Air Supply/Thermal Conditioner ASET15-1

- **Thermal treatment to evaporate volatile particles, heating temperature adjustable to 400 °C**
- **Air supply for operation between 1.5 lpm and 16.5 lpm sample flow with secondary dilution, adjustable from 1:1...1:11**
- **19" stand-alone unit, prepared for accepting an MD19 inset with easy local or remote controlled operation**
- **Completes MD19-2E and MD19-1i to a full thermoDiluter according to the GRPE/PMP draft regulation for nanoparticle measurement (R83 and R49)**

SHORT DESCRIPTION

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 growing agreement that these two fractions should be measured separately, to begin with because 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.

ASET15-1 is an instrument for thermal treatment of such aerosols or gases. In its standard setup it provides space for a MD19-2E or MD19-1i diluter unit, together with which it forms a ThermoDiluter according to the GRPE/PMP draft regulation (R83 and R49) for future nanoparticle measurement.

Exhaust sampling and dilution for nanoparticle measurement according to the GRPE/PMP draft regulation (R83 and R49) is processed in the following steps:

I. Primary hot dilution, evaporating some of the volatile nanodroplets formed in the CVS tunnel by nucleation of gaseous chemical compounds in the exhaust (e.g. sulfates).

II. Evaporation of remaining volatiles in the Thermal Conditioner at temperatures up to 400 °C. No condensation takes place when the aerosol is cooled down when the measuring gas is below the dew point after primary dilution.

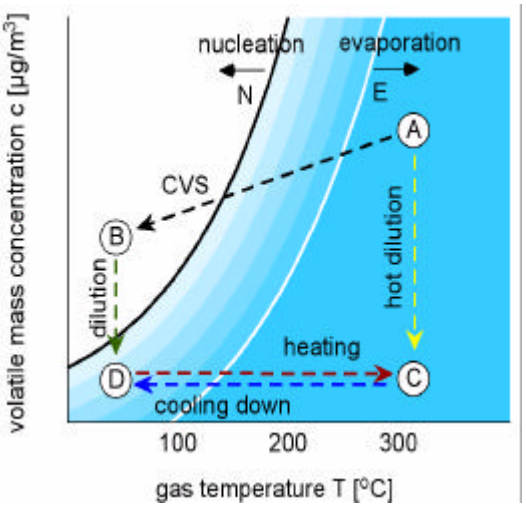
III. Secondary dilution of the measuring gas leaving the thermal conditioner to cool the gas and minimizing thermophoretic losses.

ASET15-1 is an accessory to primary hot diluters to carry out the process II (thermal conditioning) and III (secondary dilution) of the GRPE/PMP draft regulation (R83 and R49).

Adjustable secondary dilution with dilution air from the air supply allows furthermore to increase the sample flow up to 16.5 lpm.

THERMO DILUTION

In the figure on the right there is a schematic plot of the mass concentration of a volatile compound against the temperature of the surrounding gas. 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). 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 e.g. measurement on CVS tunnel 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. Hot dilution is realized in Matter Engineering rotating disk diluters. Together with Matter Engineering rotating disk diluter MD19-2E the ASET15-1 forms a complete ThermoDiluter system.

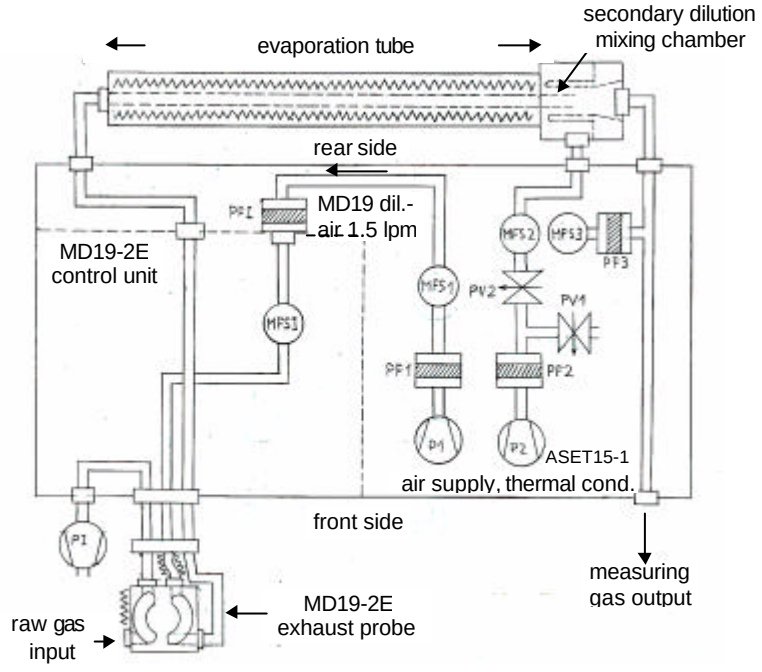
PNEUMATIC BLOCK DIAGRAM AND FUNCTION

The pneumatic block diagram shows the the ASET15-1 combined with the MD19-2E raw gas rotating disk diluter forming a Thermo-Diluter system.

