BRINCO Mechanical Management Services, Inc.
National HVAC Management Services

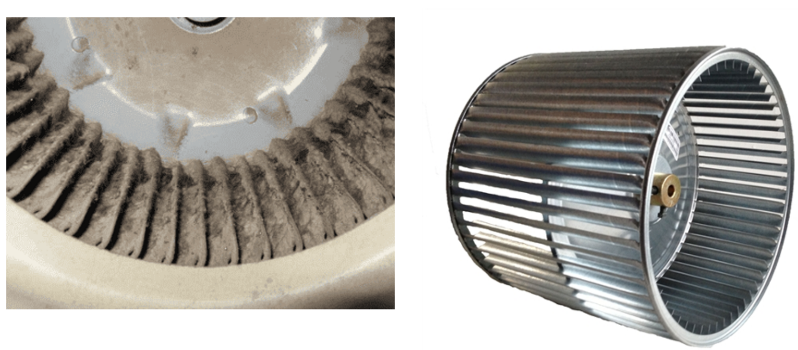
Air Filtration and Indoor Air Quality for Buildings Served by Packaged HVAC Equipment

(Demystifying HVAC) By Ron Prager

Recent History:

All HVAC systems utilizing packaged equipment are equipped with some type of filtration. Typically, these systems are fitted with U channels that can accommodate 2" thick air filters. The purpose of air filters has always been to prevent dust and debris from accumulating on the finned coils and the vanes of the blowers within the equipment. As coils get dirty, the accumulation acts as an insulator preventing efficient heat transfer between the fins and the air passing over them. The buildup on the fins also narrows the space between them, which leads to increased resistance to airflow and subsequent reduction of the air quantity passing through the coil. The vanes on blowers are typically formed into an airfoil shape that allows them to move air efficiently. As these vanes become coated with debris, the airfoil shape no longer exists and the blowers move less air. Filtration also reduces the quantity of debris that finds its way into the unit's condensate drainage components. During cooling operation, as dust is deposited on the cooling coil, condensate that forms on the fins washes the dust into the pan and drainage components. Reducing the quantity of dust that reaches the coil also reduces the amount of dust that finds its way into the condensate pan.

Buildup of debris on evaporator coil



Buildup of debris on vanes of blower wheel

Over the past thirty years, "Indoor Air Quality," has increasingly become a concern for the general public, as well as a part of design criteria. Air quality was actually first recognized as an issue during the "Energy crisis," in the 1970's. At that time, in an effort to reduce the energy required for heating and cooling, building operators began to reduce the quantity of outdoor air HVAC systems were introducing for ventilation purposes. Unfortunately, this was concurrent with increased occupancy density and the increased use of manmade materials in the manufacture of furniture, floor coverings, and saleable merchandise. As outdoor air ventilation rates were reduced, people began to feel ill due to high carbon dioxide levels caused by the respiration of many people in an enclosed space, and due to the leaching of various chemical compounds (VOC's or Volatile Organic Compounds) into the air in occupied spaces in a process known as "outgassing."

In response to what became known as **"Tight Building Syndrome,"** or **"Sick Building Syndrome,"** engineers and health experts began to look seriously at the quality of the air in conditioned spaces. They found that monitoring carbon dioxide levels and using this measurement to control the quantity of outdoor air introduced for ventilation would allow building operators to minimize energy waste while maintaining healthy carbon dioxide levels **(Demand Controlled Ventilation).** They also found that a minimum outdoor air quantity was required to dilute the contaminants produced by outgassing, and that there was an opportunity to reduce the quantity of solid particles in the air (including mold spores and other allergens) by utilizing more efficient air filters, and by the use of other more complex methods such as electrostatic precipitators and ultraviolet irradiation.

Filter Construction and Efficiency:

Air filters are classified based on the type of support structure for the filter media, the way the media is installed in the support structure, the type of media employed, and the efficiency of the media. The efficiency of the media is normally stated as its "MERV Rating." **MERV stands for "Minimum Efficiency Reporting Value," and the ratings run from 1 to 20,** with 1 being the least efficient filter and 20 being the most efficient "HEPA" filter. **HEPA stands for "High Efficiency Particulate Arrestor."** Typically, "HEPA" filters have a MERV rating of 16 or higher.

