AVL Emissions Measurement Solutions

APPROACH

AVL offers the complete range of emission test systems for certification, development and conformity of production on engine and chassis dynamometer testbeds. The latest requirements of global emissions regulations are complied with by the new iGeneration Series II product line. AVL is able to offer products with the highest quality available on the market. Testbed solutions with permanent automation and data analysis 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.

TASK

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

Further requirements result from the "In-Use" and "Real Driving Emissions" legislation, which requires checking vehicles in real operation with portable emission measurement systems.

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

The requirements placed on operators and for the automation systems are increasing because of the rising number of measurement parameters and device subsystems needed. At the same time, the demand for an increase in productivity has to be met. AVL has optimized its emission measurement technology for these challenges and offers futureproof system solutions combined with an integrated testbed automation system.

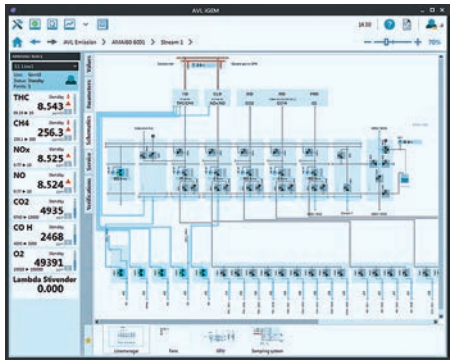
ONLY AVL COMBINES A COMPREHENSIVE AND HIGH-QUALITY EMISSION TESTING PRODUCT RANGE WITH THE IN-HOUSE KNOW-HOW OF AN ENGINE DEVELOPER AND TESTBED OPERATOR.

BENEFITS AT A GLANCE

- All-in-one solutions from a single source
- Tailored systems for certification, development and COP (conformity of production)
- Future-proofing with maximum flexibility of automation systems and the latest analyzer technologies
- High quality products due to decades of expertise and comprehensive know-how, proven by a broad installed base
- Global service support

REFERENCES

AVL has 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.



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

EXHAUST MEASUREMENT SYSTEM

AVL AMA i60 SII

The AMA i60 SII exhaust measurement system has an extended portfolio of gas analyzers (QCL, HOT CLD, FID/PMD-COMBI) and a compact, modular design. The revised, intuitive and interactive user interface supports all essential service and diagnosis functions and issues warnings in case of pending maintenance intervals. The Quality Center iQ makes it possible to monitor freely selectable variables (e.g. pressures) and visualizes the statistical evaluations of calibration check data.

MEASUREMENT PRINCIPLE

Integrated pumps draw in the measurement gas from sample points, which can be located at a distance of up to 20 m. Depending on the application, heated lines, overflow valves and pre-filters or sample point selection units located in the vicinity of the sample are used. The analysis of the measurement gas is performed using high-end analyzers – FID for THC and CH_4, CLD and HOT CLD (180 °C) for NO/NO_x, IRD for CO, CO_2, QCL for N_2O, and 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 like pressure, temperature and device status. The AMA i60 SII can also be controlled by means of an AK interface.

APPLICATION

The AMA i60 SII contains analyzers with a broad dynamic measurement range for THC, NO/NO_2/NO_x, CO, CO_2, O_2, CH_4, N_2O, NH_3 and SO_2, which can be adapted to the application (diluted/undiluted exhaust gas or gasoline/diesel/hydrogen/etc). Due to the combination with different sampling systems, the AMA i60 SII is ideally suited for the development and certification of combustion engines according to EPA (including EPA 40 CFR part 1065 and 1066), ECE (including GTR 4 and 15), Japanese and other emission regulations. Special versions and mobile remote or stand-alone units are available with optimized system designs for SULEV, SCR and other applications.

BENEFITS AT A GLANCE

- Best-in-class footprint with up to two streams plus EGR/ Tracer in one 19" cabinet
- 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 interactive flow diagram of the system
- Innovative remote diagnosis down to sensor and valve level

MOBILE EXHAUST MEASUREMENT SYSTEM

AVL AMA i60 Remote/Stand-Alone Units

The 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 the iGEM AMA bench control software on a separate computer.

MEASUREMENT PRINCIPLE

Depending on the application, various analyzer types can be used with the 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 selection 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, QCL (quantum cascade laser) for N_2O and/or NH_3 measurements and a UVD analyzer for SO_2 measurements.

The iGEM AMA bench control software allows for easy and intuitive operation of the AMA i60 Remote/Stand Alone Unit. It provides essential information on the status of an integrated gas analyzer.

APPLICATION

The AMA i60 Remote/Stand-Alone exhaust measurement system is available in the folllowing variations:

- For THC (and CH_4) and/or NO/NO_x measurements
- For CO, CO_2 and N_2O (IRD) measurements
- For NH_3 or NH_3 and N_2O measurements
- For N_2O measurements with a QCL analyzer
- For SO_2 (UVD) measurements
- For measurements of 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.

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-CO_2 determination or SCR ammonia measurements, SHED THC or EPA greenhouse gas (GHG) 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

COMBINED EXHAUST MEASUREMENT AND DILUTION SYSTEM

AVL AMA i60 COMBI

The AMA i60 COMBI combines the proven AMA i60 exhaust measurement system with 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 all-terrain vehicles (ATV). The revised, intuitive and interactive user interface with interactive flow diagram supports all essential operation, service and diagnostic functions and issues warnings in case of pending maintenance intervals. The new Quality Center iQ makes it possible to monitor freely selectable variables (e.g. pressures) and visualizes the statistical evaluations of calibration and check data.

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

MEASUREMENT PRINCIPLE

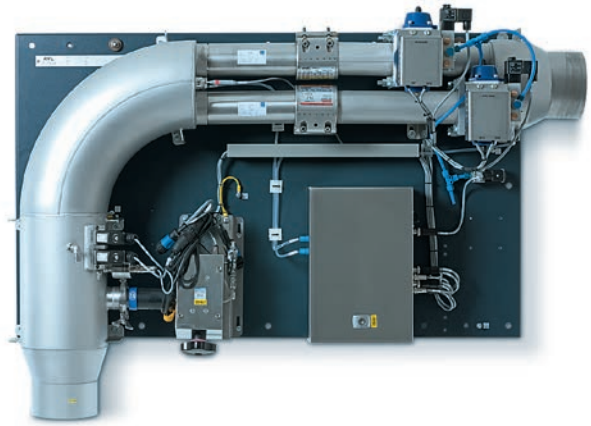
The AMA i60 COMBI comprises a gas analyzer bench for diluted modal and bag exhaust gas analysis combined with a constant volume flow dilution system (CVS). The concentration readings from the analyzer bench together with the volume flow measured with the sonic venturi of the CVS system are used to calculate 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 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 (US Environmental Protection Agency) 40 CFR part 1054/1065. A special configuration for the development and certification of motorcycles and ATVs on chassis dynamometer testbeds is also 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.

