



EMISSION INSTRUMENTS



APC^{plus} - AVL PARTICLE COUNTER

Description

Particle number is already an established metric in the development process and for certification of EURO 6 LD vehicles with diesel and GDI engines as well as EURO VI HD engines.

With the APC^{plus}, the next generation AVL Particle Counter, AVL, world leader in the field of high-end particulate measurement, has developed a compact, intelligent and maintenance friendly tool for your specific requirements in the test field.

The APC^{plus} is an online measurement device to measure solid particle number concentrations in combustion engine exhaust. The exhaust sampling is done on the one hand directly at a CVS tunnel or partial flow dilution system (PFDS), as well as at the tailpipe of an engine test bed with a heated sample line.

The APC^{plus} consists of a conditioning component (volatile particle remover VPR) and the actual particle number counter (PNC). The VPR consists of the first dilution step (particle number diluter 1 PND1), an evaporation tube (evaporation tube ET), and a secondary dilution (particle number diluter 2 PND2). The PNC is a n-butanol based condensation particle counter with a cut-off diameter of 23 nm.

Functionality Overview

- Complies with all requirements of the UNECE-R83 and R49
- Continuous measurement of the number concentration of all non-volatile particles
- Robust and precise dilution system
- Automated start-up procedure provides rapid system initialization
- Enhanced device purging for minimized particle depositions
- Easy and intuitive operation including a remote control option
- Advanced Error Handling and Device Protection
- Real Driving Emissions (RDE) measurements possible due to 10Hz data monitoring

Applications



APC^{plus} CERTIFICATION

The instrument line CERTIFICATION is used for measurements at CVS tunnels or partial flow dilution systems (PFDS) and complies with the legislative standards UN-ECE R49/83. Three fixed PCRF (particle concentration reduction factor) modes can be set: 100, 500 and 2.000.

APC^{plus} ADVANCED

The Instrument line ADVANCED is designed for comprehensive coverage of all measurement tasks at diluted (CVS and PFDS) and raw exhaust. Enhanced dilution allows a wide PCRF range from 10 to 20.000 and special device protection provides a greater operation range. The main focus lies on R&D purposes.



Benefits of the APC^{plus}

- High instrument availability even at aggressive exhaust gas compositions through the implementation of innovative materials and technologies.
- Low maintenance effort and intelligent device diagnostic especially designed for components strained by raw exhaust applications.
- Highly accurate measurements together with minimized particle losses based on an optimized thermal exhaust treatment and the use of a patented dilution principle close to the sample point.
- Enhanced dilution range and dynamic data acquisition for specific R&D applications.
- Smart and flexible integration into the testbed automation system.

The System in Detail

In order to count non-volatile particles, a special sampling method has been developed. A pump draws the exhaust gas into a sampling probe (available optionally) which eliminates all particles $>2.5 \mu\text{m}$ due to its special shape. The sampled exhaust gas is then diluted with cleaned hot air at a temperature of 150°C . This stabilizes the particle number concentration and reduces the concentration according to the PCRF, so that agglomerations and particle deposits are largely prevented.

The primary diluter is designed as a patented “Chopper Diluter”. Thanks to its compact design and the high dilution rate, the diluter can be installed directly at a CVS tunnel, a partial flow dilution system or a tailpipe on an engine test bed. Its innovative material composition largely minimizes the “particulate losses”.

The selected arrangement of the transfer volumes and the constant sampling flow guarantee dilution independent of the particle size. An automatic back purging procedure also prevents particle deposits that would bias the measurement results.

After the hot primary dilution, the diluted exhaust gas is further heated up to a temperature of 300°C to 400°C in the evaporation tube in order to convert all volatile particles into the gaseous phase. Afterwards, a secondary dilution is performed to prevent further condensation or adsorption of volatile substances and to ensure that the maximum inlet temperature of the PNC of 35°C is not exceeded.

The particle number concentration is measured in the Condensation Particle Counter (PNC) (with a size range of 23nm to $2.5\mu\text{m}$ according to UN-ECE R83/R49 specifications). The particles are enlarged due to the condensation of butanol and are detected and counted using the light-scattering method.



