AVL Consumption Measurement Systems

Integrated Consumption Testing Solutions from Engine Testbed up to On-Road Application and Flow Measurement for Component Testing

AVL Consumption Measurement Systems

YOUR BENEFITS

- Shorter time needed to achieve development targets due to reliable AVL consumption measurement systems, ensuring high levels of engine test bed availability.
- Substantially reducing testing effort by means of shorter measurement times and high levels of measurement accuracy (for example, the reduction of the measurement effort during automatic engine calibration).
- Protection of investments through modular design: Easy subsequent expandability and adaptation to new injection systems and applications.
- Compliant with the requirements regarding the measurement of bio fuels such as bio diesel or bio ethanol.
- Higher testbed efficiency and quick commissioning due to Plug & Play functionality and predictive maintenance

REFERENCES

More than 15,000 fuel consumption measurement systems supplied to OEMs and suppliers as well as institutes confirm our experience and competence in the field of fuel consumption measurement.

MARKET REQUIREMENTS

More stringent laws and regulations with regard to CO_2 and fuel consumption reductions in combination with rapidly growing measurement costs are raising the pressure on OEMs to develop engines even faster. 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 fuel is a target variable in automated optimization and calibration procedures.

The call for higher test bed efficiency does not only mean an easy installation and quick commissioning procedure for the measurement system; it also means a reliable fuel supply for the engine with preselected parameters, such as fuel temperature and pressure. Highly precise fuel temperature control is required to achieve high measurement accuracy in the overall system at the engine test bed, 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 impact on the quality of the measurement results. Engines for alternative fuels additionally require the compatibility with bio diesel or alcohol admixtures of up to 100 %.

AVL APPROACH

More than 50 years of know-how in the field of consumption measurement technology, clever modular product concepts in combination with a global presence, sophisticated service and system competences make AVL the market leader in the field of consumption measurement.

ENGINE TESTING SOLUTIONS

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. Fast and reliable verification of development progress today requires less than 1 g/kWh accuracy in fuel consumption measurement. Future tasks are demanding for high quality dynamic measurement data for optimizing transient engine operation conditions. This profound understanding of engine development requirements is reflected in AVL´s large range of standard equipment as well as customized solutions.

In addition to fuel consumption measurement systems AVL provides instrumentation for intake air mass, blow-by, oil consumption and urea for engine testbed.

VEHICLE TESTING SOLUTIONS

Reliable verification of fuel economy and advances in CO_2 reduction brings fuel consumption measurement up on the agenda for vehicle testing. AVL system solutions play a leading role for in-vehicle fuel consumption measurement on chassis dynos as well as in on-road and off-road applications. Thanks to the modular design, AVL measurement systems can be adapted to different technical requirements of engines with or without fuel return flow to the vehicle tank.

The wide measurement ranges enable fuel consumption measurement in small carburetor engines up to large diesel engines with 1MW power output. Short response time and high measurement resolution enable a high quality of dynamic flow measurement with unmatched accuracy and reproducibility.

COMPONENT TESTING SOLUTIONS

AVL flow meters are also used for End-of-Line testing of automotive fuel injection system components like valves, pumps or injectors. Individual customer solutions range from sample inspection on manual or semi-automated component test beds up to 100 % verification performed on fully automated production lines.

R&D and engine application introduce additional tasks like the verification of flow characteristics, calibration of injection maps or combustion development.

For all of these tasks AVL provides appropriate solutions with a wide spectrum of flow sensors ranging from continuous flow measurement to high resolution injection quantity analysis - particularly up to high pressure and temperature conditions.

ACCREDITED ACCORDING TO ISO 17025

AVL Calibration Laboratory

The globalization of the automotive industry requires measurement values which are comparable worldwide. Legislation covering CO_2 and fuel consumption reduction are imminent, with stricter requirements concerning the measurement uncertainty of fuel consumption.

QUALITY STANDARDS

The traceability required by the established quality assurance standards, such as ISO 9001 for measuring instruments in production and development, necessitate the calibration of measurement equipment on a regular basis.

ACCREDITATION

Measurement uncertainty and the evidence of traceability can now be established in the best way by the manufacturers of measurement equipment in the form of so-called factory calibrations, or in the context of tests, in accredited laboratories.