BENEFITS AT A GLANCE

- Integrates analyzer bench and bag sampling system in one 19" cabinet
- Very compact CVS venturi unit for flexible installation
- Fits easily onto the exhaust system of small combustion engines
- Optimized solution for SORE, motorcycle and ATV applications
- Sophisticated diagnosis functions with the support of interactive flow diagrams
- Complies with EPA 40 CFR part 1054 and 1065 as well as other worldwide exhaust emission regulations

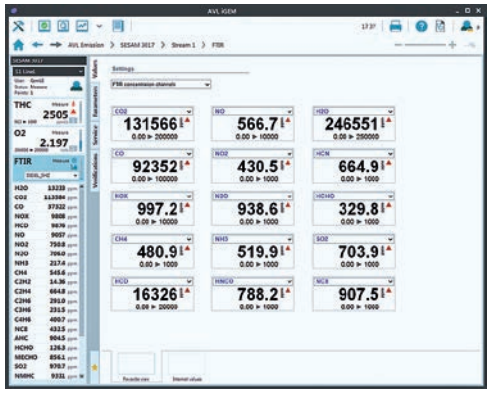


MULTI-COMPONENT EXHAUST MEASUREMENT SYSTEM

AVL SESAM i60 FT SII

The SESAM i60 FT SII provides accurate and fast measurement of the most important exhaust gas components for all automotive applications within one system. The revised, intuitive and interactive user interface supports all essential operation, service and diagnostic functions and issues warnings in case of pending maintenance intervals. The Quality Center iQ makes it possible to monitor freely selectable variables (e.g. pressures) and visualizes the statistical evaluations of calibration and check data.

The sophisticated control software iGEM SESAM is based on the iGEM software platform. The iGEM SESAM software allows for easy, intuitive operation via a touch-screen and provides a quick overview of the system status. It includes diagnostic functions and checks to be performed automatically via the integrated calendar function.



MEASUREMENT PRINCIPLE

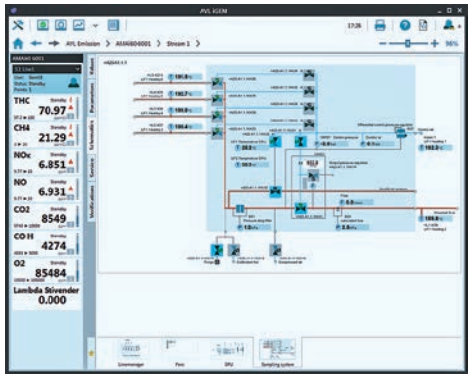
The system is available in two cabinet versions, which allow for various standard setups and the integration of different extensions. The small cabinet includes the FTIR i60 spectrometer and optionally an FID analyzer for THC measurements. The large cabinet may also contain an additional PMD analyzer for O_2 and/or an IRD analyzer for EGR (CO_2) measurements. Alternatively, the large cabinet can be equipped with two FTIR i60 spectrometers for dual stream applications providing simultaneous pre- and post-exhaust aftertreatment measurements.

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 aftertreatment systems is critical for the efficient development of new engines and powertrains. The SESAM i60 FT SII guarantees best quality measurement results and complies with legislative requirements such as Euro VI and EPA 40 CFR part 1065 and 1066 for measurements allowing FTIR.

BENEFITS AT A GLANCE

- Optimized evaluation methods and gas cell for up to three times better detection limits of 5 Hz (e.g. NH_3, N_2O)
- 35 % faster response times at lower sample flow rates (≤ 1.5 s at 8 l/min)
- Extended life time of key components like detector and laser (over 4 years)
- Self-aligned gas cell with robust and service optimized design
- Reduction and ease of maintenance and repairs



The iGEM device control SW provides full control of the heated sampling system down to valve and sensor level

HEATED SAMPLING SYSTEMS

AVL HSS i60

The HSS i60 product line consists of pre-filters, heated sample selection modules and a heated boost pump for raw exhaust measurements.

BENEFITS AT A GLANCE

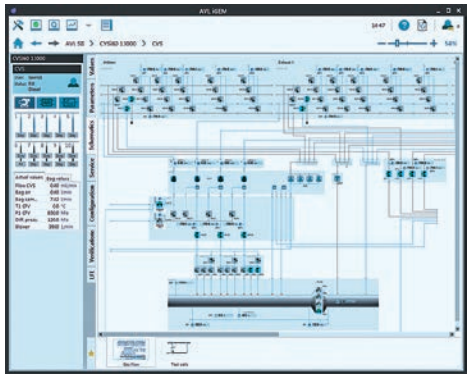
- Extendable with e.g. pressure drop sensor, pressure regulation
- Minimized delay time for transient measurements due to innovative valve manifold layout
- Optimized design to minimize wall effects (hang-up)
- Modular setup for sample point and line switching (≤ 10 inlets)
- Boost pump with controlled recirculation circuit – no bypass required
- Stand-alone pre-filter to be connected to third-party equipment

MEASUREMENT PRINCIPLE

Pre-filters remove particulates from the exhaust gas and prevent contamination of sample lines and emission measuring systems. Heated sample selection modules offer the option to switch an AMA i60 or a SESAM i60 FT to different sample points or lines. Depending on the specific model, extensions like additional inlet filters and flame traps, calibration gas inlets, backflush functionality, turbo pressure regulators, pressure drop and flow sensors are available.

APPLICATION

Different applications, like test cell sharing or large test cells, support the demand for increasingly modular and reliable heated sampling systems. The HSS i60 product line offers a broad range of applications and customized configurations. Depending on the engine and fuel type as well as on the sample point (e.g. pre-cat, post-cat, post-DPF), AVL provides different filter materials such as ceramic, fiber glass or stainless steel. To overcome the pressure drop, caused either by very long sample lines or altitude (simulation), AVL's solution is the Heated Boost Pump.



It is easy and intuitive to perform all functions in the standard operation of the CVS i60 SII. Remote operation concept and interactive self diagnosis functions to sensor and valve level allow for increased productivity as well as reduced and simplified maintenance and service work.

EXHAUST GAS DILUTION SYSTEM

AVL CVS i60 SII

The CVS i60 SII is the most compact full flow dilution system on the market. With a total flow rate of up to 30 m³, all system components fit into one 19"-cabinet. The sophisticated gas flow system guarantees fast response times and the best reproducibility for gas analysis. The extended valve manifold with increased numbers of phases (max. five) and simultaneous analyzing, purging, evacuating and filling optimizes the running of test cycles, e.g. with regard to HEV/ PHEV applications. The modular design – with up to four main flow venturis, three bag sample venturis or, alternatively, with mass flow controllers – supports all possible applications on chassis dyno and engine testbeds. The patented angulated inlet tube allows particulate measurement in accordance with ECE, EPA and Japanese exhaust emission regulations with one dilution tunnel.

MEASUREMENT PRINCIPLE

The exhaust gas is diluted with filtered ambient air close to the tailpipe outlet and then homogeneously mixed in the dilution tunnel for particulate measurement. During each phase of a test cycle, the exhaust gas bags are filled proportionally to the main flow rate of the CVS. The integrated mass emissions are calculated using the background gas concentrations in the bag and the accumulated flow rate of the diluted exhaust.

APPLICATION

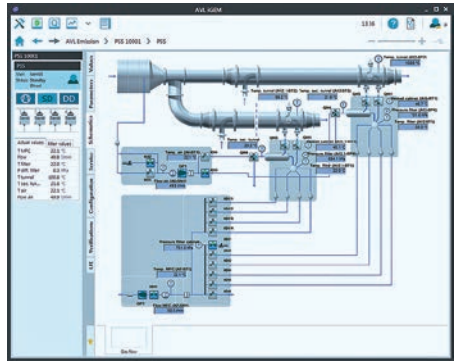
The CVS i60 SII is used for the certification of all kinds of combustion engines and fully complies with the latest emission legislation for passenger cars and commercial vehicles, such as Euro 5/6 or EPA 40 CFR part 1065 and 1066. The CVS i60 SII supports all modern drive technologies like hybrid and gas engines as well as alternative fuels including hydrogen. The CVS i60 SII is available for flow rates up to 20 m³ or 30 m³ (LD), up to 60 m³ (MD) or up to 90 m³ or 160 m³ (HD).

