testo MD19-3E

User Manual

Content

1 Declaration of Warranty

Manual Version History:

Version: V1.03

Date: September 2016

1.1. Type of Designation

This user manual refers to the instrument type and version as listed below. It replaces all previously dated user manuals for this instrument.

Type: testo MD19-3E

1.2. Manufacturer

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1.3. Warranty

Testo SE & Co. KGaA warrants that this product adheres to the specified properties for a period of twelve (12) months from the date of delivery.

Excluded from the warranty are all parts subjected to normal wear as any fuses, batteries or other consumable parts. Also excluded are: Defects resulting from abnormal use, in particular outside the intended purpose; lack of maintenance; improper use or malicious damage. Warranty is void if actions are carried out which are not described in the documentation nor authorized by Testo SE & Co. KGaA.

Testo SE & Co. KGaA does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.

There are no user-serviceable parts inside testo MD19-3E and some very sensitive parts. Do not open your testo MD19-3E, as you may damage it. Warranty is voided if the case is opened and warranty-seal is broken.

Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment.

2 Precautions

2.1. Foreword

This manual guides you through the installation, starting up, operation and maintenance procedures of the testo MD19-3E. In detail you will find information about the system as

- safety
- functionality of the testo MD19-3E, technical information and specifications
- installation of the testo MD19-3E and accessories
- handling, operation, maintenance and troubleshooting

Follow the instructions provided by this manual for safe and proper operation of the testo MD19-3E Rotating Disk Diluter.

Before installing and operating the testo MD19-3E, the operator or service has to read carefully this manual. For improper function, damages or injuries caused by ignoring the instructions by this manual no liabilities are accepted.

2.2. Liabilities

Testo SE & Co. KGaA accepts no liability to improper function or injury caused by

- neglecting the instructions provided by this manual or instructed person.
- improper installation, operation, application, or maintenance.
- operation by untrained staff.
- any technical modification not carried out by Testo SE & Co. KGaA or an authorized service partner.
- use of not genuine spare parts.

2.2.1. Liability to Content

The content of this manual is generated with most accurateness. Testo SE & Co. KGaA does not guarantee completeness, correctness and being up to date. Testo SE & Co. KGaA reserves the right to revise the content of the manual at any time and without notice.

Follow the guidelines below to ensure proper operation of the instrument:

- Read this instruction manual before installation and operation.
- Make sure that the raw aerosol pressure never exceeds 400 mbar (relative).
- Make sure that the pressures at the dilution air inlet and diluted measuring gas outlet always are within the limits of – 50...+ 10 mbar (relative)
- Always use genuine replacement parts supplied by SE & Co. KGaA.
- Always use heat protection gloves or allow the diluter block to cool down before any maintenance at the rotating disk or stator block unit.

2.3. Copyright ©

3 Safety

3.1. Risk Types

The following diagram shows typical risks that could cause damage or injury while handling the testo MD19-3E Rotating Disk Diluter.

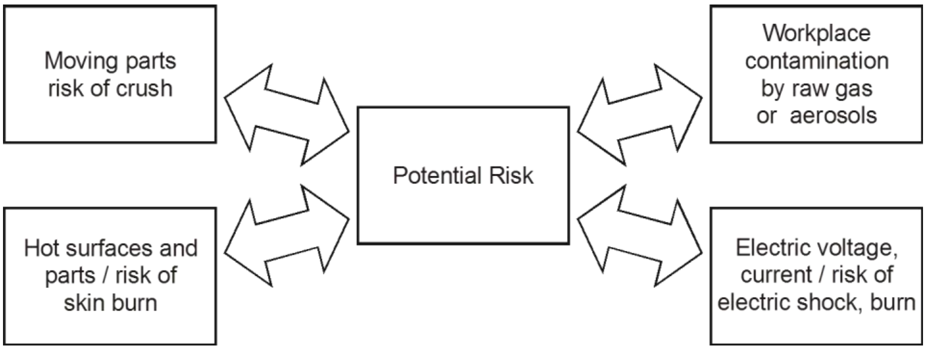


Fig. 3.1: risk types

3.1.1. Aerosol Contamination

Toxic aerosols may escape from the device, if the waste gas and measuring gas ports are not properly connected to the sensors downstream or an offtake.

3.1.2. Hot Surfaces – Burn Hazards

The diluter block is heated up to 160°C/320°F. Always wear heat protection gloves when handling the diluter disk and/or block.

3.1.3. Electrical Safety

When in operation any electrical equipment can produce dangerous voltages. Failure to observe the warnings may result in serious injury or damage. It is, therefore, mandatory that only suitably qualified personnel use this instrument. Satisfactory and safe operation of this instrument calls for proper handling in transportation, storage, installation as well as careful control and maintenance.

3.2. Labels and Explanations

When operating the testo MD19-3E, the user always is operating under certain risk factors as electricity, hot surfaces, moving parts and the aerosols which are processed by the diluter. Therefore the testo MD19-3E includes several safety features. Nevertheless, some precautions still need to be taken to ensure safe and reliable operation. Listed labels, Caution and Warning are explained in general, and the further specific labels refer to type of hazard and danger.

Caution

Caution means be careful. If you do not follow the manual instruction you might cause an instrument or accessories damage, but no human injury. Also Caution refers to important information about installation, operation and maintenance.

Warning

Warning means that improper operation could cause a serious human or instrument damage or injury with consequence of irrevocable instrument damage.

Electric Shock

Hazardous voltage. Contact may cause electric shock or burn.

Turn off and lock out system power before servicing.

Electric Ground

This sign indicates that the mains connector and cabinet ground are connected to protective earth PE.

Skin Burn

Hot surface. Do not touch. To avoid possible skin burns, wear heat protection gloves or turn heating off and allow surfaces to cool down before servicing.

Crush

Crush hazard. Keep hands clear of moving parts. Lockout/tagout before servicing.

Aerosol

Aerosols containing invisible nanoparticles and toxic exhaust gases are handled. Diluted or undiluted aerosol may escape from the testo MD19-3E if the gas return ports are not thoroughly connected to an offtake.

4 System Overview

4.1. Dilution Principle of testo MD19-3E Rotating Disk Diluter

4.1.1. Principle

The testo MD19-3E Rotating Disk Diluter can dilute some raw gas by a dilution factor between 15 and 3000. A disk with hemispheric cavities rotates on a steel block which is equipped with two aerosol channels. In every disk cavity a well defined amount of raw gas is transported from the raw gas to the dilution air channel.

Both dilution air and diluter block can be heated to prevent any vapors in the aerosol sample from condensing into small droplets during dilution. Dilution is preferably set to a value high enough to prevent condensation even as the sample is cooled to ambient temperature.

Fig. 4.1 shows a schematic plot of the mass concentration of a volatile compound against the temperature of the surrounding gas. The section between the curves N and E marks a certain hysteresis range wherein the volatile material remains in the phase it comes from. Leaving the section crossing the other curve will cause the phase change then.

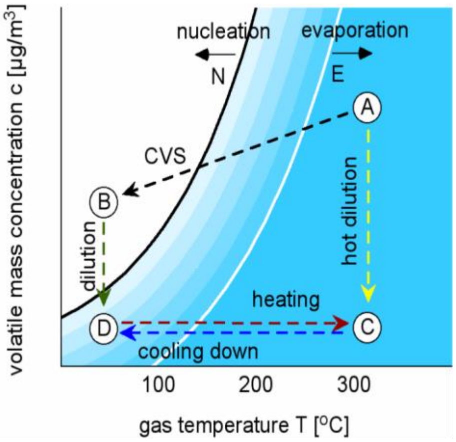


Fig. 4.1: volatile mass diagram

In a dilution tunnel both the concentration and the temperature of the substance are reduced (path A→B). During dilution, the compound passes its dew point and nucleates into nanodroplets (curve N).

Using a heated Rotating Disk Diluter, the mere formation of nanodroplets is avoided by direct sampling from the hot exhaust in combination with hot dilution (path A→C). Given a sufficient dilution factor, the volatiles will not nucleate during subsequent cooling (C→D).

The diluting parts i.e. heated diluter block and rotating disk, are placed in the so called diluter head which is an external part of the device. The diluter head can be fixed as close as possible to the source of the aerosol which should be diluted for subsequent measurements. It is connected to the control unit by one electrical and one pneumatic 3 meter long connection.

In the control unit, power supply, all controls and signal LED's, and control electronics are located, dilution air is filtered and provided to the diluter head, and a membrane pump sucks the raw aerosol through the diluter block. The rotational speed of the diluter disk depends on the dilution air flow which also is determined in the control unit.

The complete system containing control unit (right), pneumatic and electrical connections, and diluter head (left) are shown in Fig. 4.2.

Fig. 4.2: testo MD19-3E control unit, connections and diluter head

4.1.2. Applications

Usually instruments which determine nanoparticle number concentrations have specific measuring ranges, wherein measurements are possible or best accuracy of the determined values is reached. With the continuously variable rotating disk diluter it is possible to adapt particle number concentrations to the measuring range of the applied particle sensor.

Particles in the nanometer range strongly tend to coagulate which means smaller primary particles stick together, and build larger secondary particles, especially if the particle concentrations are high. This leads to smaller particle numbers and a shift of the particle size distributions towards larger diameters. In the diluter head of the testo MD19-3E the particle concentration is reduced as close to their emission source as possible before being transported to the measuring sensor, and the agglomeration effects are reduced significantly.

Depending on fuel and combustion parameters like air humidity, temperatures and residual times, combustion generated aerosols mostly do not only contain CO_2 and solid particles but also water vapor and other volatile components which may condense if the temperatures drop to ambient conditions, resulting in liquid particles which may damage or pollute the measuring sensors.

In the testo MD19-3E diluter head these components are first prevented from condensing into droplets due to the heating, then diluted to very low concentration. At low concentrations, they remain dissolved in the surrounding gas and will therefore not affect solid particle measurements anymore.

4.1.3. Functionality

The testo MD19-3E rotating disk diluter can be combined with the ASET15-1 secondary dilution system and the CU-2 digital control unit. All these components are mounted in standard 19" cases and can easily be integrated in a test bench equipped with 19" racks and Ethernet connections.

4.2. The Benefits Are

- Continuously variable aerosol dilution over wide range.
- Extremely accurate dilution even at very high rates.
- Dilution takes place directly close to the aerosol source.
- Flexible and simple operation.
- Simple integration into standard 19" racks.
- Full remote control possible in combination with digital control unit CU-2.
- Low maintenance effort needed, low down-time.
- Raw aerosol pressure up to 400 mbar (relative).
- Deviation of non-calibrated disks max. 4% / 8% (lower / upper dilution range).
- Raw gas return to the exhaust or any offtake.
- 1000 operation hours between recommended service.

4.3. The System

4.3.1. Definitions

Dilution Air	filtered air which is either sucked through testo MD19-3E by connected measuring instruments or actively fed to testo MD19-3E
Raw gas	undiluted aerosol from the emission source
Measuring gas	diluted aerosol released by testo MD19-3E the emission source

4.3.2. System Properties

The testo MD19-3E is power supplied by one phase electricity (90...240 VAC 50/60 Hz). It can be operated with measuring sensors sucking their needed amount of dilution air to which the suitable quantum of raw gas is added to reach the desired dilution. In combination with the ASET15-1 secondary dilution and condition unit, dilution air is fed to the testo MD19-3E rotating disk diluter, resulting in a certain diluted aerosol flow available for any measurements.

This external dilution air supply can also be done using compressed air and a simple mass flow controller, if no secondary dilution is needed but the pressure drop over the testo MD19-3E rotating disk diluter system is too high for the diluted aerosol to be drawn by the measuring sensor(s) downstream.