In this case state accreditation offices initially audit and accredit laboratories for their quality assurance processes and their actual measurement quality. Regular post audits ensure that the measurement uncertainty stated by the laboratory is complied

with. These audits are performed in accordance with ISO 17025. Besides such audits, the measurement quality is also checked in regular round-robin tests carried out among the laboratories.

AVL FUEL MEASUREMENT DEVICES

AVL has been accredited for the calibration of “liquid media”. Standard calibrations for AVL Fuel Measurement Devices such as FuelExact or Fuel Reference are performed on an accredited AVL calibration bench, whereby the traceability to international measurement standards are assured and the specified measurement uncertainty is met.

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Direct fuel mass flow measurement, modular design

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DYNAMIC FUEL CONSUMPTION MEASUREMENT UP TO 2 MW ENGINES

AVL FuelExact™

The AVL FuelExact™ is a high precision fuel consumption measurement system with harmonized fuel temperature control and fuel consumption measurement capable of detecting the volumetric and gravimetric fuel flow values in a highly precise manner and with the shortest measurement times. The focus is on transient measurement and on the advanced field of application for measuring engines up to 2,000 kW. The outstanding fuel temperature control stability combined with the cooling power capability of 6 kW results in a fuel conditioning performance fulfilling the requirements of transient engine development tasks. The AVL PLUtron™ sensor with onboard intelligence provides unique robustness and Plug & Play usability.

APPLICATION

AVL FuelExact™ covers applications from single-cylinder up to 2,000 kW engines in the field of engine research and development. Due to the high data rate of 100 Hz and the "Zero" step response (with AVL PLUtron™ sensor), the system is ideally suited for transient calibration methods that are increasingly being applied in the field of engine development. The AVL PLUtron™ sensor expands the application range towards development tasks with highest dynamic for close to engine measurements in returnless fuel injection systems. New and improved features consistently protect your investment.

BENEFITS AT A GLANCE

- Ideal for use in transient and dynamic fuel consumption optimization
- Unique data quality due to maximum temperature control accuracy and the application oriented design of the measuring system
- Fast and easy setup on the test bed - AVL ActiveLink™
- AVL PLUtron™: Self-diagnostic functions monitor operation conditions, optimize measurement analysis and protect the device
- Unmatched dynamics for close to engine measurement (with AVL PLUtron™ sensor)

Technical Details	
Type	AVL 740
Measurement principle	PLU or mass flow
Measurement ranges PLUtron Mass flow	 0…30 / 100 / 300 l/h* 0…150 / 250 / 500 kg/h*
Measurement uncertainty Volume/mass Density	 ≤ 0.1 % (acc. to DIN 1319) 1 g/dm³
Interfaces / output signal PLUtron	Ethernet, RS232, analog I/O, 0…10 V digital I/O CAN 100 Hz
Measurement frequency PLUtron Mass flow	 100 Hz 20 Hz
Response time PLUtron Mass flow	 10 ms < 125 ms
Fuel types	100 % bio fuels
Engine feed pressure	max. 1 MPa rel.
Control range	10…80 °C
Stability	better than 0.02 °C
Heating/cooling	3 kW / 6 kW
Power supply	3 phases 400 V AC, PE
Power consumption	3.5 kW (without heating)
Ambient temperature	5…50 °C
Dimensions (W × H × D)	960 × 1,710 × 430 mm

* With different sensors

DIRECT MASS FLOW MEASUREMENT, MODULAR, HIGHLY PRECISE FUEL TEMPERATURE CONTROL

AVL Fuel Mass Flow Meter and Fuel Temperature Control

For fuel consumption measurement, the AVL Fuel Mass Flow Meter in combination with the AVL Fuel Temperature Control represents a very versatile, flexible and modular solution for engines up to 600 kW. Using a Coriolis sensor technology optimized by AVL for fuel consumption, this solution supplies and conditions fuel with top performing temperature stability to the engine on the testbed. The AVL patented pressure control system provides constant adjustable return fuel pressures allowing back flow measurement. The FlexFuel version covers applications in the field of bio fuels and thus provides protection of investment for the future.

APPLICATION

Given its precision of 0.12 % and direct mass flow measurement capability, the AVL Fuel Mass Flow Meter with AVL 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 applied universally for different engine sizes from single-cylinder engines up to 600 kW large-scale engines and for state-of-the-art injection systems and test cycles.

