camfil

AIR FILTRATION FOR SCHOOLS

# Protecting our most valuable resources using Camfil air filtration.

CLEAN AIR SOLUTIONS

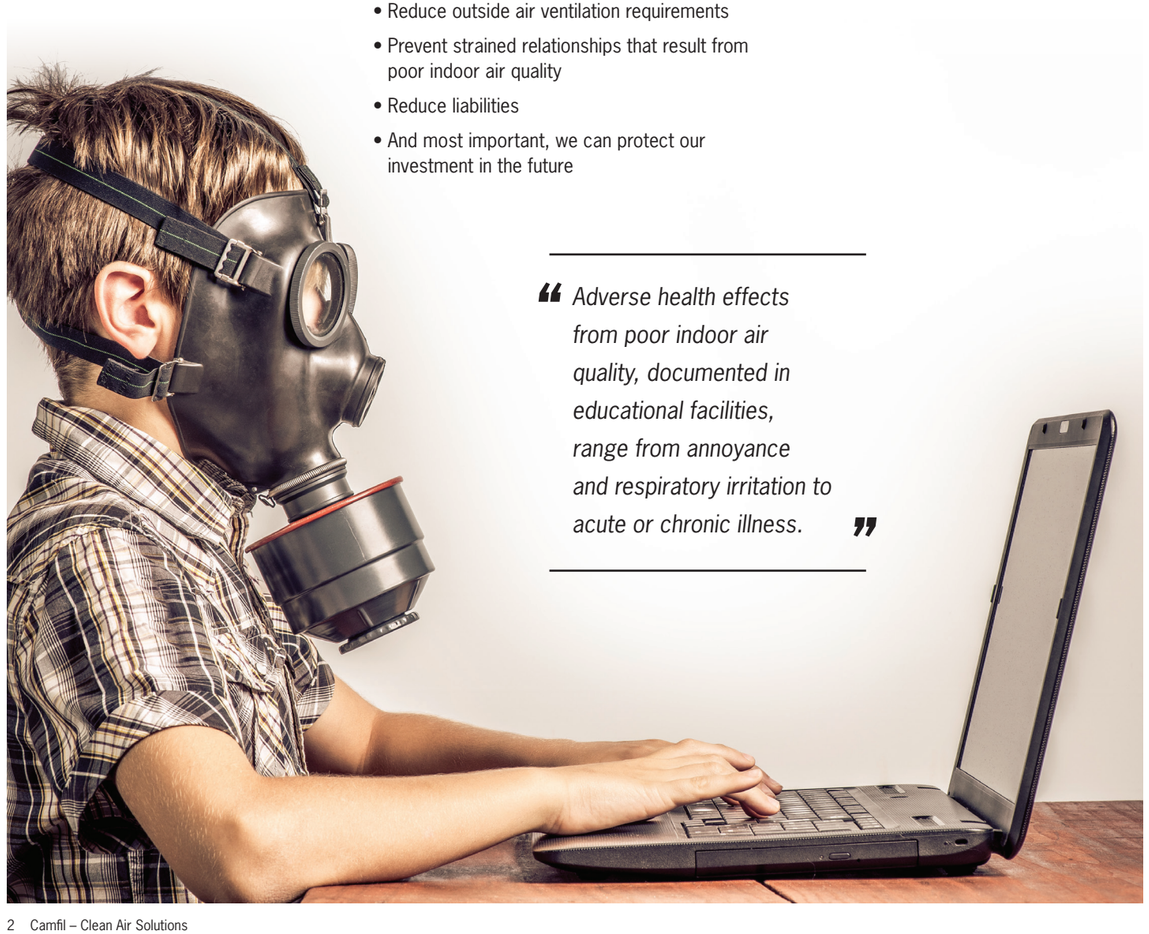
# NOTICABLE
# INDOOR AIR QUALITY

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

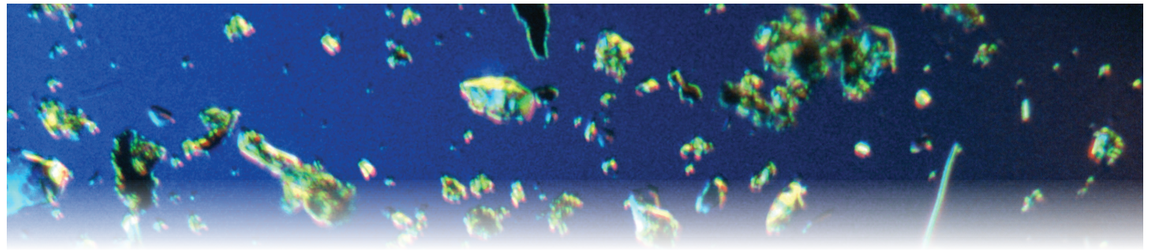
Schools present unique problems to designers and HVAC practitioners. Most schools are diverse structures with varying requirements for classrooms, gymnasiums, locker rooms, cafeterias, and auditoriums. Many schools offer photography as a subject, introducing contaminant problems associated with darkrooms.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



> *"Adverse health effects from poor indoor air quality, documented in educational facilities, range from annoyance and respiratory irritation to acute or chronic illness."*







## Particles We Breathe

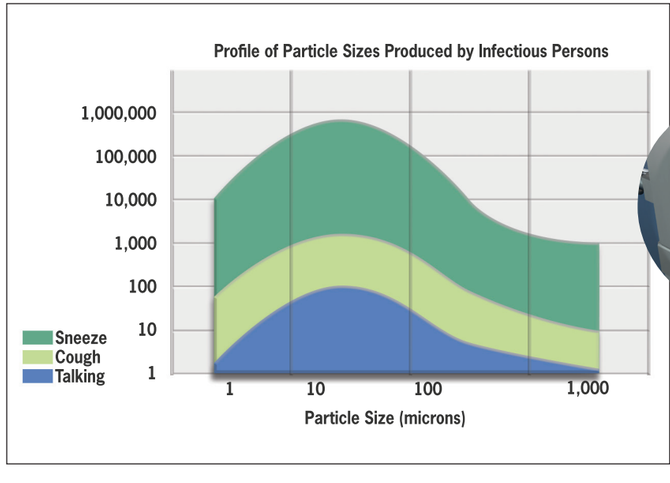
Medical authorities, industrial hygienists, and the American Society of Heating, Refrigeration, and Air Conditioning Engineers identify respirable particulate as a primary item of concern. Respirable particles can find their way into the alveolar (non-ciliated) region of the lungs, and can remain there because of their small size. Respirable particles are 0.2 to 5 microns (1 micron equals 1/25,400 of an inch). These particles include but are not limited to dust, fungi, spores, bacteria, lint, fibers, and human skin flakes. Skin flakes are an item of concern since they are prevalent in a populated environment, and they are a transport mechanism for viruses and bacteria. At rest, the human body can generate over 100,000 particles per minute that are 0.3 microns 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, 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 vaporized easily. Since removal of these vapors can be costly, it is best to limit vapors by material selection, isolation, and 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, consult with your preferred manufacturer representative for specific application recommendations.

## HVAC System Performance

The mechanism that holds a filter is often as important as the filter itself. An air filter installed in a filter track that allows air bypass might be ineffective. In a central-station air handler, a 0.25" gap around a 24" x 24" filter can allow as much as 18% of air to pass untreated. Like water and electricity, air 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.




***Your filter's efficiency is only as good as your filter housing.***

Camfil housings include the highest quality materials to ensure that all of the air moving through the system is treated by the air filters.

- Designed for standard size filters.
- Less than 1/2 of 1% leakage across the installed filters.

# INDOOR GENERATED CONTAMINANTS

## The cost of poor indoor air quality.

### Standard Classrooms

The typical office environment has a people density of 6 people per 1000 square feet. The typical classroom environment can have a density of up to six times that value. People are the largest pollution contributor to a school environment shedding millions of skin particles, bio-effluents and transmittable discharges associated with colds, flus and other health related annoyances. Bio-effluents are generated from the natural process of body respiration and increased metabolism. Although not usually health threatening, their presence can deter concentration associated with the learning experience. Additional gaseous contaminants of concern include those produced by common classroom items such as paper products, books, writing materials, clothing, and even computer equipment associated with contemporary classrooms.