Compatibility and Integration

The APC^{plus} offers an AK interface using either TCP/IP or RS232. Additionally, an innovative device control software application is available that is based on the AVL interface technology RSI (Remote Service Interface). All required software packages are integrated into the device. The device control software provides the user with different functionalities for displaying the measurement values and controlling the device. The maintenance technician is provided with detailed status displays.

Compatibility to AVL PUMA Automation Systems:

PUMA5: Hybrid Interface, analog and digital I/O
PUMA Open 1.2, 1.2.1, 1.3: Hybrid Interface, analog and digital I/O
PUMA Open 1.3.1 HF 5: via RS232C
PUMA Open 1.3.2 und >1.4: via Ethernet
GEM201L Advanced: via Ethernet

Boost - Mode (10Hz Data Logging): PUMA >1.5.x

Compatibility to non AVL Automation Systems:

VETS ONE 3.2 or EURO5 / 5+: package via Ethernet
Flexible interface in other customer specific automation systems can also be achieved by using the hybrid interface.

The system can be completely integrated into the PSS i60, so that valuable testbed space can be saved.

The APC^{plus} ADVANCED can also be used in combination with the AVL Smart Sampler Partial Flow Dilution Tunnel. This solution gives the user an efficient way to measure both particle mass and particle number at the same time.

Service

Calibration (UN-ECE R83/R49 Validation)

The calibration procedure must be carried out once a year according to the UN-ECE R83 recommendation. Since radioactive material and many sensitive measurement devices are used, we recommend sending the APC^{plus} to the AVL Graz Calibration Center for annual calibration. If the required calibration equipment is available onsite, the calibration can be carried out by the customer. In order to achieve realistic results, we exclusively use the AVL Particle Generator to provide thermally treated CAST (Combustion Aerosol Standard) Aerosol for the calibration of the measurement devices.

Adjustment (UNECE R83 Calibration)

If the measured values happen to be outside the specified tolerances, an appropriate differentiation adjustment between VPR and PNC will be carried out after written confirmation by the customer. The customer can minimize the downtime of the testbed by renting a calibration device for the period of service.



Preventive Maintenance (1000 H Service)

Every year or after 1000 operating hours, depending on whichever comes first, complete maintenance is recommended. Preventive maintenance can be executed on site or in Graz in combination with other services. As part of this maintenance the following tasks are typically performed: filter replacement, internal tubing change out, temperature sensor calibration, etc.

Factory Service for R&D devices:

Additionally to the existing services for the APC^{plus}, alternative services for R&D customers were established as well. At the APC Service Basic 2014 the CPC is not shipped to TSI but verified with CAST aerosol in the AVL calibration line.

		Service Comprehensive 2014	Service Basic 2014
Application		Certification	Certification
		R&D	R&D
Content	VPR	Preventive Maintenance	Preventive Maintenance
		Validation / Calibration	Validation / Calibration
		Exchange of PND1 if necessary	Exchange of PND1 if necessary
		Additional Repairs on VPR	Additional Repairs on VPR
	CPC	Incoming Verification**	Incoming Verification**
		Exchange saturator Wick*	Exchange saturator Wick*
		Preventive Maintenance*	Preventive Maintenance*
		Validation / Calibration*	Validation / Calibration*
		Verification before shipment**	Verification before shipment**
		Additional Repairs on CPC	Additional Repairs on CPC
		*) performed at TSI	covered
		***) performed at AVL	not covered

Scope of Supply

- 1 Primary diluter
- 1 Conditioning unit (Evaporation Tube and 2nd dilution stage)
- 1 Condensation Particle Counter (CPC)
- 1 Main connection 110/115V or 230 V
- 1 Interface link 15 m
- 1 User manual APC^{plus}
- 4 Spare HEPA Filters
- 2 Spare Particulate Filters (box of 10)
- 1 Application Kit (connection between 1st diluter and sample probe)
- 1 Transportation box



Options/Add-Ons

Sample Probe Kit CVS

The Sample Probe Kit CVS provides a complete solution for mounting the APC^{plus} at the CVS-tunnel, sample the exhaust gas with a standard probe and verify the gas dilution ratio. Following articles are included in this kit: CVS Mounting Kit, European Standard Probe Kit and Gas Check Valve.

