PRACTICAL APPLICATIONS FOR INNOVATIVE HVACR MECHANICAL SYSTEMS ENGINEERS

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Breaking The Mold

The basics are the same as ever, but it is still easy to overlook some places (and times) where fungus can flourish in a building. Review your tactics to keep mold from becoming a problem that grows on you.

IAQ ISSUE / HUMIDITY CONTROL / AIR DISTRIBUTION / SPOT COOLING

MOLD & M

In Commercial

We like to talk about breaking the mold around here, but this month, we're talking about stopping the ominous, fungal kind. Mold has several opportunities to creep in, starting before the building is even finished. Consider the risks during renovation, and the relationship between climate and building envelope, and perhaps the section on remediation won't become relevant.

MOISTURE
Buildings

by Carl C. Schultz, P.E.

Readers of this magazine should have a natural interest in the topic of mold and moisture in buildings, as HVAC systems can sometimes contribute to mold and moisture problems and, when properly designed, can help to control or eliminate them.

Designers of HVAC systems may also be asked to provide input on building envelope design with regard to insulation thickness and placement of vapor barriers. Additionally, mechanical systems can spring leaks and cause water damage that require the immediate attention of maintenance personnel. With all of the litigation and bad press associated with mold, it is wise to review the basics and make sure that the mechanical systems that you may be associated with are not contributing to mold and moisture problems.

MOLD BASICS

Mold is a member of the fungi kingdom, which, according to some scientists, includes some of the most important organisms on the planet. These would include obvious choices, such as the fungi used to produce penicillin, and those that we eat, such as mushrooms and truffles.

More importantly, fungi break down dead organic material and help vascular plants absorb essential nutrients. If it were not for fungi, we would be overwhelmed with large amounts of dead plant matter.

Besides being helpful, fungi also cause problems, as they are associated with many plant and animal diseases such as athlete's foot. On a more serious note, it is estimated that roughly 1,000 hospital patients die each year from invasive aspergillus. Generally speaking, fungi are great as long as they stay outdoors where they belong. But this is not a reasonable expectation since molds produce spores that are virtually everywhere, can be easily dispersed in the air, and can remain dormant for extended periods of time.

Fungi cannot make their own food, and thus they colonize on carbon-based, moist material that resides at a moderate temperature. In order to flourish, all fungi need is a food source, moisture, and a proper temperature range usually between 40° and 100°F. Unfortunately, many building materials, such as ceiling tiles and the paper facing of gypsum board that may get wet, are favorite foods of mold. So the key to stopping mold growth in buildings is stopping moisture accumulation in buildings.

MOISTURE IN BUILDINGS

A building should be designed to repel water, not collect it, and although this is the domain of the architect, it is good to review the principles here. Pitched roofs and building elements that protect exterior walls from the saturating effects of wind-driven rain such as overhangs and soffits can prove beneficial in this regard. Unfortunately, these "bourgeois" features became unpopular earlier in the last century through the influence of notable architects such as Gropius, Le Corbusier, and Mies van der Rohe. Exterior finishes that resist water penetration are obviously more desirable than porous materials that can store water long after a heavy rain. Additionally, a properly sloped building site can aid in the rapid removal of water away from a building after a storm, helping to keep spaces that are located at or below grade dry.

Water vapor can also enter a building by way of air leakage through gaps and holes and though solid objects in a process called diffusion. Of the two, air leakage has the potential to transport much more water vapor into the building than diffusion. Therefore, an airtight building is a good start in preventing mold and moisture damage. Limiting vapor diffusion is the role of vapor retarders, which are classified in Table 1.

A perm is a measure of the number of grains of water passing through a square foot of material per hour at a differential vapor pressure equal to one inch of mercury. A vapor barrier is defined as a Class I vapor retarder and the International Building Code defines a vapor retarder as having a permeability of 1.0 perm or less (Class II).

A building's envelope or, as they say in Europe, the fabric, should be designed so that it does not trap moisture inside of itself. If it does, then the growth of mold may follow.