Multiple studies have shown a negative causal relationship between the learning ability of children and poor air quality in the learning environment. Please contact Camfil or your local Camfil Representative for consultation and to review this information.

Aside from our responsibility of ensuring the health of students, teachers and other school personnel there is a debilitating financial penalty associated directly to not providing proper indoor air quality. The costs associated with communicable illnesses going through a school population can be severe when considering the loss of State aid for absent students and the costs associated with substitute teachers when an educator must be absent because of sickness.

For the portion of HVAC supply air that is introduced from outside air to dilute indoor generated contaminants, the designer must consider the quality of outside air. Unacceptable levels of local outdoor airborne pollutants might limit outside air introduction as you cannot clean indoor air with contaminated outside air. The United States Environmental Protection Agency (U.S. EPA) defines clean air in their National Primary Ambient-Air Quality Standards (NAAQS). If any of the listed contaminants exceed published limitations, alternate air cleaning methods should be considered. The NAAQS considers sulfur dioxide, particulate, carbon monoxide, oxidants (e.g., ozone), nitrogen dioxide, and lead. A designer should also consider other contaminants that might be introduced by the local environment. These may include emissions from industrial facilities, sewage treatment facilities, and in some cases, active farmland. If outside air is unacceptable, it must be cleaned to a level consistent with clean, outside air before introduction to a facility. Even when outside air is used, air filtration must be incorporated to protect HVAC equipment and ensure clean coils for efficient heat transfer.

The minimum standard of care to prevent the aforementioned problems should be MERV 13 efficiency filters, also having a MERV-A of 13 as defined by *ASHRAE*[1] *Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. For systems that are limited by HVAC fan capabilities nothing less than a MERV 8 filter should be applied. In situations where outside air is unacceptable because of high contaminant levels a combination of particulate filtration and gaseous filtration may apply. Application of carbon for adsorption of gaseous contaminants (e.g., VOC's and bio-effluents) can be used to simulate clean outside air. For assistance on using particulate and gaseous filtration to reduce outside air and the associated energy costs consult the Indoor Air Quality Procedure as defined in *ASHRAE Standard 62.2, Ventilation Standard for Acceptable Indoor Air Quality*. Please contact your local Camfil Representative or Camfil for guidance for using this method in educational facilities.

> *"The costs associated with communicable illnesses going through a school population can be severe when considering the loss of State aid for absent students and the costs associated with substitute teachers when an educator must be absent because of sickness."*

[1] ASHRAE – American Society of Heating, Refrigeration & Air-Conditioning Engineers





### Corridors

Corridors are usually addressed through infiltration and air filtration supplied through central air-conditioning systems. Minimally, corridors should have outside air introduction of 0.05 cubic feet of air per minute per square foot of corridor area. Package units, located for thermal comfort control, should apply a minimum filtration efficiency of MERV 8 to protect coils and maintain heat transfer efficiency.

### Auditoriums

Auditoriums present unique air-quality concerns because of intermittent occupancy. When fully occupied, they might hold 150 people per 1,000 square feet. When unoccupied, HVAC operation is required to maintain temperature. ASHRAE 62.1 recommends outside air introduction of 15 CFM per person for these applications, and minimum filtration efficiency should be MERV 8. Economics and geographical concerns with respect to equipment cost of operation indicate filtration as a precursor to introduction of outside air. Outside air can reduce to 5 CFM per person through application of MERV 13 ASHRAE particulate filtration in conjunction with carbon. Since the gaseous contaminant is primarily bio-effluent, reduced application amounts of carbon can be applied to reduce initial investment.

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

# AREAS OF SPECIAL CONCERN

## Libraries

Libraries also present a unique challenge to HVAC systems. They represent one of the most expenditure-sensitive areas of an educational facility; investment in materials (e.g., books) must be considered along with environmental protection of occupants. To protect occupants, ASHRAE 62.1 recommends outdoor air ventilation at 15 CFM per person (based on 20 people per 1,000 square feet). Minimum filtration efficiency should be a MERV 13 to reduce infectious transfer and reduce exposure to lung-damaging particles.

