Design and Characterization of a Test Stand for Performance Evaluation of Flat Filter Media

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Abstract
Filling efficiency (FE) and initial differential pressure (ΔP) are two important parameters used in the design of filters. Rating of filter media during full filter pack assembly can account for a large drop in Filling Efficiency (FE) from high efficiency particulate air (HEPA) filters. The FE of the flat, non-pleated media can be used as a benchmark for filter design to determine how a filter has been assembled. Many different design parameters can influence filter packing and results may differ between test stands. Often filtered air flow designs will perform with various media types. This paper presents the development of a test stand at the Institute of Clean Energy Technology (ICT) at Mississippi State University (MSU) to perform FE testing on flat media coupons at various velocities. Three flow rates correspond to differing flow velocity in full filter packs. This information helps to determine how much media should be included in a filter pack or a given flat design. The challenge aerosol used was dichlorophene; a standard on the FE testing. The test stand design allows for the concentration of the aerosol to be adjusted such that the test coupon would be challenged with the same concentration and particle size distribution (PSD) as different media types. The test stand can be used to evaluate a wide range of filter materials without the cost of multiple test stands. The test stand also records the differential pressure (ΔP) across the filter coupon during the test. The American Society of Mechanical Engineers (ASME) AG-1 non-pleated HEPA filters and designates a maximum and minimum. The ΔP of each clean filter coupon is recorded at each media velocity prior to aerosol challenge.

Introduction
The Institute of Clean Energy Technology (ICT) is experienced at testing and evaluating AG-1 HEPA filters and has performed evaluation of HEPA filters for many different projects related to nuclear particulate containment. One such project is the performance evaluation and qualification of newly designed HEPA filters for the Manhattan Waste Treatment Plant (WTP). ICT is currently under contract to Bechtel National, Inc. (BNI) to evaluate designs of AG-1 Section FK containment. One such project is the performance evaluation and qualification of newly designed HEPA filters for the Manhattan Waste Treatment Plant (WTP).

Test Stand Design Criteria
- Media is to be tested in flat form as circular coupons and in small-scale filter packs (folded or wound media packs). Each requires a separate testing.
- The test stand requires the flat sheet coupons to be tested at media velocities of 0.9, 1.5, 2.1, 3.0, and 4.6 m/min (3, 5, 7, 10, and 15 ft/min). These values were chosen to cover a wide range of potential filter pack media velocities and or the quadrant packs to be tested at 2.00 SD (30 in/d 75 mm/d), regardless of media velocity.
- Filtration efficiency is determined by the dilution method. Particle count testing also requires loading with tracers that are larger than 0.3 pm. Therefore, the test stand design must support aerosol generation and introduction with liquid and/or aerosol particles.
- The filter coupons must be recorded throughout each test to determine a curve of clean media and to determine filter loading. Temperature, relative humidity, and flow rate of the test stand are monitored.
- Aerosol samples to be taken upstream and downstream of the filter and measured with a Particle Sizing (MPS) instrument is used to include in full filter packs.

References

Penetration fraction is the most desired result of these tests. It is calculated by dividing the downstream concentration by the upstream concentration. This is shown with an example. An isopleth showing penetration data and a logarithmic curve fit can be seen in Figures 7 and 8. The peak of the curve indicates the most penetrating particle size (MPPS).

Results
The figure shows the particle size distribution of upstream (US) and downstream (DS) samples. The penetration fraction is calculated by dividing the downstream concentration by the upstream concentration. This is shown with an example. An isopleth showing penetration data and a logarithmic curve fit can be seen in Figures 7 and 8. The peak of the curve indicates the most penetrating particle size (MPPS).

Conclusions
- A test stand for evaluating the performance of filter media was designed, built, and characterized.
- The system is capable of testing flat sheet coupons and small scale filter packs called quadrant packs.
- The aeration system used is capable of being used with a BFMS and a LAS and the resulting data is used to determine performance, most penetrating particle size, and filtering efficiency.
- The test stand can be used as a design tool for different filter media to test the best surface area to be included in full filter packs.
- The results show that the system and test stand are able to produce the desired data with high quality.
- The requirements for this test system were achieved with the design presented herewith.

Future work will include evaluating the multiple media types and quadrant pack filter packing design strategies prescribed in ICT’s test plan for the project with BFMS. These data will aid BFMS in the selection of media to be used in the construction of radial flow HEPA filters for the Manhattan WTP.