#148, December, 2001

MOLD 101: AN OVERVIEW FOR SAFETY PROFESSIONALS

In the last five to ten years, a body of scientific and anecdotal data has grown which points to interior mold contamination as a potentially serious health threat (for example see: ACGIH, *Bioaerosols: Assessment and Control*, AIHA, *Report of Microbial Growth Task Force*, EPA, *A Guide for Mold Remediation in Schools and Commercial Buildings*, Health Canada, *Fungal Contamination in Public Buildings,* IICRC, *Standard and Reference Guide for Professional Water Damage Restoration*, OSHA, *Occupational Safety and Health Administration Technical Manual*, NYCDH *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*). In spite of this, many safety professionals do not concern themselves with mold contamination and indoor air quality (IAQ). Many safety professionals consider IAQ issues to be the business of industrial hygienists. However, there is an increasing amount of overlap between safety professionals and industrial hygienists on issues of mold contamination and remediation. Entry into confined spaces, formerly the exclusive domain of industrial hygienists, has been brought into the realm of safety professionals, and mold problems are poised to follow suit.

In light of the growing concern about mold contamination and health issues, safety professionals should be prepared to deal with these issues. This article was written to provide safety professionals with the basic understanding they will need to answer those questions. However, please note that the information in this article is a simplification and compilation of information from several sources, meant to give a general overview of mold hazards and how to deal with them. The remediation industry is currently in a state of flux, and there are few true guidelines published. The authors have attempted to cull the best of the industry's current standards in this article, but they may be subject to change as a consensus emerges.

Some Basic Information

In the common vernacular the terms mold and fungus are often used interchangeably. However, in the scientific community molds are just one of the categories of non-green plant-like organisms (along with mildew, mushrooms, yeast, rusts, and smuts) that fall under the heading of fungus. Since molds make up the largest component of the fungal classification with over 60,000 identified species, the two terms often are interchanged indiscriminately. Regardless of the type of fungal matter, they all share the characteristics of being able to grow without the benefit of sunlight. This means that the only things necessary for fungus to proliferate are a viable seed (known as a spore), a nutrient source, moisture, and the right temperature. This explains why fungal infestation is often found in damp, dark, and hidden spaces. Light and air circulation have a tendency to dry things out, making the area inhospitable for the fungus.

Another trait of all fungal types is that they can grow both through physical expansion as well as through the spread of spores, a process scientists term "sporation". A good analogy for this dual method of growth would be to think of dandelions. If the conditions are right for such weeds to grow in a lawn, they have a tendency to spread to the point where they will crowd out the grass. If the heads are plucked off the dandelion plants, the weeds will spread locally by expanding the size and number of stems. If the conditions are more favorable, the dandelions will grow their characteristic yellow flowers that ultimately turn into seedpods. At that point, the wind's physical action can transport the individual seeds great distances where they start new plants if they land in an appropriate place.

Most mold species act in a fashion similar to the dandelion. Once they get a foothold in a particular location rapid growth across the surface is possible if the moisture source is sufficient. This would be similar to the dandelion growing in size at the base during the spring rainy season. If the moisture source starts to decrease, many mold species will go into a sporation phase where they grow and release large numbers of microscopic spores into the air. Indeed, one researcher has estimated that a single round colony of penicillium mold 2.5 centimeters in diameter contains 400,000,000 spores, each spore so small that a microscope is needed to see it (Blewstone Press 42). In our analogy, the spores are the equivalent of light, fluffy dandelion seeds that so many children enjoy blowing off the stems, with the "stems" of mold referred to as hyphae. It is worth noting that certain analysis methods are able to identify hyphae as well as the individual mold spores.

The Prevalence of Fungus and Hazard Assessment

Many forms of fungus can be found throughout the natural world. People from the earliest of times have recognized not only the presence of fungus but have learned to distinguish between beneficial forms and harmful forms of these materials. The ancient Egyptians understood that the fungus called yeast was necessary if bread was to rise or beer and wine were to ferment. Many Asian nations have used dried black or green fungus for thousands of years as a seasoning for soups and sauces. There are types of mushrooms and truffles that have been known as delicacies since before the golden age of Greece. Blue cheese receives its characteristic marbling and taste from a mold. In the modern era, a common bread mold was manipulated to create the first class of disease-fighting antibiotics.