To protect the facility's investment in books, carbon should be considered for library applications. Ozone, an omnipresent contaminant, is detrimental to artifacts, paintings, and books. The primary area of concern relates to deterioration of book bindings. Ozone can be reduced through activated carbon. Carbon reacts with ozone ($O_3$) catalytically, and reforms ozone to non-detrimental oxygen ($O_2$). Outside air can also be reduced to 5 CFM per person through application of the Two-Step Design Solution. Occupants benefit from gaseous-contaminant protection designed into a system to protect books. If this method is used, two stages of pre-filtration are recommended—a MERV 8 pre-filter and a MERV 13 secondary filter.

## Gymnasiums

Gymnasiums are also places of assembly. Like the aforementioned, these areas present additional concerns and considerations. ASHRAE 62.1 recommends ventilation of 20 CFM per person (based on 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 in a gymnasium should be maintained between 65° and 68F, with at least four to six air changes per hour. Minimum filtration efficiency should be a MERV 13 to reduce infectious transfer and reduce exposure to lung-damaging particles.

Most gymnasiums are not air-conditioned, though the trend is headed toward year-round use. If air conditioning is applied, Camfil recommends the addition of carbon to reduce both bio-effluents and required outside air. For optimum performance, three stages of filtration are recommended: MERV 8 pre-filtration, MERV 13 secondary filtration, and 50% rated efficiency carbon. Outside air can be reduced to 5 CFM per person when using this method.

Additional consideration is required if occupancy increases, based on added metabolism and the population of spectators during events. Some gymnasiums serve a dual purpose as auditoriums. In these cases, 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).

Libraries and athletic areas have different reasons for controlling gaseous contaminants, books deteriorate over time because of ozone and active bodies produce odors or bioeffluents. Carbon filtration systems can be used to address these concerns.



# CONTROLLING CORROSIVE AREAS

## 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. 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 (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 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 filter efficiency should be MERV 11 to minimize streaking of walls and floors from dirt contacting moist surfaces and for the protection and comfort of the occupants.

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 MERV 8 efficiency filter. 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 is recommended.