BENEFITS AT A GLANCE

- Simultaneous bag valve functionality, separated sampling lines or backflushable bag venturis for most accurate HEV/PHEV emission testing
- Easy serviceability by front access for venturi calibration and pull-out drawer for maintenance of pumps, MFCs, etc.
- Particulate mass and particle number measurement of GDI and diesel vehicles via one dilution tunnel
- Semi- or fully-automated LFE for venturi calibration
- Minimized total cost of ownership and less power consumption through frequency-controlled blower and alternative operation without heat exchanger

PARTICULATE SAMPLER

AVL PSS i60 SII



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

The PSS i60 SII particulate sampler for gravimetric particle measurement is characterized by its innovative and compact system design for exhaust certification testing. Optimized gas flow rates combined with an enhanced mass flow control and direct electronic signal processing increase the accuracy and reproducibility of measurements, especially with regard to the extremely low PM emissions of today. The new particle filter holder design and temperature controlled sampling provide the best conditions for detecting very small particles in minute quantities. Finally, the particle filter holder is designed to be able to integrate RFID-filter trays for automated filter weighing via the AVL Filter Weighing Robot (FWR).

MEASUREMENT PRINCIPLE

The PSS i60 SII is a full-flow particulate sampling system used to collect particulates from the diluted exhaust gas on a filter during a test cycle. At the beginning and end of the test cycle, the filter is weighed and the particulate mass is calculated and the background application is considered (gravimetric-measurement).

APPLICATION

The CVS full-flow dilution based particulate mass determination is also the reference for partial flow determinations. The PSS i60 SII single dilution (SD) is used for light duty and passenger car chassis dynos. For heavy-duty and off-road engine testbeds the double dilution version PSS i60 SII DD is used. Applications for engine performance and emission development, certification and conformity of production (COP) are fully covered with the PSS i60 SII. 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 19 " cabinet
- Compatible with AVL FWR for automated filter weighing and management.
- Fulfills the latest emission legislations up to Euro 6, JASIC and EPA 40 CFR part 1065 and 1066
- Improved measurement accuracy and repeatability adequate for extreme low PM emission due to optimized gas flow and new sensor technology
- iGEM PSS provides operation, high-grade diagnostics and intelligent interfaces with easy upgradability
- Fully-automated calibration of mass flow controller (MFC)

GRAVIMETRIC PARTICULATE MATTER MEASUREMENT WITH PARTIAL FLOW DILUTION

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 , 1066 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 subsequently be 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. A new field is the certification of passenger cars on chassis dynamometers according to US 40-CFR part 1066.

APPLICATION

The Smart Sampler can be used instead of a CVS for Euro III to VI certification, and, with the addition of the "add-on sampling" option, it also provides other testing devices like particle counters with diluted exhaust samples. The option of high pressure testing allows the Smart Sampler to be used at pressures as high as 1,000 millibar (gauge), and this makes it the 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
- Automatic Filter Changer for up to 20 PM filters.

AVL Filter Weighing Chamber (FWC) for conditioning and weighing of particle filters

AVL Filter Weighing Robot (FWR) for fully automated filter weighing and management

PARTICULATE FILTER WEIGHING

AVL Filter Weighing Chamber and Robot

New legal demands for climate control during the weighing process require an optimized and enhanced weighing environment. Drastically reduced emission limits call for increased measurement accuracy of particulate mass results. AVL's solution to these new challenges is the Filter Weighing Chamber (FWC). It is a cost- and space-saving alternative to a separately conditioned clean room and offers maximum user friendliness, ergonomics and functionality. The AVL Filter Weighing Robot (FWR) automates the weighing process from conditioning to filter disposal and archiving (from 160 to 640 filters). Thus, it reduces measurement inaccuracy and increases the efficiency of the entire weighing process.

MEASUREMENT PRINCIPLE

A laminar flow with a precise monitoring of temperature and dew point is assured within the working area. In addition, the atmospheric pressure is monitored and is ready to be used for the required buoyancy correction. The ambient air inserted into the working area is prepared to achieve the clean room standard 5 according to ISO 14644-1. A vibration-decoupled weighing stone is situated in the weighing section. The high-precision scale is place on this stone. Throughout the whole weighing process, automated by the AVL FWR, the filter stays in a RFID transport ring with integrated RFID chip. Thereby, any filter data can be stored and read anytime. No moving of the filters or handling with foreceps is necessary.

APPLICATION

The AVL FWC is ideally suited for installation in laboratory and testbed environments for particle filter weighing. The working area offers sufficient space for handling and storage of the particle filters. The AVL FWR is used and controlled by means of AVL ParticleScale for the measurement of very low particulate masses.

BENEFITS AT A GLANCE

- Precise control of constant climatic conditions regarding temperature, pressure and dew point in the weighing area to comply with e.g. EPA 40 CFR Part 1065 and 1066, EURO 5/6 (LD) and EURO V/VI (HD)
- Unique and smooth integration of the AVL FWR into the existing PM weighing process
- Fully-automated, movement path and time-optimized weighing process via AVL FWR
- Intelligent storage management with four filter magazine towers and max. 640 filter storage capacity

PARTICLE FILTER MANAGEMENT IN THE WEIGHING PROCESS

AVL ParticleScale

The constant demand for increasing efficiency in the exhaust test field inevitably leads to new challenges for central management and administration of sample filters. Moreover, the many tighter regulations require a lot of effort to ensure the corresponding measurement quality. With AVL ParticleScale, AVL presents a universal solution for managing sample filters as used for particle measurement in emission tests. The intelligent particle filter management supports the user in the weighing process and offers easy handling of test and reference filters as well as reference weights throughout the whole filter life cycle.

SOLUTION

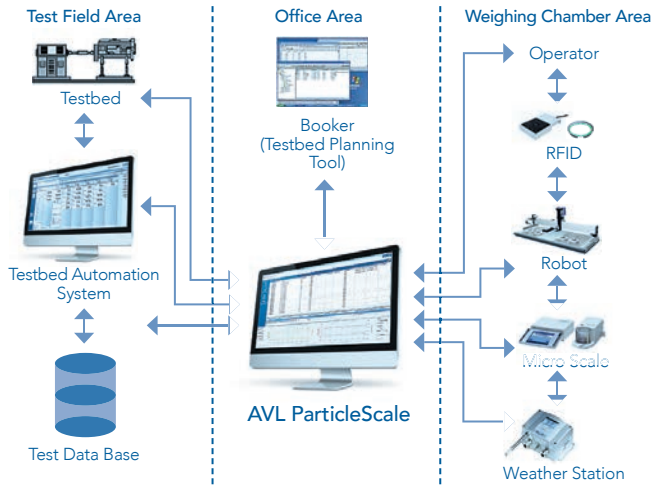
AVL ParticleScale fits ideally into the existing AVL automation system environment and leads the operator through the whole weighing process. Corresponding to the selected test cycle and/or number, size and configuration of the required sample filters as well as the compulsory conditioning time are automatically pre-defined and used in the flow control. Every filter runs through different states controlled by the program, beginning with pre-conditioning and ending with the weighing of the loaded filter and its disposal.

