Indoor Air Quality
. . . Managing Mold

In the past, relative humidity (RH) was the primary indicator of mold and mildew growth in buildings. However in recent years, experience and research indicates that RH in an occupied space is not always an accurate indicator of the moisture content throughout the building, and is not a reliable mechanism for controlling fungal growth. A change in focus to the routes of moisture entry into a building is a better predictor for finding these problems and providing strategies for their solutions.

Mold is the Problem; Moisture is the Cause:

When mold and mildew growth occurs in a building, there are actually two problems that must be solved:

1) **Remediate the mold/mildew growth itself.**
2) **Eliminate the moisture source causing the growth.**

Remediation of the mold/mildew growth means removal of the fungi and the surface materials upon which the fungi is growing. Textured materials such as fiberglass-lined ductwork, ceiling tiles, wall board and carpet cannot be effectively cleaned if mold growth on the surface material itself has occurred.

Further, if the mold/mildew and the surface materials are removed, but the moisture source is not eliminated, the problem will return in a short amount of time. Moisture is the cause of the problem; fungal growth is the result.

Eliminating the Moisture Problem:

The Relationship between RH and ERH

The relationship between RH in a space, and the Equivalent Relative Humidity (ERH) on surface materials is key to understanding and preventing fungal growth in buildings. Fungal growth does not occur in the air, it takes place on the building's surface materials. Therefore, the moisture content of the surface material becomes most important in controlling the problem.

The measurement of moisture in building materials is best presented as water activity, defined as the ratio of water vapor pressure at the surface of the moist material to that of a pure liquid surface at the same temperature and pressure. This is referred to as the ERH.

Understanding Relative Humidity Control

Absolute Humidity = The mass of water vapor in a sample of air / The volume of that sample

= Grains of water / pound of dry air

Relative Humidity = Actual vapor pressure in the air / Vapor pressure at saturation

= Percent RH (dimensionless)

As temperature increases, RH decreases
As temperature decreases, RH increases

ERH is equal to RH at the surface of the material only when the vapor pressure at the surface is equal to the vapor pressure above the surface. However, this rarely occurs since there is usually some gradient of vapor pressure from the surface into the air above, due to air movement. In summary, the RH of the air has an *indirect* influence on the surface materials' ERH, through the moistening and drying of the materials it contacts.

Building Surfaces, RH and Microbial Growth

Although RH is not always an accurate indicator of mositure content in a building, research does indicate that maintaining an acceptable RH level (consistently held below 60 percent) serves as an effective inhibitor of microbial growth. In buildings where the RH is not kept below 70%, microbials can grow on building materials depending upon:

- The amount of time that the RH is elevated
- The temperature in the space
- The fungal spores that are present
- The building surface materials present

Basic Routes of Moisture Entry into a Building

There are basically three ways that moisture gets into buildings:

- Bulk water intrusion through the building envelope *(i.e. roof, exterior walls, foundation slab and walls)*
- Moisture vapor diffusion through the exterior walls *(i.e. misplaced, missing or discontinuous vapor barriers, and building depressurization)*
- Moisture created as a result of the air-conditioning process itself *(i.e. condensation; equilibrium relative humidity)*

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Mold/Mildew Remediation:

Removal of fungal growth in an occupied building is a delicate undertaking. Most fungal spores are designed in nature to be easily disbursed through the air. They are highly prone to becoming airborne with the slightest physical movement or adjacent air currents.

Fungal spores can cause allergic reactions in humans, and the enzymes that some species produce (mycotoxins), can elicit toxic reactions. As a result, the removal of mold and mildew from contaminated building surfaces must be performed within a negative-pressurized containment, with trained personnel utilizing hepa-filtered respirators, tyvec suites, gloves and boots.

Close monitoring of the containment effort is crucial to control the escape of airborne fungal contaminants, since removal activities will generate high concentrations of bioaerosols within the containment area.

Prevention of Fungal Growth:

If you want to prevent fungal growth in buildings, you need to control moisture.

As identified on page one, there are a number of ways moisture can enter a building:

- Leaks in the roofing, walls, foundation
- Vapor diffusion through exterior walls
- As a direct or indirect result of the air-conditioning process

Remember that air-conditioning will elevate the RH within the HVAC system, and also can elevate or reduce the RH within the building.

When fungal growth has already occured, understand that to solve the problem completely you will need to:

- Remove the mold from the reservoir surfaces
- Decontaminate the affected areas
- Eliminate the moisture source(s)

The Team Approach to Managing Mold

	Industrial Hygiene	Laboratory	Mechanical Engineer
Investigation	• Site Investigation • Health complaints (questionnaire, and interviews) • Extent of microbial growth • Sampling strategy (coordinated with laboratory)	• Sampling methodology • Sampling strategy	• Moisture sources: where it is coming from; where it goes
Evaluation	• Evaluation of the microbial problem • Health effects associated with microbials identified	• Sample analysis • Analytical report and interpre-tation • Health affects associated with microbials identified	• Evaluation of the moisture and/or high humidity problems
Remediation	• Design remediation of the microbial problem • Sampling strategy during remediation	• Sampling methodology and strategy for remedi-ation and clearance • Sample analysis	• Design remediation of the moisture/ water problem

Team Approach to Solving Microbial Growth Problems in Buildings:

Prevention and remediation of microbial growth in buildings means that we are actually dealing with two problems at once (i.e. the microbial growth/ contamination problem and the excessive moisture problem).

We can solve both problems effectively and completely if we take a team approach, including the combined expertise of a microbiologist/laboratory; an industrial hygienist, and a mechanical engineer. Each member of the team plays an integral role in solving the problems of microbial growth in buildings.

For more detailed information on mold remediation, or the other services that Halliwell Engineering Associates offers, please contact our office listed below.