Fig. 4.3 shows all pneumatic components of the testo MD19-3E system. The pathways of dilution air, raw gas and diluted measuring gas are visible. The numbers and letters in small circles refer to the description in chapter 4.4 where all controls, ports, and removable diluter components are described.

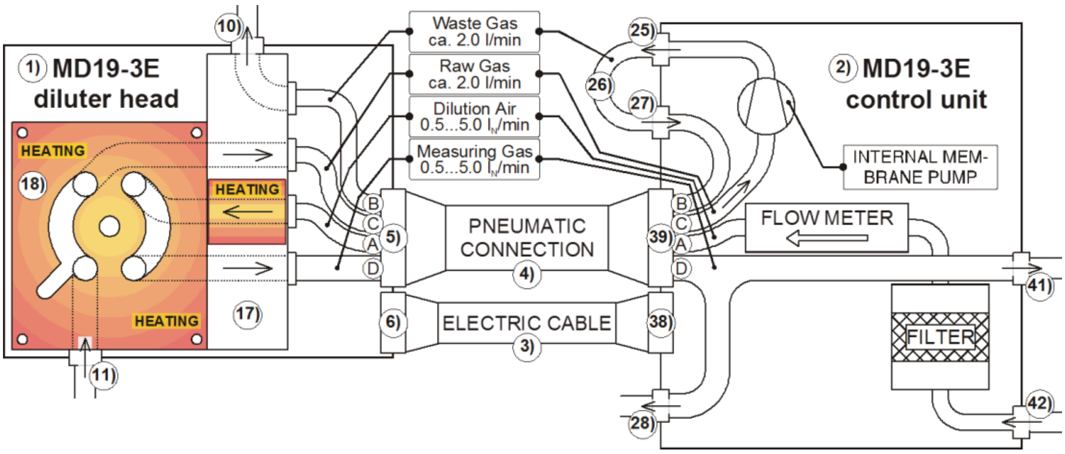


Fig. 4.3: function principle – pneumatic block diagram

1 testo MD19-3E diluter head
2 testo MD19-3E control unit
3 Electrical connection between diluter head and control unit
4 Pneumatic connection between diluter head and control unit
 tube A) Particle free dilution air duct to the diluter head
 tube B) Waste gas return to the diluter head
 tube C) Raw gas duct from the diluter head to the pump inside the control unit
 tube D) Diluted measuring gas return to the diluter head
5 Multiple pneumatic connector at the diluter head
6 Electrical connector at the diluter head
10 Waste gas outlet from diluter head to exhaust pipe
11 Raw gas inlet
17 Aerosol/dilution air duct block
18 Diluter block
25 Undiluted waste gas outlet to offtake
26 Waste gas return bridge
27 Quick coupling for waste gas inlet for return to diluter head
28 Self-sealing quick coupling for measuring gas output to sensor(s)

38 Electrical connector at the control unit
39 Multiple pneumatic connector at the control unit
40 Self-sealing quick coupling for measuring gas outlet to secondary dilution
45 Quick coupling for dilution air input

Both testo MD19-3E and testo ASET15-1 can be operated manually or by a testo CU-2 digital control unit. An electrical block diagram is sketched in Fig. 4.4. All signals entering and leaving control unit and diluter head are shown.

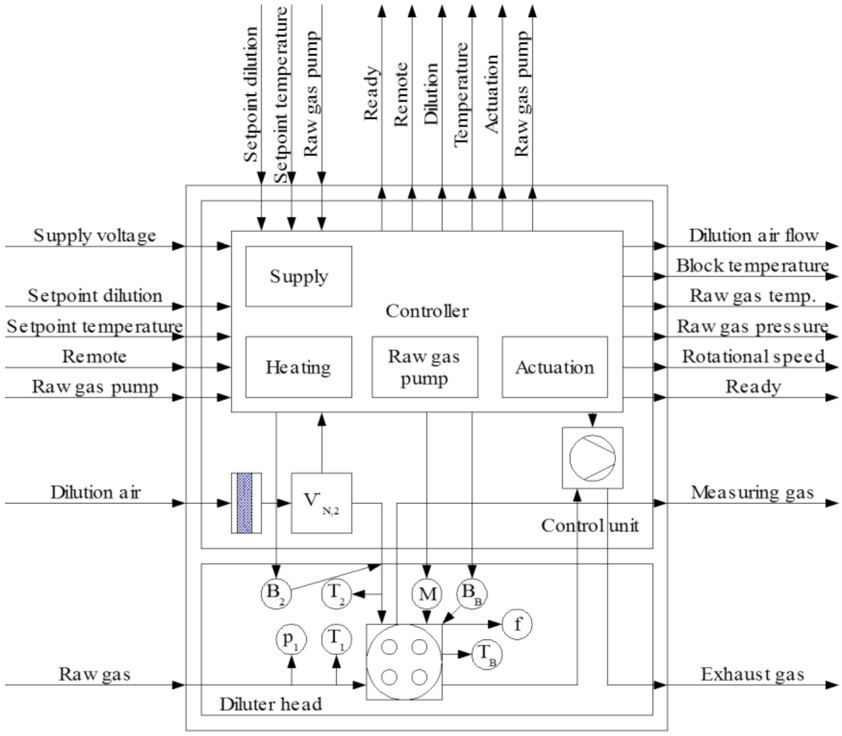


Fig. 4.4: function principle – electrical block diagram

4.4. Diluter Elements

4.4.1. Components

The testo MD19-3E consists of two main parts, the testo MD19-3E diluter head 1) and the testo MD19-3E control unit 2), which are connected by an electrical cable 3) and a multiple pneumatic tube 4). These parts are shown in Fig. 4.5.

Fig. 4.5: diluter head 1), control unit 2), electrical 3) and pneumatic 4) connections

4.4.2. Operating Elements Diluter Head

The heated parts of testo MD19-3E are covered by a protection hood to prevent unintentional skin contact and also to protect the moving parts of the rotating disk diluter.

Skin burn

Aerosol/air duct block 17) and diluter block 18) are heated up to 160°C / 320°F. The gloves enclosed with testo MD19-3E provide specified heat protection up to 160°C. Always use these gloves when handling the hot diluter head with removed heat protection hood, especially when exchanging rotating diluter disk or cleaning diluter block or disk surfaces.

Fig. 4.6 shows all ports and functional elements which are visible when the hot parts protection hood 8) is mounted and the device is ready for dilution.

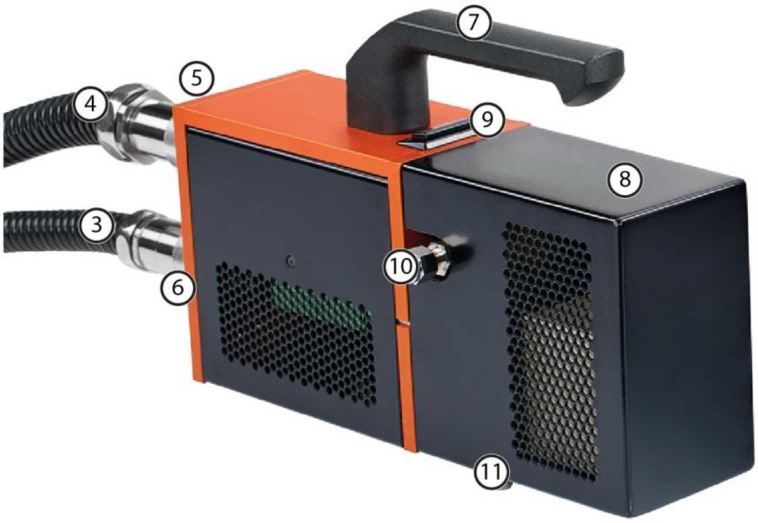


Fig. 4.6: diluter head overview

3 Electrical connection
4 Pneumatic connection
5 Multiple pneumatic connector at the diluter head
6 Electrical connector
7 Handle
8 Hot parts protection hood
9 Protection hood latch
10 Undiluted waste gas outlet (ca. 1.5 l/min)) from diluter head to exhaust pipe: 6 mm Swagelok fitting
11 Raw gas inlet (ca. 1.5 l/min) into diluter head: 10 mm Swagelok fitting

Fig. 4.7 Explains the diluting components themselves which are accessible with the hot parts protection hood 8) removed.

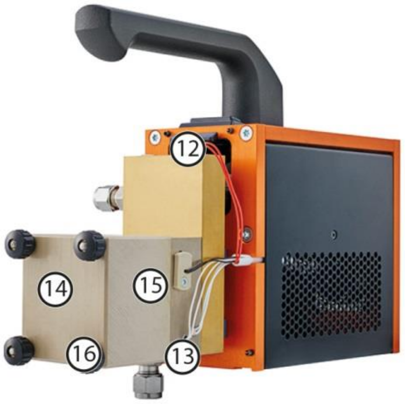


Fig. 4.7: diluter head with removed heat protection hood

12 Dilution air heating cartridge
13 Diluter block heating cartridges
14 Pressure compensation cap
15 Temperature sensors
16 Cap holder nuts with bolts
17 Aerosol/air duct block
18 Diluter block
19 Drill hole for cap holder
20 Diluter disk drive shaft
21 Diluter disk fixation cap
22 Fast lock ring
23 Rotating diluter disk

4.4.3. Operating Elements Control Unit

In Fig. 4.8 all ports and operating elements situated at the front side of the control unit are shown. The waste gas return bridge 26) is not exactly a part of the control unit but is always set between the two waste gas ports in normal use except when the control unit is connected to another offtake than the exhaust pipe where the undiluted waste gas usually is fed back.

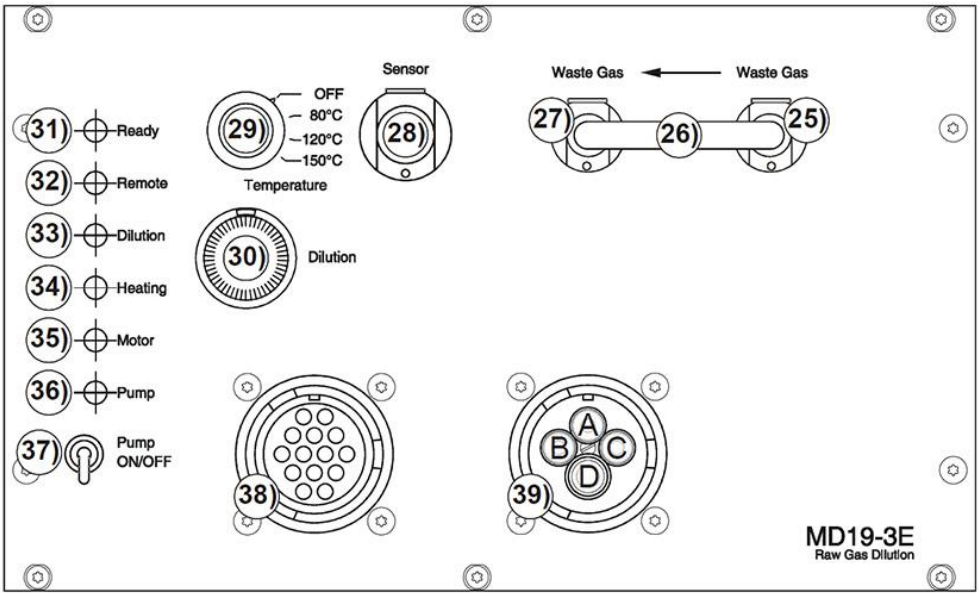


Fig. 4.8: front view of testo MD19-3E

25 Quick coupling for waste gas outlet to an offtake

26 Waste gas return bridge / connection to another offtake than the exhaust pipe
27 Quick coupling for waste gas inlet for return to the diluter head
28 Self-sealing quick coupling for measuring gas output to sensor(s)
29 Dial for temperature setting of block and dilution air heating
30 10 turn potentiometer for dilution setting
31 All signals ready LED: green: OK dark: at least one signal not OK
32 Remote control LED: green: remote controlled dark: local controlled
33 Dilution factor LED: green: OK red: out of specified range
34 Block and dil. air heating LED: green: OK red: error dark: OFF orange: heating up
35 Actuation motor LED: green: rotating red: error dark: stopped
36 Raw gas pump LED: green: running red: error dark: OFF
37 Raw gas pump switch: up: ON down: OFF
38 Electrical connector between electrical connection 3) and control unit 2)
39 Multiple pneumatic connector between pneumatic connection 4) and control unit 2)

4.4.4. Control Unit Rear Side

The testo MD19-3E control unit is a plug-in which can be integrated into the 19" case of the secondary dilution unit ASET15-1 or into a laboratory case as a stand alone unit. Fig. 4.9 shows the rear view of the plug-in. The rear side of the stand alone laboratory case is displayed in Fig. 4.10.

