Camfil Farr

Technical Services Bulletin

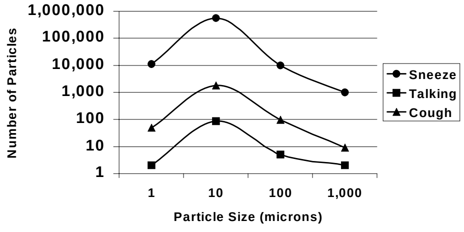
Tools for Schools
Filtration for Improved Indoor Air Quality

Most non-practitioners notice the HVAC system when it is too hot, or too cold, or in other ways not working properly. Very few think of their HVAC system as the main defense against poor indoor air quality. Air filters were originally provided in heating, ventilating and air conditioning (HVAC) equipment to protect the equipment. Heating and cooling coils expose large areas of metal surfaces that transfer energy to or from air supplied to the building. Dirt deposits on these surfaces can reduce heat transfer efficiency and impair their effectiveness. One air conditioning manufacturer has stated that coils can lose up to 30% of their effectiveness in a short period of time due to dirt build-up on the coils. Once dirty, coils require cleaning, an expensive and difficult procedure.

Cooling coils not only reduce temperature but they remove moisture from the air. If the moisture is not properly removed, through condensate drains, fungi and bacteria can breed on the coils and within the HVAC system. Maintaining a clean system, using air filtration, minimizes the risks associated with the contaminants that can affect occupant health. The more effective the air filter, the less the risk to building occupants.

The quality of the air is measured by temperature and humidity, and by the concentration of particulates and gaseous contaminants. Adverse health effects from poor indoor air quality, documented in educational facilities, range from annoyance and respiratory irritation to acute or chronic illness. When classrooms are properly controlled for comfort and are free of excessive contaminants, the learning environment is enhanced.

Profile of Particle Sizes
Produced by Infectious Persons



Reference: Duguid

Particles We Breathe

Medical authorities, industrial hygienists and the American Society of Heating, Refrigeration and Air Conditioning Engineers have identified respirable particulate as a primary item of concern. Respirable particles can find their way into the alveolar (nonciliated) region of the lungs and can remain there because of their small size. Respirable particles are 0.2 to 5 micron in size (1 micron equals 1/25,400 of an inch). These particles can include but are not limited to dust, fungi, spores, bacteria, lint, fibers and human skin flakes. Skin flakes are an item of concern as they are prevalent in a populated environment and they are a transport mechanism for viruses and bacteria.

The human body, at rest, can generate over 100,000 particles per minute that are 0.3 micron and larger. At a calisthenics level of activity, the human body can generate up to 15,000,000 particles per minute. Another particle of concern is airborne droplet nuclei. Droplet nuclei are about 3 microns in diameter and are created through coughs and sneezing.

Gases and Vapors

Gases and vapors, much smaller than particles, are also items of concern. Many compounds used in building materials, maintenance, specialized classrooms and educational materials are easily vaporized. Since removal of these vapors may be costly, it is best to limit vapors by material selection, isolation or local exhaust. In most cases, vapors are addressed by introducing proper amounts of ventilation air.

Proper ventilation and air filtration can control odors and inhibit the spread of respiratory diseases. When applying carbon to an educational facility, please consult with your preferred manufacturer representative for specific application recommendations.

The mechanism that holds the filter is often as important as the filter itself. An air filter installed in a filter track that allows air bypass may be virtually ineffective. In a central station air handler, a ¼" gap around a 24" by 24" filter can allow as much as 18% of the air to pass untreated. Air, like water and electricity, follows the path of least resistance. Ensure that all of your filters fit snugly in their tracks or holding frames and that there are no areas of air bypass in the system.

Schools present unique problems to designers and HVAC practitioners. Most schools are diverse structures with different requirements for classrooms, gymnasiums, locker rooms, cafeterias and auditoriums. Many schools also offer photography as a subject thereby introducing contaminant problems associated with darkrooms. Physics and biology laboratories present their own unique challenges to maintaining proper indoor air quality throughout the facility.

