Experimental Study of Particle Shedding From Ventilation Filters

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Introduction

The most important reason to utilize air filtration in general ventilation systems is to improve the quality of indoor air, i.e. to reduce the concentration of airborne particles. Sometimes, filters are also used to protect manufacturing process, products and manufacturing equipment. A basic requirement for the air filtration is the good efficiency during the whole filter life time. Thus, air filters should be effective and they should operate reliably for long periods of time even in varying environmental conditions. Besides this, it is necessary that under no circumstances significant amounts of contaminants will be released from the filters.

An important factor for the reliability of the air filtration is the stability of the collected particulate matter. A key question is if particle shedding takes place e.g. when the ventilation system is started or when the flow rate changes rapidly or in cases of strong pressure impacts etc. There has been some qualitative information about the instability of the collected particle mass, i.e. it has been noticed that excessive dust accumulation takes place on the surfaces of the ventilation ducts. It has also been observed in filter testing that particle release can take place right after the loading period causing problems for collection efficiency measurements. It is worth mentioning that shedding measurements are not included in conventional filter testing methods.

In principle, if some of the collected dust becomes airborne, the particle concentration may grow to high level at least for short period of time. This may be of great importance because the released dust may contain biologically active species, e.g. bacteria, fungi and pollen.

Shedding from Filter

Particle shedding from a filter can be caused either by particle emission from the filter material itself or particle emission from the collected dust. According to filter standard draft (CEN) (2) shedding also includes penetration caused by particle bouncing from the fiber surface. Particle emission from the filter material itself requires that pieces of filter material get loose and are then transported by the air flow. It has been claimed that some fibrous filter materials can emit particles because some of the fibers may break due to a mechanical stress caused e.g. by the air flow or vibration. According to Christensson and Kranz (1) the fiber emission from a new glass fiber filter decreases rapidly to the levels corresponding urban and rural background concentrations.

Particle release from the collected aerosol mass is a very complicated process because it is affected also by the physical and chemical properties of the particles. It is reasonable to assume that the properties of aerosol particles may vary strongly depending on the location and time. It is also worth noticing that the properties of collected particles may change with time (e.g. due to evaporation or chemical reactions). Thus, there may be very complicated changes in the probability of particle release.

The process of particle release from a filter medium is illustrated in Figure 1. It is reasonable to assume that there is a certain probability that any of the collected particle may become loose. Then, the released particle may either become re-captured by the filter medium or it may escape from the filter leading to an increase in the downstream particle concentration. According to this approach, collected aerosol matter slowly moves towards the backside of the filter medium.

