efficiently. The AVL battery test systems are able to implement the test runs pursuant to ISO 12405.

TESTBED CONFIGURATION

The “plug&play” AVL battery test systems are available in test cell design or in container design for flexible and/or location-independent application. Both standard solutions and customized systems are available. The AVL E-Storage-Tester (cycling unit) from the AVL E-Storage System family, actuated by the automation system AVL LYNX, is the core component of the system. AVL LYNX is characterized by an easy to operate interface and perfect integration into many further AVL software tools and furthermore is able to integrate the BMS system and implement a residual bus simulation via CAN interface.

CLIMATE CONDITIONING

Highly dynamic and precisely working climatic chambers (with the temperature range from -30 to 90 degrees Celsius) are specifically suitable for simulating the environmental conditions and for testing the energy storage systems up to automotive battery pack sizes. These simulations are part of the test runs, for example high temperature gradients within the framework of shock tests. The climatic chambers are completely integrated into the AVL safety concept which is certified by the Technical Control Board.

FEMS AND PLC CONTROL AS AN OPTION

By means of cascadable front end modules (FEMs), a parallel measurement system can be designed to check voltage, temperature, and current at cell, module, and battery pack level. Additionally, the testbed can be extended by a PLC control system monitoring the test chamber according to the configured safety matrix, including climatic chamber test station, and initiating defined reactions.

VIRTUAL PROVING GROUND TECHNOLOGY

The integration of the “Virtual Proving Ground” technology based on AVL InMotion™ offers a time and cost efficient development. Additionally provided is a test environment in order to shift integration, optimization, and validation tasks to earlier phases of the development process. The test specimen is integrated into a virtual vehicle environment and is tested systematically with reproducible driving maneuvers (“virtual fleet test”).

From the concept to reality – AVL offers turnkey complete solutions for testing high-voltage batteries.

E-Storage Tester (cycling unit from the AVL E-Storage system family.

AVL electric motor test bed with climatic chamber module.

BENEFITS AT A GLANCE

- Flexibility thanks to modular design with matched and tested components
- The highest data quality due to excellent system precision
- Dynamometers up to 20,000 rpm
- “Virtual Proving Ground“ concept based on AVL InMotion™
- Applications know-how based on the operation of its own test beds at AVL
- Global distribution and service network

AVL E-MOTOR TEST SYSTEMS (AVL EMT SERIES)

Using AVL electric motor test beds, all kinds of different electric motors – both for hybrid vehicle drives and for all-electric vehicle drives – can be developed and tested for durability. The modular test bed concept allows for test-bed design in different performance and speed classes and additionally offers the option of functional test bed expansion – either by adding software or instrumentation systems; it is even possible to add a climatic chamber module later. This makes the AVL test system a secure investment for the future.

APPLICATIONS

The AVL electric engine testbeds are used for analyzing and determining electrical, mechanical, thermal, and acoustic properties. Functionality, reliability and durability tests and cold start performance measurements can be implemented under realistic conditions. The integrated AVL PUMA automation system allows for fully automatic and, thus, time and cost efficient test runs for all relevant test procedures. All measurement data is saved with a uniform time stamp and can be processed further with the data reworking tool, AVL CONCERTO.

The optional integration of the “Virtual Proving Ground” technology based on AVL InMotion™ also offers a virtual development and test environment to implement integration, optimization, and validation tasks even on the testbed. The test specimen is (by means of simple parameterization) integrated into a virtual vehicle environment and tested systematically with reproducible, realistic driving maneuvers. Control units within the vehicle can be emulated in InMotion™ or connected as real devices to InMotion™

TESTBED CONFIGURATION

AVL electric engine testbeds are available as a standardized system or as a customized, tailored testbed solution. A special adapter system used to initially set-up the test specimen allows for quick and simple coupling of the test specimens to the dynamometer. Shaft connections are available for both low and high-speed applications. In order to measure the torque and/or efficiency, special integrated instruments with extremely high levels of accuracy are used.

AVL offers dynamometers in a variety of performance and speed classes for the entire operating range of the test specimen, from zero speed up to the positive/negative maximum speed. The high quality AVL dynamometers are also characterized by very low torque cyclic irregularities resulting in the delivery of measurement results with high levels of accuracy.

ENVIRONMENT SIMULATION

To be able to perform test runs under realistic environmental conditions, AVL e-motor test beds are equipped with a coolant conditioning system (single- or two-circuit system) for the electric motor to be tested, the relevant inverter and, optionally, a climatic chamber which enables environment simulation within the typical temperature and air humidity ranges as specified in the European and Chinese testing recommendations.

ENERGY SUPPLY

Different systems from the AVL e-Storage System family are available for supplying the unit under test with energy: The AVL e-Storage DC Power Unit™ is a DC supply capable of recovering energy. The AVL e-Storage Emulator is capable of emulating the behavior of a vehicle battery – such as discharge or recharge by energy recovery – in a realistic manner.

AVL electric motor test bed. Fitted climatic chamber module.

AVL Electric Mobility Center Graz. Electric motor and battery test beds.

AVL Inverter Testsystem, bestehend aus Energierückgewinnung, Motor & Batterie-Emulation.

BENEFITS AT A GLANCE

- Compact testing environment with no rotating mechanical parts
- Validation of firmware stability under several combinations of electrical property variants (simulation of production tolerance)
- Flexible, easy-to-use and configurable automation system
- Full compatibility with AVL InMotion™ Real Life Test System
- High reproducibility of AC and DC load cycles
- Energy-efficient test systems thanks to power recovery

AVL POWER ELECTRONICS TEST SYSTEMS

The growing complexity of modern powertrains inevitably leads to an increased need for component testing in a real-world environment at an early stage in the development process. This is even more so in the case of electrified powertrains, where all individual components of the power electronics have a significant influence on each other and therefore need to be tested individually, in a virtual environment.

To achieve this challenging goal, AVL offers flexible systems for a range of voltages and currents incorporating innovative software tools to emulate reality.

INVERTER TESTING

The AVL inverter testbed provides a comprehensive environment for the development, test and validation of inverters. On one side, the e-Storage Emulator guarantees the realistic simulation of the vehicle battery, while the e-Motor Emulator reproduces the behaviour of an electric motor including its rotor position sensor.

This flexibility permits the system to operate all inverter types - from start-stop system inverters, converters for mild and full hybrid vehicles, through to pure electric vehicles - for a broad range of applications such as hardware and software development, endurance testing and fault simulation etc.

DC/DC CONVERTER TESTING

Independent of whether the function is integrated in the inverter, or not, AVL can emulate low voltage accessories by means of a DC-load unit.

QUICK CHARGING AND ONBOARD CHARGER TESTING

AVL offers mains emulators for different voltage and power ranges. In conjunction with the e-Storage Emulator, all types of loading configurations and fault situations can be simulated.

SAFETY FIRST

The development of power electronic components is a challenging task, since numerous safety-related functions in the system need to be taken into consideration (ISO 26262). Thanks to its decades of experience, AVL is able to provide not only high-end test solutions, but also ones that are safe and easy-to-use.

View inside the AVL Inverter Test System.

Example test specimen.

SYSTEM EXTENSIONS

- Extreme testing needs extreme equipment. AVL offers climatic chambers and climatic coolant conditioning systems for power electronics testing, which can be adapted to meet customer requirements.
- Our virtual road, vehicle and driver environment (InMotion™) enables maneuver-based testing and can even generate vehicle vibration via a vibration table.
- Switch box, specifically designed by AVL to trigger diverse fault scenarios such as short-circuits, or open-circuits.

AVL turbocharger testbed and turbocharger during hot gas test.

BENEFITS AT A GLANCE

- Manufacturer-independent thermodynamic models
- High efficiency due to simultaneous measurement of turbine and compressor
- Online map calculation and visualization
- Testbed automation by means of PUMA Open
- Application know-how due to the operation of proprietary testbeds by AVL
- Worldwide service and support

AVL COMPONENT TEST SYSTEMS

TURBOCHARGER TEST RIG

Using turbocharger test systems, the thermodynamics and efficiency of exhaust gas turbochargers can be mapped and the durability of the turbochargers can be evaluated. The AVL Turbo Test Rigs combine the precision of a high-end measurement system with the robustness required for day-to-day use.

The Turbo Test Rig for turbochargers consists primarily of an industrial compressed air supply, the hot gas generator, conditioning systems, sensors and control valves. It is completed by the AVL automation and data acquisition systems, as well as the test applications for control and data analysis. In order to extend the turbine measuring ranges, it is possible to measure with the compressor circuit closed. AVL Turbocharger Test Rigs can be operated, optionally, with natural gas or oil fuel and/or diesel oil.

Along with thermodynamic measurements, the AVL Turbo Test Rig can perform all tests for operational stability of the turbocharger. For example, these comprise tests on bearing lifetime under extreme conditions, different fatigue cycles, as well as temperature and mass flow cycles close to real engine operations. In the event of thermal shock tests, the charger is heated cyclical and abruptly cooled by means of cold air.

INJECTION TEST SYSTEMS

Combustion engine technology has undergone a rapid development in recent years in pursuit of higher fuel efficiency and engine performance. Technological progress of Direct Fuel Injection systems (DGI, CRI) has contributed significantly to this effort. High precision and reproducibility of fuel injection quantity as well as improved timing control require high-precision flow measurement systems for injector characterization in production, R&D and engine application.

AVL PLU131 Flow Measurement Systems provide a variety of integrated measurement solutions for R&D and production testing of Diesel and Gasoline fuel injectors. Custom solutions range from sample inspection on semi-automated test benches to 100% control on fully automated production lines. R&D and engine application add further tasks as flow rate characteristic verification, injector timing map calibration or combustion development.

AVL provides a large spectrum of flow sensors and system solutions for these tasks with either continuous flow rate metering or injection quantity measurement.

CONTINUOUS FUEL FLOW MEASUREMENT

Fuel pump as well as Diesel and gasoline low pressure injector testing in production is performed with the AVL PLU131 flow sensor family providing for:

- High-accuracy continuous fuel flow meters for a wide temperature and pressure range.
- Large measuring range and highest resolution.
- Extreme sensor robustness and long term stability of calibration

FUEL INJECTION QUANTITY MEASUREMENT

With the Shot To ShotTM PLU131, AVL provides a state-of-the-art shot measurement system compliant with the most extreme requirements of OEMs and component suppliers. It is part of DI injector testing system solutions in R&D as well as EoL-production testing, featuring:

- Precise injection quantity measurement.
- Short measurement time in end-of-line testing
- Accurate injection rate analysis in R&D applications

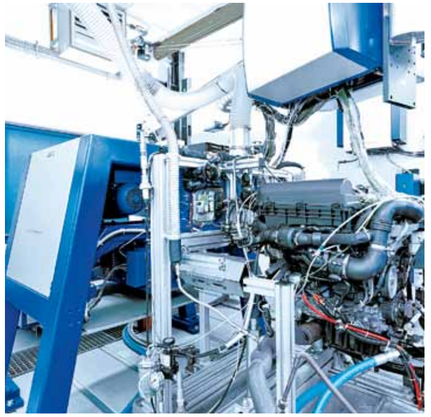
AVL PLU131 Flow Meter in a component test rig.

AQUEOUS MEDIA (ADBLUE®) AND EXTREMELY LOW FLOW RATE

Low pressure injection systems are used for Diesel engine exhaust after treatment in SCR systems for NOx reduction and HC dosers for DPF regeneration. AVL offers system solutions well adapted to the particular challenges in performance testing of these dosing systems; extremely low flow rates and small dosing quantities.

SYSTEM INTEGRATION SERVICE

AVL provides integration support to system integrators as well as end users for the full range of flow sensors and system solutions for a variety of measurement tasks.



BENEFITS AT A GLANCE

- More than 40 years of experience regarding the development and design of automatic engine testbeds and test facilities
- Proven system functionality used on a day-to-day basis within AVL operated engine development centers all over the world
- Flexibility due to modular design
- Highest data quality due to excellent system accuracy

AVL ENGINE TEST SYSTEMS

Several thousand installations worldwide and the experience gained in doing so allows AVL to offer state-of-the-art and innovative engine testbeds for a broad field of applications. The comprehensive range covers the conceptual combustion development and basic research on the compact single cylinder testbed, deditcated development and calibration testbeds and solutions for production approval. No limitation to engine size and powertrain concept. All types, from the small – engines and motorcycles up to vessel propulsion, can be tested via engines for passenger cars and commercial vehicles (off-road and on-road). Also an electrified powertrain can be tested with the AVL test systems.

AVL successfully develops engines, transmissions, and drive concepts for the automobile and transportation industries. This expertise is an integral element when designing our test systems. The testbed is designed by engine developers for engine developers. Equipped with state-of-the-art measurement, control and automation engineering, the AVL test systems are well prepared for all current and future development tasks. Modular design and an open platform philosophy with the option of system extension turn the AVL testbed system into a secure investment for the future.

Typical fields of application for AVL engine and testbed technology are as follows:

- Combustion Development and Basic Research
- Performance and emission development
- Parameterization and calibration
- Emission certification of engines for heavy-duty applications
- Endurance testing and aging of components for exhaust gas after-treatment
- Component testing near the engine
- Mechanics and function development

MITIGATING INCREASING COMPLEXITY

The engine development process must face the increasing complexity within the vehicle. Additional actuators, integrated support systems, more stringent emission laws with regional differences, new technologies and the ongoing rise in electrification - these are all topics determining the work of the development engineer. AVL continuously searches for new solutions, as well as intelligent methodology and develops numerous state-of-the-art tools that are integrated into the test system and made available to the developer.

HIGH LEVEL OF ACCURACY AND OPERATING POINT STABILITY

High measuring and data quality are core requirements to provide the development engineer with a suitable basis for making decisions. System components and instruments from AVL fully meet this requirement – highest stability at the stationary operating point or exact repeatability of dynamic procedures. The time required for measurements is reduced while simultaneously ensuring high data quality.

EFFICIENT DATA MANAGEMENT

The data management system located locally at the testbed allows to handling parameters, measurements and data in a structured manner. This system can also be shifted to a Host system. In this respect, AVL believes that networking and ASAM compliance are present at all systems involved in the development process.

Testbed arrangement for calibration and optimization.

Testbed arrangement for combustion and basic research with AVL single cylinder engine.

BENEFITS AT A GLANCE

- High level of technical system availability due to state-of-the-art, robust, tried and tested technology
- Highest level of flexibility for all customer requirements, modular individual systems functional within an overall solution
- Simple upgradability of hardware and software
- Turnkey systems for each application and customer application (container solutions)
- Huge experience on the basis of numerous turnkey projects for customers from all over the world
- Global service & support, including 24 hour service

AVL END OF LINE TEST SYSTEMS

End of line test systems for internal combustion engines are an integral and indispensable part of engine production. Within the framework of production, end of life test systems are used to evaluate, analyze and optimize the quality of internal combustion engines. The measurement, test and process systems are designed according to the customers' requirements and are based on the proven AVL hardware and software standards.

INCREASING SYSTEM COMPLEXITY WITH ENGINES

Due to the ever increasing system complexity and diversity of variants for internal combustion engines, the challenges for end of line testing increases as well. Both the increasing number of sensors and the actuation system and numerous new mechatronic systems are responsible for the aforementioned. Furthermore, engine components are increasingly purchased from third parties, whereby the quality can no longer be influenced by the OEMs. Today, a simple hot test with no load is no longer sufficient to ensure functionality and quality of a state-of-the-art engine. Today, test methodology and technology must be adapted precisely to the drives to be tested and the production processes to be used. The AVL solutions aim at integrating the production test facility into the production procedure in a holistic manner.

AVL end-of-life test solutions are available for the areas light-duty, medium-duty, and heavy-duty engines. The range of solutions starts with the verification of the functionality of subsystems in the manufacturing line and covers cold and hot tests through to quality audit testing.

Comprehensive understanding of the test mechanism and the leading system solution experience make AVL the ideal partner for designing and implementing state-of-the-art production testbed solutions.

AVL PROVIDES COMPLETE SOLUTIONS

The turnkey solution services offered by AVL range from the process analysis via planning and development through to the construction of a holistic test system integrated into production. The ready-to-operate transfer of the systems is followed by the support in the operative area by AVL.

AVL end of life test systems are best delivered as container systems and can be integrated into an existing production environment in a quick and easy manner by means of defined interfaces. Depending on the requirements, the customer is provided with manual through to fully automatic solutions.

TEST SOLUTIONS FOR ALL ENGINE SEGMENTS

On the basis of the widely varying requirements, the AVL testbed solutions are divided into the following application segments:

- Light-duty, passenger vehicle engines and light-duty commercial vehicles
- Medium-duty engines
- Heavy-duty engines

AVL offers test systems for all required test purposes; In-process verification, cold and hot tests, as well as COP/QA (Conformity of Production/Quality Assurance).

Depending on the engine technologies and the boundary conditions of production, different quality concepts are also selected and equipped with a suitable combination of test systems. This involves a combination of cold and hot tests, COP/QA also makes sense and is appropriate.

AVL offers Test Systems for all required test purposis.

BENEFITS AT A GLANCE

- Real Life Testing simulates drive tests in software
- Powertrain subsystems can be integrated as real parts into real-time simulation (X-in-the-loop simulation)
- Swap between virtual and real components at any time with one click of a mouse
- Comprehensive models are already integrated into the platform, any customer models can be imported

AVL REAL LIFE TEST SYSTEMS

AVL Real Life Test Systems is the bridge between simulation and reality. It gives the developer the capability to develop and optimize vehicle subsystems long before their first use on the road.

It is based on the real-life platform AVL InMotion™, which facilitates virtual vehicle integration under simulated real conditions. By combining simulation and reality, AVL Real Life Test Systems provides a high performance development support tool for maneuver-based testing on the testbed, which considerably reduces developmental times and costs, as well as developmental risks. Real-Life Testing can be used to test individual components within the system (electric motor, battery, inverter etc.), or the entire powertrain, or the internal combustion engines of motorcycles, cars and heavy-duty vehicles.

SIMULATION MODELS AND MANEUVER CATALOGS

Before a prototype of a new vehicle is built, the components and aggregates exist as simulation models. AVL InMotion™ uses these simulation models for testing the components on the testbed, where their interplay within the system, and comprising real and/or virtual components. Working from comprehensive maneuver catalogs, the test specimens are put through test runs corresponding to the real loads of daily driving. This means the specimens can be tested and optimized at a very early developmental stage before a single mile is driven on the real test track.

USER-FRIENDLY AND FLEXIBLE

AVL InMotion™ plugs easily into any AVL testbed. All Real-Life Test Systems come with a comprehensive library of simulation models, on top of which all customer models can be integrated. Users can swap between different simulation models while the tests are running. It is even possible to switch between a real component, e.g. an engine on the testbed, and a virtual model at the push of a button.

Existing control units in the vehicle, such as engine or powertrain control units, brake management, wheel revolution sensors etc., are simulated using AVL InMotionTM or also integrated as real parts. Information from the world outside the vehicle, such as a distance measurement system, real-time horizon provider etc. can be simulated in the Real-Life Testing for the most realistic test runs possible.

APPLICATIONS OF AVL INMOTION™

AVL InMotion™ covers many application areas:

- Development and testing of hybrid and electric vehicles
- Misuse tests (handbrake turn, popping the clutch) and networking tests (brake, powertrain, assist systems).
- Simulation of difficult vehicle situations, such as sidewalk contact when parking with a hybrid vehicle, or starting on snow with an electrically driven axle.
- Realistic drives for measuring consumption of cars and heavy-duty vehicles (media and consumer report tests) in which a pre-defined route is simulated.
- Simulation of various driver characteristics; defensive, normal, and aggressive to calculate realistic consumption
- Library of various driving conditions to be virtualized online (testing grounds, Pikes Peak, Groglocklkner-Hochalpenstrae and many more) for virtual test drives

With its scalable system, AVL InMotion™ can be adapted precisely to specific customer needs, from AVL InMotion Embedded integrated into PUMA Open, through to AVL InMotion™ pro.

Maneuver-based testing with AVL InMotion™.

BENEFITS AT A GLANCE

- Endurance strength testing in continuous unmanned operation, 24/7
- Integration tests in the virtual drive test with simulation of driver, vehicle, road and environment
- Transmission system calibration and drivability tuning at an early development stage without the need for a vehicle prototype
- Transmission and driveline testing with a directly connected prime mover as substitute for the IC engine

AVL DRIVELINE TEST SYSTEMS

AVL's testbed solutions allow many testing jobs to be performed during the driveline development process. Most of those testbed times are still awarded to endurance strength testing. New, intelligent transmission concepts as well as electrified and hybrid drive systems give the developing engineer many new possibilities for optimizing the overall system. Drivability, NVH characteristics and driving comfort must be given as much consideration as fuel consumption and exhaust emission characteristics. The task here is to resolve the conflict of objectives arising from increasing integration and calibration effort on the one hand, and the demand for shorter and more efficient development on the other.

The option to substitute the internal combustion engine with an electric prime mover with optimized inertia and design means the driveline or driveline components can be measured and the driveline can be optimized early on, before the IC engine is ready for series production. AVL's testbed solutions allow flexible and highly efficient testing of all kinds of components in different setups. The range of functions and applications can be expanded at any time with additional automation functions to include the necessary features.

ENDURANCE TESTING AND ENDURANCE STRENGTH TESTING

Endurance is proven using a number of different testing methods based on individual empirical values. Reliable testbed automation and control guarantees dependable, continuous unmanned operation in various applications, such as stationary and transient fatigue tests, simulated dynamic road tests and time-lapse tests.

INTEGRATION TESTS

High dynamic integration testbeds (powertrain-in-the-loop and vehicle-in-the-loop) are used for testing the powertrain system in virtual drive tests. Suitable simulation models for the driver, vehicle, road and environment make it easy to bring real driving maneuvers from the drive test into the laboratory environment of the high dynamic integration testbed.

This sort of testbed is based on high dynamic electric dynamometers, built to have a similar inertia to the wheel. Simulation models then calculate the respective load of each wheel during tire-road contact. The dynamometers then apply this load. This ensures the dynamic behavior of the powertrain on the testbed is identical to the drive test. This provides insights at an early development stage that would once have required time-consuming and cost-intensive drive tests.

PERFORMING

Example applications include:

- Vibration testing
- Optimizing gear shift comfort
- Optimizing control unit functions
- Drivability testing
- Recuperation
- Drive maneuvers on various surfaces to validate the overall system behavior
- Load cycle change testing (tip-in/back-out)
- Realistic curving

AVL testbeds with prime mover as IC engine substitute for front-wheel drive vehicles with transversely mounted engine.

AVL all-wheel testbed with prime mover for vehicles with longitudinally mounted engine.

BENEFITS AT A GLANCE

- Expert knowledge associated with specific tests
- Fully integrated solutions to comply with CEC, ASTM and JASCO
- Expert support and advice during laboratory operation
- A comprehensive delivery scope
- Scope of supply can also be extended to test engine

AVL FUEL AND LUBE TEST SYSTEMS

Fuels and lubes testing is a specialized branch of testing in which the engine is prepared and tested in a highly prescribed way and thereby the potentially marginal influence of the candidate fuel or lubrication oil determined.

For fuels and lubes projects the potential supply scope of AVL encompasses not only the hardware, software and service deliverables, but the test engines too; i.e. the integrated whole capable of delivering the testing objectivity and discrimination necessary.

AVL SOLUTIONS

For CEC test methods AVL can offer complete test installations with an engine prepared for test in accordance with the Test Method, mounted on a dedicated pallet. Also provided are all of the necessary items of instrumentation.

One Test System is able to support several CEC Test Methods by changing over pre-mounted Test Method pallets.

For ASTM Test Sequences AVL can offer engines prepared for test and all necessary items of instrumentation, as specified by the published Test Sequence. For such tests, a dedicated test cell is generally necessary.

In addition to CEC and ASTM tests, AVL can provide systems in accordance with JASCO requirements.

SYSTEM SCOPE

- Test Installation – engine prepared for test, pallet mounted, if appropriate, with engine conditioning systems (coolant, oil, intercooler) and engine instrumentation rigging, all as prescribed by the specific Test Method/Test Sequence documentation).
- Engine load measuring system (dynamometer)
- Testbed mechanical hardware (pallet receiver, under frame, base frame)
- Automation system
- Post processing software
- Instrumentation: blow-by and smoke meter, humidity measurement or as specified by the Test Method/Test Sequence
- Fuel consumption measurement and conditioning system
- Transducer box
- Engine services box
- Throttle actuator
- Combustion air system
- Engine exhaust with back pressure control
- Testbed and test facility services including ventilation, purge, plant cooling, chilled water, fire detection and suppression, fuel storage and distribution, electrical systems, acoustic attention
- AVL Services: Engineering, Project Management, Installation, Commissioning
- Training: Test System and Test Method
- Consumables including engines and engine parts (test dependant)
- Ongoing support

The provision of fuels and lubes testing systems, including Test installations for industry Standard Tests, depends upon the current availability of the base engines and the mandated hardware. In addition, the purchase of documentation and joining of industry working groups may be necessary.

It is suggested initial contact is made with AVL so that the appropriate advise and support can be given. Through this method, up-to-date information can be provided and the scope of projects determined.

Dynamic Oil Consumption Measurement.

Continuous Fuel Consumption Measurement

AVL EMISSION TEST SYSTEMS AND CERTIFICATION

AVL exhaust measurement systems are used for developing and certifying engines for cars, light commercial vehicles and heavy-duty vehicles (on and off-road) on the engine and roller testbed. Optimally integrated device and system solutions, consistent automation and data analysis provide the best possible basis for the highest possible productivity.

AVL offers cutting-edge instrumentation for standard gas emissions (CO, HC, NOx, and CO_2) and for particle measurement. The particle measurement technology includes devices for gravimetric measurement and for particle counting. In addition, the AVL product range includes special instrumentation for measuring ammonia emissions in SCR exhaust treatment systems, for example, or measurement systems for evaporative emissions, emissions from small off-road engines (SORE), and portable instruments for drive tests and in-use testing.

All AVL exhaust measurement systems satisfy the demands for high efficiency and productivity despite the rising number of measurement parameters, and the greater number of devices and subsystems this involves. The testbed automation integrated into the systems contributes significantly to this capability.

BENEFITS AT A GLANCE

- Refined and functionally attuned complete solutions from the wide AVL product range that can be perfectly adapted to the customer's needs
- AVL covers the entire spectrum of emissions testing from development, to certification, to special instrumentation
- High quality that comes from long experience and a large number of systems installed around the world
- Global service and support

APPLICATIONS

AVL exhaust measurement systems essentially fall into two categories, 1) engine testbeds and 2) roller testbeds. Heavy-duty vehicles for on-road and off-road use are chiefly tested and certified on the engine testbed. Light commercial vehicles and cars are developed on the engine testbed, but are certified exclusively on the roller testbed.

PARTICLE COUNTING

Recent laws have increased the importance of particle counting in the automotive industry.

In response to this, the highly sensitive AVL Particle Counter is able to measure the number concentration of all non-volatile particles in the exhaust, and allows samples to be taken from a CVS system (constant volume sampler), a partial flow dilution tunnel or directly from the raw exhaust. The AVL system stands out for its very high dilution factors, high accuracy and low maintenance requirements.

EMISSION MEASUREMENT ON THE ROAD

Alongside the proven in-vehicle opacity testing, AVL offers the M.O.V.E. PEMS series (portable emission measurement system) of cutting-edge, portable systems for measuring gaseous emissions and particle mass. AVL PEMS devices deliver highly precise measurement results and are protected against impact and vibration by damping measures.

Aside from being utilized during development, PEMS systems are becoming more important in the field, especially since the revisions to the Heavy-Duty In-Use regulation in the US, which states that vehicle manufacturers must test their vehicles for adherence to exhaust limits when in use.

AVL exhaust measurement technology integrates perfectly into the testbed environment.

AVL SESAM i60 FT for intelligent multi-component exhaust measurement.

AVL M.O.V.E. GAS PEMS – portable emission measurement system.

AVL VEHICLE TEST SYSTEMS

State-of-the-art development processes with intensive use of simulation tools and the front loading approach assign new and additional testing and validation tasks to the roller testbed that were previously reserved for road testing. The advantage of the roller in these cases is that the results are objective; reproducible test conditions that can be retrieved at any time ensure efficient testing and measuring. AVL roller testbeds with high precise and easy-to-operate measurement, control, and automation technology, PUMA OPEN VEHICLE, and the application tools (AVL INMOTION, AVL ACT, AVL DRIVE, AVL CAMEO) meets the latest requirements for state-of-the-art and future-oriented R&D tasks such as tests on hybrid and electric vehicles, as well as all requirements related to front loading; from the road to the testbed and ultimately to the simulation.

CHARACTERISTICS

The roller testbed provides for the realistic image of the road and reproducible environmental conditions. It can be used to test vehicles with any type of powertrain system. For example, the AVL roller testbed will extend its fields of application in the event of further diversification of these systems to provide a central development tool integrating all vehicle components. As the roller testbeds move closer to the engine and powertrain testbeds, significant savings are allowed for by re-using the test specifications, by correlating test results and standardizing the test tools and methods.

Furthermore, the fields of use and application of roller testbeds are also successfully increasing, making them suitable for new applications such as the shifting quality and drivability assessment, maneuver-based tests, or the powertrain calibration optimization. The combination of road, laboratory and office, together with AVL INMOTION and its excellent environment simulation, results in a rational development process.

BENEFITS AT A GLANCE

- Tried and tested roller testbed solutions for all R&D tasks with different driving, environment and driver models
- Shorter development times due to high levels of reproducibility and modeling real driving simulations
- Uniform control concept in combination with ideal data management ensures rational vehicle development and validation
- Efficient integration of the AVL tools; e.g. AVL DRIVE, AVL ACT, AVL INMOTION and AVL CAMEO into the application work on the vehicle by using them on the roller testbed

APPLICATION

Emission, endurance and R&D tests:
Along with the repeatability, the offer of proven complete solutions is a decision criterion for AVL testbed systems. The increasing complexity of the powertrain control systems and the close interaction of engine and transmission control unit with emission results often requires joint testing. SHEDS for testing fuel perspirations and height chambers are equipped with roller testbeds as well. Wind tunnels and climatic chambers are successfully combined with AVL roller testbeds. In the field of R&D, AVL tools are used intensively to optimize the drivability.
Noise and vibration tests (NVH):
More than 60 systems used worldwide demonstrate the high levels of quality and flexibility of AVL regarding project planning of individual testbed solutions. In this respect, AVL is characterized by particularly good phase control, as well as replaceable roller surfaces.
Electromagnetic compatibility tests (EMC):
AVL is unquestionably the partner with the most experience and the best reference installations in this field. Along with the exact road simulation, the focus is also on technical criteria such as lowest emissions, high acceleration of the rotary table and robust design.

BENEFITS AT A GLANCE

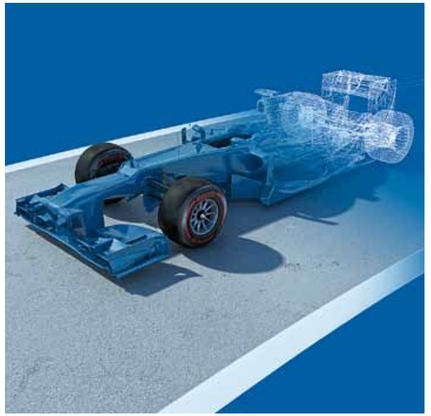
- Tried and tested roller testbed solutions for all R&D tasks with different driving, environment and driver models
- Shorter development times due to high levels of reproducibility and modeling real driving simulations
- Uniform control concept in combination with ideal data management ensures rational vehicle development and validation
- Efficient integration of the AVL tools, e.g. AVL DRIVE, AVL ACT, AVL INMOTION and AVL CAMEO into the application work on the vehicle by using them on the roller testbed

Noise and vibration testing in the NVH test environment.

Climate tests in the wind tunnel of different vehicle categories.

DESIGN

AVL vehicle roller testbed functions such as:
- Active braking support
- Implemented quality checks and service logbook
- Feed-forward type of control and innovative rolling resistance control algorithms
- Highly precise tractive force and speed measuring chains impressively demonstrate the innovative potential of the testbed solutions



BENEFITS AT A GLANCE

- Access to AVL's broad expert knowledge
- Proven hardware with many common parts
- Horizontally consistent software (AVL Suite)
- Updates for adapting to rule changes and for expanding with new functionality
- Comprehensive instruction and training program
- Maintenance program and 24-hour spare parts service

AVL RACING TEST SYSTEMS

The motorsport group of AVL can quickly and competently to all needs of motorsport customers. AVL Racing is an ideal interface between the special needs of a racing team and the wide expert knowledge of AVL: One contact at AVL Racing manages the customer's entire project and forwards it to the respective AVL specialist.

This means racing teams have the entire instrumentation and testing technology expertise of AVL at their fingertips anywhere in the world. From simulating components, to developing sensors, and full testbed systems, AVL offers quality racecar development and testing solutions that have proven their worth in Formula 1 and many other premier leagues of motorsport.

RACING ENGINE AND POWERTRAIN TESTING SYSTEMS

AVL Racing engine and powertrain testing systems stand out from the crowd with their high precision and reliability of the hardware and software. AVL solutions that have been adapted to special requirements are employed for testbed hardware wherever technically possible, whereby the number of common parts can be increased. This is a major benefit to customers in terms of maintenance and spare parts. The AVL motorsport group also benefits from AVL's software expertise in this field: special racing applications are deployed in the horizontally consistent AVL Suite, which allows all developmental steps can be performed on one software level.

CLOSE COLLABORATION AND SYNERGIES

Close collaboration between AVL Racing and the experts in series development means their extensive experience in fields, such as hybridization/electrification including battery technology, downsizing and exhaust turbocharging can be put to best use. Given certain regulation changes, in particular those limiting fuel consumption efficiency is becoming an increasingly important factor of racecar construction in many racing series. This means racing customers benefit directly from AVL's extensive experience in developing efficient solutions for series production, which are now needed just as much in racing due to the higher efficiency expectations.

COMPREHENSIVE RACING SOLUTIONS

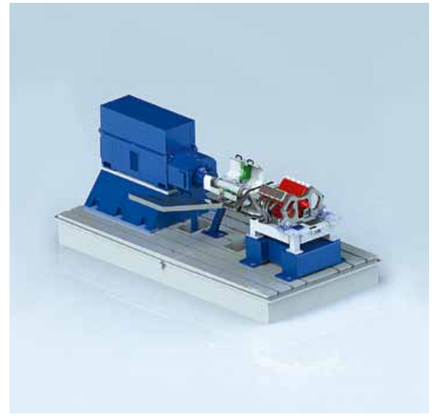
AVL also provides comprehensive solutions for racing, measurement and testing systems as well as the associated services. From customer employee training, to maintenance and parts supply with AVL eSpares, AVL Racing provides a complete solution that allows the customer to turn his full attention to racing.

HIGH-DYNAMIC AVL RACING TEST SYSTEMS

AVL's range of systems for testing conventional and electric powertrains and drive components is optimized specifically for racing. Just like the motorsport customer, AVL regularly pushes itself to the limits or the technically feasible, and sometimes even beyond.

SERVICE AND SUPPORT

On request, AVL Racing will provide on-site support and resident service (with an AVL technician permanently on-site), to ensure permanent availability or the testing system. Continual updates by AVL allow system adaptations to rule changes as well as integration of new functionality.



AVL systems for testing conventional and electric powertrains and drive components are optimized specifically for racing.

AVL DYNAMOMETERS AND ACTUATORS

APPROACH DYNAMOMETERS AND ACTUATORS

The pressure of shortening the development time with a higher level of complexity in testing is increasing, as is the demand on test cells and dynamometers. Dynamometers are the main element in a test cell. They are the components that are exposed to the hardest working conditions.

The range of performance of modern engines demands dynamometers that are of the highest quality technologically, but are also highly reliable and equipped with precise measurement devices. AVL dynamometers meet these requirements in an optimal way.

BENEFITS AT A GLANCE

- Dynamometers for different applications are available
- Test cell with fitted design results in a long life span and low maintenance
- Fast torque response is provided by rotorflux vector control of the stator current
- Low mass moment of inertia allows a high speed gradient
- IGBT converters with random pulse pattern reduce the electrical noise in the machine
- Recuperation of energy especially in endurance tests saves costs and energy
- Compact and maintenance-friendly design

TASK

Different test procedures and different engines require different dynamometers. Engine testing with the original vehicle exhaust system requires space where the dynamometer is normally mounted.

A dynamic dynamometer is needed to run dynamic test cycles. The development of intelligent powertrain components up to hybrid systems demands for a load of all components, which is comparable to the road test. Therefore, the inertia of the dynamometer should be equal to the inertia of the vehicle's wheel.

Combustion engines with high power are also calibrated and tested in low power ranges. Therefore, the requirements for torque measuring systems and their accuracy increase.

Torque peaks should not influence any technical values of the torque measuring system. Measuring units can be changed, but the dynamometer has to run with low maintenance during the whole lifetime. In case of disruption fast spare parts delivery and well trained engineers must be provided in order to support the customer.

It must be possible to upgrade dynamometers in the future.

DYNAMOMETERS AND ACTUATORS

ENGINE TEST CELLS
AVL offers dynamometers for different engines and test procedures ranging from Eddy current dynamometers, asynchronous and synchronous motors to hydraulic dynamometers for testing even the largest crosshead engines. High measuring accuracy and dynamic control are a must for AVL.

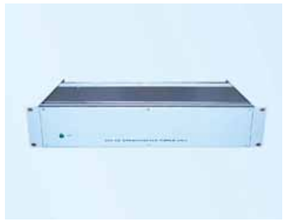
POWERTRAIN TEST CELLS
Road to rig reduces development time. Dynamometers with the inertia of a vehicle wheel fulfil the requirements of real test conditions. Powertrain test cells are available for gear boxes, passenger cars with one or more driven axles and for Formula 1 vehicles.

ACTUATORS
Most of AVL's test cells are equipped with the AVL throttle actuator THA 100. For transmission and powertrain test cells, AVL offers solutions for gear shift and clutch actuation.

AVL TEST SYSTEMS
For research and development in the vehicle industry, AVL offers fitted solutions in test, control and measuring technology. Delivered dynamometers can be upgraded with new control systems to satisfy future demands.

DIFFERENT TEST PROCEDURES AND ENGINES REQUIRE DIFFERENT DYNAMOMETERS AND FLEXIBLE ACTUATORS



Using the power unit LSE 410 for Eddy current dynamometers, very quick load changes are achieved due to the modern IGBT technology with PWM control.

BENEFITS AT A GLANCE

- Excellent full-range torque and speed control stability
- No axial forces on the shaft bearings due to drum rotor design
- No air gap adjustment required
- Very fast loading and unloading thanks to an IGBT full bridge power unit with a 4-quadrant PWM controller (substantially faster than a thyristor bridge power unit)
- High permissible coupling weights

LOAD UNIT FOR ENGINE TEST CELLS

AVL DYNOPERFORM

Eddy current dynamometers in the AVL DynoPerform series are equipped with drum rotors. An adjustment of the air gap is not necessary. A DC current flows through the exciting coils. This creates a variable magnetic field that is dependant on the exciting current. The magnetic field of the rotating rotor creates Eddy currents at the surface of the cooling chambers. This converts the mechanical energy of the engine into thermal energy. The energy is absorbed by the cooling water, which can be retroactively cooled via a cooling tower, as it is the case for the cooling water for the combustion engine.

TORQUE MEASUREMENT

The Eddy current dynamometer is a cradled dyno. The reaction force of the brake torque is measured with a strain gauge based load cell. The measuring accuracy is influenced by the linearity of the load cell and the hysteresis of the dyno. The torque measuring system is calibrated by load beams and dead weights. The measuring error of the load cell can be compensated by the measuring amplifier.

APPLICATIONS

Cost-effective dynamometer for tests in R&D, quality control and endurance

- Steady-state and transient applications.
- R&D for engines and components.
- Tests for fuel and lubrication oil.

LOAD UNIT FOR ENGINE TEST CELLS

AVL DYNOROAD

The AVL DynoRoad series is a foot-mounted dynamometer with a wide power range. With the exception of the inline torque meter, the majority of the parts are the same parts that are used in the well-known DynoExact APA dynamometer. The high permissible load on the shaft end allows users to mount an inline torque meter and an elastic coupling to reduce torque oscillations.

PRINCIPLE

The dynamometer is controlled by an IGBT converter. The recovered energy is fed back to the grid with a power factor of one. The random IGBT pulse pattern reduces the harmonics on the mains and the acoustic noise at the machine. A highly dynamic torque capability is provided by the vector control of the AC machine. The low mass inertia makes it possible to conduct transient and dynamic test runs.

APPLICATIONS

The AVL DynoRoad series is designed for steady-state and dynamic test runs. They can be used for various applications such as vehicle simulation and exhaust emission measuring of passenger car and truck engines. They can also be used for other types of applications such as component testing and friction tests.

Extremely robust asynchronous foot-mounted machine for speed- and torque-controlled operation. State-of-the-art IGBT technology with pre-selectable switching frequencies produces almost sinusoidal currents to the electrical motor and to the mains supply.

BENEFITS AT A GLANCE

- Best AC motor efficiency with lowest mains distortion due to latest state-of-the-art IGBT technology
- Highest torque response by rotorflux-vector-control of the stator current
- High speed gradient due to optimized inertia
- Robust design for operation under extreme ambient and environmental conditions
- Easy installation and commissioning

Highly precise, pendulum mounted, robust AC drive system with a state-of-the-art 4Q-IGBT converter for speed and torque controlled operation. A real-time torque calculator also provides the shaft torque of the machine in addition to the electric torque (air-gap torque).

LOAD UNIT FOR ENGINE TEST CELLS

AVL DYNOEXACT

The outstanding measuring accuracy and control dynamics offer engineers a universal tool for research and development related to engines and powertrain systems. More than 1,400 systems have already been installed. The dynamometer was developed by AVL under real test cell conditions. Existing dynos can be upgraded with new control systems.

TORQUE MEASUREMENT

It is possible to choose between two different types of cradle bearings. The first type is with ball bearings as used in Eddy current dynamometers, and the second type is with friction- and maintenance-free hydrostatic bearings. The bending beam that is used allows more movement than a load cell in the cradle bearings, which increases the life span of the bearings. All cradle parts are covered for safety reasons.

The built-in fast torque calculator is corrected with the highly accurate actual torque signal. Therefore, a fast and accurate torque signal is available for highly dynamic control loops.

APPLICATIONS

- R&D, quality and endurance testing for engine and components
- Precise vehicle and driver simulation as well as driveability optimization in an engine test cell
- Dynamic engine test for racing

BENEFITS AT A GLANCE

- Very high torque accuracy with hydrostatic bearings option
- Possibility of torque calibration check during operation
- Possibility to recalibrate the dyno down to half of the dynamometer nominal torque to increase the torque measurement accuracy for small engines
- Accurate high dynamic torque control
- Possibility of precise vehicle simulation in the test cell
- Robust industrial design for operation under extreme ambient and environmental conditions
- Easy installation and commissioning due to precommissioned components tested in a shop test

LOAD UNIT FOR ENGINE TEST CELLS

AVL DYNOSPIRIT

New requirements for engine testing demand new types of dynamometers. Standard dynos cannot be used to test an inline engine with the original vehicle exhaust system on an engine testbed because there is no space for it. The DynoSpirit hangs in a frame and the exhaust system can be installed in the available space below. The motors used for DynoSpirit have a proven, robust design that is already in use in many applications.

TORQUE MEASUREMENT

The low inertia of the dynamometer allows a stiff driveshaft connection to the combustion engine. The stiff connection provides the possibility of fast torque measurement and control. The AVL permanent magnet motors have high torque linearity and high accuracy in the open torque control loop. In combination with the AVL dynamic control package (KIWI, Emcon, ISAC), the DynoSpirit offers the highest level of dynamics and accuracy for torque control.

APPLICATIONS

- R&D, quality and endurance testing for engine and components
- Precise simulation of vehicle load on an engine test cell
- Calibration of engine management systems
- The dyno is designed for extreme ambient conditions

Highly dynamic, compact AC drive system for testing combustion engines consisting of state-of-the-art permanent magnet motor and IGBT frequency converter for 4Q operation with a digital real-time interface. Enables, together with a portal frame, testing of the original exhaust system.

BENEFITS AT A GLANCE

- Very high speed gradients thanks to an ultra low rotor inertia
- Particularly well adapted for applications where space is critical due to very small motor dimensions and weight
- Top dynamics and accurate torque control thanks to the very high motor torque linearity
- Higher torque measurement accuracy than with a foot-mounted asynchronous motor thanks to the lower temperature influence from the rotor
- Robust and compact design for operation under extreme ambient and environmental conditions

LOAD UNIT FOR POWERTRAIN TEST CELLS

AVL DYNOTRAIN

BENEFITS AT A GLANCE

- Asynchronous motors with low inertia
- Large choice of machines with a suitable speed and torque range selection
- Robust and service-friendly design
- Modular 4Q-IGBT converter system with common intermediate circuit for systems with up to five dynamometers

The AVL DynoTrain series is developed especially for use at gearbox and driveline test stands. All parts of the complete DynoTrain family fit into different test applications. This results in a flexible system for different applications and guarantees that the investment is secured.

