Air Filters: Choosing Portable Equipment…Plus

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We are learning that people feel better and perform better when their homes and schools have good indoor air quality (IAQ). Illnesses such as asthma, respiratory infections, allergies, lung cancer and environmental sensitivities are associated with poor air quality. Schools may tend toward poor indoor air quality (IAQ) for several reasons, including a concentration of classroom materials (such as art and science supplies), tight budgets that reduce maintenance, and because of high occupant density (Schools house approximately four times as many people as office buildings per square foot). There is much pollution-generating activity in classrooms, and often there are nonexistent, outdated or poorly maintained mechanical ventilation systems. Source control (avoiding the problem of dirty air) and ventilation (diluting pollution) help provide good air quality, but filtration of the air with portable devices is also sometimes useful.

This article is written for schools, but much of the information is transferable to other building types such as day cares, homes and offices.

Source Control and Ventilation

Contaminants include viruses, bacteria, breathable particles, airborne chemicals, pet dander, and more. Opening windows, using exhaust fans and full exhaust and return systems can dilute contaminants, but ventilation should not be seen as the only solution. Controlling indoor pollution at the source means removing as many causes of pollution as possible. For example, air quality benefits from low-emission cleaning and maintenance products, no indoor combustion equipment, hard-surface flooring, repairing leaks and removing mould growth, implementing fragrance-free, anti-vehicle-idling, and no-smoking programs, properly maintained and vented furnaces, and more.

Do you need extra air filtration?

Some circumstances are improved by portable air filters. They can provide a temporary solution to a pollution source, as in the case where an outdoor fuel spill caused some residual oil fumes to enter a hallway. On a few occasions, entire schools that were being replaced by new construction used portable filters to avoid the disruption of moving to temporary locations while waiting for the new schools to be finished. More commonly, putting a filter in a classroom, along with source control, can enable a teacher or student with asthma or environmental sensitivities to stay in school and to succeed.

General Information

Some filters reduce particles, some reduce gases or odours, and some do both. Note the difference between air "filters" and air "purifiers". Electrostatic purifiers and ozone generating purifiers are under examination for possible health impacts. Manufacturers and salespeople with these products are not happy about the controversy, but international health and safety agencies recommend use of proven alternatives such as source control, ventilation and effective “filtration” rather than “purification”.

There are rating systems for filters. Minimum Efficiency Reporting Value (MERV) is the most useful to date. It has a one-to-20 point system, with 20 being the best. High Efficiency Particle Arrestation (HEPA) filters are rated between 17 and 20.

It is important that filters fit snugly inside the device. Even small air leaks around the filter can reduce or negate the equipment's effectiveness.

Portable filtration devices are rated by the Association of Home Appliance Manufacturers' voluntary, third-party evaluation system. The machine's label gives the clean air delivery rate (CADR) and recommends the size of room it can clean. They are rated between 10 and 450, and machines with higher numbers can clean larger rooms. Keep in mind, however, that the amount of pollution being removed effects the life of the filter.

Air changes and cfm (Cubic Feet per Minute)
Reported cfm can be misleading. For example, the cfm of a motor in a filter unit may be 400 cfm, but the cfm of the same motor within the machine, but with filters slowing down the air flow, could be half that. Air changes per hour are more useful to know. Four air changes per hour is approaching "hospital" standard and isn't usually necessary. One air change per hour is a common target, and care needs to be taken to avoid stagnant areas.

