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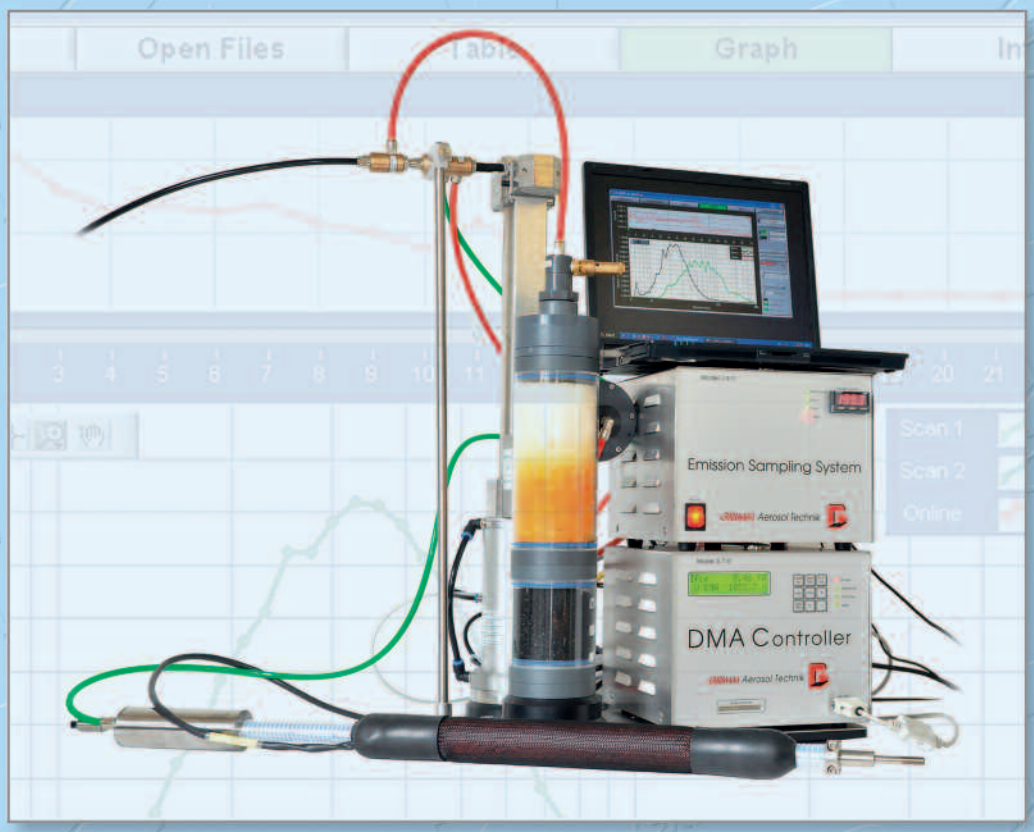
Emission Sampling System (ESS) Model 7.917

Hot gas sampler and diluter for airborne nanoparticles



Highlights:

- ✓ Sampling from hot gas with temperatures up to 500°C
- ✓ Heated sampling probe to prevent particle formation
- ✓ Stable and reproduceable dilution ratios
- ✓ Optional with one or two dilution stages
- ✓ For combination with SMPS systems

Applications:

- ✓ Characterisation of burners
- ✓ Monitoring emissions from domestic heating
- ✓ Engine exhaust studies
- ✓ Measurements in stacks
- ✓ Optimization of burner chambers and combustion processes

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The GRIMM Emission Sampling System (ESS) is designed to sample aerosol particles directly from hot exhaust gas, e.g. from fireplaces, combustion processes or engine exhaust. The sampling probe features an integrated two-stage dilution system. The dilution air of the first dilution stage is preheated, dried and free from particles and organic gases in order to avoid condensation. The second dilution is a cold dilution with particle free air.

The Emission Sampling System consists of:

- A heated sampling probe with integrated diluter
- A second (optional) cold dilution stage
- A control unit for volume flows and temperature settings and
- Filter, dryer and charcoal absorber for the dilution air.

The sampling probe (Ø 8 mm) is designed for direct connection to stacks. Since both dilution stages employ 9 lpm dilution air, the dilution ratio depends on the volume flow rate of the measuring system. For example, at a sample flow of 1 lpm it equals 1:10 or, if the second dilution stage is used, 1:100. Other dilution ratios are available upon request.

The ESS can be connected to a Scanning Mobility Particle Sizer (SMPS)* for measuring continuous real-time particle size distributions. The SMPS software offers sophisticated evaluation probabilities, e.g. conversion to emitted mass allows an on-the-spot comparisons with established non-continuous sampling techniques.