Air Quality Recommendations for Educational Facilities

Space	Winter Temp. F°	Summer Temp. F°	Recommended Ventilation Air CFM per/person (2)	Air Filter First Stage Efficiency (3)	Air Filter Second Stage Efficiency (3)
Classrooms, Auditoriums, Libraries, Administrative Areas, etc.	72	78	15	20-30% (7)	60-85% (11)
Corridors	68	80 (1)	5	20-30% (7)	
Laboratories	72	78		20-30% (7)	85% (13)
Locker Rooms, Shower Area	75	N/A (1)	5	20-30% (7)	
Mechanical Rooms	60	N/A (1)	5	20-30% (7)	
Industrial Technologies	72	78 (1)	5	20-30% (7)	60-65% (11)
Storage	65	N/A (1)	5	20-30% (7)	
Toilets	72	N/A (1)	20	20-30% (7)	

(1) Corridors, mechanical rooms and mechanical technology areas (shops) are usually not air conditioned. Shops, laboratories and toilets require additional exhaust consideration. Contact Camfil Farr for information on laboratory exhaust requirements.

(2) Outside air, or ventilation air requirements, are per ASHRAE 62-1989, Ventilation Standard for Acceptable Indoor Air Quality. Air filtration may be applied to reduce actual outside air for energy conservation. Consult Camfil Farr publication, Two-Step Design Solution.

(3) All filter efficiencies are ASHRAE dust spot efficiencies per Standard 52.1-1992. Conversion to new ASHRAE Standard 52.2, 20-30% = MERV 6-7, 60-65% = MERV 11, and 80-85% = MERV 13. MERV's are listed in parenthesis ( ) next to each dust spot efficiency listing.

Laboratories and darkrooms, locker rooms, toilets and mechanical technology areas should be under negative pressure to prevent contamination transfer to adjacent areas of the facility.

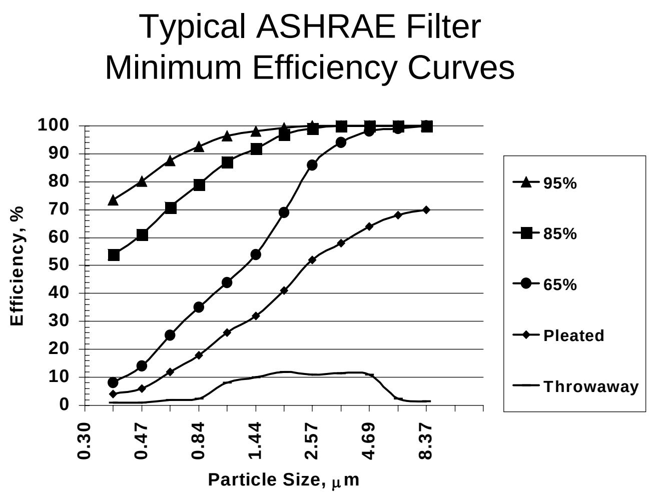
Classrooms

Standard classrooms may have occupant levels anywhere from 32 square feet per person to 50 square feet per person. As a gauge of comparison, the typical commercial office environment averages over 140 square feet per person. Given so many individuals in a confined space, it is no wonder that schools are a major indoor air quality concern. In a classroom the major source of contaminants is usually the occupants. Bioeffluents are generated from the natural process of body respiration and increased metabolism. Although not likely health threatening, the existence of such can deter the learning experience. Additional gaseous contaminant generators include classroom items such as paper products, books, writing materials, clothing and in many cases, the computer equipment associated with today's modern classroom.

In instances where outside air is introduced to dilute indoor-generated contaminants, the designer must consider the quality of the outside air. Unacceptable levels of airborne pollutants may limit outside air introduction. The United States Environmental Protection Agency (US EPA) publishes the National Primary Ambient-Air Quality Standards (NAAQS). If any of the listed contaminants exceed published limitations then alternate air cleaning methods should be considered. The NAAQS considers sulfur dioxide, particulate, carbon monoxide, oxidants (ozone), nitrogen dioxide and lead. The designer should also consider other contaminants that may be introduced by the proximity of the emitter. This may include industrial facilities, sewage treatment facilities and in some cases active farmland.

If the outside air is unacceptable, then it should be cleaned to a level consistent with clean outside air before introduction into the facility[1]. To dilute indoor contaminants, a minimum of 15 cubic feet per minute (CFM) is prescribed. This figure is based upon a maximum of 50 persons per 1,000 square feet of space.