Together with the DynoPrime, the energy runs in a loop and only the losses of the system have to be supplied from the grid.

- R&D, quality and endurance tests for gear boxes and drivelines
- Development of drivelines for vehicles with one or more driven axles
- NVH measuring

LOAD UNIT FOR POWERTRAIN TEST CELLS

AVL DYNOWHEEL

BENEFITS AT A GLANCE

- Permanent magnet-excited synchronous motors with very low inertia adapted to the real vehicle wheel
- Optimized for reproduction of realistic wheel loads and torsional behavior
- Accurate test execution and excellent repeatability due to high torque control linearity
- The tire stiffness and slip is controlled by the AVL control systems with its digital real-time interface

Two different characteristics are provided by this dynamometer: low mass inertia and very high torque at low speed.
The inertia of the dynamometer is equal to the mass inertia of a vehicle wheel. Together with the wheel slip simulation, the same driveability as on the road can be simulated. Not only the vehicle acceleration but also the driveline vibration of the vehicle is similar to reality. Fast control loops make it possible to optimize the driveline for one or two driven axles. AVL DynoWheel drives are specially developed to provide the best results when highest accuracy and control dynamics are required.

INPUT MOTOR FOR POWERTRAIN TEST CELLS

AVL DYNOPRIME

The AVL DynoPrime series is designed to replace a combustion engine on gearbox and powertrain test stands.

REQUIREMENTS

The mass inertia of the dynamometer has to be equal to the inertia of the combustion engine. Torque pulses of a combustion engine must be simulated. The center height has to be very low. If the dyno is mounted to the bell housing of a front wheel drive vehicle, enough space must be provided to mount the axle shafts.

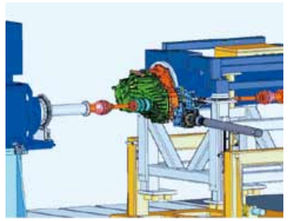
CHARACTERISTICS

- Very low inertia
- Low center height
- High overload capability

With their interfaces and dynamics the AVL drive converter of the DynoPrime corresponds to the converters of DynoTrain and DynoWheel dynamometers. The real vehicle behavior can be simulated in a system with one DynoPrime and two or four DynoWheels. The dynamometers are water jacket cooled and supplemented by a closed air cooling loop for the rotor. This makes noise measurements on a gearbox test stand more efficient.

APPLICATIONS

- Development and optimization of the driveline before the vehicle engine is available
- R&D for gearboxes, drivelines and vehicle parts that are influenced by the characteristics of the combustion engine
- Wear tests under dynamic conditions
- Noise measuring



AVL DynoPrime is a highly dynamic PMM drive system for the simulation of the rotational behavior of the crankshaft of combustion engines. The system is characterized by high nominal torques and a high overload capacity with the smallest moment of inertia.

BENEFITS AT A GLANCE

- Inertia similar to a combustion engine
- High nominal torque (larger than ICE), plus additional overload torque capability for simulation of speed oscillations
- High flexibility in the parameterization of various characteristics of engines
- Cost savings due to simpler setup of transmission and driveline testbeds
- Simple retrofitting into existing test cells is ensured by using the throttle as a demand value. Existing drive cycles can be used without any modification




	AVL DYNOPERFORM/ OMEGA	AVL DYNOROAD	AVL DYNOEXACT	AVL DYNOSPIRIT
• Product category	Passive dynamometer	Active dynamometer	Active dynamometer	Active dynamometer
• Technology	Eddy current / Hydraulic	ASM	ASM	PMM
• Design	Cradle-mounted	Foot-mounted	Cradled-mounted, optionally with hydrostatic bearings	Foot-mounted
• Torque measurement	Load cell	Torque flange	Bending beam	Torque flange
• Power	20 – 7,200 kW	120 – 1,000 kW	100 – 1,000 kW	170 – 550 kW
• Torque	25 – 62,000 Nm	100 – 7,000 Nm	80 – 5,500 Nm	530 – 1,200 Nm
• Speed	3,000 – 17,000 rpm	3,500 – 20,000 rpm	3,500 – 22,000 rpm	6,000 – 10,000 rpm
Engine testing				
• Steady-state testing	•	•	•	•
• Dynamic vehicle simulation		•	•	•
• Drivetrain / dynamic + mass zero simulation			•	•
• Driveability simulation			•	•
• Passenger car emissions		•	•	•
• Heavy duty emissions	partially	•	•	•
• Friction tests		partially	•	•
• Component testing		•	•	•
• Formula 1 / Motorsports			•	•
Powertrain / Driveline testing				
• Endurance testing			(•)	
• NVH Tests			(•)	
• Dynamic motoring with combustion simulation			(•)	
• Dynamic load with tire simulation			(•)	
• Formula 1/Motorsports			(•)	



	AVL DYNOTRAIN	AVL DYNOWHEEL	AVL DYNOPRIME
• Product category	Active dynamometer	Active dynamometer	Active dynamometer
• Technology	ASM	PMM	PMM
• Design	Foot-mounted	Foot-mounted	Foot-mounted
• Torque measurement	Torque flange	Torque flange	Torque flange / Electrical
• Power	160 – 700 kW	110 – 420 kW	80 – 640 kW
• Torque	2,000 – 4,600 Nm	880 – 4,000 Nm	35 – 2,000 Nm
• Speed	2,500 – 7,500 rpm	2,400 – 3,700 rpm	3,700 – 22,000 rpm
Engine testing			
• Steady-state testing			
• Dynamic vehicle simulation			
• Drivetrain / dynamic + mass zero simulation			
• Driveability simulation			
• Passenger car emissions			
• Heavy duty emissions			
• Friction tests			
• Component testing			
• Formula 1 / Motorsports			
Powertrain / Driveline testing			
• Endurance testing	•	•	•
• NVH Tests	•	•	•
• Dynamic motoring with combustion simulation			•
• Dynamic load with tire simulation	partially	•	
• Formula 1/Motorsports		•	•

		
	AVL THA 100	AVL DCA 1000
Technical data		
• Product category	Throttle actuator	Digital clutch actuator
• Max. shifting travel	110 mm	30 mm
• Shifting force	max. 120 N (push and pull)	max. 1,000 N (push or pull)
• Shifting speed	max. 0.5 m/s	Adjustable via throttle valves
• Travel resolution	± 0.05 mm	
• Repetitive position accuracy	± 0.05 mm	
• Data interface	Hybrid interface	Digital interface
Features	Linear Motion Limitation of shifting force Automatic adjustment of zero and end position Maintenance-free construction	Suitable for cable-operated and hydraulic-operated clutches as well as for a real clutch pedal
Typical applications	Legal driving cycles according to ECE, FTP, EPA and Japan regulations	Endurance testing for manual transmissions

AVL CHASSIS DYNAMOMETERS

APPROACH TO CHASSIS DYNAMOMETERS

Modern development processes.with an intensive use of simulation tools and a front loading approach give the chassis dynamometer new and additional development and validation tasks, which were previously reserved for road testing. The advantage of the chassis dynamometer in these cases is that the results are objective – reproducible test conditions that can be simulated at any time, and which guarantee efficient testing and measurement. AVL chassis dynamometers with highly accurate and conveniently handled measurement, control and automation technology (PUMA Open Vehicle) as well as the application tools AVL-INMOTION, AVL ACT, AVL DRIVE and AVL CAMEO fulfill the latest demands of modern and future R&D tasks such as hybrid or electric vehicle testing as well as all of the requirements related to front loading – from road to rig and finally to simulation.

BENEFITS AT A GLANCE

- Safety with regard to the certification of vehicles in the fields of emissions, mileage accumulation and R&D testing, as well as during the research of noise and electromagnetic emissions
- Shorter development times due to high levels of reproducibility in the vehicle tests.
- Improved component optimization of the vehicle through the use of uniform tools on all testbed types
- Optimization of driving behavior through the use of AVL DRIVE, AVL ACT, AVL INMOTION and AVL CAMEO on the vehicle testbed

TASK

The chassis dynamometer provides a realistic image of the road under reproducible environmental conditions. Vehicles with any kind of powertrain system can be tested, which means that with the further diversification of these systems, the applications of the chassis dynamometer are expanded to include a central development system that also integrates all of the vehicle components.

Bringing the vehicle testbeds closer to the engine and driveline testbeds enables significant savings by making it possible to reuse test specifications, correlate test results and and standardize testing tools and methodologies. However, the capability of the vehicle testbeds is also successfully increased, making them suitable for relatively new applications, such as shift quality and driveability assessment, maneuver based testing or powertrain calibration optimization.

Since data is gathered at night and on weekends, a significant increase in chassis dynamometer productivity is achieved. The subsequent data evaluation and the generation of, for example, all of the driveability calibration variants in the office environment makes it possible to simultaneously use vehicle prototypes for other calibration tasks.

AVL chassis dynamometers offer functions such as
- Active braking support
- Implemented quality checks and service logbook
- Feed-forward control mode and innovative rolling resistance control algorithms
- Highly precise tractive force and speed measurement chains impressively show the innovative potential of such testbed solutions

APPLICATIONS

EMISSION, MILEAGE ACCUMULATION AND R&D TESTING

Additional decision criteria for AVL chassis dynamometers besides reproducibility include the availability of proven complete solutions. The growing complexity of powertrain management systems and the close interaction of engine and transmission control units with emission results often requires joint testing.

In addition, SHEDS for evaporative calculations and altitude chambers are combined with chassis dynamometers for vehicle testing. Climatic wind tunnels and climatic chambers are also successfully equipped with AVL chassis dynamometers.
In the area of R&D, AVL tools for driving behavior testing are being effectively implemented more and more often.

NOISE AND VIBRATION TESTING (NVH)

The fact that over 70 systems are now in use worldwide is proof of AVL's high level of quality and flexibility in the field of project planning for individual testbed solutions. AVL's solutions in this field are characterized by particularly good phase control as well as interchangeable roller surfaces.

ELECTROMAGNETIC COMPATIBILITY TESTING (EMC)

AVL is the indisputable market leader with the most experience in this area. Along with precise road load simulation, AVL focuses on the following technical criteria: minimal radiation, high acceleration of the turntable, robust design and the best integration of measurement and sensor techniques.

THE TECHNICAL IMPLEMENTATION OF COMPLEX REQUIREMENTS IS A MATTER OF TRUST. WE ARE THE MOST INNOVATIVE CHASSIS DYNAMOMETER SOLUTION PROVIDER IN THE WORLD.




Planning, consultation, and implementation of system solutions for roller testbeds.

BENEFITS AT A GLANCE

- Robust design combined with reproducible and absolute measuring and control accuracy for being used in laboratories and in most different climate zones
- Highly precise control at 0 km/h allows for real and dynamic vehicle design and chassis modeling
- Comprehensive roller testbed designs meet all customer requirements for axle load, performance, mass simulation quality, ease of use, and extensibility
- High levels of torsional rigidity in combination with the AVL Controller allow for torque vectoring tests of state-of-the-art powertrain systems (significantly better than 0.02 km/h in synchronous operation)

ROLLER TESTBEDS FOR EMISSION AND ENDURANCE TESTS

The increasing complexity of powertrain management systems and the close interaction of engine and transmission control units (ECU and TCU), in combination with emission regulations, often requires a common R&D test.

CHARACTERISTICS

AVL ROADSIM 25“INLINE, used for testing light vehicles from mopeds up to light, four-wheeled vehicles is based on an Inline solution. There are three different product configurations: from a 400 mm wide roller via a connectible roller up to a 1,800 mm wide roller. The products for passenger vehicles, light commercial vehicles, and heavy-duty freight vehicles are based on the mid-engine principle. These are also cradle-mounted asynchronous engines which are arranged between the rollers.These are arranged between the rollers. Along with a reduction in required space, the advantage of this design is the low power dissipation and high torsional rigidity. AVL ROADSIM 48”MIM is available in two axle widths (2,300 mm and 2,744 mm) and two performance classes (150 kW and 220 kW) for front-wheel, rear-wheel, and all-wheel drive passenger vehicles and light commercial vehicles. AVL ROADSIM 72”MIM is designed for the testing of state-of-the-art freight vehicles up to a 20 t axle load. It is equipped with an axle width of 3,000 mm, as well as a robust 450 kW asynchronous mid-engine for each axle. This compact design combines the robust and highly precise testing of high-torque freight vehicles.

APPLICATION

Owing to their high accuracy and availability, these systems are used all over the world for emission certification and vehicle development all over the world. This family of products can also be used in the fields of:

- Exhaust gas emission and endurance tests
- Use in SHEDs for the testing of vehicle emissions
- Climatic and height chambers

ROLLER TESTBEDS FOR ADVANCED CALIBRATION APPLICATIONS

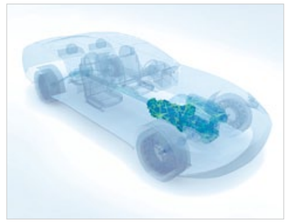
AVL offers integrated solutions for calibration tasks on roller testbeds. These are composed of the required testbed system, the attuned software solutions, and the related methodological support.

CHARACTERISTICS

The process of networking in AVL ROADSIM, AVL PUMA Open Vehicle, AVL CAMEO, AVL ACT, and AVL DRIVE results in a flexible and powerful overall solution. During this process, the roller testbed is responsible for exactly for modeling the road exactly. On the one hand the automation allows for automatic operation of the test specimen, and on the other hand it allows for a quick change-over between different reproducible operating statuses due to the close coupling with the controlled testbed. Besides controlling the test, AVL CAMEO is integrated into the entire test planning and analysis, including model formation, optimization, and map calculator. An ASAP 3 interface can be used to transfer the drivability-relevant ECU/TCU variables into the application system. AVL DRIVE ultimately evaluates the driving maneuvers and determines the notes and physical parameters. The signal of a load cell is designed as an equivalent to the longitudinal vehicle acceleration, whereby this load cell is integrated into a special vehicle support.

APPLICATION

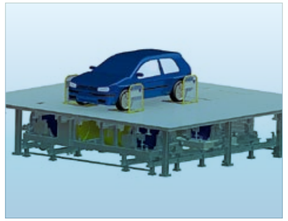
This solution is used for engine, transmission, and overall powertrain calibration. Time- and cost-intensive road tests can largely be shifted to the roller testbed. On the basis of the model-based approach, only the determined vehicle adjustment has to be verified on the road. Adjustments with different objectives, such as comfort and dynamics, are implemented easily.



Automated calibration on the roller testbed.

BENEFITS AT A GLANCE

- Highly precise and dynamic road simulation for the highest requirements in (drivability) calibration
- Integration of established tools for optimization and drivability evaluation
- High level of efficiency due to automated operation at night
- Extraordinary reproducibility and transferability between real road and roller testbed
- Visualization of completely embedded driving cycles for calibration (e.g. consideration of the parameters for height, incline, air conditioning system, and further maneuver-based factors)



Real-life testing on the roller testbed

BENEFITS AT A GLANCE

- Highly dynamic 4-engine roller testbed for the modeling of different pulling forces and speeds on all 4 wheels
- Development platform for intelligent drive concepts such as hybrid or electric drives as well as complex powertrain functions (e.g. torque/speed vectoring systems)
- Maneuver-based real-life testing on the roller testbed
- Parameterizable simulation models for the driver, road and topology, environment, and residual vehicle

ROLLER TESTBEDS 4X4 FOR ADVANCED APPLICATIONS IN R&D

The development of new drive concepts and powertrain functions entails new requirements for test systems. AVL offers high-end solutions which fulfill these challenges.

CHARACTERISTICS

All four highly dynamic load units of the roller testbed can be controlled separately or synchronously. This is not only possible for generic analyses, but also forms the basis for the basis for real-life testing in connection with AVL InMotion. Previously recorded 3D road profiles, including curves, can be modeled. Along with the conventional method (by means of coast-down coefficients), the road simulation is implemented through an advanced approach on the basis of a physical multi-body simulation model in connection with an environment, road, and driver model. This easily allows for the most different parameter variations, e.g. air resistance, vehicle weight, trailer, style of driving, etc. Additionally, a comprehensive residual bus simulation on the basis of the simulation model can also be implemented (e.g. simulation of acceleration or traffic for ACC systems).

APPLICATION

The application field of 4x4 roller testbeds for Advanced Applications is broad:

- Real consumption and emission analyses on customer-specific roads (e.g. Auto Motor and Sport track)
- Development of advanced driver assistance systems, e.g. advanced driver assistance systems with free maneuver, road, and traffic definitions
- Analysis of different (virtual and reproducible) driver types in connection with operating strategies

ROLLER TESTBEDS FOR NVH TESTING

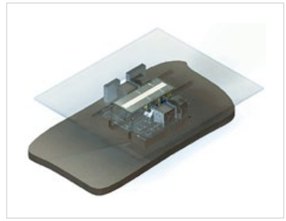
The main purpose of NVH testing is the reduction of interior and exterior vehicle noise, as well as design and quality assurance. The roller testbed is designed for transient testing requirements.

CHARACTERISTICS

Engine enclosures, etc. reduce the acoustic emissions of the roller testbed. A special acoustic damping material and design is implemented within the rollers and frame. Exchangeable roller surfaces simulate real road textures. The combination of reduced noise emissions, rigidity, and precise road simulation allows for highly efficient NVH development on the roller testbed. These combined advantages are essential for dynamic, tip-in, and “pass-by-noise” tests. The roller testbed can be upgraded with a second axle for parallel hybrid and four-wheel drive vehicles. Configurations of up to 4 engines are possible. In this case, the roller testbed controller VECON monitors the vehicle and provides exact control and monitoring functions for transient asynchronous and synchronous test modes for all of the NVH roller testbed configurations.

APPLICATION

The roller testbed is designed to examine the noise and vibration behavior, as well as influences from the vehicle body, suspension, or other vehicle components. The intention is mainly to check noise and vibration thresholds on the powertrain, chassis, and other related components. By simulating different types of powertrain configurations, the excitation of the chassis can be evaluated on the roller testbed.

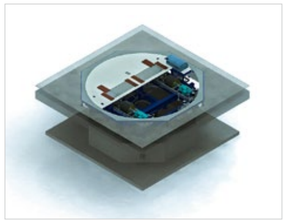


Noise recording by means of microphones on a passenger vehicle wheel in an NVH chamber.

Layout of the AVL roller testbed AVL ROADSIM NVH 4x4 LIGHT TRUCK.

BENEFITS AT A GLANCE

- Scalable and “ready-to-build” hardware and software for noise and vibration tests per wheel, axle, or vehicle
- Extremely low noise emissions due to structural measures (e.g. engine enclosures, water cooling, and suitable roller design) in the testbed design
- Simulation of real road textures due to exchangeable roller surfaces, also for speeds above 200km/h
- Extraordinary cooperation with planning engineers and construction companies and acoustic construction companies



EMC chamber with integrated vehicle roller testbed within the turntable.

Layout of the AVL roller testbed AVL ROADSIM EMC LIGHT TRUCK.

BENEFITS AT A GLANCE

- Engineered, “ready to build”, EMC shorten project implementation and certification work
- Roller testbeds with extremely low electromagnetic emissions
- Reliable EMC-optimized components and 25 years of experience in the field of EMC roller testbed construction guarantee the highest immunity to interference
- Compact EMC certified roller testbeds for the smallest pit dimensions
- Extraordinary cooperation with planning engineers and construction companies of EMC buildings

ROLLER TESTBEDS FOR EMC TESTING

EMC testing is comprised of tests which relate to the measurement of the electromagnetic emissions of the test specimen, as well as tests for checking the immunity of the test specimen. Product information such as foundation diagrams, utility matrices, and project descriptions are available for vehicles from motorcycles to freight vehicles. This information provides strong support before project planning for the EMC chamber begins.

CHARACTERISTICS

The AVL roller testbed is driven by direct current engines and is equipped with special EMC-compatible measuring equipment. In this way the following components among others are implemented: fiber optics and signal amplifiers with RF-shielded housings. The roller testbed is equipped with two movable axles, and can be rotated in order to align the vehicle in the electromagnetic field. The turntable contains the entire mechanical configuration of the roller testbed. The rotation can also be implemented while the roller testbed is in operation. Turning speeds and turntable positions can be set on the control console.

APPLICATION

Because of the dynamic turntable and rollers, it is possible to execute ABS and traction control system testing with with increased slip simulation, in addition to in addition to standard EMC testing. Yaw sensors from state-of-the-art stability systems can be tested under acceleration conditions (turntable rotation). Using the the rotation of the turntable, a steering wheel actuator can be simulated, as well as the cornering of the vehicle at different wheel speeds.

ROLLER TESTBEDS FOR SPECIAL PURPOSES AND MODERNIZATION SOLUTIONS

In addition to roller testbed products with a variety of options and variants, AVL also offers special and customer-specific solutions (e. g. chassis dynamometer modernizations). These are developed in intensive cooperation with the customer before the start of the project, and are planned in detail and built in our factory.

CHARACTERISTICS

The AVL portfolio ranges from hardware and software upgrades of control unit components over double-roller sets all the way up to large single rollers. The testbeds are designed as single- or multiple-axle testbeds (e. g. per wheel or per axle equipped with a dyno). Vehicles from motorcycles to freight vehicles can be tested. In addition to control and closed-loop control, the flexible automation system of AVL-PUMA Open Vehicle allows for the integration of measurement technology. Upgrades via an accuracy package enable a more precise force and speed measuring chain for increased control and measurement accuracy.

APPLICATION

Mechanical design, performance electronics, and automation systems are components which are needed in order to meet the requirements. However, the application is the focus. AVL offers solutions for exhaust emission certification, vehicle aging, environment simulation, maneuver-based testing, acoustic testing, electromagnetic compatibility testing and much more. All types of AVL and third party testbeds can be upgraded with the AVL modernization packs. Furthermore, it is possible to complement and extend the basic application of the roller testbeds in order to be modernized by additional application.

Full range of services from motorcycles to truck vehicle testbeds.

Modernization of control unit components and integration of existing AVL and third party roller testbeds into the AVL VECON roller control.

BENEFITS AT A GLANCE

- Individual system design complies with customer-specific requirements for vehicles of any type (e.g. special vehicles such as tractors or snowmobiles)
- Adaptation to local conditions and local standards
- Robust industrial design extends the usage period of roller testbeds
- Long-term experience and successful implementations in plant engineering and with chassis dynamometer modernization
- Improved availability of service and spare parts




	AVL ROADSIM CUSTOMER-SPECIFIC	AVL ROADSIM 25"INLINE CYCLE	AVL ROADSIM 25"INLINE TRIKE	AVL ROADSIM 25"INLINE ATV
Vehicle types				
• Mopeds/motorcycles	•	•	•	•
• Three-wheelers (trikes)	•		•	•
• All terrain vehicles (ATVs)	•			•
• Light duty vehicles	•			
• Medium duty vehicles	•			
• Heavy duty vehicles	•			
Applications				
• Exhaust emission	•	•	•	•
• Fuel consumption	•	•	•	•
• Mileage accumulation testing	•			
• Driveability	•			
• SHED application	•			
• Climatic testing	•	•	•	•
• Environmental simulation	•	•	•	•
• Calibration (ECU/TCU/HCU)	•	•	•	•
• NVH testing	•			
• Efficiency testing	•	•	•	•
• Antilock brake testing	•			
• Power measurement	•			
• EMC testing	•			
Technical data				
• Inertia simulation range	customer-specific	80 kg … 450 kg	80 kg … 550 kg (w/o 2nd roller) 125 kg … 830 kg (w/ 2nd roller)	80 kg … 2,000 kg
• Roller diameter	500 mm … 3,200 mm	648 mm	648 mm	648 mm
• Distance of outer roller edges	customer-specific	400 mm	1,500 mm	1.800 mm
• Max. axle load	100 kg … 30,000 kg	500 kg	1,000 kg	1.000 kg
• Long performance/optional *	50 kW … 1,000 kW	55 kW/105 kW	55 kW/105 kW	55 kW/105 kW
• Short performance/optional *	customer-specific	82.5 kW/156 kW	82.5 kW/156 kW	82.5 kW/156 kW
• Chassis dynamometer axles	1 … 4	1	1	1
• Number of motors	1 … 8	1	1	1

*) per axle

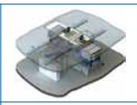




	AVL ROADSIM 48"INLINE CAR	AVL ROADSIM 48"MIL 4X4 CAR	AVL ROADSIM 48"MIM CAR	AVL ROADSIM 48"MIM LIGHT TRUCK	AVL ROADSIM 48"MIM LIGHT TRUCK HP
Vehicle types					
• Mopeds/motorcycles	•	•	•	•	•
• Three-wheelers (trikes)	•	•	•	•	•
• All terrain vehicles (ATVs)	•	•	•	•	•
• Light duty vehicles	•	•	•	•	•
• Medium duty vehicles		•		•	•
• Heavy duty vehicles					
Applications					
• Exhaust emission	•	•	•	•	•
• Fuel consumption	•	•	•	•	•
• Mileage accumulation testing	•	•	•	•	•
• Driveability	•	•	•	•	•
• SHED application	•	•	•	•	•
• Climatic testing	•	•	•	•	•
• Environmental simulation	•	•	•	•	•
• Calibration (ECU/TCU/HCU)	•	•	•	•	•
• NVH testing					
• Efficiency testing	•	•	•	•	•
• Antilock brake testing					
• Power measurement		•			
• EMC testing					
Technical data					
• Inertia simulation range	454 kg ... 2,722 kg (2WD) 800 kg ... 2,722 kg (4WD)	150 kg ... 2,722 kg (2WD) 800 kg ... 2,722 kg (4WD)	454 kg ... 2,722 kg (2WD) 800 kg ... 2,722 kg (4WD)	454 kg ... 5,448 kg (2WD) 800 kg ... 5,448 kg (4WD)	454 kg ... 5,448 kg (2WD) 800 kg ... 5,448 kg (4WD)
• Roller diameter	1,219.2 mm	1,219.2 mm	1,219.2 mm	1,219.2 mm	1,219.2 mm
• Distance of outer roller edges	2,300 mm	2,300 mm	2,300 mm	2,744 mm	2,744 mm
• Max. axle load	2,000 kg	2,500 kg	2,000 kg	4,500 kg	4,500 kg
• Long performance/optional *	147 kW	306 kW	153 kW/220 kW	153 kW/220 kW	153 kW/220 kW
• Short performance/optional *	208 kW	516 kW	258 kW/432 kW	258 kW/432 kW	258 kW/432 kW
• Chassis dynamometer axles	1 … 2	2	1 … 2	1 … 2	1 … 2
• Number of motors	1 … 2	4	1 … 2	1 … 2	1 … 2

*) per axle

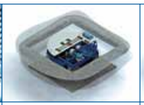
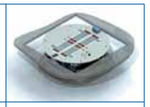




	AVL ROADSIM 72"MIM TRUCK	AVL ROADSIM NVH 2x1 LIGHT TRUCK	AVL ROADSIM NVH 2x2 LIGHT TRUCK	AVL ROADSIM NVH 4x2 LIGHT TRUCK	AVL ROADSIM NVH 4x4 LIGHT TRUCK
Vehicle types					
• Mopeds/motorcycles		•	•	•	•
• Three-wheelers (trikes)		•	•	•	•
• All terrain vehicles (ATVs)		•	•	•	•
• Light duty vehicles		•	•	•	•
• Medium duty vehicles		•	•	•	•
• Heavy duty vehicles	•				
Applications					
• Exhaust emission	•				
• Fuel consumption	•				
• Mileage accumulation testing	•				
• Driveability	•				•
• SHED application					
• Climatic testing	•				
• Environmental simulation	•				
• Calibration (ECU/TCU/HCU)	•				
• NVH testing		•	•	•	•
• Efficiency testing	•	•	•	•	•
• Antilock brake testing			•		•
• Power measurement			•		•
• EMC testing					
Technical data					
• Inertia simulation range	3,500 kg ... 30,000 kg	450 kg ... 5,400 kg	450 kg ... 5,400 kg	450 kg ... 5,400 kg (2WD) 800 kg ... 5,400 kg (4WD)	450 kg ... 5,400 kg (2WD) 800 kg ... 5,400 kg (4WD)
• Roller diameter	1,828.8 mm	1,910 mm	1,910 mm	1,910 mm	1,910 mm
• Distance of outer roller edges	3,000 mm	2,300 mm	2,300 mm	2,300 mm	2,300 mm
• Max. axle load	12,000 kg / 20,000 kg	3,000 kg	3,000 kg	3,000 kg	3,000 kg
• Long performance/optional *	450 kW	271 kW	270 kW	271 kW	270 kW
• Short performance/optional *	675 kW	407 kW	378 kW	407 kW	378 kW
• Chassis dynamometer axles	1 ... 2	1	1	2	2
• Number of motors	1 ... 2	1	2	2	4

*) per axle



	AVL ROADSIM EMC CERTIFICATION	AVL ROADSIM EMC ATV	AVL ROADSIM EMC CAR	AVL ROADSIM EMC LIGHT TRUCK	AVL ROADSIM EMC TRUCK
Vehicle types					
• Mopeds/motorcycles	•	•	•	•	•
• Three-wheelers (trikes)	•	•	•	•	•
• All terrain vehicles (ATVs)	•	•	•	•	•
• Light duty vehicles	•		•	•	•
• Medium duty vehicles				•	•
• Heavy duty vehicles					•
Applications					
• Exhaust emission					
• Fuel consumption					
• Mileage accumulation testing					
• Driveability				•	
• SHED application					
• Climatic testing					
• Environmental simulation					
• Calibration (ECU/TCU/HCU)					
• NVH testing					
• Efficiency testing	•	•	•	•	•
• Antilock brake testing	•	•	•	•	•
• Power measurement	•		•	•	•
• EMC testing	•	•	•	•	•
Technical data					
• Inertia simulation range	150 kg ... 4,000 kg (2WD) 300 kg ... 4,000 kg (4WD)	250 kg ... 2,000 kg (2WD) 500 kg ... 2,000 kg (4WD)	400 kg ... 4,500 kg (2WD) 800 kg ... 4,500 kg (4WD)	400 kg ... 4,500 kg (2WD) 800 kg ... 4,500 kg (4WD)	400 kg ... 4,500 kg (2WD) 800 kg ... 4,500 kg (4WD)
• Roller diameter	500 mm	630 mm	955 mm	955 mm	955 mm
• Distance of outer roller edges	2,200 mm	1,500 mm	2,200 mm	2,600 mm	2,700 mm
• Max. axle load	2,000 kg	1,000 kg	2,500 kg	5,000 kg	10,000 kg
• Long performance/optional *	15 kW	108 kW	216 kW	216 kW	216 kW
• Short performance/optional *	15 kW	173 kW	346 kW	346 kW	346 kW
• Chassis dynamometer axles	2	2	2	2	2
• Number of motors	4	2	4	4	4

*) per axle

AVL MODULAR TEST CELL MECHANICS AND CONTROL ROOMS

APPROACH

A prerequisite for smooth test processes is sophisticated testbed mechanics in combination with ergonomically designed control room equipment. Based on long-term experience from all kinds of realized projects, AVL provides systems designed for the customer's specific application – for engine, powertrain, hybrid, racing and component test beds.

AVL's modular concepts allow a high degree of scalability from simple durability testbeds to highly sophisticated and complex powertrain development testbeds.

BENEFITS AT A GLANCE

- Reduced setup times due to mounting of the test specimens on pallet systems
- Quick and easy fixing of the pallets on the testbed
- Wide range of standardized drive shaft systems, with automatic docking function, if required
- Easy adaptation to changing requirements due to modular and ergonomic design of control room equipment
- Shifting test run preparation and evaluation from the test cell to the office by using the PUMA FlexiCart™ as simulator

TASK

The demands for more productivity in modern test facilities are constantly increasing. Besides intelligent measuring technique and automation, the mechanical automation of testbeds can essentially increase productivity by minimizing the setup and testbed down-times and increasing the quality of test results due to an appropri-ate design.

The pursuit of increased productivity also affects the testbed control rooms in the form of constantly changing requirements and work situations. Consequently, highly process-oriented design and functionality is required for control room equipment.

Quick installations and a simple setup of the testbed equipment require drive shaft systems with standardized mounting possibilities.

Unproductive duties like engine commissioning and decommis-sioning, rigging, media conditioning, system checks, calibration, service, maintenance and repair tasks have to be shifted out of the test cell to ensure optimal test cell utilization.

Support of the test facility's processes via Test Lab Management Software capable of planning test execution tasks and resources (test cells, personnel, pallets, sensors, etc.,…) is another area in which demands for increased productivity are on the rise.

Preparation and checking of test runs without utilizing the testbed are also required to improve testbeds availability.

REFERENCES

AVL PALLET SYSTEMS
As a supplier of various testbeds to premium car manufacturers worldwide as well as internal testbeds, AVL has a first hand knowledge of engine and powertrain developers.

AVL DRIVE SHAFT SYSTEMS
Having delivered more than 1000 drive shaft systems, we have acquired extensive experience in shaft dimen-sioning.

AVL TEST STATION
Process-oriented design, which has been recognized with a famous design award, fulfills ergonomic as well as functional requirements. By combining control room com-ponents with office furniture, a flowing transition between test stand operation and the office area is no longer a problem.

AVL FLEXI CART
The functions of the PUMA Open FlexiCart range from use as a simulator in the office to real test operation at an exist-ing testbed with the PUMA Open "Migration" program. A huge number of PUMA 5 test fields have already been migrated to PUMA Open using AVL's FlexiCart™.

BY USING MODULAR TESTBED MECHANICS, AVL'S TEST FACTORY WAS ABLE TO DOUBLE THE NUMBER OF TESTED PROJECTS PER YEAR (FROM 70 TO 150 UNITS) WITHOUT INCREASING RESOURCES.




Growing demands concerning a quick installation and a simple setup of the test bed equipment require drive shaft systems with standardised mounting possibilities.

BENEFITS AT A GLANCE

- Comfortable preassembly and alignment of the test specimen and the measuring equipment in separate setup rooms
- Quicker connection of the media supply by quick couplings or docking plate systems
- Qualified engineering partners for complex drive shaft demands
- Wide range of standardized drive shaft systems

THE WAY TO HIGH TEST FIELD EFFICIENCY

AVL PALLET & DRIVE SHAFT SYSTEMS

AVL pallet systems meet customer demands for reduced test specimen changing and mounting times, thereby shortening testbed downtimes and lowering costs through automation. AVL pallet systems enable simple and easy pre-mounting and aligning of the test specimen and instrumentation in a separate setup room, and even pre-testing of the test specimen outside the test bed is possible with an appropriate level of automation.

AVL DRIVE SHAFT SYSTEMS

Drive shaft systems not only serve for the mechanical power transfer between the test specimen and the dynamometer on steady-state or dynamic test beds, they also influence the vibration behavior of the entire system.

APPLICATION

AVL pallet and drive shaft systems cover the whole range of operating requirements for passenger car, commercial vehicle and racing engines. Different sizes, scopes and specific characteristics of the test specimen or the test application result in different standard drive shaft dimensions, suitable for:

- PC and LD diesel and gasoline engines < 250 kW
- HD diesel engines < 600 kW

AVL standard pallet systems can be used for the following applications:

- PC & LD engines: engine-only and powerpack applications
- HD engines: engine-only applications

THE FLEXIBLE SYSTEM HOUSING AND SIMULATOR SOLUTION

AVL TEST STATION & AVL PUMA OPEN FLEXICART™

AVL TEST STATION

The new, highly flexible operating room concept of AVL takes into account the constantly changing requirements and work situations when executing engine and powertrain tests.
The modular and variable system can also be easily adapted at any time to new workflows or spatial requirements.

In addition, compact and intelligent solutions are available particularly for cramped space conditions (e.g. container testbeds).

AVL PUMA OPEN FLEXICART™

The functions of the PUMA Open FlexiCart™ range from use as a simulator in the office to real test operation on an existing testbed with the PUMA Open “Migration” program.

When using the PUMA Open FlexiCart™ as a simulator, the customer is able to prepare sets of parameters and test runs for real test operation already in the office.
The customer can easily carry out a PUMA Open Training for his personnel on the PUMA Open FlexiCart™ within an ideal office environment.

Ready to go: The PUMA Open FlexiCart™ is delivered with all required hardware components, in order to be able to start simulation/migration operation right away.

BENEFITS AT A GLANCE

AVL Test Station

- Ergonomic accessibility and optimal use of space
- Industrial and EMC compliant design
- Patented modular design for easy extension

AVL PUMA Open FlexiCart™

- Parameter and test run preparation in the office
- Training of customer’s personnel in the office
- PUMA Open test operation on a real testbed during “Migration” test phase

			
	ELASTIC CV SHAFT	ELASTIC CARDAN SHAFT	CV-JOINT SHAFT
Area of Use	PC, LD < 250 kW	PC, LD < 250 kW HD < 600 kW	PC, LD < 250 kW
Notes	Preferred for use in gasoline engines with max. engine speed up to 8000 rpm.	Used for LD diesel and HD diesel and gasoline engines. Maximum engine speed up to 8000 rpm.	Used on engine testbeds in combination with gearbox dummy and vehicle clutch. Maximum engine speed up to 8000 rpm.

			
	CARDAN SHAFT	HIGH ELASTIC SHAFT	HD-ELASTIC CARDAN SHAFT
	PC, LD < 250 kW HD < 600 kW	PC, LD < 250 kW HD < 600 kW	HD < 600 kW
	Used on engine testbeds in combination with gearbox dummy, vehicle clutch or two-mass flywheel. Maximum engine speed up to 8000 rpm.	Typically used for LD diesel, HD diesel and gasoline engines. Maximum engine speed up to 8400 rpm.	Used for HD diesel engines with SAE flange on flywheel. Maximum engine speed up to 3300 rpm.

AVL MEDIA CONDITIONING SYSTEMS

APPROACH

The performance of combustion engines strongly depends on the media conditions. For a better reproducibility under almost real conditions there is a need of a high dynamic control of the media conditioning units. For 25 years AVL has intensively developed different compact conditioning systems and technologies, which are used in high-end engine test cells. If standard systems are not available customer-specific units are designed by AVL.

BENEFITS AT A GLANCE

- A modular design makes it usable in a wide range. For different applications different modules are available
- High control accuracy in steady state and dynamic mode ensures exact data from the test procedure and increases the test bed efficiency
- Extreme temperature and pressure ranges for simulating conditions at the test bench, which are hard to achieve on the road
- Easy integration to the automation system enables a quick initialisation (Plug&Play)
- Good repeatability allows a fast achievement of the development goal
- Minimized downtime with robust and reliable design
- Short commissioning time
- Flexible use due to a mobile design
- Less maintenance work required

TASK

The thermodynamic and mechanical behaviour of a combustion engine is influenced by gases and fluids.

The relation between temperature and pressure in fluids and gases gives a high potential in development for different applications. For exhaust emissions in particular, test consistency and reproducible conditions are in high demand.

Compared to the real application on the road, there are quite constant ambient conditions in the test cell. To prepare the engines for those real situations, it is necessary to simulate different conditions like altitude or climatic conditions in the test cell.

High efficiency in testing requires high reliability and high reproducibility of the control and measurement results in a wide application range.

REFERENCES

CONSYSAIR APPLICATIONS

The combustion air conditioning system has been delivered 200 times around the world. There has also been a large number of custom tailored systems for extreme conditions. Pressure ranges from -400 bar to +200 mbar and temperatures from -40 °C to +90 °C.

CONSYBOOST APPLICATIONS

The boost air conditioning is designed as a secondary cooled heat exchanger or as a spray version for pressures up to 5 bar and temperature of 200°C or more. Units with a power of 200 kW have already been delivered.

CONSYSCOOL APPLICATIONS

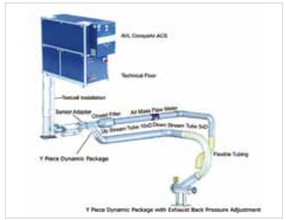
AVL conditioning systems are installed at 500 test cells worldwide. The application starts with end of line and ends in research and high dynamic racing test cells.

CONSYLUBE APPLICATIONS

The oil conditioning system is installed at engine test cells, single cylinder research engines and gearbox test cells.

MORE THAN 1000 SYSTEMS ALL OVER THE WORLD IN DIFFERENT APPLICATIONS UNDERLINE THE PERFORMANCE AND RELIABILITY OF THE AVL MEDIA CONDITIONING DEVICES.



Installation example of an AVL ConsysAir together with an Air Mass Flow Meter (AVL FLOWSONIX™) and with the Dynamic Option. A short connection line improves the performance of the whole system. A maximum length of 12 m should not be exceeded.

BENEFITS AT A GLANCE

- The dynamic package allows high dynamic test runs with nearly zero delay time
- Optimized investment costs through parallel operation of 2 to 3 test beds with an ConsysAir
- The good repeatability of the measuring values increases the efficiency of the test cell
- The wheel type can be moved from one test cell to the other
- An interface to the AVL-PUMA is available

INTAKE AIR CONDITIONING DEVICE

AVL CONSYSAIR

The AVL combustion air conditioning system “ConsysAir” is a modern conditioning system to control the main parameter of the combustion air. Independent of the engine speed and torque, temperature and humidity are controlled in small tolerances.
To control the pressure under dynamic conditions AVL offers the “Dynamic Package” with a very short delay time (<3 sec.)

CONTROL PRINCIPLE

The intake air temperature will be adjusted by cooling and heating; the humidity by cooling and moistening. The desired pressure will be increased by the blower or decreased by throttle valves. An internal air re-circulation system provides high control response also at low air flow rates.

APPLICATION

There is a fare range covered by the 5 standard units. For special applications, specially designed systems can be delivered. The customer can choose between THP stationary (ACS - Mode - closed air inlet) or TH dynamic (TCS-Mode - open air inlet).For climate chambers and for altitude simulation of several 1000 m the AVL CONSYSAIR is installed.

COOLANT CONDITIONING DEVICE

AVL CONSYSCOOL

The coolant conditioning system AVL ConsysCool with combined primary and secondary circuit control is used for bringing the engine coolant to a free definable temperature and to keep it within tight limits. Additionally it enables the quick preheating of the coolant and, on request, pressure ratio control in the primary circuit. The ConsysCool consists of a base unit for high-precision temperature control with included controllers. Additional components (options) enable the upgrade of unit to additional functions.

CONTROL

3 different control loops can be used according to the different application. In addition to the temperature control the coolant pressure can be controlled by compressed air.

APPLICATION

The total range of ConsysCool fulfils the requirements on nearly all engine tests. In end of line tests, single cylinder research engines and high dynamic application for race car engines the AVL-ConsysCool supports the research engineers.

The main components are installed in the bottom part of the system CC-200/450. These allows the separation from the upper part (electric panel, expansion tank) and the placement in the intermediate floor. More space in the test cell is the benefit.

BENEFITS AT A GLANCE

- One system for a wide application range
- Easy integration in the automation system (PUMA) with a comfortable Device User Interface. Controllers are in the device
- Flexible use by a modular design of several options
- High reproducibility due to good control accuracy for steady state and even dynamic operation
- Robust design in stainless steel piping for a long lifetime and therefore lower costs of ownership
- Easy positioning in the test cell or below the floor with a very compact design

All components are installed in a compact frame with wheels and covers. This allows a flexible use in different test cells. The arrangement of the components, at the bottom of the unit ensures that the oil level in the oil pan is always higher than in the conditioning unit. Oil back flow to the oil pan is therefore prevented.

BENEFITS AT GLANCE

- Stainless steel tubing avoids dissociation of rust particles and guarantees long-term value.
- High control accuracy and dynamics increase the test bed efficiency.
- Faster control response due to a primary controlled oil circuit.
- The compact design enables the installation close to the unit under test (engine or transmission) and therefore keeps the external oil volume small.
- Flexible in applications due to several connection modes such as connection to the oil sump or to the oil pressure circuit.

OIL CONDITIONING UNIT

AVL CONSYSLUBE

The oil conditioning unit AVL ConsysLube conditions the engine or transmission lube oil temperature and oil supply pressure to a pre-definable set value and keeps it within a certain tolerance at steady state and dynamic operation of the unit under test (UUT). The actual temperature value can be taken from the device or preferably from the UUT.

The actual pressure value must be taken from the UUT. Electrical heating is incorporated for preheating of the lube oil and better control dynamics at transient operation.

CONTROL PRINCIPLE

The PID control is carried out by an external system (e.g. PUMA OPEN). The temperature control is performed by a mixing valve (heat exchanger/electrical heating). The supply pressure control is handled by a control valve in the bypass between the supply and return lines to/from the unit.

APPLICATION

The main applications for ConsysLube are engines up to 400 kW (customized solution for bigger engines available). Several connection modes and unit options allow different applications like oil pan conditioning, oil pressure control and pre-heating. For oil conditioning on gear boxes the AVL ConsysLube can also be used.

BOOST AIR CONDITIONING UNIT

AVL CONSYSBOOST

The Boost Air Conditioning Unit AVL ConsysBoost conditions the boost air temperature at a pre-definable set value and keeps it within a tight tolerance range mainly for steady state applications. The boost air from the turbo charger is indirectly conditioned by controlling the cooling water flow on the secondary side of the heat exchanger.