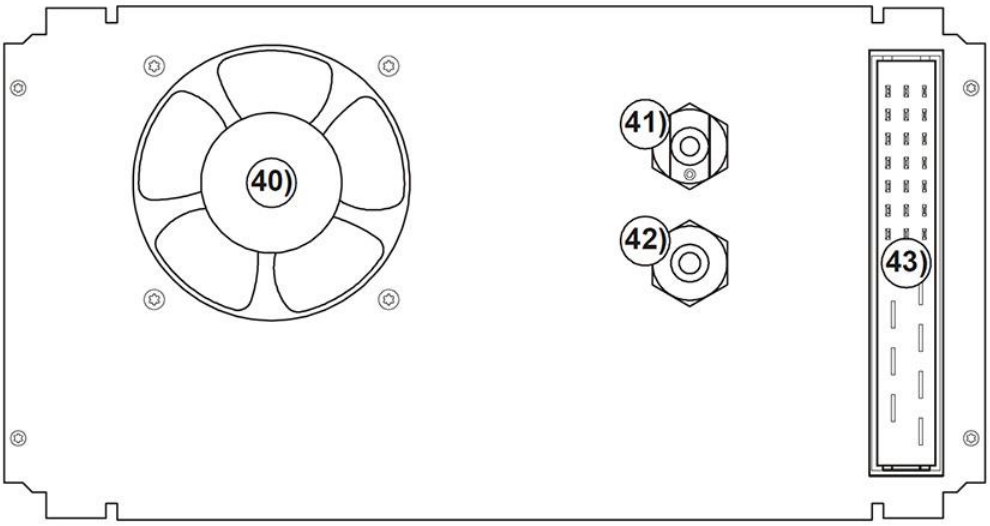


Fig. 4.9: rear view plug-in unit

40 Ventilator
41 Self-sealing quick coupling for measuring gas output to secondary dilution
42 Quick coupling for dilution air input to testo MD19-3E rotating disk diluter
43 Connector to electronic circuit

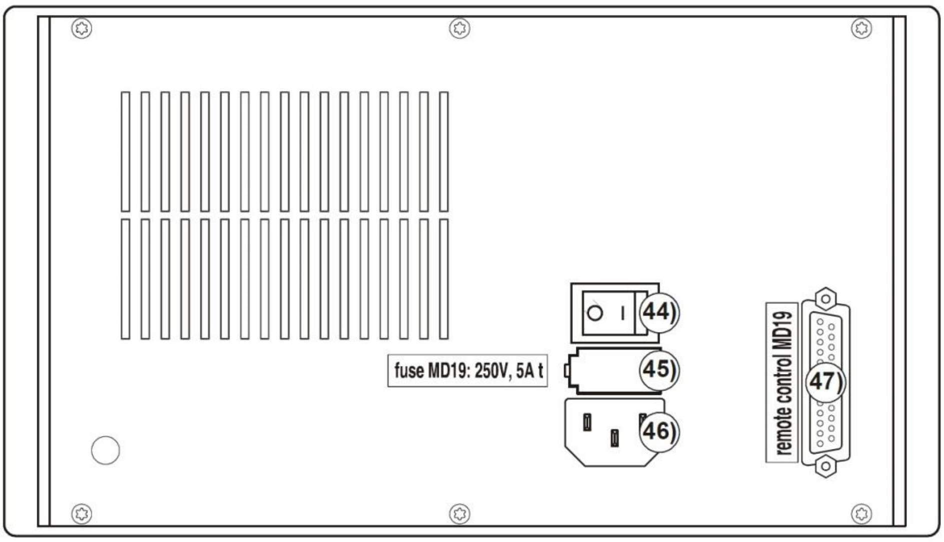


Fig. 4.10: rear view laboratory case

44 Mains switch
45 Fuse testo MD19-3E: 250 V, 5.0 A, t
46 Mains connector
47 Remote control interface connector: 25 pin D-Sub female

4.4.5. Important Remarks

The testo MD19-3E Rotating Disk Diluter is constructed to dilute exhaust or flue gas from combustion processes in diesel engines, light oil burners or wood or coal combustion. It may also be used for gases or aerosols emerging from other processes. The dilution ratio is specified for gases and aerosols containing particles in the size range 10...1000 nm.

Electric Shock

When in operation, any electrical equipment can produce dangerous voltages. Ignoring these warnings may result in serious injury or damage of the equipment. It is mandatory that only suitably qualified personnel are allowed to work on this instrument. Satisfactory and safe operation of this instrument necessitates proper handling in transportation, storage and installation as well as careful control and maintenance.

Skin Burn

Dilution block and other parts of the diluter head are heated up to 160°C / 320°F. The gloves enclosed with testo MD19-3E provide specified heat protection up to 160°C. Always use these gloves when handling the hot diluter head with removed heat protection hood, especially when exchanging rotating diluter disk or cleaning diluter block or disk surfaces.

Aerosol

Diluted or undiluted aerosol may escape from the testo MD19-3E if the gas return ports are not thoroughly connected to an offtake. Never operate the system without having either the waste gas outlet connected to an offtake or to the waste gas inlet for returning the aerosol to the exhaust pipe.

Caution

Ensure that the specified raw gas pressure range of -30 mbar to +400 mbar is not exceeded. Too much negative pressure can lift the disk from the block leading to uncontrolled dilution conditions, while too high positive pressure may damage disk surface and enhance the drive torque over the motor torque maximum.

5 Installation and Setup

Note: Numbers – e.g. 30) = dilution setting potentiometer – refer to the operating elements illustrated in chapter 4.4.

5.1. Mounting of the Diluter Head

The diluter head is designed for direct mounting to a tail pipe or stack. Tests of different sampling probes have shown that particle loss due to anti-isokinetic effects can be neglected for all types of probes shown in Fig. 5.1 in nanoparticle measurement in the size range from a few tenths to a few hundred nm.

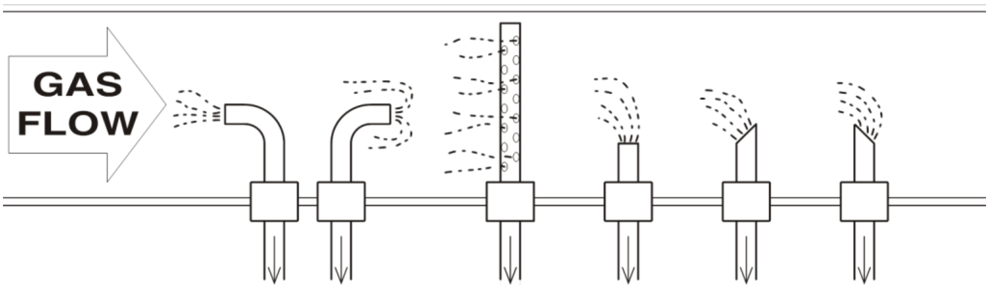


Fig. 5.1: different types of sampling probes

More attention should be paid to inhomogeneous particle concentration across the tail pipe or stack diameter. To compensate its influence, a sampling probe according to Fig. 5.2 is recommended. The exhaust is sampled through holes of 1...2 mm diameter for averaging the sampling across the tail pipe or stack diameter.

Fig. 5.2: mounting of sample probe head

An example for how to mount the diluter head is shown in Fig. 5.2. The sample inlet tube should be kept as short as possible while the raw gas return path can be longer.

5.2. Aerosol Tubing

The testo MD19-3E rotating disk diluter is using the principle of hot dilution which means that the sample probe head block and dilution air are heated up to temperatures of 80°C, 120°C or 150°C, adjustable on the dial 29). This method keeps evaporated liquids above their dew points, during and after the dilution, and avoids the generation of volatile nanoparticles by nucleation. Its main advantage is that the diluted aerosol is not mixed with additional nanoparticles caused by the sampling and dilution process. The diluted aerosol provides, therefore, genuine information about the particles sampled from the combustion process.

Exhaust of combustion processes can pollute the parts which conduct the undiluted gas, depending on the particle concentration and characteristics. To guarantee safe and accurate function and to prevent damage of the unit, please consider the following points:

- Follow the instructions for cleaning and service maintenance described in chapter 8.
- To prevent condensation in the undiluted gas tube do not switch on the raw gas pump before the dilution block is heated up to the temperature set on dial 29) or in the remote control software.
- To avoid condensation in the undiluted gas, ensure that the temperature of the tubes between the exhaust pipe or stack and the exhaust probe is not lower than the selected block temperature.
- Heat up and insulate the undiluted gas tubes and keep them as short as possible to minimize particle loss by diffusion and agglomeration.
- In case of high dust concentration in the exhaust (e.g. coal or wood combustion) use a cyclone or an impactor between sampling tube and diluter head to precipitate coarse particles larger than approx. 5 µm. For long time sampling (more than a few hours) it is recommended to clean the sampling tube by periodically blowing compressed air back into the tube. This can be done by using two valves, one to protect the exhaust probe while the other valve is opened to the compressed air supply.

Loss of particles can be minimized if the following instructions are observed in the sampling lines from the aerosol source to the sensors.

5.2.1. Diffusion Losses

Loss of particles by diffusion in the gas tubes can not be avoided but can be calculated or read from diagrams like the one in Appendix A.4.

Example:

- Parcicle size: 30 nm
- Length of gas tube: 3 m
- Sample flow: 1 l/min
- Diffusion losses according to diagram in Appendix: approx. 2.3 %/m
- Total diffusion losses: **approx. 7 %**

The diffusion losses are proportional to the length of the gas tube, inversely proportional to the sample flow and independent to the tube inner diameter. Reference: William C. Hinds (1999): Aerosol Technology, Properties, Behaviour and Measurement or Airborne Particles, John Wiley & Sons, page 164, table 7.6.

5.2.2. Tube Properties

In general, tubes of highly insulating material are not qualified for the sampling of nanoparticles. Particle loss by electrostatic effects can be much higher compared to the calculated diffusion losses.

- For this reason, do not use teflon, standard silicone or PVC tubing.
- Metallic tubes (e.g. Steel, copper, brass) are free from particle loss, except by diffusion.
- Flexible tubes made of electrically conductive material have been found to behave similar to metallic tubing. The following carbon loaded and therefore semi-conductive silicone rubber tube types have been tested and are recommended by Testo SE & Co. KGaA: Testo Art. No. 68013 and 68014 with inner diameters of 4 mm and 6.