BENEFITS AT A GLANCE

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

Technical Details	
Type	AVL 735S/753C
Measurement principle	Mass flow
Measurement ranges Mass flow	 0…125 kg/h
Measurement uncertainty Mass	 ≤ 0.12 % (acc. to DIN 1319)
Interfaces / output signal	RS232 analog I/O, 0…10 V digital I/O
Measurement frequency	20 Hz (analog)
Response time	< 125 ms
Fuel types	Standard* and 100 % bio fuels
Engine feed pressure	max. 600 kPa rel.
Fuel circulation quantities	Optionally 240 / 450 / 540 l/h
Control range	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)
Ambient temperature	5…50 °C
Dimensions (W × H × D)	770 × 1,630 × 345 mm

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

INDUSTRY STANDARD, ROBUST, LOW MAINTENANCE

AVL Fuel Balance and Fuel Temperature Control

The AVL Fuel Balance, which is based on the gravimetric measurement principle, is the most widely used fuel consumption meter at engine testbeds. Providing advantages such as reliable operation, measurement accuracy of 0.12% as well as extremely low maintenance expenses makes it the uncontested market leader.

APPLICATION

In combination with the AVL Fuel Temperature Control, it is the ideal solution and the industry standard when equipping research, development, quality and endurance testbeds. The AVL Fuel Balance is used for single-cylinder and large diesel engines up to 1,000 kW. In addition, it covers the entire field of application by switching the measurement range.

BENEFITS AT A GLANCE

- Minimization of testbed times due to high reliability and long maintenance intervals
- Time-saving ISO 9001 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

Technical Details	
Type	AVL 733S/753C
Measurement principle	Gravimetric
Measurement ranges Mass	0…150 kg/h
Measurement uncertainty Mass	≤ 0.12% (acc. to DIN 1319)
Interfaces / output signal	RS232, analog I/O, 0…10 V, digital I/O
Measurement frequency	10 Hz
Response time	< 440 ms
Fuel types	Standard* and 100% bio fuels
Engine feed pressure	max. 600 kPa rel.
Fuel circulation quantities	optionally 240 / 450 / 540 l/h
Control range	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)
Ambient temperature	5…50 °C
Dimensions (W × H × D)	770 × 1,350 × 345 mm

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

HIGH PERFORMANCE IN FUEL CONSUMPTION MEASUREMENT

AVL FuelSystem PLU

The AVL FuelSystem PLU is a high precision fuel consumption measurement system with integrated fuel conditioning and optional heating for continuous fuel consumption measurement in the range of 0.05 l/h to 300 l/h. The implementation of the newest AVL PLUtron™ sensor allows the fastest step response combined with a data-rate of 100 Hz.

APPLICATION

The FuelSystem PLU is used for fuel consumption measurements on engine test beds in the development of passenger car engines. The integrated automatic venting and filling procedures make the highly scalable measurement device ideal for applications on test beds where engines are changed frequently.
The internal vacuum pressure regulator allows to generate negative relative pressure in the return fuel line. This measurement device is designed for Flex Fuel, covering all fuel types from gasoline (EN228) with up to 100% alcohol (M100 or E100) and diesel (EN590) with up to 100% biodiesel (EN14214).

BENEFITS AT A GLANCE

- Enhanced test-bed efficiency through integrated functional check and online plausibility to prove the state of the hydraulic installation.
- High reliability and short installation and commissioning time enable long operational Test-bed availability.
- Low switching costs for the AVL KMA4000 installed base thanks to the 100% backward compatibility (hydraulic and electrical).

