METAS

Calibration of dust monitors

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Abstract

Health risks due to exposure to aerosols are known very well. Thus dust monitors are often used to check the air quality at workplaces and in outdoor ambient air. To compare results, calibration of the used dust monitors is crucial.
METAS is providing calibrations of dust monitors with different aerosols in the range of 0.02 mg/m³ to 100 mg/m³, traceable to SI-units.

Issues of particle mass measurements

Accurate measurements of particle mass concentration can be reached by loading a filter with a known aerosol flow rate and weighing the mass difference between the pristine and the loaded filter.
Nevertheless, this method does not give any information about temporal fluctuations of the particle concentration. Furthermore, the method is quite involved and time consuming. Information about the particle size would only be available from serial loading experiments using different impactors upstream of the filter. This would be incompatible with the time requirements of everyday measurements.

In contrast, optical instruments count and classify aerosols by size in a wide range (0.1 to >10 µm) in real time measurements at a high temporal resolution. However, information about mass concentration crucially depends on knowledge about the mass density of the measured aerosol. For ambient air with unknown fractions of aerosol species with different mass densities no accurate measurement of particle mass concentration can be obtained from optical instruments .

Nevertheless, comparability between individual instruments can be ensured by calibrating the instruments with respect to a gravimetric reference. The used calibration aerosol should ideally be similar to the usually measured aerosol.

Application of dust monitors

Determining human exposure to aerosols is an important component of health risk assessment in workplace and outdoor environments. When inhaled, aerosol particles with different sizes can deposit in different regions of the respiratory tract causing adverse health effects. Usually the assessment of air quality is based on total aerosol mass concentration (PM; PM_{10} including particles smaller than 10 µm, $PM_{2.5}$ smaller that 2.5 µm, and PM_1 smaller than 1.0 µm).
Both ambient air quality monitoring and human exposure assessment require an instrument that measures size resolved mass concentrations (PM_{10}, $PM_{2.5}$, PM_1, or inhalable, thoracic, respirable, etc.) in real time over a wide range of concentrations.