In order to determine the MERV Rating of an air filter, the filter must be tested by an independent laboratory according to ASHRAE standard 52.2. The chart below is based on this standard and shows the percentage of different particle sizes that must be captured to obtain specific MERV ratings. (*ASHRAE 52.2 is actually only used to evaluate filters with MERV ratings up to 16. Above MERV 16 other testing methods are used but the results are converted to a hypothetical MERV rating.)*

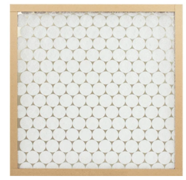
MERV VALUE	The filter will trap Average Particle Size Efficiency 0.3 - 1.0 Micron	The filter will trap Average Particle Size Efficiency 1.0 - 3.0 Micron	The filter will trap Average Particle Size Efficiency 3.0 - 10.0 Micron	Types of things these filters will trap
MERV 1	-	-	Less than 20%	Pollen, dust mites, standing dust, spray paint dust, carpet fibers
MERV 2	-	-	Less than 20%	
MERV 3	-	-	Less than 20%	
MERV 4	-	-	Less than 20%	
MERV 5	-	-	20% - 34%	Mold spores, hair spray, fabric protector, cement dust
MERV 6	-	-	35% - 49%	
MERV 7	-	-	50% - 69%	
MERV 8	-	-	70% - 85%	
MERV 9	-	Less than 50%	85% or better	Humidifier dust, lead dust, auto emissions, milled flour
MERV 10	-	50% - 64%	85% or better	
MERV 11	-	65% - 79%	85% or better	
MERV 12	-	80% - 89%	90% or better	
MERV 13	Less than 75%	90% or better	90% or better	Bacteria, most tobacco smoke, proplet Nuceli (sneeze)
MERV 14	75% - 84%	90% or better	90% or better	
MERV 15	85% - 94%	90% or better	90% or better	
MERV 16	95% or better	90% or better	90% or better	

Examples of the most common filters used in packaged equipment:


Pleated Panel Filter

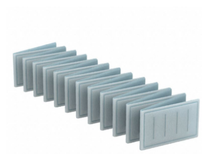

Bag Filter


Box Filter


Flat Panel Filter


Roll Media


Media Pad


Linked Filters


Ribbed Foam Washable

Filter media can be constructed from many different materials. The following are the most common media types found in packaged HVAC equipment:

- Fiberglass strands
- Polyester
- Cotton / Polyester blend
- Layered with using different media types and efficiencies
- Polypropylene
- Aluminum (Used for pre-filters in outdoor air hoods)
- Activated carbon impregnated
- Electrostatically charged

<u>Resistance to air flow:</u>

The size of the pores in the filter media and the layering of the media determine air filter efficiency**. As the pores decrease in size, the efficiency increases, as does the resistance to air flow created by the filter**. The HVAC industry measures this resistance in pressure units defined as inches of water column. *(This measurement is based on the pressure exerted by a column of water, 1 inch square with a specified height. One inch of water column is equal to approximately 1/28 of a pound per square inch (PSI).* It is important to note that over time, as a filter loads up, some pores become completely clogged and others are reduced in size by trapped debris. This leads to increased resistance to airflow based on the filter loading, which is determined by the number of hours of operation between filter replacements. Filter loading can also lead to a filter becoming more efficient over time.

Consider a 20 ton packaged rooftop air conditioner in a retail store that is designed to operate with .8" of water column of external resistance. This includes the resistance of the grilles, the supply ducts, and the return ducts. This resistance to flow is also known as **"External Static Pressure" (ESP).** Manufacturers design packaged air conditioning equipment with blowers that must overcome the resistance to flow of the internal components of the unit **(Internal static pressure),** and the external static pressure of the air distribution system. **As the volume of air flowing through the unit increases, the resistance to flow or static pressure increases exponentially.** While a manufacturer may use the same size cabinet for multiple different cooling capacities, the internal static pressure will vary based on the quantity of air the unit handles (which is a function of the unit's capacity). Manufacturers know the resistance to airflow of the internal components at different airflow rates, and design a blower package for the unit that is capable of overcoming the internal static pressure plus a standard range of external static pressures. They publish tables showing the CFM (Cubic Feet per Minute) available at different external static pressure values with the blower they included within the unit.

