



Mold 101

**Information to help you make an informed decision
about mold and your remediator.**

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In light of the growing concern about mold contamination and health issues, safety professionals should be prepared to deal with these issues. This information has been written for Caltex dealers 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. We 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.

Mold Facts

- Invisible - 4-80 microns
- Fungi : the correct term for molds, mildew, mushrooms, yeast, rusts, and smuts
- Fungi is everywhere in our environment
- Most types require free water to begin colonization
- Requires an external food source
- Releases spores for reproduction
- Cell fragments, spores, and cell by-products may be allergenic, infectious, and toxigenic
- Estimated 100,000+ species, but currently only about 100 species are identified as pathogenic to humans

Primary Requirements For Mold Growth

- Moisture
- Nutrient source
- Proper Temperature
- "Starter" Spore or Colony
- Time

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.

FUNGI

Fungi may be white, grey, red, yellow, black, brown, or greenish and have cells bound by rigid walls usually formed of chitin and glucans, which are tough proteins. Fungi may be single-celled or multicellular. Yeasts are single-celled fungi that reproduce by budding. Multicellular fungi, such as mushrooms, mold and mildew, are formed of microscopic, branched filaments called hyphae. Groups of hyphae form one or more colonies can form a visible mass called a mycelium. Fungi also produce large numbers of spores on their hyphae. Spores are small, light particles capable of producing a mature fungus. Most of the fungi found growing indoors are commonly called molds.

Fungi have complex lifecycles that may include both sexual and asexual stages. Spores can be produced by meiosis during the sexual stage, resulting in unique spores that have half as much genetic material as the parent cells. Spores can also be formed asexually by mitosis, simple cell division. Asexual spores are called sporangiospores if they are formed internally or conidia if they are produced externally.

Fungi can grow in many habitats, under wide variety of environmental conditions. However, there are two basic requirements for all mold growth.

1. Moisture

The first requirement for fungal growth is moisture. Fungi need a moisture source to begin growth, and at least some moisture to continue growing. Fungi require moisture to process nutrients, the moisture to sustain growth can come from high relative humidity for some species of fungi, such as *Cladosporium*, while others, such as *Stachybotrys*, require actual water (known as "free water").

2. External Food Source

The second requirement of mold growth is an external food source. These sources can range from simple sugars and starches to complex carbon-containing substances. Indoors, these sources include wallpaper paste, cellulose from paper and fabrics, animal skin, and wood. Fungi release enzymes to digest these substances into glucose, which is then absorbed. This process requires a source of water, nitrogen, and numerous elements. If these basic requirements are present, as they are in many instances of water damage, fungi can grow in a wide variety of climates.

Most fungi are saprobic, meaning they live on non-living organic material. These fungi are a major factor in decomposition. A few fungi are dedicated parasites, and require a living host to survive. Some other fungi can become parasitic, but only under unusual

circumstances, such as when the host is weakened by illness. A small number of fungi are symbiotic, living in partnership with another organism. These include lichens and fungi that grow around tree roots.

Fungi can spread in two ways. A good analogy for these two methods of growth is dandelions will grow there, just as mold will grow in a house if conditions are right. Dandelions can grow locally by physically expanding and growing larger, or they can spread further by producing seeds that are carried by the wind.

Many species of fungi act like the dandelion. Once they gain a foothold, they can spread rapidly across a surface as long as there is sufficient moisture. This is similar to the dandelion increasing in size across the base. If the moisture source becomes insufficient, many mold species will enter sporulation phase, where they produce and release huge numbers of spores into the air. It has been estimated that a single colony of *Penicillium* 2.5 centimeters in diameter could contain as many as 400,000,000 microscopic spores. These spores are the equivalent of the seeds produced by the dandelion in the analogy.

Common Types of Fungi

While there are thousands of types of fungal spores, some are more common than others, especially in certain environments. Some of the most common spores are Cladosporium, ascospores, basidiospores, and Alternaria.

Cladosporium

Cladosporium is the most prevalent mold in the Midwestern section of the United States. The dark mold that can be found growing on the seal of refrigerator doors is often Cladosporium. Cladosporium grows in so many areas because it does not need much moisture and can grow on a wide variety of materials, it is a mold commonly associated with hay fever and asthma.