CONTROL PRINCIPLE

The boost air temperature control is indirectly performed by controlling the cooling water flow through the heat exchanger. A circulation pump ensures an adequate flow of the cooling water in the heat exchanger even for low power applications. In addition, this pump improves the control behavior by returning the heated up cooling water back flow to the heat exchanger inlet.

For simulating the pressure drop of different engine intercoolers, a manually operated flap is installed between the AVL ConsysBoost and the engine intake duct.

APPLICATION

The standard unit ConsysBoost 1200 or 3000 is basically designed for stable temperature control during a steady state or dynamic engine operation. Alternative solutions, such as spray variants, are available for following a dynamic temperature profile.

The AVL ConsysBoost is installed in the test room, close to the engine for a fast response time and good control stability. To save space around the engine, the intercooler and stand can easily be removed from the conditioning unit and located separately, close to the engine.

BENEFITS AT GLANCE

- The precise adherence to a pre-defined boost air temperature significantly improves the reproducibility of measuring results on turbo-charged combustion engines and therefore increases the test bed efficiency.
- The ability to simulate different pressure losses for different vehicle intercoolers enables use on a wide range of engines.
- The compact and mobile unit can be moved to different test beds, savings investment costs by eliminating the need for another unit.
- Space-saving installation close to the engine by separating the conditioning part from the heat exchanger.

	AVL CONSYSAIR	AVL CONSYSBOOST	AVL EXHAUST BACK PRESSURE ADJUSTMENT
Classification	CA 400, 800, 1600, 2400, 3600	CB 1200, 3000	80, 150
Typical application	Intake air conditioning / altitude simulation on engine test beds	Engine test beds / boost air cooling	Pressure loss simulation of the exhaust line
Standard control range Temperature and accuracy	15 to 70°C +/- 0,5°C	15 to 70°C +/- 1°C	–
Advanced[1] control range Temperature and accuracy	-40 to 90°C +/- 0,5°C	–	–
Stabilization time for temperature	< 60 sec.	< 60 sec.	–
Standard control range Pressure and accuracy	+/- 100 mbar of the ambient pressure +/- 1 mbar	up to 4,5 bar abs. (450 kPa) no control	Adjustment pressure depending on the engine
Advanced[1] control range Pressure and accuracy	-400 to + 200 mbar of the ambient pressure +/- 1 mbar	up to 4,5 bar abs. (450 kPa) no control	–
Stabilization time for pressure	< 30 sec.	–	–
Advanced[1] adjustment time Pressure	< 3 sec. (Dynamic Package)	–	–
Standard control range Moisture and accuracy	8 to 20 g H20/kg dry air	–	–
Advanced[1] control range Moisture and accuracy	4 to 34 g H20/kg dry air	–	–
Standard flow rate range	20 to 3600 m3/h	20 to 3000 kg/h	–
Advanced[1] flow rate range	up to 7200 m3/h	20 to 3000 kg/h	–
Dimension	Starts with 2450 x 850 x 1950 mm (L x W x H)	Starts with 910 x 950 x 1150 mm (L x W x H)	400 x 200 x 820 mm (L x W x H)
Weight	Starts with 950 kg up to 1.600 kg	approx. 150 kg	15 to 25 kg

[1] Advanced = options or modifications

	AVL CONSYSCOOL	AVL CONSYSLUBE
Classification	CC-200, CCS-200, CC-450, CCS-450	CL-25/50, CL S 50
Max. cooling capacity	450 kW	50 kW
Advanced[1] cooling capacity	700 kW	120 kW
Typical application	In a wide range of designs for virtually any application on engine test beds	Pressure and temperature of engine and transmission oil on engine test beds
Standard control range Temperature and accuracy	70 to 125°C +/- 0,7°C stationary at engine inlet	70 to 140°C +/- 1°C stationary at engine inlet
Advanced[1] control range Temperature and accuracy	-30 to 150°C +/- 1°C stationary at engine inlet	-30 to 155°C +/- 1°C stationary at engine inlet
Stabilization time for temperature	< 3 min	< 3 min
Advanced[1] stabilization time for temperature	follows realistic temperature profiles (Dynamic Add On)	–
Standard control range Pressure and accuracy	0 to 1,3 bar +/- 0,1 bar system pressure 0,1 to 0,4 bar +/- 0,1 bar pump pressure	0,8 to 8 bar +/- 0,1 bar
Advanced[1] control range Pressure and accuracy	0 to 6 bar +/- 0,1 bar system pressure 0,1 to 0,8 bar +/- 0,1 bar pump pressure	0,5 to 15 bar +/- 0,1 bar
Stabilization time for pressure	< 1 min	< 1 min
Standard flow rate range	50 to 550 l/min	up to 60 l/min
Advanced[1] flow rate range	50 to 1000 l/min	up to 120 l/min
Dimensions	starts with 700 x 330 x 644 mm (L x W x H)	starts with 610 x 350 x 550 mm (L x W x H)
Weight	75 to 380 kg	30 to 250 kg

[1] Advanced = options or modifications

AVL FUEL CONSUMPTION MEASUREMENT ON ENGINE TESTBEDS AND IN THE VEHICLE

APPROACH

AVL has long understood the increasing importance of fuel consumption as a reference value for the development of state-of-the-art, low-consumption combustion engines, and this understanding is reflected in the in-house engine development department, among other areas. More than 45 years of concentrated know-how in the field of fuel consumption measurement technology, technological diversity and clever modular product concepts in combination with a global presence and sophisticated service and system competence make AVL the clear leader in the field of consumption measurement technology the world over.

BENEFITS AT A GLANCE

- Shorter time to achieve development objectives due to reliable AVL fuel consumption measurement systems, ensuring high levels of availability of the engine testbed and reducing significantly the test effort via shorter measurement times and high levels of measurement accuracy: One example is the reduction of the measurement effort during automatic engine calibration
- Protection of investments through modular design, subsequent expandability and adaptation to new injection systems and applications
- Supporting biofuels such as bio diesel and bio ethanol
- Increased productivity of the engine test facility due to lower product lifecycle costs: Simple and projectable maintenance and service as well as quick availability of spare parts via AVL eSpares™

TASK

Stricter laws and regulations with regard to CO_2 and fuel consumption reductions increase the pressure to develop engines even faster, coupled with rapidly increasing measurement expenditures. The development engineers of diesel and gasoline engines are increasingly forced to implement measurements in automatic operation with ever shorter measurement times or in transient modes.

In addition to accelerated test procedures, new combustion and injection technologies require instrumentation devices delivering highly precise measurements even for efficient engines with low consumption levels during cyclic tests under partial load. And this is all the more true if the fuel is a target variable in automated optimization and calibration procedures.

The call for higher testbed efficiency does not only mean an easy installation and quick commissioning procedure for the measurement system; it also means a reliable fuel supply to the engine with preselected parameters, such as fuel temperature and pressure. Highly precise fuel temperature control is required in order to achieve high measurement accuracies in the overall system at the engine testbed, even in case of low fuel consumption values.

The layout of the fuel consumption measurement system, for example fuel lines that adapt to different mixture preparation systems, has a decisive influence on the quality of the measurement results. Engines for alternative fuels additionally require the compatibility for bio diesel or alcohol admixtures of
up to 100%.

REFERENCES

EMISSIONS DEVELOPMENT IN THE FIELD OF COMMERCIAL VEHICLES

AVL has equipped engine test facilities of renowned manufacturers of commercial vehicles with the AVL Mass Flow Meter and Fuel Temperature Control. These fuel consumption measurement systems measure the transient fuel curve in a continuous, fast and precise manner.

AVL FUELEXACT™ PLU/ AVL FUELEXACT MASS FLOW

This covers a wide range of different engines and modern applications. Passenger car engine test facilities with up to 60 testbeds from the single-cylinder, gear, climate and multi-cylinder engine testbed up to 500 kW have been equipped with AVL Fuel Exact™.

BIO FUELS

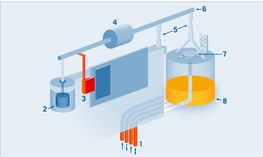
AVL obtained early experience with the application of bio fuel, such as methanol in racing and ethanol in Brazil.
AVL fuel consumption measurement systems are suitable as FlexFuel designs for Otto cycles and diesel fuels as well as for the admixtures of up to 100% bio fuels.

INSTALLED BASE

45 years of competence in the field of development and production of fuel consumption measurement systems. Already more than 15,000 systems have been delivered worldwide by AVL to be used in engine research, development, quality assurance and production, as well as for road test.

MORE THAN 15,000 SUPPLIED FUEL CONSUMPTION MEASUREMENT SYSTEMS CONFIRM OUR EXPERIENCE AND COMPETENCE IN THE FIELD OF FUEL CONSUMPTION MEASUREMENT.

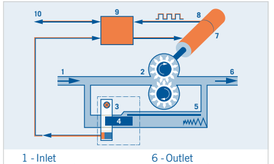
UNIQUE VARIETY OF MEASUREMENT PRINCIPLES



1 Fuel supply connections (4)
2 Damping device
3 Capacitive sensor
4 Tara weight
5 Blade spring
6 Measurement beam
7 Calibrating weight
8 Measuring vessel

GRAVIMETRIC (FUEL BALANCE)

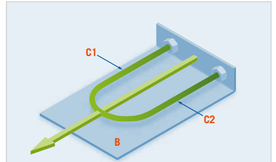
The fuel consumed by the engine is taken from a continuously weighted measurement vessel which has the same properties as the vehicle tank. The detection of the weight of the fuel is carried out with a capacitive displacement sensor that is connected to the measurement vessel by means of a beam. A calibration weight is used to perform the accuracy testing and calibration procedures in accordance with ISO9001. The calibration takes place in a fully automatic manner within a few minutes and is integrated by default into the AVL Fuel Balance.



1 - Inlet
2 - Gear meter
3 - Piston sensor
4 - Piston
5 - Bypass
6 - Outlet
7 - Servo motor
8 - Encoder
9 - Controller
9 - Signal Output

PLU MEASUREMENT PRINCIPLE

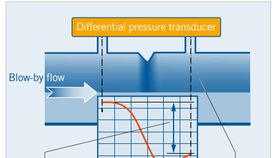
The PLU positive displacement meter combines a servo-controlled gear counter with a dynamic piston sensor. A gear meter (2) driven by a servo motor (7) with encoder (8) defines a geometric volume to pulse frequency ratio when gear rotation is adjusted to media flow. A bypass (5) ensures zero pressure difference (Δp=0) between inlet and outlet, preventing leakage flow. Flow changes immediately displace a zero-friction piston (4) in either direction. A piston position sensor (3) and a servo controller (9) provide a fast gear speed control loop keeping the piston centered.



Coriolis Force

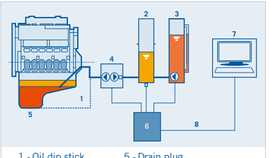
CORIOLIS

Fuel passes through a U-shaped tube, which vibrates at its natural frequency. This frequency is proportional to the fuel density, which in addition to the mass flow is a separate measurement variable and thus allows for the output of volumetric measurement values. The time lag of the vibration frequency C1 to C2 is proportional to the mass flow.



DIFFERENTIAL PRESSURE

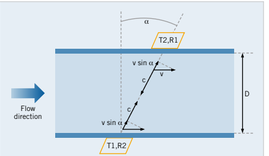
For the determination of blow-by flow the orifice measurement principle (differential pressure measurement procedure) is used. A neck (orifice) in the tube cross-section provokes a pressure drop that is measured by means of a differential pressure sensor. The shape of the orifice of the AVL Blow By Meter has been selected in a manner that, on the one hand, ensures the accuracy in both flow directions and on the other hand prevents condensation at the orifice modifying the cross-section. The selected shape of the orifice allows for a broad dynamic range of 1:50.



1 - Oil dip stick
2 - Measuring tank
3 - Refilling tank
4 - Pump
5 - Drain plug
6 - Electronics
7 - PUMA CDH – Task
8 - Hybrid interface or serial interface via RS232

GRAVIMETRIC (OIL CONSUMPTION METER)

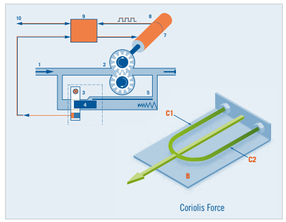
This measurement is based on the gravimetric principle. This means that oil is always sucked to a defined level or completely into a measurement tank by means of a modified dip stick or an oil drain plug. Afterwards, the weight is determined with the help of a highly precise pressure sensor. After the weight has been determined, the oil is pumped back into the oil pan of the engine. This measurement cycle consists of 3 steps: pumping (out) – weighing – pumping (back). The difference between two subsequent measurement cycles results in the oil consumption.



T - Transmitter
R - Receiver
c - speed of sound
v - flow Media velocity
α - inclination angle

ULTRASONIC TRANSIT DIFFERENTIAL TIME

The measuring principle is based on the ultrasonic transit-time differential method. In this method, two ultrasonic pulses are sent simultaneously from Transmitter 1 (T1) and Transmitter 2 (T2) right through the flowing medium. One pulse is propagating into and the other one against flow direction. The interaction between the speed of sound c and the velocity of flow v accelerates the pulse on one of the paths and decelerates the pulse on the other path. This effective propagation velocity results in different transit times through the medium: The signal at Receiver 1 (R1) arrives faster than the signal arriving at Receiver 2 (R2). The device measures the speed of sound traveling either way, corresponding to t1 and t2.



1 Inlet
2 Gear meter
3 Piston sensor
4 Piston
5 Bypass
6 Outlet
7 Servo motor
8 Encoder
9 Controller
10 Signal output

BENEFITS AT A GLANCE

- High flexibility for adaptation to different injection systems as well as a wide range of engine powers up to 2500 kW
- High efficiency on the testbed by unique repeatability and reproducibility of measurement values at minimum measurement time
- Easy service due to a large number of diagnostics functions as well as easily accessible hardware components
- Minimized commissioning effort via standardized interfaces and diagnosis functions
- System calibration according to ISO, UN ECE R49 & US EPA 40 C.F.R. Part 1065 via AVL Fuel Reference
- Measurements are not influenced by fuel pressure pulsations by fuel

FUEL CONSUMPTION MEASUREMENT

AVL FUELEXACT™ MASS FLOW & PLU

FuelExact™ is a high precision fuel consumption measurement system. Its contribution to higher testbed efficiency is assured by determination of fuel consumption with highest precision in minimum measurement time. The application focus is engines up to 2500kW. Highest temperature stability and cooling power fulfill all actual requirements regarding transient and dynamic testing.

MEASUREMENT PRINCIPLE

The FuelExact™ exists in two version: One based on the PLU measuring principle and one based the Coriolis measuring principle. For further information please refer to page 76.

APPLICATION

AVL FuelExact™ covers applications from single- cylinder up to 2,500 kW engines in the field of engine research and development Due to the high data rate of 20 Hz and the fast step response, the system is ideally suited to transient calibration methods that are increasingly being applied in the field of engine development. The FlexFuel version expands the application range towards development tasks in the field of bio fuels. New and improved features consistently protect your investment.

FUEL CONSUMPTION MEASUREMENT

AVL FUEL MASS FLOW METER AND FUEL TEMPERATURE CONTROL

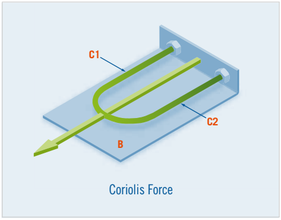
Regarding fuel consumption measurement, the mass flow measurement system AVL Fuel Mass Flow Meter and Fuel Temperature Control uses a Coriolis sensor optimized by AVL and supplies fuel of the highest temperature stability to the engine testbed. A pressure control system patented by AVL provides constant, adjustable fuel pressures and allows for a reliable and easy utilization with state-of-the-art mixture preparation systems. The FlexFuel version covers the applications in the field of bio fuels and thus provides investment protection for future development tasks.

MEASUREMENT PRINCIPLE

The fuel passes through a U-shaped tube, which vibrates at its natural frequency. This frequency is proportional to the fuel density, which, in addition to the mass flow, is a separate measurement variable and thus allows for the output of volumetric measurement values. The time lag of the vibration frequency C1 to C2 is proportional to the mass flow.

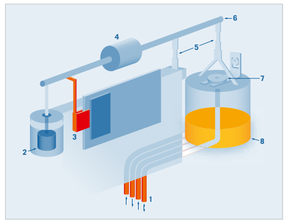
APPLICATION

Given its precision of 0.12% and direct mass flow measurement capability, the AVL Fuel Mass Flow Meter with Fuel Temperature Control can be used on all engine and chassis dynamometer testbeds in the fields of research, development and production. The measurement system can be used universally for different engine sizes from single-cylinder engines up to 600 kW large-scale engines and for state-of-the-art mixture preparation systems and test cycles.



BENEFITS AT A GLANCE

- Shorter measurement and testing times due to precise fuel temperature control better than 0.02 °C
- The patented AVL pressure control allows for a universal application in line with the requirements of state-of-the-art measurement methods and injection systems
- Increased testbed efficiency due to reliable measurement operation, integrated maintenance displays and detailed diagnosis functions
- With numerous options, a broad spectrum of applications is covered



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1 Fuel supply connections (4)
2 Damping device
3 Capacitive sensor
4 Tara weight
5 Blade spring
6 Measurement beam
7 Calibrating weight
8 Measuring vessel

BENEFITS AT A GLANCE

- Minimization of testbed times due to high levels of reliability and long maintenance intervals
- Time-saving ISO9001 testing due to calibration within a few minutes
- Fast and low-cost integration into the engine testbed due to the presence of compatible interfaces
- Fast application with different injection systems

FUEL CONSUMPTION MEASUREMENT

AVL FUEL BALANCE AND FUEL TEMPERATURE CONTROL

The AVL Fuel Balance, based on the gravimetric measurement principle, is the fuel consumption meter used most commonly at engine testbeds. Providing advantages such as reliable operation, measurement accuracy of 0.12% as well as excellent low maintenance expenses, it has an uncontested leading position.

MEASUREMENT PRINCIPLE

The fuel consumed by the engine is taken from a continuously weighted measurement vessel with all the properties of the vehicle tank.

The detection of the weight of the fuel is implemented with a capacitive displacement sensor that is connected to the measurement vessel by means of a beam. A calibration weight is used to perform the accuracy testing and calibration procedures in accordance with ISO9001. The calibration is implemented in a fully automatic manner within a few minutes and is integrated by default into the AVL Fuel Balance.

APPLICATION

In combination with the AVL Fuel Temperature Control or the AVL Cooling System, it is the ideal solution and industrial standard when equipping research, development, quality and endurance testbeds. It is used for single-cylinder and large diesel engines up to an output of 1000 kW. The entire field of application is covered with one AVL Fuel Balance by means of measurement range switching. Due to the presence of compatible interfaces, it can be easily integrated into different testbed automation systems.

FUEL MEASUREMENT SYSTEM CALIBRATION

AVL FUEL REFERENCE

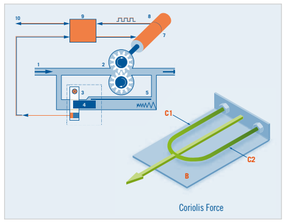
AVL Fuel Reference is an efficient calibration system that gives you a simple way to check various types of fuel consumption measurement devices including the way they are set up on the testbed. Quality assurance, ISO calibration, periodical verifications and calibration according to UN ECE R49 and US EPA 40 C.F.R. part 1065 call for this kind of calibration. Depending on your requirements, it is capable of reducing time and effort for calibration (including testbed installation) to as little as 60 minutes. This is made possible by simple installation and operation, automatic execution of calibration procedures and automatic generation of calibration reports.

MEASUREMENT PRINCIPLE

The Fuel Reference exists in two version: One based on the PLU measuring principle and one based the Coriolis measuring principle. For further information please refer to page 76.

APPLICATION

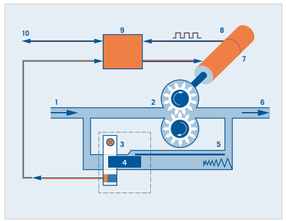
An AVL Fuel Reference unit is typically connected to a fuel measurement system instead of an engine. It compares the fuel consumption value of the fuel measurement system with the sensor value of the AVL Fuel Reference. Within the software of the AVL Fuel Reference various test runs with different flow rates and measurement times can be parameterized. For performing the test run the operator is guided by the software for manual or automatic operation.



1 Inlet
2 Gear meter
3 Piston sensor
4 Piston
5 Bypass
6 Outlet
7 Servo motor
8 Encoder
9 Controller
10 Signal output

BENEFITS AT A GLANCE

- Calibration of the entire fuel consumption measurement chain (measurement device and testbed installation)
- Compliance with all statutory guidelines and standards (ISO, US EPA 40 C.F.R. Part 1065 and UN ECE R49)
- Overall calibration effort is reduced to as little as 60 minutes
- By returning fuel to the measurement device or fuel supply system, the calibration of measurement devices is done without wasting fuel
- Compatible with all current AVL fuel consumption measurement devices



1 Inlet
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5 Bypass
6 Outlet
7 Servo motor
8 Encoder
9 Controller
10 Signal output

BENEFITS AT A GLANCE

- Dynamic flow measurement due to high accuracy even at extremely low fuel flow
- Cycle time reduction and quality improvement in end-of-line testing
- No influence on engine performance (no pressure drop; Δp=0)
- Fast testbed integration, flexible use and convenience stand-alone functionality

END-OF-LINE-TEST OF SMALL OFF-ROAD ENGINES

AVL SORE PLU 110 FUEL CONSUMPTION MEASUREMENT UNIT

The AVL SORE PLU110 fuel consumption measuring unit is used particularly in the testing of handheld small off-road engines (SORE). The unit is designed to measure down to extremely small fuel flow rates and very low supply pressure on carburetor gasoline engines without return flow. The PLU measuring principle avoids interference with engine performance ($\Delta p = 0$) in a very large flow range. Installation close to the engine gives the PLU 110T flow meter a unique dynamic measurement capability and minimizes temperature influences. As a stand-alone flow measuring unit, AVL SORE includes a density meter, a data acquisition module and flexible interfaces.

MEASUREMENT PRINCIPLE

The PLU positive displacement meter combines a servo-controlled gear counter with a dynamic piston sensor. A gear meter (2) driven by a servo motor (7) with encoder (8) defines a geometric volume to pulse frequency ratio when gear rotation is adjusted to media flow. A bypass (5) ensures zero pressure difference ($\Delta p=0$) between inlet and outlet, preventing leakage flow. Flow changes immediately displace a zero-friction piston (4) in either direction. A piston position sensor (3) and a servo controller (9) provide a fast gear speed control loop keeping the piston centered.

APPLICATION

AVL SORE PLU 110 is used in R&D production and engine testing. End-of-line tests for two-stroke SI engines include carburetor adjustment for performance optimization and emission standards compliance. Test time minimization is a primary target of EOL test design. Due to its dynamic measurement capability, the AVL SORE PLU 110 accelerates maximum power adjustment significantly and thereby contributes to efficient engine testing.

MOBILE FUEL CONSUMPTION MEASUREMENT

AVL KMA MOBILE

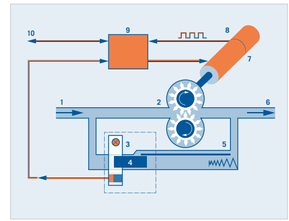
The AVL KMA Mobile is a mobile fuel consumption measurement system that sets new standards for fuel consumption measurement in vehicles on the basis of its reliability, flexibility and precision. Due to the modular design, the measurement system can be ideally adapted to the different requirements. For example, engines without return flow require only the measuring module and engines with return flow to the tank require the measuring and the conditioning module. Thanks to the large measurement ranges, it is possible to implement consumption measurement with one system – from small-scale engines to large-scale engines. In connection with the very short response time (100 ms) and the very short measurement times, dynamic measurements can also be implemented with a high measurement quality (accuracy, reproducibility).

MEASUREMENT PRINCIPLE

The AVL KMA Mobile measurement system uses the worldwide approved PLU measurement principle of the servo-controlled positive displacement meter ($\Delta p = 0$). The positive displacement meter is driven by a servo motor (7) in a way that the differential pressure across the meter is controlled to “zero”. This differential pressure of zero between sensor inlet (1) and outlet (6) results in the absence of leakage flows within the PLU sensor that could affect the measurement result. As the sensor does not cause a pressure drop, wear and tear on the sensor are minimized.

APPLICATION

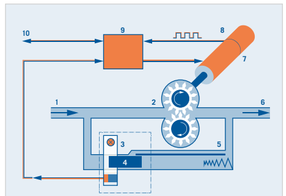
The universal fuel measurement system AVL KMA Mobile is used for fuel consumption measurement purposes in vehicles and at chassis dynamometer testbeds. The AVL KMA Mobile is available with different PLU sensors and thus allows for measuring flows between 0.16 l/h and 300 l/h. Thus, all applications from passenger cars to heavy commercial vehicles are covered.



1 Inlet
2 Gear meter
3 Piston sensor
4 Piston
5 Bypass
6 Outlet
7 Servo motor
8 Encoder
9 Controller
10 Signal output

BENEFITS AT A GLANCE

- Due to its universal applicability, the AVL KMA Mobile can be used with all common mixture preparation systems
- The reduction of the test times during road tests is made possible by the high levels of measurement accuracy and reproducibility
- The pressure required by the mixture preparation system is adjustable so that there will be no influences on the engine fuel system by the measurement system
- Simple handling due to modular design and the application of self-sealing quick couplers facilitates the integration into the vehicle



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PRODUCT AVAILABLE VIA AVL ePRODUCTS https://shop.avl.com

BENEFITS AT A GLANCE

- Cost-efficient sensor solution for mileage accumulation and similar applications
- Flexible use and comfortable options for easy system integration or stand-alone functionality
- Robust design and long-term stable calibration
- No influence on engine performance (no pressure drop; Δp=0) due to PLU measuring principle

MOBILE MILEAGE ACCUMULATION CONSUMPTION MEASUREMENT

AVL PLU 116 FLOW METER

The AVL PLU 116H is a universal fuel flow meter designed for mobile vehicle applications. Users benefit from the PLU measuring principle thanks to a large measuring range, no engine interference (Δp=0) and extreme resistance against vibration and shock. Due to the unit's lightweight design, small footprint and 12 V DC supply voltage the integration into on-road and off-road vehicles with single direction fuel flow is extremely easy. In addition, an optional installation kit facilitates flow meter setup for engines with fuel return lines (e.g. diesel engines).

MEASUREMENT PRINCIPLE

The PLU positive displacement meter combines a servo-controlled gear counter with a dynamic piston sensor. A gear meter (2) driven by a servo motor (7) with encoder (8) defines a geometric volume to pulse frequency ratio when gear rotation is adjusted to media flow. A bypass (5) ensures zero pressure difference (Δp=0) between inlet and outlet, preventing leakage flow. Flow changes immediately displace a zero-friction piston (4) in either direction. A piston position sensor (3) and a servo controller (9) provide a fast gear speed control loop keeping the piston centered.

APPLICATION

AVL PLU 116H is an excellent flow meter solution for mileage accumulation applications with focus on flexible use, simple setup, robustness and long-term stability. With large measuring ranges, medium resolution and high accuracy, it primarily serves monitoring and total consumption measurement purposes. A display unit (VAZ display) and a data acquisition unit (PLU 4000) are available as options for flexible use in various environments.

BLOW BY MEASUREMENT

AVL BLOW BY METER

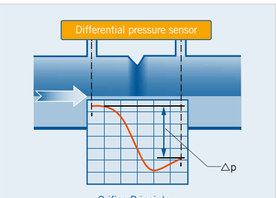
Nowadays, blow-by measurement is standard on engine testbeds. In order to be able to comply with the exhaust gas legislation for new combustion engines today and in the future, the requirements for crankcase ventilation systems will continue to increase. In order to design such systems, knowledge of the blow-by map of the engine is also required. This and the possibility of continuous measurement of the blow-by flow to monitor the engine condition, make the AVL Blow By Meter an indispensable instrumentation device for engine testing.

MEASUREMENT PRINCIPLE

In order to determine the blow-by flow, the orifice measurement principle (differential pressure measurement procedure) is used. A neck (orifice) in the tube cross-section results in a pressure drop that is measured by means of a differential pressure sensor. The shape of the orifice of the AVL Blow By Meter has been selected in a manner that ensures accuracy in both flow directions while also preventing accumulations at the blind that would modify the cross-section. The selected shape of the orifice allows a broad dynamic range of 1:50.

APPLICATION

On the basis of the interchangeable measurement ranges between 0.2 and 2400 l/min, the AVL Blow By Meter can be used from small-scale and single-cylinder engines up to ships' diesel engines. The areas of application cover engine research and optimization of the piston cylinder assembly. Furthermore, this system is used when designing crankcase ventilation systems and on quality and endurance testbeds.

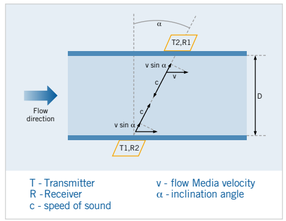


Orifice Principle

PRODUCT AVAILABLE VIA AVL ePRODUCTS https://shop.avl.com

BENEFITS AT A GLANCE

- The accuracy of 1% FSO (optional) and the reproducibility of 0.1% comply with the high requirements of engine measurement technology
- Due to the minimum pressure drop, the blow-by behavior of the engine is hardly affected
- High reliability and constant measurement readiness are realized by low dirt sensitivity
- Correct detection even of inverted blow-by flows
- Simple integration and installation on the testbed



T - Transmitter
R - Receiver
c - speed of sound
v - flow Media velocity
α - inclination angle

BENEFITS AT A GLANCE

- The unique AVL FLOWSONIX™ Air is impervious to contamination, which enables long maintenance intervals
- Marginal influence on the combustion engine due to small pressure drop in the measurement head
- Quick and easy installation for any engine type
- High availability of the measurement device due to extended calibration interval of one year
- One size fits all. Due to the wide measurement range only 2 different instrument versions are required: Light Duty or Heavy Duty
- Little space required - just 5 x DN up-stream and down-stream tubing

AIR CONSUMPTION MEASUREMENT

AVL FLOWSONIX™ AIR

Along with the fuel consumption, the air consumption is another important parameter when developing combustion engines. In emission certification, the air consumption is taken as reference value. Thus, the air consumption is an integral part of AVL testbed solutions.

The AVL FLOWSONIX™ Air consists of the components of measuring head, evaluation unit and two very short inlet- and outlet pipes (5*DN each). Due to the large measuring span of 1:80, only two different pipe diameters are needed (DN 100, DN 150) to cover the full application range of up to +/- 3200 kg/h

MEASUREMENT PRINCIPLE

The ultrasonic transit time measurement principle combined with specifically developed AVL ultrasonic sensors is capable of measuring highly dynamic bidirectional air flows with a sampling rate of up to 1 kHz. Due to this high data acquisition rate, precise measurement of the dynamic engine behavior is ensured, e.g. the resolution of pulsations in the air intake flow. In contrast to conventional air mass flow meters the measurement will be performed independently of the flow direction. Correct measurement at applications with possible reverse flows are therefore guaranteed. Additional damping systems or silencers are not necessary.

APPLICATION

The combination of high levels of measurement accuracy, a large measurement range and short response timer results in the air mass measurement being used in the following fields of application: Engine development, quality assurance, emissions development and emissions certification.

AIR CONSUMPTION MEASUREMENT

AVL AIR CONSUMPTION METER

Along with the fuel consumption, the air consumption is another important parameter when developing combustion engines. In emission certification, the air consumption is taken as reference value. Thus, the air consumption is an integral part of AVL testbed solutions.

The air consumption measurement system consists of the components of flow meter sensor (measuring tube), supply/evaluation unit and measuring section. The measuring tube is available in six different nominal widths of NW 25 up to NW 200 and is installed into the measuring section by means of quick release connections.

MEASUREMENT PRINCIPLE

The system works in accordance with the principle of the hot film anemometer. This approved measurement procedure is based on the fact that heat is withdrawn from a heated body by the air flowing around it. In the relevant measurement range, this flow-dependent cooling does not depend on pressure and temperature but on the type and number of air particles making contact with the heated surface. Thus, this procedure directly represents the mass flow of the suction air. With this procedure, the measurement value will be provided directly in the unit kg/h or the standard m³/h.

APPLICATION

The combination of high levels of measurement accuracy, a large measurement range and short response times results in the air mass measurement being used in the following fields of application: Engine development, quality assurance, emissions development and emissions certification.

Different measurement tubes up to 4000 kg/h.

BENEFITS AT A GLANCE

- The high levels of measurement accuracy across a large measurement range comply with the requirements of automatic engine calibration
- The short response time is a precondition for detecting quick engine load changes in the transient measurement range
- Simple handling due to modular design and the use of quick release connections facilitates the integration into the test facility

UREA CONSUMPTION MEASUREMENT

AVL PLUREA™

AVL PLUrea™ serves the specific requirements of SCR system application in diesel engine exhaust after-treatment. Compliance with the challengingly low limits of future exhaust emission legislation requires maximum NOx conversion ratios while avoiding ammonia slip. Successful urea dosing strategy development for a specific engine/SCR system/catalyst combination includes accurate dosing calibration over the entire engine map and comprehensive emission cycle testing. Enabling AVL measurement technology provides for fast setup, easy handling, robustness and durability in addition to accurate and reliable measurement data.

MEASUREMENT PRINCIPLE

Extremely small flow quantities and high levels of flow dynamics require a measurement position in the direct vicinity of the injector in order to minimize temperature influence on the results. Robustness towards pressure pulsations resulting from the injection is of course, an important precondition at this position. With their dual measurement principle PLU sensors are suited ideally for these measurement conditions.

APPLICATION

AVL PLUrea™ provides stationary urea flow metering as well as highly dynamic consumption measurement during transient test cycles. The system solution is used on engine or chassis dynamo testbeds as well as in vehicle testing. With accurate online measurement, AVL PLUrea™ contributes to efficient SCR system testing in all development stages of SCR system application and verification.

BENEFITS AT A GLANCE

- Efficient dosing strategy development due to dynamic correlation
- Optimized system solution for SCR-specific operational conditions
- Immediate detection of dosing deviations or SCR system malfunction and exact identification of corresponding operational conditions
- Fast testbed integration, flexible use and comfortable stand-alone functionality

OIL CONSUMPTION MEASUREMENT

AVL OIL CONSUMPTION METER

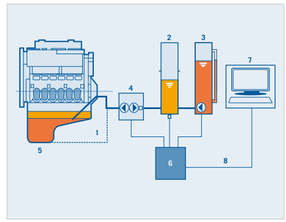
With regard to stricter emissions regulations, the determination of the lubrication oil consumption of state-of-the-art combustion engines is as important as ever. These exhaust gas and particulate matter emissions limited by the legislator confront the engine developers with a difficult task that can only be solved in the combination combustion – exhaust gas after-treatment – oil consumption development.

MEASUREMENT PRINCIPLE

The measurement works in accordance with the gravimetric principle. This means drawing the oil into a measurement tank, either completely or up to a defined level, by means of a modified dip stick or the oil drain plug. Afterwards, the weight is determined with the help of a high-precision pressure sensor. After the weight has been determined, the oil is pumped back into the oil pan of the engine. A measurement cycle consists of the three steps of pumping (out), weighing and pumping (back). The difference between two subsequent measurement cycles indicates the oil consumption.

APPLICATION

Thanks to the compact and mobile design, the measurement unit can be used in many applications. The areas of application in the field of engine development and research are the optimization of cylinder head seals, piston rings, or the valve guides, as well as inspection of oil dilution or the reasons for oil consumption. In case of durability testing, the AVL Oil Consumption Meter can also be used for monitoring or refilling the consumed quantity of oil. On production testbeds the meter can be used to check the production quality of the engines.



BENEFITS AT A GLANCE

- Up to 50% time savings compared to traditional methods
- The integrated oil refilling unit allows for extended test cycles
- The simple installation and testbed integration minimizes downtime
- The integrated operating panel on the device allows for stand-alone operation
- Due to the fully automated measurement procedure, handling the oil is avoided

	AVL FUELEXACT™ FUEL CONSUMPTION MEASUREMENT	AVL FUEL MASS FLOW METER AND FUEL TEMPERATURE CONTROL
Type:	AVL 740	AVL 735S/753C
Measurement principle:	PLU or mass flow	mass flow
Measurement ranges:		
• PLU	0.03 … 500 l/h* 0.025 … 410 kg/h*	
• Mass flow	0 … 500 kg/h*	0 … 125 kg/h
Measurement uncertainty:		
• Volume/mass	≤ 0.1% (acc. to DIN 1319)	≤ 0.12% (acc. to DIN 1319)
• Density	1g/dm³	1g/dm³
Interfaces/output signal:	Ethernet, RS232 analog I/O 0 …10 V digital I/O	RS232, analog I/O, 0 …10 V, digital I/O
Measurement frequency:	20 Hz (max.)	20 Hz (analog)
Response time:	< 125 ms	< 125 ms
Fuel types:	standard** and 100% bio fuels	standard* and 100% bio fuels
Engine feed pressure:	max. 1 MPa	< 0 … 600 kPa
Control range:	10 … 80 °C	10 … 80 °C
Stability:	better than 0.02° C	better than 0.02° C
Heating/cooling:	3 kW / 6 kW	1.6 kW / 1.6 kW
Power supply:	3 phases 400 V AC, PE	230 V, 50 Hz, 220 V, 60 Hz, 100 V, 50-60 Hz, 115 V, 60 Hz
Power consumption:	3.5 kW (without heating)	0.4 kW (without heating)
Ambient temperature:	+5 … +50 °C	+5 … +50 °C
Dimensions (W x H x D):	960 x 1,710 x 430 mm	770 x 1,630 x 345 mm
Weight (empty):	305 kg	152 kg

* With different sensors
** With max. 20% alcohol and up to 10% bio diesel

* With max. 20% alcohol and up to 10% bio diesel

	AVL FUEL BALANCE AND FUEL TEMPERATURE CONTROL
Type:	AVL 733S/753C
Measurement principle:	Gravimetric
Measurement range:	
• Mass flow	0 … 150 kg/h
Measurement uncertainty:	
• Volume/mass	≤ 0.12 % (according to DIN 1319)
Interfaces/output signal:	RS232, analog I/O 0 …10 V, digital I/O
Measurement frequency:	10 Hz (max.)
Response time:	< 440 ms
Fuel types:	standard* and 100% bio fuels
Engine feed pressure:	max. 600 kPa
Control range:	10 … 80 °C (optional -10 … 80 °C)
Stability:	better than 0.02 °C
Heating/cooling:	1.6 kW/1.6 kW
Power supply:	230 V, 50 Hz, 220 V, 60 Hz, 100 V, 50-60 Hz, 115 V, 60 Hz
Power consumption:	0.4 kW (without heating system)
Ambient temperature:	5 … 50 °C
Dimensions (W x H x D):	770 x 1630 x 345 mm
Weight:	135 kg (empty)

* With max. 20% alcohol and up to 10% bio diesel

	AVL FUEL REFERENCE	AVL SORE PLU 110 FUEL CONSUMPTION MEASUREMENT UNIT
Type:		AVL SORE PLU 110-20
Measurement principle:	PLU or mass flow	PLU
Measurement ranges:		
• PLU	0.03 … 500 l/h* 0.025 … 410 kg/h*	0.1 ... 20 l/h*
• Mass flow	0 … 150 kg/h* 0 … 500 kg/h*	
Systematic measurement uncertainty:		
• Volume/mass	≤ 0.1 % (acc. to DIN 1319)	0.2% (acc. to DIN 1319)
• Density	1g/dm³	
Interfaces/output signal:	Ethernet, RS232, frequency	RS232; analog 0 ... 10 V; frequency; Ethernet (option)
Measurement frequency:		20 Hz
Response time:	< 125 ms	< 300 ms
Fuel types:	Standard** and 100 % bio fuels	Standard **
Media density:		0.68 … 0.85 g/cm³
Operating temperature:		+10 … +60° C
Operating pressure:		0.01 … 2 bar; differential pressure Δp=0
Power supply:	230/110 V, 50/60 Hz	24 V DC
Power consumption:	type 500 W	type 50 W
Ambient temperature:	+15 ... +45 °C	10 ... 60 °C
Dimensions (W x H x D):	610 x 1,145 x 545 mm	460 x 300 x 160 mm
Weight (empty):	approx. 120 kg	12 kg

* With different sensors
** With max. 20% alcohol and up to 10% bio diesel

* Option: extended calibration range 0.05 ... 20 l/h
** With max. 20% alcohol and up to 10% bio diesel

	AVL KMA MOBILE FUEL CONSUMPTION MEASUREMENT UNIT	PLU 116H FLOW METER
Type:	AVL KMA Mobile	AVL PLU 116H
Measurement principle:	PLU	PLU
Measurement range:	0.16 … 300 l/h* 0.12 … 225 kg/h*	0.3...60/, 0.6…120/, 1.0…160l/h
Resolution:	800 … 860 pulses/cm³	44 / 80 /160 pulses/cm³
Measurement uncertainty:		
• Volume/mass	≤ 0.1% (acc. to DIN 1319)	0.3 % (acc. to DIN 1319)
• Density	1 g/dm³	
Interfaces/output signal:	RS232 (AK-compatible); frequency (RS485); analog 0...10V	Frequency; analog 0...9V *
Response time:	< 125 ms	< 500ms
Fuel types:	Standard** and 100% bio fuels****	Standard** and 100% bio fuels
Media density:	0.68 … 0.85 g/cm³	0.68 … 0.85 g/cm³
Media temperature:	-10 … +60 °C	-20 … +60 °C
Ambient temperature:	-10 … +50 °C	-20 … +60 °C
Operating pressure:		0.1 … 10 bar; differential pressure Δp=0
Engine feed pressure:	0.3 … 5 bar	
Fuel circulation quantities:	200 / 400 / 600 l/h***	
Power supply:	12 VDC, 24 VDC (optional)	11 ... 16 V DC
Power consumption:		type 10 W
Dimensions (W x H x D):	approx. 470 x 360 x 550 mm	80 x 224 x 104 mm
Weight:	35 kg	1.5 kg (empty)

* With different sensors
** With max. 20% alcohol and up to 100% bio diesel
*** Depending on number of pumps
**** only measuring module

* RS232 with optional VAZ display or PLU4000
** With max. 20% alcohol and up to 10% bio diesel

	AVL BLOW BY METER
Type:	AVL 442
Measurement principle:	Differential pressure
Measurement range:	0.2 ... 10 l/min 1.5 ... 75 l/min 3 ... 150 l/min 6 ... 300 l/min 12 ... 600 l/min 24 ... 1200 l/min 48 ... 2400 l/min
Measurement uncertainty:	≤ 1 % FSO fine linearization (option) ≤ 1.5 % FSO standard linearization
Interfaces/output signal:	RS232 (AK-compliant), analog I/O, 0 ... 10 V
Ambient temperature:	-10 ... 55 °C
Power supply:	24 V direct current
Power consumption:	35 W
Dimensions (W x H x D):	Approx. 330 x 350 x 75 mm (MR:3–150 l/min)

	AVL PLUREA™ UREA CONSUMPTION MEASUREMENT SYSTEM	AVL OIL CONSUMPTION METER
Type:	AVL PLUrea™	AVL 406
Measurement principle:	PLU	gravimetric
Measurement ranges:	0.05 … 10l/h, 0.05 … 20l/h or 0.1 … 40l/h	
Oil quantities:		
• Measurement quantity		max. 10 l
• Residual quantity		0.5 l
• Refill quantity		max. 9 l
Measurement uncertainty:	0.2% (acc. to DIN 1319) *	1% of the measurement value ±5 g (at an oil surface in the oil pan of 600 cm²) 1% of the measurement value ±10 g (at an oil surface in the oil pan of 4,000 cm²)
Interfaces/output signal:	RS232 (AK-compatible); frequency (RS485)	RS232 (AK-compliant), analog I/O, 0 ... 10 V
Measurement frequency:	20 Hz	
Response time:	< 250 ms	
Fuel types:	Aqueous urea solution acc. to ISO22241 2008/9 (AdBlue®), water with min. 1% Prevox 7400 content	Mineral, vegetable and synthetic oils, including additives (fresh and old oils)
Media density:	0.99 … 1.19 g/cm³	
Operating temperature:	+10 … +60 °C	
Operating pressure:	0.01 … 10 bar; differential pressure Δp=0	
Voltage supply:	100 ... 240 VAC 50-60 Hz	230 V, 50 ... 60 Hz, approx. 0.8 A, optional 110 V, 50 ... 60 Hz
Power consumption:	Type 50 W, max. 150 W	
Ambient temperature:		0 … 40 °C
Dimensions (W x H x D):	600 x 600 x 1,700 mm	60 x 104 x 60 mm
Weight (empty):	50 kg	approx. 60 kg

* 0.3% for total consumption between 3 g and 3 kg in dynamic cycle (ETC, FTP, etc.)

