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AIR CLEANING FOR ACCEPTABLE INDOOR AIR QUALITY

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ABSTRACT

Air cleaning has performed an important role in heating, ventilation, and air conditioning systems for many years. Traditionally, general ventilation-air filtration equipment has been used to protect cooling coils and fans. Air cleaning is suggested as a means to reduce the need for fresh air to meet ventilation requirements. Outdoor contaminants (such as pollen and pollutants) may need to be removed before air is introduced into occupied spaces. High-efficiency filters could also reduce the need to clean ducts by preventing the deposition of particulate matter.

Critical to the understanding and application of air cleaners are scientifically valid ways of testing performance. Experimental techniques to evaluate in-duct air cleaners for both particles and organic compounds have been developed. Laboratory performance data of a number of air cleaners will be presented. Building simulation models including laboratory performance data have been used to estimate the importance of air cleaners from a building system standpoint.

KEYWORDS

air cleaning; building simulation model; chamber tests; filter test system; gaseous absorbers; particle size dependent efficiency; ventilation.

INTRODUCTION

Indoor air quality depends on ventilation, source control, and air cleaning. Ventilation is critical to the health and comfort of a building's occupants, providing fresh air at controlled temperature and humidity as well as diluting and transporting bio-effluents and other contaminants from the occupied space. The flow rate of fresh air introduced into the building greatly affects energy costs from heating and cooling. ASHRAE Standard 62 (1989) prescribes the air flow rate per occupant or floor area. Figure 1 shows the location of air cleaners in a ventilation system. Source control involves selecting furnishings and equipment with low emissions.

Although source control, ventilation, and air cleaning are all methods of improving indoor air quality, this paper focuses on the role of air cleaners. Specifically, it addresses the evaluation of new test methods for particle size dependent efficiency and for gaseous absorbers.

