Camfil

Technical Services Bulletin

Mold & Air Filtration

Filtration for IAQ

Mold, or fungi, lives in virtually any building, under sinks, in bathrooms, basements, refrigerators, or any damp, dark place. At first, the mold is inconspicuous, or microscopic. After it has spread and completely covered the area with millions of cells, you start to see the mold.

Mold – A Natural Recycling Process

Molds can be destructive, but they are also beneficial. They help to make cheese, fertilize gardens, and speed decaying of garbage and fallen leaves. Today thousands of different types of mold fungi grow on and absorb food from substances such as soil, wood, decaying organic matter, or living plants and other organisms. After the devastating forest fires in Yellowstone National Park, mold was the first on the scene to begin nature's process of decaying the leftover matter and building a base for new plants and trees.

Mold in Processes

Certain types of mold have proven extremely valuable in the synthesis of antibiotics and hormones used in medicine and of enzymes used in certain manufacturing processes. Penicillin, a product of the green mold P. notatum, revolutionized antibiotic drugs after its discovery in 1929, and the red bread mold Neurospora is an important tool in genetic experiments.

An interesting fact is that if a medicine name ends in "mycin", you know it was made with mold. Another is that in a few certain kinds of cheeses, mold is added for flavor. Butchers also inject mold into animals as a preservative before they are butchered. Without mold, we would not have beer or bread. Molds also have many industrial uses, such as in the fermentation of organic acids. Some fungi, such as mushrooms and truffles, are considered tasty delicacies that enhance a wide variety of recipes, including pizza. Other molds can damage agricultural crops, cause disease in animals and humans, and form poisonous toxins in food.

Mold Proliferation

Common mold, or fungi, appears in our world as a fuzzy, cobweb-like growth over organic matter. Molds reproduce by making spores -- tiny, lightweight fragments that can become airborne. Mold and mildew are commonly used interchangeably, although the term mold is often applied to black, blue, green, and red fungal growths, and mildew to whitish growths. Black bread mold (Aspergillus niger), one of the most familiar molds, begins as a microscopic, airborne spore that germinates on contact with the moist surface of the nonliving organic matter.

The most common types of mold are Cladosporium, Penicillium, Aspergillus, and Alternaria. In our normal environments, people are exposed to molds everyday without adverse health effects. They help to challenge our body's natural protection system so we can develop natural antibodies and maintain our health against various maladies. Problems occur with individuals where systems are over challenged or where the natural system is compromised.

Fossil records suggest that molds and fungi were present 550 million years ago and may have evolved even earlier. They range from tiny, single -celled organisms invisible to the naked eye to some of the largest living multicellular organisms. In Michigan, for example, the underground portion of an individual Armillaria mushroom, a type of fungus, extends more than 30 acres. Other fungi are among the longest-lived organisms on Earth. Some lichens have a living partnership of fungus and algae, and are thought to be more than 4,500 years old.

Mold spreads rapidly, forming the mycelium (fungal body), which is made up of a fine network of filaments (hyphae). The mycelium produces other clusters of root-like hyphae, called rhizoids, which penetrate the organic material, secreting enzymes and absorbing water and the digested sugars and starches. Other clusters of hyphae called sporangiophores then reach upward, forming sporangia (knoblike spore cases), which bear the particular color of the mold species. Upon ripening, the sporangia break open and the windborne spores land elsewhere to reproduce asexually. Some molds also reproduce sexually through conjugation of gamete cells by the joining of two specialized hyphae. The resulting zygote matures into a zygospore that germinates after a dormant period. It is primarily the airborne

spores that can create an uncomfortable environment.

Mold Health Effects

Although molds are a natural part of our environment, exposure to certain types of airborne mold spores can cause allergic reactions, asthma episodes and other respiratory problems. In addition, exposure to high spore levels can cause the development of an allergy to the mold. Health impacts from mold/mildew occur when individuals are exposed to large doses of mycotoxins, which are by-products produced from the molds. Adverse health effects from exposure to mycotoxins may differ from person to person. While some people may be highly sensitive to mycotoxins and experience adverse health effects, other people exposed to the same dosage of the mold will be unaffected. The mere presence of mold found indoors does not indicate a public health risk.