However, just as mankind learned early on how to identify the good fungi, the bad ones were known as well. The book of Leviticus in the Bible contains some of the earliest known instructions for the proper procedures to deal with mold growth on interior surfaces. Ancient Roman texts document the dangers of eating moldy grain. The great potato famine of 1845-1847 was a result of a fungus called "Late Blight" and led to an estimated 750,000 deaths. A more recent occurrence of serious fungal destruction was the death of thousands of people in the former Soviet Union in the 1940s due to their ingestion of grain that was contaminated with the mold *Stachybotrys atra*. This is the same mold that some doctors link to the death of infants in Cleveland, Ohio, and around the country. *Stachybotrys* can produce serious injury after ingestion or inhalation through internal poisoning which causes hemosiderosis, bleeding in the lungs.

Since mold, mushrooms and yeast can be beneficial or harmful it becomes crucial to have some understanding of the conditions that would result in a hazard due to a fungal contamination. In other words, if there's a little bit of black mold in the corner of the shower stall, is it serious enough that people should run screaming from the building? What about a thick patch that covers half of a two foot by four foot ceiling tile and has gray spidery tentacles beginning to creep out of a black mass? Does it make a difference if these situations are in the crawlspace? The crawlspace of a factory versus the crawlspace of a school? Is the musty/mildew odor an indication of significant levels of contamination? What if you cannot find a visible source for the smell? While each situation of potential mold exposure has to be evaluated individually, there are several important items to consider in every case.

All visible interior sources of mold, or the characteristic musty/mold odors, should be investigated carefully. A small amount of visible mold or transient odors can often signal greater infestation that is hidden above ceiling tiles, below carpet, inside HVAC systems or between wall components. Such visible mold also is a sure sign of a moisture source. The investigation/hazard assessment should identify possible causes of structural or plumbing leaks, or reasons for elevated humidity levels (*i.e.*, inadequate air conditioning capacity, spraying, mixing or cooking processes, unvented shower rooms, etc.).

The location of fungal contamination has a great impact on a hazard assessment. The most significant problems are cases where mold is in an air stream. Therefore, any mold contamination of an HVAC system, particularly the supply ductwork, needs to be addressed promptly. Mold in or near occupied spaces is the next priority. Even mold in less frequently entered areas, such as basements, crawlspaces, attics or service rooms, should be addressed as doors, floors, and walls usually do not create airtight barriers necessary to contain the microscopic spores.

The amount of mold also factors into a risk assessment. While any mold should be cleaned up, larger quantities may require the use of safety equipment to protect the workers and engineering controls to protect the building occupants. Many organizations suggest that patches of mold smaller than 2-3 square feet can be cleaned with minimal precautions (NYCDH Section 3.3). Contamination up to 30 square feet requires personal protective equipment and controlled activities (OSHA 6-9). Mold infestation greater than 30 square feet normally demands site specific engineering controls such as dust partitions, air filtering devices, special cleaners, and fungicides (EPA Table 2).

Although controversial, many mold remediation specialists treat certain species differently. Because of their ability to produce mycotoxins, molds such as *Stachybotrys* and *Fusarium* many times are approached from a more conservative standpoint—including the use of negative pressure enclosures for their removal.

Measurements and Identification

There are a number of ways to evaluate fungal contamination. Although there is a tendency in our society toward scientific precision and detailed quantification, the first step in evaluating the possible impact of mold contamination is to use three of our six senses (that’s right, six senses). Generally our visual sense, olfactory sense, and common sense are enough for us to distinguish between situations that are a nuisance (the mold in the shower stall) and a potential hazard (mold growing inside HVAC ductwork). A couple words of caution are necessary any time the discussion involves the use of physical senses or common sense as the first step of an investigation for potential fungal contamination. It is important to remember that there can be a large difference in the sense of smell from one person to the next. In general, women have a more acute sense of smell than men, and non-smokers than smokers. A second consideration is the fact that exposure to fungal contaminants, even at low levels, can sensitize some individuals so that they experience progressively greater symptoms even with decreasing exposure. Therefore, some people can experience symptoms when concentrations of spores in the air are low enough that no telltale musty or moldy smell is present.