Even if outside air is used, air filtration must be applied to protect the HVAC equipment and assure clean coils for efficient heat transfer. The minimum efficiency for a classroom application should be a 25-30% [2] ASHRAE dust spot efficiency filter as defined by *ASHRAE Standard 52.1-1992, Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter*. If central station air handlers are the base equipment of design, the addition of a second stage, having a minimum dust spot efficiency of 60-65%, by the same Standard, is recommended.



ASHRAE Standard 52.2 —Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size, allows the user to evaluate a filter using particle size versus filter efficiency. In this manner, a user can specify filter efficiency based upon the size of the offending contaminant. As an example, ASHRAE recommends a removal efficiency of 65% at 0.3-micron particle size for printer or copier rooms. This filter will be what is commonly referred to as a 95% ASHRAE grade filter or by ASHRAE Standard 52.2, with a **M**inimum **E**fficiency **R**eporting **V**alue of 14.

The new Standard also allows the user to select a filter based upon the filter's minimum efficiency rather than average efficiency. Since this usually corresponds to a filter at its least efficient point, notably when clean and first installed in the system, the particle removal efficiency is from the point of the filter's installation and efficiency increases as the filter becomes dirty. An exception does exist for filters using electret media[3].

In situations where outside air is unacceptable, a combination of particulate filtration and gaseous filtration may be applicable. Application of carbon for the adsorption of gaseous contaminants (VOC's and bio-effluents) may be used to simulate clean outside air. For further assistance in particulate and gaseous applications to reduce outside air please consult *Farr's Filtration and Indoor Air Quality: A Two-Step Design Solution*. This method applies the analytical (indoor air quality) procedure as defined in *ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality*[4].

Corridors

These areas are usually addressed through infiltration and the air filtration supplied through the central air conditioning system. As a minimum, corridors should have an outside air introduction of 0.05 cubic foot of air per minute[5] per square foot of corridor area. Package units, located for thermal comfort control, should apply a minimum filtration efficiency of 20-25% to protect the coils and maintain heat transfer efficiency.

Auditoriums

Auditoriums present unique air quality concerns because of their intermittent occupancy. When fully occupied, they may hold 150 people per 1,000 square feet of space. When unoccupied, HVAC operation is required to maintain temperature. ASHRAE 62-1989 recommends an outside air introduction of 15 CFM per person for these applications. The minimum filtration efficiency should be 30-35%[6] dust spot as defined under *ASHRAE Standard 52.1-1992.* Economics and geographical concerns with respect to equipment cost of operation indicate filtration as a precursor to the introduction of outside air. Outside air may be reduced to 5 CFM per person through the application of 80-85% ASHRAE particulate filtration in conjunction with carbon. Since the gaseous contaminant is primarily bio-effluent in composition, reduced application amounts of carbon may be applied to reduce the initial investment.

Since the primary challenge of the air filtration is during occupied periods, having unoccupied periods with little challenge except re-circulation to maintain temperature, the change-out period on the final filters and the carbon is extended. Outside air introduction can be kept to bare minimums during unoccupied periods, saving energy expenditures.

Libraries

These areas present a unique challenge to the HVAC system. One of the most expenditure sensitive areas of an educational facility, the investment in materials (books) must be considered, along with the environmental protection for occupants. To protect occupants, ASHRAE 62-1989 recommends outdoor air ventilation at a rate of 15 CFM per person (based upon 20 persons per 1,000 square feet)[7]. The minimum filtration efficiency should be 30-35% dust spot as defined under *ASHRAE Standard 52.1-1992.* Like an auditorium, a library is considered a place of assembly for air filtration and HVAC requirements.

To protect the facility's investment in books, carbon should be considered for library applications. Ozone, a common contaminant existing everywhere, is a detriment to artifacts, paintings and books. The primary area of concern relates to deterioration of bookbindings. Ozone may be reduced through the application of activated carbon. Carbon reacts with ozone (O^3) in catalytic manner and reforms ozone to non-detrimental oxygen (O^2). Outside air may also be reduced to 5 CFM per person by the application of the Farr Two-Step Design Solution. Occupants will also benefit from gaseous contaminant protection designed into the system to protect the books. If this method is used, two stages of pre-filtration are recommended, a 30-35% prefilter and an 80-85% secondary filter (dust spot as defined under *ASHRAE Standard 52.1-1992).*