Technical Details	
Type	AVL 720
Measurement principle	PLU
Measurement ranges	0…30/100/300 l/h*
Measurement uncertainty Volume / mass Density	≤ 0.1% (acc. to DIN 1319) 1 g/dm³
Interfaces / output signal PLUtron	2x Ethernet, EtherCAT, CAN, RS232, digital I/O CAN 100 Hz
Measurement frequency	10 Hz
Response time PLUtron	10 ms
Fuel types	100% bio fuels
Engine feed pressure	max. 800 kPa rel.
Control range	10…70 °C
Temperature stability	better than < 0.1 °C
Heating / cooling	2 – 3 kW (optional) / 1 kW
Power supply	230 V AC, PE
Power consumption	0.4…0.8 kW (without heating)
Ambient temperature	0…40 °C
Dimensions (W × H × D)	1,000 × 1,225 × 650 mm

* With different sensors

FUEL MEASUREMENT SYSTEM CALIBRATION

AVL Fuel Reference

The AVL Fuel Reference is a professional calibration system for various fuel consumption measurement systems. This mobile unit comprising a reference sensor allows for the verification of the accuracy of the complete measurement system including all system components like fuel line installations. Quality assurance, ISO calibration, periodical verifications and US EPA 40 C.F.R. part 1065 and UN ECE R49 call for this kind of calibration. In order to increase the efficiency of the engine test field, it is also important that results from test bed to test bed are comparable.

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 to manually or automatically adjust different flow rates for the calibration points. The result: High accuracy down to low flow rates due to massively increased measurement resolution of the AVL PLUtron™ sensor.

BENEFITS AT A GLANCE

- Fast and easy setup on the test bed thanks to optimized and flexible design
- Fuel measurement systems can be uniquely and professionally calibrated according to US EPA 40 C.F.R. Part 1065 and UN ECE R49
- Applicable to the entire AVL fuel consumption portfolio
- Automated generation of a standardized calibration protocol
- Large calibration range 1:1000 (AVL PLUtron™ sensor)
- High resolution at low flow rates with the AVL PLUtron™ sensor (min. 75,000 p/cm³)

Technical Details AVL Fuel Reference	
Measurement principle	PLU or mass flow
Measurement ranges PLUtron Mass flow	 0…30 / 100 / 300 l/h* 0…150 / 250 kg/h*
Measurement uncertainty Volume/mass Density	 ≤ 0.1 % (acc. to DIN 1319) 1 g/dm³
Interfaces / output signal	Ethernet, RS232 frequency Modbus
Fuel types	100 % bio fuels
Power supply	230 / 110 V, 50 / 60 Hz
Power consumption	500 W
Ambient temperature	15…45 °C
Dimensions (W × H × D)	610 × 1,145 × 545 mm

* With different sensors

MOBILE FUEL CONSUMPTION MEASUREMENT

AVL KMA Mobile

The AVL KMA Mobile sets standards for mobile fuel consumption measurement in vehicles on the basis of its reliability, flexibility and precision. Due to the modular design, the measurement system can be adapted ideally to the different requirements of engines with or without return flow to the tank. Thanks to the large measurement span, it is possible to measure fuel consumption on a large range of different engine sizes. In connection with the very short response time (125 ms) and the very short measurement times, dynamic measurements can also be performed with a high measurement quality (accuracy, reproducibility).

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 the measurement of flows between 0.16 l/h and 300 l/h. Therefore, all applications from passenger cars to heavy commercial vehicles are covered.

BENEFITS AT A GLANCE

- Due to its universal applicability, the AVL KMA Mobile is suitable for all common mixture preparation systems
- The reduction of road test times is enabled by high levels of measurement accuracy and reproducibility
- No influence on the engine due to adjustable pressures
- Simple handling due to modular design and fast integration into the vehicle via quick couplers

Technical Details	
Type	KMA MOBILE
Measurement principle	PLU
Flow measurement ranges	0…75 / 150 / 300 l/h
Measurement uncertainty Volume/mass Density	 0.1 % (acc. to DIN 1319) 1 g/dm³
Interfaces	Frequency, analog, serial (AK command)
Measurement frequency	2 Hz (serial)
Response time ($T_{10,90}$) of flow measurement	< 125 ms
Environmental temperature	-10…+50 °C
Media temperature	-10…+60 °C
Operational pressure	-30…500 kPa rel.
Fuel types	Standard and 100 % bio fuel*
Fuel circulation quantity	200 / 400 / 600 l/h**
Voltage supply	12 V DC, 24 V DC (optional)
Power consumption	~ 75 W, max. 450 W conditioning module
Dimensions Measuring Module Conditioning Module	 470 × 200 × 550 mm (W x H x D) 470 × 170 × 550 mm (W x H x D)
Weight	~ 15 kg, conditioning module 20 kg
Option	Density Meter, Conditioning Module