Certain types of mold are considered toxic and can cause serious health effects. These species include Stachybotrys chartarum, Aspergillus versicolor, A. flavus, A. fumigatus and Fusarium moniliforme. Stachybotyrs Chartarum is a greenish-black mold that forms in environments with high moisture such as those that have water damage, water leaks, excessive humidity, condensation and flooding. The health effects of Stachybotyrs Chartarum range from short-term irritation to extremely serious illnesses. Stachybotrys chartarum can produce mycotoxins that can develop into an indoor air quality problem. Stachybotrys chartarum has the potential to cause symptoms such as coughing, wheezing, runny nose, irritated eyes or throat, skin rash or diarrhea.

Certain population groups have a greater health risk when exposed to mold. These people include infants and children, the elderly, immune-compromised patients, pregnant women and individuals with respiratory conditions. Pathogenic mold can cause serious health effects in persons with suppressed immune systems, those taking chemotherapy, or those with HIV/ AIDS. Allergenic molds, normally not dangerous, can cause allergy or asthma symptoms.

Mold Distribution

Mold spores are carried by air currents and predominate in the summer and early fall. In warm climates, they thrive year-round. Cutting grass, harvesting crops, or walking through tall vegetation may provoke an allergic reaction.

Extreme mold cases are possible without precautions.

Molds, mildews, bacteria and dust mites, all sources of allergic reactions within our species, like the same environmental conditions that we do, warmth and moderate to high humidity. Mold needs little more than a constant moisture supply for survival. Water-damaged carpets, ceiling panels, walls, and paneling are prime sites for new growth if they are allowed to stay damp. When molds and mildew are disrupted, they release their spores into the air and the result is a bioaerosol formation.

Mold and mildew may be found in the ductwork of any HVAC system. If there are leaks in the ductwork, or places where moisture and outside air get into the system, mold and mildew can grow. They can be found on the coil of an air conditioner or in the connection between the unit and the ductwork. Moisture problems are worse where ductwork insulation is on the inside as opposed to the outside of the duct. The insulation's porous surface collects dust and moisture. Mold and mildew may also grow on dirty air filters.

Air Filtration

When considering mold control, air filters serve the purpose of limiting the amount of spores in a given volume of air, thus limiting the reproduction capabilities of the mold. Mold needs three things to

Water and nutrients offer a fertile breeding ground for mold. Flood damage should be repaired or replaced as soon as possible to prevent cross-contamination.

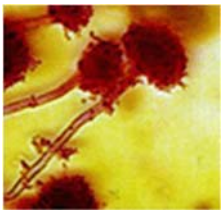
survive: appropriate temperatures, nutrient (food sources), and water. All three of these items are indigenous to an HVAC system. Typical HVAC system temperatures range from 85° F to 140° F. Airborne contaminants, including molds, can become nutrients for other airborne molds, and water may be common in the area of coils or actually introduced through humidifiers.

Proper application of HVAC components per the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) recommended practices serves to limit the possibility of contaminant growth within a system. The two most important considerations are the removal of contaminants (nutrients) and moisture. The presence of mold in buildings is becoming more common due to more airtight construction practices that improve insulation and energy efficiency but precipitate moisture in walls and ceilings.

Mold spores are well over 1.0 micron in size and are easily removed by applying air filtration according to ASHRAE recommendations. Even a pleated panel filter with a Minimum Efficiency Reporting Value (MERV 6) per ASHRAE filter Testing Standard 52.2 will have an average efficiency of more than 80 percent against most molds. One key consideration is that air must be moved through the filter for the filter to remove the contaminants. If elevated mold contamination levels are suspected, increasing the air changes to the space may have a debilitating effect on the mold's reproduction. As more air is moved through the air filter, the removal efficiency of the total space contaminant is increased.
If a health situation exists specific to a species of mold, the application of proper air filtration with appropriate air conditioning system operation can reduce exposure. Some mold requires a higher level of filtration efficiency for removal because of its smaller particle size. The chart on page 4 lists some common mold species and the filter efficiency that should be applied.

The most important component of control is the limitation of water in the environment and in the HVAC system. ASHRAE recommends that spaces have a controlled humidity level of under 60 percent. Consistently exceeding this level is a prescription for problems. Try placing a slice of bread in a dish with some water next to a slice of bread on a dish alone and watch the result.