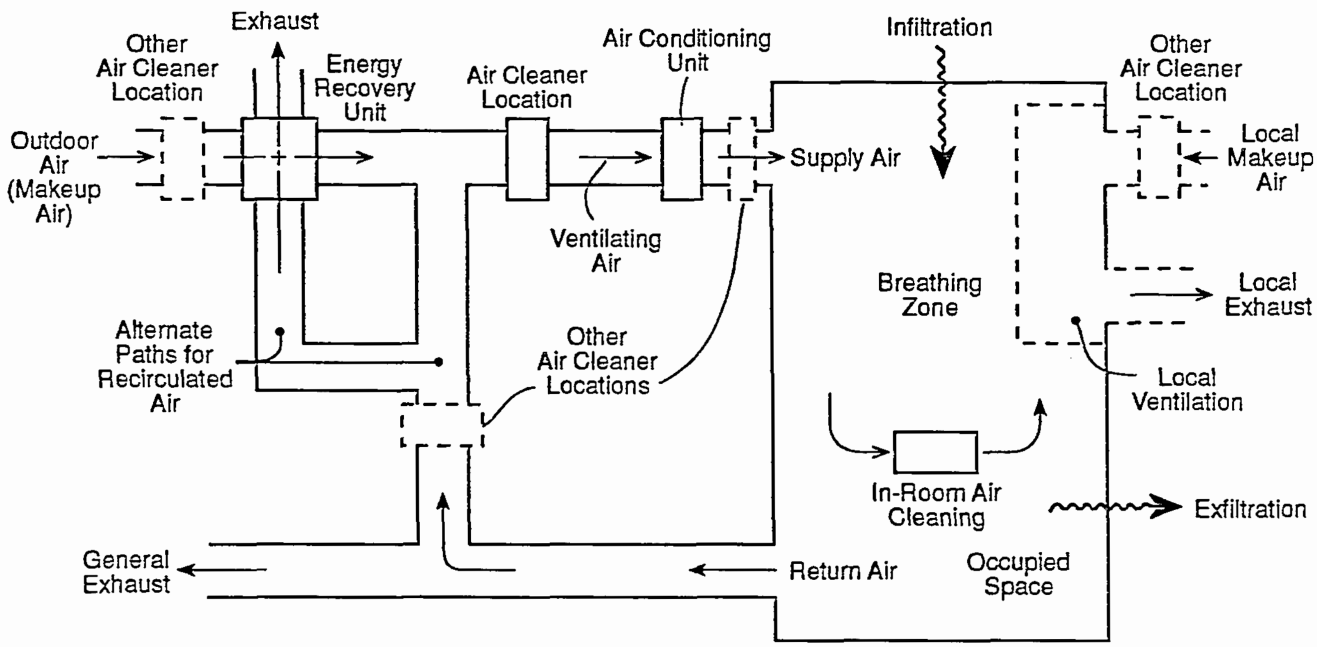

Fig. 1. Location of air cleaners in a ventilation system (after ASHRAE, 1989).

AIR CLEANER EVALUATION

Particle Removal

Particle size collection efficiency for air cleaners usually has a minimum in the 0.1- to 1.0-µm range. The overall efficiency is a function of the filter design and air flow rate (Ensor *et al.*, 1994). Particulate biological materials can be removed by filters depending on their physical size. Also, viable material may be associated with dust. The capability of filters to remove biological materials was reviewed recently by Foarde *et al.* (1994).

General ventilation filters are usually tested in the United States following ASHRAE 52.1-1992 (1992). The method has two major parts: the arrestance test and the atmospheric dust spot test. The arrestance test, which was designed primarily to test the filter's ability to protect ventilation equipment, is conducted with a mixture of dust, carbon powder, and lint. The dust spot efficiency test is conducted with outdoor air and is a measure of the reduction of soiling by the filter.

The requirements for test data more appropriate for indoor air quality specifications have prompted the development of new test methods with particle counting instrumentation to obtain particle size dependent efficiencies (Ensor *et al.*, 1994). In a project conducted for the U.S. EPA, Hanley *et al.* (1994) measured the particle size dependent efficiency for a wide range of air cleaners. These data provided background for a research program conducted for ASHRAE (Hanley *et al.*, 1993) to resolve technical problems and develop a quality assurance framework required for a new standard test method. The test duct is shown in Figure 2. Water containing potassium chloride is either atomized or sprayed to form solution droplets that evaporate to form solid particles. Particle size is controlled by the solution salt concentration and droplet size. An optical particle counter is used to obtain the concentration as a function of particle diameter (0.3–10 µm) up- and downstream of the air filter. Electrical mobility separators and condensation nuclei counters have been used to measure removal efficiencies of particles to 0.014–µm diameter. Arrestance dust from ASHRAE 52.1 without the carbon can be injected into the system to artificially load the filter to simulate use. Figure 3 shows an example of the test results. The test system can be used to test a wide range of filters, from simple furnace filters to high-efficiency filters used for cleanrooms.

