

Be sure. **testo**

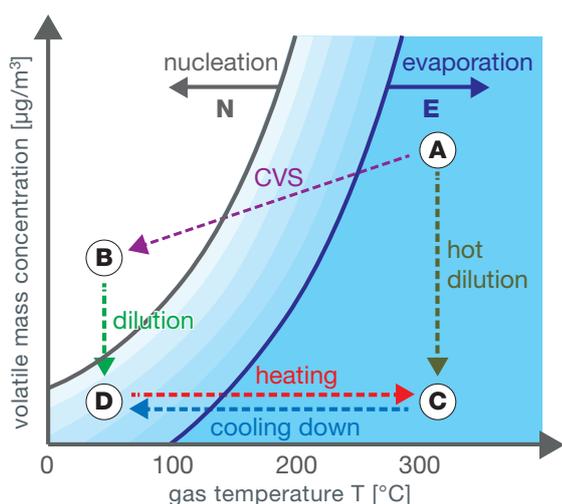


Raw gas sampling and conditioning for particle characterization.

Volatile particle remover testo ViPR
Rotating disk diluter testo MD19-3E

All in one – Sampling, diluting and conditioning for particle emissions characterization.

Hot vehicle exhaust contains both solid particles (carbonaceous soot, ash) and vapors of volatile substances (water, sulfate, hydrocarbons). During sampling in standard dilution tunnels the latter tend to condense into nanodroplets which are detected as particles together with the non-volatile soot particles. There is an agreement to measure these two fractions separately. On the one hand, the measurement of solid particles is much better reproducible than that of nanodroplets, on the other hand because the respective health effects suggest different metrics for the two fractions.



In a dilution tunnel both the concentration and the temperature of the substance are reduced ((A) --> (B)). During dilution, the compound passes its dew point and nucleates into nanodroplets (curve N). Subsequent secondary dilution ((B) --> (D)) will reduce the number concentration of the droplets, but is unable to evaporate them, because of a hysteresis effect between nucleation and evaporation.

A strategy to avoid the mere formation of nanodroplets is direct sampling from the hot exhaust in combination with hot dilution ((A) --> (C)). Given a sufficient dilution factor, the volatiles will not nucleate during subsequent cooling ((C) --> (D)) even though the same final state is assumed as through dilution tunnel and secondary dilution ((A) --> (B) --> (D)). However, in some applications direct sampling is not possible, and nanodroplets already exist in the gas sample (B). In those cases the diluted gas sample (D) has to be heated above the evaporation point of the compound ((D) --> (C), crossing curve E). Like with hot dilution, the compound remains in vapor phase upon subsequent cooling ((C) --> (D)). The combination of diluter and heater ((B) --> (D) --> (C) --> (D)) is known as ThermoDiluter.



PMP compliant volatile particle remover

testo ViPR.



Hot dilution is carried out with Testo's rotating disk diluter **testo MD19-3E** ①. The combination of a rotating disk diluter, an air supply evaporation tube – **testo ASET15-1** ② and a data acquisition unit **testo CU-2** ③ forms a complete ThermoDiluter system known as volatile particle remover **testo ViPR**.

The European Commission introduced with the standard EURO 5b in 2011 new particle emission limits, based on number concentration of solid particles. The instrumentation and protocol needed for this measuring task was developed in the UN Particle Measurement Program – PMP.

testo ViPR represents a PMP-compliant system for sampling, diluting and conditioning of raw gas for particle characterization. It is the latest generation of equipment based on the famous "Golden Instrument"-reference during the crucial phase of PMP-Program and uses the award-winning, patented "Volatile Particle Removal" technology, while more advanced in terms of operation, automation and ease of use.