APPLICATION

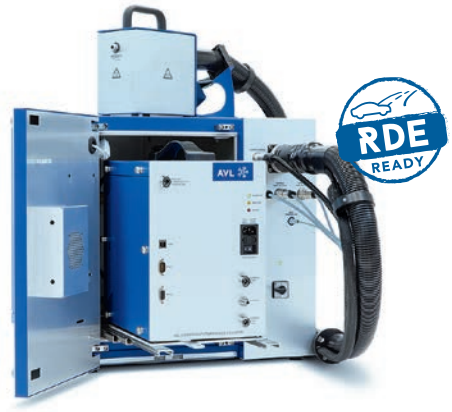
Even for a small number of weighings, AVL ParticleScale enhances the measurement quality of the particle weighing process. On large exhaust test fields, it also increases the efficiency. For further automation of the particle weighing, AVL ParticleScale can serve as an interface between the user and the AVL Filter Weighing Robot (FWR).

BENEFITS AT A GLANCE

- Increased efficiency and quality assurance thanks to intelligent particle filter management
- Central administration of all used test and reference filters as well as weights in the test facility
- Climate data monitoring as well as calculation and storing of the exhaust test measurement results according to current legislation
- Clearly structured and intuitive graphical user interface with extensive configuration and customization options
- Secure identification of filter sets by RFID or barcode labeling
- Easy integration into an external system based on a flexible .NET architecture



Robot control and climate data monitoring, AVL ParticleScale graphical user interface with filter list (active/history)



COUNT ON IT

APC^{plus} – now AVL CPC inside

The APC^{plus} – AVL Particle Counter measures the transient particle number concentration of solid particles in combustion engine exhaust. The new core sensor AVL CPC of enhanced functionality further improves the APC^{plus} performance by both optimizing service and calibration costs. It complies with the legal requirements of UN-ECE R83 and R49 and is the ideal tool for specific R&D applications to be ahead of the RDE challenge.

MEASUREMENT PRINCIPLE

The exhaust sampling is carried out, conducted either directly at a CVS tunnel or a partial flow dilution system (PFDS), or, for R&D applications, directly at the tailpipe of an engine testbed with a heated sample line. Legislation (UN-ECE R83 and R49) requires a complex conditioning system for removing the volatile fraction of engine exhaust. It consists of:

- a hot primary dilution (PND1),
- an evaporation tube (ET) and
- a cold secondary dilution (PND2).

AVL has developed a patented chopper diluter to ensure a very high, size-independent dilution that also allows to use the system to sample from raw exhaust gas during R&D. The particle number concentration is measured by a particle counter (CPC) with a cut-off characteristic specially adapted for automotive applications. The extended measurement and operating temperature range of the AVL CPC guarantees a maximum of test results even under toughest conditions on the engine testbed.

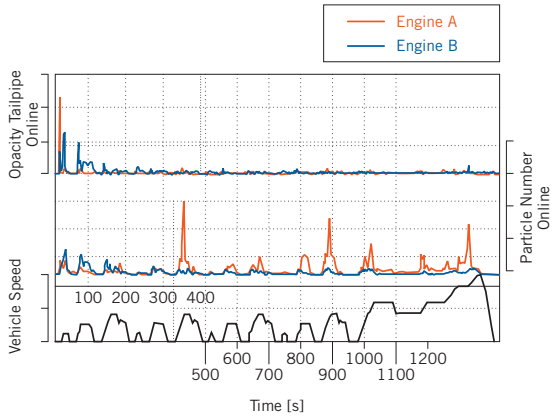
APPLICATION

- 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

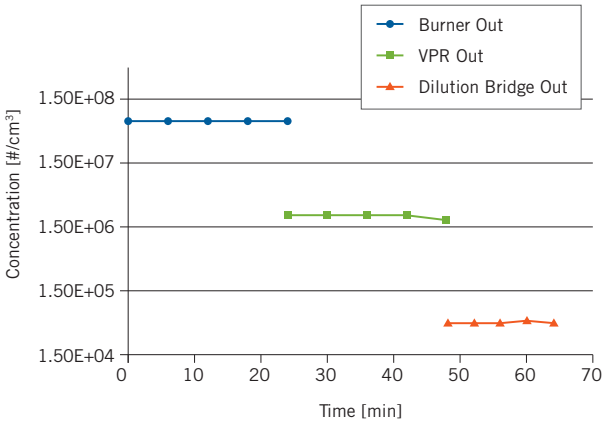
BENEFITS AT A GLANCE

The brand-new combination of APC^{plus} with built-in AVL CPC allows:

- Highest application flexibility due to a three times higher sensor concentration range and best in class dilution accuracy and stability
- Maximum test utilization even under harshest testbed conditions due to a 60 % higher temperature operating range of the AVL CPC
- Unique combination of APC^{plus} and AVL Smart Sampler for highest data quality combined with minimum test effort
- Reduction of service and calibration costs by up to 20 % and throughput times by up to 25 %
- AVL ActiveLink™ for a more efficient and flexible use of AVL measurement instruments, especially in combination with AVL PUMA Open 2™ testbed automation systems



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



The figure shows the aerosol stability of the three available sample outlets

ON-SITE CHECKS FOR PARTICLE MEASUREMENT DEVICES

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
- Adjustable particle sizes

FUNCTIONAL PRINCIPLE

The AVL Particle Generator is a stand-alone device for generating a pre-conditioned 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 etrations and size distributions. An integrated touch-screen display and four pre-adjusted operating points ensure straightforward and fast operation. The pre-adjusted operating points and the recommended applications 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
- Comparison measurement of Micro Soot Sensors and PM-PEMS devices

BENEFITS AT A GLANCE

- Generation of a highly stable combustion aerosol
- Wide range of applications due to integrated dilution stages
- Calibrated operating points for a convenient verification of particle measurement devices
- Straightforward on-site quality checks of particle measurement devices
- Utilization as stand-alone device
- Integrated touch-screen for simplified operation

TRANSIENT SOOT MEASUREMENT

MSS^{plus} – 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 generally a main contributor to particulate emissions. Soot is also the main parameter when evaluating the efficiency of DPF systems.

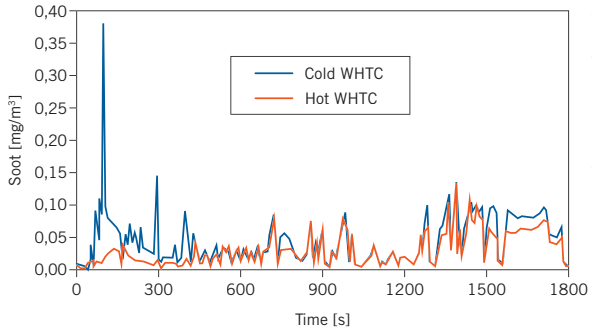
MEASUREMENT PRINCIPLE

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 – is 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 optional 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.

MSS AVL 483 – Cold and hot WHTC



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 concentrations can be observed.