Kinds of Air Cleaners

1. Ozone Generating Air Purifiers are best avoided. Ozone is a gas that reacts readily with other chemicals/substances to form many byproducts, from harmless water to harmful breakdown products such as aldehydes. Ozone doesn't remove particles. It destroys odours. Some manufacturers insist purifiers that use low level ozone clean the air without causing harm, but Canadian and international health and safety regulators recommend avoiding ozone-producing units. Ozone reacts with and can damage lung tissue. NIOSH recommends the upper limit of .01 ppm not be exceeded at any time. The US FDA limits ozone to .05 ppm for medical devices. The US EPA's standard is a maximum 8-hour exposure of .08 ppm. No agency in the US or Canada has approved ozone air cleaning devices for use in occupied spaces. There is also evidence that at concentrations that don't exceed public health levels, ozone doesn't effectively remove viruses, bacteria, mold, or many chemicals. Also, variations in outdoor ozone levels, and indoor conditions such as ventilation and proximity to the ozonator make it difficult to control the actual level of ozone in the breathing space. When there are other more effective, no-risk air cleaning devices available, why choose ozone?

2. Ionizers and Ultraviolet light (UV) are not fully understood yet for their effectiveness and possible side effects. Ionizers disperse negatively (or positively, depending on the design) charged ions into the air. Some claims are that they attach themselves to particles and cause them to become negatively (or positively) charged so they will attach themselves to surfaces such as walls or furniture. Research has shown ionizers to be less effective in removing particles of dust, tobacco, smoke, pollen and fungal spores than HEPA filters.

3. Turbulent Flow Precipitation (TFP) units target particulate, but they don't remove Volatile Organic Compounds (VOCs). Before HEPA filters became less expensive, TFP units were a good but somewhat less effective alternative. TFP claim to remove about 95% of 1 micron size and 90% of .5-.9 micron, as compared to HEPA's 95% of 0.1 micron particles and 99.97% of 0.3 micron particles. Some TFP manufacturers are augmenting their particulate removal efficiency by adding HEPA filters. One should watch for foam parts, as off gassing foam can be a problem for some people.

4. Electrostatic air purifiers can be up to 50% efficient (particle removal) on average (MERV 5-8), but these can create finer particles when dirty and create ozone when clean. They tend to be expensive to repair and require high maintenance.

5. Particle Filters. Particulate are minute droplets of liquids or physical solids suspended in the air. Some are large enough to be seen and some are microscopic. (One source estimates about .01% of house particles can be seen. That 8% of those not visible are fungus and spores, dust mites and their feces. One source said that ninety percent of house dust is microscopic. Of course this depends on the house.)

Examples of Particle Types:
- Biological: pollens, spores, molds, bacteria, viruses, hair, skin cells, insect byproducts, and food byproducts.
- Mineral: asbestos, clays/silica, carbon, lead, man-made fibres, hydrocarbons.
- Combustion products: tobacco or wood smokes, particles generated by cooking or heating appliances, and industrial processes.
- Radioactive: radon-decay products

Particles are measured in microns. Particles between five and 10 microns tend to be caught in the nose and throat. Particles smaller than this travel readily into the lungs.

Examples of particle sizes:

10 microns	heavy atmospheric dust and fly ash
5-10 microns	molds, pollens, average dust
1-5 microns	bacteria, light dust (i.e., fine chalk or drywall dust)
.3 microns	tobacco smoke, bacteria
.1 microns	viruses & bacteria (Some are smaller than .01 microns. Some are larger. Anthrax is 1 micron wide & 4-10 microns long.)

A few years ago ASHRAE developed a performance rating based on knowing the composition of test dust and size, and also on particles that are respirable. This is called a MERV rating (Minimum Efficiency Reporting Value). MERV ratings are on a scale of zero to 20, with 20 being the best rating. There are three or four labs in the US that test for MERV ratings.

This rating system removes the ambiguity of the "% efficiency" claims made by manufacturers. For example, 95% efficient is 95% of what? Is it 95% efficient at filtering out .3 micron particles? .1 micron particles? Is the claim based on the number of particles removed or mass removed? "95% efficient" referred to particle weight means that the filter will remove 90% of the weight of particles. This is deceiving because only 10% of airborne particles contribute about 90% of the weight of all particles in air. In other words, this 95% efficient filter can let 90% of the air's particles through.

