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DEKATI® FPS ACCESSORIES

Instrument description

The Dekati® Fine Particle Sampler is FPS-4000 a complete sampling system for particle measurements from high concentrations and pressures and from hot and humid conditions. The adjustable dilution factor is in two phases; controlled temperatures and rapid dilution allow a well-defined sample transformation from vehicle exhaust or power plant stack conditions to suitable concentrations for most measurement devices.

Accessories

FPS accessories are designed to make the instrument suitable for various applications in different measurement conditions.

Accessories include:

- Heaters for combustion applications
- Engine exhaust/small duct application
- Stationary source/large duct application
- Vortex cooler for enhanced cooling
- Residence time chamber for nucleation studies
- Pressurized air filtration and drying unit
- Automatic pressure regulator
- Dekati® Thermodenuder
- Extension cable set
- Dekati® Axial Diluter or Dekati® Diluter

Heaters for combustion applications

The FPS-4000 is a versatile sampling system for controlled dilution of aerosols. When combustion aerosols are diluted, a common practise is to use two stage heated dilution to eliminate condensation and nucleation. In this setup the first stage dilution air is heated to match raw sample temperature to reduce the concentration of volatile compounds without risk of condensation. The second dilution stage operates in ambient temperature to further dilute the sample and to reduce the sample temperature to ambient level. All heaters are are connected and controlled via FPS program interface.

The dilution air heater (DH-1723/1711) is the same in all applications requiring heated dilution. The heater is used to heat the dilution air in the first stage between 20 °C and 350 °C, depending on the raw sample temperature.

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A short probe heater (DH-1423/1411) is applied for automotive and small duct applications where duct or tailpipe sizes can range from 1 to 50 cm in diameter. The probe heater connects directly over the primary dilution stage. The setup is shown on the right

A longer stack heater (FPS-4230/4110) is applied for stationary source and large duct applications. In addition, a mini-cyclone is included in the heater structure to remove large particles from the sample stream. The nominal cut-point of the mini-cyclone is 2.5 µm. The stack heater setup is shown below.

Specifications: Dilution air heater (DH-1723/1711)

Power consumption	1000 W
Max temperature	500 °C
Material	AISI 316
Connection	Tube connector for 10 mm pressurized air tube Female Swagelok® for 8 mm pipe

Specifications: Probe heater (DH-1423/1411)

Power consumption	350 W
Max temperature	400 °C
Material	AISI 316
Connection	2 x NW40 flange

Specifications: Stack heater (FPS-4230/4110)

Power consumption	350 W
Max temperature	400 °C
Material	AISI 316
Connection	NW40 flange, mini-cyclone isokinetic nozzles
Mini-cyclone cutpoint	2.5 µm nominal, flow correction available

Vortex™ cooler (ELA-407) for enhanced cooling

FPS can be used with cooled dilution to enhance condensation when sampling hot combustion gases. Normally water or air is used as a cooling agent, but if the raw sample temperature is very high, additional cooling may be required. The Vortex™ reduces the cooling air temperature down below 0 °C to achieve more efficient cooling.

Specifications

Cooling agent	Pressurized air
Cooling agent flow	600 lpm
Cooling agent pressure	4-6 bar absolute
Connection	Tube connector for 10 mm pressurized air tube Female 8 mm Swagelok® connector

Residence time chamber (ELA-400) for nucleation studies

When combustion aerosol nucleation studies are conducted, a common practice is to use cooled dilution to enhance nucleation. The nucleated particles are however very small to be reliably detected with aerosol instruments. A good practice to grow particles to detectable range is to give particles a known and well-defined residence time.

When nucleation studies are carried out with FPS-4000, cooled dilution is used in the first dilution stage. A residence time chamber (ELA-400) is then applied between the first and second dilution stages.

Residence time of the sample in the chamber can be calculated from the FPS saved data file with the following formula:

$$t = \frac{12 * \pi}{Q}$$

where t is residence time in seconds and Q is flow in the residence time chamber. Q can be calculated from the save data file with the following formula $Q = Qsample + MF1$, where Qsample is the raw sample flow into the FPS and MF1 is the measured flow of dilution air into the primary diluter.

