Bypass Air: What You Don't Filter Can Hurt You

The Effects of Bypass Air on Indoor Air Quality and HVAC Operating Costs

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Proper HVAC air filtration is at the heart of good indoor air quality (IAQ). Filters help keep both the HVAC system clean and the indoor environment free from dust and particulates. Building operating costs and IAQ can be negatively affected when proper attention is not paid to filter installation and maintenance.

A key problem in buildings today is bypass air, a condition where air flows through the system without passing through the filter. 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.

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Bypass air can cause fouling of HVAC coils and fans, which can increase operating costs through inefficient operation and increased maintenance. It can also affect IAQ by reducing the performance of the filters purchased, increasing the amount of airborne contaminants reaching the building occupants.

Air Filters and IAQ

Effective air filtration provides the primary defense for building occupants and HVAC equipment against pollutants generated within a building as well as pollutants from air drawn into a building for ventilation. That's why selecting the right HVAC filter is so critical.

The type and performance of the filter selected may be driven by the type of facility. Some buildings such as hospitals, laboratories, food processing facilities, and many industries have specific filtration requirements dictated by the activities that take place there. In the absence of a use-specific filtration requirement, a good rule of thumb is to purchase the highest efficiency air filter the HVAC system is capable of handling.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has created test standards that quantify the performance of air filters. ASHRAE 52.2-1999 measures both the efficiency and pressure drop of a filter. Efficiency is a measure of the filter's ability to remove airborne particles of various sizes. A MERV (Minimum Efficiency Reporting Value) is assigned to the filter based on its efficiency over three different particle size ranges (0.3 to 1 micrometer, 1 to 3 micrometers, and 3 to 10 micrometers). A MERV of 5 is least efficient, while a rating of 16 is most efficient.

Pressure drop is a measure of the airflow restriction created by the filter. A low pressure drop typically translates into better energy efficiency. A high pressure drop means the HVAC system has to work harder and use more energy to move air through the building.

In typical commercial office buildings, ASHRAE recommends a minimum filter performance of MERV 6. Recent studies suggest that a more realistic minimum efficiency is MERV 8 to provide good system cleanliness and efficient system operation.

Air Filters and HVAC Operating Costs

There are more than 4.6 million commercial buildings in the United States today. A surprising 40 percent of the energy used in these buildings goes into heating, cooling and ventilating. Filters play a significant role in the energy consumed by commercial HVAC systems. The lower the filter's airflow resistance, or pressure drop, the lower the energy consumption will be.

Filters are not the only source of airflow restriction in commercial HVAC systems. Dirty heating and cooling coils create turbulence and can also restrict airflow. Low-performing HVAC filters with efficiencies below MERV 4 trap less than 20 percent of the large particles that foul coils. High-performing MERV 8 filters trap more than 70 percent of these contaminants and keep systems substantially cleaner and operating more efficiently.

While initial purchase price has become the determining factor for filter selection, it's important to understand that energy used by filters far outweighs the initial price of the filter itself. In fact, energy costs can be ten times the initial filter price for a standard pleated filter, and four to five times the price for a higher efficiency filter. If one calculates the total lifecycle cost of a filter, including initial purchase price, installation, energy consumption, and disposal, energy will typically account for more than 80 percent of the total cost.

Surprising Effects of Bypass Air

Improper filter installation and poor gasketing creates gaps around the filters in HVAC systems, allowing air to bypass the filter. On the surface, the gaps may seem small and insignificant. 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 10 mm 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.
- 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.

Summary and Conclusion

Proper selection, installation and maintenance of HVAC system filters can positively affect indoor air quality, 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. Selecting filters with a low pressure drop can reduce energy consumption and reduce operating costs per square foot. Finally, properly installing and sealing filters can avoid filter bypass and let your filter investment provide maximum benefits.

Many filter distributors in North America are members of The National Air Filtration Association (NAFA) and have completed training to receive a Certified Air Filter Specialist (CAFS) rating. These distributors are trained to help facility managers and maintenance professionals select and install the right filter. For more information on finding a NAFA-trained filtration distributor, visit www.nafahq.org.

References

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