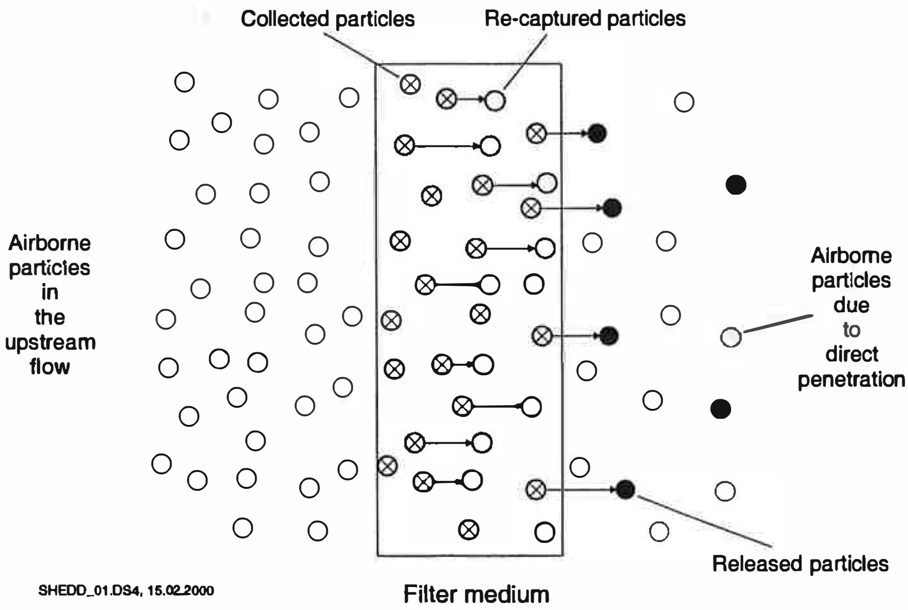

Figure 1. Particle shedding from the collected aerosol mass

Test Methods

Particle shedding was studied by measuring the concentrations of released particles from the downstream of the filter material. Particle concentrations were measured with an optical particle counter (MetOne 237). The principle of the laboratory test system is shown in Figure 2. This system includes a filter material test equipment which was used to create a controlled air flow through the filter sample. A timer-controlled valve was used to create a periodical oscillation flow. The frequency of the oscillation was 0.5 Hz and the amplitude 610 % of the nominal air flow velocity.

Filter loading was made with SAE Fine test dust generated with Palas RBG1000 dust feeder. In some experiments a mixture of SAE Fine and diesel fume was used. The concentration of particles released by the filter was measured from the downstream air immediately after the loading was stopped. HEPA filtered air flow was used to create an abrupt stop for the filter loading. Measurements were made at several levels of filter loading.

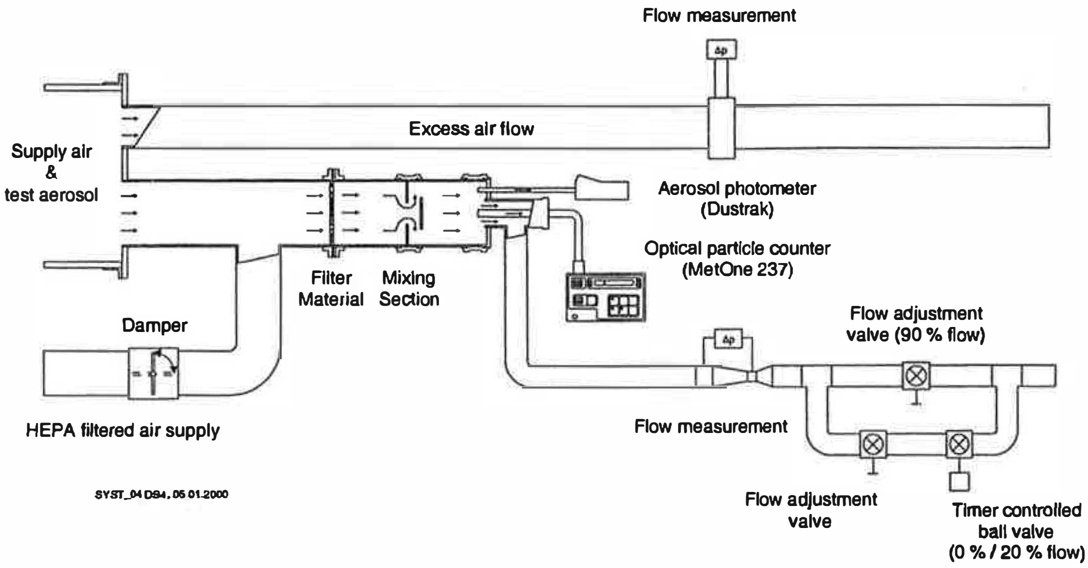

Figure 2. Principle of the filter material test system.

Results

Figures 3–4 show examples of the results which were obtained in the laboratory tests with class F5 and F7 filter samples which were cut from glass fiber bag filters. The air velocity through the filter sample was adjusted to the nominal value, i.e. nominal flow rate divided by total filter area. The reported results correspond to average concentrations measured during the period of 15 minutes right after the stop of filter loading. These figures also show the concentrations corresponding to standard clean room cleanliness classes (FS 209 E).

It must be strongly emphasized that the particle concentrations measured in the filter material tests do not necessarily correspond to the concentrations in true operation conditions. Thus, these results should so far be used for the comparison of various filter materials only.

Figure 3 shows the test results which were obtained with class F5 filter loaded with SAE Fine test dust. According to this result, the concentrations of particles released by class F5 fibrous filter are in the range corresponding to the standard clean room classes M5–M7. The corresponding concentration values obtained with a class F7 filter material are much lower as shown in Figure 4. Thus, filter class seems to a very important factor for the importance of the particle shedding.

Figure 5 shows the results which were obtained when filter material (F5) was loaded with a test aerosol which contained 75 % SAE Fine test dust and 25 % diesel fume. These results clearly indicate that the presence of diesel fume significantly decreases the concentration of the re-entrained particles (see Figure 3).