	AVL FLOWSONIX™ AIR	AVL AIR CONSUMPTION METER
Type:	AVL FLOWSONIX™ Air	Air Consumption Meter
Measurement principle:	Ultrasonic transit differential time	Hot film anemometer
Measuring span:	1:80	1:40
Measurement range:	0(20)…+/– 1600 kg/h (LD version) 0(40)…+/– 3200 kg/h (HD version)	100...4000 kg/h*
Measurement uncertainty:	< ±1% of reading	< ±1% of measured value
Reproducibility:	< ± 0.25% of reading	< ± 0.25 %
Influential effects:		
• Temperature effect		< 0.03 % / K
• Pressure effect		≤ 0.2 % / 100 kPa
Interfaces/output signal:	AK Interface Ethernet (TCP/IP) AK Interface RS232 Analog 0…10V, 4…20mA (1kHz) Digital I/O	analog, RS 232
Response time:	T90 = <10ms	T63 = 12ms
Temperature of air:	–25° C … +80° C	–25 °C … +80 °C
Medium pressure:	0.6 ... 2.5 x 102 kPa(2.5 bar abs.)	0.6 ... 2.5 x 102 kPa (2.5 bar abs.)
Ambient temperature:		–25...+80 °C (measuring tube)
Measuring head	–20°C … +60°C	–25...+50 °C (evaluation unit)
Evaluation unit:	–20°C … +60°C	–25 … +85 °C
Protection class:	IP54	IP54
Power supply:	110/230 VAC +/– 15% 50/60 Hz +/– 5%	230 VAC, 115 VAC
Power consumption:	38 W	38 W (evaluation unit) 10 W (measuring tube)

* With different sensors

DYNAMIC INJECTION MEASUREMENT TECHNOLOGY

APPROACH

With the introduction of the diesel CR and DGI technologies, the requirements with regards to flow measurement for engine development have changed over the course of the last two decades. Both in the field of research and development and in the field of production, the continuous fuel consumption measurement has been complemented by cycle-related injection quantity measurements and the analysis of the corresponding rate curve. Driven by the goals of reducing fuel consumption and emissions, we are currently experiencing a new spurt of innovation in the field of combustion development with a major impact on injection technology and injection measurement technology. As a pioneer in applications for common rail and GDI technologies, AVL remains the market leader in dynamic injection measurement systems with the Shot to Shot™ measurement technology developed for this purpose.

BENEFITS AT A GLANCE

- Shorter development times: Cycle-synchronous correlation of injection quantities and time behavior with the relevant system and engine parameters
- Reduction of measurement times: High measurement accuracy reduces the measurement period on the testbed or in the production line
- Protection of development steps: Precise analysis, for example of minimal quantities and multiple-injections, as components of the indicating data collection
- Robust development tool: Efficiency due to universal applicability and high long-term stability of the calibration

TASK

Decreasing exhaust gas emissions limits and the requirements for continuously lower fuel consumption values are currently the primary driving forces for the further development of engine technology. The strategy and the precise control of the fuel combustion play a central role here. With different focuses, this in turn requires the precise analysis of the injection rate curve related to the engine cycle:

- The development and production of capable injectors and injection systems require the precise analysis of the opening and closing behavior. Testing the injector during production requires high precision and long-term reproducibility of the injection quantity measurement.
- Combustion strategies with layer loading and multiple-injection sequences play an important role in the development of GDI internal combustion engines today. The highest measurement resolution of the low separation times at partially low injection quantities pose extreme challenges for the measurement technology here.
- The exact optimization of performance, consumption and exhaust gas emissions on diesel engines has become an extremely complex task due to the application of different components for exhaust gas aftertreatment. The precise quantity measurement of multiple-injections down to the smallest partial injections has to be implemented across the overall engine map in realistic conditions.

The Shot to Shot™ measurement technology is used in all examples mentioned above, and thanks to its superior characteristics, it contributes to providing the products and services of our customers with a competitive advantage.

REFERENCES

COMBUSTION DEVELOPMENT ON SINGLE-CYLINDER ENGINES

STS provides an important contribution to the correlation of characteristic combustion and injector parameters in realistic conditions. The research departments of the most renowned German automobile manufacturers and suppliers are among our customers.

PRODUCTION TESTING OF INJECTORS

The current challenges with 100% testing of injection quantities are measurement time reduction, minimal injection quantities and the required measurement accuracy. STS serves as the only practical means of production measurement for the market leader in SCR systems.

ENGINE CALIBRATION

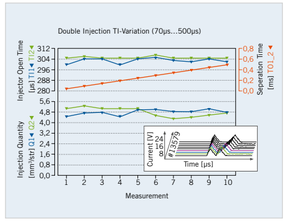
The parameterization of the engine controller with map data on the system testbed equipped with STS reduces calibration expenditures on the multi-cylinder engine by a significant extent. As a standard tool, STS has been ensuring the timely and economical implementation of development projects at AVL for years.

INSTALLED BASE

More than three decades of competence in the field of flow sensory systems. More than two decades of experience in the field of injector testing and more than three years of successful applications of STS measurement systems in a variety of customer-specific applications with widely varying requirements.

THE COMPETENCE AND EXPERIENCE OF AVL SUPPORTS CUSTOMERS IN KEEPING UP WITH THE FAST PROGRESS OF INJECTOR TECHNOLOGY AND IN MASTERING HIGH-TECH PRODUCTS OF TODAY AS EVERYDAY TECHNOLOGIES OF TOMORROW.



Gasoline Upstream – Multiple-Injection Analysis: Injection quantity and injector open time measurement of a double injection profile with variable separation time (TI = 70 ... 500 µs).

BENEFITS AT A GLANCE

- Flexibility: Applications are possible on both the high-pressure side of the injector (upstream) and low-pressure side (downstream)
- Versatility: Large measurement ranges for flow and injection quantities combined with high measurement accuracy down to minimal quantities
- Shorter development times: Quick characterization of prototypes due to shot measurement at the operating engine or at the spray chamber
- Relevant results: No influence on the injection system due to the instrumentation device principle (Δp = 0)

GASOLINE INJECTION QUANTITY MEASUREMENT

AVL STS PLU 131 GASOLINE

Research and development are two application focuses in the field of internal combustion engines for the AVL Shot to Shot™ PLU 131 flow measurement system. In the course of such work, the shot quantity measurement and the details of the chronological rate curve for the fuel injection provide valuable findings for the optimization of combustion behavior. Furthermore, shot quantity measurement has become increasingly widespread as part of production testing for fuel injectors.

MEASUREMENT PRINCIPLE

The dual PLU measurement principle provides STS with a very flexible hydraulic configuration of the measurement design due to the combination of a rotatory and a translatory positive displacement meter. As a result, the STS measurement system can be used on the high-pressure side of the injector (upstream) and in the low-pressure area (downstream).

APPLICATION

The versatility of STS provides for the additional option of a dynamic injection quantity measurement at the operating single-cylinder engine and at the spray chamber, turning the AVL Shot to Shot™ PLU 131 flow measurement system into an indispensable measurement tool when characterizing injectors and developing spray image and combustion behavior.
When looking at the example of stratified charge combustion with its cascades of subsequent injections, the importance of these measurement values becomes particularly clear.
However, STS is now also used for 100% series testing purposes in the manufacturing of injectors for homogenous operation.

DIESEL INJECTION QUANTITY MEASUREMENT

AVL STS PLU 131 DIESEL

For diesel applications, the AVL Shot to Shot™ PLU 131 flow measurement system is used for the research, development and production of injectors, injection systems and the corresponding combustion engines.

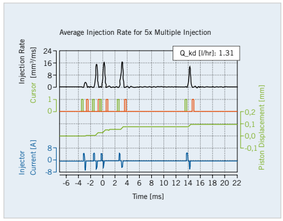
The connection with the AVL indicating technology family IndiAdvanced offers convenient options for rate curve analysis as part of the indicating data collection. The timing analysis and the minimal quantity measurement in particular are very important measurement variables for the multiple-injections during diesel combustion.

MEASUREMENT PRINCIPLE

In diesel applications, the system is used in downstream configuration on the low-pressure side of the injectors at up to 250 bars of counter pressure. The dual PLU measurement principle entails the combination of a rotatory and a translatory positive displacement meter. Using STS, you can determine the injection quantities in a highly precise manner and also record the rate curves at a high resolution.

APPLICATION

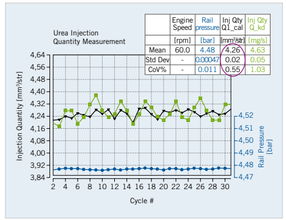
Diesel CR injection systems are pre-calibrated during the engine development procedure at AVL on the fully instrumented multiple-cylinder system testbed in order to save valuable development time and costs on the engine testbed at a later point in time.
Renowned heavy duty vehicle manufacturers use STS to optimize their unit-injector fuel injection systems on full HD engine testbeds, for example. Within the framework of 100% testing of the injector series production, STS complies with the extreme requirements of a robust, fast shot quantity measurement with high accuracy.



Diesel Downstream – Multiple-Injection Analysis: Injection rate measurement of a typical CR diesel multiple-injection sequence with pilot, main and post injections. Piezo injector current, piston sensor displacement and cursors for quantity measurement are seen below.

BENEFITS AT A GLANCE

- Compliance with the emission limits through reliable characterization of the relevant parameters to control the multiple-injection systems
- Reduction of engine testbed development time for the calibration of injection systems due to pre-mapping of injection parameters on the injection system testbed
- Cost efficiency of the production test due to short measurement times and robust measurement systems
- High relevance due to large operating ranges for pressure and temperature, which allow different loads and speeds to be measured in realistic conditions



Urea Upstream Injection Quantity Measurement: Injection quantity statistics over 30 injections of an injector characteristic test down to extremely low flow rates of 10g/h.

BENEFITS AT A GLANCE

- Relevant results: Application on high-pressure side of injector (upstream) for shot quantity measurement on low-pressure injectors
- Development safety: High level of measurement accuracy across a broad measurement range with minimal influence on the system
- Production quality: Fast and precise measurements across the full range of operating parameters when testing injectors with the 100% test

UREA INJECTION QUANTITY MEASUREMENT

AVL STS PLU 131 UREA

The development and production of SCR injection systems requires precise shot quantity measurement of the urea dosage into the exhaust gas system. In doing so, the characterization and testing of curves and functionality are implemented in an advantageous manner and under realistic conditions for both injectors and complete injection systems.

MEASUREMENT PRINCIPLE

Just like for low-pressure fuel injection, a precise measurement of the undisturbed SCR system can only be implemented at the feed side (upstream) of the injector. The most important difference compared to fuel here is the extremely low level of urea consumption, which amounts to only 5% of diesel consumption.

With these extreme requirements, the AVL Shot to Shot™ PLU 131 is the only flow measurement system that also satisfies the requirements for measurement accuracy. This is achieved through the dual PLU measurement principle with two complementing sensors for dynamics and injection quantities.

APPLICATION

For measuring the minimal quantities of the urea injectors, component testbeds for SCR system development comply with extreme requirements for constant pressure and temperature conditions, as well as for the precision of the flow measurement. This is the only way to ensure that the actual injector properties are characterized without disruptive error sources. The high level of measurement accuracy at extremely low flow rates down to 0.01 l/h is also the reason that AVL Shot to Shot™ PLU 131 Urea has been the only approved means of measurement in the production system of the world market leader for SCR systems since 2006.

FLOW MEASUREMENT FOR COMPONENT TESTING

AVL PLU131F, PLU131S, PLU131U

The AVL product line PLU131 offers a wide range of high precision flow meters for all kinds of applications in various fields of combustion engines. In addition to standard flow meter versions for all kinds of fuels and test fluids, specialized models for water or urea solution are available. Other device types have been designed for high media pressure up to 200 bar and high media temperature up to 150 °C.

The different measuring ranges cover everything from small quantity measurement at 0.05 l/h up to high flow rates of 300 l/h. The measuring accuracy is 0.1% of the measured value over the complete measuring range of the individual device types of 1:300.

MEASUREMENT PRINCIPLE

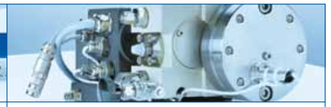
The dual PLU measuring principle entails the combination of a rotatory and a translatory positive displacement meter. The servo-controlled gear counter determines the flow volume from the rotation. The dynamic piston sensor controls the engine speed and ensures zero pressure difference ($\Delta p = 0$) between inlet and outlet. This prevents internal leakage flow in the sensor. Over the complete measuring range, no pressure difference is generated in the hydraulic system to be measured by the measuring device.

APPLICATION

The main fields of application of the PLU 131 are test benches and production lines for automotive fuel supply components. The PLU measuring principle is suitable for pulsating flows and can be applied in direct hydraulic adaptation for the testing of pumps, injectors and control valves on the inlet (upstream) side as well as on the outlet (downstream) side. AVL PLU 131 sensors increase measurement accuracy and reduce measuring time for continuous flow measurement.

BENEFITS AT A GLANCE

- Reduced measurement time due to high-precision flow rate measurement
- High flexibility due to broad range of media compatibility and extremely large measuring ranges
- Reliable results with upstream measurement (high-pressure side) and non-interference between meter and hydraulic system ($\Delta p = 0$)
- Low cost of ownership due to outstanding robustness and long-term stability of calibration



	AVL STS DIESEL AND GASOLINE	AVL STS UREA
Type number:	STS PLU 131-Q-P-D-S-FU	STS PLU 131-Q-P-D-S-AD
Standard configuration:	Downstream or upstream	Upstream
Typical application:	Research and development, racing, system calibration, production	
Measurement variables:	Flow rate, shot volume, injection parameters (flow rate curve with up to 10 partial injections, injector current, injector opening and closing times, pressure, temperature).	
Measurement principle:	Servo positive displacement meter	Servo positive displacement meter
Measurement range:		
• Flow rate	0.01 … 10 l/h or 0.02 … 20 l/h or 0.4 … 40 l/h	0.01 … 10 l/h or 0.02 … 20 l/h
• Shot volume	0.1 … 200 mm³ or 0.3 … 600 mm³ or 0.5 … 1,000 mm³	0.1 … 200 mm³ or 0.3 … 600 mm³
Measurement uncertainty:		
• Flow rate*	0.1% for calibration factors of medium flow rate	0.1% for calibration factors of medium flow rate
• Shot volume**	1% at > 2 mm³ shot volume	1% at > 10 mm³ shot volume and 4 Hz cycle rate
Cycle rate:	1 … 50 Hz (up to 150 Hz upon request)	1 … 10 Hz (up to 150 Hz upon request)
Media:	Fuel and diesel fuels and common test media; alcoholic additives up to 100%	Aqueous urea solution according to DINV70070 (AdBlue®)***, water with at least 1% Prevox share****
• Media density range	0.69 … 0.85 g/cm³ (further densities upon request)	0.99 … 1.19 g/cm³ (further densities upon request)
Operating temperature range:		
• Medium:	-30 … +70 °C	+10 … +60 °C
• Environment:	-30 … +60 °C	+10 … +60 °C
	up to 150 °C with optional cooling flange	
Operating pressure range:	0.01 … 20 or 0.02 … 200 bar Up to 250 bar upon request.	0.01 … 10 bar Up to 20 bar upon request.
• Differential pressure	ΔP=0 (PLU measurement principle)	ΔP=0 (PLU measurement principle)
• Counter pressure	No minimum counter pressure required	No minimum counter pressure required
Interfaces:	RS232 or TCP/IP (data collection)	RS232 or TCP/IP (data collection)
Voltage supply:	100–240 V AC 50/60 Hz	100–240 V AC 50/60 Hz
Power consumption:	Max. 200 W	Max. 200 W
Dimensions (W x H x D):	393 x 143 x 210 mm (sensor)	393 x 143 x 210 mm (sensor)
Weight (not filled):	16 kg (sensor)	16 kg (sensor)
Safety:	CE	CE
Calibration:	Traceable back to German national standard (PTB)	Traceable back to German national standard (PTB)

* Measurement uncertainty of the calibration factors of the flow meter at repetition conditions with medium HAKU at 20 °C and 1 bar pressure.
** Shot volume according to GUM (Guide to the Expression of Uncertainty in Measurement) for an optimized injection system.
*** AdBlue® is a trademark of the VDA for the official name Urea AUS 32 according to DIN 70070.
**** P3-Prevox 7400

	AVL PLU 131S	AVL PLU 131F	AVL PLU 131U
Measuring principle:	PLU	PLU	PLU
Flow measurement ranges:	0.05 ... 10, 0.05 ... 20, 0.1 ... 40, 0.2 ... 80, 0.3 ... 150, 0.8 ... 300 l/h	0.05 ... 10, 0.05 ... 20, 0.1 ... 40, 0.15 ... 75, 0.3 ... 150, 0.8 ... 300 l/h	0.05 ... 10, 0.05 ... 20, 0.1 ... 40 l/h
Measurement uncertainty: *)	0.1% For sensor calibration factors of average flow rates	0.1% For sensor calibration factors of average flow rates	0.2% For sensor calibration factors of average flow rates
Interface:	Frequency output (max. 150 kHz), Differential pulse signals according to RS485 standard	Frequency output (max. 80 kHz), Differential pulse signals according to RS485 standard	Frequency output (max. 150 kHz), Differential pulse signals according to RS485 standard
Dynamic response time:	<100ms	<100ms	<100ms
Media:	Commercially available gasoline and diesel fuels and compatible test fluids, alcoholic additives up to 100%	Commercially available gasoline and diesel fuels and compatible test fluids, alcoholic additives up to 100%	Aqueous urea solution acc. to ISO22241 2008/9 (AdBlue®) **, water with 1% Prevox 7400 content
Media density:	0.69 ... 0.85 g/cm³	0.69 ... 0.85 g/cm³	0.99 ... 1.19 g/cm³
Operating temperature:	(further density ranges on request) Media: -30 ... +70 °C Environment: -30 ... +60 °C	(further density ranges on request) Media: -20 ... +70 °C Environment: -20 ... +60 °C	(further density ranges on request) Medium: +10 ... +60 °C Environment: +10 ... +60 °C
Operating pressure:	0.02 ... 20 bar, 0.02 ... 200 bar	0.1 ... 10 bar	0.01 ... 10 bar
Supply voltage:	24 V DC +20%/-10%	24 V DC +20%/-10%	24 V DC +20%/-10%
Power consumption:	40 W	40 W	40 W
Dimensions: (W x D x H)	335 x 216 x 140 mm 363 x 216 x 140 mm including cooling flange	340 x 216 x 133 mm	335 x 216 x 140 mm
Weight:	12 kg	10 kg	12 kg
Calibration:	Traceable to National Institute of Metrology (PTB)	Traceable to National Institute of Metrology (PTB)	Traceable to National Institute of Metrology (PTB)

* Measurement uncertainty of the calibration factors of the flow meter at repetition conditions with medium HAKU at 20 °C and 1 bar pressure.
** AdBlue® is a trademark of the VDA for the official name Urea AUS 32 according to DIN 70070.

COMBUSTION MEASUREMENT TECHNOLOGY

APPROACH

Based on detailed knowledge and experience in the methodology of combustion analysis, AVL has created practical tools and devices that make the complex thermodynamic processes in the engine visible and understandable. In order to support all phases of development, AVL offers different solutions for different tasks in combustion development, application and calibration.

Perfectly integrated and matched components are the benefits offered to customers by the only complete combustion analysis measurement solution available worldwide.

BENEFITS AT A GLANCE

- Full indicating measurement chain with consistent communication, unique in the world
- Solutions for all applications with full flexibility
- Perfect integration and communication with testbed and application system
- Data security through integration into the testbed data management system
- High precision of measurement through inbuilt plausibility checks
- Open, homogeneous solutions for user-specific adaptations

TASK

These days, legislation acts as a major driving force on the automotive market and brings about current development needs and trends.

Effective drive systems with the lowest emissions possible at moderate costs will be in high demand for all engines sizes. At the same time, the market is changing rapidly as a result of new manufacturers of engines/models appearing on the market and intensifying the competitive pressure on all OEMs.

All these circumstances lead to a trend of radically shortened development cycles in general. Due to peripheral conditions, combustion will increasingly become the central focus of tests because future engine maps, for example, will incorporate several combustion concepts. Therefore, all test engineers, calibration engineers and development engineers as well as test-field managers are facing increasing complexity.

Engineers are facing new challenges again since they increasingly need stronger interaction and correlation between combustion analysis results in engine automation and control systems faster than ever before.

REFERENCES

ALL APPLICATION FIELDS

For basic engine calibration, optimizing fuel consumption or emissions, combustion noise and mechanical diagnostics, optimizing engine performance or developing new combustion methods: AVL equipment is used worldwide, whenever detailed information about the combustion process is needed.

CERTIFIED PRODUCT DEVELOPMENT PROCESS

The AVL combustion analysis software IndiCom is developed using the certified software development process CMMI. CMMI monitors the development in terms of time, budget and, most importantly, achieved quality.

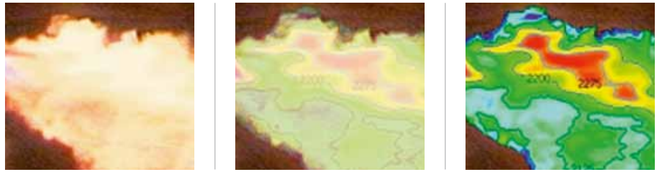
IN-HOUSE POWERTRAIN ENGINEERING EXPERIENCE

All AVL combustion analysis tools are practically tested and optimized in close cooperation with our in-house powertrain engineering teams. This is the key to offering products of the highest quality and reliability, another unique benefit for our customers.

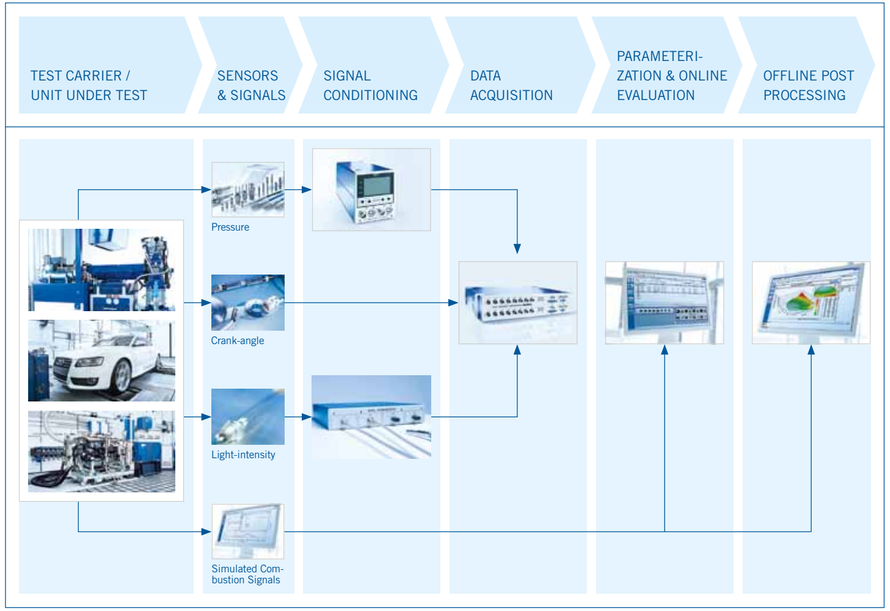
INSTALLED BASE

Problem solving competency based on AVL's long-term experience in combustion analysis and the fact that AVL is the only manufacturer of a full indicating measuring chain make AVL the customer's preferred choice and the market and technology leader for high-end combustion analysis.

DUE TO THE COMBINED USE OF INDICATING AND VISUAL METHODS I NOW UNDERSTAND THE PROCESSES INSIDE THE COMBUSTION CHAMBER.



COMPLETE MEASURING CHAIN FOR COMBUSTION ANALYSIS



SINGLE CYLINDER RESEARCH ENGINES AND TESTBEDS

AVL single cylinder engines and AVL single cylinder testbeds are used for combustion and basic research as well as for visualizing fuel injection and combustion phenomena with transparent access to the combustion chamber (via glass liner fitted to the cylinder head). The benefit is that the prospects of success are tested under realistic engine conditions long before the concept is applied to the full engine.

Single cylinder engines cover a range from small passenger car engines up to heavy duty truck engines. Given their modular structure, they allow for standardized, fully equipped engines as well as individual, customized solutions for all scales.

APPLICATION

Typical applications for single cylinder research engines and testbeds are combustion development, injection development, flow studies with laser measuring methods (basic research), lube oil development, fuel development, alternative fuel research and investigations on gas engines and heavy fuel engines.

OVERVIEW OF RESEARCH ENGINES

Variant	Bore	Stroke	Displacement	Rev. speed	Peak pressure
Series 540 Car Size	65 mm to 100 mm	60 mm to 95 mm	0.2 l to 0.75 l	8000 rpm	200 bar
Series 580 Light Duty Size	80 mm to 110 mm	90 mm to 130 mm	0.45 l to 1.2 l	5000 rpm	200 bar
Series 530 Heavy Duty Size	110 mm to 145 mm	120 mm to 170 mm	1.2 l to 2.8 l	3000 rpm	300 bar

BENEFITS AT A GLANCE

- Single cylinder compact testbeds (including dyno and more) as cost-efficient compact systems and turnkey solutions
- Ideal combination of testbed and research engine for professional operation of single cylinder engines
- Robust design of engines for highest demands under extreme conditions
- Exact replication of customer-specific multi-cylinder engines ensure excellent correlation to the production engine
- Possibility of extensive combustion R&D projects at AVL's internal transparent engine laser laboratory and application support from AVL experts

PRODUCT AVAILABLE VIA AVL ePRODUCTS https://shop.avl.com

In addition to pressure signals robust and highly accurate crank angle signals are a basic requirement for high quality of the combustion analysis. AVL offers therefore solutions for simple and flexible installation with angle encoders of series 365.

BENEFITS AT A GLANCE

- Maximum precision and outstanding thermodynamic properties due to the unique piezoelectric crystal $GaPO_4$, Double Shell sensor housing
- Integration of all piezoelectric pressure sensors into AVL SensorDataManagement SDM™
- Flexible sensor solutions for manifold application fields
- For highly demanding applications like super charged engines special sensor types are offered with extreme high robustness and durability

SENSORS FOR COMBUSTION ANALYSIS

AVL offers piezoelectric pressure sensors in all typical dimensions from M5 to M14 for a wide range of applications at the engine. AVL uses for uncooled sensors the unique piezoelectric crystal $GaPO_4$ with its outstanding thermodynamic properties. The AVL portfolio includes sensors for absolute and low pressure measurement as well as sensors for measuring needle and valve lift. Manifold crank angle encoder solutions, specifically designed for individual application fields, are used for a precise determination of crank angle signals.

APPLICATION

- AVL sensors are used for the thermodynamic analysis and calibration of combustion engines
- The specific “double shell” design of the GR14D fulfils the strict requirements regarding low deformation sensitivity specifically needed for racing application fields
- The AVL spark plug solutions, available in sizes M 12x1.25 and M 14x1.25, with a broad range of heat values and spark positions, are easily adaptable and fulfil the require¬ments for high measurement precision. Therefore they are best suited for in-vehicle applications as well.

AVL crank angle encoders of the 365 series are available in different designs:
The 365C for standard mounting at the free crankshaft end, the 365X for mounting at the shaft between engine and dyno or the 365R (“massfree marker trace”) especially designed for racing applications, small sized engines or engines with limited direct access to the crank shaft.

INDICATING AMPLIFIER SOLUTIONS

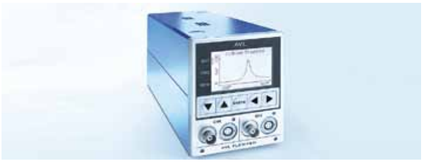
The FI Piezo and FlexIFEM product families enlarge AVL’s indicating amplifier product range to include a new intelligent amplifier concept. FI Piezo and FlexIFEM are able to already provide the first indicating results cycle by cycle in addition to the measured signals, thus offering a new range of applications for the engine engineer.

APPLICATION

The applications of the microIFEM range from cylinder pressure to the measurement of piezo-resistive signals (e.g. low pressure indicating). The FI Piezo and FlexIFEM can additionally be operated on a stand-alone basis (integrated front display). Furthermore all variants of all indicating amplifier families can be operated stand-alone (via stand-alone parameterization software) or optionally controlled remotely (via AVL IndiCom).

Typical application fields for all 3 product families are research, light-duty development, heavy-duty development, large engines and racing applications. In addition, the FI Piezo and FlexIFEM are suitable for endurance testing (engine monitoring on the testbed and in-vehicle), for in-vehicle performance testing (engine protection) and for use on large engines for on-board measurement.

The FlexIFEM Noise is a stand-alone device for combustion noise analysis, best suited for benchmark activities or as a reference noise meter through the complete development process. The new FlexIFEM Knock is the new stand-alone knock monitoring device, which can be used for durability tests or as a reliable engine protection for R&D activities.



PRODUCT AVAILABLE VIA AVL ePRODUCTS https://shop.avl.com

The AVL microIFEM is the well-proven, modular and advanced amplifier concept and is best suited for applications directly at the testbed and in vehicle.

BENEFITS AT A GLANCE

- Peak pressure monitoring without indicating system (calculation results at standalone FI Piezo or FlexIFEM)
- Best suited for stand-alone usage due to integrated parameterization, front display and monitoring functionality (including limit detection and alarm signals)
- Maximum data quality due to full support of AVL SensorData-Management SDM™ in all amplifier families
- Cost effective, as a result of scaleable channel configurations for single FI Piezo, FlexIFEM, microIFEM or cascaded systems

The indicating systems AVL IndiModul, AVL IndiSet or AVL IndiMaster stand for high performance and flexibility in order to fulfill all high developed combustion analysis tasks at the test bed.

BENEFITS AT A GLANCE

- Full system modularity from 8 up to 96 high speed channels on two different platforms
- Performance of endless measurements due to Gigabit Ethernet communication and support of multi-core processors
- No missing of critical situations during test run due to continuous monitoring with simultaneous event measurement
- Real time results for reduction of development duration (real time calculation of user-defined algorithms with streamed raw data enables immediate provision of indirect combustion parameters)

MODULAR INDICATING SYSTEMS

The high performance indicating system line covers all engine power classes, is suitable for all applications and is continuously optimized for the newest requirements in the field of combustion development.

The AVL IndiModul is the optimal measuring device if a small high performance system is required. It combines up to 8 indicating channels with real time calculation in one compact device.

The AVL IndiSet with a maximum of 16 fast analogue input channels per unit is ideal for complex developing tasks. Due to its high performance data acquisition this system is optimal for development and calibration at the test bed.

The AVL IndiMaster is a universal high speed data acquisition system with fully flexible channel configuration. It is ideally suited for all demanding crank angle and time based acquisition and analysis tasks when flexibility or very high channel counts are required.

ALL IN ONE INDICATING SYSTEMS

The AVL FlexIFEM Indi is a 1- or 2 channel indicating system with integrated charge amplifier and therefore a scalable solution for test bed applications, upgraded by default with software and hardware preconditions for best acquisition- and calculation capacities. This device can be used in stand alone operation whereby its integrated display enables a permanent monitoring of the pressure signal.

The AVL IndiMicro sets a new benchmark in respect of compact combustion measurement technology. Due to the high level of flexibility there exist unprecedented mounting possibilities for a broad range of mobile applications. This device can also be used in stand alone operation for output of indicating parameters via real time CAN interfaces.

The AVL IndiSmart offers high user friendliness when acquiring and analyzing measuring data on 8 indicating channels. With integrated charge and multipurpose amplifiers it is the most powerful system in the All in One indicating systems line. An integrated crank angle calculator with signal processing for inductive or hall signals and real time CAN output completes this device.

Decreasing emission limits and increasing demands on driveability cause Information for verifying and optimizing combustion processes in vehicle application, that make new demands on combustion measurement technology.

YOUR BENEFITS AT A GLANCE

- Ideal for base calibration of the engine, engine monitoring and development
- Flexible use due to application packages for gasoline and diesel engines
- Compact design for in-vehicle use
- Direct integration into the application system (e.g. INCA)
- Functionally expandable for the measuring tasks of tomorrow

AVL INDICOM™ INDICATING SOFTWARE

Combustion engine and drivetrain development are quickly increasing in complexity. At the same time, development cost and time pressure are escalating. Understanding the combustion processes and the influences of the many engine parameters are the key to optimizing modern engines and using their full potential. The current product generation AVL IndiCom™ is the answer to these increasing demands for even more flexibility and performance where powerful calculation tools, measurement automation and professional visualization are combined with an easy-to-use interface.

APPLICATION

Measurements for all applications, ranging from standard combustion measurements to continuous monitoring, model-based calibration (with AVL CAMEO™), cold start and vehicle testing, optical flame evaluation and more, is possible with AVL IndiCom™. It is built to cover future applications as well, due to powerful real-time calculations and flexible and customizeable online calculations (based on CalcGraf). The integration into any test cell automation environment is supported by tailored and generic interfaces. In addition, the full compatibility with generic post-processing tools like AVL CONCERTO™ also enhance the application possibilities.
The specific software extension AVL GCA (gas exchange and combustion analysis) is used online at the testbed for indicating purposes with AVL IndiCom™. Results provided by “GCA online” are immediately available in order to perform automated calibration e.g. at low end torque. AVL GCA is also used offline in conjunction with AVL CONCERTO™ in the office and is designed for the detailed analysis of the combustion process and gas exchange, delivering additional results that cannot be measured on the testbed (e.g. air fuel ratio inside the combustion chamber, residual gas). The calculation can also be carried out for dynamic operation. AVL GCA is seen as a virtual sensor based on AVL BOOST.

BENEFITS AT A GLANCE

- Reduced measurement preparation time and easy-to-use advanced functionalities via the workflow-oriented user interface
- Supports the engineer to make fast and qualified decisions based on professional evaluations and clear presentations
- Fast and efficient problem solving in development and calibration through the unique combination of conventional pressure-based with new optical-based combustion analysis
- Seamless combination of measurement and simulation with AVL IndiCom and AVL GCA (gas exchange and combustion analysis)
- Integration into any test cell automation environment supported by tailored and generic interfaces

AVL VISIOLUTION SYSTEMS OPTICAL ACCESS TO THE ENGINE

With the help of optical measuring methods, deep insights into the complex processes of fuel mixture and combustion beyond the findings of the pressure indicating method can be achieved. AVL Visiolution technology helps users understand the whole process in detail and therefore provides the right tool for improving performance with regard to fuel consumption, mixture formation, exhaust emission and engine power.

The system is based on indicating in the combustion chamber. AVL Visiolution technology provides the perfect tool for flame evaluation, thermal radiation and injection monitoring, making complex processes more clear.
The formation of pollutant emission in transient operation becomes understandable. Engineering duties are finished in record time and with utmost precision.

MEASURING PRINCIPLE

Visioknock / VisioFlame / VisioTomo: Special spark plugs or head gaskets equipped with glass fibers allow optical access to the combustion chamber. This allows observation of flame propagation, localisation of knock and access to combustion patterns.

VisioFEM: Cycle-precise, cylinder-specific recording of phenomena that contribute significantly to pollutant emissions.

VisioScope: Carburetion, fuel injection, soot formation and temperature distribution are recorded by endoscope and camera.

BENEFITS AT A GLANCE

- Measurement in highly transient operation
- Best suited for exploring injection strategies
- Find critical emission cycles
- Engineering mixture formation
- Evaluate flame propagation
- Evaluate thermal risk
- Detect potential for knock limit improvement
- Detect root causes of irregular combustion
- Cold start / tip-in / tip-out emission evaluation
- Services covering the whole Visiolution range
- Perfect interface to existing AVL indicating chain

AVL SINGLE CYLINDER RESEARCH ENGINES AND COMPACT TESTBEDS

The work with single cylinder research engines offers the significant advantage that the prospects of success are tested under realistic engine conditions long before new concepts are applied to the full engine.

Product range
AVL's single cylinder engines cover everything from small car engines up to large truck engines. Engines equipped with optical top-works offer transparent access to the combustion chamber. The AVL single cylinder compact testbeds are the ideal combination of engine and testbed for professional operation of single cylinder engines.

Product properties
- Bore diameters from 65 to 145 mm, displacement from 0.2 to 2.8 liter and max. firing peak pressure up to 300 bar
- Best suited for basic research and investigation of fuel injection and combustion phenomena
- Possibility of R&D projects at AVL's internal transparent engine laser laboratory

AVL SENSORS FOR COMBUSTION ANALYSIS

AVL offers piezoelectric pressure sensors for direct use at the combustion chamber, at inlet and exhaust channels, as well as absolute pressure sensors for the injection line or hydraulic systems.

Product range
A wide portoflio of uncooled and cooled pressure sensors in all standard dimensions, mounted directly or via adapter solutions at spark or glow plugs, can be used for engine development and calibration tasks. Manifold crank angle encoder solutions as well as TDC sensors, needle lift and valve list sensors complete the portfolio.

Product properties
- All uncooled pressure sensors are equipped with the AVL-exclusive piezoelectric crystal $GaPO_4$
- each pressure sensor is equipped with SID Sensor Identification to fully support AVL SensorDataManagement SDM™

AVL INDICATING AMPLIFIER SOLUTIONS

Modular indicating amplifier systems for usage from simple exploitation of strain-gauge, piezo-resistive or inductive sensors to the intelligent amplification of piezoelectric signals and calculation of indicating parameters.

Product range
The portfolio of AVL's flexible indicating amplifier families of the microIFEM, FI Piezo and the FlexIFEM is suitable for all application fields. Different form factors make it best suited for stand-alone usage as well as fully integrated into the testbed environment.

Product properties
- Flexible due to 1-, 2- or 4-channel configurations
- Full support of AVL SensorDataManagement SDM™
- Cycle-by-cycle calculation results available already at the amplifier

AVL INDICATING SYSTEMS

They are the link between the sensor and the data acquisition software and therefore provide the basis for the acquisition of cylinder pressure signals and the relevant calculations of revealing indicating parameters.

Product family
The All in One device line, consisting of FlexIFEM Indi, IndiMicro and IndiSmart, stands out due to its combination of a signal amplifier and acquisition unit which enables mobile application.

The indicating systems IndiModul, IndiSet and IndiMaster are data acquisition systems that stand out due to their high functionality. They are the perfect tools if high performance as well as flexible configuration at the test bed is required.

Product features
- Broad coverage of development processes for combustion engines
- Standard software platform, based on IndiCom
- Support of standardized interfaces for automation – or additional measuring systems
- Support of the complete measuring chain from the sensor to the data post processing

AVL INDICATING SOFTWARE AVL INDICOM™

The increasing complexity in combustion engine and drivetrain development versus the shorter development time requires intelligent software tools to easily turn the mass of acquired data into meaningful information. AVL IndiCom™ is especially focused on meeting these demands.

Product range
AVL IndiCom™ is available in several standard configurations for the corresponding indicating system families. Additional application packages (gasoline or diesel packages) and functional extensions allow a modular configuration regarding specific application needs. Further more the SW-option AVL GCA provides values not measurable such as residual gas.

Product properties
- Workflow-oriented user interface for parameterization, measurement, interactive analysis and reporting
- Calculation library with pre-defined calculation models, fully extendable with user-specific algorithms
- Optimized compatibility with AVL CONCERTO™
- Additional values by AVL-GCA, the virtual sensor

AVL VISIOLUTION SYSTEMS OPTICAL ACCESS TO THE ENGINE

Wherever results of the classical pressure indicating method are no longer sufficient on their own, optical measuring methods offer additional answers. AVL Visiolution technology provides the right tools and services to improve performance regarding fuel consumption, mixture formation, exhaust emission and engine power.

Product range
A wide portfolio of optical measurement systems is offered by AVL. Starting with the small VisioFEM system, ideally in combination with the VisioPressure-Sparkplug, through to the Visioknock and VisioFlame systems and up to the VisioTomo sytems for high-end analysis of processes within the combustion chamber.

Product properties
- Optical access via special spark plugs, endoscopes or special cylinder head gasket sensor
- Optical signal recording systems with up to 160 channels

AVL EMISSIONS MEASUREMENT SOLUTIONS

APPROACH

AVL offers the complete range of emission test systems for certification, development and series monitoring on engine and chassis dynamometer testbeds. The latest requirements of the global emissions regulations are complied with by the current iGeneration product family. AVL is able to offer the products with the highest quality currently available on the market. Testbed solutions with permanent automation and data analysis, that are integrated in the best possible manner, provide the basis for the highest possible productivity.
AVL particulate measurement technology comprises a wide range of applications. AVL offers test devices for measuring the lowest soot concentrations, for gravimetric measurements and for particle number counting as well as portable devices for in-vehicle testing during R&D and in-use compliance testing. Special conditioning units allow for measurements at high temperatures and pressures in front of filter systems (DPF). These special conditioning units also enable test cycles during high altitude simulations. With the Micro Soot Sensor and the Opacimeter, AVL offers solutions for determining emissions while driving as well.

BENEFITS AT A GLANCE

- Complete testbed solutions from one highly experienced supplier
- Tailored systems for certification and/or development and/or COP (conformity of production)
- Readiness for the future thanks to the latest technology as well as flexible automation systems
- Broad, globally installed base with comprehensive know-how
- Global service support

TASK

The dramatically decreasing emission limits and the increased use of alternative fuels pose great challenges for engine and vehicle developers. On the basis of ever more complex engine and exhaust gas aftertreatment strategies and new requirements, such as the limitation of the particle number or the concentration of NH_3, the complexity of testbeds and the requirements for automation systems are increasing dramatically. Along with the currently limited emission components, more and more substances are also being measured. These include, for example, nitrogen compounds such as NO, NO_2, NH_3, N_2O, HNCO or aldehyde compounds such as formaldehyde and acetaldehyde.

Further requirements result from “in-use” legislation, requiring truck manufacturers to check compliance with the emission limits over the entire service life and to use portable emission measurement technology.

The requirements for sampling are increasing as well, for example due to higher emission pressures in front of filter systems or by the need to avoid chemical reactions and deposits during probe gas sampling in emission measurements of SCR systems.

Considering the rising number of measurement parameters as well as the devices and sub-systems to be used, the requirements for the operators and for the automation systems are increasing as well. Nevertheless, the demand for an increase in productivity has to be met at the same time. AVL has ideally prepared its emission measurement technology for these challenges and offers future-proof system solutions in connection with the integrated testbed automation system.

REFERENCES

50 YEARS OF EXPERIENCE IN THE FIELD OF EMISSION AND PARTICULATE MEASUREMENT
All leading OEMs and suppliers as well as institutes and authorities like EPA, CARB and TUEV use AVL Exhaust gas measurement technology.

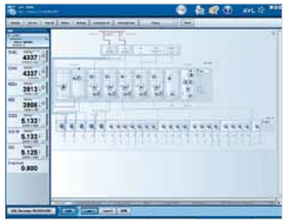
INSTALLED BASE PARTICULATE MEASUREMENT
More than 30 manufacturers already use the new AVL Particle Counter within the framework of vehicle certification and development.

6,800 Smoke Meters
2,200 Opacimeters
520 Smart Samplers
700 Micro Soot Sensors
450 Particle Counters
as of December 2012

INSTALLED BASE GASEOUS EMISSIONS MEASUREMENT
2,400 exhaust measurement systems
550 SESAM-FTIR
570 CVS systems
470 particulate samplers
600 emission automation systems

ONLY AVL COMBINES A COMPREHENSIVE AND HIGH-QUALITY EMISSION TESTING PRODUCT RANGE WITH THE IN-HOUSE KNOW-HOW OF AN ENGINE DEVELOPER AND TESTBED OPERATOR.



The iGEM AMA software allows for easy, intuitive operation of the AMA i60 via a touch-screen. It provides a quick overview of the bench status, including all streams and analyzers. The control software allows diagnostic functions to be performed automatically via the integrated calendar function.

BENEFITS AT A GLANCE

- Safe investment in state-of-the-art, intelligent technology of the highest flexibility and retrofitability
- First-class measurement results with regard to accuracy, reproducibility and response times for all applications
- Substantially reduced expenses for installation, operation, service and total cost of ownership
- Graphical user interface with individual flow diagram of the system
- High-quality development process and comprehensive test and integration programs guarantee high, measurable quality

EXHAUST MEASUREMENT SYSTEM

AVL AMA i60

The AVL AMA i60 exhaust measurement system is characterized by new gas analyzers and a compact, modular design. The intuitive, interactive graphical user interface supports all essential service and diagnosis functions and issues warnings in case of pending maintenance intervals.

MEASUREMENT PRINCIPLE

Integrated pumps draw in the measurement gas from the sample point, which can be located at a distance of up to 20 m. Depending on the application, heated lines and pre-filters or sample point selector units located in the vicinity of the sample are used. The analysis of the measurement gas is performed by means of conventional analyzers – FID for THC and CH_4, CLD for NO/NO_X, IRD for CO, CO_2 and N_2O as well as PMD for O_2. After several correction steps, the raw values of the analyzers provide concentration values that can be transmitted to a test cell automation system along with other information. The AMA i60 can also be controlled by means of an AK interface.

APPLICATION

The AMA i60 contains analyzers with a broad dynamic measurement range for THC, NO/NO_2/NO_X, CO, CO_2, O_2, CH_4, SO_2 and NH_3 depending on the configuration. If required, the measurement ranges can be adapted to the measurement application (diluted/undiluted exhaust gas or gasoline/diesel/hydrogen/etc.). Due to the combination with different sampling systems, the AMA i60 is ideally suited for the development and certification of combustion engines in accordance with all worldwide valid emissions regulations (incl. EPA 40 CFR part 1065). Special versions and mobile remote or stand-alone units are available with optimized system designs for SULEV, SCR, hydrogen and other applications.