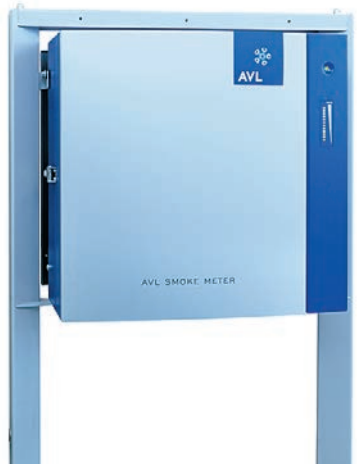
BENEFITS AT A GLANCE

- Transient measurement of soot concentration [mg/m³]
- Measures soot – no cross sensitivity to other components
- High sensitivity (resolution 0,01 µg/m³, detection limit 1 µg/m³)
- Wide measurement range of 1 µg/m³ to 1,000 mg/m³ (with conditioning unit)
- Exhaust back pressures up to 2,000 mbar, temperatures up to 1,000 °C (with conditioning unit)
- Can be used on chassis dyno, engine test cell and for on-board measurements
- Automated thermophoretic loss compensation, providing automatic calculation and display of the loss corrected soot signal

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. The device has become the proven and tested standard in the automotive industry. The variable sampling volume and thermal exhaust conditioning ensure a wide range of applications, from combustion optimization at prototype engines to production monitoring.



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.

MEASUREMENT PRINCIPLE

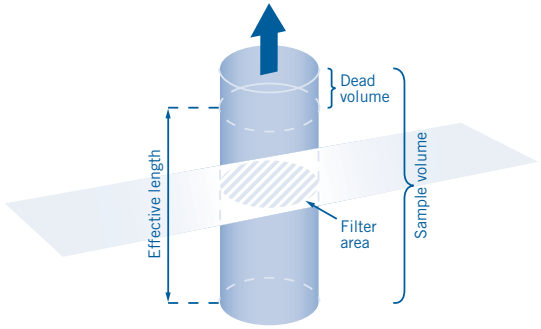
A defined flow rate is sampled from the engine's exhaust pipe through a clean filter paper in the instrument. The filtered soot causes blackening on the filter paper which is detected by a photoelectric measuring head and evaluated in the microprocessor to calculate the result in FSN and mg/m³. The extremely 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 enables measuring 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, the system can also be used for testing at the end of the production line, enabling the detection of 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 5,000 m above sea level and altitude simulation up to 5,000 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 three bars exhaust back pressure for engines with exhaust aftertreatment systems – optional
- Remote-control service with intuitive user interface – optional

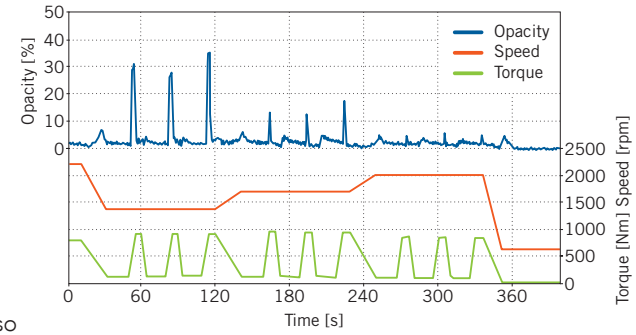


$$\text{Effective length} = \frac{\text{Sample volume} - \text{Dead volume} - \text{Leak volume}}{\text{Filter area}}$$

OPACITY MEASUREMENT

AVL Opacimeter

Recent emissions legislation is increasing requirements for transient test procedures. To comply with tough future emission 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.



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

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.

BENEFITS AT A GLANCE

- High measurement dynamics for transient test runs
- Pre-programmed test cycles, such as ELR or ECE-R24
- High measurement value resolution and signal stability thanks to the conditioning of all essential parts (N = 0.01 %, k = 0.001 m^{-1})
- Also suitable for exhaust gas back pressure of up to +3,000 mbar relative pressure (with high pressure option)
- Low maintenance costs due to the robust design

EMISSION CALIBRATION DEVICES

AVL iCAL

The accuracy of exhaust measurement systems is highly dependent on the quality and precision of the calibration devices used. The AVL iCAL calibration devices guarantee excellent accuracy and reliability and minimize operating costs through fully automated routines. This substantially reduces the time required by the operator. The AVL iCAL calibration devices allow for manual or fully-automated verifications of analyzers (linearity and NO_x converter check) and system leak checks (CFO test).

MEASUREMENT PRINCIPLE UND APPLICATION

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

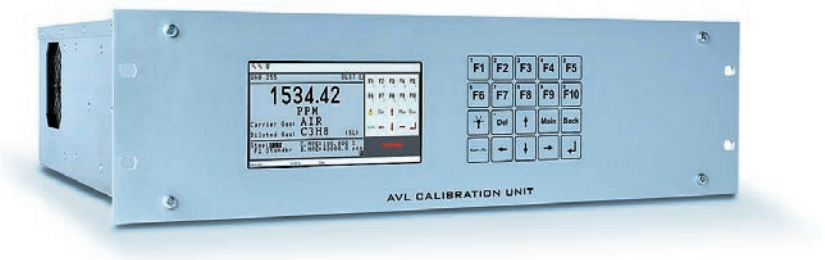
The NO_x converter tester iCAL NGU is used to check the efficiency of the NO_x converter of CLD analyzers. The technology is based on the gas phase titration between NO and O_3 and provides known concentrations of nitrogen dioxide (NO_2). The ozone (O_3) is generated by means of corona discharge in an 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 HBU heated bubbler unit is used to humidify air or test gases for execution of automated quality checks on the exhaust gas measurement systems. The gases are led through two heated water tanks. The water content is measured via a high precision chilled mirror hygrometer. The iCAL HBU supports the sample dryer verification as well as the CLD quench verification according to EPA 40 CFR part 1065.

BENEFITS AT A GLANCE

- High level of precision (< 0.4 % of the selected step)
- Pressure-independent flow stability
- Plug & Play integration
- Simple use and operation
- Excellent long-term stability
- Remote diagnosis down to valve and sensor level
- Factory-calibrated and individually certified, NIST traceable



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 & play and are visualized in the iGEM software.

EVAPORATIVE EMISSIONS DETERMINATION SYSTEM

AVL VT/VV-SHED

VT/VV-SHED systems incorporate state-of-the-art technology responding optimally to clients needs. Long-term experience in the field of analytics and in-house analyzer development as well as automation expertise form the foundation of 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 for the required calibration devices (such as gas dividers, CFO propane injection testers and sensor calibration references) are standard.

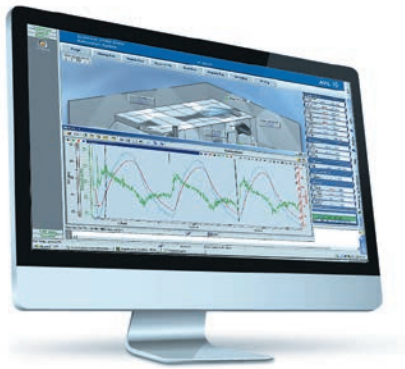
APPLICATION

SHED systems are designed for the evaporative emission measurements of vehicle components (e.g. tank systems) as well as entire vehicles. AVL SHED systems cover both certification and R&D purposes and offer a broad range of applications:

- Available chamber sizes of 1 m³ – 110 m³ (Micro–Magnum)
- Passive-SHED: measurement of bleed emissions
- Running-Loss: chamber with integrated chassis dyno
- ORVR for fuel tank filling tests
- Point-Source solutions
- Temperature control system for motor vehicle tanks (heated pad extension)

BENEFITS AT A GLANCE

- Uniform and analytically optimized system for minimum background measurements
- Flexible modular design
- Integrated standard test procedures and checks (Diurnal, HotSoak, DBLT, Background, etc.) meeting the latest worldwide emission requirements (e.g. EPA, CARB, EU)
- Automated test procedures with an extensive safety concept
- Software extension (e.g. Hybrid)
- CE conform / ATEX certified equipment



SHEDCon automation: Intuitive and easy to use graphical user interface with integrated service and diagnostic functions

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 show themselves to be state-of-the-art by providing a wide range of test solutions and supporting standard certification, individual R&D and durability testing.