The variability in human perception of airborne fungal contaminants is one of the reasons why testing can be so important. Choosing the type of test you use, however, can be just as important as choosing to test. Whether it's air samples or surface samples for possible fungal contamination you can choose between direct analysis samples and cultured samples.

Until a few years ago, especially for airborne samples, direct analysis samples were not well regarded. This was due primarily to sampling techniques that resulted in low collection efficiencies and the variability in collection media. With the advent of a commercially available cassette that standardized the collection medium and increased collection efficiency, the use of direct analysis sampling has grown tremendously. Many professionals in the IAQ field now use direct analysis samples as their initial screening tool because the results report both viable (*i.e.*, spores that are capable of reproduction under the right conditions) and the non-viable spores. In addition to quantifying the spores in the air that can cause allergic reactions but might not grow because they are desiccated or have been altered in some fashion, the direct analysis system allows for the identification of hyphal fragments which helps determine if the spores are from an interior source. A faster turnaround time and simplified collection process are other reasons why the use of direct analysis samples has increased in popularity for investigations of possible fungal contamination.

If more detailed analysis of the fungal contamination is necessary, cultured samples are used. In this sampling technique, air is impacted against petri dishes with specific types of sampling media. These dishes are then incubated under controlled temperature and humidity conditions and the resulting growth visually examined. By its very design the cultured samples do not identify non-viable spores even though such material can also contribute to allergic reactions, but the technique does allow a more precise determination of fungal types (species and sub-species levels as compared to genus level for direct analysis samples). There is a built-in waiting time of 3 to 7 days while the samples grow in an incubation chamber.

Standards and Guidelines

Regardless of which sampling technique is utilized, it is difficult to find definitive standards for comparison of fungal sample results. The instruction manual that OSHA uses for its inspectors has some recommendations for indicators of indoor contamination (these are noted in colony forming units per cubic meter of air [cfu/m^3]). OSHA tells its inspectors that levels of 1000 cfu/m^3 or greater indoors is a matter of concern for further investigation. The American Conference of Govermental Industrial Hygenists (ACGIH) has a relatively new manual on biological contamination, but even that doesn't have hard numbers for either cultured sample or direct analysis sample results. What most of the expert guidance documents do indicate is that comparisons should be made between out-of-doors and inside the building, and between complaint areas and non-complaint areas with the levels and types of biological organisms compared to determine whether indoor amplification is present.

The wide range of natural spore levels is dependent on the season, the surrounding vegetation, and even time of day. This fact makes the collection of out-of-doors comparison samples critical. However, these sorts of comparisons are not very helpful in determining the effectiveness of mold cleanups or even doing the risk assessment for the building occupants who have complaints about the indoor environment. In an effort to deal more effectively with such cases, a number of scientists and consultants around the country, led by Dan Baxter of San Diego, California, have assembled large bodies of anecdotal information that relates fungal counts from direct analysis samples to complaints and symptoms of building occupants. This data has pushed a number of experts to adopt 2000 counts of mold spores per cubic meter of air (c/m^3) as a maximum for a clean building. Just as important as the total count, these quasi-industry standards set limits for species that are known to generate more significant allergic reactions (*i.e.*, *Penicillium* and *Aspergillus* at less than 1000 c/m^3 each) as well as species that have toxigenic properties (*i.e.*, *Stachybotrys* or *Fusarium* are not acceptable in indoor air at any level) (ETA Internal Document).

There is some reason to be optimistic that continued studies of the relationship between airborne mold levels and health effects will eventually move the information from a quasi-industry standard to a full-fledged consensus standard and perhaps ultimately provide the basis for regulatory guidance.

Cleaning Up and Controlling Mold Contamination

Although fungus species are natural organisms found throughout the world, their presence in our houses, schools, and offices often creates health hazards that have to be dealt with in an effective manner. The key to controlling fungal growth is to remove the moisture, the nutrients, or the source of spores. In ancient times the technology was such that their only option was to try and remove the source of the mold contamination itself and pray that it didn't return. This is illustrated quite clearly in the Biblical book of Leviticus. The priests were history's first known mold inspectors. Homeowners with mold growth on their walls were instructed to scrape it off and then have the area checked by the priest. If successive scraping or cleaning did not keep the mold from coming back, the house was to be destroyed and the debris dumped in an "unclean" place (Bible Leviticus 14:43-45). While this may seem harsh, it does graphically illustrate that the serious health consequences of indoor mold contamination were well known over 3,000 years ago.