Conclusions & Recommendations



Aspegillus has a particle diameter of 3.5 micron. If it becomes airborne it may be removed by a MERV 9 filter when matched with a proper number of air changes

To prevent mold proliferation in your building:

- Reduce indoor humidity by:
  - Maintaining the building under positive pressure (which keeps moisture and nutrients outside the building in their natural environment)
  - Following ASHRAE HVAC system design guidelines (30% to 60% RH maintenance)
  - Venting moisture-producing sources to the outdoors (locker room exhaust, bath exhaust, cooking exhaust)
- Control growth at the source by:
  - Looking for and correcting the cause of water stains on ceilings, walls and floors
  - Assuring plumbing fixture integrity
  - Assuring that all HVAC drain pans are sloped properly and that drains are free of obstruction
  - Inspecting HVAC equipment periodically for sources of contaminant or moisture buildup
  - Eliminating all sources of condensation, windows, piping, etc.
  - Sealing penetrations in walls or floors, especially below ground
  - Checking for moldy odors
  - REMOVING ANY SOURCE OF FREESTANDING WATER.

If mold is discovered, fix the source of the problem. In most cases, the best level of control requires the complete removal of the contaminated items. This may include completely replacing wallboard, sheet rock, and carpeting or damaged organic materials (wood-bearing products). Light instances of contamination may be cured using a weak bleach solution. In this case, you must assure that the contaminated item be allowed to dry completely.

The control of mold in our environment requires diligence and the application of good building and HVAC system housekeeping. The key to air quality control in any application is to maintain contaminant dosage at acceptable levels, whether the level is sensory or definitive based upon a health guideline. Air filtration always plays a major role in this arena.

Camfil Product Literature

ASHRAE MERV 8 and 8-A

Camfil 30/30® , Bulletin 1002
Camfil Aeropleat® III, Bulletin 1008
Camfil Aeropleat® IV Bulletin 1012

ASHRAE MERV 9 to MERV 14, 9A to 14A

Camfil Aeropac®, Bulletin 1602
Camfil Durafil®, Bulletin 1515
Camfil Riga-Flo®, Bulletin 1303
Camfil Opti-Pac®, Bulletin 1513

The above items may be downloaded in PDF format from the Camfil website at http://www.camfil.us.

Relative Mold Size & Required Filter Efficiency

Mold/Fungi	Diameter (microns)	Filter Selection (MERV)
Phialophora spp.	1.5	13
Exophiala jeanselmei	2	13
Acremonium spp.	2.5	9
Geomyces pannorum	3	7
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Histoplasma capsulatum	3	
Paecilomyces variotii	3	
Wallemia sebi	3	
Emericella nidulans	3.3	
Penicillium spp.	3.3	
Phoma spp	3.3	
Aspergillis spp.	3.5	6
Absidia corymbifera	3.8	
Coccidioides immitis	4	
Trichoderma spp.	4.1	
Aureobasidium pullulans	5	
Chaetomium globosum	5.5	
Cryptococcus neoformans	5.5	
Stachybotrys spp.	5.7	
Eurotium spp.	5.8	
Scopulariopsis spp.	6	
Sporothrix schenckii	6.5	
Botrytis cinera	7	
Mucor plumbeus	7.5	
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Rhizopus stolonifer	8	
Cladosporium spp.	9	
Helminthosporium	12.5	
Blastomyces dermatiitidis	14	
Rhodoturula spp.	14	
Alternaria alternata	14.4	
Ulociadium spp.	15	
Epicoccum nigrum	20	
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Paracoccidioides brasilensis	23	

The above chart lists some common mold and the filter efficiency required to remove airborne particles in the corresponding size range. For removal efficiencies of over 80%, a minimum of 6 air changes per hour are required. Filter selection is based upon the average efficiency of the air filter, initial efficiency may be lower. Lowest listed efficiency noted is MERV 6 based upon minimum efficiency standards for minimum filter selection as published by cognizant authorities. Consult your Camfil Representative for more information. When the entire spectrum of indoor air contaminants are considered a MERV 13 filter should be the primary filter of consideration.

Document References

ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE Handbook— HVAC Applications, 2012
ASHRAE Handbook— Fundamentals, 2010