It consists of several modules: a coarse particle pre-classifier, a volatile particle remover (VPR), a condensation particle counters (CPC) and a data acquisition unit for data recording and remote control. The VPR itself ensures that only solid particles arrive at the CPC, by means of two independent dilution stages with an evaporation tube in between. The data acquisition unit is designed to communicate with a dedicated PC and is prepared for additional analog signal input and output in up to five independent channels, e.g. trigger and measuring signals from test benches or additional sensors.

testo ViPR supports automotive engineers in many other applications beyond type approval. Due to its versatile hardware design, it offers the flexibility needed in automotive research and development environment.

testo ViPR is compact and easy to transport; special configurations can be used in mobile applications. The same piece of equipment can be connected to a full-flow CVS tunnel or directly to the tailpipe of an engine under test, simply following the daily changing needs without further hardware adjustment. Absolute emission measurement is just one option, relative measurement, e.g. when characterizing filters or other exhaust after treatment systems, is just a switch away.

testo ViPR at a glance:

- Developed in compliance with UNECE R83 and R49 regulations
- Together with a CPC provides number concentration of solid nanoparticles
- Transient measurement for recording driving cycle tests
- Primary diluter for direct connection to tail pipe or on CVS dilution tunnel
- Easy PC-linked operation

The complete PMP-system **testo ViPR**.

The complete system consist of following parts:



1 Rotating disk diluter **testo MD19-3E**

Accurate dilution of aerosols usually requires precise and stable mass flow control, especially if large dilution ratios and ranges are requested. Our improved and longtime proven rotating disk method of dilution avoids several problems of the conventional dilution technique such as frequent weekly linear checks or nozzle clogging. The portable dilution head **1b** allows to dilute the nearest possible to the aerosol source. This flexibility in the sample intake saves costly add-ons to avoid particle coagulation. The diluter can be assembled from its standalone version into the **testo ASET15-1** to build a compliant **testo ViPR** (UNECE-R83 for Euro 5b/6). A PMP compliant cyclone is optionally delivered with regulated 2.5 µm cut off.

2 Thermodiluter **testo ASET15-1**

Thermodiluter **testo ASET15-1** is the combination of an evaporation tube and secondary diluter for the removal of volatile particles from a dilute exhaust sample. During dilution and cooling of vehicle exhaust (e.g. in a CVS tunnel) vapors of volatile material condense into nanodroplets, which distort the measurement of nanoparticles. **testo ASET15-1** bounces volatiles back into the vapor phase. A free adjustable dilution range from 1 to 11 and the adequate temperature drop allows to use our system with a CPC or SMPS or eventually any other instrument for particle characterization.

3 Data acquisition unit **testo CU-2**

testo CU-2 digital control unit enables an easy way to store data and organize the information collected during testing and measurement. **testo CU-2** data acquisition unit uses AK protocol. It is assembled into the **testo ViPR** and provides four different control modes:

- AK Host Remote Control – the particle number measurement system can be integrated in a test rig. **testo CU-2** Digital Control Unit can be controlled by a host computer connected by serial RS232 port or Ethernet connection. Communication protocol is AK over TCP/IP or RS232. Optionally a second host computer can be connected via Ethernet.
- Remote Computer Software Control – the system can be controlled by a remote-desktop connection.
- Software Control – the system is operated via testo NanoMet software user interface.
- Manual Control

Technical specifications testo ViPR

sampling, dilution	with rotating disk diluter type testo MD19-3E
dilution ratio	adjustable range 1:15 to 1:3000
hot dilution	heated dilution block and dilution air
heating temperatures	+80 °C / +120 °C / +150 °C adjustable on rotating switch
mechanical set up	dilution on separate exhaust probe for connection to sampling probe
additional data	see data sheet for testo MD19-3E
thermal conditioning	with air supply evaporation tube type testo ASET 15-1
air supply primary dilution	1.5 normative liter per minute
secondary dilution factor	1 to 11
heating temperature	ambient to +400 °C / +752 °F
particle measurement	
number concentration	by CPC, any model with RS 232 serial interface
accuracy, size range, response time resolution	depending on CPC model
resolution	CPC resolution + 1 pt / ccm

system control	with digital control unit type testo CU-2
functionality	· control of dilution, thermal conditioning and sensor · measurement with real time data recording of connected analog and serial signals · logging speed adjustable up to 2 data sets per second · check of connected modules on safe and reliable operation
software	standard software available for legal transient and constant load tests on vehicles and combustion engines
remote PC-operation	ethernet communication (TCP/IT)
additional measuring signals	5 free analog inputs can be used to connect additional sensors and signals
mechanical set up	all 19" modules mounted in mobile 19" cabinet or rack
dimensions	standard type 55 (84 HP) x 30 (6U) x 60 cm (without pump & CPC)
weight	standard type 60 kg
supply voltage	90 to 260 VAC, 50/60 Hz; power consumption max. 300 VA (without pump & CPC)

