

ENVR 116L
Aerosol Technology Laboratory
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FILTRATION

Background

Ventilation filters are used in office buildings and in homes to clean the air. One reason for using these filters is to prevent particles from collecting on the heat exchange coils in the heating or cooling system. Dirty coils hinder heat transfer, and reduce the thermal efficiency of the HVAC system. A second reason for using the filters is to remove particles that might be harmful to health or affect aesthetics. Pollens, spores, and animal dander from pets can be a problem; inorganic dust from clothing or dirt is a nuisance.

The ability of filters to remove particles depends on mechanisms such as inertial impaction and diffusion. Impaction is the predominant removal mechanism for particles larger than a few micrometers, and diffusion is effective for particles smaller than a few tenths of a micrometer. For particles of intermediate size, both impaction and diffusion contribute. If the air velocity through a filter is relatively high, impaction efficiency improves and diffusion efficiency decreases. At relatively low velocities, impaction is less effective but diffusion increases.

The topic of filtration is discussed “Aerosol Technology” by Hinds, our textbook in the fall aerosol course. We also discuss filtration for several weeks in my course ENVR 251, Air Pollution Control. We will not go deeply into filter performance here, but if you have interest in this topic you can take a look at the Hinds book or at the material on the website for ENVR 251 at <http://www.unc.edu/courses/2005spring/envr/251/001/>.

Ads on TV remind us to change ventilation filters often so that we can maintain the performance of our heating and air conditioning systems. But why is it important to change these filters? How well do they work at removing particles? In this lab we will investigate the collection efficiency of a ventilation filter used in the air handling system in Baity Lab. This filter is reasonably representative of the filters used in office buildings and in homes.

Procedure

We will use the Aerosizer to measure the efficiency of a filter on the particles in room air. We will conduct the tests at several filtration velocities. Through this test we hope to establish whether these filters collect incoming particles of all sizes, as they should. We will also determine whether filtration velocity has an effect on filter performance.

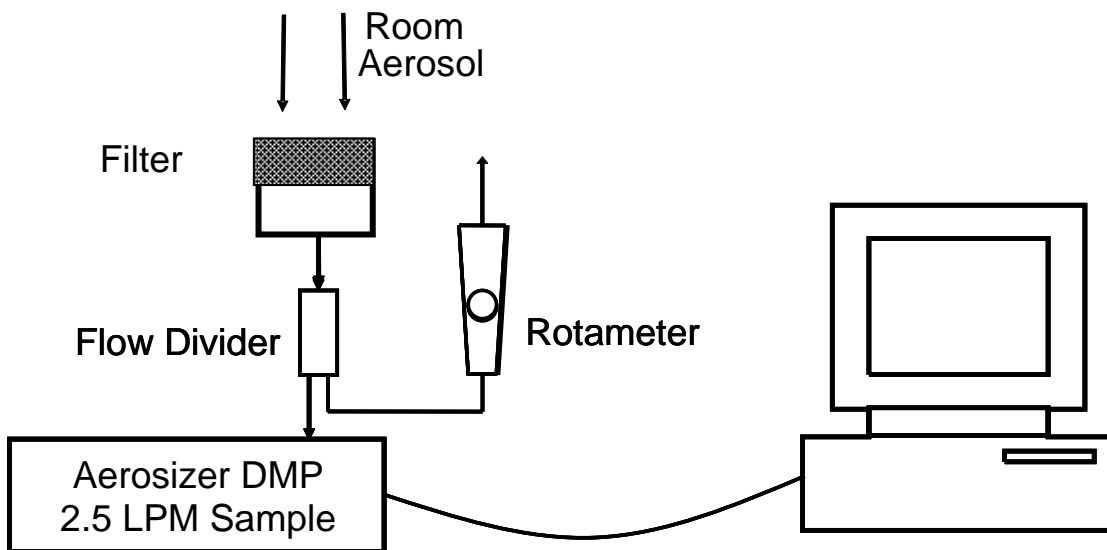
Filtration Velocity

First, you will need to determine an appropriate range for filtration velocity in these tests. To do this, go up to the mezzanine in the high bay of the Baity Lab and locate the air handler for the heating, ventilating and air conditioning (HVAC) system. Two filters are mounted on the front of this unit.

Measure the air velocity through these HVAC filters while the unit is operating. If it is not running, adjust the temperature setting on a thermostat until the unit comes on. To measure velocity, use three instruments: an Alnor swinging vane anemometer, a Bacharach rotating vane anemometer, and a TSI thermal anemometer. Take measurements across the face of the filter using each instrument, compare the readings from each of the instruments, and decide on a representative filtration velocity for your tests.

Collection Efficiency

Cut a piece of a new ventilation filter from the filter you will find in the middle lab, and fit it into the round, plastic filter holder that you will use for these tests. This filter holder is mounted to the equipment you will use, and is shown in the schematic diagram below. Measure the diameter of the filter, and from this measurement determine the effective surface area of the filter. Multiply the filter surface area by the air velocity you found for the HVAC filter, to obtain the target air flow through the filter for your tests.



The figure above shows how the equipment will be set up. Room air will flow through the filter and to a flow divider. Air flow into the instrument can be set using the computer that controls the Aerosizer itself. For this experiment, the air flow into the Aerosizer should be 2.5 LPM. The balance of the flow will go to a rotameter connected to lab vacuum. The air flow

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through the rotameter should be adjusted to be the difference between the target air flow through the filter and the 2.5 Lpm flow that goes into the Aerosizer.

Review the operation of the Aerosizer from your notes in the fall aerosol course. This is the instrument that you calibrated in that course. The description of the calibration lab is on the aerosol course website, at <http://www.unc.edu/courses/2005fall/envr/116/001/>.

The Aerosizer will be used with the filter attached to its inlet, then with the filter removed, then with the filter attached again, removed again, and attached again for a total of five measurements: F, No F, F, No F, F. Filter penetration, Pt, will be the number of particles measured when the filter is attached, divided by the number of particles measured when the filter is not attached. Penetration can be calculated for particles of each size detected by the Aerosizer.

$$Pt = \frac{N_{\text{filter attached}}}{N_{\text{no filter attached}}}$$

With the five measurements you make, you can establish four penetration measurements for particles of each size. The first pair of measurements F, NoF, establish the first penetration measurement. The second penetration measurement comes from the second and third measurements, NoF, F, and so on. With four penetration measurements for particles of each size, you can determine both average penetration and the standard deviation for particles of each size in room air.

Now adjust the rotameter so that the velocity of air through the filter is 25% of the original velocity and repeat the penetration measurements. Finally, adjust the rotameter so that the filtration velocity is four times the original and again measure penetration for particles of all sizes. If you are unable to adjust flows to the values desired, just do the best you can.

When we discussed the Aerosizer in the fall course, we noted that counting efficiency is not constant for particles of all sizes. That is, the instrument might count 100% of the particles that are 1 μm in diameter that pass through it, but only 10% of the 0.5 μm particles. As a result, size distributions measured by this instrument will be biased. In the work you do here, this bias is unimportant because our outcome variable is a ratio of concentrations measurements for particles of the same size. If the Aerosizer measures only 10% of the particles of a particular size, then a penetration determined for particles of that size will still be accurate, as long as counting efficiency does not depend on concentration.

Report

Outline briefly what you did. In the same figure, plot average penetration against particle diameter at all three filtration velocities. Use error bars to indicate one standard deviation for each measurement. Decide whether the ventilation filter is effective at removing particles in room air, and whether filtration velocity has an effect on penetration

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Your report must not exceed four pages. The first page should contain only your name, the date, and a brief paragraph that summarizes your work and findings.