5.2.3. Handling of Quick Couplings

The quick coupling for diluted gas outlet 41) at the rear side of the control unit plug-in is opened / closed automatically when the unit is put into an appropriate device like the secondary dilution unit ASET15-1.

The couplings at the front side have to be handled by the operator if the diluted aerosol is drawn through port 28) or if another offtake than the exhaust pipe is used to remove the excessive undiluted waste gas from the waste gas outlet of the control unit 25). Fig. 5.3 shows how the plug of a tube is disconnected from the quick coupling. Pushing down the button at the top of the quick coupling will release the plug which can be pulled out then.

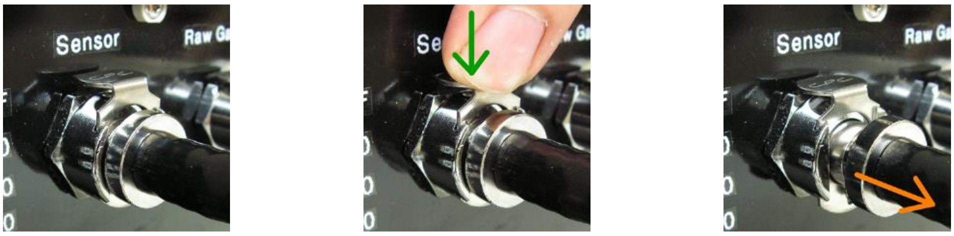


Fig. 5.3: handling of quick couplings at the control unit front side

The plug catching ring will remain down when the plug is disconnected from the coupling. When a plug is pulled in, the ring and button will jump up and automatically lock the plug. If the plug cannot be inserted, the fixation ring might be in the wrong position. Push down the release button and insert the plug again.

5.2.4. Connect Another Offtake to the Control Unit

Aerosol

Undiluted aerosol may escape from the control unit if the waste gas outlet of the diluter head 10) is connected to an exhaust pipe and the plug of the waste gas bridge 26) is connected to the waste gas return port of the control unit 27) inhibiting the self-sealing function of the quick coupling. Never leave the unused plug of the disassembled waste gas bridge in the waste gas return coupling 27).

The plugs of the waste gas bridge 26) which are shown in Fig. 5.4 can be used to connect the waste gas outlet 25) of the control unit to a separate offtake. To remove the bridge tubelet, loosen the sleeve nut.

Fig. 5.4: one end of the waste gas bridge with plug

The tube can then be pulled from the nipple. Slip the sleeve nut over the new tube leading to the offtake. Put the tube over the nipple and tighten the sleeve nut according to Fig. 5.5.

Fig. 5.5: install a different tube

5.3. Preparation, Heating Up Phase

The dilution can be chosen with a higher and a lower dilution range, depending on the number of cavities of the disk 23).

Note: In all instructions of this manual, higher dilution ration DR = 1/DF means lower dilution factor DF and vice versa.

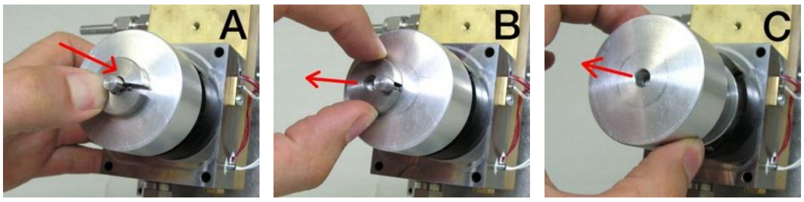
5.3.1. Preparation of Diluter Disk and Block

Clean surfaces of diluter disk 23) and diluter block 18) are necessary to ensure correct diluting function and long durability. Ensure the accurate cleanliness of these parts as follows:

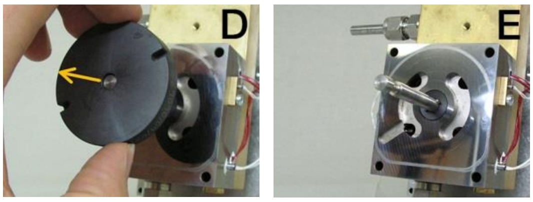
Skin Burn

The dilution block is heated up to temperatures up to 160°C / 320°F. Avoid any skin contact to hot parts. Use heat protection gloves (enclosed with the testo MD19-3E accessories) for any handling while parts of the diluter head are hot, especially when exchanging the disk 23)

- Open the protection hood latch 9) and remove the hot parts protection hood 8).
- Loosen the cap holder nuts 16) and remove the pressure compensation cap 14).
- move the fast lock ring 22) from the shaft 20) by pushing it in axial direction towards the diluter block and pulling it radially so that the shaft neck can slide through the slit according to Fig. 5.6 A and B.
- Remove the diluter disk fixation cap 21) by pulling it in axial direction from the shaft following Fig. 5.6 C.



Fast lock ring (A and B), disk fixation cap (C)



Diluter disk (D) and lay bare the diluter block (E)

Fig. 5.6: removal of the rotating diluter disk for cleaning disk and block surfaces

- Pull the diluter disk 23 from the shaft as shown in Fig. 5.6 D.
- Select the diluter disk according to the desired dilution range. For lower dilution factors, choose the 10 cavities disk, for higher dilution factors the one with 8 cavities.
- Clean disk and block surfaces with a cleaning alcohol and a clean soft paper wipe. Testo recommends to use pure (≥99.8%) ethanol for analysis or isopropyl alcohol.
- Dry the surfaces with another paper wipe and remove possible lints by blowing them away with compressed air.
- Put the selected disk back on the shaft. Make sure the disk torque transfer notch meets the drive bolt crossing the shaft.
- Reassemble the diluter components in reversed order. Ensure that the rubber gasket is properly inserted into its notch when mounting the pressure compensation cap 14)

5.3.2. Setting Up the testo MD19-3E Dilution System

- Connect the electrical 3) and pneumatic 4) connections between control unit 2) and diluter head 1).

- Connect the diluter head directly or via heated tubes to the exhaust pipe. Keep the tube length as short as possible to minimize the influences of coagulation and particle losses (see chapters 5.2.1 and 5.2.2 for tubing recommendations).
- Make sure the waste gas outlet of the control unit 25) is either connected to an offtake or to the inlet for waste gas return 27) when the raw aerosol is fed back to the exhaust via raw gas outlet of the diluter head 10).
- If the device is not integrated in a ASET15-1, connect your sensor(s) to the diluted gas connection on the front side of the control unit 28).

If the testo MD19-3E is integrated into an ASET15-1 secondary dilution unit, no tube should be plugged into the diluted gas connection on the front side 28). Any flow into or out of port 28) will perturb the aerosol flow and therewith the dilution of the secondary dilution unit ASET15-1.

- Make sure the raw gas pump switch 37) is in “OFF” position (down).
- Connect the power supply cord to the mains connector 46), turn on the mains switch 44) and make sure the mains switch remains accessible during operation.
- Choose the heating temperature for the diluter block and dilution air on dial 29)
- Ensure a certain diluted gas flow by drawing connected sensor(s) or by actively fed dilution air. The unit requires a minimal flow of approx. 0.4 l/min in the measuring gas channel to keep the dilution air heating in operation.
- When no gas is drawn by the sensor(s), the “dilution factor” LED 33) lights up red independently of the setting of the dilution setting potentiometer 30). It will turn to green when dilution air flow is detected and the rotational speed of the diluter disk is within the specified range.
- Wait until the “block and dilution air heating” LED 34) lights green and indicates that the set temperature is reached.
- Turn on the raw gas pump switch 37) to feed raw gas to the dilution air and therewith start real dilution.

5.4. Raw Gas / Raw Aerosol Properties

5.4.1. Raw Gas Pressure

The testo MD19-3E rotating disk diluter is equipped with a pressure compensation cap 14) which ensures that overpressure in the raw gas channel of the diluter block 18) will not lift up the disk 23) which would lead to undefined dilution conditions.

Due to the difference between the compensation pressure and the ambient pressure inside the dilution air channel the disk is pushed towards the diluter block 18), leading to enhanced drive torque and disk surface wear. The motor torque is sufficient up to a continuous pressure difference of 300 mbar and pressure peaks up to 400 mbar.

Any pressure difference may cause increased disk surface wear, even below 300 mbar. This means the dilution will be correct but the disk may not reach 1000 operation hours.

If the raw gas pressure (e.g. caused by backpressure of a particle trap) exceeds 300 mbar or if long-term measurements with significant pressure even within the mentionned limits are performed, it is recommended to use an external pressure reduction.

You may protect your testo MD19-3E diluter head by introducing a valve and an opening between exhaust pipe and diluter head as shown in Fig. 5.7 to reduce the pressure. The valve has to be adjusted to an opening, where more than 2 l/min are flowing through the valve over the whole pressure range which will be applied to the diluter head inlet 11). Lead the excess raw gas to an exhaust air system.

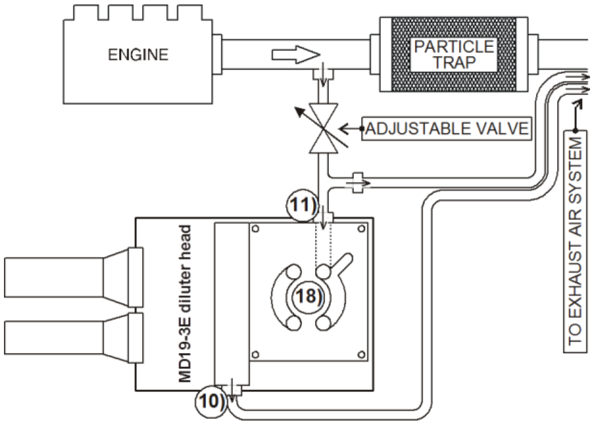


Fig. 5.7: measurement setup if raw gas pressure exceeds 300 mbar

5.4.2. Raw Gas Temperature

To protect diluter head parts like disk coating, tube fittings etc., the temperature of the diluted gases must not exceed 200 °C. The raw gas pump will stop if the inlet gas temperature is too high to prevent damage to the diluter head and tubes.

5.4.3. Verification of Correct Operation

During the heating up phase, the correct operation of the dilution system can be checked as follows:

- If the device is used stand-alone, connect your sensor(s) to the diluted gas connection on the front side 28). Otherwise turn on the testo MD19-3E Dil Air supply pump of the ASET15-1 where the testo MD19-3E is integrated. Some gas must flow through the testo MD19-3E.
- Make sure the internal pump switch 37) is „OFF“ (down) and the dilution potentiometer 30) is on zero position.
- Remove the hot parts protection hood 8). The pressure compensation cap 14) has to remain installed over diluter disk 23) and block 18).
- Increase the dilution ratio on the potentiometer. The disk must start to rotate with increasing frequency. The rotational speed can be observed at the coupling element shown in Fig. 5.8 when the hot parts protection hood 8) is removed.