Ordering information testo ViPR

Mat. No.	Description
1122B	testo ViPR - Volatile Particle Remover with PMP calibration Compliance with UNECE R49 and R83 regulations Consisting of testo MD19-3E, testo ASET15-1 and testo CU-2
1122	EEPC - Engine Exhaust Condensation Particle Counter EEPC TSI 3790 and vacuum pump
202	testo MD19-3E - Rotating Disk Diluter for Emissions Incl. diluter head, control unit, accessories box, country specific power cord and calibration sheet
<i>Please select the country specific power cord</i>	
78021	Power cord 2 m, 3 x 1 mm ² CH-plug
78022	IEC power 2.5 m 3 x 1 mm ² , Schuko plug
78023	Power cord 2 m, 3 x 1 mm ² US-plug
78024	Power cord 2.5 m, 3 x 1 mm ² GB-plug
78025	Power cord, 3 x 1 mm ² AU-plug
Accessories and spare parts testo MD19-3E	
262	PCF2.5 (Cyclone) - Remove Coarse Particles (cut-off 2.5 µm)
69090	10 cavities disk (nominal dilution ratio 1:15 - 1:300)
69091	8 cavities disk (nominal dilution ratio 1:150 - 1:3000)
79900	O-Ring kit for testo MD19-3E pneum. connector
3006	testo MD19-3E block
79010	Membrane pump
79230	Heating cartridge
3009	HEPA-Filter

Mat. No.	Description
251	testo ASET15-1 - Active Dilution Air Supply with Evaporation Tube Incl. Air supply, evaporation tube, accessories box, country specific power cord and calibration sheet
<i>Please select the country specific power cord</i>	
78021	Power cord 2 m, 3 x 1 mm ² CH-plug
78022	IEC power 2.5 m 3 x 1 mm ² , Schuko plug
78023	Power cord 2 m, 3 x 1 mm ² US-plug
78024	Power cord 2.5 m, 3 x 1 mm ² GB-plug
78025	Power cord, 3 x 1 mm ² AU-plug
Accessories and spare parts testo ASET15-1	
98050	Filter DIF-LN-30
98029	Rotary Vane Pump, 21 l/min
98003	Rotary Vane Pump, 3.1 l/min
3009	HEPA-Filter
504	testo CU-2 - Digital Control Unit for NanoMet, network enabled Incl. control unit, accessories box, connection cables to testo MD19-3E and testo ASET15-1, software and country specific power cord
<i>Please select the country specific power cord</i>	
78021	Power cord 2 m, 3 x 1 mm ² CH-plug
78022	IEC power 2.5 m 3 x 1 mm ² , Schuko plug
78023	Power cord 2 m, 3 x 1 mm ² US-plug
78024	Power cord 2.5 m, 3 x 1 mm ² GB-plug
78025	Power cord, 3 x 1 mm ² AU-plug
3020	Yearly Service Pack (including calibration) for testo MD19-3E
3021	Yearly Service Pack (including calibration) for testo MD19-3E + testo ASET15-1
2025	PMP Calibration for testo ViPR

Rotating disk diluter **testo MD19-3E.**

testo MD19-3E is a rotating disk diluter which provides a dilution ratio ranging from 1:15 up to 1:3000. This dilution method avoids several problems of the conventional dilution technique and opens new ways for application in aerosol and gas measurements, particularly in processes where programmable dilution ratios in a large range are required.

testo MD19-3E is a source/stack version for direct sampling on stacks or exhaust pipes. The undiluted gas parts, the dilution unit and the dilution air may be heated up to selectable temperatures. This avoids condensation of raw gas components sampled from exhaust source.