An analogy would be this:
It is like having a big dog that weighs 200 lbs. and 99 one-pound pups. When they come to a fence, the 99 pups easily run through but the heavy dog cannot. It can be claimed the fence was 67% efficient because it stopped 67% of the dogs (particles). Reality is that the fence is like a filter that let 99% of the particles through! The little particles are what can cause most of the problems.

Furnace dust filters (often called rock-catchers) 2-3% efficient at particle number removal. MERV 1-4
Media filters up to 8% efficient at particle removal, MERV 1-4
Electrostatic up to 8% efficient at particle removal, MERV 1-4
DC charged electrostatic (up to 12VDC) up to 10% efficient at particle removal, MERV 5-8

Note that all of these can be advertised as being up to 95% efficient if the claim refers to weight and not particle number removal.

The following have commercial applications:
High density media filters (used in hospitals in general surgery) MERV 13-17
HEPA filters 99.97% efficient down to .3 microns and a MERV rating of 17-20

Typically, a MERV rating of 12 or higher represents a filter that can help sensitive students and staff.

Health effects from inhaling various particles:
- irritation of eyes, throat, nose, lungs
- impaired respiratory mechanics such as coughing, wheezing, shortness of breath
- aggravating existing respiratory conditions such as asthma, allergies, or bronchitis
- impacts on the immune system or central nervous system
- cancer

How many particles per square foot is the safety target?
It is a moving target because different people have differing needs. Some individuals may have an asthma attack triggered at 500,000 particles per cubic foot while others are much more tolerant. At 300,000 particles per cubic foot, one dealer I consulted reported his worst client sleeps well through the night, feels well rested, is less congested and uses less medication.

If a company states its filter will remove 90% of allergens such as pollen, they are probably referring to 2 microns in size. Good filtration usually means that the target area will have only 1/3 or less of the contaminant level outside. Depending on outside levels, that may or may not be adequate for the occupants, however.

6. Airborne Chemical Filters. VOCs such as those from furnishings, personal care products, combustion, and mold mycotoxins are missed by particle catchers, but can be absorbed by carbon and other media filters. Some VOCs are removed by HEPA filters, but mostly because a few chemicals attach themselves to particles that are caught in the filter. The Cutter Information Corporation defines VOCs as "one of a class of chemical compounds that contain one or more carbon atoms and tend to evaporate at room temperature and normal atmospheric pressure."

There are naturally occurring organic compounds too, such as mold mycotoxins and aldehydes and keytones, which are breakdown products from mold mycotoxins, that won't be removed by particulate filters. Activated carbon or other media such as zeolite are needed to remove VOCs from the air.

Activated carbon filters: Tiny cavities trap gasses. Natural ozone which is trapped actually helps to break down chemicals within the "pockets". Several kinds of media filters are available for use in removing different target chemicals.

Also important is the possibility that building occupants may be sensitive to materials in the filters. Most people do well with activated carbon filters, but sometimes highly sensitive individuals need alternatives such as VOC cartridges or filter beds of tiny glass beads.

Further to this, some carbon filters have a microbial pesticide in the form of a silane-modified quaternary amine that is bonded to the carbon. While it does kill molds and bacteria/viruses, it

may create unexpected and subtle adverse health effects in sensitive individuals. Basic, unmodified, activated carbon tends to be preferable.

Considerations for People with Environmental Sensitivities (ES or EI) or Multiple Chemical Sensitivity (MCS):
People with EI or MCS often experience health symptoms from even very low levels of pollutants. Sensitivities can be highly individual. To understand this condition more fully, see Medical Perspective on Environmental Sensitivities by Dr. M. Sears http://www.chrc-ccdp.ca/pdf/envsensitivity_en.pdf . It is helpful to use filtration devices with certain characteristics. Even then, it is often necessary to allow the individual to self-test for possible reactions to the devices or the materials that make up the devices. As just mentioned, many tolerate activated carbon well, but some might do better with another filtration medium.