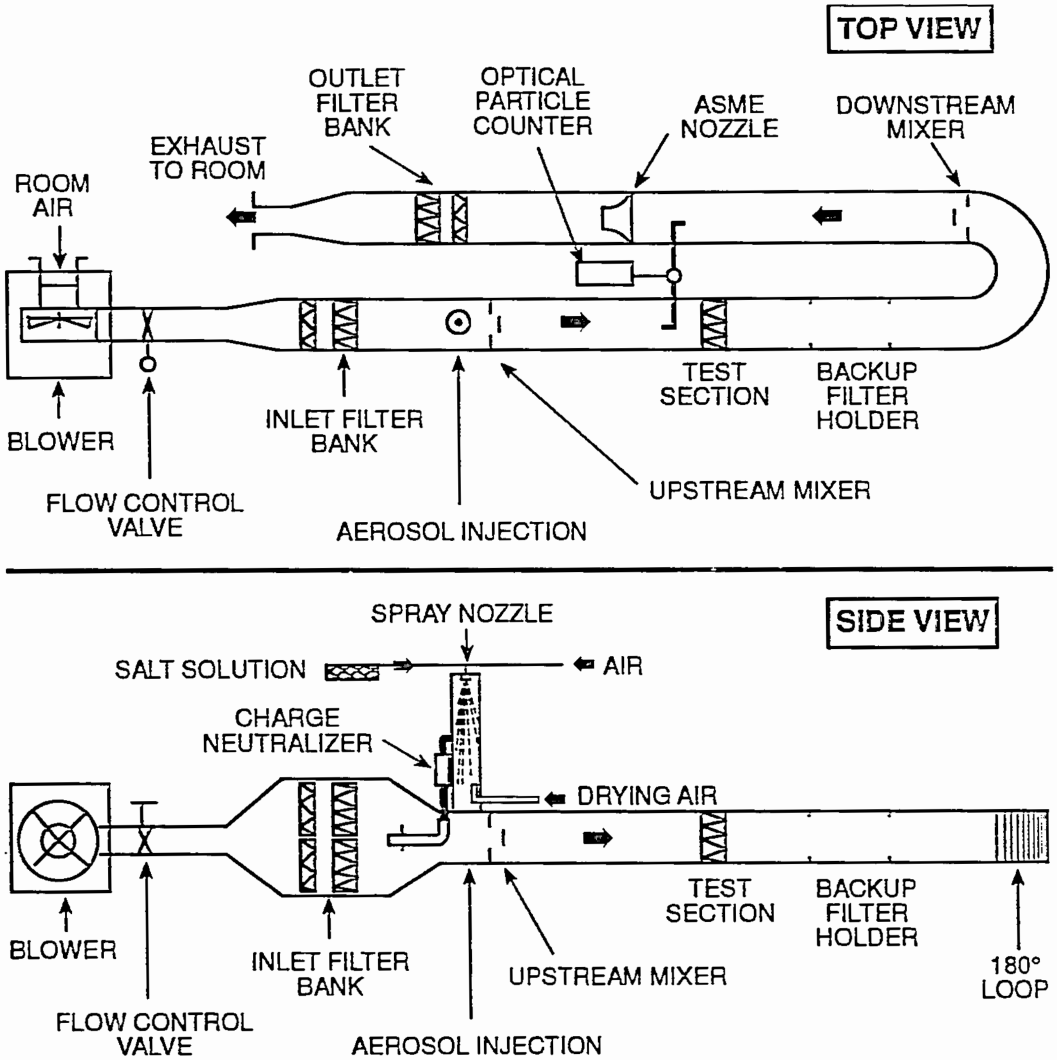

Fig 2. Schematic illustration of new filter test system.

<u>Gas Removal</u>

Removal of gases is highly dependent on the chemical and physical properties of specific compounds. The absorption of a gas is not a steady-state process. Gases can be absorbed and desorbed as changes in concentration cause shifts from equilibrium. Standard tests are not now available to evaluate air cleaners for gaseous compounds to obtain efficiency and long-term life data required for indoor air quality applications. Two laboratory tests are under development: media samples and full-scale air cleaners. The test conditions were developed by examining two application scenarios: filtering outdoor air and filtering indoor recirculated air (VanOsdell, 1992). Because activated charcoal is very sensitive to relative humidity above 50%, relative humidity and temperature must be carefully controlled (Liu, 1993).

<u>Chamber Tests</u>

The evaluation of in-room air cleaners has generally been conducted in test chambers. One standard method was published by AHAM (1987) for particle challenges of tobacco smoke, Arizona road dust, and pollen. The clean air delivery rate (CADR), a product of initial efficiency and air flow, is computed from the concentration decay in the chamber. The CADR is used to compare air cleaners in a voluntary program by the manufacturers.