Source removal is an option that is used quite frequently today if visible mold growth is present on porus materials. Physical removal is still the best choice for plaster, drywall, ceiling tiles, cellulose insulation, cardboard boxes, and other such materials that harbor visible fungal contamination. In less extreme cases, removing the moisture source and cleaning the surface with a sanitizer/biocidal agent can be effective. If such techniques are employed it is essential that the sanitizing agent come in full contact with the fungal material for the required amount of time. Whether it is excess humidity, condensation or moisture intrusion as a result of roof leaks, pipe failures, or subgrade seepage, the water intrusion must be controlled. To err in either one of these critical control activities is to invite recontamination. This is why the ACGIH guidelines call for porus materials that have been wet for longer than 48 hours to be removed regardless of whether the leak came from a clean or dirty water source.

The cleanup and/or removal of fungal contamination requires appropriate work practices and personal protective equipment. Anyone who is going to intentionally disturb fungal contamination in any way should protect themselves with a respirator or filtering face-piece (minimum N-95 rating on the face-piece) (NYCDH, EPA, AIHA). Individuals engaged in a cleanup should not confuse a filtering face-piece with a dust mask, although both are now available at many hardware and discount stores. A standard mask for nuisance dust does not provide appropriate seals or filtration to minimize inhalation of disturbed spores.

When advising individuals about mold cleanups our organization recommends surgical gloves underneath cotton or leather work gloves as critical for individuals who are involved in the removal of contaminated materials. If it is cleanup and sanitizaton, heavy duty rubber gloves are necessary to protect the worker from possible chemical exposures. Large scale removal or cleanup projects may require the use of disposable body coverings, hoods, and booties to minimize the cross-contamination from work areas to clean areas in the building.

Depending on the type and amount of material to be dealt with, it may be necessary to isolate the work area from other areas in the building through the use of plastic sheeting to seal doorways, windows, vents, and other openings. If the potential for airborne dispersion of contamination is significant, it may be necessary to utilize large filtering fans to create negative pressure inside the specific work area. As such, many large mold remediation projects take on the appearance of an asbestos or lead abatment job site. Incorporating the techniques of separate decontamination stations, sealing of debris, and proper waste loadout from asbestos or lead types of projects can also be beneficial to large scale mold remediation activities.

It should be noted that there are some consultants and contractors in the restoration and mold remediation industry that feel that the precautions of work area set-up such as decontamination chambers and negative pressure are unnecessary overkill which artificially inflates the price. One of the main arguments of the "set-up minimalist" is that the mold contamination does not have the same dangerous properties as asbestos, lead, or hazardous waste. Nevertheless, continued medical research, an increasingly high level of liability associated with such work, and the practical aspects of utilizing more extensive set-up to minimize the amount of post-remediation cleaning that needs to be accomplished to reach clearance levels are factors that are pushing more and more projects toward extensive set-up.

To be sure, not every project needs full-scale asbestos-style precautions. Indeed, there are several products currently on the market that provide limited tools and supplies for homeowners and maintenance/custodial workers to properly deal with small sections of mold contamination. Even in such smaller projects the basic principles of isolation, limited dust generation during removal, thorough sanitization, encapsulation of residual mold, and proper disposal are useful.

A Parting Word

Although mold is a naturally occuring phenomenon, the presence of extensive mold growth indoors has been known as a source of concern since ancient times. Today, however, we do not have the benefit of priests trained and tasked to properly identify mold contamination and advise building owners of the proper techniques for dealing with the situation. Lacking priests to ask, many companies will be turning to their safety professionals for answers to their mold remediation questions. Hopefully this article has provided some of the necessary background to deal with those inevitable questions. For more in-depth information and advice about dealing with mold problems, safety professionals are urged to contact one of the growing number of businesses that deal with mold hazard assessment and remediation.

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This article was published in the August 2002 Professional Safety magazine.