Since filters are typically installed **within the HVAC equipment**, the <u>resistance of the filter is included in the manufacturer's "internal static pressure"</u> calculations. **In order to standardize, most manufacturers calculate the internal resistance with a clean MERV 4 flat filter installed in the unit.** The static pressure drop (resistance) through this filter is assumed to be <u>**.1"**</u> of water column. If an end user installs filters that offer greater resistance than the filters manufacturers include in their internal static pressure determination, this increased resistance must be added to the anticipated external static pressure estimate. Due to the large variation in air distribution system designs, manufacturers provide a table or fan curves that show how much air the unit will be capable of moving at different <u>external</u> <u>static pressures</u>. *(Typically ranging from .2" of water column to 2" of water column)* These tables or curves also show the **blower speed and blower horsepower** required to move different quantities of air at different external static pressure values. The tables include ratings for all blower drives and motors available for a particular unit. A typical table for a 20 ton packaged rooftop unit is shown below. Note that the different color variations represent three different blower drive packages available for this unit.

Fan data (cont)

Carrier

48HC*D24, 20 TON WITH EnergyX, VERTICAL SUPPLY/RETURN — FAN PERFORMANCE

CFM	AVAILABLE EXTERNAL STATIC PRESSURE (in. wg)									
	0.2		0.4		0.6		0.8		1.0	
	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
6,000	**605**	**1.48**	**674**	**1.77**	738	2.08	798	2.41	854	2.74
6,500	**644**	**1.82**	709	2.14	770	2.47	827	2.81	881	3.17
7,000	**683**	**2.22**	744	2.56	802	2.91	857	3.28	908	3.65
7,500	722	2.68	781	3.04	836	3.41	888	3.80	938	4.19
8,000	762	3.20	818	3.58	870	3.97	920	4.38	968	4.79
8,500	803	3.78	855	4.19	905	4.60	953	5.02	999	5.46
9,000	843	4.43	893	4.86	941	5.30	987	5.74	1032	6.19
9,500	884	5.15	932	5.61	978	6.06	1022	6.53	1065	7.01
10,000	925	5.95	970	6.43	1015	6.91	1057	7.40	1098	7.89

CFM	AVAILABLE EXTERNAL STATIC PRESSURE (in. wg)									
	1.2		1.4		1.6		1.8		2.0	
	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
6,000	907	3.10	958	3.46	1006	3.84	1052	4.23	1097	4.63
6,500	932	3.54	981	3.92	1027	4.31	1073	4.72	1116	5.14
7,000	958	4.04	1005	4.43	1051	4.84	1094	5.27	1137	5.70
7,500	985	4.59	1031	5.01	1075	5.44	1118	5.87	1159	6.32
8,000	1014	5.21	1058	5.65	1101	6.09	1142	6.55	—	—
8,500	1044	5.90	1087	6.35	1128	6.82	1168	7.29	—	—
9,000	1075	6.66	1116	7.13	1156	7.61	—	—	—	—
9,500	1106	7.49	1146	7.98	—	—	—	—	—	—
10,000	1139	8.40	—	—	—	—	—	—	—	—

NOTE: **Boldface** indicates field-supplied drive is required.

Standard static 690 — 863 RPM, 4.9 Max BHP
Medium static 835 — 1021 RPM, 6.5 Max BHP
High static 941 — 1176 RPM, 8.7 Max BHP

The rule of thumb for packaged air conditioning equipment is to design the system to move a volume of 400 cubic feet of air per minute, per ton of cooling capacity. This rule dictates that a 20-ton unit move 8000 cubic feet of air per minute (CFM). Sometimes the engineer designing the system will lower that value down to a minimum of 300 CFM per ton, or increase it up to 500 CFM per ton to meet the specific temperature and humidity conditions at a site. As the CFM per ton is decreased, the latent capacity of the equipment (*Ability to remove humidity*) increases and the total cooling capacity of the equipment decreases.

Manufacturers publish the minimum and maximum allowable airflows at which each unit can operate. If the airflow drops below the minimum, the cooling coils can freeze causing condensate leaks. As ice forms on the coils and then thaws, water and chunks of ice can fall outside the unit condensate pan and cause leakage into the conditioned space. In some cases, ice can block the outlet of the condensate pan causing the pan to overflow. Other issues such as nuisance tripping of safety controls, and possible compressor damage are also caused by insufficient airflow. During heating operation, flow rates below 300 CFM per ton can decrease the life expectancy of heating components and cause nuisance tripping of heating safety controls. This becomes an important consideration when considering increasing filter efficiency, as the minimum airflow required by the equipment manufacturer must be maintained. If the maximum allowable airflow is exceeded, space humidity may not be controlled, or compressor damage can result. Once a system installation is complete, a Certified Test & Balance Contractor adjusts the size of the motor pulley that drives the blower to obtain the quantity of CFM specified by the design engineer. He also records the speed of the blower (RPM), the static pressure, (Inches of Water Column) and the amount of current the motor is drawing (Amps) at the required airflow.

