Bypass Air: What You Don't Filter *Can* Hurt You and Your HVAC System

Effective air filtration provides a primary defense for building occupants and HVAC equipment against airborne pollutants that can cause health problems as well as HVAC system maintenance problems. That's why selecting the right filter and proper HVAC maintenance are so critical.

When it comes to selecting air filters, many people turn to MERV. The Minimum Efficiency Reporting Value is assigned to filters based on their minimum fractional particle size efficiency, as determined under the ASHRAE 52.2 Test Standard. In the MERV rating scale, a MERV 1 is least efficient at removing airborne particles, while a MERV 16 is most efficient.

The ASHRAE 52.2 test provides more than just a single MERV rating, however. It provides the efficiency of the filter over three particle size ranges: E1 (very fine particles in the 0.3 to 1.0 micrometer range), E2 (fine particles in the 1.0 to 3.0 micrometer range), and E3 (coarse particles in the 3.0 to 10.0 micrometer range). The E1, E2 and E3 ASHRAE 52.2 test values for a given filter provide a more complete picture of a filter's filtration performance over the three particle size ranges. The 52.2 test also provides additional information such as initial pressure drop, which can impact energy usage during the filter's life.

In typical commercial office buildings, ASHRAE recommends a minimum filter performance of MERV 6. However, recent studies suggest that a more realistic minimum efficiency is MERV 7 to 11 or higher to provide good system cleanliness and efficient system operation.

Surprising Effects of Bypass Air

Even a filter with a high MERV may not protect the HVAC system and building occupants from airborne particles if it is not installed and maintained correctly and air is allowed to bypass the filter instead of flowing through it.

When air bypasses the filter, airborne dust and particulates can cause fouling of the coils and fans of the HVAC system. Fouling reduces airflow through the HVAC system and heat transfer in the coils, which can add up to a significant increase in energy costs.

Bypass occurs when filter media is not properly sealed in the filter frame, when filters are not properly installed and gasketed in filter racks, or when air handler doors and ducts are not properly sealed.

Improper filter installation and poor gasketing create gaps around the filters – gaps which may seem small and insignificant on the surface, but in reality even small gaps can have a surprising effect on filter performance. For example, a mere 1 mm gap in the installation of a MERV 15 filter can reduce its efficiency to MERV 14. A gap of 10mm can decrease performance all the way down to MERV 8. Because higher efficiency filters also typically have a higher pressure drop, bypass tends to have a larger effect on high performance filters. The amount of dust built up on the filter also has an effect on bypass flow. The smallest bypass flow occurs when a filter is clean and can increase by as much as 10 percent when filters are dirty. (Ward, Siegel)

In a simulation of filter bypass, Siegel (2002) suggested that even moderate amounts of filter bypass can dramatically increase HVAC heat exchanger fouling. Siegel and Nazaroff (2003) note that fouled heat exchangers have diminished heat transfer performance and increased pressure drop, leading to significantly increased energy use and decreased heating and cooling performance.

From the standpoint of IAQ, Ward and Siegel show that respirable particles are not appreciably removed in the [filter] gap, which means that bypass is significantly detrimental to indoor air quality. The authors concluded that an HVAC design that employs high efficiency filters to prevent health problems associated with indoor fine particles may fail to perform as intended due to bypass.

Filter Installation and Maintenance

Filters will only do their job and perform as specified when they are installed and maintained correctly. To avoid bypass air and make sure that all the air in the system goes through the filter, consider these installation tips:

- Before installation and periodically during operation, visually inspect filters and replace ones that are damaged.
- Install the filter according to the air flow direction indicated on the frame.
- Make sure that all filter housings have good filter gaskets, preferably with a non-porous gasketing material.
- Check to be sure that the filters are properly seated in the filter housing or channel.
- Ensure that the filter fasteners are in place and correctly installed, especially if filters are serviced from the downstream side.
- Check to ensure that the bank of filter frames is rigid and well reinforced to avoid collapse.

If the filter looks like this after you take it out of its packaging, don't install it.

- Caulk any cracks between filter banks and the duct wall to prevent leaking of unfiltered air.
- Make sure all air handler entry doors are gasketed and tightly sealed.

Proper filter maintenance is also crucial to keeping HVAC ductwork clean. If dirt accumulates in the ductwork, and if the relative humidity reaches the dewpoint (so that condensation occurs), then bacteria and mold may grow. This is especially the case in HVAC systems with acoustical duct liners, which are frequently used in air handler fan housings and supply ducts to reduce sound transmission and provide thermal insulation.

After filters are properly installed and operating, they should be monitored to make sure they are providing maximum filtration while not overtaxing the supply fan capability or leading to a "blow-out" situation with no air filtration. Scheduled maintenance and monitoring of established pressure drops across the filter or filter bank can be determining factors, along with specific variations in environmental conditions such as humidity and seasonal changes.

Conclusion

Proper selection, installation and maintenance of HVAC system filters can positively affect IAQ, improve energy efficiency, and reduce maintenance in commercial buildings. Selecting high-quality filters with a minimum efficiency of MERV 8 (or higher, depending on building purpose) will minimize HVAC coil and fan fouling while providing high-quality indoor air for building occupants. Finally, properly installing and sealing filters can avoid filter bypass and let your filter investment provide maximum benefits.

Bottom Line for Facility Managers and HVAC Professionals:

Does your building suffer from bypass air? Bypass air can reduce the performance of your building's HVAC system, including the filters you've purchased, leading to reduced IAQ and increased maintenance and energy expenses. Be sure to pay close attention to proper filter installation and maintenance procedures to avoid this problem.

Bottom Line for Filter Manufacturers and Distributors:

Providing your customers with explicit directions concerning the proper filter installation and maintenance procedures will help to avoid IAQ and operating cost problems relating to bypass air.

References

Siegel, J. 2002. Particle Deposition on HVAC Heat Exchangers. Ph.D. dissertation, University of California, Berkeley.

Siegel, J.A. and Nazaroff, W.W., "Predicting Particle Deposition on HVAC Heat Exchangers." Atmospheric Environment. 37 (2003), 5587-5596.

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