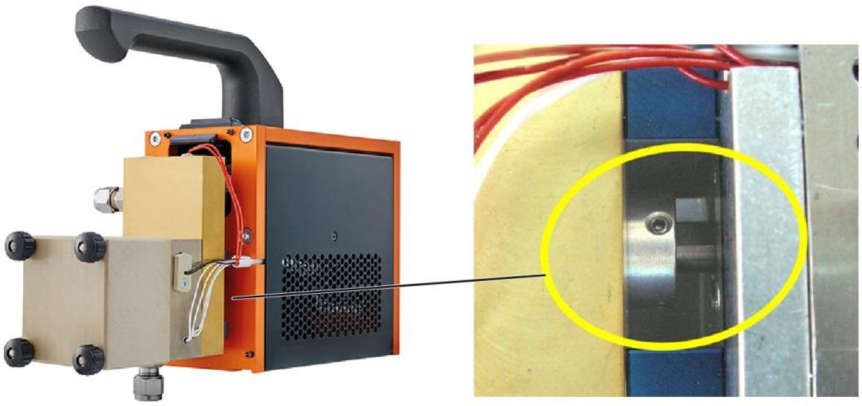


Fig. 5.8: coupling element as rotation indicator

No disk rotation may be caused by:

- No gas is drawn by the connected sensors.
- Too strong friction leading to blocked disk on block surface. The electric current of the rotation drive is controlled. The „Motor“ LED 35) lights up red when an upper current limit is exceeded due to mechanical overload. This fault can mostly be removed by checking and cleaning disk and block surfaces according to chapter 5.3.1.
- Too high pressure of the raw gas. To inhibit a lifting of the disk from the block surface caused by pressurized raw gas, the compensation cap ensures raw gas pressure surrounding the diluter disk. The force induced by this compensation pressure leads to more friction between disk and block surface. If the raw gas pressure exceeds 400 mbar,

the disk rotation may be inhibited, especially in combination with worn or polluted disk and block surfaces. You may reduce the disk surrounding pressure by introducing a valve between source and diluter following chapter 5.4.1

- Some leakage of the pneumatic system. Please check the multiple pneumatic connectors at the control unit and the diluter head. Fig. 4.3 helps you to understand the path of dilution air/diluted aerosol.
- Electrical or mechanical failure which needs to be repaired by the manufacturer or instructed service staff.

6 Operating Instructions

6.1. Dilution Factor

Note: The dilution factor depends on the temperature in the exhaust diluter block 18) which can be heated up to different temperatures. The nominal dilution range from 1:15 to 1:3000 refers to a block temperature of 80 °C set on dial 29). Correction factors have to be applied when operated at other tempteratures.

6.1.1. Abbreviations, Units and Symbols

DR	Dilution Ratio	e.g. 1/20 = 0.05
DF	Dilution Factor	e.g. 20
pot[%]	setting of potentiometer 30)	0...10 corresponds to 0...100 %
CF	Calibration Factor	nominal 1'500 (10 cavities disk) and 15'000 (8 cavities disk) Refer to calibration sheet for specific factors.
TF	Temperature correction Factor $= \frac{T_{abs,\ Heat}}{T_{abs,\ Ref}} = \frac{T_{Heat} + 273.15°C}{80°C + 273.15°C}$	TF(OFF) = 0.83 TF(80 °C) = 1.00 TF(120 °C) = 1.11 TF(150 °C) = 1.20
PCRF	Particle Concentration Reduction Factor; if testo MD19-3E is operated without additional dilution/particle reduction: PCRF = DF	
l/min (STP)	Standard liter per minute: unit for gas volume flow at 1013,25 hPa / 0°C	
Q_{DA}	Dilution Air flow through the testo MD19-3E Rotating Disk Diluter	
Q_{RG}	Raw Gas flow through the raw gas channel in the diluter block	
Q_{MG}	diluted Measuring Gas flow to the connected instrumentation which is either determined by the connected sensor(s) or by the actively feeding air supply, e.g. ASET15-1	

6.1.2. Calibration Certificate

Fig. 6.1 shows an example of a testo testo MD19-3E Rotating Disk Diluter calibration certificate. The plot in the center of the calibration sheet visualizes the linearity of the data collected during the calibration procedure. The calibration setup details are described in the boxes at the top, the resulting values at the bottom of the calibration certificate.

A identification of the calibrated device: diluter type and serial number
B identification of the installed diluter disk: disk type, production lot, serial number
C dilution settings: sample flow drawn by the sensor, dilution air and head temperature
D calibration aerosol properties: material, description of size distribution

E calibration laboratory equipment description
F linear regression parameters evaluated in terms of the calibration procedure
G calibration factor CF=1/S
H description how dilution ratio DR and dilution factor DF can be calculated out of the calibration factor CF and the potentiometer setting pot[%].

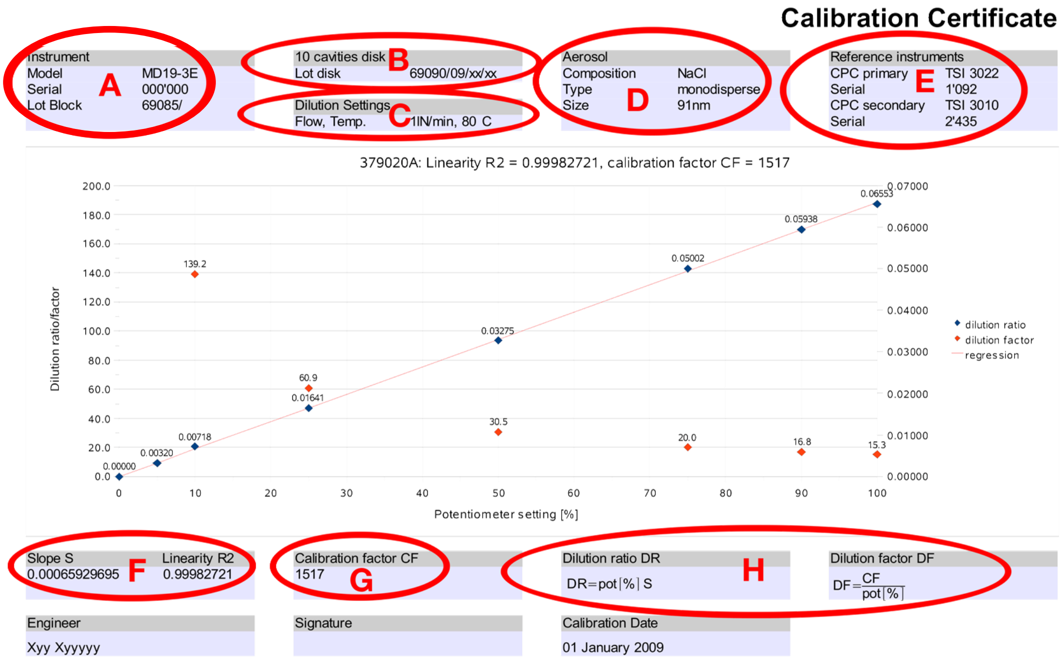


Fig. 6.1: calibration certificate

6.1.3. Available Calibrations

Besides the Testo SE & Co. KGaA standard calibration, the testo MD19-3E Rotating Disk Diluter also can be ordered calibrated fulfilling the PMP regulations. This more extensive PMP calibration is available only if the device is integrated in an ASET15-1 secondary dilution system.

For PMP compliant measurements, a yearly calibration is mandatory. Testo SE & Co. KGaA recommends also the standard calibration to be done by the manufacturer or a local service provider once a year.

6.1.4. Adjustable Dilution Ranges

The diluter is calibrated on a nominal range from 1:15 to 1:3000. The dilution factor DF can be calculated as follows:

- dilution factor $DF = \frac{CF}{pot[\%]}$

The nominal values of the calibration factors are

- CF = 15'000 for the 8 cavities disk 23)
- CF = 1'500 for the 10 cavities disk 23)

The effective values are listed on the calibration sheet as it is described in chapter 6.1.2.

These nominal values refer to a heating temperature of 80 °C selected on dial 29). If other temperatures are chosen, the formula for the dilution factor has to be compensated by the f[°C] factors mentioned above.

- dilution factor $DF = \frac{TF(°C) \cdot CF}{pot[\%]}$

The dilution ratio has a linear relationship to the rotation frequency of the disk and the dilution air flow Q_{DA}. The rotation frequency is proportional to the product of the potentiometer 30) setting and the dilution air flow:

- $f_{rot} \propto pot[\%] \cdot Q_{DA}$

Q_{DA} is given by the gas flow drawn by the connected sensor(s). To compensate its influence, Q_{DA} is measured and electronically multiplied with the potentiometer 30) setting to determine the rotation frequency of the disk 23).

The dynamic range of the rotation frequency is limited to a nominal frequency of approx. 2.5 Hz when potentiometer 30) is set to 100 % and the dilution air flow Q_{DA} is 1.5 l/min.
When Q_{DA}[l/min] · pot[%] exceeds 150, the "Dilution" LED 33) signalises that the rotational speed is in overrange. Fig. 6.2 illustrates the settable ranges of dilution factor DF depending on the sample flow $Q_{MG} = Q_{DA}$ and the number of cavities on the disk. This figure shows that for Q_{DA} > 1.5 l/min potentiometer 30) must be set to a value below 100 % where the "Dilution" LED is not lit up.

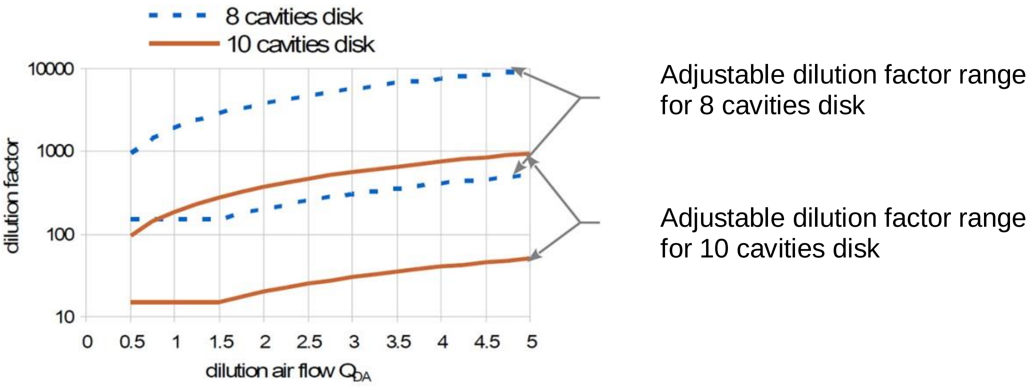


Fig. 6.2: settable dilution factor ranges

6.2. Block and Dilution Air Heating

The diluter block and dilution air usually are heated to 80°C, 120°C or 150°C to prevent condensation of vapors into volatile particles. As a result of the dilution the concentration of the vapors is reduced to a level where no condensation occurs anymore, even at low temperature, and it remains in the gas phase.
PMP regulations require a primary dilution temperature of at least 150°C. For measurements which do not have to meet PMP requirements often 120°C or 80°C are set to minimize the influence of the heating to the sample characteristics.
The maximum deviation from the temperature setpoint is +/- 5°C. To ensure temperatures above 150°C when PMP compliant measurements are performed, the setpoint in this mode is 155°C. Therefore the nominal value 150°C is the minimum temperature during operation in this mode. The temperature ranges at all standard temperature set points are as follows:

heater setpoint	effective tempe-rature range	minimum effective temperature	temperature correction factor
OFF	ambient, typically 20°C		0.83
80°C	80 +/- 5°C	75°C	1.00
120°C	120 +/- 5°C	115°C	1.11
150°C	155 +/- 5°C	150°C	1.21

6.3. Manual Dilution Setting

- Wait until the „Heating" LED 34) lights green and indicates that the diluter block and the dilution air heating are heated up to the temperature chosen on dial 29).
- Set potentiometer 30) to zero and start the internal pump on switch 37).
- If the testo MD19-3E is used stand-alone, ensure the sensor(s) connected to the measuring gas output on the front side of the control unit 28) draw some gas trough testo MD19-3E.
- If the testo MD19-3E is integrated into an testo ASET15-1, turn on the testo MD19-3E Dil Air supply.
- Since there is no rotation, the sensor(s) draw(s) particle free air from ambient air through the dilution air input 42) and internal particle filter.
- Reduce the dilution factor by increasing the potentiometer setting. Observe the reading of your sensor(s) to find an optimal dilution adjustment. Depending on the tube lengths, response time will be from a few seconds to 30 sec.
- Read the setting (0...10.0 = 0...100 %) of the potentiometer 30) and calculate the dilution factor $\mathrm{DF} = \frac{\mathrm{TF(°C) \cdot CF}}{\mathrm{pot[\%]}}$
  The calibration factor CF = nominal 1500 (10 cavities disk) and 15000 (8 cavities disk). Refer to calibration sheet for specific factors.
  Example:

  pot[%] = 40 %
  10 cavities disk with CF = 1521
  TF(120 °C) = 1.11

  $$\mathrm{DF} = \frac{\mathrm{TF(°C) \cdot CF}}{\mathrm{pot[\%]}} = \frac{1.11 \cdot 1521}{40} = 42.2$$

Ensure that:

- the „Heating" LED 34) indicates that the temperature chosen on dial 29) is reached.
- the „Dilution" LED 33) lights green and indicates that the set dilution is within the specified range.
- the „Ready" LED 31) confirms no error signal occurs.
- the disk is rotating continuously (see chapter 5.4.3).