MOBILE EXHAUST MEASUREMENT SYSTEM

AVL AMA i60 REMOTE/ STAND ALONE UNIT

The AVL AMA i60 Remote and Stand Alone Units have been designed to serve as an extension to an existing AMA i60 analyzer bench (Remote Unit) or as a separate small analyzer bench (Stand Alone Unit). The Remote Unit is controlled by the AMA i60, the Stand Alone Unit by an iGEM AMA bench control software on a separate computer.

MEASUREMENT PRINCIPLE

Depending on the application, various analyzer types can be used with the AVL AMA i60 Remote/Stand Alone Unit. Integrated pumps draw in the measurement gas from the sample point. Heated lines and pre-filters or sample point selector units are used in the vicinity of the sample point. The analysis of the sample gas is performed using high-end gas analyzers – FID for THC and CH_4, CLD for NO/NO_X, IRD for CO, CO_2 and N_2O as well as an LDD laser diode analyzer for NH_3 measurements and a UVD analyzer for SO_2 measurements.

APPLICATION

The AVL AMA i60 Remote/Stand Alone exhaust measurement system is available in four variations:

- for THC (and CH_4) or NO and/or NO_X measurements
- for CO, CO_2 and N_2O measurements
- for NH_3 combined with NO/NO_X or N_2O measurements
- for SO_2 measurements
- for measurements of e.g. oxygenated components using an Innova analyzer

The system is ideally suited for the development and certification of combustion engines in accordance with emissions regulations worldwide as well as SCR exhaust aftertreatment systems in accordance with European heavy duty regulations.

The iGEM AMA bench control software allows for the intuitive operation of the AMA i60 Remote/ Stand Alone Unit. The AMA i60 Remote Unit is controlled by the AMA i60. As a Stand Alone Unit the system is equipped with its own PC and the iGEM AMA bench control software.

BENEFITS AT A GLANCE

- Compact mobile unit, which is easy to move around and to use at different sampling points
- Allows for short sample transfer lines resulting in fast response with high accuracy
- Optimized packages for applications like heated THC/NO_X measurements or EGR determination based on CO_2 or SCR ammonia measurements using a laser diode analyzer or SHED THC measurements
- Substantially reduced setup time and total cost of ownership thanks to the use of proven i60 technology, the well-known iGEM AMA user interface and diagnosis functions

The CVS valve matrix is integrated into the AMA i60 COMBI cabinet. The compact dilution unit is prepared for wall or ceiling mounting to perfectly fit the testbed conditions.

BENEFITS AT A GLANCE

- Integrates analyzer bench and bag sampling system into one 19" cabinet
- Very compact CVS venturi unit for flexible installation
- Fits easily onto the exhaust system of small combustion engines
- Optimized for SORE and motorcycle applications
- Sophisticated diagnosis functions with the support of interactive flow diagrams
- Complies with EPA 40 CFR part 1054 as well as other worldwide exhaust emission regulations

COMBINED EXHAUST MEASUREMENT AND DILUTION SYSTEM

AVL AMA i60 COMBI

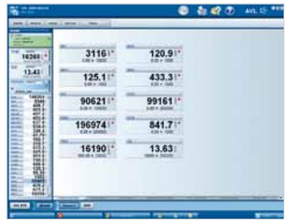
The AVL AMA i60 COMBI combines the proven AMA i60 exhaust measurement system with well-known components of the CVS i60 dilution system, resulting in a very compact and modular design. The system is best suited for certification/audit and R&D testing of Small Off-Road Engines, motorcycles and ATV's. The intuitive, interactive graphical user interface supports all essential service and diagnosis functions and issues warnings in case of pending maintenance intervals.

MEASUREMENT PRINCIPLE

The AVL AMA i60 COMBI comprises a gas analyzer bench for diluted modal and bag exhaust gas analysis combined with a constant volume flow dilution system (CVS). The concentration readings from the analyzer bench together with the volume flow measured with the sonic venturi of the CVS system are used to calculate the exhaust mass emissions in a very simple, reliable and accurate way. The analysis of the diluted sample gas is performed by means of NDIR, FID and CLD gas analyzers.

APPLICATION

The AVL AMA i60 COMBI contains analyzers with a wide dynamic measurement range for THC, CH_4, NO/NO_x, CO, CO_2 and N_2O, depending on the configuration. It is ideally suited for the certification of gasoline small off-road engines (SORE) with less than 19 KW, in accordance with EPA 40 CFR part 1054. Furthermore, a special configuration for the development and certification of motorcycles on chassis dynamometer testbeds is available. To comply with the EPA greenhouse gas regulations (GHG) the AMA i60 COMBI is designed to easily integrate the corresponding gas analyzer for CH_4 measurements.



The sophisticated control software iGEM SESAM is based on the iGEM software platform. The iGeneration have a common GUI providing the same look & feel and interface concept.

BENEFITS AT A GLANCE

- Every single FTIR comes with individual gas calibration certificate and verified accuracy
- Optimized analysis methods for different applications and fuels, based on decades of AVL's FTIR application experience
- Fast response times with accurate and synchronous measurement of NO, NO_2, N_2O, NH_3, CO, CO_2, CH_4 as well as alcohols, aldehydes and more within one device
- Low operating costs due to low maintenance system with no need for regular calibration
- Easy operation and flexible integration into the testbed automation system

MULTI-COMPONENT EXHAUST MEASUREMENT SYSTEM

AVL SESAM i60 FT

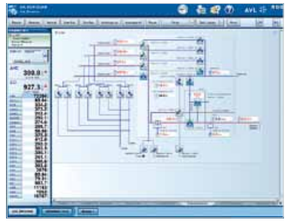
The AVL iGeneration product family now includes the multi-component exhaust measurement system SESAM i60 FT, which has lifted the SESAM product, the market leader in FTIR automotive exhaust measurements, to a new level by harnessing the software and hardware synergies of the iGeneration. New requirements for emission testing as well as the adoption of the FTIR in European and American legislations have driven the design of the SESAM i60 FT. It supports flexible configurations responsive to user needs for state-of-the-art emission equipment.

MEASUREMENT PRINCIPLE

The SESAM i60 FT is a modular system allowing for the integration of optional FID (THC) and PMD (O_2) analyzers and an IRD (CO_2) analyzer for EGR stream. Another configuration allows for second FTIR for simultaneous pre- and post-exhaust after treatment measurements. The SESAM i60 FT with optimized evaluation methods and individual factory calibration for each FTIR guarantees best quality measurement results. It complies with legislative requirements such as Euro VI and EPA 40 CFR part 1065 for measurements allowing FTIR.

APPLICATION

Today's exhaust gas aftertreatment systems for combustion engines are getting more and more complex, especially since the introduction of SCR catalysts and the increased use of alternative fuels. Understanding the detailed chemical reactions in engine exhaust and after treatment systems is critical to achieve the optimal and efficient development of new components, engines, control systems and powertrains. The SESAM i60 FT provides the accurate and fast measurement of the most important exhaust gas components within one system to ideally support AVL's customers in both R&D and certification.



The iGEM device control SW provides full control of the HSS down to valve and sensor level.

HEATED SAMPLING SYSTEMS

AVL HSS i60

The HSS product line consists of Pre-Filters, Heated Sample Selection Modules and a Heated Boost Pump for raw exhaust measurements.

MEASURING PRINCIPLE

Pre-Filters remove particulates from the exhaust gas and prevent from contamination of sample lines and emission measuring systems. Heated sampling systems offer the possibility to switch an AMA i60 or a SESAM i60 FT to different sample points or lines. Sample Points are e.g. single cylinders of an engine, while sample lines are e.g. different testbeds that share one emission measuring system. Sample Selection Modules come with 2 up to 4 inlets or up to 10 inlets and 1 outlet. In addition dual stream modules with up to 9 inlets can be chosen. Depending on the specific model further extensions like additional inlet filters and flame traps, calibration gas inlets, backflush functionality, turbo pressure regulators, pressure drop and flow sensors, etc. are available. The Heated Boost Pump is required to overcome the pressure drop in case of very long heated sample lines.

APPLICATION

Depending on the engine and fuel type as well as the sample point (e.g. pre-cat, post-cat, post-DPF) different filter materials such as ceramic, fiber glass, stainless steel or titanium can be used. Boost pumps are used in applications with very long distances (> 17m) from the sampling point to the emission measuring system. Typical applications are test cell sharing and large test cells as used in marine vessel engine testing. Furthermore, boost pumps are applied in altitude and altitude simulation testbeds.

BENEFITS AT A GLANCE

- Extendable with e.g. pressure drop sensor, pressure regulation, etc.
- Minimized delay time for transient measurements due to innovative valve manifold layout
- Optimized design to minimize wall effects (hang-up)
- Sample point and sample line switching (up to 10 inlets)
- Boost pump with controlled recirculation circuit – no bypass required
- Stand Alone Pre-Filter to be connected to 3rd party equipment

EXHAUST GAS DILUTION SYSTEM

AVL CVS i60

All functions for the standard operation of the CVS i60 are easy and intuitive to perform. Remote operation concept and interactive self diagnosis functions down to sensor and valve level allow for an increased productivity as well as reduce and simplify maintenance and service work.

The CVS i60 is the most compact full flow dilution system on the market. Four binary switchable venturis with a total flow rate of up to 30 m³ plus a heat exchanger and bag sampling system (without bags and blower) fit into one 19" cabinet. The CVS i60 includes a sophisticated pneumatic gas flow system with compact and modular bag manifolds, providing fast response times and the best reproducibility for gas analysis. The modular design with up to four venturis and 16 sample bags covers a wide range of applications for chassis dyno as well as engine testbeds. The technically verified angular flow inlet allows particulate measurement of all direct injected engines via one dilution tunnel according to European, American and Japanese emission legislation.

MEASUREMENT PRINCIPLE

The exhaust gas is diluted at a mixing point close to the tailpipe outlet. A blower of sufficient size sucks the diluted exhaust through the venturis, which can be combined to reach up to 15 different flow rates. During each phase of a driving cycle bags are filled proportionally to the main flow rate of the CVS. The integrated mass emissions can be calculated using the gas concentrations in the bags and the accumulated flow rate of the diluted exhaust.

APPLICATION

The CVS i60 is a full flow dilution system for the certification of all kinds of combustion engines, which fully complies with the latest emission legislation for light and heavy duty vehicles, such as Euro 5/6 or EPA 40 CFR part 1065/1066. The CVS i60 is available for flow rates from 1 to 30 m³ (light duty), 8 to 60 m³ (medium duty) or from 15 to 180 m³ (heavy duty). Special flow rates are available on request. The CVS i60 supports all current standard and alternative fuels including hybrid and hydrogen.

BENEFITS AT A GLANCE

- Best accuracy and reproducibility for ultra-low emissions sampling in compliance with the latest legislation (e.g. EPA 40 CFR part 1065/1066)
- Most compact CVS on the market, required test cell floor space is reduced by 50%
- iGEM CVS provides support e.g. for automated CFO checks or LFE calibration
- Minimized total cost of ownership through frequency-controlled blower and alternative operation without heat exchanger
- Particulate measurement of GDI and diesel vehicles via one dilution tunnel

All functions for the standard operation of the PSS i60 are easy and intuitive to perform. Intelligent self-diagnosis functions and fully automated MFC calibration simplifies and reduces maintenance and service work.

PARTICULATE SAMPLER

AVL PSS i60

The AVL PSS i60 particulate sampler fully complies with the technical requirements for gravimetric particle measurement. Its impressive, innovative design makes it suitable for a wide range of applications for passenger cars and utility vehicles. Thanks to appropriate software functionality the system provides intelligent diagnosis functions as well as interfaces to test cell automation systems. By integrating an AVL Particle Counter 489, the PSS i60 (SD) combines traditional gravimetric particulate measurement and particle counting in one 19" cabinet.

MEASUREMENT PRINCIPLE

The PSS i60 is a particulate sampling system for full flow CVS systems. Particulate sampling systems are used to collect particulates from the diluted exhaust gas on a filter during a test cycle. At the beginning and at the end of the test cycle the filter is weighed and the particle mass is calculated (gravimetric measurement).

APPLICATION

The PSS i60 SD is used for light duty and passenger car chassis dynos. In the European legislation particulate measurement is also mandatory for GDI engines and likely for all engines in the future. For heavy duty and off-road engine testbeds the double dilution version PSS i60 DD is used. Applications for engine performance and emission development, certification and conformity of production (COP) are fully covered with the PSS i60. The system is used on transient and stationary engine testbeds for R&D, certification and quality control as well as on chassis dynos for HD vehicles.

BENEFITS AT A GLANCE

- Compact design enables the installation of a heated FID, particle background measurement and an AVL Particle Counter APC 489 in one single 19" cabinet
- Fulfills the latest emission legislations up to Euro 6, Japan JASIC for light duty and EPA 40 CFR part 1065 for heavy duty applications
- Improved measurement accuracy and repeatability adequate for the extreme low PM emission due to optimized gas flow and new sensor technology
- iGEM PSS provides intuitive operation and high-grade diagnostics, intelligent interfaces with easy upgradability
- Fully automated MFC calibration with a Laminar Flow Element (LFE)

GRAVIMETRIC PARTICULATE MASS SAMPLING

AVL SMART SAMPLER

The AVL Smart Sampler is a partial flow dilution system used in gravimetric particulate matter sampling from internal combustion engines in accordance with ISO 16183, 40-CFR 1065 and all other relevant global regulations.

MEASUREMENT PRINCIPLE

A partial flow dilution system such as the AVL Smart Sampler mixes and dilutes a small sample of the exhaust flow with air under controlled conditions. This allows particulates to form in a repeatable manner simulating reactions in the atmosphere. The system samples the diluted exhaust over a filter medium where the particulates are captured and can be subsequently weighed. The flexible design also allows the AVL Smart Sampler to be used as a diluter for particle counting according to ECE regulation No. 49 and Global Technical Regulation No. 4. For particle counting, the system operates as it does for gravimetric measurement with a proportional sample of the diluted exhaust diverted to an optional particle counting device.

APPLICATION

The Smart Sampler can be used in place of a CVS for Euro 3 to Euro 6 certification, and, with the addition of the "add-on sampling" option, it also provides other testing devices like particle counters with diluted exhaust sample. The option of high pressure testing allows the Smart Sampler to be used at pressures as high as 600 millibar (gauge) and this also makes it a perfect tool for efficiency evaluations and the optimization of DPF systems. The Smart Sampler can also be used for analyzing the influence of different fuels on PM emissions. The same Smart Sampler is suitable for sampling everything from small portable engines to the largest engines and can easily be moved between test cells for maximum flexibility.

Above: Due to the small and modular design of the Smart Sampler it can be placed even in smallest test cells

Left: The Smart Sampler's software is intuitive and easy to use

BENEFITS AT A GLANCE

- Fulfills all relevant regulations.
- Fast warm up time: Smart Sampler is ready for operation in 15 minutes from a cold start.
- With the optional add-on sampling, the Smart Sampler acts as a diluter for particle counting applications.
- Modularity of components allows for simple structuring of options; future upgrades are simple and can be done at the customer's site.
- Rapid set up time for quick test cell changeovers.

ParticleScale graphical user interface

PARTICULATE FILTER WEIGHING

AVL FILTER WEIGHING CHAMBER AND PARTICLESCALE

The AVL Filter Weighing Chamber is substantially improved for PM filter conditioning and weighing meeting newest emission legislations. The AVL Filter Weighing Chamber is a cost efficient and space saving alternative to a separate conditioned clean room for filter weighing.

MEASURING PRINCIPLE

A vibration-decoupled weighing stone is situated in the weighing section, used for placing the optionally included precision scale. A vertical, low-turbulence flow with laminar air circulation is used to keep the working area clean. The front side of the working surface is covered by a height adjustable front window, which can be opened and closed electrically. In the conditioning mode the window is fully closed. With the EPA1065/1066 extension, the FWC is equipped with iris ports in the front window. These iris ports allow access to the working area whilst the window is closed. With that feature, the tight temperature and dew point tolerances for the conditioning environment can be secured also during the weighing process.

APPLICATION

The AVL ParticleScale software supports with managing particulate filters the weighing process. It automatically reads the results from the precision scale and stores result data linked to the corresponding test cycle for further mass emission calculations.

- Handling of primary & secondary filters, filter sets and filter stocks
- Clear representation of all particulate filters and their lifetime status
- Supervision of pre- and post-conditioning times of the particulate filters
- Environmental data monitoring with limit warning
- Buoyancy correction acc. to newest regulations (EPA 40 CFR part 1065, EURO VI)

BENEFITS AT A GLANCE

- Compact and space saving solution for clean room standard 5 according ISO 14644-1
- Cost efficient alternative to a clean room for conditioned particle filter handling and weighing, e.g. according to EPA 40 CFR part 1065/1066, ECE R83/R49
- Increased measurement accuracy by direct read of the buoyancy correction values in the micro scale
- Can be integrated into test field environments using AVL ParticleScale software
- Maintenance and calibration display with self-test functions

PARTICLE COUNTING

AVL PARTICLE COUNTER

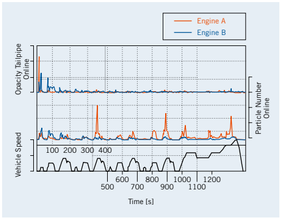
Particle emissions in modern IC engines are approaching a range in which they are only detectable with highly sensitive instruments. The current mass-based methods for the detection of emissions from modern Euro 5 engines are reaching their detection limits, especially in measurements behind a diesel particle filter (DPF). The AVL Particle Counter complies with the current UN-ECE-R83 legislation, which includes requirements for measuring the particle number per km. The system measures the number concentration of all non-volatile particles in the exhaust and allows for sampling from a CVS system, a partial flow dilution tunnel or directly from the raw exhaust.

MEASUREMENT PRINCIPLE

The counting of particles with a condensation particle counter according to PMP requires a complex conditioning system (volatile particle remover, VPR) consisting of two dilution stages, which provide a high and stable dilution and an evaporation tube to remove all the volatile particles. The first dilution stage is the core of such a system and therefore AVL has developed a chopper diluter to ensure a very high, size independent dilution, which also makes it possible to use the system to sample from raw exhaust gas during R&D. Particle losses are minimized by mounting this diluter immediately at the sample position. Due to the special design of the VPR, it is also easy to clean and the purging of the system is done automatically during start-up.

APPLICATION

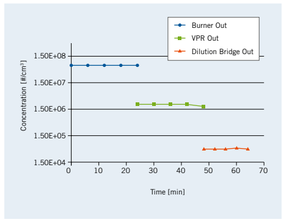
- Certification according to UN-ECE-R83 and UN-ECE-R49 procedure
- Applications in research and development
- Applicable on engine and chassis dynos
- Sampling from CVS systems, partial flow dilution tunnels or directly from raw exhaust
- Suitable for diesel and gasoline engines



The figure shows the results of an NEDC test with two different vehicles. The number of particles of vehicle A has significant peaks in comparison to vehicle B. Despite being the lowest concentrations, the emission differences can be measured with the AVL Particle Counter.

BENEFITS AT A GLANCE

- Fulfills all PMP requirements (UN-ECE-Regulation 83 & 49) without any time consuming adjustments
- Long-term stability and high reproducibility shown in official and customer test campaigns
- Robust and precise dilution system without particle size dependency
- Accurate measurement due to the immediate dilution at the sampling position
- Less service and maintenance effort
- Small dimensions and optimized system configuration for easy transportation and fast installation into the testbed
- Automated startup features make the system ready for measurement within the shortest possible time



The following figure shows the aerosol stability of the 3 available sample outlets.

BENEFITS AT A GLANCE

- Generation of highly stable and repeatable combustion aerosol
- Wide range of applications due to integrated dilution stages providing scalable concentrations
- Calibrated operating points for straightforward on-site quality checks of particle measurement devices
- Utilization as stand-alone device
- Integrated touch-screen for simplified operation
- Low Total Cost of Ownership

PARTICLE GENERATION

AVL PARTICLE GENERATOR

Particle number measurement is the new requirement for certification measurements according to Euro 5/6 and EURO VI. In addition to the legal requirements of an annual device calibration, on-site quality checks of critical components such as the dilution system and the particle number counter are highly recommended. Apart from particle number checks there is also a demand for on-site verification of other particle measurement devices. Those requirements necessitate a particle generator with:

- adjustable dilution over a wide dilution range,
- highly stable and repeatable particle generation.

FUNCTIONAL PRINCIPLE

The AVL Particle Generator is a stand-alone device for generating a highly stable and repeatable combustion aerosol. Aerosol particles are first formed during combustion of propane and then pre-treated and diluted in an integrated Volatile Particle Remover system. The pre-treatment process stabilizes particle size and number concentration while ensuring reduction of volatile and semi-volatile particles. A further dilution stage with a dilution bridge can decrease the concentration to very low levels. The three dilution stages allow a wide range of applications that require different concentrations and size distributions. An integrated touch-screen display and four pre-calibrated operating points ensure straightforward and fast operation. The calibrated operating points and the defined dilution ranges are based on many years of AVL expertise in the field of particulate measurements.

APPLICATIONS

- On-site quality checks of particle counting devices
  - Particle Concentration Reduction Factor check
  - Particle Number Counter linearity check
  - Particle Number Counter cut-off check
- Relative comparison between two particle measurement devices

TRANSIENT SOOT MEASUREMENT

AVL MICRO SOOT SENSOR

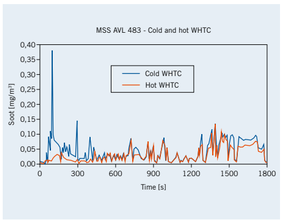
The continuous lowering of emission limits requires increased development efforts and maximum precision during exhaust aftertreatment and combustion system development. In engine development, soot emission has always been measured as the first parameter because it is an important indicator of combustion quality and is generally a main contributor to particulate emissions. Soot is also the main parameter when evaluating the efficiency of DPF systems.

MEASUREMENT PRINCIPLE

The AVL Micro Soot Sensor is based on the photo-acoustic principle. In this method, an absorbing substance – in our case the black carbon particles – are irradiated with modulated light. The periodic warming and cooling and the resulting expansion and contraction of the carrier gas produce a sound wave which is detected with a microphone. With soot-loaded air or exhaust gas, the signal increases proportionally to the concentration of soot in the measured volume.

APPLICATION

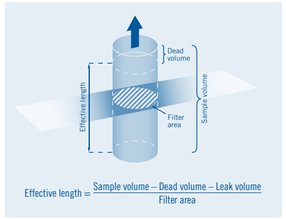
Due to its high sensitivity and wide measurement range, the Micro Soot Sensor can be used for measuring at the point where exhaust leaves the engine and also at the end of the tailpipe. With the optionally available conditioning unit, which provides dilution and pressure reduction, the instrument can also withstand the high pressures and temperatures upstream of a DPF, making it a perfect tool for the evaluation and development of DPF systems. The Micro Soot Sensor is likely to be used also as a soot monitor in dilution tunnels. The instrument can be used as a stand-alone device, and thanks to its various interfaces (including RS232 with AK protocol, digital/analog interface, TCP-IP), it can also be easily integrated into testbed automation systems.



The figure shows the MSS soot signals of two WHTC tests. One was done with warm and the other with cold engine conditions. Especially at the beginning of the test big differences in the soot concentrations can be observed.

BENEFITS AT A GLANCE

- Transient measurement of the soot concentration [mg/m³]
- Measures soot – no cross sensitivity to other components
- High sensitivity (resolution 1 µg/m³, detection limit typically ~5 µg/m³)
- Wide measurement range of 5 µg/m³ to 1000 mg/m³ (with conditioning unit)
- Exhaust back pressures up to 2000 mbar, temperatures up to 1000°C (with conditioning unit)
- Can be used on chassis dyno, engine test cell and for on-board measurements



The measuring principle of the Smoke Meter makes it highly versatile. The variable sampling volume allows measurements on any generation of large engine or car engine, independent of the soot content in the exhaust.

SMOKE MEASUREMENT WITH FILTER PAPER METHOD

AVL SMOKE METER

The AVL Smoke Meter is a filter-type smoke meter for measuring the soot content in the exhaust of diesel and GDI (gasoline direct injection) engines. It has become an industry standard for developing modern engines. The result of the measurement is displayed as a filter smoke number (FSN) conforming to the standard ISO 10054 or as soot concentration (mg/m³).

MEASUREMENT PRINCIPLE

A defined flow rate is sampled from the engine's exhaust pipe through a clean filter paper in the instrument. The filtered soot causes blackening on the filter paper which is detected by a photoelectric measuring head and evaluated in the microprocessor to calculate the result in FSN or mg/m³. The extremely high reproducibility of the AVL Smoke Meter is guaranteed by its variable sampling volume method and thermal heating. The sampling volume can be set automatically depending on the exhaust soot concentration. This makes it possible to measure even the low soot levels of modern CI engines.

APPLICATION

Due to the easy installation and variable sampling volume, the AVL Smoke Meter can be used on engine testbeds as well as on chassis dynamometers. The smoke measurement comprises the whole range from modern diesel engines with aftertreatment systems to GDI engines. The many possible applications make it a perfect all-round system. The standardized measurement values can be compared all over the world, offering an additional benefit to globally operating companies. Thanks to the high repeatability achievable in the measurement values, the system can also be used for testing at the end of the production line. Making possible the detection from very small tolerance deviations.

BENEFITS AT A GLANCE

- High measurement resolution (0.001 FSN or 10 µg/m³) and low detection limit (0.002 FSN or 20 µg/m³)
- Timely paper change due to remaining filter paper indicator
- Altitude measurements up to 5000 m above sea level and altitude simulation up to 5000 m
- High reproducibility, improved cleaning efficiency and increased robustness against wet exhaust gas due to shop air purging of the gas path – optional
- Extended application range up to 3 bars exhaust back pressure for engines with exhaust aftertreatment systems – optional
- Remote-control service with intuitive user interface – optional

OPACITY TESTING

AVL OPACIMETER

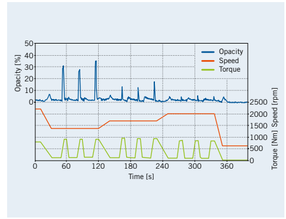
Recent emissions legislation is increasing requirements for transient test procedures. In order to pass tough future emissions limits, it is also necessary to monitor an engine's particulate emissions during transient operation even in the early stages of the engine R&D process. The development of modern diesel and gasoline engines requires a dynamic measurement instrument with high resolution.

MEASUREMENT PRINCIPLE

The AVL Opacimeter measures the opacity of contaminated air, in particular of diesel exhaust emissions. A measuring chamber with a defined measuring length and non-reflecting surface is filled homogeneously with exhaust gas. The loss of light intensity between a light source and a receiver is measured, and the opacity of the exhaust gas is calculated based on this. The very fast response time of 0.1 sec, the easy-to-use data evaluation and the ability to use the device upstream and downstream of a DPF (diesel particulate filter) make the AVL Opacimeter a perfect tool for development tasks where extremely fast measurement is the key.

APPLICATION

The AVL Opacimeter can be used on engine testbeds and on chassis dynamometers. The device is already preconfigured to automatically run the legally required tests ECE-R 24 – EEC 72/306, HD Euro III, Euro IV and Euro V ELR test, ISO 8178, and SAE J 1667. As a partial-flow system for the online measurement of the exhaust gas opacity of diesel engines, the AVL Opacimeter is a unique system that satisfies not only legal standards but is also a perfect tool for meeting the demands of engine development and production.



Example: opacity as a percentage during a prescribed test cycle (ELR – European Load Response test).

BENEFITS AT A GLANCE

- High measurement dynamics for transient test runs
- Pre-programmed test cycles, such as Euro ELR or ECE-R24
- High measurement value resolution and signal stability thanks to the conditioning of all essential parts (N = 0.1%, k = 0.0025 m^{-1})
- Also suitable for exhaust gas back pressure of up to +3000 mbar relative pressure (with high pressure option)
- Low maintenance costs due to the robust design

PRODUCT AVAILABLE VIA
AVL ePRODUCTS
https://shop.avl.com

The new PC software makes it easy to display and save time-resolved measurement values on a standard notebook during a test drive.

BENEFITS AT A GLANCE

- Mobile online opacity measurement with high measurement dynamic
- Option of two user-defined output channels
- Short installation time (plug and play system)
- Built-in calibration (linearity check)
- Easy handling thanks to small dimensions and light weight
- Low power demand (OTR can draw its power from a cigarette lighter)
- Easy control and data display via standard notebook PC
- Powerful software for easy data post-processing

IN-VEHICLE OPACITY TESTING

AVL ON-THE-ROAD OPACIMETER

Satisfying the stringent exhaust emissions limits requires sophisticated aftertreatment systems and combustion technologies, which increases the number of parameters to be optimized during development. Vehicle optimization during real-world driving on the road is one important approach for achieving short development times and keeping vehicle quality at a high level. One important criteria for the vehicle quality perceived by the customer is the visible smoke produced during cold start and during acceleration.

MEASUREMENT PRINCIPLE

The AVL OTR is a pressure-filled partial-flow opacimeter with a special sampling probe for the mobile and online emission measurement of smoke density. The sensor unit (chamber for opacity measurement) is pressure-filled with exhaust gas. This sensor unit is mounted with a special box close to the open tail pipe. A control cable connects the sensor unit with the 24 to 12 VDC voltage converter and the PC's serial COM interface. The new PC program makes it easy to control the instrument during the tests. Perfect online monitoring with the display of graphs and data post-processing after a test run using the saved data file are now provided by the AVL Instruments PC software.

APPLICATION

Easy handling, short installation times for the complete system on the vehicle and low power consumption make the OTR Opacimeter the perfect tool for mobile opacity recording during real-world driving tests.

PORTABLE MEASUREMENT SYSTEM FOR PARTICULATE EMISSIONS

AVL M.O.V.E PM PEMS

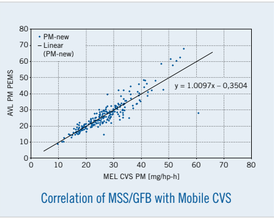
The addition of particulate matter (PM) limits to the U.S. EPA Heavy Duty In-Use (HDIUT) rules calls for portable PM measurement devices to be installed on board a vehicle. The implementation of such a limit in the European in-service conformity legislation is planned within the coming years. Soot and PM measurements are also important during development: soot is an indicator of the combustion system quality and the efficiency of a filter system (DPF). PM is limited by legislation and needs to be checked already during development. Measurements on board a vehicle require compact, easy to install and robust devices which correlate to test cell equipment.

MEASUREMENT PRINCIPLE

The PM PEMS is a combination of two measurement principles and consists of two units: the photo-acoustic measuring unit for the continuous measurement of soot concentrations and a gravimetric filter module which conditions the exhaust gas and measures PM using the gravimetric filter method. At the end of the test the loaded PM filter is weighed with a microbalance. By using the transient soot signal and the filter weight as inputs a time resolved PM signal is calculated as required by the in-use legislation. The calculations are available in AVL Concerto PEMS.

APPLICATION

The AVL PM PEMS is fully integrated into the AVL M.O.V.E in-vehicle testing platform. AVL System Control is the central device that integrates the exhaust flow meter, the PM PEMS, the AVL GAS PEMS as well as additional signals which are required for mass emission calculations. The PM PEMS can also be easily integrated into existing portable systems. In this case the device can be operated independently as it does not need any external input signals. Control, data storage and operation are performed via a notebook PC. The data integration is done with AVL Concerto PEMS.



Correlation of MSS/GFB with Mobile CVS

Correlation of PM PEMS with CVS

BENEFITS AT A GLANCE

- U.S. EPA approved system for HDIUT testing
- Easy integration into existing systems
- Clear, precise and mass related soot and integral PM measurement
- Full set of diagnosis features to ensure reliable results
- Compact dimensions and light weight
- Short installation time and low maintenance effort
- Robustness proven in many test campaigns

AVL M.O.V.E GAS PEMS and AVL Concerto PEMS Result Screen.

BENEFITS AT A GLANCE

- Internal climate concept for accurate measurements in a wide ambient temperature range and under changing ambient conditions
- Robust against vibration through internal dampers and external damping options
- High measurement accuracy even in the low measurement range
- Low span and zero drift for long measurement intervals
- Special “Hybernate” mode to reduce warm-up time

PORTABLE MEASURING SYSTEM FOR GASEOUS EMISSIONS

AVL M.O.V.E GAS PEMS

Measurements with portable emission measurement systems (PEMS) on the road are an efficient way to keep the development effort at a reasonable level even if the requirements regarding fuel economy, emissions and customer expectations are increasing. PEMS systems are also needed for in-use compliance testing where heavy duty vehicle manufacturers have to report compliance with emission standards. Such measurements require robust and compact devices which are able to withstand the rough testing conditions and which provide reliable and accurate measurements over long test durations and under changing ambient conditions.

MEASUREMENT PRINCIPLE

The AVL GAS PEMS is a compact and robust PEMS system for measuring the THC, NO/NO_2 and CO/CO_2 concentrations in the exhaust gas of diesel and gasoline vehicles and engines. High measurement accuracy is achieved through the use of proven test cell analyzers which are optimized for the mobile application. All analyzers are temperature conditioned to ensure reliable measurements even at changing ambient conditions. The GAS PEMS is controlled via AVL M.O.V.E System Control which stores the data, calculates the online emissions and provides interfaces to access e.g. ECU/ CAN bus data and additional sensors.

APPLICATION

The low drift of the analyzers makes the AVL GAS PEMS a perfect tool for legal in-use compliance tests with long test durations of eight hours or more. An internal climate concept allows measurements in a wide ambient temperature range from -30°C to 45°C which is needed e.g. during cold tests. Internal dampers and external damping options ensure reliable operation even when installed on non-road machinery.

EMISSION CALIBRATION DEVICES

AVL iCAL

The accuracy of exhaust measurement systems is highly dependent on the quality and precision of the calibration devices used. Accordingly, AVL has spared no expense to develop the most accurate devices on the market. In order to allow for the highest quality standard and to minimize operating errors, our calibration devices are also available in fully automated design. This substantially reduces the time required by the operator.

MEASUREMENT PRINCIPLE AND APPLICATION

The AVL gas divider iCAL GDU is a highly precise device for the calibration of gas analyzers. The underlying physical principle is based on the combination of calibrated, critical nozzles allowing for dilution of the test gases in an accurate manner. The pressures of the calibration and dilution gases are controlled by means of a highly precise pressure controller with extraordinary long-term stability.

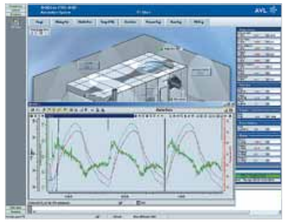
The AVL NO_X converter tester iCAL NGU is used to check the efficiency of the NO_X converter in CLD analyzers. The technology is based on the gas phase titration between NO and O_3 and provides known concentrations of nitrogen dioxide (NO_2). The ozone (O_3) is generated by means of corona discharge in an atmosphere consisting of pure oxygen (O_2).

The iCAL CFO (critical flow orifice) propane injection tester is used to inject a precise quantity (e.g. of propane) into the CVS dilution system or into a SHED chamber. The injected quantity is compared to the mass measurement of the CVS dilution system or the SHED chamber. For improved accuracy, the iCAL CFO is temperature-stabilized at 50°C. Most regulations require the regular implementation of this CFO test.

The iCal calibration devices allow manual or fully automatic verifications of analyzers (linearity, NO_X converter check) and system leak checks (CFO test). These devices can be connected to the exhaust measurement system by plug and play, and are visualized in the iGEM software.

BENEFITS AT A GLANCE

- High level of precision (< 0.4% of the selected step)
- Pressure-independent flow stability
- Plug and play integration
- Simple use and operation
- Extraordinary long-term stability
- Remote diagnosis down to valve and sensor level
- Factory-calibrated and individually certified, NIST traceable
- Backward compatible with AVL systems of former generations
- Integrated or external versions of the different devices available



A user-specific GUI provides operating elements of the testbed system for simple and intuitive use. A configurable online data recorder allows detailed analyses. Real-time information and error handling complete the user interface.

EVAPORATIVE EMISSIONS DETERMINATION SYSTEM

AVL VT/VV-SHED

AVL VT/VV-SHED systems constitute a state-of-the-art test system with specifically adjusted optimization with regard to the individual analysis tasks. The focus has been placed specifically on material selection, automation and gas analytics. Long-term experience in the field of analytics and in-house analyzer development as well as automation expertise form the basis for this homogeneously adjusted complete system. Integrated interfaces to fuel and canister conditioning devices make this a complete solution for the entire area of application.

MEASUREMENT PRINCIPLE

A one-bag system is used for volume compensation, which can be configured as an active or passive regulating module. A dynamic PID controller guarantees ideal temperature control within the chamber.

The SHED AMA i60 is available as an analysis unit equipped in different configurations for the specific measurement tasks (e.g. ethanol, methanol, aldehydes, etc.). Fully integrated interfaces to the required calibration devices (such as gas dividers, CFO propane injection testers and sensor calibration references) are standard.

APPLICATION

AVL SHED systems cover a wide range of applications for R&D tests or for certification purposes:

- Passive/mini SHED (especially for component testing)
- Midi SHED (for tank systems, motorcycles, SORE products)
- Full-size/maxi SHED (for passenger cars and SUVs)
- Magnum SHED (vans, trucks)
- Running loss SHED (special system with integrated chassis)

BENEFITS AT A GLANCE

- Uniform and analytically optimized testbed system
- Compliant with legislation (EPA, CARB, ECE, etc.)
- Improved flexibility, quality and reproducibility of the test results accelerate development processes
- Improved user interface for extremely simple operation and service-friendliness
- MSR stand-alone system topology for independent online test automation, even without a PC
- “Optimized total cost ownership” system concept supported by AVL Global Customer Service, eSpares and remote interface

CANISTER CONDITIONING UNIT

AVL CANLOAD

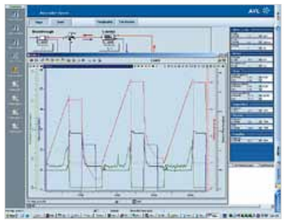
Current trends and future demands concerning alternative fuels and various drive concepts require adequate and flexible test systems. AVL CANLOAD systems constitute a state-of-the-art test system by providing specific test solutions for a wide range and supporting standard certification, individual R&D and durability testing.

MEASUREMENT PRINCIPLE

The AVL CANLOAD pneumatic unit is designed for all standard applications based on butane / nitrogen or fuel vapor handling. It provides all required functions including individual valve matrix control, canister interface and mass-flow regulation. The elimination of volumes between valves and canister combined with intelligent software functions, e.g. delay time evaluation and time based purge routines, etc., increases accuracy and repeatability. Specially designed mass-flow controllers are providing free adjustable mass flow rates.

APPLICATION

AVL CANLOAD is part of the AVL Evaporative Emission System, which has been specifically designed and developed to perform automotive evaporative emission tests. It also covers in particular the future requirements based on new driving concepts as well as new fuel mixtures. A special material selection and an adequate system design will guarantee reliable test data. This includes standard audit and certification test cycles as well as specific customized R&D processes and durability testing. Operating together with the AVL VT/VV-SHED systems, it stands for a complete facility allowing the whole evaporative test procedure to be carried out, from canister conditioning and refueling to final emission data evaluation.



Canload Device automation: Improved graphical Look & Feel operation interface for manual operation, specific diagnostics and services.