* Conditioning Module with max. 20 % methanol / ethanol
** Depending on number of pumps

FUEL FLOW MEASUREMENT ON COMPONENTS, ENGINES AND VEHICLES

AVL PLUtron™ CLASSIC

As a universal flowmeter AVL PLUtron™ CLASSIC is suitable for a very wide range of applications in the automotive sector. It impresses with a truly "Plug & Play" usability in setup and operation based on integrated sensors and onboard intelligence empowering self-diagnostic functions. It simplifies all those flow measurement applications, where experts are not available, yet reliable results must be produced quickly in changing or unknown environments. Users benefit from the advanced PLU measuring principle by a much larger dynamic range, no influence on the tested circuit ($\Delta p = 0$) and extreme robustness against vibration and shock. An optional integrated density meter also allows the direct measurement of mass flow with the PLU.

APPLICATION

AVL PLUtron™ CLASSIC is an ideal solution for In-vehicle testing on gasoline vehicles as passenger cars or motor cycles, where robustness against pressure pulsation and vibration is an increasingly important feature for achieving reliable results. Flow measurement in component production testing is another demanding field of application. The higher PLUtron resolution offers faster stabilization and shorter measurement time than all other devices. AVL PLUtron™ CLASSIC is an outstanding solution for many more applications on test beds as well as in the lab, which focus on flexible use, simple setup and robustness. Please ask us for references regarding your own requirements. Optionally, mobile display and an integrated density meter are available.

BENEFITS AT A GLANCE

- Unique Plug & Play usability for optimized workflow
- Reliable results under rough conditions due to robust design and long-term stable calibration
- Higher flexibility due to large measuring ranges with highest resolution and accuracy
- Up to 15% shorter test time in component production at affordable cost of ownership
- No influence on engine performance

Technical Details	
Type	PLUTRON™ CLASSIC
Measurement principle	PLU
Flow measurement ranges	0…30 / 100 / 300 l/h
Measurement uncertainty	0.3% (acc. to DIN 1319)
Interfaces	CAN, frequency, analog, serial, USB (user software)
Measurement resolution	48,000…8,200 pulses/cm³ (internal)
Response time (T_{10-90}) of flow measurement	< 80 ms
Environmental temperature	-20…+60 °C
Media temperature	-20…+70 °C
Operational pressure	0…2 MPa rel.
Media	Standard and 100% bio fuel; compatible test media
Voltage supply	9…48 VDC
Power consumption	~ 60 W
Dimensions	346 × 109 × 97 mm (W × H × D)
Weight	6.5 kg
Protection	IP67
Option	Integrated density meter (650…1,150 kg/m³)

UREA CONSUMPTION MEASUREMENT IN SCR SYSTEM ON DIESEL ENGINES

AVL PLUrea™ – Urea Consumption Measurement System

AVL PLUrea™ serves the specific requirements of SCR system application in diesel engine exhaust after-treatment. Compliance with the challenging low limits of future exhaust emission legislation requires maximum NO_x conversion ratio 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.

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

Technical Details	
Type	AVL PLUrea
Measurement principle	PLU
Flow measurement ranges	0…10 / 20 / 40 l/h
Measurement uncertainty	0.2% (acc. to DIN 1319)*
Interfaces	Frequency, analog, serial (AK command)
Measurement frequency	20 Hz (serial)
Response time (T_{10-90}) of flow measurement	< 250 ms
Environmental temperature	+10…+60 °C
Media temperature	+10…+60 °C
Operational pressure	-10…1,000 kPa rel.
Media	Aqueous urea solution acc. to ISO22241 2008/9 (AdBlue®), water with min. 1% Prevox 7400 content
Voltage supply	100…240 V AC 50 / 60 Hz
Power consumption	typ. 50 W, max. 150 W
Dimensions	600 × 600 × 1,700 mm (W x H x D)
Weight	~ 50 kg
Option	Density meter, Back Flow Conditioning Module

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

FULLY AUTOMATED OIL CONSUMPTION MEASUREMENT IN ENGINE R&D AND QUALITY TESTING

AVL Oil Consumption Meter

Against the backdrop of stricter emission legislation, the determination of the lubrication oil consumption of state-of-the-art combustion engines is as important as ever. These limitations on exhaust gas and particulate matter emissions being enacted by legislators confront engine developers with a difficult task that can only be solved with a combination of combustion, exhaust after-treatment and oil consumption development.