After digesting the information above, one can begin to see that increasing air filter efficiency on an existing system, will increase the resistance to air flow within the system and will therefore reduce the quantity of air being moved through the system.

The questions to consider are:

1. How much will the quantity of air circulated be reduced? (*With filters both clean and fully loaded*)
2. Will the new quantity be less than the manufacturer's required minimum?
3. Can adjustments be made to the existing blower package to bring the circulated air quantity with higher efficiency filters installed back to the original quantity?
4. Can the existing motor provide the power required to operate the blower at the speed required with the new air filters?

In some situations, pulleys can be adjusted to accommodate this additional resistance. However, looking at the fan data table above, depending on how much the speed must be increased, the existing blower motor may not be large enough to provide the power required to overcome the increased resistance of more efficient air filters. The table below provides the pressure drop through clean 2" thick air filters with different MERV ratings provided by one filter manufacturer.

When attempting to estimate the effect of increased filter efficiency on airflow, there are two additional complications. The first is that the pressure drop ratings posted by different filter manufacturers are based on different face velocities between 300 and 500 feet per minute. (***The face velocity is determined by dividing the circulated air quantity by the square footage of filter area installed in the unit.***)

The second issue is, as filters become loaded with solids, the pressure drop across the filters increases. **The pressure drop across a filter that requires replacement can actually be double the drop across a clean filter.** When calculating the additional pressure drop across filters with high MERV ratings, one must consider what the drop will be when the filters are fully loaded. The sample air filter pressure drop chart below shows how face velocity affects the pressure drop through filters with different efficiencies, and the difference in pressure drop between clean filters and loaded filters.

Sample Air Filter Pressure Drop					2" Thick
		Face Velocity = 300 Feet per Minute		Face Velocity = 500 Feet per Minute	
Description	MERV Rating	Clean Filter Pressure Drop (" WC)	Fully Loaded Filter Pressure Drop (" WC)	Clean Filter Pressure Drop (" WC)	Fully Loaded Filter Pressure Drop (" WC)
Flat Poly Panel	4 to 5	0.1	0.2	0.14	0.28
Economy Pleat	7	0.14	0.28	0.18	0.36
Standard Pleat	8	0.25	0.5	0.3	0.6
Hi EFF Pleat	11	0.3	0.6	0.35	0.7
Higher Eff Pleat	13	0.35	0.7	0.42	0.84

Filtration and The Covid 19 Pandemic:

The Covid 19 Pandemic has been, and is, currently driving government agencies and building operators to review building HVAC systems with respect to how these systems can help reduce the spread of the disease. ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) is the primary source for all HVAC related reference standards and research, and while new information continues to be distributed, the three main areas recommended for upgrades are **increased ventilation, increased filtration, and humidification.**

Increased ventilation:

All mechanical codes currently in effect, require that if a space is mechanically heated or cooled, the system must be capable of introducing a minimum quantity of outdoor air for ventilation purposes, and the building owner must maintain the system and operate it continuously during periods when the building is occupied. This minimum quantity is determined using various methods depending on the particular code that is in effect, but basically, the quantity is based on occupied square footage, type of occupancy, and number of people.

Some HVAC systems utilize a control strategy known as "Demand controlled ventilation," where the minimum outdoor air quantity is reduced significantly below the code-required minimum and the air in the occupied space is monitored for carbon dioxide content, or a counter monitors the number of people present within the space. This control strategy allows the outdoor air dampers on the system to open in response to an increase in occupancy or carbon dioxide levels within the occupied space. As the number of people increases, the carbon dioxide levels increase, and the quantity of outdoor air introduced into the space increases.

In response to the pandemic, the CDC, ASHRAE, OSHA, and other individual state authorities are recommending that the **quantity of outdoor air introduced by HVAC systems be adjusted to the maximum quantity possible** that will still allow the equipment to function properly. This is an attempt to use dilution to reduce the quantity of the virus an individual is exposed to. They are also recommending that **demand controlled ventilation be disabled** so that the minimum quantity of outdoor air introduced is at least the code required minimum for the maximum occupancy of the conditioned space.