MEASUREMENT PRINCIPLE AND SOLUTION

The 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 provide freely adjustable mass flow rates.

The CANLOAD enables the conditioning of activated carbon filters (ACF), which are used in the tank systems of vehicles. During this procedure, the ACF is loaded with butane- and fuel-vapor up to full saturation and is flushed again afterwards. This test verifies the ACF's correct functioning and is compulsory for further evaporative emission measurements (SHED) and fuel tank filling tests (FUELLOAD) of vehicles. The modern system design enables flexible alignment with constantly increasing requirements in the field of fuel mixtures and powertrains (hybrid).

BENEFITS AT A GLANCE

- Modularly extendable design for up to four lines simultaneously
- ORVR simulation modules supporting R&D
- Hybrid vehicle canister testing, e.g. dynamic purge functions
- Fully-automated, unmanned operation
- Continuously variable fuel loading rate and scavenging airflow rate
- Gravimetric control function (use of two balances)
- CE conform / ATEX certified equipment

CANLOAD device automation: improved graphical look and feel operation interface for manual operation, specific diagnostics and services

NEW CHALLENGES FOR ENGINES AND VEHICLE DEVELOPMENT

REAL DRIVING EMISSIONS (RDE)

The Real Driving Emissions (RDE) legislation is adding the road as a new environment for emission testing and certification. Compared to the current test environments, which are designed and optimized for perfect reproducibility and a removal of external influences, driving a vehicle on the road under "real-life" conditions will never be 100 % reproducible. The influence of the road profile, the ambient conditions, the traffic situation as well as the behavior of the driver will significantly influence the results. One-to-one comparison of test results will not be possible; instead it is nessecary to handle and evaluate the test data using statistical methods. The RDE legislation will require the engines to be clean under all operating conditions. This will impose significant challenges on the design and calibration of engines. Here RDE can become a door opener for alternative technologies as well as for alternative development processes.

AVL OFFERS SIMULATION AND TESTING TOOLS FROM INSPIRATION TO OPEN ROAD

RDE is imposing new challenges and complexity on today's approach for the development of vehicles and engines. There is certainly no magic bullet to battle the increasing complexity, but AVL's complete solution portfolio makes a difference. AVL can support any development project for RDE at all levels:

INSTRUMENTS AND DEVICES

Leading the market in various fields, AVL is committed to providing best in class performance, certified compliance with legislations as well as easy integration in test systems.

TEST SYSTEMS

AVL covers the full range of test environments, from first ideas in the office to the open road. Consistent operation across all test environments is ensured. AVL M.O.V.E iS is a tailored testing solution for the RDE on-road application.

PROCESS SUPPORT

AVL software supports the test operation, calibration, model based development and data management through the entire development process.

PORTABLE MEASURING SYSTEM FOR GASEOUS EMISSIONS

AVL M.O.V.E GAS PEMS iS

The AVL M.O.V.E GAS PEMS iS is a compact, lightweight and easy-to-install Portable Emission Measurement System (PEMS) for measuring the NO/NO_2 and CO/CO_2 exhaust gas emissions of diesel and gasoline vehicles. It is especially optimized for the Passenger Car "Real Driving Emissions" (RDE) application where low power consumption, compact dimensions, low weight and safe operation are extremely important. The new solution is based on the proven GAS PEMS and, therefore, provides the same high measurement accuracy.

MEASUREMENT PRINCIPLE

The system can flexibly be installed inside and outside the vehicle on a standard trailer hook mounting system to avoid any exhaust making its way into the vehicle, so protecting the test driver. The system is rain proof and additionally protected by a cover. The protective cover is designed to also optimize the wind drag coefficient to avoid influence to the test vehicle performance. The power distribution, including the batteries, can be mounted on top of the measuring module and are protected by the cover. With an optional trailer hook the GAS PEMS iS system does not need any modification to the test vehicle. The GAS PEMS iS system can be preinstalled on the carrier, warmed up and is ready to use. Then you simply install it on the trailer hook and connect the sample lines to your exhaust system with the quick clamps provided. A ready-to-go installation can be achieved in less than three minutes!

AVL GAS PEMS iS installed on a trailer hook mounting system

APPLICATION

Due to its compact, lightweight and smart design, the AVL M.O.V.E GAS PEMS iS is an efficient solution for the upcoming EU Real Driving Emission (RDE) and Chinese NO_x regulations for HD vehicles. It is also an efficient solution for "on-the-road" engine and vehicle development and vehicle surveillance testing.

BENEFITS AT A GLANCE

- Optimized and complete solution for RDE application
- Compact and lightweight
- Fast and safe installation
- Flexible installation in or outside the car and with or without exhaust flow meter
- No additional damping plates needed for passenger car application
- Wide operating range from –30 °C to +45 °C
- High measurement accuracy
- Y-type heated line is available in the case of dual exhaust pipe configurations

PORTABLE MEASUREMENT SYSTEM FOR PARTICLE NUMBER EMISSIONS

AVL M.O.V.E PN PEMS iS

The AVL M.O.V.E PN PEMS iS is a compact and robust continuous particle number [#/cm³] measurement device for on-road applications. This low weight and low power PN PEMS solution is especially designed to meet the Real Driving Emissions (RDE) requirements for gasoline and diesel vehicles. The modular concept enables the smart integration into the M.O.V.E iS platform and completes the AVL RDE solution for passenger cars. The PN PEMS iS incorporates AVL's broad expertise in particle number measurement methodology.

MEASUREMENT PRINCIPLE

The sample probe is located at the tailpipe of the vehicle and has been optimized to keep particle losses as low as possible and achieve maximum reproducibility.

The exhaust treatment unit includes a temperature controlled and diluted exhaust sampling unit and a volatile particle remover (VPR) to minimize particle losses and enables an optimum correlation to existing particle number (PN) instruments on the testbed which is compliant to UN-ECE R83. To fulfil the legislative requirements despite challenging limitations regarding size and weight, a patented Catalytic Stripper was introduced to remove the volatile fraction of the engine exhaust with high efficiency.

The Advanced Diffusion Charger technology is a further enhancement of the well-known corona discharge principle and has a directly proportional correlation with particle number [#/ccm]. Due to its robustness and low maintenance effort, the progressive sensor technology fulfills perfectly the challenging requirements of real world measurements.

APPLICATION

The modular design enables high flexibility for different applications:

- Standalone PN PEMS configuration with independent power supply
- Complete setup (Gas + PN PEMS) with combined sample probe

BENEFITS AT A GLANCE

- Compact, lightweight and robust solution optimized for RDE
- Innovative exhaust sample treatment to reduce particle losses and to reduce particle losses for best correlation to UN-ECE-R83 PN instruments.
- Modular concept: The PN PEMS iS can be operated both as a standalone device or integrated into the iS platform in combination with the Gas PEMS iS module

AVL M.O.V.E PN PEMS iS

PORTABLE MEASURING SYSTEM FOR GASEOUS EMISSIONS

AVL M.O.V.E GAS PEMS / GAS PEMS iX

Measurements with portable emission measurement systems (PEMS) on the road are an efficient way to keep the development effort at a reasonable level even as the requirements for fuel economy, emissions and customer expectations increase. 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 can withstand rough testing conditions and provide reliable and accurate measurements over long test durations and under changing ambient conditions.