Dilution air for MD19-2E is generated in ASET15-1 by pump P1 through particle filter PF1. The flow is measured in flow sensor MFS1 and adjusted and electronically controlled to 1.5 lpm.

The measuring gas after primary dilution in MD19-2E enters the evaporation tube of the conditioner on the rear side. Volatile particles will be evaporated if their evaporation – temperature is below the adjusted and elecronically controlled heating temperature, typically 300 °C.

Cooling down and secondary dilution takes place in the mixing chamber following the evaporation tube. No recondensing takes place when the concentration of the gaseous components is below the dew point as explained above.



The construction of the secondary diluting section is optimized for minimal thermophoresical losses by mixing the aerosol with the secondary dilution air in a laminar flow section where the dilution air builds a sheath between the cold walls and the aerosol from the conditioner.

Secondary dilution air is generated by pump P2 through particle filter PF2.Two proportionality valves PV1 and PV2 are used to adjust and control the flow measured in MFS2 within the range of 0–15 lpm corresponding to a secondary dilution factor from 1:1 to 1:11. The calibrated flow can be set on the scaled 10-turn potentiometer on the front panel.

The gas flow from the measuring gas output is determined by the connected sensor(s). It is therefore mandatory that the sum of the gas flow in the evaporation tube (1.5 lpm) and the adjusted secondary

dilution air is above the gas flow into the sensors. This is checked by MFS3 where the excess measuring gas is escaping through particle filter PF3. A green LED is lighted up when this flow is in the range of 0.3 – 1.5 lpm. A red LED signalizes when this flow is below 0.3 lpm or in the opposite direction and a yellow LED is lighted up when the flow is above 1.5 lpm.

Analog and digital in- and outputs enable the user to operate the air supply and thermal conditioner in remote operation. When a high digital input signal (5 V DC) is connected to the remote input all functions are controlled by external signals.

ELECTRICAL AND MECHANICAL SPECIFICATIONS

Air supply part	**Specification**
Primary dilution	
MD19 dilution air	1.5 lpm (volume flow at normal conditions 1013 mbar/0°C)
Accuracy	3 %
Secondary dilution	
Air supply flow	0 – 15 lpm (volume flow at normal conditions 1013 mbar/0°C)
Accuracy	3 % of set value + 0.1 lpm
Secondary dilution factor	1 - 11
Dilution factor setting (DF)	
Local operation	On scaled 10-turn potentiometer from 1 – 11, resolution 0.02
Remote operation	Analog input 0 – 10 V DC corresponds to DF 1 - 11
Accuracy	5 % of set value
Thermal Conditioner part	
Heating temperature	Ambient – 400 °C/752°F
accuracy	+/- 2°C/4°F
Appr. heating up times	From ambient to 200°C = 2 min., 300°C = 4 min. 400°C = 7 min.
Electrical	
Remote operation	All functions controlled by digital (5VDC) and analog (0-10VDC) signals
connector	25-pole D-Sub female interface connector on rear side
Mains supply	93 – 264 V, 50 – 60 Hz
Power consumption	Max. 350 VA without MD19-diluter, max. 450 VA with MD19-diluter
Mechanical	
Case	3U-19”-rack case for rack mounting with handles left ½-19” half wired for MD19-diluter plug in unit (see note **)
Dimensions	485 x 146 x 530 cm (w x h x d)
Weight	13.5 kg without MD19-diluter, 17.5 kg with MD19-diluter
Evaporation tube	mounted on rear side of 19” case
Thermoretic losses	See diagram and tables in chapter 7.2

**** MD19-2E and MD19-1i with S/N below 100’665 have to be modified to be pluggable into ASET15-1. This modification can also be carried out by instructed personnel on customer side by replacing the back plane of the MD19-control unit.**

Ordering numbers

Item	**Ord. no.**
Air Supply/Thermal Conditioner ASET15-1	251
MD19 back plane with pluggable gas connector fitting to ASET15-1 (see note **)	?????
Carrying case (optional on request)	95011

Ma, 29.04.2005