Increased Filtration Efficiency:

In my personal opinion, it is probable that filters with a MERV 13 or higher efficiency rating can help to reduce the transfer of the airborne viruses to some degree assuming those particles including live virus are actually reaching the filters in the equipment. While the virus itself is smaller than the pores in the filter media, the fact that the virus is attached to other particles or contained in droplets or aerosols supports this theory. We know that if a unit can be retrofitted with HEPA filters, (MERV 16 and higher) there is proof that filtration can remove viruses, however most packaged equipment cannot be retrofitted with filters of this efficiency. As stated above, the current thinking is that increasing air filter efficiency to MERV 13 will trap a certain percentage of the virus directly and a greater percentage of the virus that has attached itself to other particles. Particle size is a major factor in determining how long droplets remain in the air, as well as the ability of filtration to trap the virus. Relative humidity is a major factor in determining if those droplets become aerosolized. The majority of larger emitted droplets (larger than 10 microns) typically land on surfaces 3' to 7' from the source. Most likely, these large droplets have no chance of reaching the air filters in a packaged air conditioning unit, however, they may become aerosolized after landing on surfaces as the moisture within the droplets evaporates. Note that filter efficiency is only applicable to the air that actually passes through the filter media. In packaged equipment, a portion of the air bypasses the filters due to filter rack construction, the way the filters are installed, and the lack of seals between the cabinets and the filters.

Regardless of the arguments with respect to the ability of increased filtration to reduce the spread of Covid 19, the common theme voiced by most government agencies involved, is that high efficiency air filtration is desirable and to whatever degree filtration can reduce virus exposure, measures should be taken to increase the efficiency of filtration to the highest levels possible for the installed equipment. New York State required that large malls retrofit their equipment with MERV 13 filters prior to reopening, if the equipment was capable of operating with these filters. If retrofitting with MERV 13 was not a possibility, the building managers had to retrofit with MERV 11 filters. In New York City, establishments serving food are required to upgrade their filters to MERV 13 efficiency and be able to produce a statement signed by a trained HVAC professional that the requirement has been met, or that the equipment cannot utilize MERV 13 filters.

The latest version of California's Title 24 now requires that new HVAC systems be designed for and equipped with MERV 13 air filters. In some areas of California, health inspectors are visiting retail stores and requiring that MERV 13 filters be installed based on California's OSHA recommendations.

We are seeing residential building codes being revised to require high efficiency filtration in new homes and new HVAC systems. We anticipate commercial building codes will soon follow suit.

Can Filtration Efficiency be Increased:

Most packaged equipment can physically accommodate a filter with a maximum MERV rating of 13. The limiting factor for this type of equipment will be how much the airflow will decrease when using higher efficiency air filters and how this will adversely affect equipment operation. Building operators are attempting to determine the highest efficiency filter their equipment can accept, the initial cost of the upgrade, the ongoing cost of the upgrade, and what the possible adverse effect will be on equipment operation if higher efficiency filters are installed. Due to the many blower types and sizes, the quantity and sizes of air filters required in a particular unit, the total CFM currently being circulated, the number of hours of operation between filter changes, and the resistance of the existing air distribution system, it is extremely difficult to determine the effect of upgrading filter efficiency on equipment operation prior to actually installing the new filters.

While we are piloting other protocols, the only current reliable method of ensuring that HVAC equipment is moving the required air volume and introducing the code required minimum of outdoor air is to engage the services of a certified test & balance contractor to take measurements and make adjustments.
If a building operator is not willing to engage a certified test and balance contractor, and the equipment is equipped with remote monitoring via an energy management or building automation system, the operator can review discharge air temperatures prior to and after retrofitting with high efficiency filters. As stated earlier, a decrease in air volume will cause a decrease in temperature of the air leaving the cooling coil when a unit is operating in cooling mode. Conversely, a reduction in air volume will result in an increase in the temperature of the discharge air when operating in heating mode. Monitoring the discharge air temperature will allow visibility as to how quickly the filters are loading and if temperatures are dropping low enough to allow coils to freeze during cooling operation, or rise high enough to cause the unit to trip out on its high limit safety control when heating. Using remote monitoring, it may be possible to set up an "alarm," condition to notify the building operator if the airflow has been reduced to unacceptable levels.