FUEL CONSUMPTION MEASUREMENT FOR SMALL OFF-ROAD ENGINE TESTING

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 ($\Delta p = 0$) over 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.

ENGINE CRANKCASE VENTILATION FLOW MEASUREMENT

AVL Blow By Meter

Blow-by measurement nowadays is standard on engine testbeds. To be able to comply with the emission legislation for new combustion engines today and in the future, the requirements for crankcase ventilation systems will continue to increase. In order to design these systems, knowledge of engine blow-by mapping 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 instrument for engine testing.

APPLICATION

On the basis of the interchangeable measurement ranges between 0.2 and 2,400 l/min, the AVL Blow By Meter can be used from small-scale and single-cylinder engines up to diesel engines for ships. 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.

BENEFITS AT A GLANCE

- The accuracy of 1 % FSO and the reproducibility of 0.1 % comply with the strict requirements of engine measurement technology
- Due to the minimal pressure drop, the original blow-by behavior of the engine is almost unaffected
- High reliability and constant measurement readiness are realized through low dirt sensitivity
- Correct detection even of reverse blow-by flows
- Simple integration and installation on the testbed

Technical Details	
Type	AVL 442
Measurement principle	Differential pressure
Measurement ranges	0.2 … 10 l/min 1.5 … 75 l/min 3 … 150 l/min 6 … 300 l/min 12 … 600 l/min 24 … 1,200 l/min 48 … 2,400 l/min
Measurement accuracy	≤ 1 % FSO fine linearization (option) ≤ 1.5 % FSO standard linearization
Interfaces / output signal	RS232 (AK-compliant), analog I/O, - 10 … + 10 V
Power supply	24 V DC
Power consumption	35 W
Ambient temperature	- 10 … 55 °C
Dimensions (W × H × D)	Approx. 330 × 350 × 75 mm (MR: 3 … 150 l/min)

INJECTION QUANTITY MEASUREMENT

AVL Shot-to-Shot™ PLU 131

Primary field of application for the AVL Shot-to-Shot™ PLU 131 flow measurement system is research and development of internal combustion engines. The combination of the AVL STS PLU flow sensor with the AVL IndiAdvanced high-speed data analysis technology offers a powerful and flexible development tool. Injection quantities and injection rates of fuel injectors or complete injection systems can be determined precisely with a single device. Investigation of flow characteristics at different pressure, multiple injection timing analysis and rate shaping, pressure wave compensation or optimization of combustion parameters are some of the more common tasks in R&D of fuel injection equipment as well as for its engine application. Furthermore, shot quantity is an established test characteristic for component production.

APPLICATION

Diesel and Gasoline injectors are characterized with AVL STS PLU 131 on component test benches regarding injection rate, injection quantity as well as open and closing delay times in various stages between component design and system application. Complete injection systems are pre-calibrated on a fully instrumented multiple-cylinder STS measurement system. And even in production testing AVL STS systems satisfy the extreme durability and stability requirements for fast shot quantity measurement with high accuracy. Upstream setup on the high-pressure side of a Gasoline injector is a unique feature of the AVL Shot-to-Shot™ PLU 131 enabling spray chamber, single-cylinder and even full engine operation.

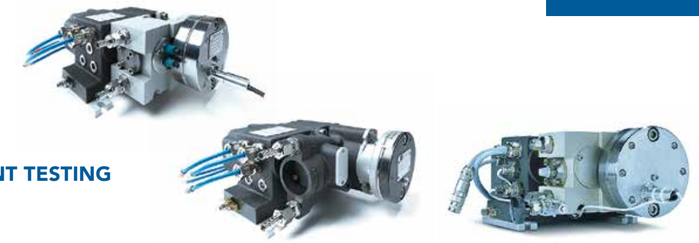
BENEFITS AT A GLANCE

- Injection quantity and injection rate and timing analysis
- Fully automated test cycles
- Automatic detection of multiple injections
- High accuracy down to small injection quantities
- Extremely large measuring ranges (1:1,000)
- No speed limitation
- Complete cycle availability (360°/720°)