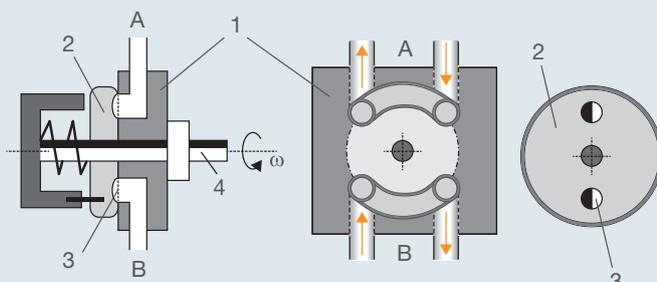


Working principle of the dilution method

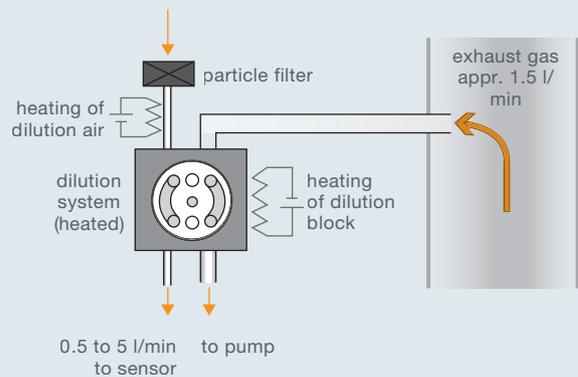
testo MD19-3E uses the rotating disk method to dilute a sample of raw gas for measurement. The unit is supplied with two disks (8 and 10 cavities) for different dilution ranges. This allows setting up dilution ratios from 1:15 to 1:3000. The raw exhaust emissions are sampled at a rate of approximately 2.0 l/min.

A portion of the raw exhaust fills up each cavity of the rotating disk and is transported to the measurement channel where it is mixed with HEPA-filtered, particle-free dilution air. The dilution ratio is a linear function of the disk calibration factor (corresponding cavity volume and number of cavities per disk), the rotation frequency and the flow rate of the dilution air as follows:

$$\text{Dilution ratio (DR)} = \frac{\text{Disk calibration factor} \times \text{Disk rotation frequency}}{\text{Dilution air flow rate}}$$



- A raw gas channel
- 1 body
- 3 disk cavity
- B measurement channel
- 2 rotating disk
- 4 axis of rotation



Cyclone PCF2.5



The PCF2.5 cyclone module has been developed to provide a robust, simple-to-use instrument designed to remove coarse particles from the raw gas drawn out of a CVS tunnel. It typically cuts off particles with aerodynamic diameter above 2.5 µm. It is used to fulfill the recommendations according the UNECE R83 and R49 regulations.

These coarse particles are kept in a catchment tank while small particles are directed into the **testo MD19-3E** dilution system. The cyclone is mounted on a support plate that fits onto the **testo MD19-3E** diluter head. It is optimized using short tubing from the inlet to the **testo MD19-3E** port, achieving minimized particle losses.

testo MD19-3E at a glance:

- Continuously variable aerosol dilution over a wide range
- Adjustable dilution ratio with no tools or recalibration required
- Extremely accurate dilution even at high rates
- Dilution takes place directly close to the aerosol source
- Raw gas return to the exhaust or any off-take
- Built-in heater with selectable temperatures to avoid condensed volatile materials
- Simple integration into standard 19" racks
- Low maintenance effort needed, low down-time
- 1000 operation hours between recommended service

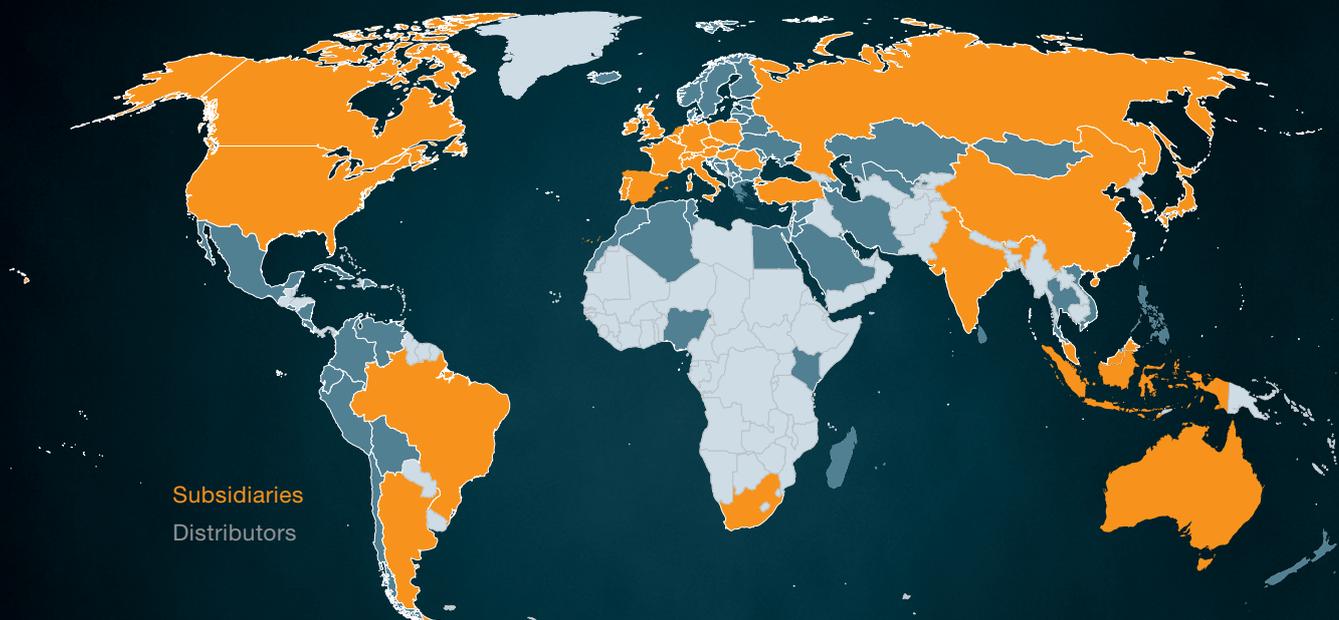
Technical specifications **testo MD19-3E**