## Laboratories and Darkrooms

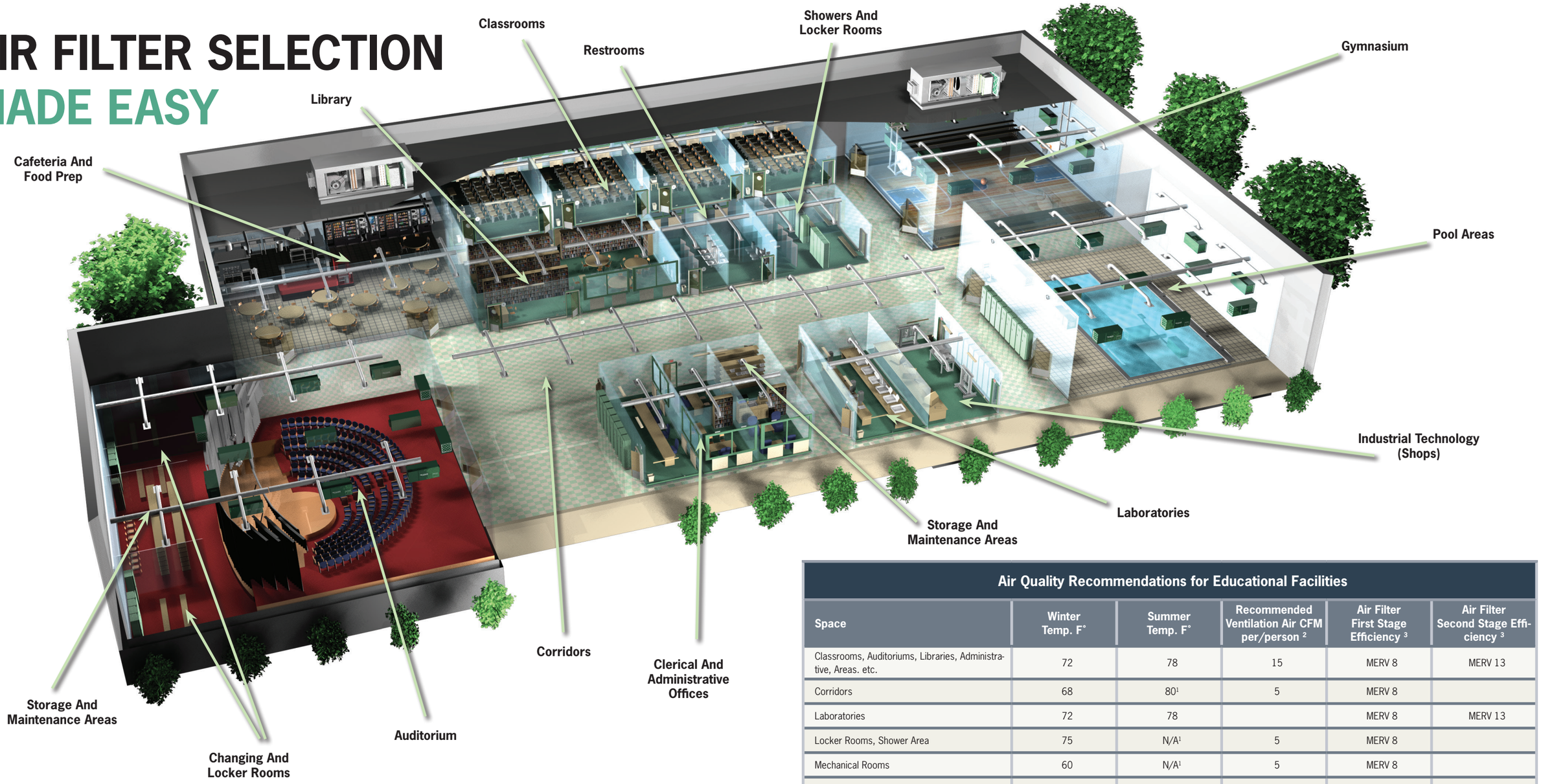
These special purpose rooms, in middle and secondary schools, may require fume hoods with special exhaust systems. A makeup air system may be required if there are several fume hoods within a room. If there are no fume hoods, a room exhaust system may be required for odor removal, depending on the type 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[1] commonly apply MERV 8 prefiltration and MERV 13 final efficiency filters. Outside air ventilation for these areas (based upon 30 persons per 1,000 square feet) should be 20 CFM per person.

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.

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.

# AIR FILTER SELECTION MADE EASY




In most school applications, Camfil recommends MERV 13 filters for the best balance of particle removal efficiency, low energy expenditures and a long filter life. Depending upon individual facility considerations, common configurations may include the Hi-Flo® ES as the only filter stage or a Camfil Farr 30/30® with a Durafil® ES² for two-stage designs. Camfil recommended filters also have a MERV-A equivalent to their published MERV—this ensures sustained filter performance over the entire life of the filters. Coarse fiber, or synthetic media products, lose efficiency over time often sacrificing filter efficiency resulting in a dirtier environment.