Gymnasiums

Gymnasiums are also considered a place of assembly. Like the aforementioned, these areas present additional concerns and considerations. ASHRAE 62-1989 recommends a ventilation air rate of 20 CFM per person (based upon 30 people per 1,000 square feet). The primary contaminant in this case is bio-effluents produced by occupants with a high rate of metabolism. Temperature[8] in a gymnasium should be maintained between 65° and 68° F with at least four to six air changes per hour. Minimum air filtration efficiency for these areas should be 30-35% dust spot as defined by ASHRAE *Standard 52.1-1992.*

Most gymnasiums are not air-conditioned, although the trend appears headed towards year round use. If air conditioning is applied, Camfil Farr recommends the addition of carbon to reduce bio-effluents and reduce the required outside air. For optimum performance, three stages of filtration are recommended 30-35% prefiltration, 80-85% secondary filtration and 50% rated efficiency carbon. Outside air may be reduced to 5 CFM per person using this methodology.

Additional consideration must be applied if occupancy increases, based upon the added metabolism and population of spectators for events. Some gymnasiums also serve a dual purpose in some facilities as an auditorium. In this case, outside air or total system CFM must be adjusted to accommodate a five-fold increase in occupancy (30 people per 1,000 square feet to 150 people per 1,000 square feet).

Pool Areas

Selection of all materials of construction for a pool area is extremely important based upon the corrosive atmosphere created by the pool's humidity and the chemicals used in maintenance. The air conditioning system requires the same jurisprudence. Pool areas must have their own HVAC system. Because of the nature of human activity, excessive drafts and air motion must be avoided. If possible, the pool area should be isolated from the rest of the facility. The pool area should be under a negative pressure[9] (0.05 to 0.15 inches of water) with respect to the rest of the facility.

Pool HVAC systems often include a reheat system to dehumidify during periods when outdoor humidity may be high. When outside conditions are appropriate these units may use up to 100% outside air to condition/dehumidify the pool area. This taxes the HVAC system in the effort to maintain design conditions[10] for educational facility pool areas at 75° to 85° F. Care should be exercised to maintain the relative humidity between 50% and 60% due to the evaporative cooling effect on a person emerging from the pool. A higher humidity level will encourage corrosion and condensation.

The type of air distribution system influences the amount of air introduced into the pool area. Air volume above the minimum calculated value to maintain comfort may be recirculated provided the recirculated air is dehumidified and filtered to reduce contaminants to safe levels. Filters should be chosen based upon construction to avoid reaction with air contaminants. The minimum dust spot efficiency, per ASHRAE 52.1-1992, should be 45% to 60% to minimize streaking of walls and floors from dirt contacting moist surfaces and for the protection and comfort of the occupants[11].

For pool areas, outside air is rarely replaced or supplemented by filtration, as air introduction is used to assist in controlling humidity and odors.

Industrial Technology (Shops)

These occupational training areas incorporate heat and contaminant producing machinery (tools), welding apparatuses and curing kilns. The designer should consult with facility planning authorities to assure proper airflow distribution is maintained. Airborne contaminants are produced from woodworking, glues, welding fumes, oils and paints. The average occupancy is 30 people per 1,000 square feet. Due to the nature of the contaminants produced, air quality is best addressed by a combination of outside air, filtration and possibly dust collection equipment.

The minimum level of air filtration, for protection of equipment and occupants is a 30-35% dust spot efficiency filter as defined by *ASHRAE Standard 52.1-1992.* These facilities have special exhaust requirements for welding, soldering, auto repair and paint booths. In addition, a dust collection system is sometimes prescribed and the clean collected air may be returned to the space. Industrial shops have a high sensible load due to the operation of the shop equipment. Since these areas are rarely air conditioned, the use of ventilation air at 20 CFM per occupant[12] is recommended.

Laboratories and Darkrooms

These special purpose rooms, in middle and secondary schools, may require fume hoods with special exhaust systems. A makeup air system may be required if there are several fume hoods within a room. If there are no fume hoods, a room exhaust system may be required for odor removal, depending on the type of experiments conducted in the room and whether animals are kept within the room.

The filtration for the air supply depends on the requirements for the laboratory. Conventional educational facility chemistry and physics laboratories[13] commonly apply 30-35% prefiltration and 85% final efficiency dust spot efficient filters (per ASHRAE Standard 52.1). Outside air ventilation for these areas (based upon 30 persons per 1,000 square feet) should be 20 CFM per person. For applications allowing reduction of outside air in laboratories, please consult your local Farr Representative.