Technical Details	
Type	AVL STS PLU 131
Measurement principle	PLU
Flow measurement ranges	0…30 / 100 / 300 l/h
Injection quantity	0…200 mm^3 / 0…600 mm^3
Measurement uncertainty	0.1 % (flow rate) 1 % (injection quantity > 2 mm^3)
Interfaces	CAN / frequency / analog / serial / USB (user software)
Measurement resolution	800 kHz
Injection rate	1…180 Hz
Environmental temperature	-30…+70 °C
Media temperature	-30…+60 °C
Operational pressure	0…20 MPa rel.
Media	Standard and 100 % bio fuel; comparable test media
Voltage supply	100…240 V AC 50 / 60 Hz
Power consumption	~ 100 W
Dimensions	335 × 216 × 140 mm (W x H x D)
Mass	~ 16 kg
System compomnents	STS PLU 131 Sensor, STS Control unit, IndiShot Data accquisition unit, IndiCom STS Software
Option	Cooling flange for media temperature up to +150 °C

FLOW MEASUREMENT FOR COMPONENT TESTING

AVL PLU 131



The AVL PLU 131 product line 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 meters versions for all kinds of fuels and test fluids, specialized models are offered for high media pressure up to 20 MPa and high media temperature up to 150 °C. Other device types have been designed for special media like urea solution. Different measuring ranges cover everything from small quantity measurement at 0.05 l/h to high flow rates of 300 l/h. The measurement accuracy is 0.1 % of the measured value over the complete measuring range of the individual device types of up to 1:500.

APPLICATION

Production lines and quality test benches for automotive fuel supply components are the applications, which profit most from the high resolution and high precision of PLU 131 flow meters. The PLU measurement 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. With its high accuracy down to low flow rate 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 large measuring ranges
- Reliable results with upstream measurement in high-pressure / high-temperature environment
- Non-interference between meter and hydraulic system (Δp = 0)
- Low cost of ownership due to outstanding robustness and long-term stability of calibration

Technical Details	
Type	PLU131S
Measurement principle	PLU
Flow measurement ranges	0…10 / 20 / 40 / 80 / 150 / 300 l/h
Measurement uncertainty	0.1 % (of reading)
Interfaces	Frequency, serial (service software)
Measurement resolution	47,000…1,600 pulses/cm^3
Response time (T_{10-90}) of flow measurement	< 100 ms
Environmental temperature	-30…+70 °C
Media temperature	-30…+70 °C
Operational pressure	0…20 MPa rel.
Media	Standard and 100 % bio fuel; comparable test media
Voltage supply	24 VDC
Power consumption	~ 40 W
Dimensions	335 x 216 x 140 mm (W x H x D)
Mass	~ 15 kg
Protection	Ex II 2 G EEx d IIB T6
Option	Cooling flange for media temperature up to +150 °C

AIR CONSUMPTION MEASUREMENT IN R&D; EMISSION CERTIFICATION AND QUALITY ASSURANCE

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 1:70, only two different pipe diameters are needed (DN 100, DN 150) to cover the full application range of up to ± 2,600 kg/h.

APPLICATION

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

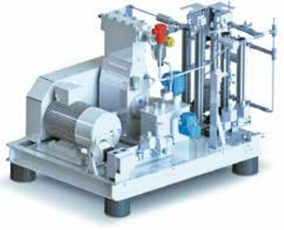
BENEFITS AT A GLANCE

- The unique AVL FLOWSONIX™ Air is not sensitive 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 × DN up-stream and down-stream tubing

Technical Details	
Measurement principle	Ultrasonic transit time
Measurement ranges	0 (± 20) … ± 1,400 kg/h (LD Version) 0 (± 40) … ± 2,600 kg/h (HD Version)
Response time	T_{90} = < 10 ms
Reproducibility	± 0,25 % of reading
Measurement uncertainty	< ± 1 % of reading
Temperature of air	- 20 … + 80 °C
Operating pressure max.	250 kPa abs.
Pressure drop of Measuring Head	0.25 kPa
Ambient temperature of Measuring Head	- 20 … + 60 °C
Ambient temperature of the Evolution Unit	- 20 … + 60 °C
Interfaces	AK interface Ethernet (TCP/IP) AK Interface RS232 CAN Bus Interface Analog 0 … 10 V, 4 … 20 mA Digital I/O
Power consumption	25 W
Power supply	110 / 230 VAC ± 15 % 50 / 60 Hz ± 5 %
Normal size DN	LD Version 100 mm HD Version 150 mm

COLD TEST UNIT, LARGE ENGINE FUEL SYSTEM, HIGH PRESSURE FUEL SYSTEM

AVL Customized Fuel Systems



Besides the standard applications of Engine R&D that can be covered by our wide portfolio of standard solutions, engine developers and manufacturers may require specific features for their fuel system in order to achieve their development or production goals.