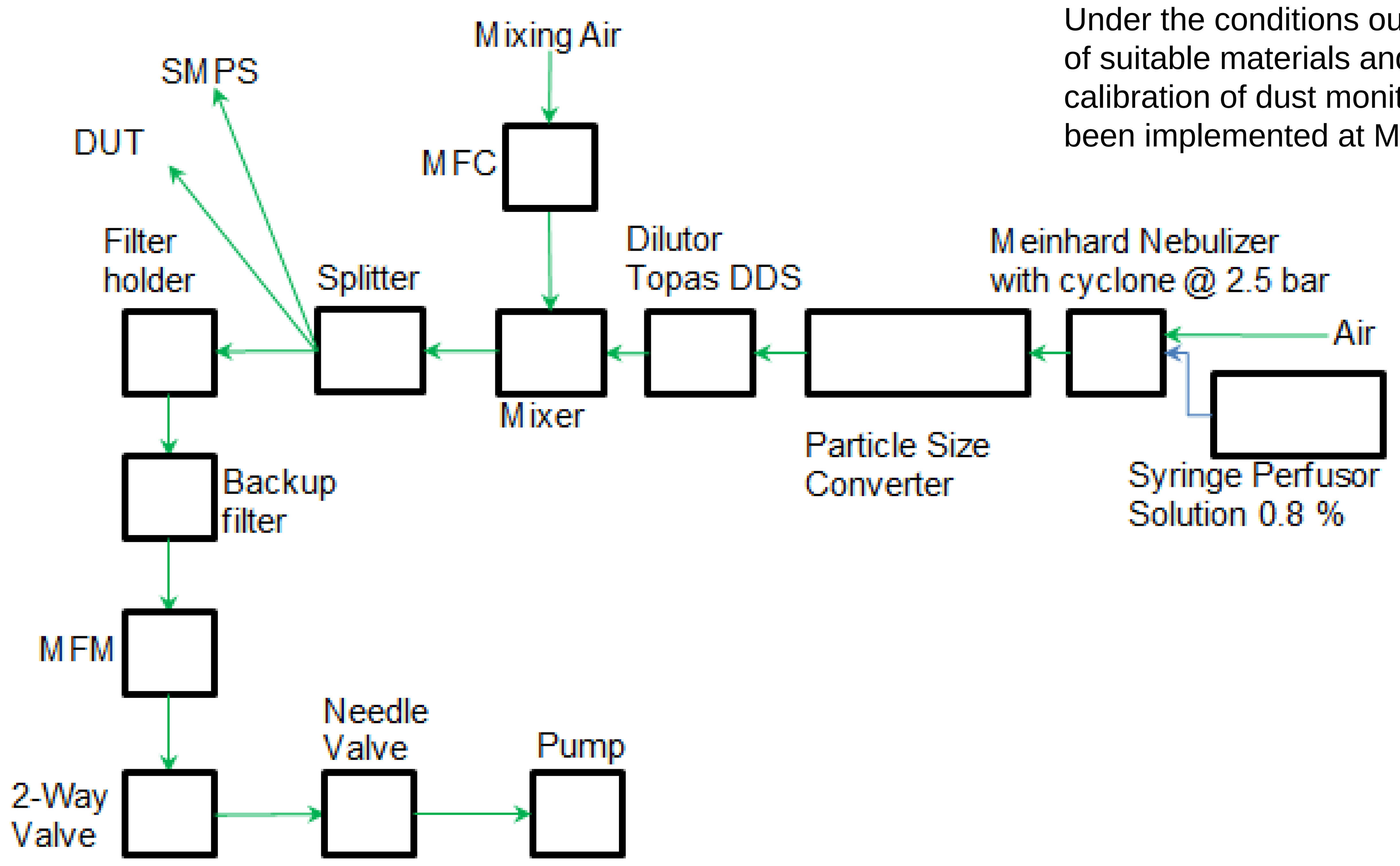

Fig. 2: Example of a calibration set up.
Generated aerosol: Emery oil
MFC: Mass Flow Meter
MFM: Mass Flow Meter
SMPS: Scanning Mobility Particle Sizer

$\gamma_{Reference}$ (mg/m³)	γ_{DUT} (mg/m³)	Efficiency DUT (γ_{DUT} / $\gamma_{Reference}$)	$U_{Efficiency}$
0.0251	0.06	2.23	0.138
0.0257	0.06	2.30	0.110
0.2033	0.50	2.46	0.065
0.2228	0.51	2.27	0.062
0.5195	1.27	2.45	0.047
0.5563	1.31	2.36	0.048
0.8440	2.11	2.50	0.052
1.0640	2.56	2.41	0.025
3.0911	7.50	2.43	0.017
3.2932	7.97	2.42	0.019

Uncertainty of Measurement

The reported uncertainty of measurement is stated as the combined standard uncertainty multiplied by a coverage factor $k = 2$. The measured value (y) and the associated expanded uncertainty (U) represent the interval ($y \pm U$) which contains the value of the measured quantity with a probability of approximately 95 %. The uncertainty was estimated following the guidelines of the ISO (GUM:1995).

The measurement uncertainty contains contributions originating from the measurement standard, from the measurement method, from the environmental conditions and from the object being measured. The long-term characteristic of the object being measured is not included.

Fig. 1: Extract of a calibration certificate

Calibration procedure

The calibration aerosol is generated either by nebulising a solution (e.g. emery oil, salt) or dry powder dispersion (e.g. Arizona Road Dust). The mass concentration of the aerosol can be varied by using a dilutor. The size distribution of the generated aerosol is measured prior to each calibration measurement.
The aerosol needs to be dry, non-hygroscopic and non-volatile at room temperature, to prevent any weight changes of the material deposited on the filter of the gravimetric reference method.

The reference method consists of loading a filter with a known aerosol flow rate and measuring the mass difference between pristine and loaded filter with an ultra-micro balance. Both measurements of aerosol flowrate and the deposited aerosol mass are traceable to the SI.
For low mass concentrations, the loading time can increase to 5h in order to obtain sufficient particle mass deposited on the filter. Thus long-term stability of the generator is essential.

The material of the filter is also very essential. In particular it needs to be hydrophobic and unaffected by any adsorption or desorption from the gas phase.

Conclusion

Under the conditions outlined above (stable aerosol generation, usage of suitable materials and accurate determination of parameters) calibration of dust monitors, traceable to IS-units, is possible and has been implemented at METAS .

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