If the facility has laboratories of special needs, additional considerations must be made for special programs. High-efficiency particulate air (HEPA) filters should be provided for special spaces where research materials or animals are particularly susceptible to contamination from external sources. HEPA filtration of the supply air is necessary in such applications as environmental studies, specific pathogen-free research animals, nude mice, dust-sensitive work and electronic assemblies. In many instances, biological safety cabinets or laminar flow clean benches (which are HEPA filtered), rather than HEPA filtration for the entire room may be used. Please consult your Farr Representative for more information on these specialized applications.

Any associated storage and preparation rooms are generally exhausted continuously to remove odors and vapors emanating from stored materials. Adequate ventilation for these areas is essential.

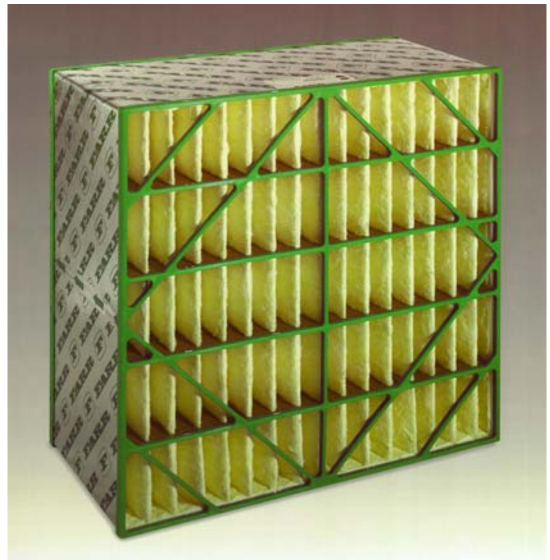
Additionally a local exhaust fan with a wall-mounted on-off switch may be needed for the occasional removal of excessive odors.

Conclusion

On any given school day, 51 million people, or one in five of the entire United States population, occupies a school building. There are 110,000 schools in over 15,000 districts, with 2.3 million teachers, 126,000 administrators and 600,000 support staff. By providing proper indoor air quality we can:

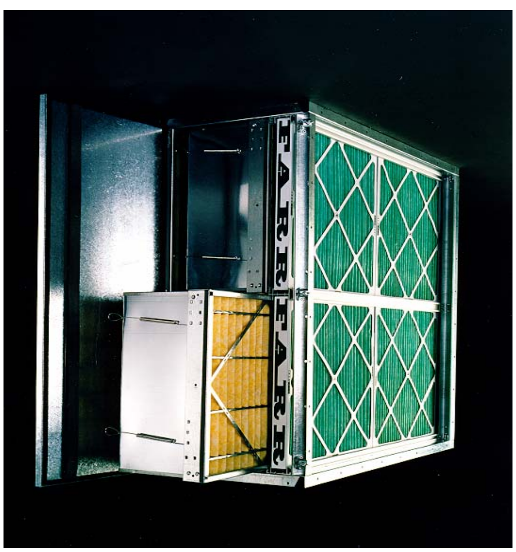
- Reduce absenteeism for students and staff
- Reduce building deterioration and improve energy efficiency
- Reduce outside air ventilation requirements
- Prevent strained relationships that result from poor indoor air quality
- Reduce liabilities
- And most important, we can protect our investment in the future.

Camfil Farr Products Applicable to Educational Facilities



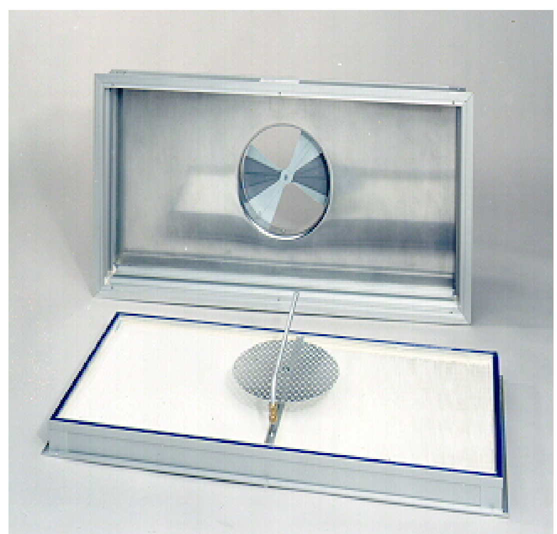
Camfil Farr 20-20® - medium efficiency ASHRAE filtration (MERV 6) for unit ventilator, package units and 1-5 ton air handler applications.