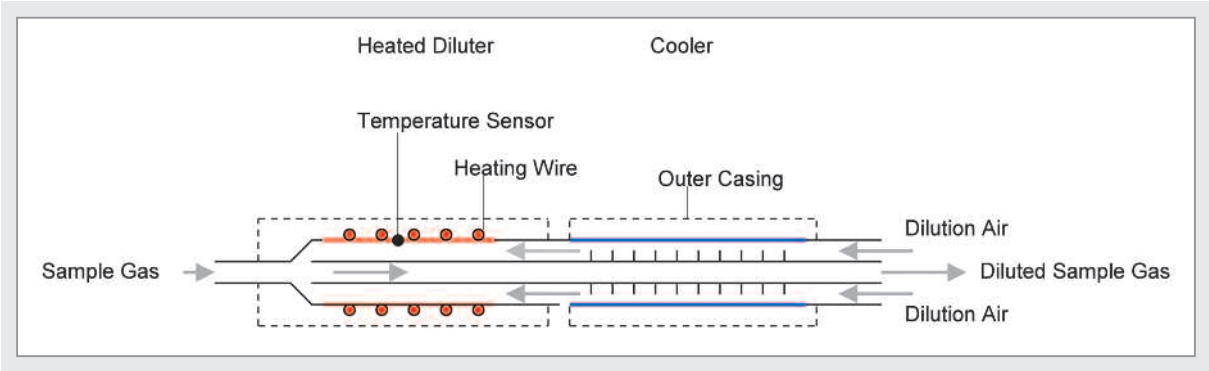
* Please consult our separate data sheets for more information on our SMPS systems

Principle of the sampling probe

The sampling probe of the ESS consists of a heated diluter and subsequent cooler as shown in the figure below.

This dilution and sample conditioning serves three purposes:

a) Condensation prevention, i.e. prevent the formation of new particles which were not present in the original sample gas.
b) The particle concentrations are reduced to the range covered by the measuring system.
c) The sample air temperature is adapted to the temperature range required by the measuring system.



Schematic of the sampling probe

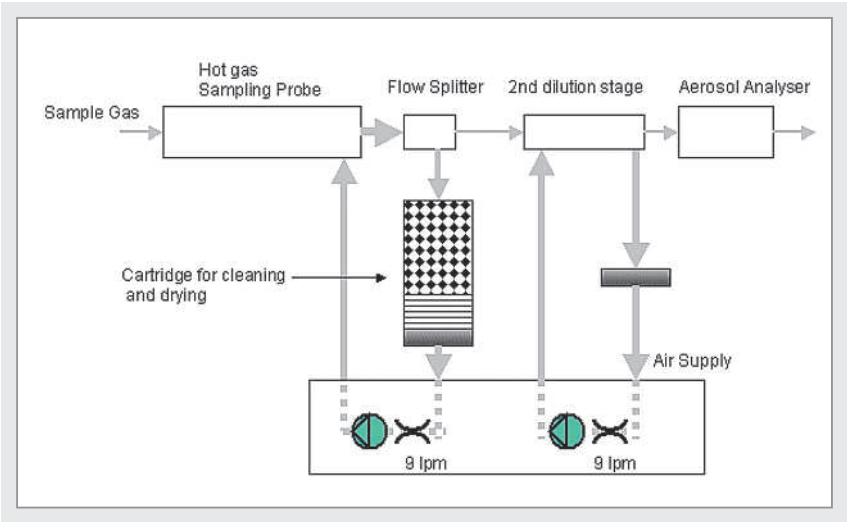
The heated diluter employs a counter flow principle. The dilution air flows in the outer tube towards the point where it is mixed with the hot sample gas. This outer tube is attached to an electric heater. A temperature sensor is directly connected to the outer surface of the heating tube.

The temperature of the diluter can be set by the user, in the range of room temperature to 200°C. A temperature of up to 500°C is tolerated for the sample gas.

Downstream of the diluter, the diluted and heated sample gas passes through an aerosol cooler. This cooler works as well with the counter flow principle and uses the dilution air as cooling medium. Thus, the diluted sample gas is already close to room temperature at the outlet of the sample probe and the dilution air is already preheated when flowing into the heater.

The flow of the complete dilution system is shown in the next figure. Downstream of the sampling probe, the diluted sample air passes a flow splitter. This flow splitter guides a small but representative part of the total flow into the second dilution stage or alternatively directly into the measuring system. The main part of the flow is drawn into a filter cartridge, which

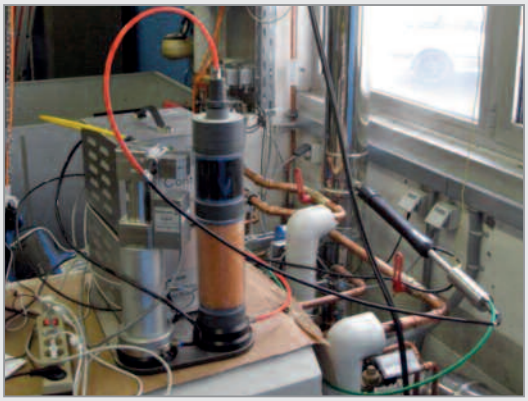
(a) removes the particles,
(b) removes the humidity (using silica gel), and
(c) removes organic gases from the air flow (using active carbon).