Facilities built in cold climates have typically been designed so that the envelope dries toward the cold and dry outdoor environment. This is accomplished by placing a vapor barrier near the warm

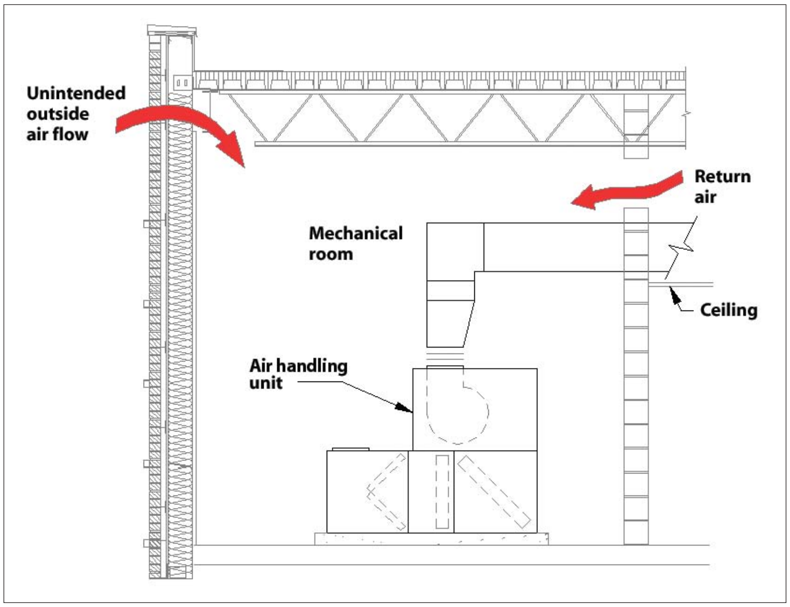

FIGURE 1. **HVAC systems can pull in warm, moist air that may then condense in building cavities.**

or inside of the envelope.

Buildings built in hot and humid climates on the other hand, would tend to be designed so that the envelope dries to the cooler and drier indoor environment. Current thinking would limit the use of vapor barriers to cold and very cold climates and use vapor retarders and air barriers in hot and humid climates.

Renovation projects where building use or occupancy changes occur are prime candidates for envelope moisture problems. Classic examples involve facilities located in cold climates that are converted to data centers, museums, or similar uses where winter humidification is required. The architect who is responsible for upgrading the building envelope needs guidance from the mechanical engineer on placement of insulation and the vapor barrier in these types of projects. Many of these older facilities have masonry façades, with little insulation and no vapor barrier. The building exterior in these instances can suffer severe damage from repeated freeze and thaw cycles resulting from the moisture that accumulates in the masonry during the winter months.

HVAC SYSTEMS

Except in those applications mentioned above where humidity must be added such as in data centers, operating rooms, and museums, the building's HVAC system should work to dry the building. There are many examples of where HVAC equipment and systems are misapplied and result in elevated indoor moisture levels. For instance, certain types of HVAC systems and equipment such as fancoil units, unit ventilators, and packaged terminal air conditioners are not necessarily designed to handle large latent loads sufficient to overcome deficiencies in building envelope design or those that are associated with high ventilation demands. Their use should be thoroughly reviewed and may need to be supplemented with equipment designed to accommodate these latent loads.

Oversizing DX equipment is also a common contributor to elevated indoor humidity levels, as this will cause the equipment to cycle excessively under low-load conditions. This behavior will keep the evaporator coil from becoming cold enough for any length of time to do the latent cooling required to remove moisture from the air.

The General Services Administration (GSA) should be commended for taking a leadership role in setting the standard for IAQ with its manual *Facilities Standards for the Public Buildings Service* that was published in 2003. For instance, the GSA recommends limiting coils to 12 fins/in. and 8 rows for effective and efficient cleaning. Drain pans are not only to be adequately sloped but are to be constructed of stainless steel and are to be insulated.

On the subject of filters, the GSA requires 30% to 35% pre-filters and 85% final filters, which is based upon the older 1992 ASHRAE Standard 52.1, which measured dust arrestance. ASHRAE's newer Standard 52.2, issued in 1999, measures particle size efficiency and would equate to minimum efficiency reporting value (MERV) 8 for the prefilters and MERV 13 for the final filters. Although many engineers have been instituting these practices for years, it is good to see these standards incorporated into a widely used design manual.

The GSA is also taking the initiative by requiring UV light to be "incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer." Although the control of airborne microbes is mentioned in this standard, it is believed that the primary purpose here is to keep coils and drain pans clean. There are more complex applications of UV equipment where the purpose is to kill airborne biological agents passing through the airstream. This type of application may require additional research to back up the benefits before this practice can be widely applied.

Not only is it important for the HVAC system to dry the air prior to its delivery to the space, but it must also work to dry out the building envelope during warm, humid periods by keeping the building under positive pressure especially in the summer months. Some HVAC systems can work in a detrimental manner by pulling in this moist air where it can condense inside wall cavities. Fancoils concealed in soffits and AHUs utilizing mechanical rooms and ceiling plenums as return air paths can cause portions of the building envelope to operate at pressures less than those of the outdoors.

Another common problem are exhaust fans that run during unoccupied periods when the other HVAC systems are shut off, causing them to play catch-up with the latent load early the next morning.