CVS Mounting Kit

To ensure a proper function of the primary diluter, it has to be mechanically mounted using a stressless connection for the sampling probe. The kit consists of variable clamp rings, a mounting plate for the primary diluter and adjustable bars for an optimal application at the various CVS tunnels.

European Standard Probe Kit

According to the latest UNECE R83 regulation, only solid particles, which are smaller than 2.5 µm, should be counted. This requires a particle size pre-classification. To meet this requirement we provide a Euro Norm standard sampling probe kit which can be used on different CVS tunnels.

Automatically switchable Gas Check Valve

The gas check function is designed for verification of the gas dilution ratio via the gas analyzers on a testbed. With the gas check valve, connected at the inlet of the primary diluter, the gas dilution ratio check can be performed without disconnecting the diluter from the CVS-tunnel. It is operated via the AVL device control software.

Tailpipe-Sampling Kit

The APC^{plus} ADVANCED is also suitable for tailpipe-measurements without any adaptation steps. The tailpipe sampling kit represents the optimal solution for tailpipe measurements and consists of a multiple-hole sampling probe and an additional heated sample line with a length of 500 mm. The additional heated sample line minimizes particle deposits and guarantees more reliable measurement results.

Trolley with conditioning unit

The instrument carrier, equipped with wheels, is built in a 19" rack. A conditioning unit and a compressed air preparation module are included making measurements up to 45°C ambient air possible. For transportation, the primary diluter can be fixed on the top of the carrier.

High pressure Option

The High pressure option allows the APC^{plus} ADVANCED to be used during measurements with an exhaust gas backpressure of up to 2000mbar (relative), e.g. before a Diesel Particle Filter (DPF).

AVL InScreen

With AVL InScreen, one or more AVL measurement devices can be controlled via Ethernet. The AVL devices can be monitored and if needed, controlled with the touch sensitive display. The peripheral equipment (mouse, keyboard) can be connected via USB interfaces. For easy mounting on the testbed we also offer a bench cabinet and a 19" rack mounting frame.

PND1 exchange Unit

In case of a defective primary diluter unit (PND1), AVL proposes the storage of the PND1 including the heating line as a spare part in order to shorten the down time of the test facility. So, if an APC 489 shows conspicuous results, it is possible to instantly change the PND1 including the heating line to quickly restore the function of the device.



Specifications

Models	APC ^{plus} CERTIFICATION	APC ^{plus} ADVANCED
Confirmed standards	UN/ECE-R83 (Rev.4), UN/ECE-R49 (Rev.5)	
Field of application	Diluted measurement (CVS), partial flow dilution (PFDS)	Diluted measurement (CVS), partial flow dilution (PFDS) raw exhaust measurement
Measuring components	Particle number concentration of non-volatile particles (#/cm ³)	
Measuring range	0 –10.000 #/cm ³ (calibrated)	0 –10.000 #/cm ³ (calibrated), up to 50.000 #/cm ³ (single count mode)
Measuring principle	Laser scattering condensation particle counting (CPC)	
Lower particle size limit	23nm (50% ± 12% eff.), 41nm (90% + eff.)	
Rise time (t ₉₀)	≤ 5 s	
Sample handling conditions	+5°C...25°C (up to 45°C with optional cooling trolley), ±200 mbar (up to 2000 mbar for the APCplus ADVANCED)	
Sample flow rate	5 l/min (diluted)	5 l/min (diluted) 4-7 l/min (raw)
Dilution factors	Adjustable in 3 calibrated steps: 100, 500, 2000	100 to 20000 (14 steps calibrated): PND1: 10 to 1000 PND2: 10, 15, 20
PCRF _{TOT}	100-2000	100-20000
Volatile particle removal efficiency	99 % or higher for tetracontane	
Evaporation tube temperature	350°C	300 - 370°C adjustable
Interfaces	TCP/IP via AK-Protocol, RS232 via AK-Protocol, Hybrid interface (Digital, Analog I/O)	
Power supply	90...240 V AC, 50/60Hz, ~850W	
Compressed air supply	30 lpm	
Dimensions	482 (19") x 445 (10HU) x 650 mm	
Weight	~ 47kg	