Long-term testing of gas adsorption filters for ventilation systems

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Abstract
A test rig for long-term tests of activated carbon filters was developed consisting of eight parallel test-filter sections. The test-rig was installed on the roof of a six-storey commercial building located in the centre of Göteborg, Sweden. By this arrangement, eight activated carbon filters are tested simultaneously under realistic conditions, using the pollutants in the ambient outdoor air as challenge substances.

Introduction
Field tests performed using existing ventilation systems equipped with activated carbon filters can provide valuable data obtained under realistic conditions. One advantage, in addition to the fact that the concentrations will be realistic, is that the activated carbon filter will be simultaneously exposed to a variety of substances, as opposed to laboratory test where the filter is challenged with one single substance prevailing in concentration. Long-term tests have demonstrated that the service life of activated carbon filters can be in excess of one year, even in buildings located in an urban environment [1, 2]. The present paper gives details about the design of the test rig and the intentions of the project. The paper also presents results from the first five months of filter testing using the test rig described. The investigation will provide new data as regards the performance of different filter types operating simultaneously under identical outdoor climatic conditions, which means for instance low temperature and high relative humidity during extended periods.

Materials and methods
The test rig has one common inlet for outdoor air, see Figure 1. After the air inlet, a particle filter of class EU7 (F85) is installed in order to clean the air from particles before it reaches the activated carbon filters. Downstream from the particle filter, the air stream is divided into eight parallel ducts with a circular cross-section, each with an inner diameter of 160 mm. Test specimens of activated carbon filters are installed in each of the eight ducts. The ducts join in one common suction box and the air flow is generated by a radial fan located downstream of the suction box. The air velocity in the ducts is checked using a hot wire anemometer inserted about 0,5 m downstream of the test filter specimen and the stability of the total air flow rate is checked by continuously monitoring the static pressure in the suction-box where the eight ducts join.

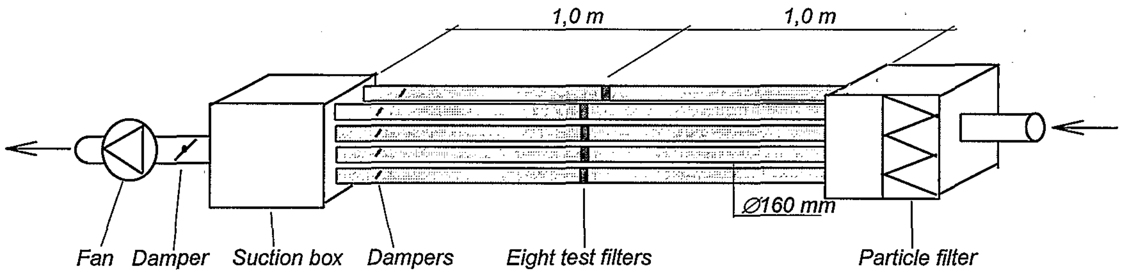

Figure 1. Sketch of the filter test-rig.

The test-rig is placed outdoors, which means that the tested filters have the same temperature as the outdoor air. Four different types of foam-bed filters are tested in parallel, and two specimens of each filter media type are tested simultaneously. The thickness of each filter is 24 mm, and the results summarised below are obtained using an air velocity of 0.8 m/s through the filters:

Concentrations upstream and downstream of each filter are measured using passive samplers for nitrogen dioxide (NO_2), nitrogen monoxide (NO), ozone (O_3), sulphur dioxide (SO_2) and a variety of volatile organic compounds (VOCs). At both upstream and downstream concentration measurements, the passive samplers are inserted a distance of about 0,6 m from the test filters. The passive samplers are repeatedly exposed for 2-4 weeks distributed over periods of several months. After exposure the passive samplers are sent to the Swedish Environmental Research Institute (IVL) for analysis. The rest rig is located at one of the monitoring sites of the local environmental protection office in Göteborg, which provide continuously measured ambient concentrations of the substances mentioned above. In addition, the monitoring station provides data of the outdoor temperature, relative humidity and other climatic parameters.

Results

Below, some examples of the results obtained after five months of measurements are given. For instance, the SO_2 removal efficiency for a filter with impregnated carbon spheres was initially above 90%, and there is no tendency of decreasing efficiency over the five months. For a filter with granular carbon, which contains less carbon, there is a tendency of decreasing removal efficiency (about 80% after five months).

Furthermore, the initial efficiency for NO_2 was found to be about 50% for the filter with impregnated carbon spheres, and after five months the efficiency is still maintained above 30%. The filter with granular carbon shows a decrease of the efficiency to less than 10% over the first five months. It can be noted that the NO concentration tends to increase somewhat over the filters, which could be due to chemical transformation of NO_2 to NO in the filters. This observation has been made also in a previous work [3].

Initial removal efficiencies for O_3 are observed between 58% and 79%, and after five months between 36% and 76%. The filter with impregnated carbon spheres shows higher removal efficiency after five months than the other filters.

The pressure drops are found to be below 30 Pa for all of the tested filters. Finally, it must be noted that the filters tested have a depth of 24 mm only. Previous tests have mostly been carried out using 60 mm filters, which also is a dimension usually used in practice, when activated carbon filters are installed in buildings. Furthermore, the test is carried out at a quite high air velocity resulting in a contact time of 30 ms only. Future activities within the project will include tests also at longer contact times.

References

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