6.4. Analog Input/Output

The dilution factor DF may be set by an external source and/or read by an external measurement device. The dilution factor set by the potentiometer 30) will be ignored if 5 VDC are applied to the remote control pin and of the connector at the rear side of the control unit. The analog voltage signal on the dilution factor pin will then replace the potentiometer setting.

dilution factor $\mathrm{DF} = \frac{\mathrm{TF(°C) \cdot CF}}{10 \cdot \mathrm{U_P}[V]}$ where the voltage range is U_P = 0...10 VDC

Example:

U_P = 4 V
10 cavities disk with CF = 1521
TF(120 °C) = 1.11

$$\mathrm{DF} = \frac{\mathrm{TF(°C) \cdot CF}}{10 \cdot \mathrm{U_P}[V]} = \frac{1.11 \cdot 1521}{10 \cdot 4} = 42.2$$

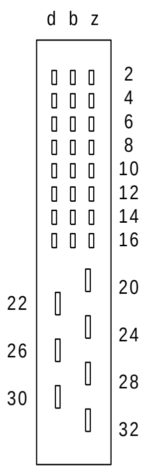
The pin assignment of the analog input/output connector is described in chapter 7.

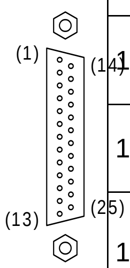
7 Electrical Connections

7.1. Analog/Digital Interface

Several relevant control and indication signals of the dilution unit are led to normalised connectors on the rear side for measurement with high ohmic (R_{in} > 1 MΩ) instruments, programming with low ohmic DC-voltage sources, or as relay contacts for function indication.

3U/42HP plug-in unit F24/H7 connector 43)	labora-tory case 25 pin D-sub female connector 47)	F24 / H7 pin	D-sub pin	signal description	analog / digital	input / output	signal range
		2d	(2)	dilution air flow Fd	A	O	0...10 VDC = 0...5 l/min
		4d	(16)	set dilution factor	A	I	0...10 VDC = 0...100 %
		6d	(5)	motor speed (4.3 mV/1/min)	A	O	0...10 VDC = 0...2.7685 1/s
		6b	(17)	digital ground	D		0 VDC for digital inputs / outputs
		8z	(18)	raw gas pump ON / OFF	D	I	0 VDC: OFF 5 VDC: ON
		10d	(8)	raw gas temperature	A	O	0...10 VDC = 0...250 °C
		10b	(20)	raw gas pressure	A	O	0...10 VDC = 0...2000 mbar
		12b	(9)	instrument ready	D	O	0 VDC: error 5 VDC: ready
		12z	(21)	remote control ON/OFF	D	I	0 VDC: local 5 VDC: remote
		14d	(24)	analog ground	A		0 VDC for analog inputs / outputs
		14z	(10)	set heated parts temperature	A	I	0...10 VDC = 0...200 °C
		16b	(25)	diluter block temperature	A	O	0...10 VDC = 0...200 °C
		16z	(11)	analog ground	A		0 VDC for analog inputs / outputs
		28z		power supply L			90...240 VAC 50/60 Hz
		30d		power supply N			90...240 VAC 50/60 Hz
		32z		protection ground PE			





7.2. Mains Supply

Connect the power cord plug to a grounded power socket. The IEC mains connector 46) on the rear side of the laboratory case includes the mains switch 44). The fuse holder 45) is located on the rear side of the laboratory case, between mains switch and the mains connector. The one phase power cord delivered with the instrument is equipped with a country-specific plug and protective ground.

Mains supply voltage: 90 ... 240 V, 50/60 Hz, max. 300 VA
Fuse type: slow switching fuse 250 V, 5 A, t, 5 x 20 mm

Warning
In case of a blown fuse, replace it only with the specified type of fuse. If the fuse is repeatedly blown, the dilution unit must be sent to the manufacturer or to an instructed service station for checking and repair.

Electric Shock
Make sure that the protecting ground pin of the country specific plug is correctly connected to the protecting ground contact of your socket. If the plug is replaced, ensure the yellow/green ground wire of the cable is properly connected to the new ground pin or the case is otherwise connected to protective ground which is usually indicated by the ⏚ sign.

7.3. Remote Control

The testo MD19-3E rotating disk diluter can be remote controlled when used together with a testo CU-2 digital control unit.

The remote control and data acquisition software Nanomet is delivered together with testo CU-2.

8 Maintenance and Calibration

Caution
When disconnecting the pneumatic connection between exhaust probe and control unit, precautions have to be taken that condensed matter which can drop out from the undiluted gas tube does not pollute the environment.

Testo SE & Co. KGaA recommends performing regular maintenance measures to ensure long and proper function of the testo MD19-3E rotating disk diluter. An overview of the maintenance measures is available in appendix A.3

8.1. Disk and Block Maintenance

8.1.1. Diluter Disk and Block Cleaning

Skin Burn
The diluter block 18) and attached parts such as the diluter disk 23), fixation cap 21), fast lock ring 22), drive shaft 20), and pressure compensation cap 14) are heated up to 160°C / 320°F. Let the parts cool down before carrying out the manipulations described below!

The diluter head and especially the undiluted gas tubes are exposed to very high particle concentrations, depending on the instrument's application. Cleaning of the diluter block and disks is essential for long lasting performance and reliability of the instrument.

- Dismount the diluter disk 23) following the instructions in chapter 5.3.1.
- Clean the surfaces of diluter disk 23) and block 18) with a cleaning alcohol and a clean soft paper wipe. Testo recommends to use pure (≥99.8%) ethanol for analysis or isopropyl alcohol. Take care that no dust remains in the cavities.
- Visually check the quality of disk and block surface. If the block surface starts to get scratched due to the worn disk coating, the disk should be replaced immediately.
- The inside of the diluter block may be contaminated with dust after long series of measurements in high particle concentrations. Clean the disconnected tubings by carefully blowing compressed air through the raw gas inlet 11), the waste gas outlet 10) and ports B and C of the pneumatic diluter head connector.

Caution
Never blow out the tubings without having removed the diluter disk 23) and without having pneumatically disconnected the diluter head from the control unit. The overpressure resulting from blowing with compressed air may damage diluter components and sensor(s) installed downstream the diluter.

- Select the disk 23) according to the desired dilution range. For lower dilution factors, choose the disk with 10 cavities, for higher dilution factors the one with 8 cavities.

8.1.2. Disk and Block Lifetime

If careful cleaning of disk 23) and block 18) surfaces is performed every 8 operating hours and the diluter is operated without pressure difference between raw gas and ambient, at least 1000 operating hours are expected for one disk-block combination.

The disk is made of a ceramic material with a polymer coating while the block is made of hardened stainless steel. If the disk is not used until the polymer coating is completely worn but exchanged before the ceramics get in touch with the steel surface, the disk can be exchanged easily by the operator and no block exchange will be necessary. For this item, either several individually calibrated disks can be ordered together with the testo MD19-3E Rotating Disk Diluter, or some non-calibrated disks can be purchased. Due to narrow manufacturing tolerances, the error caused by non-calibrated disks will be max. 8 % for the 8-cavities disk and max. 4 % for the 10-cavities disk.

Higher raw gas pressure significantly enhances disk polymer surface wear and therefore reduces the disk lifetime.

8.2. Calibration

The Testo SE & Co. KGaA standard calibration of the testo MD19-3E Rotating Disk Diluter is performed using neutralized 90 nm NaCl particles in air with diluter block and dilution air temperature set to 80 °C.

Besides the standard calibration, the testo MD19-3E Rotating Disk Diluter also can be ordered calibrated fulfilling the PMP regulations. This more extensive PMP calibration is available only if the device is integrated in an ASET15-1 secondary dilution system.

The calibration performed by Testo SE & Co. KGaA or a local service provider is valid during one year. It is recommended to send the device once a year back to the manufacturer or to the local service provider for service and calibration, like it is mandatory if the diluter is used for PMP-compliant measurements.

8.3. Pneumatic Connection Between Diluter Head and Control Unit

The multiple pneumatic tube 4) between diluter head 1) and the control unit 2) contains 3 tubes with inner diameter 4 mm and one tube with inner diameter 6 mm, integrated into a flexible, protective tube. Two of these tubes conducting the undiluted gas from the diluter head to the membrane pump in the control unit and back to the diluter head for waste gas return are strongly exposed to dust and acid condensate from the sampled raw gas. They need a periodical cleaning service after a series of measurements:

- Disconnect the multiple pneumatic connection 4) from the control unit 2) and the diluter head 1).
- Ensure that dust and liquid blown out of the tube can not pollute the environment.
- Blow carefully compressed air from a pressure air pistol or a pressurized dispenser into ports B and C of one of the two connectors of the multiple pneumatic tube. The ports are labeled in Fig. 8.1.
- Check the O-ring seals in the connectors of the pneumatic connection and replace them if necessary (see also appendix A.1: Extent of Delivery)

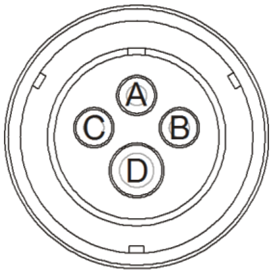


Fig. 8.1: connector of the pneumatic connection tube

tube A)	particle free dilution air duct to diluter head
tube B)	waste gas return to diluter head
tube C)	raw gas duct from diluter head to control unit
tube D)	Diluted measuring gas return to the diluter head

8.4. Pump Service

The membrane pump inside the control unit case ensures the raw aerosol flow through the diluter head. The aerosol is drawn to the control unit and guided back to the diluter head for being returned into the exhaust pipe.

When the undiluted gas flow is significantly reduced by pollution in the pump, correct diluter function can be constricted. It is recommended to check the raw gas flow at the diluter head inlet every 50 operating hours using a flow meter like a rotameter or mass flow meter. If the raw gas flow falls below 1.0 l/min even with freshly cleaned connection tubes according to chapter 8.3, the pump should be replaced or maintained.

It is expected that pump maintenance or replacement can get necessary every 200 to 1000 operating hours, depending on the polluting properties of the measured raw gas. This can be done by Testo SE & Co. KGaA or an authorized local service partner.

8.5. Storage, Acclimatization

Fast ambient temperature changes may result in condensed water on and inside the instrument. This may cause serious damage of electronic parts, e.g the controller or safety devices.