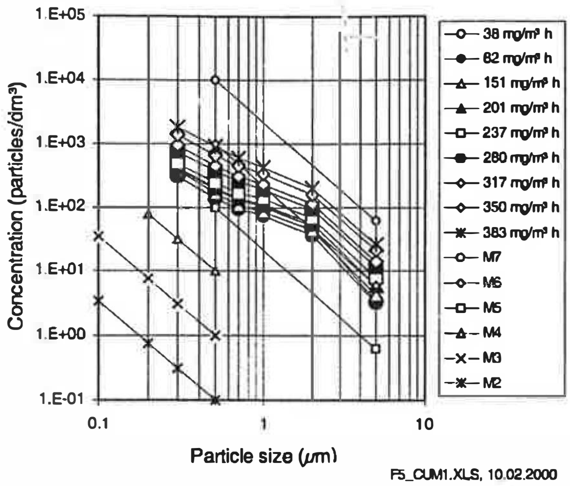

Figure 3. Cumulative particle number concentrations. (SAE Fine, filter class F5).

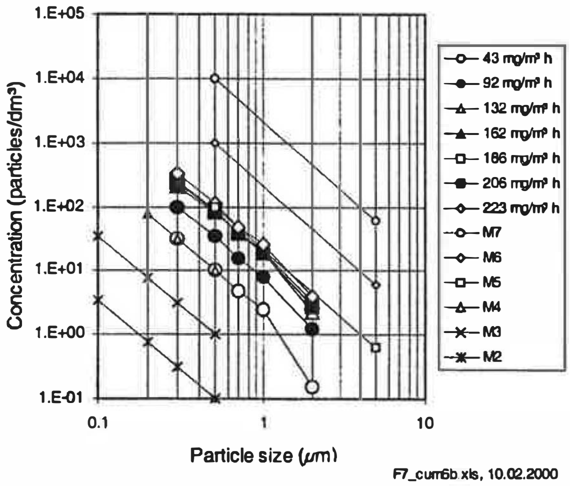

Figure 4. Cumulative particle number concentrations. (SAE Fine, filter class F7).

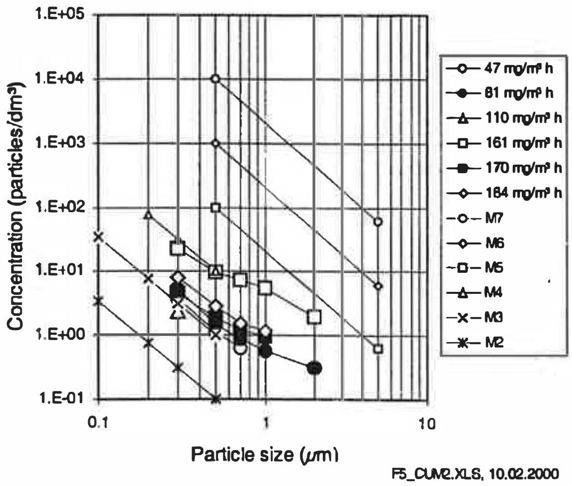

Figure 5. Cumulative particle number concentrations. (SAE Fine & diesel fume, filter class F5).

Conclusions

The laboratory studies made by filter material samples indicate that the concentrations due to particle shedding depend strongly on the properties of the filter. The concentration of particles re-entrained from F7 filters is much lower than from class F5 filters. In general, the measured particle concentrations in these tests were relatively low, e.g. in the case of F7 filter concentrations were within the limits of M5 cleanliness class.

The shedding from a fibrous filter also depends on the composition of the loading test aerosol. Thus, the simulation of true filter operation conditions in laboratory is very difficult. A large amount of field measurements and laboratory tests with different test aerosols should be made to determine a proper test aerosol for particle shedding simulation. Field measurements are also necessary to determine the significance of particle shedding in true operation conditions.

References

1. Christensson B, Kranz S. Glass Fiber Emission from Air Filters. Proceedings of the 4th International Symposium on Ventilation for Contamination Control, Ventilation '94 (Jansson A and Olander L., editors). Arbete och Hälsa 18(1994), Part 2, pp. 437–440.
2. prEN 779, Final draft, February 2000.