BENEFITS AT A GLANCE

- Uniform and flexible system design for synthetic gas & fuel vapor testing
- Flexibility, quality & reproducibility to accelerate Canister R&D processes
- User friendly and simple operator interface, intelligent service functions
- Self-sufficient test automation for reliable, productive operation

	AVL SMART SAMPLER	AVL MICRO SOOT SENSOR
Measurement principle	Gravimetric measurement	Photo-acoustic measurement
Measurement value output	g/Kwh, g/bhp-hr, g/test	Concentration of soot (mg/m³)
Main applications	Certification (HD) and R&D (HD and LD)	Engine (diesel, GDI) and exhaust aftertreatment development
Measurement range	Detection as low as 0.0 g/kW-hr	0–50 mg/m³ (up to 1000 mg/m³ with conditioning unit)
Detection limit	–	~5 µg/m³
Display resolution	Depending on the value	0.001 mg/m³
Rise time	(t50) 125 ms with 2m interconnect	≤ 1 sec
Maximum exhaust pressure	600 millibar with high pressure option	Up to 2000 mbar (with conditioning unit)
Maximum exhaust temperature	800 degrees with high pressure option	Up to 1000°C (with conditioning unit)
Inputs/outputs	(RS232 or Ethernet) digital input for start/stop 0-10V analog inputs for fuel and air	TCP-IP; RS232; digital I/O; analog I/O
Consumption (power/shop air)	5000 VA/670 lpm @ ~5 bar	1000 VA (including conditioning unit) / ≤ 4 lpm @ 1 bar
Weight	260kg	~15 kg (measuring unit) ~20 kg (conditioning unit)
Dimensions (W x H x D)	790 x 1900 x 660 mm (main + filter cabinet + trolley)	482 x 178 x 530 mm (measuring unit) 482 x 222 x 530 mm (conditioning unit)
Data rate	–	up to 5/s digital, 100/s analog
Sample flow	0.5 to 2.0 g/s (1.5g/s typical)	≤ 4 lpm
Ambient operating temperature	5 to 55°C	5 to 43°C
Repeatability	typically < 5%	~5 to 10% (depending on dilution ratio)

	AVL PARTICLE COUNTER	AVL SMOKE METER
Measurement principle	Primary diluter, evaporation tube, porous tube diluter (VPR)/ condensation particle counter	Measurement of filter paper blackening
Measurement value output	Particle number concentration of non-volatile particles (#/cm³)	FSN (filter smoke number) or mg/m³ (soot concentration)
Main applications	Certification according to UN-ECE-R49, UN-ECE-R83, R&D	Diesel engine (HD or LD) and GDI development
Measurement range	0–10,000 #/cm³ (calibrated), up to 50,000 #/cm³ in single count mode	0 … 10 FSN
Detection limit	≤ 0.1 P/cm³	0.002 FSN or ~0.02 mg/m³
Display resolution	0.1 P/cm³	0.001 FSN or 0.01 mg/m³
Rise time	< 5 sec	–
Maximum exhaust pressure	-200 mbar ... +200 mbar, (Max. 2000 mbar with high pressure option)	(-300*) -100 to 400 mbars (-500*) -200 to 750 mbars with the special sampling option 0 to 3000mbars with the high-pressure option (*) option with activated altitude simulation
Maximum exhaust temperature	200°C, (up to max. 400 °C with Tailpipe Sampling Kit Option, up to max. 1000 °C with High Pressure Option)	600 °C with standard 340 mm sample probe (800 °C with 780 mm long sample probe)
Inputs/outputs	TCP-IP, RS232, AK protocol, digital I/O, analog I/O	2 serial RS232 interfaces with AK protocol Digital via Instrument Controller 42101 Ethernet interface with InPort option installed with AK protocol
Consumption (power/shop air)	600 VA/30 lpm @ 2 + -0.1 bar	≤ 700 VA/ no shop air required
Weight	~25 kg	< 40 kg
Dimensions (W x H x D)	482 x 445 x 650 mm	560 x 620 x 300 mm
Data rate	5/s	–
Sample flow	5 lpm	~10 lpm
Ambient operating temperature	5°C to 25°C (up to 45°C with optional conditioning)	5 to 55°C
Repeatability	~5%	~3% of measuring value

	AVL PARTICLE GENERATOR
Output:	Combustion Soot Particles
Particle size range:	10-100 nm
Concentration range:	Up to 1x10^7 Particle/cm^3
Dilution Ranges:	• Dilution Rate Stage 1: up to 20 (adjustable) • Dilution Rate Stage 2: 4 (fixed) • Dilution Rate Stage 3: 4 and higher (adjustable)
Sample Outlets:	• Burner out (undiluted) • VPR out (after Stage 2) • Dilution Bridge out (after Stage 3)
Temperatures:	up to 400 °C (1st dilution and evaporation tube)
Exhaust gas flow:	Up to 15 l/min (thermally pretreated)
Fuel gas:	Propane (99.9%)
Dilution air:	Filtered compressed air (up to 40 l/min depending on the dilution, 1 bar gage pressure)
Quench gas and mixing gas:	Nitrogen (99.9%)
Flow control:	High precision mass flow controllers
Power supply:	90…240 V AC, 50/60Hz, 1000 W
Dimensions (WxHxD):	482 (19") x 222 (8.75"), 610 (24") mm
Weight:	< 30 Kg
Touch-screen:	5.7" 640x480

	AVL OPACIMETER	AVL ON-THE-ROAD OPACIMETER
Measurement principle	Pump-filled sampling opacimeter	Pressure-filled sampling opacimeter
Measurement value output	Opacity N (%) or absorption coefficient k (m^{-1})	Opacity N (%) or absorption coefficient k (m^{-1})
Main applications	Certification and R&D	Onboard opacity measurement during R&D and vehicle optimization
Measurement range	N = 0 … 100% or k = 0 ... 27.9 m^{-1}	N = 0 … 100% or k = 0 … 99.99 m^{-1}
Detection limit	N: 0.1%, k: 0.0025 m^{-1}	N: 0.5%, k: 0.02 m^{-1}
Display resolution	N: 0.01%, k: 0.0001 m^{-1}	N: 0.1%, k: 0.01 m^{-1}
Rise time	0.1 s	Depending on the back pressure of exhaust gas (~1 s)
Maximum exhaust pressure	-100 mbar … +400 mbar (including pulsation peaks), 0 mbar … +3000 mbar with high pressure option (including pulsation peaks)	End of line – ambient level
Maximum exhaust temperature	0 … 600°C (800°C with high pressure option)	500°C at sample point (sample probe: 2 m)
Inputs/outputs	RS232; digital I/O; analog I/O	PC – USB – analog converter: analog output 0 … 5 V (12-bit resolution @ 50 Hz data rate)
Consumption (power/shop air)	1000 VA/100 lpm max. @ 4 ... 10 bar	60 VA/ no shop air required
Weight	~47 kg	~18 kg (incl. car mounted box)
Dimensions (W x H x D)	650 x 420 x 450 mm	500 x 310 x 400 mm (car mounted box)
Data rate	Up to 5/s digital, 50/s analog	50/s (analog)
Sample flow	40 to 50 lpm	Up to 40 lpm depending on exhaust pressure
Ambient operating temperature	5 to 50°C	5 to 45°C
Repeatability	≤ 3%	~5%

	AVL M.O.V.E PM PEMS	AVL M.O.V.E GAS PEMS (available Q4 2011)
Measurement principle	Photo-acoustic and gravimetric measurement	NDUV (NO/NO_2), HFID (THC), NDIR (CO, CO_2)
Measurement value output	mg/m^3 (soot concentration), g/kWh, g/hp-hr, g/test (with additional equipment)	ppm, vol% (g/km, g/kwh, g/hp-hr… with additional equipment)
Main applications	In-use testing according to U.S. EPA 1065 rules, R&D	In-use testing according to U.S. EPA 1065 and EU PEMS rules, R&D
Measurement range	0–600 mg/m^3 (soot concentration)	THC: 0 - 30,000 ppmC1; NO: 0-5,000 ppm; NO_2: 0-2,500 ppm; CO: 0-5 vol%, CO_2: 0-20 vol%
Zero drift	–	THC: < 1.5 ppmC; NO/NO_2: 2 ppm/8h; CO: 20 ppm/8h; CO_2: 0.1 vol%/8h
Detection limit	~0.005 mg/m^3 (soot concentration)	
Display resolution	0.001 mg/m^3 (soot concentration)	
Rise time	≤ 1s	
Maximum exhaust pressure	up to 2000 mbar (with pressure reduction unit)	+-50 mbar (end of tail pipe)
Inputs/outputs	1 x TCP-IP, 1 x RS232, 2 x analog inputs, 4 x analog outputs, 1 x digital input/output	1 x TCP/IP, 1 x CAN (CAN bus monitoring), 8 x analog outputs, 4 x analog inputs, 5 x digital inputs, 4 x digital outputs
Consumption (power/shop air)	24V or 110/230V (depending on the version), < 400VA (@ 20°C ambient temperature and after warm-up) no shop air required	24VDC, < 450VA (@ 20°C ambient temperature and after warm-up, with 2m heated line) no shop air required
Weight	~45 kg	~50 kg
Dimensions (W x H x D)	482 x 422 x 530	482 x 356 x 540
Data rate	up to 5 Hz for defined values	up to 5 Hz for defined values
Sample flow	≤ 7 lpm	≤ 3.5 lpm
Ambient operating temperature	5-43°C	-30-45°C

	AVL AMA i60 R1C **Single stream cabinet**	AVL AMA i60 **Single/dual stream cabinet***
Dimensions		
• Basic unit (W x H x D)	660 x 1550 x 900 mm	660 x 1970 x 900 mm
Weight		
• Basic unit	150 kg	250–450 kg (depending on configuration)
Operation		
• Basic unit	External desktop/notebook	Optionally integrated PC with touch screen/key-board and touchpad or external desktop/notebook
Voltage supply		
• Basic unit	3~400 VAC (3/N/PE) ± 10%, 50/60 Hz ± 2%, max. 11 kVA 2x 100-120 VAC (N/PE) ± 10%, 50/60 Hz ± 2%, max. 6.0-7.2 kVA	
Maximum configuration		
• Basic unit	1 stream + EGR / Tracer	2 streams + EGR / Tracer
Ambient conditions		
• Temperature	5–40°C (41–104 °F)	
• Relative humidity	Max. 80%, non-condensing	
• Ambient pressure	800–1050 hPa (11.6–15.23 psi)	
Sample and test gases		
• Sample flow rate	10 l/min (per stream)	
• Condensate disposal	Peristaltic pump	
• Supply and test gas inlet pressure	1000–3000 hPa (14.5–43.51 psi) rel.	
• Zero gas	Nitrogen/Synthetic air	
• FID fuel	40%/60% H_2/He	
• FID burner air	Synthetic air	
• Control air (HFID)	Compressed air	
• CLD ozone generator	100% oxygen (O_2)	
• CLD NO_x converter efficiency	≥ 95%	

*Also available as double cabinet version for three or four sample streams plus EGR / Tracer

	AVL AMA i60 **Remote/Stand Alone Unit**	AVL AMA i60 **COMBI**
Dimensions		
• Basic unit (W x H x D)	approx. 535 x 1040 x 700 mm	660 x 1970 x 900 mm
• Dilution unit (W x H x D)		approx. 1200 x 720 x 430 mm
Weight		
• Basic unit	approx. 150 kg (depending on configuration)	250–450 kg (depending on configuration)
• Dilution unit		approx. 100 kg
Operation		
• Basic unit	External desktop/notebook	Optionally integrated PC with touch screen/ keyboard and touchpad or external desktop/notebook
• Dilution unit		Remote controlled by CAN bus
Voltage supply		
• Basic unit	230 VAC ± 10%, 50/60 Hz, max. 3.6 kVA 100 - 120 VAC ± 10%, 50/60 Hz, max. 3 - 3.6 kVA	3~400 VAC (3/N/PE) ± 10%, 50/60 Hz ± 2%, max. 11 kVA 2x100–120VAC(N/PE)±10%,50/60Hz±2%,max.7.2kVA
Maximum configuration		
• Basic unit		1 stream + optional CO raw stream
• Dilution unit		Single or Dual Venturi
Ambient conditions		
• Temperature	5–40°C (41–104 °F)	5–40°C (41–104 °F)
• Relative humidity	10–90%, non-condensing	Max. 80%, non-condensing
• Ambient pressure	800–1050 hPa (11.6–15.23 psi)	800–1050 hPa (11.6–15.23 psi)
Sample and test gases		
• Sample flow rate	FID: approx. 3.6 l/min CLD: approx. 1.6 l/min IRD: approx. 10 l/min (per stream) LDD: approx. 10 l/min	10 l/min
• Sample flow rate (CO raw stream)		6 l/min
• Condensate disposal (CO raw stream or extraction to the top)	Peristaltic pump (for IRD)	Peristaltic pump
• Supply and test gas inlet pressure	1000–3000 hPa (14.5–43.51 psi) rel.	1000–3000 hPa (14.5–43.51 psi) rel.
• Zero gas	Nitrogen (Synthetic air for FID)	Nitrogen/Synthetic air
• FID fuel	40%/60% H_2/He (for FID)	40%/60% H_2/He
• FID burner air	Synthetic air (for FID)	Synthetic air
• Control air (HFID / CVS)	Compressed air	Compressed air
• CLD ozone generator	100% oxygen (O_2) (for CLD)	100% oxygen (O_2)

	AVL CVS i60 20 // 30 Sm³ **Light Duty**	AVL CVS i60 MD 60 Sm³ **Medium Duty**
Dimensions (W x H x D)		
• Control and bag cabinet	660 x 1970 x 900 mm	
• Dilution tunnel	Ø 273 x 2730 mm	Ø 350 x 3500 mm
Weight		
• Control and bag cabinet	250 kg	170 kg
Operation		
• Control and bag cabinet	Integrated PC with touch screen/keyboard/touchpad or external desktop/notebook	
Voltage supply	400 VAC ± 10% 50/60 Hz, 3P/N/PE	120/230 VAC ± 10% 50/60 Hz, 1P/N/PE
Ambient conditions		
• Temperature	5–40°C	
• Relative humidity	5–80%, non-condensing	
• Ambient pressure	950–1050 hPa	
General supply		
• Compressed air	4–6 bar; purified, free of oil and water; 10 l/h	
• Water inlet pressure	3–6 bar; difference pressure > 3 bar	
• Water inlet temperature	10–20°C	
• Water consumption	0–20 l/min // 0–30 l/min	0–95 l/min
Venturis		
• Number	4	3
• Flow rate per venturi	1–16 m³/min	6–30 m³/min
• Number of dilution steps	15	7

	AVL CVS i60 90 // 160 Sm³ **Heavy Duty**
Dimensions (W x H x D)	
• Control and bag cabinet	660 x 1970 x 900 mm
• Dilution tunnel	Ø 460 x 4600 mm
Weight	
• Control and bag cabinet	170 kg
Operation	
• Control and bag cabinet	Integrated PC with touch screen/keyboard/touchpad or external desktop/notebook
Voltage supply	120/230 VAC ± 10% 50/60 Hz, 1P/N/PE
Ambient conditions	
• Temperature	5–40°C (41–104 °F)
• Relative humidity	5–80%, non-condensing
• Ambient pressure	950–1050 hPa
General supply	
• Compressed air	4–6 bar; purified, free of oil and water; 10 l/h
• Water inlet pressure	3–6 bar; difference pressure > 3 bar
• Water inlet temperature	10–20°C
• Water consumption	0–145 l/min // 0–260 l/min
Venturis	
• Number	3
• Flow rate per venturi	15–90 m³/min
• Number of dilution steps	7

	AVL PSS i60 **Single Dilution**	AVL PSS i60 **Double Dilution**
Dimensions		
• Basic unit	660 x 1970 x 900 mm	
• Heated particle filter unit	555 x 900 x 360 mm	
• Particle filter	Ø 47 mm	Ø 47 mm; Ø 70 mm
Weight		
• Basic unit	250 kg	
• Heated particle filter unit	30 kg	
Operation		
• Basic unit	Optionally integrated PC with touch screen/keyboard and touchpad or external desktop/notebook	
Power supply		
• Basic unit	400 VAC ± 10% 50/60 Hz, 3P/N/PE	
Ambient conditions		
• Temperature	5–40 °C (41–104 °F) 25°C (77 °F) with integrated AVL APC 489	5–40°C (41–104 °F)
• Temperature heated particle filter unit	47°C ± 5°C (116.8 °F ± 41 °F)	
• Ambient pressure	950–1050 hPa (13.78–15.23 psi)	
• Relative humidity	5–80%, non-condensing	
General supply		
• Compressed air	4–6 bar; purified, free of oil and water; 10 l/h quality grade according to PNEUROP recommendation 6611/1984 or DIN ISO 8573-1	

	AVL SESAM i60 FT **Small Cabinet**	AVL SESAM i60 FT **Large Cabinet**
General		
• Dimensions (W x H x D)	600 x 1,330 x 920 mm	670 x 1,970 x 980 mm
• Weight	200 kg	450 kg
• Operation	Integrated PC, keyboard and touchpad, external display	Integrated PC, touchscreen (optional), keyboard and touchpad
• Max. configuration	1 FTIR stream	1 FTIR stream with THC, O_2 and secondary EGR-CO_2 stream or 2 FTIR streams
• Power supply	1x230 VAC (N/PE) ± 10 %, 50/60 Hz ± 2 %, max. 2.8 kVA 1x120 VAC (N/PE) ± 10 %, 50/60 Hz ± 2 %, max. 2.8 kVA	3–400 VAC (3/N/PE) ± 10 %, 50/60 Hz ± 2 %, max. 3.6 kVA 3x120 VAC (N/PE) ± 10%, 50/60 Hz ± 2%, max. 3.6 kVA
• Host communication	AK commands per RS232, LAN (TCP/IP)	
Ambient conditions		
• Temperature	5 – 30 °C, 5 – 40 °C with integrated air condition	
• Relative humidity	5 – 80 %, non-condensing	
• Ambient pressure	900 – 4000 hPa (13 – 58 psi)	
FTIR spectrometer data		
• Sampling rate	1 or 5 scans per second (1 Hz and 5 Hz version available)	
• Data rate	all measured gas components at 1 Hz / 5 Hz	
• Spectral resolution	0.5 cm^{-1}	
• Measurement cell	Gas cell heated to 191 °C (375.8 °F)	
• Response time	t_{10} to t_{90} within 1 s (Fast Response version within 300 ms)	
• Sample flow rate	10 l/min per stream (20 l/min for Fast Response version)	
• Detector cooling	Liquid nitrogen, 50 ml/h	
• Zero/purge gas	Nitrogen/synthetic air, 0.6 – 1.5 l/min	
• Compressed air	5 – 6 bar rel. max. 140 l/min per FTIR stream	
Measured gas components (depending on selected evaluation method)	CO, CO_2, H_2O, NO, NO_2, N_2O, NH_3, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8, C_4H_6, C_2H_3OH, CH_3, OH, CH_3CHO, HCHO, HCOOH, SO_2, IC_5, NC_5, NC_8, HNCO, HCN, COS, AHC	
Calculated gas components	NOx, (NO + NO_2), NMHC, Hydrocarbons, HCD, HCG	

	PRE-FILTER C	PRE-FILTER
Filter cartridge	various available	
Material in contact with sample	Stainless steel, Viton, Teflon	
Sample gas flow	up to 20 l/min	
Sample gas inlet pressure	–200 … +300 mbar	
Sample gas inlet pressure with optional pressure regulator	– –	–200 … +3000 mbar Outlet pressure 500 … 1300 mbar abs.
Sample line connection	Compression type fitting, 8 mm outside diameter	
Temperature range	113°C … 191°C / 235 .4°F ... 375.8°F	
Temperature accuracy	± 5°C / 41°F	
Warm up time (temperature)	45 min	
Required operation gas	Compressed air 5 ... 7 bar, with backflush 6 bar recommended	
Compressed air connection	Festo push-in fittings, 6 mm outside diameter	
Compressed air quality	PNEUROP 6611/1984, Particulates class 2 (<1 µm, <1 mg/m³) Oil contamination class 1 (<0.01 mg/m³) Dew point 3 (+2°C or 10°C below ambient)	
Power supply	230 VAC ± 10 %, 50/60 Hz ± 2%, 10A pre-fuse 100 - 120 VAC ± 10 %, 50/60 Hz ± 2%, 15 A pre-fuse	
Power consumption	230 VAC: max. 2000 W, 120 VAC: max. 1700W 100 VAC: max. 1200W	230 VAC: max. 1900 W, 120 VAC: max. 1800W 100 VAC: max. 1500W
Heated sample line	230VAC: 2 x max. 1300 W but max. 1700 W for both heated lines 120VAC: 2 x max. 1300 W but max. 1300 W for both heated lines 100 VAC: 2x max. 1100W but max. 1100 W for both heated lines	230VAC: 1 x max. 1300 W, 1 x max. 600 W but max. 1500 W for both heated lines 120VAC: 1 x max. 1300 W, 1 x max. 600 W but max. 1300 W for both heated lines 100VAC: 1 x max. 1100 W, 1 x max. 600 W but max. 1100 W for both heated lines
Temperature control circuits	for PT100 temperature sensor thermocouples (Typ K, NiCr-Ni) are optionally available	
Ambient conditions	–30 … +45°C / –22 … 113°F, 0% – 85% humidity non condensing, 600 – 1100 mbar, abs.	
CANBus connector	2 x 9-pin Sub-D	
Dimensions (W x H x D)	155 x 400 x 340 mm / 6.1 x 15.75 x 13.39 in	210 x 630 x 430 mm / 8.26 x 24.8 x 16.9 in
Weight	13 kg / 28.66 lb	18 kg / 40 lb

	HSS i60 MEDIUM MODULE	HSS i60 LARGE MODULE
Filter cartridge	various available	
Material in contact with sample	Stainless steel, Viton, Teflon	
Sample gas flow	up to 30 l/min	
Sample gas inlet pressure	–200 … +300 mbar	
Sample gas inlet pressure with optional pressure regulator	–200 … +3000 mbar Outlet pressure 500 … 1300 mbar abs.	
Sample line connection	Compression type fitting, 8 mm outside diameter	
Temperature range	113°C … 191°C / 235 .4°F ... 375.8°F	
Temperature accuracy	± 5°C / 41°F	
Warm up time (temperature)	45 min	
Required operation gas	Compressed air at 5 ... 7 bar, with backflush 6 bar recommended	
Compressed air connection	Festo push-in fittings, 6 mm outside diameter	
Compressed air quality	PNEUROP 6611/1984, Particulates class 2 (<1 µm, <1 mg/m³) Oil contamination class 1 (<0.01 mg/m³) Dew point 3 (+2°C or 10°C below ambient)	
Power supply	3 ~ 400 VAC (3/N/PE) ± 10%, 50/60 Hz ± 2%, 16 A pre-fuse 2 x 100 - 120 VAC ± 10 %, 50/60 Hz ± 2%, 30 A pre-fuse	
Power consumption	400 VAC: max. 7500W, 120 VAC: max. 5100W 100 VAC: max. 4200W	400 VAC: max. 10200W, 120 VAC: max. 9500W 100 VAC: max. 6800W
Heated sample line	400 VAC: max. 1300 W per heated line 120 VAC: 1 x 1100 W 4 x 850 W 100 VAC: 1 x max. 900 W 4 x max. 700 W	400 VAC: 2 x max. 1300 W 9 x 700 W 120 VAC: 2 x max. 1150 W 9 x max. 650 W 100 VAC: 2 x max. 900 W 9 x max. 650 W
Temperature control circuits	for PT100 temperature sensor thermocouples (Typ K, NiCr-Ni) are optionally available	
Ambient conditions	–30 … +45°C / –22 … 113°F, 0% – 85% humidity non condensing, 600 – 1100 mbar, abs.	
CANBus connector	2 x 9-pin Sub-D	
Dimensions (W x H x D)	430 x 660 x 480 mm / 16.93 x 25.98 x 18.90 in	430 x 1010 x 480 mm / 16.93 x 39.76 x 18.90 in
Weight	27 kg / 59.52 lb	40 kg / 88.14 lb

	HEATED BOOST PUMP
Material in contact with sample	Stainless steel, Teflon
Sample gas flow	12 l/min
Sample gas inlet pressure	600 … 1300 mbar abs.
Sample line connection	Compression type fitting, 8mm outside diameter
Temperature range	191°C / 375.8°F
Temperature accuracy	± 5°C / 41°F
Warm up time (temperature)	45 min
Required operation gas	Compressed air at 5 ... 7 bar
Compressed air connection	Festo push-in fittings, 6 mm outside diameter
Compressed air quality	PNEUROP 6611/1984, Particulates class 2 (<1µm, <1mg/m³) Oil contamination class1 (<0.01mg/m³), Dew point class 3 (+2°C or 10°C / 35,6°F or 50°F below ambient)
Power supply	3 ~ 400VAC (3/N/PE) ±10%, 16A pre-fuse 2 x 100 - 120 VAC ± 10 %, 50/60 Hz ± 2%, 30 A pre-fuse
Power consumption	400 VAC: max. 7500W, 120 VAC: max. 5100 W 100 VAC: max. 4600W
Heated sample line	400 VAC: 4 x max. 1300 W 120 VAC: 4 x max. 1100 W 100 VAC: 4 x max. 950 W
Temperature control circuits	for PT100 temperature sensor thermocouples (Typ K, NiCr-Ni) are optionally available
Ambient conditions	–30 … +45°C / –22 … 113°F, 0% – 85% humidity, non condensing, 600 – 1100 mbar, abs.
CANBus connector	2 x 9-pin Sub-D
Dimensions (W x H x D)	486 x 660 x 480 mm / 19.13 x 25.98 x 18.90 in
Weight	35 kg / 77.16 lb

	AVL VT/VV-SHED
Type	FS 45 (full size SHED)
Function	1-bag compensation module for active or passive volume balance/adaptation
Chamber volume [m³]	45
Bag volume	Approx. 20% of the chamber volume
Bag material	Conditioned Kynar or Tedlar
Temperature range	15–45°C (optional up to 80°C)
Temperature dynamics	0.5–1.0°C/min (between 20 and 40°C)
Control system	MSR-PID
Material	
• Interior	Stainless steel, cold milled (optional electronically polished)
• Exterior	Steel sheet metal powder-coated RAL 9006
Design/insulation	PU sandwich system, thickness approx. 80-100 mm
Analysis system	SHED AMA i60
HFID measurement ranges [ppm]	10/30/100/300
Optional analytics	For ethanol, methanol, R134a, methane, aldehydes
Optional accessories	(Certification) AVL iCal CFO (automatic retention test) AVL iCal gas divider (automatic Lin-check)

	 FILTER WEIGHING CHAMBER ADVANCED	 FILTER WEIGHING CHAMBER EPA 1065
General		
• Outer dimensions L x W x H	approx. 1800 x 800 x 1950 mm	
• Power supply	230 VAC, 50/60 Hz	
Air conditions working area		
• Clean room classification	ISO 14644-, classification 5	
• Temperature	22 ± 1 °C	
• Humidity	45 ± 8 % r.D. (with closed window)	45 ± 3 % r.D. (with closed window)
• Dew point	9.5 ± 2 K (with closed window)	9.5 ± 1 K (with closed window)
Ambient conditions		
• Clean room classification	ISO 14644-1, < classification 8	
• Air temperature	18 - 34 °C	
• Temperature gradient installation room (max.)	+/- 1 K/10 min	
• Humidity	5.1 – 13.4 g/kg	
• Humidity gradient installation room (max.)	+/- 1 % r.D./ 10 min	
City water supply		
• Temperature	< 20 °C	
• Flow rate nominal	5 l/h	
• Operating pressure min./max.	4 - 6 barg	
• Conductivity	< 2,000 µS/cm	
• Water hardness	< 30 °dH	
• Silt density index	< 5 SDI	
Process cooling water		
• Flow rate	2.0 m3/h	
• Feed flow temperature	< 6.0 ± 0.5 °C	
• Temperature gradient feed flow	< 0.5 K/10 min	
• Return flow temperature	< 25 °C	
• Max. operating pressure	5 barg	
• Differential Pressure feed/return flow	0.8 - 1.2 bar	
• Differential pressure stability	< 0.2 bar/5 min	
• Water hardness	7-14 / 4-8 °fH / °dH	
• pH-value	8.3 - 9.5	
• Max. oxygen concentration	0.1 mg/dm3	

AVL M.O.V.E
INTEGRATIVE MOBILE VEHICLE EVALUATION

APPROACH

Based on strong powertrain and vehicle development know-how, AVL has created a new in-vehicle measurement platform.

AVL M.O.V.E is a compact and robust product line for a wide range of in-vehicle applications. It provides results for in-use conformity tests, vehicle calibration and vehicle benchmarking.

AVL M.O.V.E offers tailored solutions for different applications based on a modular device concept controlled by a central integration unit, which takes over the device handling, data storage and post-processing. The package is rounded off by a universal mounting concept and a common power supply.

BENEFITS AT A GLANCE

- Complete measurement solution for integrated consumption, emission and driveability calibration
- Central device handling, data acquisition and post-processing
- Modular plug-in solution for fast installation
- Compact and robust design for use in harsh environments

TASK

Strong market demands for minimum emissions, optimized fuel consumption as well as maximum driving fun within complex system environments, which leads to an increasing number of vehicle tests.

Main application areas:
In-use testing
For the heavy duty market, in-use conformity testing has been in force in the US since 2007. New PM requirements were added in 2010. Other markets are very likely to follow and new requirements for marine and locomotive are under discussion.

In-vehicle measurement
Nowadays in-vehicle testing challenges the application engineer with a wide variety of different measurement systems. The market demands integrated solutions with central device control, data handling and post-processing.

Electrification and combined systems (hybrid)
The trends of electrification and hybridization are leading to more complex drivetrain systems that require more detailed analyses of xCU interactions in the vehicle. The component integration and system optimization increase the workload in the vehicle. Here a seamless measurement platform is the key factor for further increases in efficiency.

REFERENCES

ALL APPLICATIONS
AVL Instruments are used all over the world for the reduction of emissions and consumption as well as the optimization of combustion systems.The derived know-how in these fields was the cornerstone for the development of AVL M.O.V.E. The system's flexibility and robustness facilitate its use in different environments.

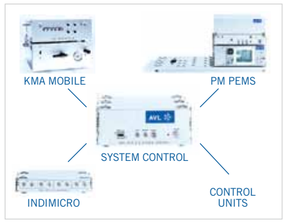
POWERTRAIN ENGINEERING KNOW-HOW
Powertrain and vehicle development know-how is a fundamental aspect for all AVL ITS product developments. A continuous process of sharing information and defining new functional requirements guarantees the technical leadership position of AVL in this application field.

DATA CONSISTENCY
The use of uniform measurement principles and methods guarantees the consistency between AVL M.O.V.E and AVL testbeds. This simplifies the development and increases the efficiency of our customers due to a consistent philosophy. In addition, new testing methods can easily be developed based on this new approach.

UNIFORM DATA POST-PROCESSING
The comparison of test data within different development environments is a key factor. Concerto is a generic post-processing tool with open interfaces which supports efficient post-processing and data handling.

PARALLEL OPTIMIZATION OF MULTIPLE DESIGN PARAMETERS INCREASES PROJECT EFFICIENCY AND SUPPORTS A BETTER UNDERSTANDING OF INTERACTIONS



System Control for central device integration, data aquisition and result calculation

SYSTEM INTEGRATION

AVL M.O.V.E SYSTEM CONTROL

Current in-vehicle measurement set-ups consist of a multitude of different measuring devices. The devices are not connected to a central data acquisition system and the measurements cannot be automated comprehensively.

SOLUTION

AVL M.O.V.E System Control meets this challenge and offers a robust and compact integration platform for in-vehicle measurement technologies that centrally collects all relevant measuring data such as

- Exhaust gas components
- Combustion data
- Fuel consumption
- Driveability

and processes them in an efficient data post-processing and evaluation tool.

Calculation: Based on the available values, further results can be defined and calculated as required.
Data recording: All measuring channels as well as all calculated channels are recorded and saved in a single file (AVL I file format.
Visualization: The graphical user interface provides all typical visualization objects (e.g table, X/Y-Plot, bar chart, single values, etc.), which the user can freely configure.

Automated measurements: Control sequences, calculations, measurement processes and even evaluations and report generation can be automated by means of a script function.
Reporting: Data post-processing and visualization are based on the powerful tool AVL CONCERTO.

BENEFITS AT A GLANCE

- Robust design for mobile operation in the vehicle
- Central operation and control of devices
- Central data acquisition and seamless data evaluation
- Easy and flexible integration sensors and measuring devices

MEASUREMENT OF GENERAL SIGNALS

AVL M.O.V.E SMART-FEM

In addition to the measurement of vehicle parameters, general signals (e.g. temperature, voltage, etc.) are becoming more and more important in many in-vehicle applications. Such signals have to be measured depending on the application. Modern powertrain concepts demand new signal types and increased acquisition rates.

SOLUTION

AVL M.O.V.E SMART-FEM is a configurable I/O measurement system consisting of two components. The central unit (called Smart Box) is indented for attaching different conditioning modules. The Smart Box is connected to the M.O.V.E System Control via a CAN bus interface.

The signal conditioning modules are called Smart The following input types can be measured:

- temperatures (thermocouples, RTDs)
- voltages
- currents
- resistances
- strain gages

Further modules are under development.

Flexible I/O system for mobile applications

BENEFITS AT A GLANCE

- Modularity: The Smart Box can be equipped with different Smart Devices
- Expandability: Designed for further demands (e.g. high voltage)
- Flexibility: Measurement of temperatures, voltages, currents, measurement bridges in one device

Vibration dampened mounting plates for passenger car applications. Robust environmental housings for operation under harsh environmental conditions.

AVL M.O.V.E MOUNTING CONCEPT

VEHICLE INSTALLATION

Different environments and various mounting situations require high flexibility with regard to safe device installation. The area of in-vehicle applications ranges from motorcycles to excavators.

SOLUTION

The AVL M.O.V.E mounting concept is designed to fulfill all requirements regarding the safe and secure installation of devices. Each device features a robust design and is optimized for operation under rugged environmental conditions. For operation in the trunk of a passenger car, the devices are secured on a dampened mounting plate.

However, some applications (e.g. off-road testing on construction equipment) require additional protection against shock, vibration, rain and dirt. For these particular applications, AVL M.O.V.E offers dedicated, rugged protective cases.

BENEFITS AT A GLANCE

- Secure fixation of devices
- Simple system extension
- Fast installation

AVL M.O.V.E POWER SUPPLY

VEHICLE INSTALLATION

In addition to device installation, power supply strongly depends on different use cases and customer philosophies. Customers today follow a broad range of power supply strategies including mains power (for system heat-up), generators (long-term independent operation), batteries (short-term independent operation) and/or vehicle power supply.

SOLUTION

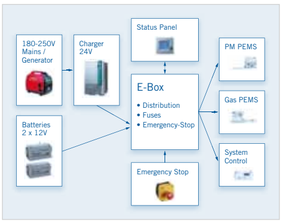
All AVL M.O.V.E devices operate on 24VDC power. The power supply concept is designed for operation of the M.O.V.E devices independently of the vehicle power supply. The E-Box provides the following features:

Handling of power sources: The E-Box enables the user to seamlessly switch between different power sources such as (a) mains/generator power during system heat-up and (b) batteries for back-up power supply.

Power distribution: The E-Box distributes the power to the M.O.V.E devices and at the same time takes care of safe battery loading (different battery types and sizes are supported). The system monitors the energy flows and shows the remaining battery power on a display.

Device and cable protection: All connectors are protected against polarity reversal. The safety concept involves separate fuses for all inlets and outlets.

Emergency stop: Upon pressing the emergency stop button all critical components of the M.O.V.E system (e.g. heated lines, etc.) are immediately disconnected from power. However, communication between the devices remains active in order to avoid any damage that can be caused by a complete shut down.



Schematic of M.O.V.E power supply with integrated emergency stop function and central power distribution.

BENEFITS AT A GLANCE

- Different supply strategies
- Integrated emergency stop circuit
- Central power distribution

AVL M.O.V.E SYSTEM CONTROL

AVL M.O.V.E System Control is the central unit for device controlling, data acquisition, online result calculation and visualization. Its robust and compact design allows for use in harsh environments. Other systems (measurement devices, application systems, vehicle CAN and xCU systems) can be easily integrated via the provided interfaces. One common file is used for data storage.
See page 94.

AVL M.O.V.E PM PEMS

AVL M.O.V.E PM PEMS is a mobile device for measuring total particulate matter certified by the EPA for in-use conformity testing. It is a combination of time-resolved soot and integral particulate mass measurement.
The compact system consists of two enclosures: The measuring unit with the photo-acoustic measurement cell and a Gravimetric Filter Module (GFM).
See page 128.

AVL M.O.V.E GAS PEMS

AVL M.O.V.E GAS PEMS is a portable emissions analyzer for measuring THC, NO/NO_2 and CO/CO_2 concentrations in the exhaust gas of diesel and gasoline vehicles. It will complete the AVL PEMS portfolio in 2011. The compact system is characterized by its robust design, wide operating temperature range and high measurement accuracy, particularly with regard to the low measurement range.
See page 129.

AVL KMA MOBILE

AVL KMA Mobile is a flexible solution for high-precision in-vehicle fuel consumption measurement. Due to the wide measuring range, consumption measurements can be performed for small and large engines with a single system.
The short response time (100 ms) allows for highly accurate results during transient engine operation.
See page 76.

	AVL M.O.V.E SYSTEM CONTROL	AVL M.O.V.E PM PEMS	AVL M.O.V.E GAS PEMS	AVL KMA MOBILE
Application	Integration platform	Particulate measurement	Gaseous exhaust gas measurement	Consumption measurement
Dimensions	241 x 90 x 350mm	482 x 422 x 530mm	482 x 356 x 540mm	470 x 360 x 550mm
Weight	~ 4.5kg	~ 45kg	~ 50kg	35kg
Operating temperature	-20 … 60°C	0 … 45°C	-30 … 45°C	-10 … 50°C
Humidity	5 … 95% non condensing			
Power supply	9 … 36VDV	24VDC or 110/230 VAC*	24VDC	
Power consumption	~50W	~400W	~450W**	~480W

*Depending on the version
**After warm-up @ 20°C ambient temperature and with 2m heated line

AVL M.O.V.E INDIMICRO

AVL M.O.V.E IndiMicro is a compact 4-channel solution for combustion analysis. Its small size and the combination of signal amplification and powerful data acquisition qualifies the system for detailed combustion analysis for mobile applications.
The IndiMicro can also operate as a stand-alone device providing real-time processing of result values on an integrated CAN bus interface, which can be used for calibration and limit monitoring.
See page 107.

AVL M.O.V.E SMART-FEM

AVL M.O.V.E Smart-FEM is a compact and modular data acquisition system dedicated to mobile use in vehicles. It is designed for highly accurate measurements under harsh environmental conditions. The Smart-FEM consists of the central housing (called Smart Box) and signals conditioning modules (the Smart Devices). One Smart Box can be flexibly equipped with up to four Smart Devices and outputs the measured data via the CAN bus.
See page 95.

AVL-DRIVE

AVL-DRIVE captures various driveability-related sensor and CAN bus signals. These input quantities are collected by the DMU (DRIVE Main Unit) and passed on to the AVL-DRIVE software for further processing and analysis. About 100 different driving modes (e.g. part load acceleration) are detected and more than 450 driveability-related criteria are rated in real time.
See page 166.

AVL CONCERTO PEMS

AVL CONCERTO PEMS is a post-processing tool for PEMS applications based on AVL CONCERTO (see page 150). The software effectively supports the user by evaluating, correlating and validating the measured data after the tests. Predefined layouts (e.g. for legislative heavy duty in-use testing evaluations) reduce the work for complete test validation and report generation to a few mouse clicks. CONCERTO PEMS also offers “one click” import tools for data coming from third-party PEMS devices.

	AVL M.O.V.E INDIMICRO	AVL M.O.V.E SMART-FEM	AVL-DRIVE	AVL CONCERTO PEMS
Application	Combustion measurement	I/O subsystem	Driveabilty evaluation	
Dimensions	241 x 45 x 270mm	241 x 45 x 370mm	140 x 35 x 230mm	
Weight	~ 1kg	~ 3kg	~ 1kg	
Operating temperature	-35 … 50°C	-40 … 80°C	-20 … 70°C	
Humidity	5 … 95% nicht kondensierend			
Power supply	9 … 36VDC			
Power consumption	25W	10W		

A KALEIDOSCOPE OF SIMULATION POSSIBILITIES

INCREASING SIMULATION DEMAND

The challenge of reducing time and costs along the product development cycle causes a growing demand to replace physical prototypes with virtual prototypes applying frontloading. The vast range of variables in modern powertrain systems and the increasingly considered interaction of all vehicle components are to be mastered in the most efficient manner. Engineers are facing a great number of challenging development and simulation tasks which necessitate more than just 'good software'.

The unique power of AVL Advanced Simulation Technologies is derived from the systemic netting of single simulation results to integrated, multidimensional simulation platforms on the basis of AVL's deep engineering expertise. Those simulation platforms address the key tasks of the powertrain development process. The close loop with measurement enables a very early verification of testing data and the significant reduction of test efforts.

OUR STRENGTHS HELP YOU TO CUT DEVELOPMENT COSTS AND TIME

- Robustness, ease of use and completeness of physicalmodels enabling simulation as a "frontloading" development tool
- Exceptionally reliable and practical simulation solutions, that solve development problems with a high level of accuracy and confidence
- Simulation solutions focussing on powertrain Engineering and therefore providing problemtailored capabilities for model set-up and result presentation to the powertrain development teams
- Experienced local support and powertrain simulation teams serving your global development activities

AVL SIMULATION WORKFLOWS THROUGHOUT...

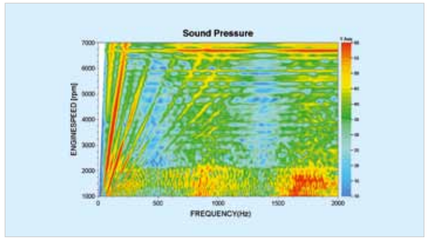
AVL's unique simulation power is the combination and integration of AVL software tools, 3rd party tools, testing and analysis methods with seamless simulation workflows that guide the user through to practical solutions.

...THE PRODUCT CREATION PROCESS

AVL's simulation workflows address application tasks that cover all aspects of the product creation process. The huge complexity of these tasks is bundled to multidimensional simulation platforms on the basis of AVL's deep engineering know-how.

POWERTRAIN ENGINEERING INSIDE / CLOSE LINK TO TESTING

AVL BOOST



AVL BOOST

MARKET REQUIREMENTS

The automotive market places demands such as fuel efficiency, passenger comfort, and emissions limits on today's vehicle designs. The ability to meet the majority of these demands is highly influenced by the combustion engine.

These idealized targets often conflict, as demonstrated by the constant tradeoff between high performance and fuel efficiency, for example. To meet core specifications required by the vehicle team, engine designers must balance dozens, if not hundreds, of engine parameters. The use of simulation tools, whether it be purely math-based, or integrated with hardware in the test bed and vehicle environments (hardware-in-the-loop), is essential.
AVL BOOST is an advanced and fully integrated "Virtual Engine Simulation Tool" with advanced models for accurately predicting engine performance, acoustics and the effectiveness of exhaust gas aftertreatment devices. It supports engine development in such a way that for a given vehicle concept, the required torque and power can be delivered in combination with optimized emissions, fuel consumption and passenger comfort (acoustics and transient behavior).

AVL APPROACH

AVL BOOST – the well established "Virtual Engine Simulation Tool" with high fidelity simulation models for

- combustion and pollutant formation in the cylinder
- exhaust gas aftertreatment
- acoustic analysis

AVL BOOST STRENGTHS

- Powertrain expertise drives software development
- Specialized user interface designed for engine engineers
- Consistent 1D and 3D aftertreatment simulation in AVL BOOST, AVL FIRE® and AVL CRUISE
- Engineering, testing and software under one roof
- Support provided by experienced engineers from local AVL offices around the world

INTEGRATED SOLUTIONS WITH AVL BOOST

AVL BOOST – AVL FIRE®

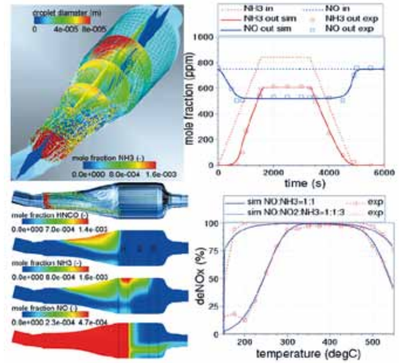
AVL BOOST offers the possibility to model any part of the intake or exhaust manifold in full 3D by coupling the 1D flow solution with AVL's FIRE® 3D CFD software. This offers the possibility of time, as well as the cost effective optimization of key elements such as the intake plenum (EGR mixing) or the close-coupled catalyst (uniformity, heat- up and conversion).

AVL BOOST – AVL CRUISE

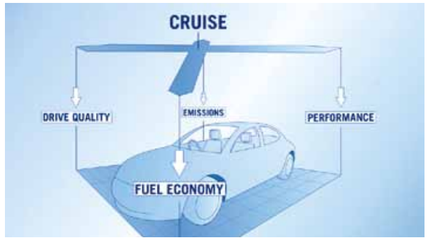
AVL CRUISE is a software package developed for vehicle simulation. Typically AVL CRUISE uses engine maps for performance and emissions data, however a direct coupling to an AVL BOOST engine model can be selected for even higher accuracy, especially for transient analysis.

GCA – GAS EXCHANGE AND COMBUSTION ANALYSIS

Although today's engine test beds are equipped with a variety of sensors, certain important performance and combustion parameters (for example residual gas concentration, volumetric efficiency, scavenging efficiency, trapped mass) cannot be measured directly. This limitation is overcome by GCA, an integration of AVL BOOST into AVL's test bed environments IndiCom and Concerto. This integration provides engine engineers access to crucial results for their development tasks.



AVL CRUISE



AVL CRUISE

VEHICLE SYSTEM SIMULATION REQUIREMENTS

Cost reduction and time pressure in vehicle development demand highly flexible simulation systems. The models that these tools produce need to be able to fulfill their functions throughout the duration of the product development workflow in order to prevent the initial concept from being lost under the weight of conflicting engineering demands and compromises regardless of the driveline topologies. The increased complexity of advanced vehicle concepts requires the interdisciplinary cooperation of teams, since vehicle-level simulation tools need to be able to leverage the communication between different teams and ensure consistency in model and data management. Resources for the time and cost-intensive development, as well as the validation and maintenance of vehicle-level simulation tools are hard to justify, yet comprehensive tools are required in order to create the product defining attributes such as fuel economy, emissions, performance and drivability with an optimized cost/benefit ratio.

CONSISTENT SIMULATION MODELS AND APPLICATION-FOCUSED WORKFLOWS

AVL CRUISE supports everyday tasks in vehicle system and driveline analysis throughout all of the development phases, from concept planning through to launch and beyond. Its application envelope covers conventional vehicle powertrains through to highly-advanced HEV systems. CRUISE offers a streamlined workflow for all kinds of parameter optimization and component matching – guiding the user through to practical and attainable solutions. Due to its structured interfaces and advanced data management, AVL CRUISE has established itself as a data communication and integration tool for different teams within world-leading OEMs and their suppliers. This facilitates consistent target definition and the traceability of the decisions made in reaching the best overall results for the developed product.

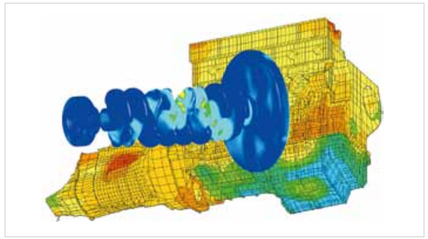
AVL CRUISE STRENGTHS

- Realistic vehicle system modeling of any topology with complete vehicle component models and scaleable fidelity.
- Inclusion of all simulation vehicle system analysis tasks and workflows.
- Intelligent and consistent management of data throughout teams, applications and workflows.
- Developed with OEMs engaged in leading-edge vehicle and powertrain design – AVL CRUISE incorporates much of the experience of those companies.

YOUR BENEFITS

- Simulate driveline structures efficiently, from the standard to the most complex.
- Perform all fuel economy, emissions and performance tests in a single run with the same vehicle model.
- Hybridize conventional vehicles with a few mouse clicks.
- Explore new transmission concepts such as automated manual transmissions (AMT) and dual clutch transmissions (DCT).
- Execute very large parameter optimization and component matching tasks with DOE functions.
- View the energy and power flows graphically for the whole powertrain.

AVL EXCITE



AVL EXCITE

MARKET DRIVERS

AVL's EXCITE family of products are the leading market simulation tools for powertrain NVH and durability assessment. The powertrain development process is increasingly subject to opposing pressures. As the requirements for strength, durability and noise reduction rise, so do associated time and cost pressures. This challenge can only be met through the use of efficient simulation and calculation tools. During the development process particular attention has to be paid to the cranktrain, since its components are subject to considerable mechanical stress and contain some of the major sources of mechanical noise in combustion engines.

Development engineers require tools that enable them to create models from the planning stage onwards. These tools must be as realistic as possible during the concept, with increasing precision through the later development stages. Math-based models assist engineers in producing higher quality products while achieving shorter development times and lower costs

AVL APPROACH

AVL has developed complimentary tools for simulating and calculating individual components and submodels as well as the entire system.

HIGH FIDELITY SYSTEM SIMULATION

Complete systems and individual components with various modeling depth levels can be built or scaled for each stage of the development process. The models can be adapted to meet the requirements made of them, ensuring the optimum balance between simulation effort and accuracy.

POWERTRAIN ENGINEERING INSIDE

With many years of experience in the field of engine development, AVL's software uses accurate and validated mathematical models in order to provide calculation results that are as realistic as possible. AVL simulation solutions are highly application oriented.

CLOSE LINK TO TESTING

The AVL EXCITE Designer tool provides results in a format that enables an electric motor to reproduce the torsional vibrations of a combustion engine on the transmission test bed. In this way, AVL EXCITE enables customers to save time and costs during the testing phase of a project.

AVL TOOLS FOR STRENGTH, DURABILITY AND NVH SIMULATIONS

AVL EXCITE POWER UNIT

is the industry's leading tool for calculating the dynamics, strength and acoustics of combustion engines, transmissions and powertrains. It is also used for the detailed analysis of local hydrodynamic effects in oil-lubricated contacts (slider bearings, piston-liner contacts).

AVL EXCITE DESIGNER

uses analytical methods in order to enable the fast and realistic dimensioning of crankshafts and powertrains at an early stage in the development process.