- Do not store the instrument outdoor, the storage environment must be clean and dry.
- After long time storage or transport with cold ambient condition or thermal fluctuation, the instrument requires adapting slowly to the local ambient conditions before starting up.
- If condensed water has been formed, wait at least 12 hours before installation and starting up.
- Avoid mechanical damage and agitation.
- Storage temperature range: -10°C to +60°C.

8.6. Operation Environment Requirements

Caution
Read this section carefully before setting up testo MD19-3E rotating disk diluter. Testo SE & Co. KGaA is not liable if the instrument is damaged, caused by the operation environment not meeting the requirements.

Caution
The testo MD19-3E rotating disk diluter is designed to be installed in a laboratory, test stand or a temporary test set-up. The instrument is not intended to be used outdoor or in a dusty or wet environment.

IP protection degree	IP 20. testo MD19-3E is protected against accidental contact to dangerous parts of the instrument. It is not protected against intrusion of sand, dust or water. Avoid operation in dusty or wet environment for safe and reliable operation.
operating tempe-rature range	The operating ambient temperature range is +10°C to +40°C if free air circulation around the device is ensured.
humidity range	The ambient relative humidity range (RH) is 0% to 80%, max. 80%@30°C, linearly degrading to 50%@40°C, non condensing.
shocks and vibrations	Avoid operation under any kind of shock or vibration.

9 Appendix

9.1. Extent of Delivery

testo MD19-3E delivery consists of the following items:

item #	description		
1	testo MD19-3E diluter head 1)		
2		10 cavities disk 23) for lower dilution range, mounted on diluter head	
3	testo MD19-3E control unit 2)		
4		waste gas return bridge, mounted on control unit 26)	
5	pneumatic connection between MD19-3E head and control unit, length 3 m 4)		
6	electrical connection between testo MD19-3E head and control unit, length 3 m 3)		
7	testo MD19-3E accessories box, containing:		
8		8 cavities disk 23) for upper dilution range	
9		operating manual testo MD19-3E Rotating Disk Diluter	
10		set of 2 calibration certificates for both diluter disks (certificates are not contained if testo MD19-3E is integrated into a ViPR system which was calibrated according to PMP standards)	
11		IEC power cord	for Switzerland
		or	for Germany, France, Italy, Korea, etc.
		or	for USA, Canada, Japan, etc.
		or	for United Kingdom, etc.
12		10 mm outer diameter stainless steel tube for connecting the diluter head raw gas inlet to the aerosol source, length 200 mm	
13		6 mm outer diameter stainless steel tube for connecting the diluter head waste gas outlet to the waste gas return, length 200 mm	
14		pneumatic connection plug for self-sealing measuring gas outlet coupling	
15		O-ring kit containing 8 sealings for pneumatic connector	
16		1 pair heat protection finger gloves	

9.2. Specification, Technical Data

aerosol	Exhaust gases or air which contains nanoparticles
raw gas flow	Approx. 1.5 l/min
measuring gas flow	full dilution range: 0.6...1.5 l/min @ high dilution factorsup to 5 l/min
raw gas pressure	– 20...+ 300 mbar relative to ambient for low dilution (high rotational speed) – 20...+ 400 mbar relative for short time and high dilution
power supply	90...240 VAC, 50/60 Hz, max. 300 VA

local operation	pump switch, temperature dial, dilution potentiometer, LED indicators
remote operation	• in combination with CU-2 • controlled with analog DC signals 0...10 VDC
assembly	• together with ASET15-1 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 total: ca. 13.2 kg
operating conditions	T_{amb}: 10 ... 40 °C 0...80% relative humidity, 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 ASET15-1 system
conformity	testo MD19-3E Rotating Disk Diluter is in conformity with the following standards or other related documents: EN 61326-1 : 2006 / B1 Electrical equipment for measurement, control and laboratory use. EMC requirements. EN 61010-1 : 2001 Safety requirements for electrical equipment for measurement, control and laboratory use. EN 61000-3-2 : 2006 Electromagnetic compatibility (EMC) – Limits for harmonic current emissions EN 61000-3-3 : 1995 Electromagnetic compatibility (EMC) – Limitation of voltage fluctuations and flicker in low-voltage supply systems and therefore is in conformity with the following European Directives in their current versions: 2004/108/EG Electromagnetic compatibility 2006/95/EG Low voltage directive

9.3. Maintenance Overview

Testo SE & Co. KGaA recommends taking some maintenance measures to ensure long and proper function of the testo MD19-3E rotating disk diluter. The procedures listed below are described more detailed in chapter 8.1.

maintenance interval	approx. operating time	
daily	8 hours	Clean disk 23) and block 18) surfaces with pure ethanol or isopropanol.
weekly	50 hours	Visually check disk 23) and block 18) surface quality. If the diluter was mainly operated with raw gas pressures > 100 mbar, a disk replacement may be necessary even if 1000 operating hours are not reached yet.
		Blow out tubes B and C of the pneumatic connection 4).
		Check the flow at the raw gas inlet 11). If the flow is significantly reduced, the raw gas pump has to be maintained or replaced.
monthly	200 hours	Blow out the channels in the diluter block 18)
	1000 hours	Disk 23) replacement
yearly		Service and system calibration by Testo SE & Co. KGaA or local service provider.

Skin Burn
The diluter block 18) and attached parts such as the diluter disk 23), fixation cap 21), fast lock ring 22), drive shaft 20), and pressure compensation cap 14) are heated up to 160°C / 320°F. Let the parts cool down before carrying out the manipulations described above!

Caution
Never blow out the tubings without having removed the diluter disk 23) and without having pneumatically disconnected the diluter head from the control unit. The overpressure resulting from blowing with compressed air may damage diluter components and sensor(s) installed downstream the diluter.

9.4. Diffusion Losses

In chapter 5.2.1 the procedure to estimate diffusion losses in tubes was described. Fig. A.1 shows some curves from which the approximate particle loss can be determined depending on particle size and aerosol.

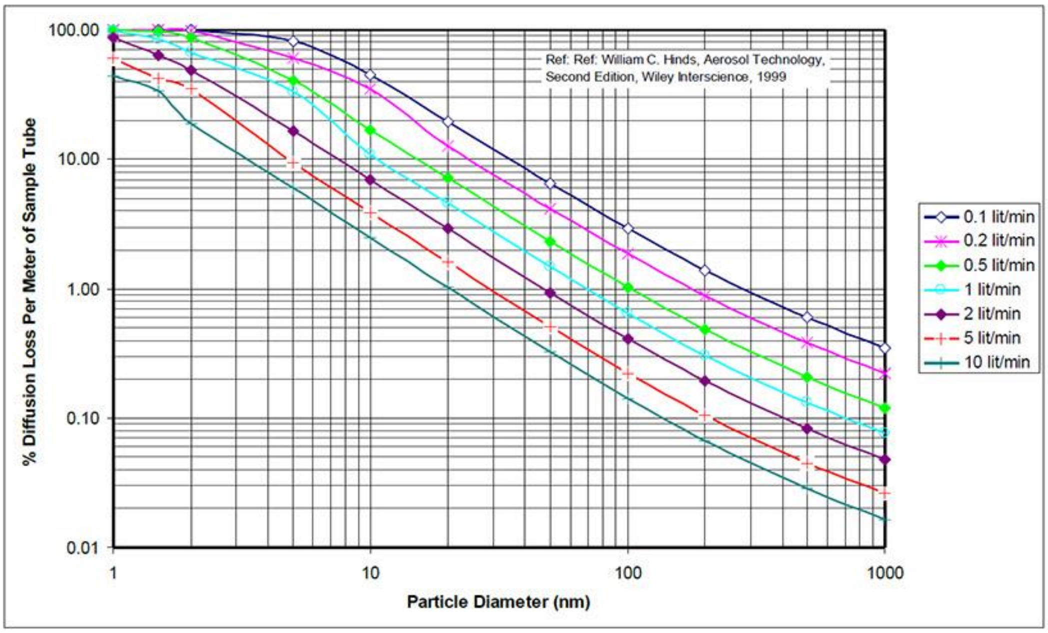


Fig. A.1: particle loss according to:
William C. Hinds, Aerosol Technology, Second Edition, Wiley Interscience, 1999

9.5. Swagelok Fittings

The testo MD19-3E diluter head is equipped with one Swagelok 10 mm fitting at its raw gas inlet 11) and one Swagelok® 6 mm fitting at the waste gas outlet 10). The enclosed or any other metallic 10 and 6 mm tubes can safely be connected following the original Swagelok® instructions which are downloaded from www.swagelok.com.
Fig. A.2 shows how the components of a Swagelok® fitting and a steel tube are arranged, and how the sleeve nut is tightened.
SWAGELOK TUBE FITTING INSTRUCTIONS for 1 in. (25 mm) and smaller fittings

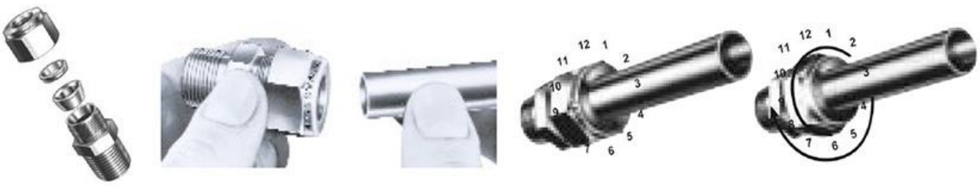


Fig. A.2: arrangement of the Swagelok tube fitting

9.5.1. Installation

Note: These instructions apply to traditional fittings and fittings with the advanced back-ferrule geometry.

- 1. Insert tubing into the Swagelok tube fitting.
- 2. Make sure that the tubing rests firmly on the shoulder of the tube fitting body and that the nut is finger-tight.
- 3. Scribe the nut at the 6 o’clock position.
- 4. While holding fitting body steady, tighten the nut 1¼ turns to the 9 o’clock position.

9.5.2. Reassembly Instructions

You may disassemble and reassemble a Swagelok tube fitting, port connector, cap, and plug many times.

- 1. Insert tubing with pre-swaged ferrules into the fitting body until the front ferrule seats.
- 2. Rotate the nut with a wrench to the previously pulled-up position. At this point, a significant increase in resistance will be encountered.

- 3. Tighten slightly with a wrench.