AVL customization of its fuel systems allows you to extend their capabilities to specific applications such as climatic chamber application, large diesel engines testing or high fuel pressure supply for racing applications. Other solutions can be offered on demand, please contact us to discuss your specific needs.

APPLICATION

For climatic chamber, the fuel system is extended with an external secondary cooling circuit with components capable of delivering continuously down to - 30 °C fuel temperature to the engine with high stability.

For Large Diesel Engine applications, AVL has scaled up the FuelExact Mass Flow hydraulics concept to higher consumption up to 1,500 kg/h. It is key to achieving the fuel efficiency target of the engine development program.

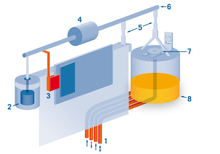
High performance gasoline applications may require testing of the injection system with variable pressures up to 50 MPa while measuring accurately the fuel consumption.

BENEFITS AT A GLANCE

- Permanent - 30 °C … - 10 °C fuel temperature supply to the engine provides real simulation of operating conditions in cold climates and measurement of the fuel consumption at those temperatures.
- Highly flexible testing and best measurement repeatability for Large Diesel Engines up to ~7 MW and 3,000 l/h engine feed flow rate. A specially designed venting tank ensures permanent venting of the returned fuel and a low return pressure for realistic testing conditions.
- The AVL FuelExact™ can be extended with a High Pressure Fuel System supplying directly the rail of the gasoline injection system with up to 50 MPa fuel pressure.

For detailed technical information about our customized solutions, please contact our local sales organization.

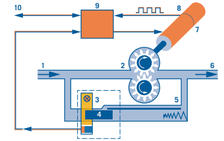
Unique variety of Measurement Principles



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)

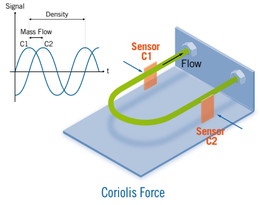
The fuel consumed by the engine is taken from a continuously weighted measurement vessel which has the same properties as the vehicle tank. The detection of the weight of the fuel is carried out with a capacitive displacement sensor connected to the measurement vessel by means of a beam. A calibration weight is used to perform the accuracy testing and calibration procedures in accordance with ISO 9001. 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

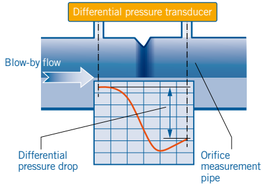
PLU MEASUREMENT PRINCIPLE

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 ($\Delta p = 0$) 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.



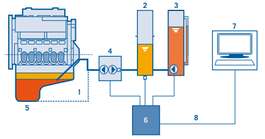
CORIOLIS (MASS FLOW)

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

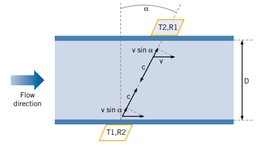
For the determination of blow-by flow the orifice measurement principle (differential pressure measurement procedure) is used. A neck (orifice) in the tube cross-section provokes a pressure drop that is measured by means of a differential pressure sensor. The shape of the orifice of the AVL Blow By Meter means that it, on the one hand, ensures the accuracy in both flow directions and, on the other, prevents condensation at the orifice that might modify 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 with modified dip stick or an oil drain plug. Afterwards, the weight is determined with the help of a precision 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 three steps: pumping (out), weighing and 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

ULTRA SONIC TRANSIT TIME

The measuring principle is based on the ultrasonic transit-time differential method. Two ultrasonic pulses are sent simultaneously through the flowing medium from Transmitter 1 (T1) and Transmitter 2 (T2). One pulse is propagating into the flow and the other one against it. 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.

FOR FURTHER INFORMATION PLEASE CONTACT:

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