Specifications

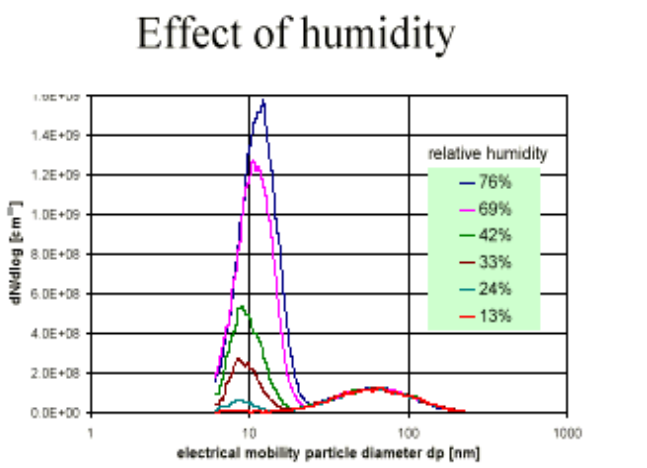
Dimensions	
Length	0.5 m
Diameter	0.04 m
Material	AISI 316
Connection	Fits between FPS dilution stages

Pressurized air filtration and drying unit (DI-1010b))

When aerosol from a combustion source is diluted, it is important that the dilution air is dry and particle free. DI-1010b, the pressurized air drying and filtration unit can be used to condition the pressurized air. Both units include particle and oil filters to remove impurities from pressurised air. DI-1010b unit uses a molecular sieve and silica gel for drying while DI-1032 has a membrane dryer to dry the air.

Importance of conditioning dilution air

Humidity in dilution air can cause several problems in the measurements. If humidity is high enough, condensation may occur inside instruments causing unpredictable problems. In addition, DI-FPS system flows are calibrated with dry air and humidity causes difference to calibrated values. Humidity can also cause changes in the measured particle size distribution by inducing nucleation. Dilution air humidity effect on nucleation is presented in the figure on the right.



If dilution air contains particles, they are directly seen as a background concentration in measurements made after the dilution system. This is especially important when doing low concentration combustion measurements, such as engine exhaust measurements after a DPF. When using the FPS-4000, it is very important that the dilution air does not contain any particles, because airflow control is done with critical orifices which must not get blocked.

DI-1010b Specifications

- Particulate filters
  - Filter element that exceeds ISO Class 3 for maximum particle size and concentration of solid contaminants
  - One filter before and second after the dryer
- Coalescing filters for oil removal
  - Filter element that exceeds ISO Class 1 for maximum particle size and concentration of solid contaminants, and on maximum oil content
  - Additional activated carbon filter element that exceeds ISO Class 1 on maximum oil content
- Desiccant Dryer
  - Atmospheric dew point as low as -52 °C
  - Molecular sieve and silica gel for drying
  - Total air flow 311 m^3 with dry desiccant at 7 bar, 21 °C, saturated inlet (100% RH)
- Pressurized air
  - Max pressure: 8 bar
  - Max flow rate: 250 lpm

DI-1032 Specifications:

- Particulate filters
  - Filter element that exceeds ISO Class 3 for maximum particle size and concentration of solid contaminants
- Coalescing filters for oil removal
  - Filter element that exceeds ISO Class 1 for maximum particle size and concentration of solid contaminants, and on maximum oil content
  - Additional activated carbon filter element that exceeds ISO Class 1 on maximum oil content
- Membrane dryer
  - No moving parts no maintain, repair or wear out
  - No consumables to replace
  - No liquid condensate to dispose of
  - Dew point as low as -40 °C
- Pressurized air
  - Max inlet pressure: 7 bar
  - Flow rates >200 lpm

Automatic pressure regulator (FPS-4005)

It is important to keep the operation pressure of the FPS system stable and correctly adjusted. In a normal FPS system, this is achieved with a regulator in the valve unit. If there is a need to adjust the system dilution factor frequently, the pressurized air supply fluctuates or the valve unit needs to be situated in a hard to reach place, use of the regulator may be troublesome. For this reason, Dekati has developed an automatic pressure regulator, which keeps the operation pressure always nominal without adjustment by user. The pressure regulator can be applied for FPS units manufactured after 05/2005 without modification and to all version 2.0 units with a small modification possible to carry out during normal instrument service at Dekati.