Ascospores

Ascospores are also a very common type of mold. There are many different species of ascospores, and they are found both outdoors and inside. They are generally not toxic, but can cause allergies if the exposure concentration is high enough.

Basidiospores

Basidiospores are another broad category of spores. They are nearly as common as ascospores, and are also found both outside and in. Basidiospores are generally not toxic, but, like ascospores, they can cause allergies.

Alternaria

The fourth common type of mold is Alternaria. Alternaria is the most common mold found in bathrooms, where it grows around the edges of showers and toilets. It is also found in dust and on window frames. Alternaria is generally not toxic, but can cause allergies in some people.

Molds caused by water damage

The molds that are found in houses with water damage can be different from the normal molds mentioned above. Molds often found in water-damaged buildings include Aspergillus, Penicillium, Stachybotrys, and Fusarium. These molds require higher levels of moisture than the common indoor and outdoor molds, and they are linked to much more severe health effects.

Aspergillus and Penicillium

Aspergillus and Penicillium are the more common molds found in water-damaged buildings. They are similar in configuration and spore size and often appear together in samples. Aspergillus and Penicillium grow quickly on water-damaged materials such as wallboard and carpeting. Often within 48 to 72 hours after the first water intrusion. Some species of Aspergillus and Penicillium can produce toxins, including aflatoxin, which is an extremely potent carcinogen. Nearly all species are highly allergenic to humans.

Stachybotrys

Stachybotrys is the most well known of the toxic molds, and, as such, it requires somewhat more detail than the other toxic molds discussed here. For this reason, a more detailed article on Stachybotrys is included at the end of this Topic.

Fusarium

Fusarium is another mold that is found in some water-damaged buildings. Like Stachybotrys, it requires high levels of moisture, so it is often found in humidifiers and other areas of standing water. Also like Stachybotrys, Fusarium produces potent mycotoxins. Fusarium mycotoxins particularly affect the nervous system, causing headaches, memory loss, coma, and death.

The Prevalence of Fungus and Risk 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 mold risk 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 mold 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, and special cleaners.

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.

Pathogenicity and Clinical Significance of *Stachybotrys*

Similar to various genera of filamentous fungi, *Stachybotrys* produces trichothecene mycotoxins, the satratoxins. Trichothecenes are potent inhibitors of DNA, RNA, and protein synthesis. They modulate inflammatory reactions and alter alveolar surfactant phospholipid concentrations. These toxins may be acquired by ingestion of food products contaminated with the fungus or experimentally, via direct inhalation of the spores. In addition to its mycotoxins, *Stachybotrys* produces an hemolysin, stachylysin, which lyses sheep erythrocytes. The existence of the mycotoxin, as well as the stachylysin, has been demonstrated in some strains.

The pathogenicity of *Stachybotrys* was first observed in cattle and horses in Russia in 1920. Stomatitis, rhinitis, conjunctivitis, pancytopenia and neurological disorders developed in animals following ingestion of hay contaminated with *Stachybotrys*. The syndrome was called stachybotrytoxicosis. This outbreak was the first to draw attention to *Stachybotrys* and its toxins. Later in the 1970s, it was claimed that Yellow Rain attacks in Southeast Asia were associated with the use of aerosolized trichothecenes as an agent of biologic warfare. However, this claim remained scientifically unproven.

Following these, animal studies have been undertaken to demonstrate the pathogenic effects of the trichothecenes. In one of these investigations, intranasal administration of trichothecenes to mice was studied. Severe intra-alveolar, bronchiolar, and interstitial inflammation were observed following the intranasal exposure. However, simulation of intranasal exposure by exposing the mice to extensive surface growth of toxigenic *Stachybotrys* and high air flow did not produce these toxic effects, suggesting that the development of toxicosis in nature following inhalation is unlikely. This finding also suggested that mycotoxins of *Stachybotrys* can be produced or get airborne only under certain environmental settings.