One way to avoid these types of problems is to provide a DOAS that dehumidifies the ventilation air and works to keep the building positively pressurized by moving dry air through the building cavities from indoors to the outdoors. The GSA now requires that air-handling systems be designed to ensure continuous positive pressure in the building with respect to the outdoors until the outdoor temperature falls below 40°. At this time, the building is specified to be neutral pressure with respect to the outdoors. Mechanical concepts developed to carry out this requirement include DOAS for both perimeter and interior zones that are sized to meet the ventilation requirements of these respective zones.

CONSTRUCTION MOISTURE

The construction process itself can often be the culprit in the cause of mold growth, since a building can be open to the elements for long periods of time allowing snow and rain to saturate construction materials. Even after the building is closed in, activities such as concrete curing, wallboard finishing, and painting liberate significant quantities of moisture. This moisture needs to be removed to prevent mold growth. Certainly, closing the building up as soon as practical is important, but also keeping it closed by utilizing temporary construction doors is wise.

Occasionally, there will be a push to get the building's HVAC system operating before interior work starts with the thought that temporary heating and cooling can be economically provided in this manner. It is also hoped that the cooling function will help to dry out building materials and speed the construction process. This strategy should be discouraged as construction dust and dirt can foul the ductwork and equipment and eventually serve as a potential food source for mold.

Additionally, the HVAC systems are typically not suited for reducing

FIGURE 2. UV light in AHU applications can be used to control biological growth on cooling coils. (Photo courtesy of Steril-Aire.)

the large amounts of moisture that can accumulate during the course of construction. A better approach is to use construction drying equipment that is specifically designed for this purpose. This equipment uses a desiccant dehumidification process that relies on natural gas or propane heating for the reactivation of the desiccant wheel. A construction drying contractor would provide the required equipment and technicians who would monitor moisture content of building materials and move the equipment around as required to "chase" the moisture. This approach can keep a project schedule on track by increasing the drying rate of construction materials.

MOLD REMEDIATION

What do you do if you come across a facility that has a mold problem? First, you need a plan that not only assesses the size of the mold and moisture problem, but also identifies the source of the water and moisture. Without discovering and subsequently solving the water problem, the mold will likely reappear shortly after the remediation attempt.

Equally important is that care be taken not to disturb the discovered mold before appropriate containment precautions are in place. For instance, moldy wallboard may have 1 to 10 million spores per square inch and inappropriate investigative techniques could liberate them to spread throughout the facility. Mold covered items should not be touched with bare hands and it is not good to get spores in the eyes or breathe them.

Consequently, it is important to wear personal protective equipment (PPE) when disturbing mold. PPE can range from the minimum requirements of gloves, goggles, and N-95 mask to the maximum, which includes disposable full body clothing, foot coverings, and full-face respirator with HEPA filter.

Water damage needs to be addressed immediately, as items such as carpet and backing need to be dried within 24 to 48 hours to be successful in preventing mold growth. Removing water with an extraction vacuum along with the use of fans and dehumidifiers helps to accelerate the drying process. Ceiling tiles and insulation that are wet should be discarded. Replaceable books and paper items should also be thrown away. If valuable, they can be photocopied before discarding or they can be dried in a frost-free freezer or meat locker. Water-damaged wallboard can be dried in place if there are no obvious signs of swelling and if the seams are intact; otherwise, discard and replace. It is also suggested that the wall cavity be ventilated if possible to facilitate drying. Hard surfaces can be vacuumed and damp wiped with a mild detergent.

A limited containment enclosure is recommended when there are between 10 and 100 sq ft of mold contaminated surfaces. Beyond this, full containment is recommended. Limited containment consists of polyethylene sheeting from the floor to the ceiling with a slit entry and covering flap. The supply and return vents would be sealed off, and negative pressure would be applied through a HEPA-filtered fan system. Full containment differs in that two layers of fire-retardant polyethylene sheeting are used, and an air lock chamber is created for the entry.

Class	Permeability	Example
I	0.1 perm or less	Polyethylene sheeting
II	Between 0.1 and 1.0 perm	Kraft-faced fiberglass batt insulation
III	Between 1.0 and 10 perm	Gypsum board with one coat of latex paint

TABLE 1. Classification of vapor retarders.

CONCLUSION

Moisture in commercial facilities can cause damage to building materials and foster the growth of mold. Mold, in turn, can cause adverse health conditions and trigger litigation. Attention to current thinking with regard to building envelope and mechanical system design can go a long way in limiting exposure to the problems associated with mold and moisture in buildings.**ES**

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