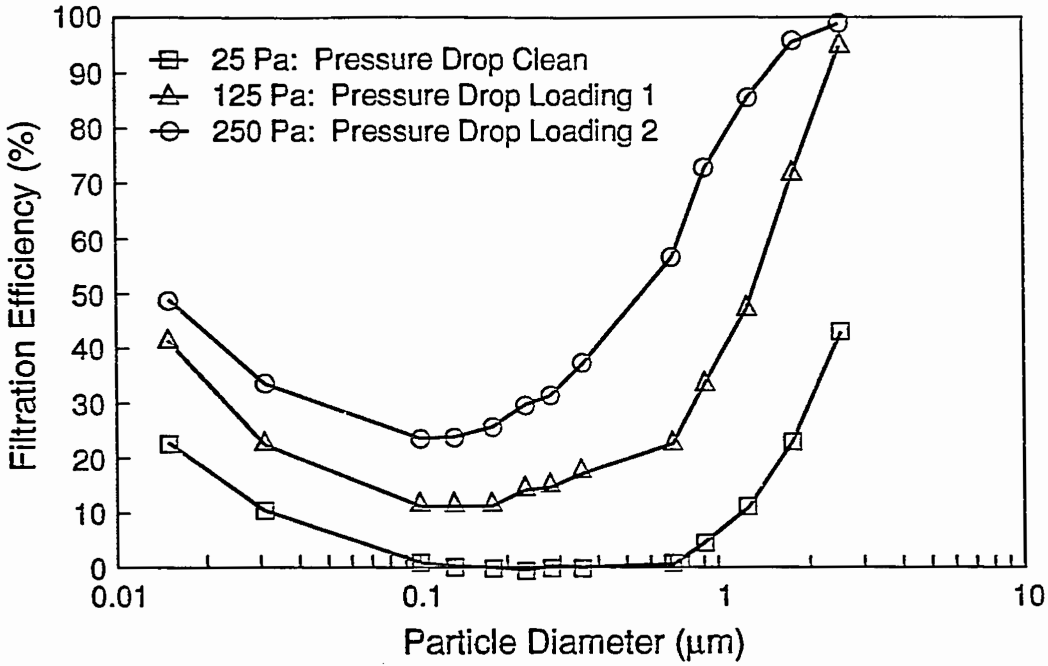

Figure 3. Fractional filtration efficiency of 25-30% ASHRAE efficiency pleated panel filter at 1.30 m/s for clean and dust-loaded condition.

AIR CLEANER APPLICATION

As air cleaners become better characterized as individual units, the next step will be understanding the effectiveness of the devices. A number of factors affect application of air cleaners in buildings: the location of air cleaners in the ventilation system may be critical because of environmental conditions such as humidity and transport of contaminants to the filters; in-duct laboratory tests are conducted at constant volume while in heating, ventilation, and air conditioning (HVAC) systems the air flow may diminish as the filter pressure increases with loading; infiltration and exfiltration in the building may have a significant effect on the indoor air concentrations; contaminants in the building may be complex mixtures affecting efficiency; and maintenance, ease of use, and costs may be significant considerations in selection.

Computer simulations to estimate the changes in contaminant concentrations in a building have been conducted with various air cleaning scenarios (Owen *et al.*, 1990, 1992). A building model consisting of rooms connected by the ventilation systems and by doors and corridors was used to evaluate air cleaner efficiencies, location, and sources of contaminants on concentration in the rooms as a function of time. There is a need for field studies to confirm these computer predictions based on laboratory air cleaner efficiency data. An important challenge will be understanding the integration of air cleaning in the building system.

CONCLUSIONS

Air cleaning has a very significant role in the indoor environment by protecting the HVAC system and the occupants from contaminants. Recent research in the development of new test methods for both particulate and gas air cleaners will greatly facilitate selection of appropriate systems. However, much research needs to be done before we understand the interaction of air cleaning and the occupied space.

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17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Simulation	Pollution Control	13B	
Air Cleaners	Test Chambers	Stationary Sources	13A, 13I	14B
Ventilation	Air Filters	Indoor Air		13K
Particles		Particulate	14G	
Organic Compounds			07C	
Mathematical Models			12A	

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