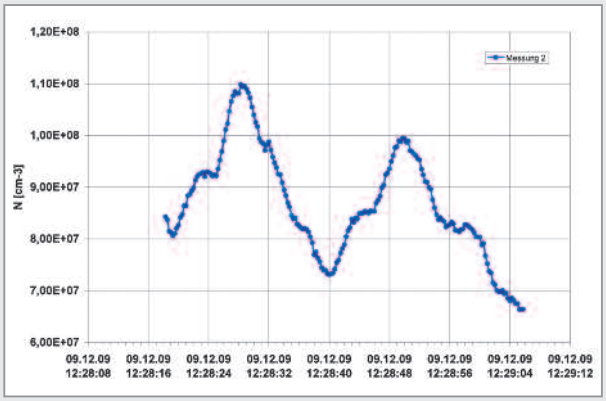


As illustrated in the figure, this cleaned air is recirculated and used as dilution air. The air flow of the dilution air is generated by an air supply box, which contains pumps and critical nozzles.

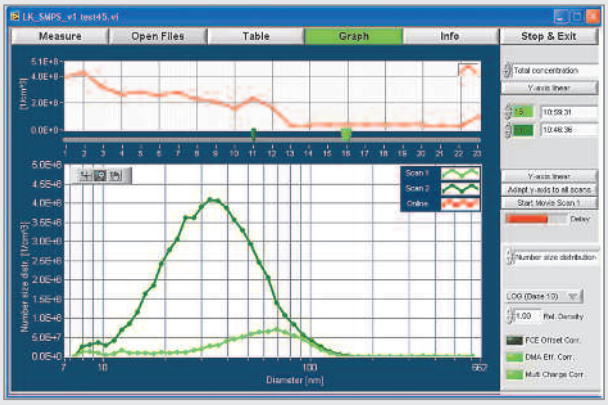
Flowchart of the complete dilution system

Application Examples

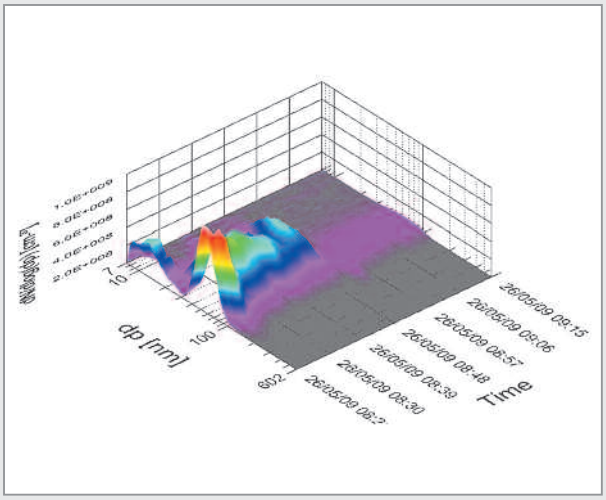




Emissions of a 15 kW pellet burner, measured with the ESS and a DMA with electrometer. The figure shows the concentration of particles in the 47 nm size channel as a function of time, the periodic fluctuations reflect the dropping of individual pellets into the furnace chamber.



Particle number concentrations in the exhaust gas of a wood burner. Upper graph: Total number concentrations as a function of time. Lower graph: Number size distributions. The high values correspond to the emissions without emission treatment system, the low values to the emissions with employed treatment system.



Emissions from a universal burner in operation. The 3D graph shows number size distributions as a function of time.

Specifications

Diameter of sampling probe inlet:	O.D. 8 mm
Flow Rate of dilution air:	9 lpm (both for first and second dilution stage)
Flow control:	Critical nozzles with constant temperature
Dilution ratio using a SMPS+E system:	
First Stage:	1:10 at 1 lpm Sample Flow
Second Stage:	1:10 at 1 lpm Sample Flow (total dilution ratio 1:100)
Dilution ratio using a SMPS+C system:	
First Stage:	1:31 at 0.3 lpm Sample Flow
Second Stage:	1:31 at 0.3 lpm Sample Flow (total dilution ratio 1:961)
Maximum temperature of the heater:	200°C
Maximum temperature of the Sample Gas:	500°C
Tolerates Pressure:	± 100 mbar vs. ambient pressure

Publications

F. Schneider, J. Spielvogel, T. Hock and M. Pesch, 2010: On-line Nanoparticle Size Distribution Measurements of a 15kW Pellet Burner. Chemical Engineering Transaction, Vol. XXIII, 2010 - AAAS10 Proceedings (Advanced Atmospheric Aerosol Symposium) by AIDIC Servizi S.r.l.

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