Stachybotrys has interested health care workers for two reasons. The first is its possible role in development of sick building syndrome. *Stachybotrys* is one of the contaminants inhabiting buildings with major problems in mechanical system design, construction, and operational strategies, leading to excess indoor moisture. However, *Stachybotrys* is only one of the fungal genera isolated in these buildings and in fact it is less common and in

lesser amounts compared to other mould genera. *Aspergillus*, *Penicillium*, *Alternaria*, and *Cladosporium* spp. are more frequently isolated under these settings. Also, the definition and diagnosis of sick building syndrome is unclear and even more importantly, sick building syndrome may result from several chemical and physical factors as well as biological factors, including moulds. These ideas suggest the possibility that *Stachybotrys* may play a role in development of sick building syndrome, but most probably together with other factors.

In a nested case-referent study of adult-onset asthma, domestic exposures to moulds, environmental tobacco smoke, and the presence of a wood stove were found to be associated with adult-onset, building-related asthma. On the other hand, in three buildings with moisture-damaged interior surfaces where *Stachybotrys chartarum*, *Aspergillus versicolor*, and *Penicillium* spp. were isolated and satratoxins were detected, cases with symptoms consistent with potential asthma and interstitial lung disease were identified. The presence of IgE specific to *Aspergillus* spp., *Cladosporium*, and *Stachybotrys chartarum* in serum was found to be related to the sick building syndrome in another study.

The second reason why *Stachybotrys* drew attention was its possible role in development of acute idiopathic pulmonary hemorrhage and hemosiderosis in infants. In the years 1993 to 1998, several infant cases of acute idiopathic pulmonary hemorrhage and hemosiderosis were reported. *Stachybotrys* was cultivated in their water-damaged houses. The initial cases consisted of 37 infants living in a limited geographic area in Cleveland, Ohio. Later, reports on additional cases followed. Also, *Stachybotrys* was isolated from bronchoalveolar lavage fluid of a child with pulmonary hemorrhage. Why did the infants, but not the adults, get the disease? Most authors speculated that the rapidly growing lungs of the infants were probably more vulnerable to the pathogenic effects of *Stachybotrys* toxins. These toxins presumably produced capillary fragility and eventually precipitated pulmonary hemorrhage in the rapidly growing lungs.

However, despite all that was reported about the association between acute idiopathic pulmonary hemorrhage and *Stachybotrys*, later analysis showed that the presented data were misleading. No statistically-significant association between acute idiopathic pulmonary hemosiderosis and *Stachybotrys* could be found. In summary, what we know today is limited and speculative and thus the health risks of environmental exposure to *Stachybotrys* are unclear. The actual role of *Stachybotrys* alone in development of human disease is yet poorly defined. We don't know whether it is similar or unlike the other mycotoxin-producing filamentous fungi with respect to its pathogenic potential. Other mycotoxin-producing moulds which are found to achieve higher indoor concentrations than *Stachybotrys*, should be evaluated with respect to their potential to produce acute idiopathic pulmonary hemorrhage and other pathologies.

Methods of Remediation

Unfortunately there are no government-set mandates for the mold remediation process yet. Thus there are many remediators doing the remediation in many different ways which can lead to some confusion and, at worst, improper remediation. We have compiled here a short list of some remediation practices that should be avoided as well as an explanation of the BioForce remediation technique.

Chlorine Bleach

Chlorine bleach is a biocide which means that it will kill any living organism. At first glance this would seem to be a good choice for mold remediation but there are several problems which lead the EPA to recommend that it not be used. The first problem is that not only is it harmful to the mold it is harmful to the workers, the buildings inhabitants and the materials to which it is applied. Second, while the bleach can kill everything on the surface of the materials it is applied to it does not remove all the mold. Mold has roots which it sinks into the materials on which it grows. When you apply bleach it will clean the surface and leave the roots which will grow back if moisture is present. Also when the sodium hypochlorite breaks down the chemical process draws moisture to the area. Make sure your remediator is not using bleach or a product with sodium hypochlorite as the active ingredient.

Borates

Many companies that remediate mold have added the service to what their company already does and therefore treat the mold with a product they are already familiar with. Sometimes this can be a problem. Many pest control companies treat mold with borates (Disodium Octaborate Tetrahydrate). The two most popular are Timbore and Bora-Care. These are pesticides labeled for fungi. These products can kill the mold and leave a residual that will inhibit re-growth but the problem is that they do not remove the mold. Dead mold can be as harmful as live mold in some cases and the EPA guidelines state that the mold must also be removed. If your remediator is using borates make sure he has an effective and comprehensive plan for removing the mold afterwards.