Specifications

Power consumption	Max. 10 W, power supply included
Connections	In/out pressurized air 10 mm tubing connector
Response time	< 2 s from actual pressure change to adjustment
Accuracy	+/-10 mbar at operating point of 4500 mbar abs

Dekati® Thermodenuder (ELA-423)

Dekati® Thermodenuder is designed to remove volatile and semivolatile compounds from sample aerosol particles. Before the analysis of hot exhaust particles, the sample usually needs to be cooled and diluted to the acceptable range of the measurement instruments. An uncontrollable sample handling may lead to condensation and supersaturation of the vapour compounds and thus different results in particle concentration, size distribution, composition and shape.

In the Dekati® Thermodenuder these volatile and semivolatile compounds are vaporized by heating the sample aerosol with an aerosol heater. After heating the volatile compounds are adsorbed in easily exchangeable active charcoal in the adsorber section, where the sample is also cooled.

The sample aerosol particles have much slower diffusion velocities (for 10 nm particles < 1/100) than the vaporized compounds. This is the main reason why the vaporized volatile compounds are collected efficiently in the active charcoal section while the sample aerosol particles follow the gas streamlines unaffected. The sample aerosol is cooled by pressurized air driven around the Thermodenuder adsorber section. Dekati® Thermodenuder is designed for flow rates of 10-20 lpm. The Dekati® Thermodenuder heater and cooling can be directly controlled with the FPS system.

Specifications

Flow rate	10–20 lpm
Maximum operating temperature	300 ºC
Cooling medium	Air or water
Weight	7.5 kg without filter cartridges
Dimensions	
Length:	95 cm
Width:	22 cm
Inlet	12/10 mm pipe
Outlet	R 1/2”, inner diameter of the connector should be 10 mm
Electric power	230 V/230 W 110 V/230 W

Extension cable set (ELA-441)

In some applications it is necessary that the FPS sampling probe is located further away from the FPS control and valve unit. With ELA-441 extension cable set, you can take the probe 8 meters further from the FPS control and valve unit. The set contains 8-meter extension cables for the following items:

- DH-1723 Pressurized air heater
- DH-1423 OR FPS-4230 OR ELA-438 (same cable fits all)
- Cables for three thermocouples
- Cables for P1 and P2 pressure sensors
- 3 x pressurized air tubing

Dekati® Axial Diluter (DAD-100) and Dekati® Diluter (DI-1000)

Some measurement instruments (CPCs, Etc…) require very high dilution factors when measuring particles from combustion sources. In order to increase the FPS dilution factor range, a single DAD-100 or DI-1000 can be applied directly after the FPS to increase the total dilution factor to the range of 200-2000. The diluter can be connected directly to one of the FPS flow divider outlets. This way, it is possible to measure with different dilution

factors at the same time by connecting some instruments to the FPS flow divider and some to the additional diluter.

Dekati® Axial Diluter (DAD-100) on the left and Dekati® Diluter (DI-1000) on the right

DI-1000 Specifications

Sample air flow (inlet)	~7 lpm
Diluted sample flow (outlet)	60 lpm
Dilution factor	1:8 (1:10).
Dilution air pressure	2 bar
Temperature	0–450 °C
Weight	2.8 kg
Total length	360 mm
Maximum diameter	120 mm
Inlet	12 mm male pipe
Outlet	12 mm male pipe
Exhaust	12 mm male pipe
Dilution air	8 mm female
Material	AISI 316

DAD-100 Specifications

Undiluted sample flow	0.1-10 lpm (1-3 lpm typical)
Dilution air flow	1-100 lpm (10-30 lpm typical)
Outlet flow	Undiluted sample flow + Dilution air flow
Dilution factor	Delivered with fixed setting as agreed
Undiluted sample temperature range	Up to 500 °C
Operation pressure	As agreed
Material	AISI 316 (Stainless Steel)
Inlet pipe	12 mm
Outlet pipe	12 mm
Pressurised air inlet	12 mm female Swagelok®
Pressure sensor range	0-4000 mbar abs

For more information, please contact Dekati Ltd.