Camfil Farr 30/30® - medium efficiency ASHRAE filtration (MERV 7) for air handler applications 5 tons and larger.



Camfil Farr Glide/Pack® - ASHRAE grade filter housing ensures that all of the air seen by the filter will be treated by the filter.

Camfil Farr Riga-Flo® - medium-to-high efficiency ASHRAE filtration (MERV 11 to MERV 15) for application in air handlers or built-up bank systems. The Farr E-Series offers an ecologically friendly air filter.



Camfil Farr Specialty Items – such as the pictured HEPA efficiency ceiling filter module for application in laboratories or specific source control

Please contact Camfil Farr or your local Camfil Farr representative for a complete catalog or General Products Catalog (Bulletin # GP-001C).
HTTP://WWW.CAMFILFARR.COM

Document References

[1] ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality, Page 9, 6.1.2
[2] 25-30% and 30-35% ASHRAE dust spot designators actually relate MERV 6/7 performance when considered under ASHRAE Standard 52.2 (cotton/polyester blend pleated filters) Actual Handbook quotations require updating per revised references and Standards.
[3] "Long Term Characteristics of HVAC Filters in a Real Environment", Dr. Stein Hanssen, Norwegian University of Science & Technology, Presented at Indoor Air '96'.
[4] ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality, Page 7, 6
[5] ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality, Page 10,Table 2.2
[6] 1995 ASHRAE Applications Handbook, Page 4.2
[7] ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality, Page 10,Table 2.2
[8] 1995 ASHRAE Applications Handbook, Page 4.4
[9] 1995 ASHRAE Applications Handbook, Page 4.7
[10] 1995 ASHRAE Applications Handbook, Page 4.7
[11] 1995 ASHRAE Applications Handbook, Page 4.7
[12] ASHRAE Standard 62-1989, Ventilation Standard for Acceptable Indoor Air Quality, Page 10
[13] 1995 ASHRAE Applications Handbook, Page 13.8

Additional References

Duguid, J.P. "*The size and duration of air-carriage of respiratory droplets and droplet-nuclei*" Journal of Hygeine 54 (1945): 471-479

Lidwell, O.M. and R.E.O. Williams. *The epidemiology of the common cold*." Journal of Hygiene 59 (1961): 309-334

Indoor Air Pollution, An Introduction for Health Officials, Joint Publication of American Lung Association, American Medical Association, U.S. Consumer Product Safety Commission, and The U.S. Environmental Protection Agency

Indoor Air Quality, Tools For Schools, IAQ Coordinators Guide, U.S. Environmental Protection Agency, EPA 402-K-95-001, part of *Tools for Schools Action Kit*

Technical Bulletin, Air Cleaning Devices for HVAC Supply Systems in Schools, Arthur E. Wheeler, PE, Wheeler Engineering, published by Maryland State Department of Education, December 1992

Industrial Ventilation, A Manual of Recommended Practice, American Conference of Government Industrial Hygienists

The following are available on Camfil Farr Internet Home pages (http://www.camfilfarr.com)

NAAQS – U.S. Environmental Protection Agency Clean Air Quality Standards

Relative sizes of common airborne bacteria and viruses.

Product Literature

Camfil Farr 20-20® - A low pressure drop alternative to fiberglass, polyester, and other throwaway filters. Consult Camfil Farr Bulletin B-1308-1.

Camfil Farr 30/30® - ASHRAE medium efficiency pleated filters available in 1" 2" and 4" depths. Consult Camfil Farr Bulletin B-1305-5.

Camfil Farr Riga-Flo® - High efficiency ASHRAE filtration (45-95%) in a rigid disposable pack. Consult Camfil Farr Bulletin B-1306-1 and/or B-1306-17.

Camfil Farr Hi-Flo® - High efficiency ASHRAE filtration (40-95%) in a variety of depths and sizes. Consult Camfil Farr Bulletin B-1300-24.

Camfil Farr Absolute filters - Consult Camfil Farr Bulletin B-1304-10.

Camfil Farr Carbon Products - Consult Camfil Farr Bulletin B-1306-6 and/or B-2200-1.