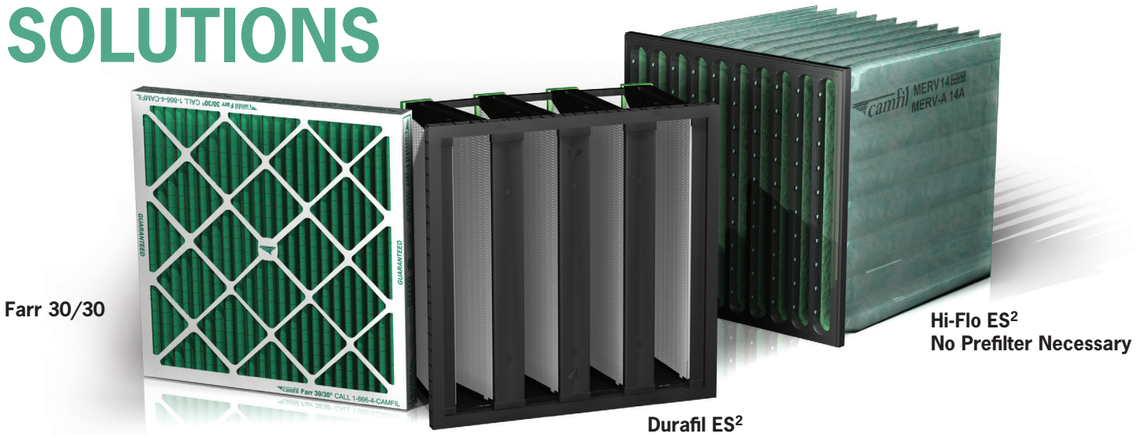
Camfil's ASHRAE Testing Guide details ASHRAE Standard 52.2 and the importance of MERV-A consideration.

**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 | MERV 8 | MERV 13 |
| Corridors | 68 | 80[1] | 5 | MERV 8 | |
| Laboratories | 72 | 78 | | MERV 8 | MERV 13 |
| Locker Rooms, Shower Area | 75 | N/A[1] | 5 | MERV 8 | |
| Mechanical Rooms | 60 | N/A[1] | 5 | MERV 8 | |
| Industrial Technologies | 72 | 78[1] | 5 | MERV 8 | MERV 11 |
| Storage | 65 | N/A[1] | 5 | MERV 8 | |
| Toilets | 72 | N/A[1] | 20 | MERV 8 | |

**Footnotes**
1. Corridors, mechanical rooms, and mechanical technology areas (shops) are usually not air conditioned. Shops, laboratories, and toilets require additional exhaust considerations. Contact Camfil for information regarding laboratory exhaust requirements.
2. Outside air, or ventilation air requirements, are per ASHRAE 62.1, Ventilation Standard for Acceptable Indoor Air Quality. Air filtration can reduce outside air for energy conservation.
3. All filter efficiencies are Minimum Efficiency Reporting Values (MERV) per ASHRAE Standard 52.2.
Laboratories, darkrooms, locker rooms, toilets, and mechanical technology areas should be under negative pressure to prevent contamination transfer to adjacent areas of a facility.

# CAMFIL 5-STAR SOLUTIONS




Farr 30/30

Hi-Flo ES²
No Prefilter Necessary

Durafil ES²

## FARR 30/30®

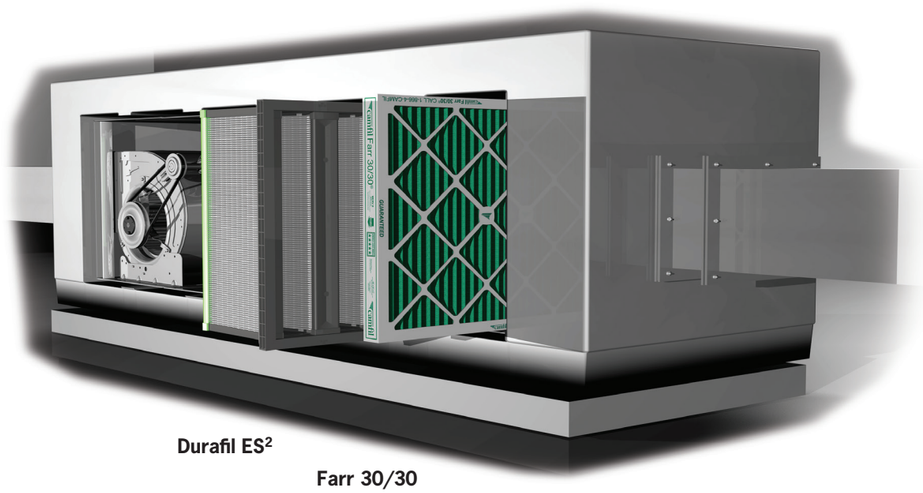
With its industry leading 5-Star ECI Rating, the Camfil Farr 30/30 sets the standard for medium efficiency air filtration. When used as a prefilter, a stand-alone HVAC filter, or as the main filter in custom data room air conditioning units, the Farr 30/30 will remove nuisance dusts and staining particles, and increase the life of downstream final filters by removing contaminants that shorten the life of final filters. Using a mechanical efficiency to provide MERV 8 and MERV 8-A performance levels, the Farr 30/30 will maintain its efficiency throughout the life of the filter.

