Essential improvements for a reliable fractional efficiency testing of air filters

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The measurement of fractional efficiency is an important tool to characterise filters and filter media quick and unambiguously. International standards are developed to compare the fractional efficiency of the filter under defined and comparable conditions as e.g. the ISO TS 11155-1/DIN 71460 for cabin air filters, the EN779/ASHRAE 52.2 for general air ventilation filters, the ISO/DIS 19713 for engine air filters and the ISO CD 20564 for crankshaft ventilation filters.

1. Aerosol generation

The ISO/DIS 19713 for engine air filters is based on ISO 5011 and describes in part 1 the fractional efficiency test with KCL in a particle size range of 0.3µm up to 5 µm. Part 2 describes the fractional efficiency test with ISO A2 fine or ISO A4 coarse test dust in the particle size range of 5 µm up to 40 µm.

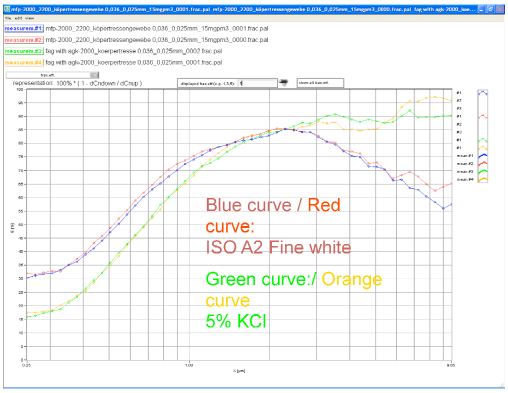

Figure 1: Comparison of fractional efficiency with ISO A2 fine and KCL

The initial fractional efficiency of the same filter varies with different challenge aerosols, thus one must pay attention in comparing fractional efficiencies according to ISO/DIS 19713 Part1 and Part 2. Figure 1 shows the fractional efficiency of a metal wire mesh filter media. The blue and red fractional efficiency was measured with ISO A2 fine as a challenge aerosol, at the green and orange curve KCL was used.
The possible reasons for the difference in fractional efficiency with the two different aerosols will be discussed in comparison with an uncharged DEHS aerosol.
A particle size selective treatment of the challenge aerosol can be used to improve counting statistics for coarse particle and reduce loading effects caused by the fine fraction of the challenge aerosol. We will show the advantages of this proceeding on the example of a fractional efficiency test with ISO A4 coarse.

2. Particle sizing and counting

To determine the fractional efficiency a light scattering aerosol spectrometer (LSAS) according to ISO FDIS 21501-1 must be used due to the required high particle size resolution and good particle size classification accuracy as well as the possibility to measure in high concentrations. Using an optical particle counter according to ISO 21501-4 is not sufficient for this application. These counters are designed for particle detection in low concentrations of clean room applications with comparably low particle size resolution.

The new welas® digital 3000 white light scattering aerosol spectrometer with a new digital signal processing offers various special advantages in fractional efficiency testing due to:

- **Two welas® aerosol sensors integrated in one device** for up- and downstream measurements (quasi-simultaneous) can be assembled directly at the sample taking, leading to a minimisation of losses in the sampling lines.
- **The straight and vertical air flow through the welas® aerosol sensor** in combination with a large duct diameter of 6mm and a high sample air flow of 5 l/min allows as well large particle up to 40 µm to pass sensing zone of the sensor without interruption.
- The **selection of different welas® aerosol sensors for different concentration ranges** offers the possibility to select the appropriate sensor e.g. **welas® 2300** for low concentrations in testing initial efficiencies and the appropriate sensor e.g. **welas® 2070** for high concentrations to test incremental efficiencies during the loading procedure.
- The **new integrated coincidence correction of new welas® digital**, which allows to increase the max. concentration limit of the aerosol sensor up to factor 5, leading to improved sizing accuracy and resolution in high concentrations up to 10^6 P/cm³.
- The **high time resolution of 10 ms** to evaluate particle size distribution and concentration. Thus fractional efficiencies can be analysed in the shortest possible time frame and with regard to best statistical safety.

3. Aerosol transport and sample taking

Two locations for up- and downstream sample taking are a requirement in filter testing according to ISO/DIS 19713 and thus a proof of the aerosol sampling system is necessary.

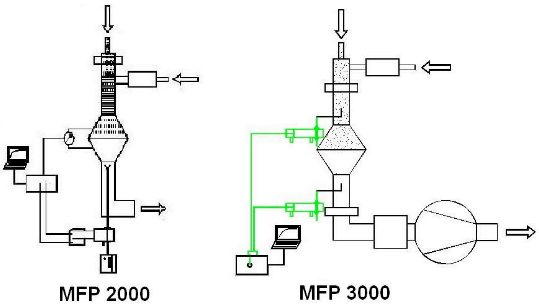

Figure 2: Comparison of MFP 2000 with one sample taking downstream and MFP 3000 with sample taking up- and downstream

In combination with

- defined flow conditions
- a homogenous aerosol distribution
- and a representative sample taking

in up- and downstream, the correlation ratio – the difference between up- and downstream sampling without filter - as described in ISO/DIS 19713 is a helpful tool to obtain reliable fractional efficiencies independently from the design of the test bench. The results of fractional efficiency of a filter media tested at the MFP 2000 with one sample taking optimized for large particle due to vertical design of the duct and sample taking in downstream only (see Figure 2) and tested at the MFP 3000 with up- and downstream sample taking (see Figue 2) are compared and the influence of the correlation ratio is shown.

In this presentation we will explain and show on basis of measurement data, how the new technologies, a size selective treatment of the challenge aerosol and the new welas® digital 3000 with integrated coincidence correction are used to obtain reliable and representative fractional efficiencies up to 40 µm in accordance with the above mentioned standards.