Steam Cleaning

The issue with this practice is pretty self explanatory. Steam is water and water causes mold to grow. When steam cleaning mold the surface is cleaned and the roots are left behind to re-grow utilizing all the moisture that has just been introduced.

The BioForce Advantage

At BioForce we use a product called Cal-Brite manufactured by Caltex International Ltd. It is designed to be applied to the surface to be cleaned and once that is done it actually goes in and foams up to remove and destroy all of the mold/roots or other contaminants

present. The remediation is done with all the proper containment and protective equipment necessary. Once the remediation is complete the area is dried and all moisture problems are fixed. We then do clearance testing to be sure the problem is solved.

“Cal-Brite is environmentally safe, nontoxic, USDA approved, water-based, biodegradable, and was accepted by the USDA in 1988. Cal-Brite is manufactured by Caltex International, LTD and BioForce Mold Remediation is the exclusive dealer in the Greenville area.” Kevin Sodhi, Caltex International, LTD.

Containment

The purpose of containment during remediation activities is to limit release of mold into the air and surroundings, in order to minimize the exposure of remediators and building occupants to mold. Mold and moldy debris should not be allowed to spread to areas in the building beyond the contaminated site. The two types of containment recommended are limited and full. The larger the area of moldy material, the greater the possibility of human exposure and the greater the need for containment. In general, the size of the area helps determine the level of containment. However, a heavy growth of mold in a relatively small area could release more spores than a lighter growth of mold in a relatively large area. Choice of containment should be based on professional judgment. The primary object of containment should be to prevent occupant and remediator exposure to mold. For example, a remediator may decide that a small area that is extensively contaminated and has the potential to distribute mold to occupied areas during cleanup should have full containment, whereas a large wall surface that is lightly contaminated and easily cleaned would require only limited containment.

Limited Containment

Limited containment is generally recommended for areas involving between 10 and 100 square feet (ft²) of mold contamination. The enclosure around the moldy area should consist of a single layer of 6-mil, fire-retardant polyethylene sheeting. The containment should have a slit entry and covering flap on the outside of the containment area. For small areas, the polyethylene sheeting can be affixed to floors and ceilings with duct tape. For larger areas, a steel or wooden stud frame can be erected and polyethylene sheeting attached to it. All supply and air vents, doors, chases, and risers within the containment area must be sealed with polyethylene sheeting to minimize the migration of contaminants to other parts of the building. Heavy mold growth on ceiling tiles may impact HVAC systems if the space above the ceiling is used as a return air plenum. In this case, containment should be installed from the floor to the ceiling deck, and the filters in the air handling units serving the affected area may have to be replaced once remediation is finished. The containment area must be maintained under negative pressure relative to surrounding areas. This will ensure that contaminated air does not flow into adjacent areas. This can be done with a HEPA-filtered fan unit exhausted

outside of the building. For small, easily contained areas, an exhaust fan ducted to the outdoors can also be used. The surfaces of all objects removed from the containment area should be remediated/cleaned prior to removal. The remediation guidelines can be implemented when the containment is completely sealed and is under negative pressure relative to the surrounding area.