BENEFITS AT A GLANCE

- Wide operating temperature range and high accuracy even in 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
- The GAS PEMS iX allows in addition to measure the CH_4 concentrations

MEASUREMENT PRINCIPLE

The AVL GAS PEMS/ GAS PEMS iX are compact and robust PEMS devices for obtaining the emissions of vehicles during real life operation on the road. The GAS PEMS measures the THC, NO/NO_2 and CO/CO_2 concentrations in the exhaust gas of Diesel and Gasoline Vehicles. The GAS PEMS iX also allows the measurement of CH_4 concentrations. Reliable test cell analyzers, which are optimized for mobile application, ensure high measurement accuracy. All analyzers are temperature conditioned to achieve reliable measurements even in changing ambient conditions. The GAS PEMS/ GAS PEMS iX is controlled via AVL M.O.V.E System Control, which stores all data and provides interfaces to access e.g. ECU/CAN bus data and additional sensors.

APPLICATION

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

AVL M.O.V.E GAS PEMS and AVL CONCERTO PEMS result screen

PORTABLE MEASUREMENT SYSTEM FOR PARTICULATE EMISSIONS

AVL M.O.V.E PM PEMS

In 2010 particulate matter (PM) limits were added to the US EPA Heavy Duty In-Use (HDIUT) rules. This requires manufacturers to prove their vehicles meet the PM limits even after many years of operation. A corresponding European In-Service Conformity legislation is already in preparation as well as regulations for off-road machinery, both in the US and in the EU. Soot and PM measurements are also important during development: Soot is an indicator of combustion system quality and the efficiency of a filter system (DPF). PM is limited by legislation and needs to be checked during development. Measurements on board a vehicle require compact, easy-to-install and robust devices which correlate to test cell equipment.

MEASUREMENT PRINCIPLE

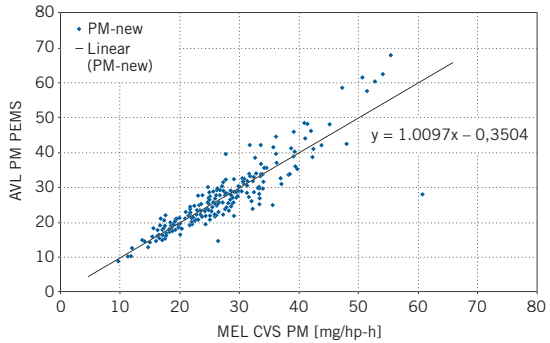
The PM PEMS is a combination of two measurement principles and consists of two units: the photo-acoustic measuring unit for the continuous measurement of soot concentrations and a gravimetric filter module which conditions the exhaust gas and measures PM using the gravimetric filter method. At the end 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 and additional signals 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 notebook. The data integration is done with AVL CONCERTO PEMS.

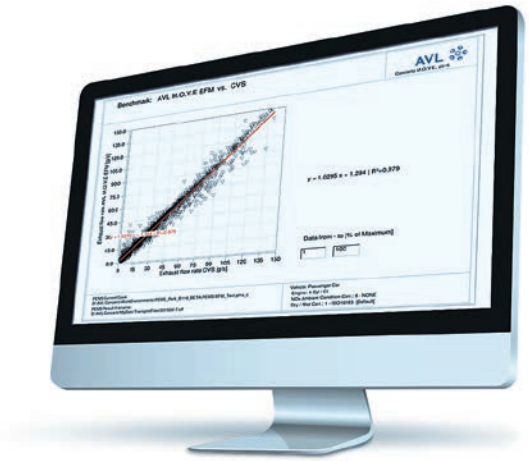
BENEFITS AT A GLANCE

- Ready for Euro VI HD in-service conformity (ISC) testing due to proportional sampling
- US EPA approval for Heavy-Duty in-use testing (HDIUT)
- Short installation time and easy to operate
- High measurement accuracy
- Easy integration into existing PEMS systems
- Robustness proven in multiple evaluation projects and with customers
- Based on proven AVL measurement technology



Correlation of PM PEMS with CVS

Correlation of MSS/GFB with Mobile CVS



Benchmark result for a 4-cylinder diesel engine

DEVICE FOR MEASURING THE EXHAUST MASS FLOW RATE OF INTERNAL COMBUSTION ENGINES

AVL M.O.V.E EXHAUST FLOW METER (EFM)

The AVL M.O.V.E EFM is a cost effective, accurate and robust exhaust mass flow measuring device with a special focus on the In-Use/ Real Driving Emissions (RDE) testing applications. The AVL EFM is fully integrated into the comprehensive AVL M.O.V.E in-vehicle measurement systems and can also be used as a "standalone device" e. g. on chassis dynos or engine test cells. Different interfaces allow for a flexible integration into automation and data acquisition systems.

MEASUREMENT PRINCIPLE

The AVL M.O.V.E EFM is based on the proven and robust "differential pressure" measurement principle. It consists of the EFM tube which is installed on the tail-pipe of the vehicle and the EFM control box which includes the electronics and the pressure transducers. The EFM tube and the EFM control box is separated for the most flexible installation. The EFM box is temperature conditioned to achieve high accuracy at changing ambient conditions.

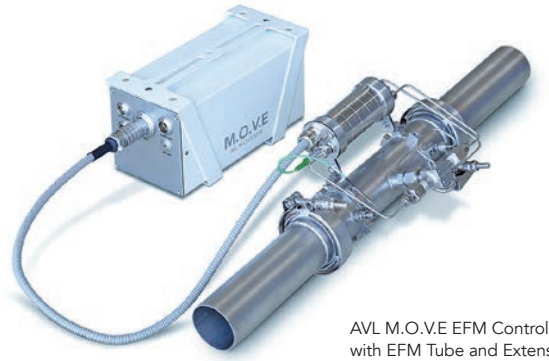
The usage of high-speed pressure transducers ensure accurate measurements at dynamic flow conditions in the exhaust duct. The EFM Control Box is water and dust protected (IP Protection Class 65) for the most reliable operation under harsh ambient conditions.