## DURAFIL® ES²

The Durafil ES² offers high efficiency particle removal down into the sub-micron particle range to protect the most sensitive semiconductor and electromechanical equipment from contamination. Its glass mat media maintains efficiency throughout the life of the filter and its increased media area ensures maintained low pressure drop and longer filter life. The Durafil ES² can save 40% or more in energy expenditures when compared to competitive products.

## HI-FLO® ES

The Hi-Flo ES uses a Camfil-exclusive high loft micro fine glass media to capture particles down into the sub-micron particle range to protect data center equipment from contamination. The Hi-Flo ES may be used as the only filter in a single-stage system eliminating pressure drop and service requirements associated with two-stage filtration systems that require a prefilter. Available in MERV 11, MERV 13, MERV 14 and MERV 15, its MERV and relative MERV-A testing values are equivalent ensuring that performance is maintained throughout filter life.




Durafil ES²

Farr 30/30

ENERGY COST INDEX

## 5-Star ECI Rating

Camfil's filters are rated as 5-Star filters through the Energy Cost Index (ECI) program. Based upon a five-star scale, the Energy Cost Index is an indicator of what a filter will cost over its lifetime. The best rating – five stars – indicates that the filter is the most energy-efficient, longest lasting filter available.




GlidePack

## The Camfil MultiTrack GlidePack®

The Camfil MultiTrack GlidePack, shown with a 30/30® prefilter and Durafil® ES² secondary filter, is the housing of choice for new or retrofit installations. It is designed to have less than one-half of 1% leakage from the housing to the conditioned space and less than one-half of 1% leakage across the filters. This ensures that all of the air moving through the system is treated by the air filters. Only a well-designed housing can ensure that the system efficiency matches the air filter efficiency.

The MultiTrack includes track adapters that slide easily in or out to facilitate different type of filters so the proper filters can be applied to the application. For ranges, the most common selection includes a Camfil 2" or 4" deep 30/30® and a Camfil Hi-Flo® SR.

The GlidePack includes static taps so magnehelic gages may be installed to evaluate filter life, a key requirement to ensure that ranges are getting full use of filter life.

Your filter's efficiency is only as good as your filter housing. Camfil housings include the highest quality materials to ensure that all of the air moving through the system is treated by the air filters.

- Designed for standard size filters.
- Less than 1/2 of 1% leakage across the installed filters.

## Life Cycle Cost Analysis

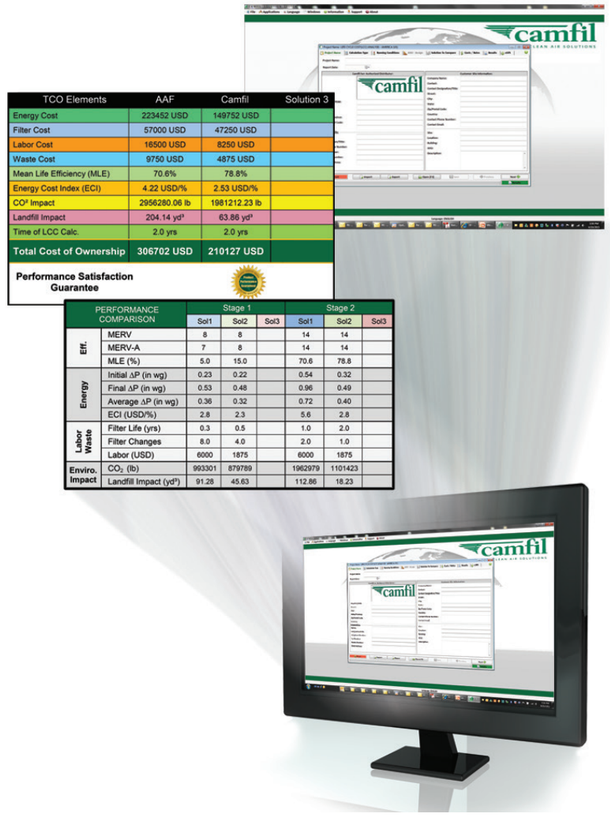
*Camfil software to optimize your filter selection.*

