An overlooked opportunity for sustainability

AIR-FILTER Life-Cycle Cost

Though seen as disposable, air filters can have significant and far-reaching impacts on HVAC-system performance

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Life-Cycle Cost analysis is something we do every day as consumers. It has taken us from bias-ply tires to radial tires, which provide longer life and better performance, and led many of us to purchase hybrid vehicles, a decision based on the price of gasoline and calls for energy independence.

During the development of ANSI/ASHRAE Standard 180, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems, there was extensive discussion of the decision to run HVAC system components to failure. In many cases, building owners find running equipment to failure cheaper than maintaining equipment over time. Given prevailing attitudes toward sustainability and concerns about environmental impact, however, running to failure is falling out of favor.

Although each of these air filters has a minimum-efficiency reporting value of 13, their Life-Cycle Costs may vary considerably.

Properly maintained, the main components of HVAC systems—coils, fans, casings, controls—should last 20 years or longer. One component that has a major impact on the cost of maintenance, the lifetime of other components, energy use, and the protection of building occupants and processes, however, is considered disposable: the air filter.

Key Factors
Contaminant capture. In the selection of air filters, the primary consideration should be maintained contaminant-capture efficiency. Once that is assured, the Life-Cycle Cost of air filtration can be analyzed.

Most critical to the analysis of air-filter Life-Cycle Cost is pressure drop, or resistance to airflow, over the life of a filter. Filter selection should be based on the fan curve made by the original system designer. In some cases, with constant-speed fans, operating outside of original design pressure-drop parameters—by selecting filters with too little or too much resistance—can result in unnecessarily high energy use. In such instances, a blower may have to be re-balanced to its fan curve for energy savings to be achieved.

Fortunately, most systems today employ variable-frequency drives (VFDs), which adjust to system demand, allowing a wider range of acceptable resistance. In a VFD system, the...
lower the resistance, the lower the demand for energy required to move air through filters and, thus, the greater the number of air changes per hour, which results in a higher contaminant-removal rate.

Design plays a major role in a filter’s resistance to airflow. Generally speaking, the greater the amount of media within a given area (e.g., 200 sq ft of media in a 24-in.-by-24-in.-by-12-in. box filter vs. 58 sq ft of media in a 24-in.-by-24-in.-by-12-in. box filter), the lower the resistance to airflow, as air has a greater number of paths. It is analogous to moving 100 cfm of air through a 6-in. round duct as opposed to an 8-in. round duct; resistance in the latter is only 20 percent of the former. However, simply cramming more media into a filter could result in a higher resistance to airflow and a shorter life. Media configuration is important in the design of high-media-area products, perhaps even more important than the amount of media itself.

**Contaminant loading.** Air filters with long loading curves use less energy over their lives and require fewer changeouts. In states with additional fees associated with medical-facility refuse removal, the cost of removing final filters can be exorbitant, often dwarfing the cost of the filters themselves.

As media area increases, contaminant-loading curves decrease exponentially. Figure 1 shows the loading curves of three identically configured and sized air filters, each with a different amount of total media area. Relative period of time is shown on the x-axis, as loading curves are relative to contaminant loading, which is specific to a geographic area or facility.

In Maine, an air filter may last the equivalent of four periods before requiring changeout, while in New York City, it may last only one period because of increased contaminant load. Filter-service intervals must be based on local air quality. Thus, if a company is applying Life-Cycle Costing companywide and it has buildings in New York, Los Angeles, and Toronto, it must establish the proper change interval for each of those locations.

**Environmental impact.** Materials used in manufacturing, disposal methods, and carbon footprint are important considerations in air-filter Life-Cycle Cost analysis. Many localities offer tax advantages for “green” products.

![Figure 2: Life-Cycle Costing software in various forms, from simple Web input pages to spreadsheet templates to detailed packages, is available from manufacturers.](image-url)
Analysis

To begin a Life-Cycle Cost analysis of an air-filtration system:

- Ensure the products selected meet the contaminant-removal efficiency specified originally by the designer or the filter-efficiency requirements specified as the system was upgraded.

- Ensure the products selected will maintain the specified level of contaminant-removal efficiency throughout their life in the system. This can be done by requiring any filter installed in the system to meet the minimum-efficiency reporting value (MERV) from ANSI/ASHRAE Standard 52.2. Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size, and have the same numerical MERV-A value from ANSI/ASHRAE Standard 52.2 Appendix J. Appendix J provides an optional method of conditioning a filter to demonstrate efficiency loss that might be seen in the field.

- Review manufacturers' published literature for resistance to airflow and the amount of media area in each filter stage. Additionally, request filter-loading curves to determine the product with the longest curve. Manufacturers typically supply a product test report with this data. Request data as defined in ANSI/ASHRAE Standard 52.2.

- Calculate filter-change labor, disposal costs, and a product's overall carbon footprint using calculations from cognizant authorities.

Most manufacturers have computer software to perform these tasks (Figure 2). These programs allow comparison of filters and development of “what-if” scenarios, considering variables such as filter cost, energy cost (dollars per kilowatt-hour), labor per filter, disposal labor, carting expense, carbon footprint, and local air quality.

A Life-Cycle Cost analysis must consider all factors. Alternative scenarios should be examined to ensure a facility owner is receiving the best return on investment without compromising an HVAC system's ability to remove harmful contaminants.

Software can provide details regarding filter costs, energy use, labor involvement, waste, carbon footprint, and even mounting hardware. In any calculation, energy will be the overriding factor.

Gaseous-Contaminant-Removal Products

Products designed to remove gaseous contaminants from air (typically, carbon-based media or oxidizing pellets) come in many configurations, requiring, in most cases, consultation with a gaseous-contaminant-removal professional. To apply Life-Cycle Costing to gaseous-contaminant-removal products:

1) Determine the contaminants of concern and the acceptable levels of those contaminants for the application at hand. Choose a suitable surrogate for testing.

2) Record the gaseous-contaminant-removal product's installation date.

3) After three or six (preferred) months, remove and seal in an airtight container a small quantity of the carbon or oxidizing pellets or a portion of the bonded media.

4) Send the sample to a laboratory with a request to...
determine remaining life in terms of capture ability relative to the surrogate or contaminants of concern.

5) Apply the percentage from the laboratory results to the installed period, and calculate the remaining life. These types of products should be changed at 80-percent capacity to avoid contaminant breakthrough (contaminants downstream of the filter bank).

Gaseous-contaminant-removal-product manufacturers are developing software based on historical data. Because of the complexity of contaminants, general Life-Cycle Cost filter-analysis software for gaseous contaminants may be years away.

Conclusion

One or two consultations with an expert in particulate or gaseous-contaminant control can save a facility owner thousands of dollars in filter-replacement and maintenance costs a year. Positive steps can be taken without the need to redesign equipment, increase equipment footprint, or compromise the standard of care.

HVAC systems use 30 percent of the nation's energy. As much as 40 percent of HVAC-system electricity demand could be reduced by applying air-filter Life-Cycle Cost analysis.

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