The Cost of Increasing Filter Efficiency:

The chart below can be used for **current relative cost comparison** between air filters with different MERV ratings. This chart provides a multiplier to compare the cost of filters with different MERV ratings against the cost of a MERV 4 flat panel filter. Cost comparisons were determined based on a single manufacturer's posted price sheet for a 16" X 20" X 2" filter. **Actual cost difference may vary.**

Air Filter Cost Comparison

Multiplier X Current MERV Filter Cost = Cost of Higher Efficiency Filter

MERV 4	MERV 8	MERV 11	MERV 13
1	1.6	2.1	3.2

Note: Based on 16 X 20 X 2 Filter Size

In addition to the cost difference of the actual filters, other costs may need to be factored in such as:

1. Cost to engage a Certified Test and Balance to adjust the blower drive.

2. Cost to replace pulleys, belts, motors, and electrical components
3. Cost to replace filters more frequently
4. Increase in energy cost due to increased power required to move the air.

Note that by increasing air filter efficiency, the blower horsepower required to move the same volume of air against the increased resistance of the more efficient filters is also increased. This translates to higher energy costs based on increased power usage and increased demand. In extreme cases, should the blower motor horsepower need to be increased, upsizing the blower motor may require that the power feeders to the equipment, and the motor starter or VFD (Variable Frequency Drive) be upsized as well.

To Summarize:

- Indoor air quality has become more of a concern recently due to the pandemic.
- Building Operators have expressed an interest in upgrading air filter efficiency due to:
  - New code requirements and government agency recommendations
  - The need to show occupants and employees they are keeping them safe
  - Future liability concerns
- Manufacturers typically rate their equipment with flat MERV 4 filters that have a pressure drop of .1" WC when clean.
- Increasing air filter efficiency increases the pressure drop across the air filter substantially, increasing the static pressure the blower must overcome.
- Equipment that was set up to operate with MERV 4 filters when installed will probably require adjustment to the blower sheave, or replacement of the sheave, to operate with higher efficiency air filters (possibly the blower motor as well).
- In some cases, equipment may not be capable of operating properly with MERV 13 filters with the existing blower assembly.
- High efficiency filters will load more quickly than MERV 4 filters and may require replacement more frequently.
- High efficiency filters are significantly more costly than MERV 4 filters
- Some air will bypass the filters regardless of the efficiency rating.
- The use of higher efficiency air filters will increase energy usage and demand.
- Availability of MERV 11 and 13 filters has become an issue in some areas due to the sudden current high demand for these items.
- Retrofitting existing equipment with high efficiency filters may be desirable for multiple reasons, but doing so is far more complex than simply swapping filters, and the adverse effects on unit operation and cost may be significant.
- In most cases we do not know the external static pressure the equipment is currently operating at, so it is extremely difficult to determine in advance what adjustments must be made or what components must be replaced prior to actually installing high efficiency filters.
- It is impossible to know how often higher efficiency filters will require replacement as this is a function of the particle sizes being trapped, the number of hours of operation of a particular unit's blower and the face velocity across the filters in that unit model.
- Some building operators currently have set their systems to energize the blowers only on a call for heating or cooling, rather than operating them continuously whenever the building is occupied regardless of code requirements. If this strategy is now changed and the blowers operate continuously, more frequent filter replacement may be required, especially if higher efficiency filters are being installed.

My Recommendations:

1. **Comply with all current codes immediately. You need to do this as a responsible building operator and to confirm that all requirements are being in the event of future liability issues.**

2. If it is determined that a multisite building operator wishes to upgrade the efficiency of their air filters, I recommend that this program begin with sites where new equipment is being installed. Other than measures required due to the pandemic, typically, code required increases in filter efficiency apply only to equipment installed after the code takes effect, and the equipment can be ordered with and adjusted at the time of installation for the MERV rated filters that are installed. During preventive maintenance visits, these units should have filters replaced with those of the same MERV rating as the filters installed at the time of installation.

3. If a building operator wishes to upgrade filter efficiency on existing systems, I recommend that a certified test and balance contractor be engaged to adjust the system to accommodate the increased pressure drop caused by the new filters, and that he or she determines if sheave replacement is required and what size the new sheave and drive belt must be.

4. Indoor coils and blower wheels should be cleaned prior to upgrading the efficiency of the air filters as restricted coils will artificially increase the static pressure the blower is operating at and dirty blower vanes will not be able to move the air quantity the blower is rated for.

5. Like any substantial change in system design or operating strategy, I recommend that increasing filter efficiency be piloted in a small number of sites in different geographic locations initially, and that the new filters be inspected at 30 day intervals to determine how fast they are loading and what the anticipated replacement frequency will be. If a building is equipped with an Energy Management or Building Automation System, the operator should monitor the discharge air temperature on equipment where filter efficiency was upgraded to determine the effect of the new filters and how quickly they are loading.