Camfil has developed a life cycle cost (LCC) software for optimizing air filters used in ventilation systems. It examines multiple parameters looking at filters, not only in terms of price but:

- Energy cost
- Operating hours
- Different environments
- Filter quality
- Labor costs
- Dust cleaning
- Disposal costs
- MLE

Based upon the design of the system, and user input if there is a filter service history, calculations are performed to determine the minimum number of filters needed for the lowest total cost over a given time period. Significant factors include average filter pressure drop, filter life and energy costs. The Camfil LCC comprehensive database incorporates 20 years of documented real life performance of Camfil products as well as competitive air filter brands.

*Discover your lowest total cost of ownership while providing superior air quality.*



| TCO Elements | AAF | Camfil | Solution 3 |
|---|---|---|---|
| Energy Cost | 223452 USD | 149752 USD | |
| Filter Cost | 57000 USD | 47250 USD | |
| Labor Cost | 16500 USD | 8250 USD | |
| Waste Cost | 9750 USD | 4875 USD | |
| Mean Life Efficiency (MLE) | 70.6% | 78.8% | |
| Energy Cost Index (ECI) | 4.22 USD/% | 2.53 USD/% | |
| $CO^2$ Impact | 2956280.06 lb | 1981212.23 lb | |
| Landfill Impact | 204.14 yd³ | 63.86 yd³ | |
| Time of LCC Calc. | 2.0 yrs | 2.0 yrs | |
| Total Cost of Ownership | 306702 USD | 210127 USD | |
| Performance Satisfaction Guarantee | | | |

| PERFORMANCE COMPARISON | | Stage 1 | | | Stage 2 | | |
|---|---|---|---|---|---|---|---|
| | | Sol1 | Sol2 | Sol3 | Sol1 | Sol2 | Sol3 |
| Eff. | MERV | 8 | 8 | | 14 | 14 | |
| | MERV-A | 7 | 8 | | 14 | 14 | |
| | MLE (%) | 5.0 | 15.0 | | 70.6 | 78.8 | |
| Energy | Initial ΔP (in wg) | 0.23 | 0.22 | | 0.54 | 0.32 | |
| | Final ΔP (in wg) | 0.53 | 0.48 | | 0.96 | 0.49 | |
| | Average ΔP (in wg) | 0.36 | 0.32 | | 0.72 | 0.40 | |
| | ECI (USD/%) | 2.8 | 2.3 | | 5.6 | 2.8 | |
| Labor Waste | Filter Life (yrs) | 0.3 | 0.5 | | 1.0 | 2.0 | |
| | Filter Changes | 8.0 | 4.0 | | 2.0 | 1.0 | |
| | Labor (USD) | 6000 | 1875 | | 6000 | 1875 | |
| Enviro. Impact | $CO_2$ (lb) | 993301 | 879789 | | 1962979 | 1101423 | |
| | Landfill Impact (yd³) | 91.28 | 45.63 | | 112.86 | 18.23 | |

## CAMFIL is a world leader in air filters and clean air solutions.

Camfil is a global leader in the air filtration industry with more than half a century of experience in developing and manufacturing sustainable clean air solutions that protect people, processes and the environment against harmful airborne particles, gases and emissions.

These products are used globally to benefit human health, increase performance and reduce energy consumption in a wide range of air filtration applications.

Our 26 manufacturing plants, six R&D sites, local sales offices and 3,800 employees provide service and support to our customers around the world.

Camfil is headquartered in Stockholm, Sweden. Group sales in the global air filtration market total more than 730 million US dollars.



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