AVL EXCITE TIMING DRIVE

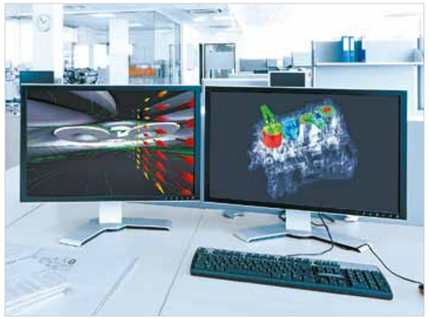
ensures reliable results for all kinds of valve trains and timing drives. It covers the entire workflow starting from the kinematic designing of cam profiles and the dynamic behavior of individual components, up to entire timing drives driven by gears, chains or belts.

AVL EXCITE PISTON & RINGS

is an efficient tool for sizing piston assemblies. The piston ring module can be used to calculate absolute values for inter-ring pressures, piston ring movements and blow-by, as well as the reliable trend prediction of lube oil consumption.

- Robust and optimized solver for short calculation times
- Parameter-based simulation models – easy variation of design parameters
- Hybrid modeling approach (2D workspace with a 3D view capability) for easy and fast model generation
- Customizable GUI – user definable for template definition
- Integrated standard workflows for crankshaft dynamics and NVH analysis, extendable by user defined workflows
- Automated, application oriented and user extendable 2D post-processing (standard reports)
- Design Explorer - integrated tool for DoE and optimization
- Interfaces to 3rd party CAE software (FE, optimization) and application programming interface for smooth integration into the existing CAE environment

AVL FIRE®



AVL FIRE®

The automotive industry continues to focus on delivering products with improved quality, performance and comfort. However new market conditions are affecting product development activities, with a renewed driver being environmental friendliness.
In order to meet these demands, automotive engineers require development tools which provide accurate representations of complex systems in the virtual world. The ever increasing number of design parameters of traditional and 'alternative' powertrain systems means that early concept analysis becomes increasingly important. Powertrain thermodynamic analysis using 3D computational fluid dynamics (CFD) tools is one such discipline.

Through years of development and advancements, AVL's 3D CFD software AVL FIRE® fulfills these demands. AVL FIRE® is used every day by hundreds of powertrain engineers in order to accurately predict results in a flexible, robust and fast way. AVL FIRE® customers make design decisions earlier, and with greater confidence.

AVL FIRE® is primarily used by researchers and development engineers working in internal combustion (IC) engine engineering. It is integrated into their specific product development processes. AVL FIRE® enables users to test the quality and performance of their work even before prototype hardware is created. Development cycles are shortened and costs are reduced, even though the number and complexity of the tasks being performed is significantly increased.

AVL APPROACH

As the leading simulation program in the field of combustion engine analysis, AVL FIRE® specializes in the accurate prediction of engine gas exchange, mixture formation and combustion, as well as emissions and exhaust gas aftertreatment.

1. HIGH FIDELITY SYSTEM SIMULATI ON

The overall environment and individual components of AVL FIRE® allow the system to be applied to any phase of the development process. The broad range of available models allows users to properly balance simulation effort and desired precision.

2. POWERTRAIN ENGINEERING INSIDE

AVL's simulation tools are uniquely supported by over six decades of engine development experience. Our own consulting and services business depends on AVL FIRE® to deliver results, and provides our software team with invaluable insight into current and future requirements.

3. CLOSE LINK TO TESTING

The virtual inspection of engine phenomena with AVL FIRE® enables shorter development times and the reduction of costs. New techniques, such as coupling to optimization tools, allow for the investigation of more design variations. The result is a more robust prototype on the test bed, allowing for targeted testing, reduced development time, and a higher quality endproduct.

AVL FIRE® STRENGTHS

- AVL FIRE® is a complete CFD environment, and includes a solver, as well as pre- and post-processing tools which are embedded in an intuitive graphical user interface. There is no need to purchase 3rd party tools, even for the most complex tasks.
- AVL FIRE® is based on proven state-of-the-art solver technology, capable of handling general polyhedral computational elements, and offering a robust platform for continuous enhancement.
- AVL FIRE® offers automated meshing technology for arbitrarily complex geometries including multiple moving parts; this helps to drastically reduce setup time for complex engine models.
- AVL FIRE® offers a consistent set of physical and chemical models in order to cover various types of fluid flow applications, in particular those related to IC engines and combustion systems.
- AVL FIRE® development effort is complemented by AVL's internal R&D activities, as well as extensive industry and academic partnerships.
- AVL FIRE® provides an open code structure enabling researchers to apply the tool to advanced combustion concepts (e.g. HCCI and PCCI).
- AVL FIRE® offers leading market technology in order to simulate exhaust gas aftertreatment systems.

CUSTOMER BENEFITS

- AVL FIRE® is specifically tailored to meet the requirements of automotive research and development engineers
- AVL FIRE® is flexible in order to allow users to adjust modeling complexity and integrate the software into their CAx framework
- AVL FIRE® is a proven tool, used daily in AVL's engine development process and by hundreds of customers worldwide
- AVL FIRE® is easy to use thanks to automated pre-/post-processing, integrated application specific workflows and pre-defined solution control files
- AVL FIRE® provides reliable and accurate simulation results thanks to extensively validated chemical and physical models
- AVL FIRE® computational models are continuously developed and enhanced via in-house research activities and partnerships with leading technology centers world-wide
- Customer support is provided by engineers who know powertrains and powertrain development

AVL TESTBED AUTOMATION

APPROACH

As the leading partner for innovative testbed automation systems, AVL has put the focus on an open and scalable integration platform for the most varied testbed types for many years now. The range of applica¬tions covers endurance testing, engine development, emis-sions test¬ing, component testing and electric motor testing, driveline testing all the way to racing and vehicle testing. The further develop-ment of the platform is driven by a continuous dialog with our custom-ers and close cooperation with dedicated beta customers to ensure best in class products. Whether for global OEMs or local medium sized companies our philosophy supports efficiency during test operation.

BENEFITS AT A GLANCE

- All testbed configurations and all test applications on one common platform – resulting in lower maintenance, operating, and training costs
- Integrated concepts for front loading in the overall vehicle development process to cut down development time and respectively time-to-market
- Using the PUMA Open Test Run Library significantly reduces the time to prepare tests and helps to decrease the number of test runs by enabling customer standards
- High level of automation and integration – the requirement for unmanned operation
- Global operations without language barriers: User interfaces available in English, German, French, Swedish, Japanese, Chinese, Italian, Russian, Spanish and Korean.

TASK

Currently, protection of the climate and global concern about the environment are the main drivers of development in the automotive industry. On the basis of the dynamics within emissions legislation and due to changed customer preferences, topics like increasing efficiency and new drive concepts are increasingly important. Au-tomation systems have to take into account these trends by means of innovative application solutions, e.g. for exhaust gas testing or for hybrid drives. Providing these solutions first and foremost requires profound application know-how, along with knowledge in the field of automation.

Furthermore, along with the product properties, the factors of costs, time to market and product quality are decisive for the competitive-ness within the automotive industry today. Accordingly, testbed automation has to support the production of results characterized by higher levels of quality and repeatability, integration of the testing procedure – across national borders and between different systems as well as minimization of unproductive procedures.

Finally, the best automation system is of no use if it is not available in a reliable manner. Despite continuously changing basic condi-tions, short product lifecycles in the field of IT, changing functional requirements and numerous test applications to be supported, the systems have to be reliable. This concerns product quality and delivery dependability as well as maintainability and expandability. Investment security is constantly in focus.

REFERENCES

ALL TESTBED TYPES, ALL APPLICATIONS

What do testbeds for engines, turbo chargers, electric mo-tors, powertrains and vehicles have in common? What can be found in the R&D testbed, at the certification testbed and end of line? Answer: modular solutions on the basis of the AVL automation platform.

CERTIFIED PRODUCT DEVELOPMENT PROCESS

Up to this point in time, AVL is the only automation system manufacturer, with develop-ment processes that have been assessed in accordance with CMMI Level 3. CMMI as-sesses whether the software is delivered in a timely manner, at the stipulated budget and in the agreed quality.

HOLISTIC APPROACHES FOR INCREASED EFFICIENCY

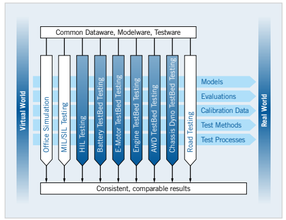
Many factors have to be right in order to increase efficiency. Accordingly, AVL automation systems support pallet-com-pliant IO modules, intelligent pallet handling, workflow sup-port and plausibility checks on results.

INSTALLED BASE

With over 3000 active systems AVL PUMA Open is the global industry standard for the test bed automation. The related data acquisition system usu-ally consists of AVL F-FEMs (approx. 36.000 installed modules).

30 YEARS OF EXPERIENCE IN DEVELOPMENT AND OPERATION OF DIFFERENT TESTBED TYPES LEAD TO MAXIMISED EFFICIENCY.



One common automation platform as basis for a wide range of testing applications - this results in increased productivity by reuse of parameters and test specification and the correlation of result data causing positive effects like the use of common process management and data handling tools as well as IT infrastructure across the whole product development process and hence reduction of training needs and maintenance costs.

BENEFITS AT A GLANCE

- Securing of high data quality through exchangeability of test methods and procedures between different testbed types
- Productivity increase by reuse of parameters between testbed configurations
- Reduced efforts for maintenance and training due to common platform
- Reliable results due test execution, simulation and control fully synchronized and in hard real time
- Open architecture thanks to standard interfaces and common technology like ASAM, VB Script and Matlab®/Simulink®

AUTOMATION SOFTWARE

AVL PUMA OPEN

By integrating all system functions, PUMA Open guarantees seamless management of all testing tools and testbed components. It coordinates the data flow starting from testbed control and test sequencing to data acquisition, processing and finally archiving.

PRINCIPLE

PUMA Open supports its users throughout their daily work process targeting maximization of efficiency and productivity on the testbed. Its comprehensive and intuitive graphical tools for the preparation, execution and evaluation of test runs are critical features for efficient testbed operation. In addition to Standard features such as fully automated test runs or manual operation, the PUMA Open automation system provides reliable and precise control of measuring devices, test cell facilities, units in testing and all of the safety-relevant monitoring features. The user's task of creating new test runs in PUMA Open is made easier and faster by the graphical test run editor. Even with the ever-increasing complexity of test runs, they are now compiled and configured graphically via drag and drop. Combined with the ability to define library components like subroutines and a state-of-the-art Version control system, the complete traceability of test results can be achieved effortlessly.

APPLICATION

PUMA Open is the common platform for test automation:

- Component testbeds: from the fuel pump to the turbocharger
- Electric motor testbeds: covering full 4 quadrant testing
- Engine testbeds: from endurance, end of line and emission testing to high end racing applications
- Driveline testbeds: from transmission durability to complete powertrain optimization.
- Vehicle testbeds: from mileage accumulation to driveability optimization up to emission certification

BASIC ECU CALIBRATION WITH PUMA OPEN

MAP SEQUENCER

The option Map Sequencer represents AVL's entry-level solution for calibration of powertrain control units (xCU) on PUMA Open test beds. It is derived from the AVL powertrain calibration Software CAMEO which was designed by development engineers specifically for the automotive industry. As consequence it contains all the best in-class features required to run automated tests for ECU calibration.

PRINCIPLE

The Map Sequencer is optionally available for PUMA Open and is seamlessly integrated in the automation system. After defining the calibration procedure within a PUMA Open test run, it will be executed directly on the test bed workstation.
Using approved CAMEO principles it is designed to run automated engine calibration procedures for gasoline and diesel engines independent from engine type and size.

APPLICATION

The Map Sequencer enables the quick design and execution of various basic calibration tasks typically required for engine, transmission or hybrid control units. Appropriately it provides lean solutions containing a workflow for all required steps for the calibration process. The test design as part of PUMA Open test libraries enables the setup of map sequence procedures either as Variation Lists or as automated Full Factorial Lists. The seamless integration into PUMA Open speeds up the phases for design and execution of calibration procedures.

The execution of the calibration procedure of the Map Sequencer is visualized clearly arranged at the PUMA Open testbed: The operating point schedule (left) and the ECU full factorial parameter changes per operating point (right)

BENEFITS AT A GLANCE

- Create calibration sequences quickly by configurable testrun elements from PUMA Open standard toolbox – no programming knowledge required
- Calibration specific features like relative setting, model based adjustments, stabilization criteria available
- Calibration parameters, curves and maps easy to parameterize using well-arranged tables
- Predefined procedures allow high degrees of standardization keeping full flexibility for various calibrations tasks
- Optimal support of the calibration process with task specific user interfaces

The screenshot shows PUMA Open including a 3D online animation of maneuver and track, a graphical testrun sequence and a recorder for data acquisition

BENEFITS AT A GLANCE

- Integrate various driving maneuvers directly into PUMA Open testruns
- Creation of own tracks or use of In Motion / Carmaker track library
- Reuse parameters of approved AVL vehicle and wheelslip simulation (EMCON ISAC)
- No additional hardware for maneuver simulation required
- Common data management of maneuvers, testbed and acquisition
- Direct simulation feedback by 3D environment visualization of vehicle and road

REAL-LIFE TESTING WITH PUMA OPEN

INMOTION™ EMBEDDED

Today's development of electric and conventional powertrains requires more and more possibilities to do Real-Life Testing at the testbed and simulate the relations of various driving maneuvers

The PUMA Open Option InMotion Embedded is designed for maneuver and event based testing e.g. Real Word Consumption NEDC to evaluate real-world driving behavior at the testbed. This is reached by a high-performance virtual driver-road-environment, into which the unit under test is embedded.

PRINCIPLE

In addition to PUMA Open Step Sequences or Road Profile Sequences the Maneuver Sequences are parameterized as part of PUMA Open test libraries in graphical test procedures. They can be prepared upfront in the office and easily adapted during runtime at the testbed. Maneuvers are typically defined by the parameterization of a maneuver control, a 3D road model, a driver and the vehicle definition of AVL ISAC.

APPLICATION

The maneuvers are executed in the real time environment of the PUMA Open Testbed Workstation. For direct testbed control PUMA activation objects can be placed on the Virtual track. The online animation of vehicle and environment in 3D provide full Simulation feedback to the user and allow a Visual evaluation of driving dynamics at run-time.

DATA PLAUSIBILIZATION

AVL PODD

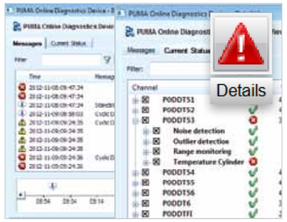
AVL PUMA Online Diagnostic Device™, AVL PODD gives instant response in different levels to simplify the information. A triangle will immediately signalize any contradiction with regard to the collected values and a clear message which channel or method is suspect. Further a detailed window will inform about the status of the continuous diagnosis of the verified channels. The testbed operator (or the automation system) can decide if a problem is relevant and requires reaction. For offline analysis integrated data reports give overview about problems detected by AVL PODD.

PRINCIPLE

Fully integrated in PUMA Open AVL PODD complements the testbeds online plausibility- and quality checks with central management and easy operation. AVL PODD is delivered with a standard set of plausibility rules which are based on AVL's practical experience in test bed operation and used in the in-house testfield of powertrain engineering.

APPLICATION

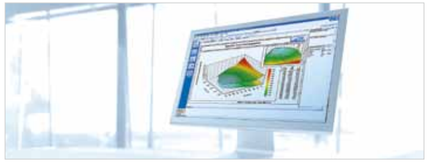
Despite the increasing use of automation systems, faulty and repetitive tests take place during test operation. If, for example, a sensor is broken or disconnected, PODD will recognize this and within the automatic testrun a customer specific test sequence could react on it. Even differences in cylinder temperatures can be detected by AVL PODD. The diagnosis tool supports online plausibility and quality checks to produce correct and highly accurate measurement results.

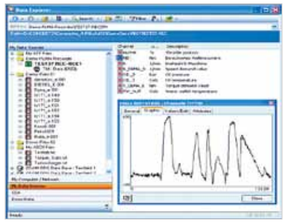


PODD offers different levels of detail: the simple triangle warns the operator when anything goes wrong. The messages then offer a first explanation while the details view display a complete status of the system configured.

BENEFTIS AT A GLANCE

- Increasing testbed efficiency
- Higher levels of process safety and improvement of data quality
- Automatic, immediate warning in case of implausible results
- Reduced know-how required for testbed operation
- Quality certificate for measurement data





The standard support of manifold data formats, like Inca MDF, ASAM ATF/ODS, ASCII, AVL IFile, AVLCTF and more than 20 further formats, shows the generic usage of CONCERTO. In addi¬tion customer speci¬fic extensions are possible on demand as well.

BENEFITS AT A GLANCE

- One window to the whole world of automotive data, combining the flexible approach of a generic tool and the implementation of application specific know-how accessible directly at the user interface
- Offers a common view to data from automation-, simulation- and measurement systems
- Re-use at manifold application fields like engine-, powertrain-, emis-sion- or hybrid- and battery testing lead to reduced training effort
- Merging routines for asynchronous datasets such as transient emissions data, combustion data, ECU data or vehicle data including cycle-based, crankshaft-based or time-based data

DATA POST PROCESSING

AVL CONCERTO

The main actual post-processing task is, to support the user by getting the relevant information out of the mass of produced data during the testruns. AVL CONCERTO is a universal tool for data post processing and for easy data exchange, where the conversion of stored data into meaningful information is quick and intuitive, no matter about the origin of the data. In addition, given its open interfaces and integrated comparison mechanisms, CONCERTO is the central tool for the correlation of data from automation-, simulation- and measurement-systems.

APPLICATION

Due to its modular packages CONCERTO ideally supports dedi-cated application fields like evaluation of testbed data, detailed combustion analysis, evaluation of emission data, reporting of engine calibration data, visualization of hybrid testbed data and much more.

AVL CONCERTO builds a common platform for all data post processing tasks within one tool:

- starting from data management (incl. data search, data filtering and navigation)
- through interactive analysis (e.g. advanced cursor functionalities)
- and calculation possibilities (integrated calculation tools from simple calculator to advanced programming environment and formula editor, including pre-defined libraries for application specific calculations)
- to advanced reporting tasks (from simple diagrams up to reduction of data evaluation time due to fully automated advanced reports).

EVALUATION AND CLASSIFICATION

AVL MAGIC

With ever-increasing amounts of data being generated either on the testbed or through in-vehicle measurements, the scope of post-pro-cessing work is also on the rise. To address this issue, one solution is to shift some data preparation and analysis tasks from the Office to the testbed or to the car. Another one is to apply intelligent data reduction to measurement results in order to automatically extract the parts of interest.

PRINCIPLE

Fully integrated with AVL PUMA Open on the testbed, with MCD system (INCA® ETAS) in the car and with AVL CONCERTO at the office. AVL MAGIC allows to define data evaluation and calculation tasks using build-in functions such as signal processing, event and fault detection or classification. The evaluation tasks can then be applied sequentially to one or more data sources. On the testbed or in the car, it enables direct access to all online values and to evalu-ate them.

APPLICATIONS

- Battery testing: Several gigabyte of test result data are gener-ated each day per testbed. MAGIC offers very powerful and flexible data reduction possibilities, thanks to its processing capability and its event detection functionality
- Unit under test monitoring: Testbed users want to track the engine activity and history. MAGIC offers continuous statistical analysis of the engine behavior (e.g. pressure, temperature depending on speed and torque), independently of the used testbed.

Graphical view of the job sequence preparation and the event visualization

BENEFITS AT A GLANCE

- Reduced need for storage capacity via online and offline data reduction
- Fast and automatic online evaluation with direct access to the results by the automation system
- Reduced post-processing effort by intelligent data reduction
- Efficient implementation of new evaluations due to the graphical interface together with an extensive library of predefined functions

Easy operation thanks to a dynamic and intuitive graphical user interface. The entire test cycle is run fully automatically.

BENEFITS AT A GLANCE

- Certification and development of test procedures and analysis with corresponding monitoring and control functions
- Support of all essential emission legislations for heavy duty on-highway and off-road engines, as well as simulation of light duty test cycles on engine dynamometers
- Test-specific graphical user interface guides the testbed operator through the entire test procedure
- Sophisticated formula database for emission calculation allows for central formula management
- Dynamic evaluation protocols allow for easy reporting of test results

AUTOMATION SYSTEM FOR EMISSION TESTING ON ENGINE TESTBEDS

AVL iGEM ENGINE

Emission measurements for the certification of heavy duty highway and off-road engines have to comply with different legal requirements. The test procedures, test data evaluation as well as the test conditions for such emission tests are specified by regulations and are subject to strict limits. During engine development for pas¬senger cars, legislative test cycles are increasingly being simulated on engine testbeds and often require additional emission devices and evaluation methods. The iGEM Engine automation software is best suited to support all these types of testing and provides the required flexibility. All current emission legislation is supported by iGEM Engine. The high degree of automation simplifies the Opera¬tion of emission engine testbeds.

SOLUTION

Pre-configured and tested legal test cycles, intelligent device control as well as calculation and reporting of test results based on iGEM Offline are the core components of iGEM Engine. These components, together with AVL's long time experience in engine certification, are the unique basis for the correct implementation of the latest emission regulations and legislation within iGEM Engine. Flexible adaptations of the test cycles in terms of testbed configuration or test reports are as easy as integration into a test field.

APPLICATION

The emission automation software iGEM Engine is designed for the development and certification of heavy duty highway and off-road engines as well as for the development testing of light duty and pas¬senger car engines on dynamic engine testbeds.

AUTOMATION SYSTEM FOR EMISSION TESTING ON CHASSIS DYNAMOMETER TESTBEDS

AVL iGEM VEHICLE

Continually changing international emission legislation as well as new engine designs and measurement methods create a market demand for innovative solutions in the automation of emission testbeds. iGEM Vehicle, the new AVL system for emission testing of chassis dynamometers, is the answer to these challenges. Intelligent, innovative, intuitive: These are the three characteristic features that best describe the new product family "iGeneration". Based on decade-long experience in the automation of emission testbeds, iGEM Vehicle was created with state-of-the-art software. This software is designed for the future, making it a safe and worthwhile investment.

SOLUTION

Based on the already established success of AVL PUMA Open, iGEM Vehicle offers high scalability. It also allows simple adjustments for different testbed configurations to be made based upon individual user needs. This means that it offers the highest level of flexibility and independence to the user. This flexibility makes it possible to fulfill the legal requirements today as well as tomorrow.

APPLICATION

The iGEM Vehicle is used for certification, research & development, or production compliance purposes. iGEM Vehicle offers the best solution for passenger car, medium duty and heavy duty truck and motorcycle emission automation. It also provides a variety of customized application packages.

Easy operation thanks to a dynamic and intuitive graphical user interface. The entire test cycle is run fully automatically.

BENEFITS AT A GLANCE

- Valid emission test certification packages - covering all current standards
- Fully automated procedures in the preparation of common devices for testing, calibration and checks
- Simple and flexible integration of new measurement devices using device abstraction as well as an extensive driver library
- Efficient tools to create custom test cycles and test applications
- iGEM Offline – a powerful data evaluation tool with a central formula database – both adhering to legal requirements and yet offering individualized report templates

AVL PUMA OPEN

AVL PUMA Open is the application-oriented automation system for the components, engine, powertrain and vehicle testbeds of AVL. Based on the basic functionality required for all applications, PUMA Open is delivered in scalable packages.

TECHNICAL DATA

- Operating system Microsoft® Windows7 32bit / 64bit or XP with the real-time system Tenasys INTime® and Oracle® database
- Real time processing with up to 10 kHz
- Data flow with F-FEM I/O: up to 100.000 values/sec.
- Steady-state measurement: 20.000 values/sec per Measurement
- Continuous measurement: up to 100.000 values/sec with up to 1.000 channels
- ASAM standards: ASAP3, MCD-3MC, MCD-3D, ODS, GDI, ACI
- fast xCU Interface with iLinkRT
- On-Board-Diagnostic Interface EOBD/OBD II
- Support of current technology: MATLAB®/Simulink®, VB Scripting
- Interface: A2CAN, CAN Open, Profibus DP, IEEE1394, TCP/IP, UDP/IP, RS232, OPC, EtherCAT®
- Interface to common Power analyzers

SOFTWARE- AND HARDWARE PACKAGES

- PUMA Open Logging Lab
- PUMA Open End of Line Testing
- PUMA Open Component Test
- PUMA Open Component Test Advanced (Turbo Charger Test)
- PUMA Open endurance testing
- PUMA Open Electric Motor Test
- PUMA Open Engine Testing
- PUMA Open Performance and Emission Testing (with iGEM Engine)
- PUMA Open Vehicle testing
- PUMA Open Powertrain and Transmission testing
- PUMA Open High End Racing

Extensions*)

- Visual Basic scripting
- Operational data acquisition
- Pallet handling
- Programmable test cell control
- Reference Cycle Monitoring
- Extension Packages Engine Testing (HD/LD/Non-Road HD)
- Application Library Endurance Testing
- Application Library Drivability
- Application Library MATLAB™ Interface
- InMotion Embedded
- Map Sequencer

EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

*) If not contained in the software package

AVL EMISSION TEST AUTOMATION

On the basis of the versatile requirements, modern emission testbeds have turned into complex measurement systems. Efficient use and flexible functionality along with highly reliable measurement results require high levels of automation. Changing legal requirements further increase the complexity. AVL's solution allows the user to comply with the specified test procedures for determining exhaust gas emissions and to present complete results.

TECHNICAL DATA

- Automation solution for engine and vehicle testbeds
- Automated test procedure and analysis of the test results in accordance with the legal standards
- Flexible functional scope from certification solutions to complete solutions for development applications
- Versatile solutions in accordance with emissions legislation for chassis dynamometer testbeds as well as light duty and heavy duty engine testbeds

LIGHT DUTY ENGINE EMISSIONS

Increases in efficiency in the engine development process can be achieved by making use of the benefits of dynamic engine testbeds. It is essential in this area to comply with the basic conditions for exhaust gas measurements specified in the corresponding guidelines. AVL's packages contain suitable methods for different measurement equipment (e.g. undiluted raw exhaust gas measurement or diluted CVS measurement).

HEAVY DUTY ENGINE EMISSIONS

With dynamic testbeds for the engines of utility vehicles, the focus is on strict compliance with the legislation despite the flexible use of advanced functions and additional measurement methods for engine development. AVL's packages guarantee the correct test procedure and display the results in a legally compliant and clear manner after the test has been completed.

LIGHT DUTY VEHICLE EMISSIONS

The requirements with regard to the efficiency and reliability of the exhaust gas after-treatment systems of modern passenger car engines are increasing. Accordingly, providing reliable results in the range of ultra low emissions is the most important requirement for modern chassis dynamometer testbeds. The corresponding AVL packages are ideally suited for use in emission certification, development and production control.

AVL CONCERTO

AVL CONCERTO is a tool for generic as well as application-specific data post-processing. Application-specific libraries are implemented and the user is guided via a workflow-oriented user interface, on the testbed as well as in the office. Due to its open interfaces, CONCERTO is the ideal tool for central data correlation and evaluation, no matter where the data comes from.

TECHNICAL DATA

- Correlation and evaluation of data coming from automation, simulation and measurement systems
- Support of generic interfaces like COM, Active-X and specialized interfaces like ASAM-ODS and ASAM-CEA
- Graphical formula editor for crank-angle- and time-based calculations
- Full programming environment for user-specific formulas, macros and scripts
- Large objects library for numerical and graphical objects (incl. ISO maps, 3D maps, video objects, difference maps, etc.)
- Specific templates and algorithms for evaluation of combustion data, powertrain testbed data, emission data, hybrid- and battery testbed data, etc.

AVL MAGIC

AVL MAGIC automates the extraction, the evaluation and the classification of large amount of data (>Gb). It can be used on the testbed, directly in the car or at the office. Typical applications are: durability OBD, battery tests, road profile replication, calibration data analysis for conventional, hybrid and electric vehicles.

TECHNICAL DATA

- Fully integrated with PUMA Open
- Fully integrated with MCD system (INCA® ETAS) for usage in vehicles
- Efficient and lean interface with CONCERTO
- Compatibility with a wide range of data formats
- Graphical interface to configure job sequences with a batch run editor to automate tasks
- Full mathematical functions library and Visual Basic scripting capability
- Conditioning the data by harmonizing the frequencies and aligning the time basis
- Event evaluation library to extract part of interest within large amount of data and provide calculations on the recognized events
- Signal fault detection and correction library to identify and clean raw data from abnormal or irrelevant values
- Classification library to organize the values in such a way that trends and profiles can be seamlessly outputted

AVL PODD

AVL PODD detects permanently faulty measurements on a PUMA Open testbed by observing defined measurement channels and identifying operating points which deliver inaccurate, unfeasible or faulty values during runtime. Either the operator decides if suspect channels are relevant and require a reaction. All diagnostic results can be processed automated in PUMA Open.

TECHNICAL FACTS:

- Fully integrated in PUMA Open
- Standard parameterization with up to 100 channels
- Online tuning of parameters
- Automatic postmortem storage behavior of faulty areas
- Signal check rules (physical and statistical methods)
- Plausibility rules (logical median comparison)
  Examples:
  – Logical temperature / pressure chains
  – Carbon / oxygen mass flow balance
- Flexible to extend with customer specific rules
- 3 modes of operation:
  – Standstill diagnosis (“Good Morning Check”)
  – Cyclic diagnosis (“permanent verification”)
  – Measurement synchronous diagnosis (“mark steady state data with quality stamp”)

AVL F-FEM/F-FEM SNAP-IN

AVL F-FEM stands for highly precise measurements, demand value settings and control under rough testbed conditions. With the new product family F-FEM Snap-in, the acquisition of data is integrated into the pallet in a vibration-protected manner.

TECHNICAL DATA

- Real-time data acquisition with up to 5kHz per channel, supporting IEPE (ICP®) sensors (e.g. acceleration sensors)
- Compact design with up to 32 channels in one measurement slot*)
- Measurements on batteries, e-motors and inverters with up to +/- 1’000V **)
- Fully synchronized: max Jitter < 0.1µs
- Automatic calibration of measurement channels (option)

New with F-FEM Snap-in:

- Flexible equipment due to clever slot system for data acquisition and pressure measurement slots
- Sensor cabling and pressure hosing already implemented in the setup area
- Quick pallet replacement: Connection via one multiple connector only
- Vibration protection and IP65 protection

*) F-FEM-AIT
**) F-FEM-AIF HV and F-FEM-AIS HV

	 PRESSURE MEASUREMENT SNAP-IN UNIT	 F-FEM-DDC SNAP-IN UNIT
Description	Snap-in unit for acquisition of up to 12 independent pressure signals in the field of engine and powertrain testing in the automotive industry. The snap-in unit can be equipped with up to 12 pressure transducers and is designed for installation in the AVL Measurement Box.	Snap-in unit with 8 channels for output of voltages and/or currents, including 16 I/O discrete channels for digital control signals. In addition, the digital input channels can be used as 8 counter channels for one or two track sensors for event counting and/or frequency measurement. All connector sockets are equipped with quick locks.
Data interface	CANopen DS404	IEEE1394
Power supply	24 VDC	24 VDC
Ambient temperature	0 to 60 °C**	0 to 60 °C**
Data acquisition / max. update rate	200 Hz	1 kHz
Analog channels	12 inputs	8 outputs
• Voltage		•
• Current		•
• Thermocouple		
• PT100/1000		
• Resistance		
• Bridge		
Analog input features	– Digital temperature compensation – Automatic sensor detection	
Pressure (gauge, absolute)	•	
Digital IO		16 in / 16 out***
Counter input (frequency, period, events)		8****
Digital frequency output (frequency, PWM)		8****

* F-FEM-AIS only
** -20 to 60 °C with optional heating
*** 8 relays, 8 transistors
**** Shared with digital input and output

	 F-FEM-AIN, F-FEM-AIS SNAP-IN UNIT	 F-FEM-AIT SNAP-IN UNIT	 F-FEM-AIF SNAP-IN UNIT
Description	Snap-in unit with 16 channels for the measurement of voltages, currents, temperatures, resistances and measuring bridges. The channel assignment can be configured in the software by the user. All analog input sockets are equipped with quick locks. The snap-in unit is designed for installation in the AVL Measurement Box.	Snap-in unit with 32 channels for the measurement of temperatures and small voltages. The channel assignment can be configured in pairs by the user in the software. All analog input sockets are equipped with quick locks. The snap-in unit is designed for installation in the AVL Measurement Box.	Snap-in unit with 16 channels for the dynamic measurement of voltages and currents. The channel assignment can be configured in the software by the user. All analog input sockets are equipped with quick locks. The snap-in unit is designed for installation in the AVL Measurement Box.
Data interface		IEEE1394	IEEE1394
Power supply	IEEE1394	24 VDC	24 VDC
Ambient temperature	24 VDC	0 to 60 °C**	0 to 60 °C**
Data acquisition / max. update rate	0 to 60 °C** 200 Hz	10 Hz	5 kHz
Analog channels	16 inputs	32 inputs	16 inputs
• Voltage	•	•	•
• Current	•		•
• Thermocouple	•	•	
• PT100/1000	•	•	
• Resistance	•		
• Bridge	•		
Analog input features	– Digital anti-aliasing filter – 24-bit analog resolution – Prepared for TEDS – Single-channel isolated analog input*	– Digital anti-aliasing filter – 24-bit analog resolution – Prepared for TEDS	– Digital anti-aliasing filter – 24-bit analog resolution – Prepared for TEDS – Single-channel isolated analog input – Signal conditioning for IEPE (ICP®) sensors

* F-FEM-AIS only
** -20 to 60 °C with optional heating

			
	F-FEM-AIS HV	F-FEM-AIF HV	CURRENT MEASUREMENT SYSTEM HV
Description	Universal snap-in unit with 16 inputs for the measurement of voltages (±13.5V), currents (±25mA), temperatures (thermo couples, resistance thermometers), resistances and measuring bridges on high voltage levels (up to ±1'000V)	Snap-in unit with 16 inputs for the measurement of voltages (up to ±1'000V) on energy storage and electric motor/inverter systems. The measurement range of each channel is software-configurable by the user.	Closed loop current transducer with high accuracy and large bandwidth which does not use Hall generators, connectable to any F-FEM voltage input (±10V). Measurement ranges: 60 A to 1'000 A
Data interface	IEEE1394	IEEE1394	Analog (-10 V … +10 V)
Power supply	24 VDC	24 VDC	24 VDC
Ambient temperature	0 to 60 °C*	0 to 60 °C*	0 to 60 °C
Data acquisition rate max.	200Hz	5kHz	5kHz
Analog channels	16 Inputs (universal)	16 Inputs (voltage)	1 Input (current)
• Voltage	•	•	
• Current	•		•
• Thermocouple	•		
• PT100/1000	•		
• Resistance	•		
• Bridge	•		
Isolation voltage	1.000 V	1.000 V	1.000 V
Analog input features	– Digital Anti-Aliasing Filter – 24 Bit analog resolution – Analog input channels separately isolated	– Digital Anti-Aliasing Filter – 24 Bit analog resolution – Analog input channels separately isolated	The magnetic flux created by the primary current is compensated by a secondary current. The zero-flux detector is a symmetry detector using two wounded cores connected to a square-wave generator. The secondary compensating current is an exact representation of the primary current.

* -20 to 60 °C with optional heating

POWERTRAIN CALIBRATION

APPROACH

Modern powertrain development is setting up more and more challenges for the automotive industry. Essential features like performance, dynamics, fuel consumption, emissions and acoustics depend on an optimized tuning of the control units. On the one hand those calibration tasks are getting more complex but on the other hand optimal results in a shorter amount of time are demanded. To cover the wide range of tasks in their daily work calibration engineers need efficient tools to put new methods into practise.

BENEFITS AT A GLANCE

- software tools support development engineers during the entire calibration workflow
- influences of XCU parameters are getting easier to understand
- models can be reused throughout the different stages of the development process
- full utilization of the test facility due to intelligent test runs – even in unmanned 24 hour operation
- tools are supported and maintained on a global scale (roll-out capability for test facilities and different locations)
- development focus on calibration tasks instead of on the development of calibration tools

TASK

More than ever steady results in solving all calibration tasks require modern software tools that meet the complexity of the assignments.

During their usage within the development process those methods have to meet requirements like data quality, reproducibility, stability and safety. This is the only way to solve tasks like e.g. dynamic procedures of modern powertrains combined with low emissions satisfactorily.

The aspired and necessary efficiency of calibration workflows demands permanent derivatives of methods regarding their practical usability. AVL has a long-time experience and is leading in the development of high performance methods in XCU calibration. Our focus is to provide a complete workflow for each single calibration task. A significant increase in efficiency when using AVL calibration software has been proved in worldwide pratical usage.

REFERENCES

AVL CRETA-CALIBRATION DATA MANAGER

As a central data management system for calibration data, AVL CRETA supports a traceable application process that is indispensable for series projects. Short access times, high levels of stability and safety, as well as easy operation are key criteria.

AVL CAMEO – INTELLIGENT REDUCTION OF CALIBRATION TESTING EFFORT

This software is the leading tool for intelligent test procedures and DoE methods (including modelling & optimization) in calibration. With the open CAMEO plug-in concept and the full integrability of MATLAB SIMULINK, personal dynamic procedures can be created in a simple and fast manner.

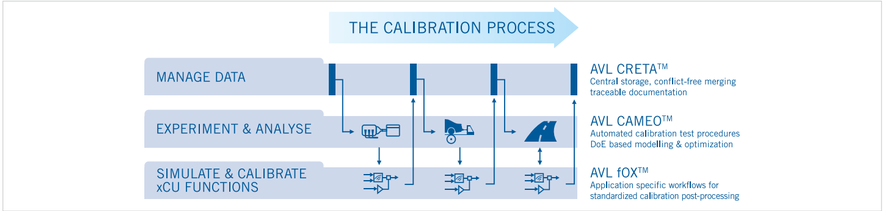
AVL fOX - A NEW WAY OF THINKING ABOUT CALIBRATION TOOLS: CUSTOMIZED, PROFESSIONAL, EASILY ADAPTABLE

With this new product AVL provides a post-processing tool for the development of customized offline calibration workflows that lets you calibrate your individual xCU functions.

INSTALLED BASE

More than 600 CAMEO installations with most OEMs and supplier companies, as well as more than 5,000 CRETA users constitute the reference of the AVL calibration software for the entire powertrain. Experience and know-how are at the heart of the industrialized software solutions for engine and transmission calibration.

AVL CALIBRATION TECHNOLOGIES PRODUCT PORTFOLIO



AVL CRETA

AVL CRETA is a calibration data management tool, which permits a traceable and conflict-free merging and administration of ECU and TCU calibration data during the entire calibration process. Standardized methods for pre-calibration of new projects up to monitoring of the calibration maturity will allow an efficient handling of engine and transmission calibration data.

- Traceable administration and documentation of control unit data
- Defined and conflict-free generation of control unit datasets
- Quick pre-calibration of initial datasets
- Plausibility check of datasets against reference data from former projects
- Easy project- and quality monitoring through integrated reporting mechanisms
- Unlimited data exchange with calibration partners
- Easy operation by using wizards
- Offline version for test trips

AVL CAMEO

AVL CAMEO integrates the process into one tool and thus offers a highly effective tool for powertrain calibration.Our software takes control over the testbed and the xCU application/calibration system to guarantee an efficient and rational calibration process. The AVL CAMEO powertrain calibration software is the result of a cooperation with many well known automotive companies. It contains leading functions for automized testing including methods of optimized test planing, including DOE evaluations, modelling and optimization.

AVL CAMEO offers a wide range of applications for engines and control units such as:

- Gasoline Engine Calibration (e.g. base calibration, torque structure, charge calibration,...)
- Diesel Engine Calibration (e.g. torque structure, base calibration, hydraulic,...)
- Driveability Calibration (e.g. power on/off, tip in/out,...)
- Transmission Calibration

AVL fOX

A new way of thinking about calibration tools: customized, professional, easily adaptable. One of the most time-consuming parts in the calibration work is the data post-processing, which is the conversion of raw test-result data into values suitable for populating control-unit labels. The post-processing of test results usually requires macros for lengthy data-plausibility checking and recalculations, for which a deep knowledge of the control-unit software is often needed (xCU functions). AVL fOX™ embodies all the features contained in these macros, allowing a customized easy data plausibility check, integrated xCU function simulation, automated script execution and powerful map interpolation.

- high robustness of calibration data
- easily adaptable workflows
- high performance in management and processing of large amounts of data

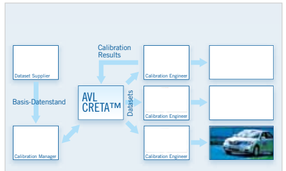
AVL fOXLAB

AVL fOXLab™ is the tool to standardize the calibration process and to save the know how across your complete calibration department. Based on a library of calibration specific building blocks, calibration workflow templates can be generated and distributed easily. Every workflow template gets the same look and feel out of the box, you only have to think about how to solve your calibration problem. The training effort is minimized, a one time training is needed, afterwards the calibration engineers can jump into new workflows really easily. With the help of workflow specific help, the know how is transported to all calibration engineers.

With AVL fOXLab™ in combination with the AVL fOX™ Runtime a wide range of calibration tasks can be solved:

Diesel:
Torque Matching, Friction Maps, Temperature Corrections, Cold start, Restart, DPF and SCR strategies, Idle Control, Cruise Control, OBD for Air Path, Fuel Path, Base Diagnostics, IUPR, etc.

Gasoline:
Torque Structure, Air Path, Knock control, Boost Pressure Control, Cruise Control, Catalyst Heating, Restart, WarmUp, OBD diagnostics, IUPR, etc.



AVL CRETA Applicationprocess Example

AVL CRETA is a Client/ Server solution which allows a central storage, a conflict-free merging and a traceable documentation of control unit calibration data.

BENEFITS AT A GLANCE

- Increased robustness of calibration, thus reduced risks of recall actions after SOP
- Reduced time required and therefore costs for calibration data management by up to 50 percent
- Worldwide operation and unrestricted data exchange with partners and suppliers
- Integrated application know-how based on more than 1.500 calibration projects
- Easy and intuitive tool operation

CENTRAL DATA AND PROCESS MANAGEMENT

AVL CRETA™

Fifteen years ago engine control units contained approximately up to 500 parameters or so-called labels; nowadays the number of labels has increased up to 30,000! A large amount of labels, lots of vehicle variants and globally distributed team assignments are a common phenomenon within powertrain development projects, making them highly complex. The large volume of data created during the development phase requires standardized methods for storing and documenting results before transferring them to the series production.

APPLICATION

AVL CRETA calibration data manager provides those methods and the required process-related measures for today's organizations. The software allows an improved handling of engine and transmission calibration data during the entire development process. Clearly assigned label responsibilities will avoid conflicts when merging calibration data from different sources and thus guarantee consistent results. A common data repository forms the backbone of CRETA and helps distributed calibration teams around the globe share project relevant information easily and ensure a smooth collarboration with partners. CRETA is characterized as an easy-to-use software with a strong application orientation. Standardized methods for precalibration of new projects up to monitoring of calibration maturity will guarantee high efficiency in calibration work. AVL CRETA contributes to meeting the top priorities of today's powertrain developers: reduced time to market, better robustness of products and improved collaboration. Compared to conventional methods, AVL CRETA increases the quality of calibration results while reducing data management costs by up to 50 percent.

INTELLIGENT REDUCTION OF CALIBRATION EFFORT

AVL CAMEO™

ECU calibration is a major task in modern powertrain development. Despite an increasing complexity of modern control units and higher degrees of freedom calibration effort itself must be decreased.

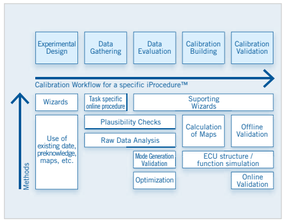
The CAMEO powertrain calibration environment is structured in four modules to cover all tasks within the calibration process. CAMEO DoE TEST GENERATOR to generate all kind of calibration test procedure, CAMEO TESTBED for running CAMEO iProcedures on the testbed, CAMEO GLOBAL MODEL GENERATOR to perform modeling and optimization tasks and CAMEO MAP GENERATOR to calculate eCU/tCU map surface.

APPLICATION

The CAMEO Powertrain Calibration Environment offers a wide range of applications for any kind of engine and any ECU, such as:

- Gasoline Engine Calibration (e.g. charge or torque calibration…)
- Diesel Engine Calibration (e.g. torque structure, base calibration…)
- Driveability Calibration (e.g. power on/off, tip in/out…)

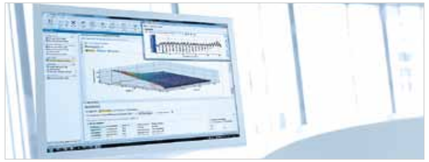
CAMEO TRANSMISSION is part of AVL´s solution for an automized transmission calibration on the testbed and on the dynamometer. CAMEO takes control over a robot or AVL DRICON (which controls the automated gear shifting) and varies the TCU parameters. The system also contains AVL DRIVE for transmission to detect gear shifting quality. After finishing the test the program supports the optimizing of TCU parameters to achieve the highest possible quality.