Here is a list of advised general device features for EI/MCS sufferers:
- Use filters, not purifiers.
- Avoid plastics.
- Use metal case and parts. (Baked-on paint or stainless steel)
- No foam parts or foam filters.
- A true HEPA filter.
- Large activated charcoal bank (or other tolerated medium). Flexible charcoal sheets are less useful.
- No antimicrobial or other chemical treatments in/on filters or device parts.
- Fan motor located upwind of the filter system to remove any fan motor fumes, ozone byproduct, or lubricant (use low-emission, less-toxic lube).
- Well-fitted filters to avoid leakage.

Approximately 3% of Canadians have been diagnosed with EI. Many more in classrooms have asthma, and some 70% of asthmatics experience symptoms when exposed to airborne chemicals. It may be wise to choose filter devices with the above general characteristics when making selections for classroom use.

Noise:
Smaller devices operating on maximum setting may create noise and make hearing in a classroom difficult, damage the teacher's voice, and possibly cause other effects of noise pollution. Consider choosing larger devices and operating them on a low setting in order to reduce the sound of the fan motor and of rushing air.

7. Other:
Some promote the use of vacuum cleaners with either water filters or HEPA filters as combination vacuums and air filters. Use vacuums as vacuums (with HEPA filtration) and use air filtration systems for air filtration. Despite manufacturers' claims, they are not mutually interchangeable due to motor size/noise, capacity/amount of air filtered, and other reasons.

Filters Need Maintenance

One drawback of filtration is that filters need replacing. Manufacturers can only give estimates of the life of filters. It all depends on how polluted the area being cleaned is and how long the filters have been in. For media filters there comes a point where they begin to shed the pollution they have collected. One house I was helping with had a strong odour of fish throughout the

house and no one knew where it was coming from, as no fish had been cooked in months. It was the air filter in an upstairs bedroom in need of clean filters. In a tour of the old Halifax West High School we noted that rooms with HEPA and carbon portable filter units smelled of sweat and stinky sneakers! The filters were over-loaded.

HEPA filters become more efficient as they fill up - until they reach a point where they are clogged. The rate of air flow slows down and consequently the machine loses the desired rate of air cleaning ability. As well, the filter may collapse and therefore lose its filtering capabilities. Reinforced media filters are recommended. Typically, HEPAs can last up to five years and high density media up to one, depending on the pollution load.

So, maintenance is important to effective filtration. Systems need to be designed for ease of maintenance. A service schedule (or a professional service package) that will maintain filter units is important.

The cost of replacement HEPA filters has gone down by more than half (~$125 vs $300) in the past few years.
It is extremely important to view a particle count demonstration before purchasing.
A filter is less effective when it does not have a 100% air seal.

Integrated Systems

Some supplementary filter units can be integrated into new building systems or can be added to existing buildings, usually above the T-bar. They can serve single or multiple rooms, but should be sized accordingly. The systems can have zero pressure drop, and should be sized for close to one air filtration per hour. If ducted to the outside, they can be set with either a positive or negative pressure. Systems can have flexible, semi-rigid ducting to help improve air circulation. Supply and exhaust should point away from each other and be as far apart as possible. Polypropylene soft plastic is more stable than some flexible ducts, and some manufacturers are colouring their polypropylene ducts to differentiate them from the cheap dryer ducts. Rust-proof metal ducts are preferable, and should be washed to remove any surface oil film. Be sure installation is done by a professional.

Farming or industrial communities may need more filtration, not only against polluted outdoor air, but also because farm children tend to bring more pollution into the classroom on their clothing.

If filters are being used in a newly built school, the filters must be stored dry and away from mold and chemicals. Replace the filters after commissioning and building flush-out, and before occupants use the school. It may be recommended to replace the filters again after the first six months and then less frequently after that, according to the manufacturer's recommendations.

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