aerosol	exhaust gases or air which contains nanoparticles
raw gas flow	approx. 1.5 l/min
measuring gas flow	full dilution range: 0.6 to 1.5 l _N /min @ high dilution factors up to 5 l _N /min
raw gas pressure	-20 to +300 mbar relative to ambient for low dilution (high rotational speed) -20 to +400 mbar relative for short time and high dilution
power supply	90 to 240 VAC, 50/60 Hz, max. 300 VA
local operation	pump switch, temperature dial, dilution potentiometer, LED indicators
remote operation	· via Ethernet in combination with testo CU-2 · controlled with analog DC signals 0 to 10 VDC
assembly	· together with testo ASET 15-1 integrated in 19" case · stand alone in a 3U / 42HP laboratory case
weight	diluter head: ca. 4.5 kg control unit in laboratory case: ca. 5.6 kg pneumatic and electrical connections: ca. 3.1 kg
operating conditions	T _{amb} : +10 to +40 °C 0 to 80 %RH, max. 80% @ +30°C, linearly degrading to 50% @ +40°C, non-condensing
calibration	· standard calibration with 90 nm NaCl particles in air, diluter temp: +80 °C · UN-ECE R83 calibration possible if integrated in testo ASET 15-1 system

Ordering information **testo MD19-3E**

Mat. No.	Description
202	testo MD19-3E - Rotating Disk Diluter for Emissions Incl. diluter head, control unit, accessories box, country specific power cord and calibration sheet
<i>Please select the country specific power cord</i>	
78021	Power cord 2 m, 3 x 1 mm ² CH-plug
78022	IEC power 2.5 m 3 x 1 mm ² , Schuko plug
78023	Power cord 2 m, 3 x 1 mm ² US-plug
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78025	Power cord, 3 x 1 mm ² AU-plug
Accessories and spare parts testo MD19-3E	
262	PCF2.5 (Cyclone) - Remove Coarse Particles (cut-off 2.5 µm)
69090	10 cavities disk (nominal dilution ratio 1:15 - 1:300)
69091	8 cavities disk (nominal dilution ratio 1:150 - 1:3000)
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3006	testo MD19-3E block
79010	Membrane pump
79230	Heating cartridge
3009	HEPA-Filter
3020	Yearly Service Pack (including calibration) for testo MD19-3E

Your partner in nanoparticle management.



Our former specialist in nanoparticle management Matter Aerosol has been a member of the Testo family since 2010. In 2015 it has been fully integrated into the Testo AG. With the full integration of the nanoparticle measurement technology business sector, Testo AG is pursuing the objective of a targeted and customer-oriented utilization of the synergies in Research & Development, as well as the extensive and proven possibilities and means available in industrial production, service and sales.

The extensive, specialized and recognized Research & Development know-how of Matter Aerosol is now completed with more than 50 years' expertise from Testo AG as a world market leader in the field of professional measurement technology. With this new arrangement, perfect solutions in the nanoparticle measurement technology sector will be developed for you.

Get in contact with our specialists:

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