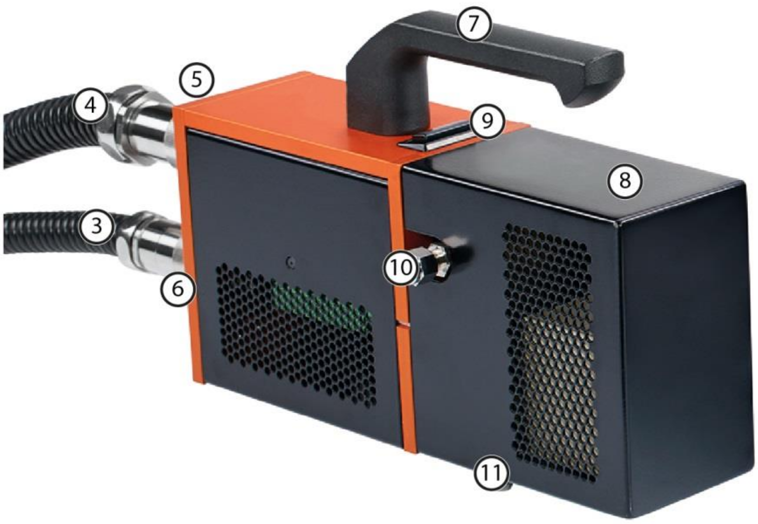
9.6. Definitions, Units and Conversion Table

Pressure		Pascal	Bar	Pound per square inch			
		(Pa)	(bar)	(psi)			
	1 Pa	1	$1.0 \cdot 10^{-5}$	$1.450 \cdot 10^{-4}$			
	1 bar	$1.0 \cdot 10^{5}$	1	14.504			
	1 psi	6 894.8	0.0689	1			
Length		Meter	Centimeter	Millimeter	Micro-meter	Nanometer	Inch
		(m)	(cm)	(mm)	(µm)	(nm)	(") = (in)
	1 m	1	100	1 000	$1.0 \cdot 10^{6}$	$1.0 \cdot 10^{9}$	39.37
	1 cm	0.01	1	10	$1.0 \cdot 10^{4}$	$1.0 \cdot 10^{7}$	0.3937
	1 mm	0.001	0.1	1	1 000	$1.0 \cdot 10^{6}$	0.0394
	1 µm	$1.0 \cdot 10^{-6}$	$1.0 \cdot 10^{-4}$	1.001	1	1 000	$3.937 \cdot 10^{-5}$
	1 nm	$1.0 \cdot 10^{-9}$	$1.0 \cdot 10^{-7}$	$1.0 \cdot 10^{-6}$	0.001	1	$3.937 \cdot 10^{-8}$
	1 " = 1 in	0.0254	2.54	25.4	$2.54 \cdot 10^{4}$	$2.54 \cdot 10^{7}$	1
Temperature		Celsius	Fahrenheit				
		(°C)	(°F)				
	0 °C	0	32	T[°C] = (T[°F]-32)/1.8			
	100 °C	100	212	T [°F] = T[°C] · 1.8 + 32			
	0 °F	-17.78	0				
	100 °F	37.78	100				
Mass		Kilogram	Gram	Pound	Ounce		
		(kg)	(g)	(lb)	(oz)		
	1 kg	1	1 000	2.205	35.27		
	1 g	0.001	1	0.0022	0.0353		
	1 lb	0.4536	453.6	1	16		
	1 oz	0.0283	28.35	0.0625	1		
Volumetric		Cubic Meter	Liter	Milliliter	Cubic Inch	Cubic Foot	
		(m3)	(l)	(ml) = (ccm)	(cin)	(cft)	
	1 m^3	1	1 000	$1.0 \cdot 10^{6}$	61 024	35.315	
	1 l	0.001	1	1000	61.024	0.0353	
	1 ml = 1 ccm	$1.0 \cdot 10^{-6}$	0.001	1	0.0610	$3.531 \cdot 10^{-5}$	
	1 cin	$1.639 \cdot 10^{-5}$	0.0164	16.387	1	$5.787 \cdot 10^{-4}$	
	1 cft	0.0283	28.317	$2.832 \cdot 10^{4}$	1728	1	
Volumetric flow							
		(l / min)	(m^3 / h)				
	1 l_N / min	1	0.060				

	1 m^3 / h	16.667		1									
	1 l_N =	1 standard liter at 0 °C, 1 013.25 hPa											
Units													
	Length	m	meter	cm	centi-meter	mm	milli-meter	nm	nano-meter				
	Mass	kg	kilo-gram	g	gram								
	Time	h	hour	min	minute	s	second						
	Electri-city	A	ampère	V	volt	VA	volt-ampère	Ω	ohm				

10 Designation of All testo MD19-3E Rotating Disk Diluter Elements

1 testo MD19-3E diluter head
2 testo MD19-3E control unit
3 Electrical connection
4 Pneumatic connection between diluter head and control unit
tube A) Particle free dilution air duct to the diluter head
tube B) Waste gas return to the diluter head
tube C) Raw gas duct from the diluter head to the pump inside the control unit
tube D) Diluted measuring gas return to the diluter head
5 Multiple pneumatic connector between pneumatic connection 4) and diluter head 1)
6 Electrical connector between electrical connection 3) and diluter head 1)
7 Handle
8 Hot parts protection hood
9 Protection hood latch
10 Waste gas outlet from diluter head to exhaust pipe: 6 mm Swagelok fitting
11 Raw gas inlet into diluter head: 10 mm
12 Dilution air heating cartridge
13 Diluter block heating cartridge
14 Pressure compensation cap
15 Temperature sensors
16 Cap holder nuts with bolts
17 Aerosol/air duct block
18 Diluter block
19 Drill hole for cap holder
20 Diluter disk drive shaft
21 Diluter disk fixation cap
22 Fast lock ring
23 Rotating diluter disk
25 Waste gas outlet quick coupling
26 Waste gas return bridge / connection to separate offtake
27 Quick coupling for waste gas inlet for return to the diluter head
28 Self-sealing quick coupling for measuring gas output to sensor(s)
29 Dial for temperature setting of block and dilution air heating
30 10 turn potentiometer for dilution setting
31 All signals ready LED: green: OK dark: at least one signal not OK
32) Remote control LED: green: remote controlled dark: local controlled
33) Dilution factor LED: green: OK red: out of specified range
34) Block and dil. air heating LED: green: OK red: error dark: OFF
orange: heating up
35) Actuation motor LED: green: rotating red: error dark: stopped
36) Raw gas pump LED: green: running red: error dark: OFF
37) Raw gas pump switch: up: ON down: OFF
38) Electrical connector between electrical connection 3) and control unit 2)
39) Multiple pneumatic connector between pneumatic connection 4) and control unit 2)
40) Ventilator
41) Measuring gas output to sec. dilution
42) Quick coupling for dilution air input to testo MD19-3E rotating disk diluter
43) Connector to electronic circuit
44) Mains switch
45) Fuse testo MD19-3E: 250 V, 5.0 A, t
46) Mains connector
47) Remote control interface connector: 25 pin D-Sub female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10
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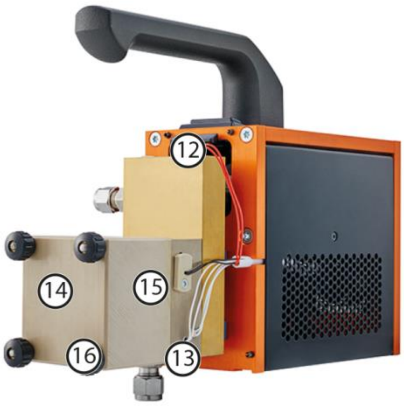
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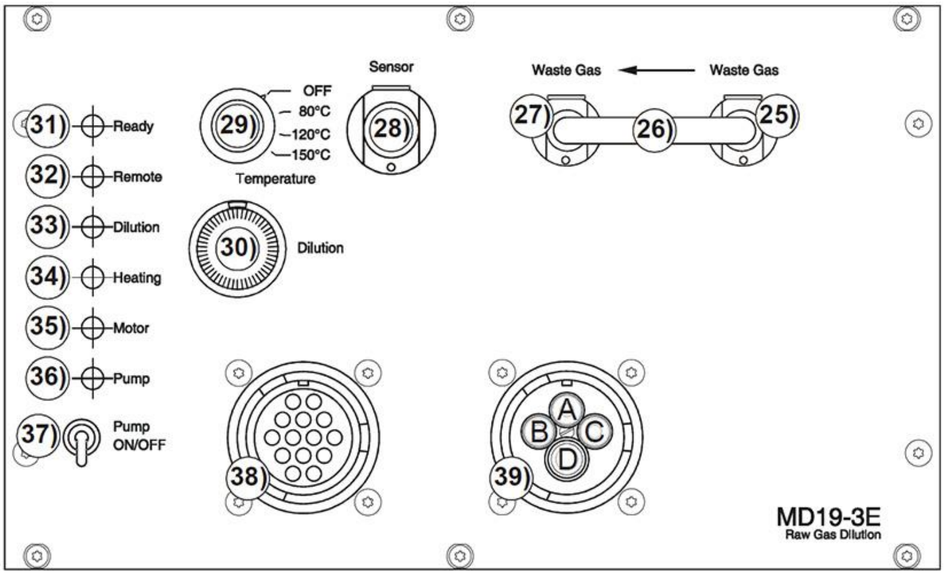
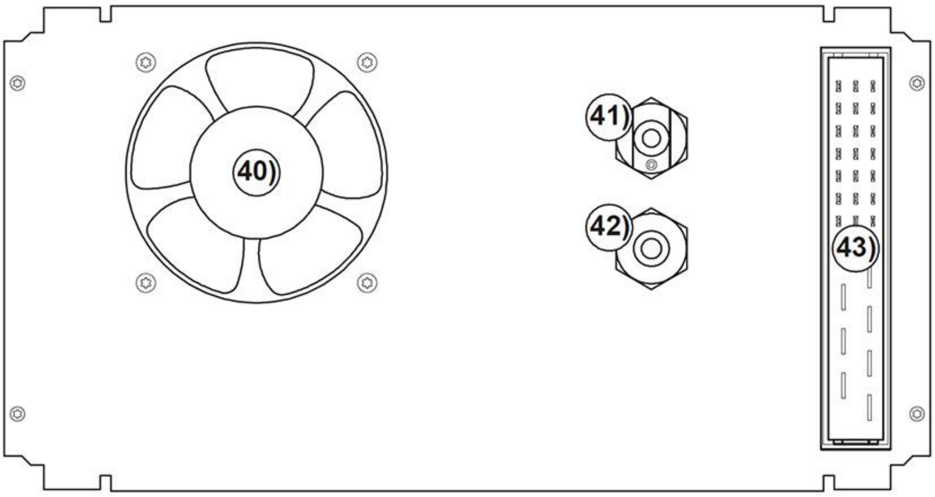
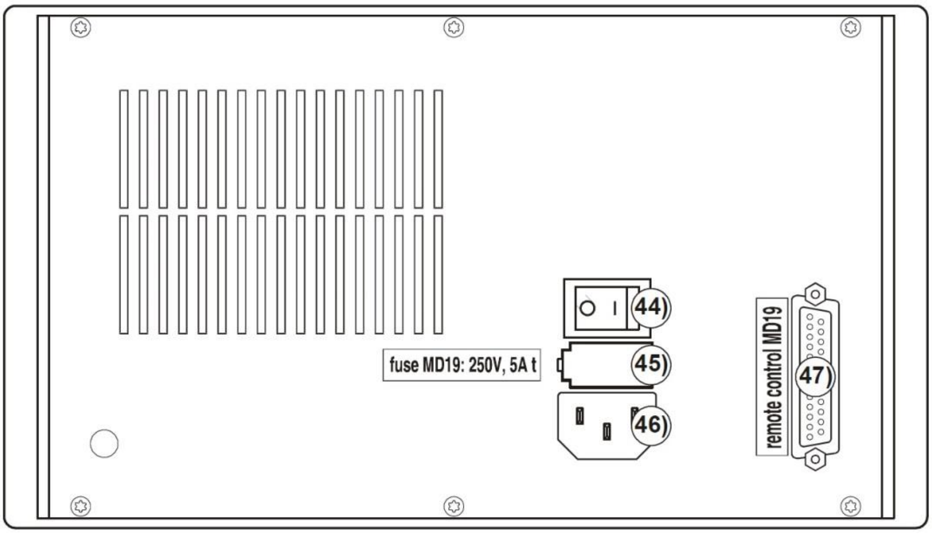

Sensor
Waste Gas
Waste Gas
31) Ready
32) Remote
33) Dilution
34) Heating
35) Motor
36) Pump
37) Pump ON/OFF
29)
OFF
80°C
120°C
150°C
Temperature
28)
27)
26)
25)
30)
Dilution
38)
39)
A
B
C
D
MD19-3E
Raw Gas Dilution


40)
41)
42)
43)


44)
fuse MD19: 250V, 5A t
45)
46)
remote control MD19
47)

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