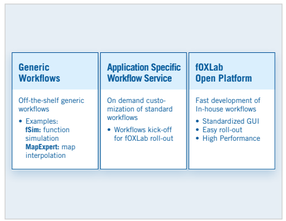


AVL CAMEO is a software tool with a unique user interface for the complete calibration process. Thus it improves the efficiency and the consistency of calibration work.

BENEFITS AT A GLANCE

- Simple user interface for standard tasks
- Reduction of measuring time/use of unmanned operations
- Powerful open interfaces (Matlab, .net, Simulink, ...) permit the integration of customer specific or other products as well as task orientated solutions





AVL fOX Productline provides solutions for A wide variety of calibration tasks and user groups.

BENEFITS AT A GLANCE

- Performance, consistency, standardized GUI: All post-processing steps included in a workflow with a standardized GUI and a performance, which allows processing huge amounts of data. All your calibration tools with the same look and feel.
- Easily adaptable workflows: Every calibration workflow can be adapted easily, thanks to the fOX component library, which includes powerful and standardized modules for calibration tools. AVL fOX is adaptable to any xCU type.
- Already available generic workflows: Standard workflows are developed to accomplish the most common daily work, independently from the specific calibration tasks.

ENHANCING THE POWERTRAIN CALIBRATION PROCESS

AVL fOX™

One of the most time-consuming parts in the calibration work is the data post-processing, which is the conversion of raw test-result data into values suitable for populating control-unit labels. The post-processing of test results usually requires macros for lengthy data-plausibility checking and recalculations, for which a deep knowledge of the control-unit software is often needed (xCU functions).

DAILY USE WITH GENERIC WORKFLOWS

AVL fOX™ provides four generic workflows, which can be used on a daily basis by all calibration engineers. These standard workflows cover a wide range of possible calibration applications based on advanced map calculation and editing and simulation.

AVL fOX MAPEXPERT

In the daily work of a calibration engineer it is often needed to convert measurement data into maps (control unit parameters), combine some maps for simulation or recalculation, execute an analysis of data and statistics, modify existing maps and deal with further tasks which may appear during the workflow.

AVL fOX fSIM

is workflow for the simulation and calibration xCU models. With fSim the engineer can simulate the behavior of an xCU model by different datasets and measurement series (steady state or dynamic, from test bed or vehicle) and finally adjust the calibration to improve the accuracy.

STANDARDIZING THE POWERTRAIN CALIBRATION PROCESS

AVL fOXLAB™

AVL fOXLAB™ enables the user to create AVL fOX™ workflow templates based on parameterization and scripting. Based on a powerful base library with calibration specific elements the workflow developer can define the workflow template including the User Interface and all logics based on scripts.

AVL fOXLab™ supports an easy distribution of the workflow templates to all calibration engineers independent of 3rd party tools. The calibration engineers only need a AVL fOX™ Runtime to do their daily work on a powerful and professional platform.

EASY TO USE GUI DESIGNER FOR PROFESSIONAL WORKFLOW STEPS

Design your workflow and the corresponding workflow steps in an easy to use GUI Editor. Based on a large number of standard GUI Elements a professional and powerful user experience can be designed.

PROFESSIONAL SCRIPTING FOR APPLICATION SPECIFIC LOGIC

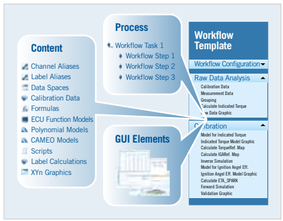
For the workflow logic AVL fOXLab™ provides a powerful scripting engine based on Python 2.6 with full access to all data elements and functions of fOX™.

INCLUDE YOUR WORKFLOW SPECFIC HELP

By the easy to use help editor, you can define your help for the workflow, to save and distribute your know how. Include also pictures in your help files for perfect documentation.

DISTRIBUTE AND MANAGE YOUR fOX™ WORKFLOW TEMPLATES

The workflow templates are stored on the AVL fOXLab™ database for continuous development. The distribution is done by a file export and simple import in the AVL fOX™ Runtime.



Combine content, process and GUI to an easy to use calibration workflow.

BENEFITS AT A GLANCE

- Powerful calibration specific elements: Use calibration specific content and GUI elements out of the base library to create a standardized template for your calibration problem.
- Easily distributable workflow templates: Workflow templates can be easily distributed between your calibration engineers on a single file basis including all necessary workflow elements.
- Document and protected know-how: By the use of compiled simulation models you can secure your knowledge easily. With the use of the included documentation system, the calibration know-how can be easily transferred to the users and the training effort is reduced.

AVL TESTBED CONTROL AND SIMULATION ON ENGINE AND POWERTRAIN TESTBEDS

APPROACH

Decades of experience in the field of testbed control as well as detailed knowledge of the development processes of our customers have significantly influenced the development of the AVL testbed controllers. The need for highly accurate real-time simulation models is increasing with the "road to rig" approach. The major challenge in today's vehicle development is focused on rapidly shortening vehicle development cycles. Vehicle simulation which is more than just vehicle inertia simulation enables significant progress in vehicle optimization and calibration, e.g. driveability, as well as real world emission and fuel consumption optimization. AVL introduced a virtual vehicle model for engine test beds which enables the simulation of real-world shaft oscillation phenomena (e.g. jerk). The counterpart for powertrain testbeds is a patented solution for the vehicle dynamics with wheel slip simulation. These requirements led to the creation of a modular and scalable controller with integrated simulation platform that ideally covers all requirements from individual testbeds up to applications in large-scale test facilities.

BENEFITS AT A GLANCE

- Reproducible and accurate results due to approved and optimized control algorithms
- High level of user-friendliness in the manual operation
- Approved safety concept for unmanned operation, 7 days a week, 24 hours a day
- Central administration of the parameterization in test facilities
- Fast road to rig due to highly accurate real-time simulation
- Open simulation platform for the integration of customer models

TASK

Parameterizing engines and their variants for different vehicles and countries constitutes the highest expenditure of time in the development cycle today. In order to accomplish this on testbeds in an automated manner, it is essential to have precise control over test subjects and the load facility.

In order to increase efficiency, it is necessary for control parameters to be managed centrally in the test facilities, and it must be possible to unambiguously associate these parameters with the test results.

During the operation of the testbed control system, the operator requires only minimal expert knowledge. Uniform, graphically supported, online-compatible parameterization that is also continuous across different testbed types reduces the expenditures for training measures as well as sources of errors.

The option of adding functionality when specifically required allows for targeted investments. Here, the modular structure of the control system offers ideal adaptability to the current requirements with regard to measurement value collection, control functions and real-time platform.

REFERENCES

All manner of applications have been successfully equipped with EMCON: from simple testbeds for continuous operation, development testbeds with vehicle simulation, powertrain testbeds and components testbeds, all the way to racing testbeds. Globally, several large-scale test facilities with more than 30 testbeds each profit from the complete integration into the testbed automation system. AVL ISAC offers a scalable simulation solution from road load, vehicle inertia, powertrain oscillations, to wheel slip. The flexibility and the open character of the system allow the customer-specific adaptations and the direct integration of MATLAB® / Simulink® control algorithms which can be created by the user. In this regard the EMCOM real-time platform offers the ideal basis with the extension AVL ARTE.Lab™.

DRIVEABILITY EVALUATION AND SIMULATION

Over 10 years of experience in driveability evaluation and simulation. More than 50% of all OEM's and transmission manufacturers successfully use AVL-DRIVE and VSM in engine and powertrain development and for quality assurance.

INSTALLED BASE

More than 3400 testbed control systems (including stand alone) of the current generation are in successful use, proving their capabilities around the clock.

A CONTINUOUS CONCEPT FOR ALL TEST JOBS – EASY TO OPERATE SCALABLE, APPROVED IN MORE THAN 3400 TESTBEDS.




DYNAMOMETER CONTROL STANDALONE BME 400

BENEFITS AT A GLANCE

- Precise operation through excellent torque and speed control stability over the whole performance range
- Standalone operation
- Bumpless change of control modes
- Communication with a host system by remote interfaces
- Reliable and approved safety concept

The AVL standalone digital dynamometer control systems consist of hardware and software for the control of a variety of dynamometers. The system uses proven algorithms to control the dynamometer and depending on the configuration also combustion engines. The dynamometer conditions are monitored with predefined and definable responses. The control system has an ergonomically designed operating panel. Incremental pulse wheels permit the exact setting of demand values while the bumpless change of control modes is ensured. The LCD shows demand and actual values as well as parameter settings and operating menus.

ENGINE & DYNO CONTROLLER AVL EMCON STANDALONE ADVANCED

BENEFITS AT A GLANCE

- Features as of BME 400
- Additionally full support of combustion engine control
- Fast controller parameterization due to user-friendly GUI
- Online graph for support of controller tuning
- Execution of customer-specific MATLAB®/Simulink®-based real-time models on same EMCON Standalone Advanced HW
- Upgrade of control system to be integrated into AVL PUMA Open

The AVL EMCON 400 Standalone Advanced is a complete digital test bed control and monitoring system for a combustion engine and dynamometer on an engine test bed. It includes a runtime environment to execute MATLAB® Simulink®-based real-time applications created with AVL ARTE.Lab™. An EMCON Standalone Advanced Web Client enables the parameterization of the controller by using the standard browser on the office PC. The Web Client provides a number of intuitive and user-friendly GUIs to edit some of the most frequently used EMCON database arrays.

ENGINE & DYNO CONTROL EMCON 400

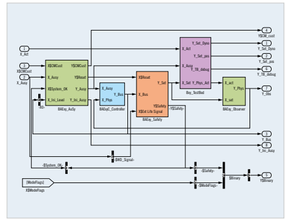
The EMCON 400 is a complete digital testbed control and monitoring system which can be completely integrated into the AVL testbed automation system PUMA Open. The system uses proven algorithms to control DC and AC (synchronous and asynchronous) machines as well as eddy current and hydraulic dynamometers from AVL and other suppliers. The dynamometer and testbed conditions are fully monitored with definable responses. The standardized control methodology and applications lead to high quality in the control of engine testbeds and powertrain, driveline and racing testbeds.

TECHNICAL FEATURES

The control software operates on a powerful INTEL™ hardware with an INtime® real-time operating system. The EMCON 400 features coupled, non-linear closed-loop control. With its high control accuracy and dynamics, over- and undershooting are minimized. Up to 32 additional system conditions can be monitored with definable delay time and response type. Optimized process flows and control frequencies allow the full performance of dynamometers to be used. Standardized algorithms for complex applications such as EPA-compliant starts allow the global comparability of measured results. Besides the standard control modes, user-definable quantities can also be controlled.

APPLICATION

EMCON 400 is suitable for all types of testbeds and can also be used in test fields. It is the ideal basis for integrating online simulation into the testbed, such as AVL ISAC for driver and vehicle simulation. With this extension, high dynamic torque control is also possible. Furthermore, additional simulation models created with AVL ARTE.Lab™ can be seamlessly integrated.



The control algorithm for high dynamic torque control is implemented using MATLAB®/Simulink®. It is seamlessly integrated in the AVL real-time environment.

BENEFITS AT A GLANCE

- Precise operation through excellent torque and speed control stability over the whole performance range
- Completely integrated into the AVL testbed automation system PUMA Open
- Synchronization of control demand values with the data acquisition of the AVL testbed automation system
- Bumpless change of control modes
- Open for the integration of AVL simulation software ISAC and customer-specific simulation models
- Reliable and approved safety concept

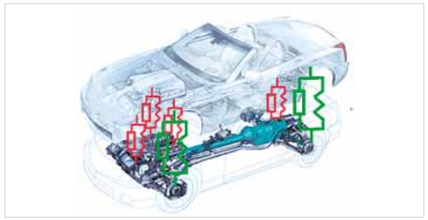
DRIVEABILITY EVALUATION AVL-DRIVE™

BENEFITS AT A GLANCE

- Automatic driving mode detection and categorization
- Objective assessment of vehicle driveability feeling
- Comprehensive and objective driveability benchmarking
- Frontloading of driveability calibration with AVL-DRIVE and VSM to testbed, HIL and office
- More efficiency in driveabiliy calibration process (less time with higher quality)

The wide and continuously growing selection of different vehicle, engine and transmission types demands tools for greater efficiency and quality in the development of driveability.
AVL offers AVL-DRIVE as a comprehensive and objective driveability assessment tool for passenger cars, trucks and buses with MT, AMT, AT and DCT. AVL-DRIVE supports the entire vehicle development process from road to rig to math.

DRIVEABILITY SIMULATION VSM

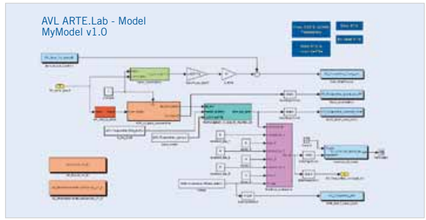


BENEFITS AT A GLANCE

- Frontloading of calibration from the vehicle to testbed through simulation and objective evaluation of vehicle driveability
- Virtual pre-optimization of vehicle and drivetrain in the office and on the testbed
- Virtual replacement of hardware components: Axles, shafts, tires, …
- Simulation of 85% of AVL-DRIVE criteria with an accuracy exceeding 90%
- AVL-DRIVE and VSM are fully integrated in PUMA Open (incl. Driveability Libraries)

The so-called “Vehicle Simulation Model” (VSM) is a mathematical model for the simulation of driveability in real-time. Its flexible model structure as well as the tight connection to AVL-DRIVE™ offers the option of frontloading the optimization of driveability in earlier development steps, thereby avoiding repetitive loops in the development caused by missed driveability targets, for example.

MODEL REAL-TIME INTEGRATION AVL ARTE.LAB™

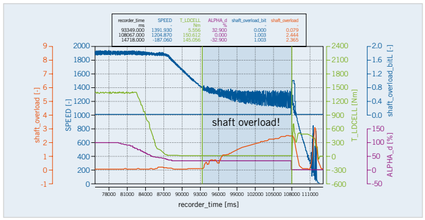


BENEFITS AT A GLANCE

- Seamless integration of customer-specific Simulink® models
- No additional HW, no MATLAB®/Simulink® required on testbed
- Online parameterization of models with Model Parameter Editor
- Update/calculation frequency of models up to 1kHz

AVL ARTE.Lab™ is an open simulation environment for the integration of real-time applications into AVL PUMA Open and AVL EMCON Standalone Advanced. AVL ARTE.Lab™ uses MATLAB®/Simulink® for modeling of engine and powertrain components and systems as well as other real-time applications. It consists of the development environment AVL ARTE.Lab™ Studio SDK and the run-time environment for the execution of real-time models AVL ARTE.Lab™ RTE. A generic Model Parameter Editor (MPE) allowing the smooth management of the model parameters at run-time is provided. AVL ARTE.Lab™ Explorer is an extension to visualize internal processes in models of the MATLAB®/Simulink® based real-time applications.

PREVENTION OF DAMAGE ONLINE SHAFT MONITORING



BENEFITS AT A GLANCE

- Reliable online monitoring of shaft overload
- Easy to adapt shaft characteristics using online parameterization

APPLICATION

The developed algorithm enables reliable monitoring in all operating states, including stationary and transient operation as well as during engine start and stop. In manual and automatic testbed operation, critical system states with regard to the shaft load are detected, and the unit under test can be stopped.

Unexpected behavior of the unit under test can excite the testbed shaft connection. This leads to a high demand for monitoring and safety systems. Existing monitoring functions have to date protected the engine and dyno system. AVL’s new online shaft monitoring offers a solution to protect the shaft through online detection of shaft overload resulting from undesired oscillations.

	 UUC 400 (HW & SW)	 BME 400	 EMCON 400 (HW & SW)
Dyno interface:			
• Dyno types	n.a.	All AVL dynos	all AVL dynos, others on request
• n- and T- control	n.a.	•	•
• Controller frequency	up to 1000 Hz	up to 1000 Hz	1000 Hz, 5000 Hz[1)]
Engine interface:			
• n- and T- control	•	•	•
• Multiple N/x-control	Option	n.a.	•
• Logic control (ignition, ...)	•	n.a.	•
• Engine monitoring	•	n.a.	•
Throttle Actuator Interface			
• Hybrid	•	Set value only	•
• Drive-by-wire 400	Option	n.a.	Option
• CAN	Option	n.a.	Option
Operator interface:			
• Parameter adjustment	Via PUMA	Via P400	Via PUMA
• System hardware	PUMA Open - Computer	Intel (19“/4HU rackmount)	PUMA Open - Computer
Remote interface to other automation systems:			
• RS232	n.a.	•	n.a.
• Hybrid	n.a.	Option	n.a.
• CAN	n.a.	Option	n.a.
• Ethernet	n.a.	Option	n.a.
Simulation functionality:			
• High dynamic torque control @ 5000Hz	n.a.	n.a.	Option
• Vehicle & driver simulation ISAC	n.a.	n.a.	Option
• Simulation model cont. variable transmission	n.a.	n.a.	Option
• Simulation model automatic transmission	n.a.	n.a.	Option
• Simulation model double clutch transmission (DCT)	n.a.	n.a.	Option
• Interface external simulation	n.a.	n.a.	Option

[1)] high dynamic torque control

	 ROAD LOAD + MASS & ROAD GRADIENT 400	 VEHICLE AND DRIVER SIMULATION ISAC 400
Time-based demand values	Yes	Yes
Distance-Based Demand Values	Yes	Yes
Road load simulation	Via equation or look-up table of up to 10 points	Via equation or look-up table of up to 10 points
Road gradient simulation	Yes	Yes
Drivetrain ratio simulation	One tunable parameter	Simulation of cardan shaft, differential, axle and wheels
Drivetrain oscillation simulation	Not available	Simulation of drivetrain oscillation and damping behavior
Transmission simulation	Only one ratio for the whole drivetrain	Manual with inertia and efficiency simulation
Alternative transmission simulation		Automatic transmission cont. variable transmission
Clutch simulation	Not available: alternative is a real clutch on testbed	Zero-inertia simulation when clutch is ”open“, simulation of engagement during gearshifting
Vehicle simulation	Simulation of vehicle mass	Simulation of vehicle mass and drivetrain inertia
Driver simulation	Control of throttle only	Simulation of driver with variable gearshifting behavior
Gear shift criteria		Speed, vehicle speed, 2D lookup tables with lookahead functionality
Additional control modes	RG/Alpha RG/V	RG/Alpha RG/V
Online change of parameters	Yes	Yes
Look ahead driver		option
External simulation interface		option
Pre-requisite	EMCON400 with torque control time below 10 msec	EMCON400 with high dynamic torque control

TEST INFORMATION MANAGEMENT

APPROACH

Since the beginning of networking testbeds in the early eighties, AVL as the first provider of engine testbeds has been working on optimized solutions to support the employees in the fields of planning and preparation of test jobs, including support at the testbed and further processing of test results. The continuity between the individual components to form a highly efficient information chain from development to test facilities makes an important contribution to increasing the efficiency of the overall development process.

BENEFITS AT A GLANCE

- Enhanced utilization of the testbeds (according to an AVL study, an average potential increase of 20 percentage points)
- Optimization of the productive test time
- Reduced time and costs for administrative activities due to central data management
- Fast response times due to remote monitoring of the entire test facility

TASK

During the past twenty years, the focus of the fast development in the field of test technology of engines and powertrains has been on technical enhancements in the field of measurement technology, automation and control. With regard to the functionality, user guidance, stability and performance of test systems, decisive steps have been taken and the test methodology has been further developed on a continuous basis. However, within the framework of the race for increased productivity, shorter development times and lower costs, the pressure to develop new synergies between human beings and systems (interaction in complex and heterogeneous system environments) is increasing. Test information management, handling data and information intelligently at all levels, plays an increasingly important role.

A significant productivity gain in terms of testbed utilization can be achieved by integrating all test systems into a central data management system, in order to minimize delays and downtimes at the testbed.

Another efficiency factor is to optimize the workflow throughout the entire test operation in order to prevent unnecessary losses of time or quality. Test facilities require flexible systems that can adapt continuously to the employees' working environment and at the same time guarantee smooth performance of all standard tasks.

An individual balancing of standardization and flexibility is the success factor for increased productivity and reduced stress for all employees concerned.

REFERENCES

CENTRAL WORLDWIDE DATA MANAGEMENT

Using the SANTORIN HOST™ system, all data is organized centrally within the test facility in a shared database and provided to the testbeds across several applications, from engine tests and transmission systems to component tests.

PROCESS SUPPORT IN THE ENTIRE TEST OPERATION

The AVL TestFactory Management Suite™ (TFMS™) supports the users from test request and planning to test analysis. Due to seamless integration into the test process, it is possible to realize additional potentials for increased efficiency.

REMOTE MONITORING OF TESTBEDS

AVL TestGate™ provides users within the test facility with efficient remote access to the online data of the testbeds and HOST systems via a Web browser, offering a real-time overview of the status of all test beds.

INSTALLED BASE

More than 200 SANTORIN HOST™ installations with about 2000 networked AVL testbeds worldwide combine the experiences of more than 25 years of development with new innovations to increase the efficiency in test operation for engine, transmission, component and vehicle tests.

AVL SOLUTIONS FOR TEST INFORMATION MANAGEMENT INCREASE THE EFFICIENCY AND QUALITY DURING TEST OPERATION FOR LOCALLY AND GLOBALLY NETWORKED TEST FACILITIES.

Relocating parameterization and analysis tasks to the office workplace saves valuable testbed time.

BENEFITS AT A GLANCE

- Comparable measurement data throughout the test facility thanks to a central database containing all measurement data and variables for testbeds from AVL and other suppliers
- Shorter setup times with parameterization from the office
- Shorter downtimes with data analysis in the office
- Reduced costs and time for administrative activities due to central data management for parameters and result data
- Efficient user management due to centrally managed access rights for testbeds and analysis
- Simple data exchange with external systems by means of open interfaces standardized in accordance with ASAM-ODS

CENTRAL DATA MANAGEMENT FOR TESTBEDS

AVL SANTORIN HOST™

Individual automation systems are networked with a productive test facility in an ideal manner. Parameters and results are stored centrally in a database, standardized in accordance with the ASAM-ODS standard, and the data is available for all users at any time. AVL HOST systems are designed for test facilities with between 1 and 70 automation systems.

APPLICATION

In order to achieve continuous utilization of test beds, all activities impairing continuous test operation have to be kept away from the testbed. These activities include, for example, the definition of the test run parameters or the analysis of the result data.

Furthermore, efficient test facility operation is only guaranteed when the data can be applied and compared across several testbeds. For this, all data, such as variables, units, dimensions, fuel data, calibration data, formulae, etc., are stored on the central data server and made available to the testbeds. As a result, centrally created test runs can be executed on different testbeds and the result data can be compared between different testbeds. The results are analyzed either locally at the testbed or at the office workstation.

The integrated interfaces, standardized in accordance with ASAM-ODS, provide many third party suppliers with access to information within the test facility by means of open, defined programming interfaces and file formats.

STANDARDIZED DATA STORAGE

AVL SANTORIN ASAM ODS SERVER™

Central storage of heterogeneous data, logical connection of the contents as well as uniform access mechanisms are the basic preconditions for efficient cooperation in state-of-the-art test facilities. On the basis of compliance with the globally approved standard ASAM-ODS, the AVL SANTORIN data server provides the infrastructure for corporate solutions for consolidated storage and manufacturer-independent analysis of data in the development process. Comprehensive tools for managing and processing the data allow the creation of scalable server structures.

APPLICATION

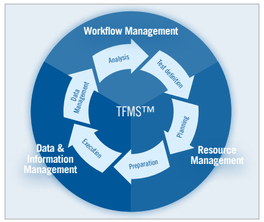
Within the framework of the engine and powertrain development process, there is an increasing need to link information between different test applications. The sources of this information are different test facilities of different generations and manufacturers. The testbeds for applications, such as engine development, transmission testing, endurance tests, noise and vibration tests or crash tests, provide non-compatible results in different file formats.

In order to provide the participants in the vehicle development process with unrestricted access to all generated data, integrated IT solutions are required at several levels. These also have to be able to forward the test results to another central database (SANTORIN data server). The communication basis for this is the ASAM-ODS standard. The end users can comfortably access all data by means of the ASAM-ODS server SANTORIN.

The SANTORIN software tools allow powerful, central data management solutions to be developed to give employees efficient access to all data in the test operation.

BENEFITS AT A GLANCE

- Simplification of the data analysis for users thanks to uniform access to testbed data of different manufacturers
- Use of a standardized analyzing tool for cross-application measurement data, e.g. engine, powertrain, component and vehicle tests
- Efficient teamwork due to consolidation of data from different test facilities or locations
- Reduction of the time and costs for administrative activities due to standardization and centralization of test data



TFMS™, our modular test facility management system, can be configured to many applications (engines, gears, components, rollers, etc.). Open, standardized interfaces make TFMS™ easy to integrate into existing IT infrastructures, guaranteeing automated information flow from ordering to conclusion of a test.

BENEFITS AT A GLANCE

- Higher utilization of the testbeds (typically an increase by 20 percentage points, according to an AVL study)
- Reduction of non-productive times (e.g. tests to be repeated due to incorrect methodology or erroneous parameters)
- Reduction of the time and costs for administrative activities and redundant, manual data transfers
- Continuous utilization optimization through comparison of planned and actual utilization
- IT-supported standardization and continuous optimization of the workflow

TEST FACILITY MANAGEMENT

AVL TESTFACTORY MANAGEMENT SUITE™

The AVL TestFactory Management Suite™ is the first modular system to standardize and automate the core processes within the test facility. The core tasks of the system comprise managing all data in an efficient manner and activities related to test jobs, test equipment and units under test. Traditionally, this is implemented by different persons with the help of different systems.

APPLICATION

While there is a trend towards increasing complexity of the processes and diversity of the systems in test facilities, the test costs are to be reduced drastically. Simultaneously, the reliability, reproducibility and quality of the process are to be improved. The TestFactory Management Suite™ supports the users in achieving these seemingly contradictory objectives.

In order to support the seamless implementation of test processes, the system controls the work steps and provides all data and documents that are relevant in the corresponding step. This way, the planning, definition and implementation of test jobs as well as inventorying, maintenance, and calibration of test equipment are managed and optimized with the help of the TestFactory Management Suite™. The existing system environment within the test facility is not replaced, but the TestFactory Management Suite™ integrates and interacts with the existing systems, such as project management, unit under test and calibration data management. Thus, the TestFactory Management Suite™ taps into the unused productivity potential of a test facility through cross-networking and providing the corresponding information at the right time and place.

REMOTE MONITORING

AVL TESTGATE™

Get an overview of the status of the entire test facility – easily via Internet and Web browser from your office, while traveling or from any other location with Internet access. You can retrieve the current status of all testbeds, loaded parameters and online measurement values at any time.

APPLICATION

Within the test facility, TestGate™ supports users of different fields in monitoring, managing and diagnosing testbeds.

- The testbed operator can retrieve data from PUMA testbeds (PUMA 5.5, Puma 5.6 or PUMA Open), from Non-PUMA testbeds and from HOST systems, in order to obtain a detailed status overview.
- Testbed administrators obtain an overview of the entire test facility and can determine the status of the overall test facility in a very efficient manner. Thus, they can diagnose malfunctions quickly by navigating to a certain testbed from the overview and retrieving details.
- The responsible development engineer can use TestGate™ to observe the status of his testbed. Furthermore, he can support testbed operators from his office or his home office by means of an Internet connection.

Furthermore, TestGate™ makes use of the existing security mechanisms of the test facility thus avoiding additional user management within TestGate™.

The TestGate™ start screen shows a compact overview of the current status and measured values from all testbeds. It also allows mobile access to the status of each testbed at any time, over a network connection to the test facility (e.g. via Internet).

BENEFITS AT A GLANCE

- Fast and safe remote access to testbeds from any Internet connection
- Clear, graphical status representation of all testbeds within the test facility
- Reduced response times for support activities
- Improved and simple access to test information and administrative information
- Simple company-wide roll-out without software installation at the personal computer: TestGate™ requires just a Web browser

AVL CUSTOMER SERVICES

APPROACH

We understand the tremendous challenges our customers face with CO_2 reduction, high numbers of vehicle variants and powertrain setups as well as tough cost and efficiency targets. That's why AVL Customer Services has designed a portfolio for "Serving our customers anywhere, at any time, with everything necessary to achieve their testing objectives."

COMPREHENSIVE SERVICE PORTFOLIO

Our modular service portfolio meets all your requirements, from basic services for equipment and staff to fully tailored service programs for complete test fields.

GLOBAL SOLUTION COMPETENCE

AVL's global network of highly qualified experts at more than 35 locations provides the know-how, proximity and responsiveness that is essential in today's globalized, fast-paced world.

MAXIMIZED UTILIZATION

New technology provides new functions and features. AVL Customer Services helps you to maximize the value of your investment. Premium AVL testing technology combined with Best-in-Class Services ensure an optimized product and service package.

BENEFITS AT A GLANCE

- Short ramp-up phase and maximized long-term availability of your test equipment
- Optimized value of your investment through tailored service programs
- Safe and reliable operation due to knowledge transfer from AVL's experts
- Application specific solutions for your individual testing tasks

TASK

Running a test system is an extremely challenging task, both technically and economically.
AVL's service solutions safeguard the availability and usability of your testing equipment and measurement devices in all phases of the product lifecycle, avoiding the high cost of operational downtime and the risk of inaccurate testing results.

In case the unexpected happens, AVL Customer Services has highly qualified service personnel ready, to be at your site within the shortest possible time. AVL Customer Services can share its expertise with your experts in the form of professional training and support. This is what we call the "Fast track to comprehensive skills and results".
Leading edge technology needs innovative service solutions. AVL Customer Services provides the best possible service solutions as a partner to many of the industry's leading companies - every single day.

AVL CUSTOMER SERVICES
EXPERIENCE THE ADDED VALUE.

REFERENCES

GLOBAL PRESENCE AND SERVICE QUALITY

AVL operates a worldwide network of service experts. More than 600 employees (some 480 employed field staff) are ready to assist our customers in more than 35 locations. 14 hotlines also guarantee our customers access to professional support.

SOFTWARE/HARDWARE CARE

AVL CARE controls services in more than 50 test facilities and 1,000 testbeds. A CARE service level agreement with clearly defined performance criteria guarantees the efficient operation and maintenance of software and hardware. We provide you with fast and direct access to expert support with our AVL CAREline™ team.

INTEGRATED RESIDENT SERVICES

More than 20 customer test facilities enjoy the benefits of a permanent on-site AVL team. Maintenance, support and operation of more than 600 testbeds worldwide is carried out by AVL. AVL also operates more than 130 of its own testbeds at 14 different locations.

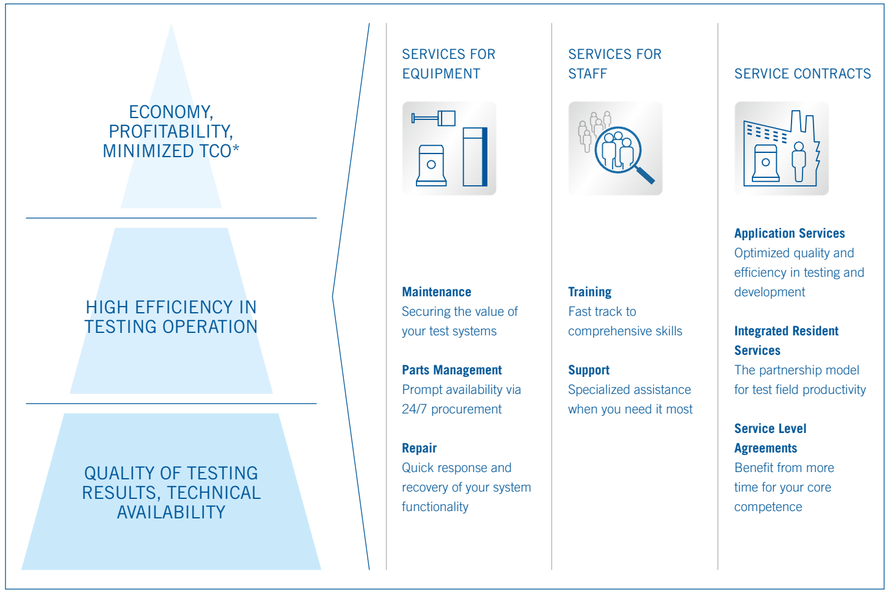
APPLICATION SERVICES

AVL supports you in increasing efficiency and testing effectiveness. Using the right calibration methodology and infrastructure can reduce the testing time by more than 70%. A tailored service concept can boost utilization rates to >80% and technical availability to >97% due to AVL's combined know-how in testing and engineering.

A TRULY COMPREHENSIVE SERVICE PORTFOLIO. WHAT MORE COULD I POSSIBLY NEED?




AVL CUSTOMER SERVICES – EXPERIENCE THE ADDED VALUE



*) Total cost of ownership

MAINTENANCE

Careful maintenance makes a significant contribution by ensuring that measurement systems remain competitive and retain their long-term value.

HARDWARE MAINTENANCE

AVL Maintenance is based on product-specific maintenance schedules. There is a tailored maintenance schedule for every product. Certified service engineers ensure quality and use original parts only.

FACTORY/ON-SITE CALIBRATION

Quick and reliable calibration and adjustment procedures are implemented by certified calibration centers. By using only highly trained experts who comply with rigorous standards, we ensure the highest accuracy and quality.

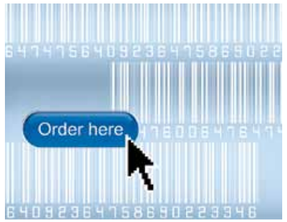
SOFTWARE MAINTENANCE

Clearly defined maintenance procedures guarantee the quality of software and improvements to keep it up to date. Feedback from all users is analyzed and used to remedy any errors or implement any enhancements. The enhancements are available to all users by means of software hotfixes and service packs. As a result, all users benefit from the feedback of others and from the systematic enhancement procedure mentioned above.

Securing the value of your test systems.

BENEFITS AT A GLANCE

- Fewer unplanned downtimes
- Reproducible measurement results makes comparison of measurement data easier
- No expensive measurement errors and unnecessary repetitions
- Qualified employees guarantee efficient and high quality maintenance and calibration work
- Costs and time can be planned around tailored maintenance schedules and fixed prices
- The value of software and equipment is secured through systematic maintenance and enhancement



Prompt availability via 24/7 procurement.

PARTS MANAGEMENT

The quick supply of spare parts is an integral factor for reducing unplanned downtimes. The AVL spare parts program offers a comprehensive solution for standard and customer-specific parts and it combines short delivery times and cost efficiency.

AVL eSPARES™

AVL eSpares™ is a web shop covering the total business process: online parts catalog, online availability check, online price information, direct order option and follow-up. Adjusted logistics processes and a global logistics concept provide for express and on-time deliveries all over the world. Processing RMA deliveries (return merchandise authorization), value contracts (AVL eVoucher) and downloading product information can be performed on the Internet. Roughly 3,500 registered users currently take advantage of the web shop with 24h service.

CUSTOMER-ORIENTED SPARE PARTS SOLUTIONS

Customer-specific spare parts support plans are developed based on the installed devices/systems and failure probabilities. Combination options with AVL Quick Stock (on-site storage solutions) help to ensure system availability at the highest level. AVL eSpares™ can be easily integrated into the purchase systems of customers or online marketplaces on the basis of standardized interfaces, such as the BMEcat/XML.

BENEFITS AT A GLANCE

- Fewer downtimes due to quick access to original spare parts
- Current product and price information via the online web shop
- Cost-optimized spare parts ordering with straightforward ordering procedures
- Efficient solutions for securing system availability by means of customer-specific spare parts concepts
- Total cost optimization through simplified supplier management and less tied-up capital
- Comprehensive spare parts portfolio with long-term availability

REPAIR

Unexpected breakdown is one of the main customer concerns. To ensure short downtime of the instrument or system, AVL offers a comprehensive repair portfolio including on-site repair and factory repair with a rental service option.

ON-SITE REPAIR

On-site repair is carried out according to EN 13306:2001 after the identification and recognition of an error in order to restore a product to a properly functioning state. Certified AVL technicians provide an accurate error diagnosis and quickly eliminate the problem at the customer site. AVL technicians are equipped with state-of-the-art tools for professional and efficient intervention on site.

FACTORY REPAIR

AVL offers rapid and high quality repair services in certified Repair Centers. Because repair work is performed by specialists using original AVL parts and following certified processes, reliable high quality repair can be guaranteed. AVL also offers a flat-rate system for the majority of its products. This means transparent costs as well as easy and fast processing.

The repair activities performed are documented in a repair report. Check-out tests are executed according to AVL test regulations.

RENTAL SERVICE

The availability of spare devices is very useful for minimizing downtime during the repair, maintenance or calibration of instruments. AVL's rental solution offers a cost efficient alternative to ensure productive operation.

Quick response and recovery of your system functionality.

BENEFITS AT A GLANCE

- Minimization of downtimes by combining on-site repair, factory repair and rental service
- Quick recovery of the functionality of the devices ensured by certified AVL technicians
- Sustainable problem-solving due to the exclusive use of original AVL parts

Fast track to comprehensive skills.

BENEFITS AT A GLANCE

- Sustained and rapid knowledge build-up
- Improved ability to perform testing tasks
- Competitive advantage due to shorter development cycles
- Reliable system operation
- Highly motivated staff

TRAINING

Engine and Powertrain development takes place in an extremely challenging and competitive environment. Fast time-to-market requirements, increasing complexity and strong cost pressure form the backdrop to all development projects.
AVL offers a comprehensive range of professional knowledge management and training services to guarantee that AVL test and measurement technology can be operated with the maximum efficiency and productivity. Our knowledge and experience in the fields of powertrain development, test equipment and simulation technology for on and off-road applications informs the systematic and highly professional skills development that takes place in the AVL Skills Center.
The AVL Training philosophy is content and method tailored to different groups of users and job requirements. By using state-of-the-art communication techniques including WBT (Web-Based Training) we ensure rapid build-up of knowledge for safe, reliable and highly competent operation of the products and systems.
Professionally skilled trainers (through regular practical assignments) impart the necessary knowledge to perform the testing tasks.

PRODUCT TRAINING

A wide range of standard courses teach the skills to specific user groups for operation, functionality, parameterization and maintenance of AVL test and measurement technology. Tailored courses to solve customer-specific operation and parameterization tasks are also available. All courses take place at the customer's location or in AVL Skills Centers.

TECHNOLOGY SEMINARS

These seminars provide the latest guidelines for handling with existing and new technologies (e.g. electrification, hybrid, emissions), new testing topics as well as legislative demands.

SUPPORT

AVL customers are provided with comprehensive assistance during daily operation in order to make the most of their testbed systems.

START-UP / OPERATION SUPPORT

Powertrain and vehicle test facilities have to be productive to fulfill the expected time schedule in development and testing. The operation phase starts after commissioning of test equipment and staff training. Especially during ramp-up phases of test facilities, the required learning times can result in capacity shortages and inefficiency. With the Start-Up / Operation Support running, test facilities are optimized and temporary capacity shortages are bridged. Therefore, productive operation is achieved earlier and usage is increased in a sustainable manner.

HELP DESK SUPPORT

Help Desk Support is provided as Hotline or AVL CAREline™.
Users can communicate with the service organization using the AVL Hotline. Product-specific or general topics of daily operation are recorded and handled by the AVL service organization.
The AVL CAREline™ offers direct access to experts, and the specific contact persons are adapted to the customer's organization. Specially trained employees resolve queries within contractually guaranteed response times.

Specialized assistance when you need it most.

BENEFITS AT A GLANCE

- More efficient procedures and shorter ramp-up phases by means of Start-Up / Operation Support adapted to the needs of the customer
- Improved usage of tool capabilities and efficient realization of test procedures by expert support during system parameterization
- Optimal flow of information and quick problem resolution due to clearly defined contact persons

Optimized quality and efficiency in testing and development.

BENEFITS AT A GLANCE

- Reliable and optimized application of test systems
- Reduced development time due to less test and measuring effort, e.g. through high test bed automation rate
- Improved quality of development process through consistent, standardized processes
- Higher quality of results, e.g. through use of online data plausibility checks, statistical raw data evaluation and model based approaches
- Know-How transfer from AVL to customer

APPLICATION SERVICES

OEMs have to adopt the latest methodologies and tools to fulfill today's demands and future targets in calibration and powertrain vehicle testing. An organization has to have:

- Correctly specified, reliable facilities (test beds, instrumentation and tools)
- People with the appropriate skills to achieve the best from the available tools and methodologies

AVL provides Application Services by assigning application experts who are temporarily or permanently on site and work at the customer's facility together with the customer's personnel. Examples:

APPLICATION SERVICES FOR ENGINE TEST BEDS

AVL experts provide deep knowledge, e.g. in the use of AVL CAMEO and AVL PUMA OPEN in XCU diesel or gasoline calibration tasks. Post processing, for example in the form of model-based approaches, can also be part of these services. Application Services lead into productive use of new methodologies, e.g. "Design of Experiment" (DoE) and tools in ECU calibration.

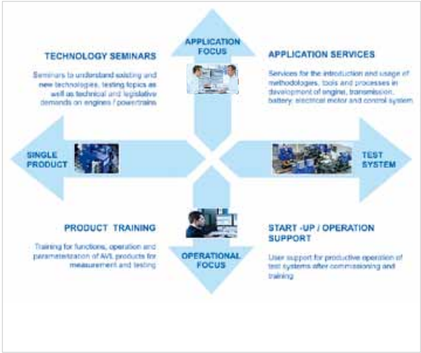
APPLICATION SERVICES FOR POWERTRAIN TEST BEDS

There are different combinations of configurations and testing targets for powertrain test beds: It could be only a transmission with electrical input or a complete hybrid powertrain with 4WD. For this broad range of targets AVL experts support in answering the following questions: How to investigate durability in relation to a specific load profile? What is the best approach to evaluate shifting behavior of an automatic transmission or to pre-calibrate a TCU? How to get a specific test from the road into the test cell? AVL supports with competence to show the possibilities and limitations of new approaches.

AVL CUSTOMER SERVICES – EXPERIENCE THE ADDED VALUE

Our services fit seamlessly into the powertrain and vehicle development process as shown in figure 1. Different departments co-operate in this process. A service provider has to understand the interaction of all parties involved in order to identify synergies and ensure efficient service implementation. This results in added value for the whole process.

The service quadrants, shown in figure 2, are the foundation for realizing the added value. Application Services are a necessary addition to the described service portfolio: they encompass the different customer applications as well as the customer-specific tool chain. The results are high efficiency and high data quality.



The partnership model for test field productivity.

BENEFITS AT A GLANCE

- Maximum efficiency in test operation thanks to personnel know-how and experience
- Secured functionality and guaranteed technical availability of testbed systems
- Personnel deployment adapted to the actual work load
- Reduced costs due to well-defined processes and responsibilities, allowing the focus on core competences

INTEGRATED RESIDENT SERVICES

Integrated Resident Services (IRS) are customer-specific partnership models. These models are responsible for the maintenance and the support of test equipment and the implementation of test programs. IRS means that customers can concentrate on core competences, reduce their costs and optimize productivity.

MAINTENANCE/REPAIR

The partnership model comprises all activities in the field of maintenance, repair and device calibration, including the coordination of sub-contractors and other suppliers.

SUPPORT SERVICES

User support and/or test procedure parameterization, problem/case analysis and solutions, data post-processing and result analysis. Possible objectives are start-up, system optimization, continuous process enhancement and knowledge transfer to the personnel of the customer.

OPERATING TESTBEDS

AVL can provide operating services or even take over full responsibility for operation of a test facility. This typically includes mounting the unit under test, implementing the test program, monitoring the test procedure, checking the data for plausibility, managing the resources and documentation.

SERVICE LEVEL AGREEMENTS

Service level agreements between AVL and our customers define the contents and the level of services. The agreed services are based on the implementation of measurement criteria, and the level of goal achievement can be measured. This makes planning easy and reduces costs.

SOFTWARE CARE

The focus of the agreement is on support by the AVL CAREline™. CARE customers have clearly assigned contact persons with guaranteed expertise, meaning that problems are solved quickly. A typical CARE agreement contains software maintenance and software subscription, guaranteeing access to the latest software and functionality. Upon customer request, the agreement also includes installation services as well as the commissioning of testbed software and hardware.

HARDWARE CARE

This service level agreement contains the maintenance and repair of measurement devices and testbeds. Support by means of the AVL CAREline™, customer-specific spare parts solutions and inclusion of factory repair round off the package. The agreement guarantees high levels of technical availability of the systems and optimal quality measurement results.

The extended warranty for measurement devices is a special version of HW CARE. If the systems are maintained regularly in accordance with the maintenance instructions, an all-inclusive agreement covers unplanned service work and spare parts.

Benefit from more time for your core competence.

BENEFITS AT A GLANCE

- Using competitive software and measurement devices in an efficient manner by means of quick and solution-oriented support by product experts (AVL CAREline™)
- Ensuring test operation with uniform software status that is ideal for the application by means of SW CARE
- Securing the value of hardware and software through regular maintenance work
- Reducing ongoing operating costs through services that can be planned, the use of product experts and high-volume scaling effects

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