APPLICATION

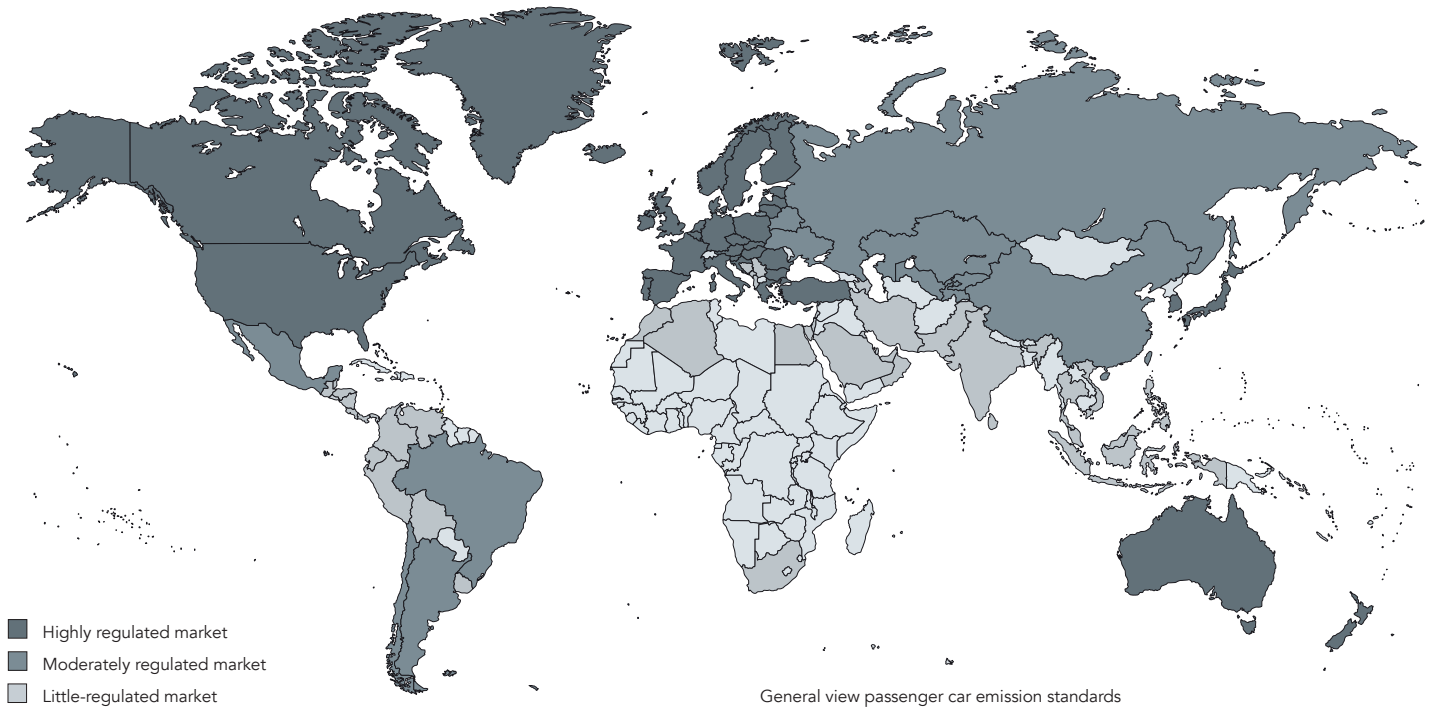
Due to its robust design, high measurement accuracy and flexibility in installation and operation, the AVL M.O.V. E EFM is a perfect solution for the In-Use/ RDE testing application or use on engine test cell or chassis dyno. It can be flexibly used either in combination with AVL M.O.V.E or as a standalone device.

BENEFITS AT A GLANCE

- Wide range of supported applications: From small passenger car up to heavy-duty truck engine, operation either in combination with AVL M.O.V.E or standalone e. g. on test cell
- High measurement accuracy even at changing ambient and highly dynamic conditions in the exhaust
- Fulfills all relevant legal requirements
- Flexibility in installation to allow for the most easy and safe mounting
- Quick and easy integration into AVL M.O.V.E and other automation and data acquisition systems



AVL M.O.V.E EFM Control Box with EFM Tube and Extensions



General view passenger car emission standards

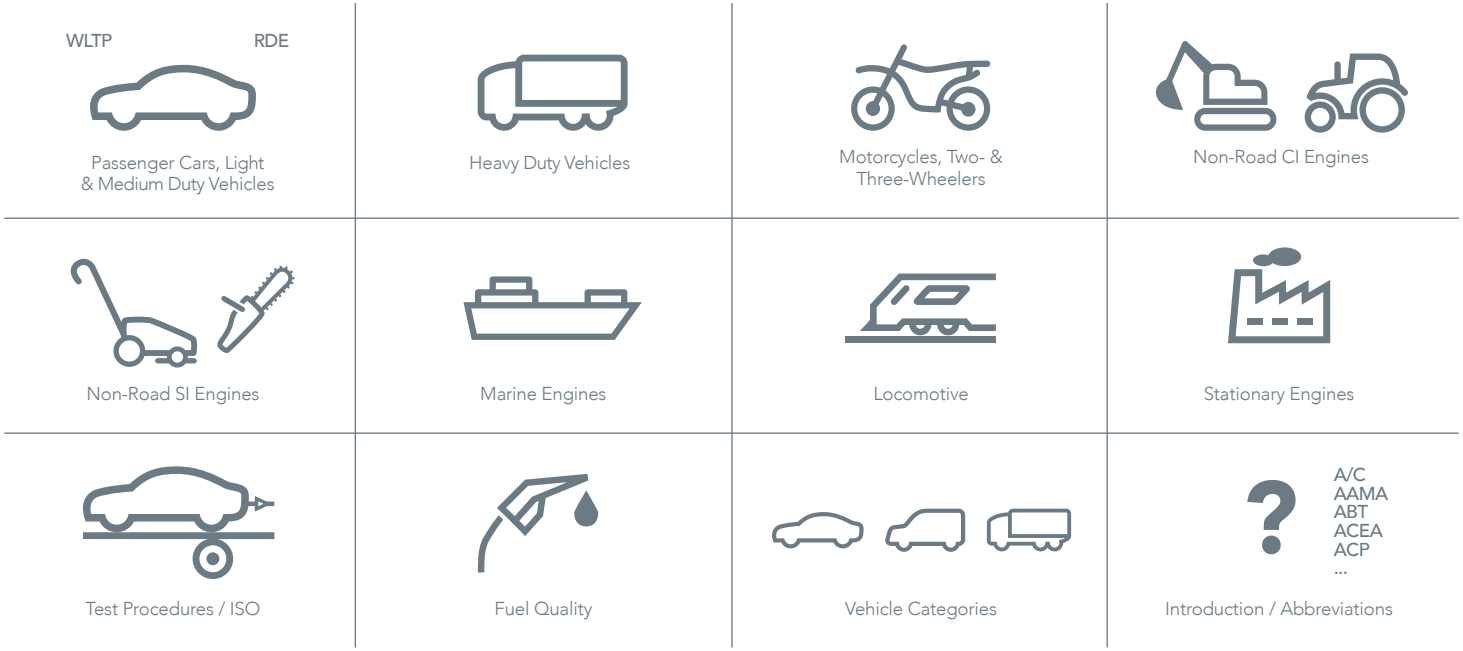
AVL Emission Regulation Report (AVL EmRep)

Increasingly stringent regulation of tailpipe emission and CO_2 is one of the major drivers for the technologies of future powertrains and test systems. AVL offers a well established tool to monitor the global developments: the continually updated AVL EmRep.

AVL EMREP KEEPS YOU UP-TO-DATE WITH EVER CHANGING REGULATIONS!

It offers a comprehensive summary of current and future regulations and covers trends in law-making for a broad range of internal combustion engines, motor vehicles, hybrid and electric vehicles, non-road equipment and many more.

Long experience and global presence ensure high quality data and the latest information.



AVL EmRep is your single source for:

- Highlights and view-at-a-glance information
- Detailed regulation requirements and specifications for development engineers and experts, serving as a reliable reference
- Future regulatory trends, to keep you informed on the evolution of standards and requirements in your fields of applications

AVL EmRep contains clear, structured and condensed information on regulations, proposals and forecasts regarding rule making for

- Tailpipe emissions
- OBD
- CO_2 emissions
- Fuel and electrical energy consumption
- Electric and alternative fueled vehicles
- Fuel quality
- Test procedures

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