Full Containment

Full containment is recommended for the cleanup of mold contaminated surface areas greater than 100 ft² or in any situation in which it appears likely that the occupant space would be further contaminated without full containment. Double layers of polyethylene should be used to create a barrier between the moldy area and other parts of the building. A decontamination chamber or airlock should be constructed for entry into and exit from the remediation area. The entryways to the airlock from the outside and from the airlock to the main containment area should consist of a slit entry with covering flaps on the outside surface of each slit entry. The chamber should be large enough to hold a waste container and allow a person to put on and remove PPE. All contaminated PPE, except respirators, should be placed in a sealed bag while in this chamber. Respirators should be worn until remediators are outside the decontamination chamber. PPE must be worn throughout the final stages of HEPA vacuuming and damp-wiping of the contained area. PPE must also be worn during HEPA vacuum filter changes or cleanup of the HEPA vacuum. The purpose of containment during remediation activities is to limit release of mold into the air and surroundings, in order to minimize the exposure of remediators and building occupants to mold. Mold and moldy debris should not be allowed to spread to areas in the building beyond the contaminated site. The two types of containment recommended in Table 2 are limited and full. The larger the area of moldy material, the greater the possibility of human exposure and the greater the need for containment. In general, the size of the area helps determine the level of containment. However, a heavy growth of mold in a relatively small area could release more spores than a lighter growth of mold in a relatively large area. Choice of containment should be based on professional judgment. The primary object of containment should be to prevent occupant and remediation exposure to mold. For example, a remediation may decide that a small area that is extensively contaminated and has the potential to distribute mold to occupied areas during cleanup should have full containment, whereas a large wall surface that is lightly contaminated and easily cleaned would require only limited containment.

Personal Protective Equipment (PPE)

If the remediation job disturbs mold and mold spores become airborne, then the risk of respiratory exposure goes up. Actions that are likely to stir up mold include: breakup of moldy porous materials such as wallboard; invasive procedures used to examine or remediate mold growth in a wall cavity; actively stripping or peeling wallpaper to remove it; and using fans to dry items.

The primary function of Personal Protective Equipment (PPE) is to avoid inhaling mold and mold spores and to avoid mold contact with the skin or eyes. The following sections

discuss the different types of PPE that can be used during remediation activities. Please note that all individuals using certain PPE equipment, such as half-face or full face respirators, must be trained, must have medical clearance, and must be fit-tested by a trained professional. In addition, the use of respirators must follow a complete respiratory protection program as specified by the Occupational Safety and Health Administration.

Skin and Eye Protection

Gloves are required to protect the skin from contact with mold allergens (and in some cases mold toxins) and from potentially irritating cleaning solutions. Long gloves that extend to the middle of the forearm are recommended. The glove material should be selected based on the type of materials being handled. If you are using a biocide (such as chlorine bleach) or a strong cleaning solution, you should select gloves made from natural rubber, neoprene, nitrile, polyurethane, or PVC. If you are using a mild detergent or plain water, ordinary household rubber gloves may be used. To protect your eyes, use properly fitted goggles or a full-face respirator with HEPA filter. Goggles must be designed to prevent the entry of dust and small particles. Safety glasses or goggles with open vent holes are not acceptable.

Respiratory Protection

Respirators protect cleanup workers from inhaling airborne mold, mold spores, and dust. **Minimum:** When cleaning up a small area affected by mold, you should use an N-95 respirator. This device covers the nose and mouth, will filter out 95% of the particulates in the air, and is available in most hardware stores. **Limited:** Limited PPE includes use of a half-face or full-face air purifying respirator (APR) equipped with a HEPA filter cartridge. These respirators contain both inhalation and exhalation valves that filter the air and ensure that it is free of mold particles. Note that half face APRs do not provide eye protection. In addition, the HEPA filters do not remove vapors or gases. You should always use respirators approved by the National Institute for Occupational Safety and Health. **Full:** In situations in which high levels of airborne dust or mold spores are likely or when intense or long-term exposures are expected (e.g., the cleanup of large areas of contamination), a full-face, powered air purifying respirator (PAPR) is recommended. Full-face PAPRs use a blower to force air through a HEPA filter. The HEPA-filtered air is supplied to a mask that covers the entire face or a hood that covers the entire head. The positive pressure within the hood prevents unfiltered air from entering through penetrations or gaps. Individuals must be trained to use their respirators before they begin remediation. The use of these respirators must be in compliance with OSHA regulations.

- Always maintain the containment area under negative pressure.
- Exhaust fans to outdoors and ensure that adequate makeup air is provided.
- If the containment is working, the polyethylene sheeting should billow inwards on all surfaces. If it flutters or billows outward, containment has been lost, and you should find and correct the problem before continuing your remediation activities.

Disposable Protective Clothing

Disposable clothing is recommended during a medium or large remediation project to prevent the transfer and spread of mold to clothing and to eliminate skin contact with mold. Limited: Disposable paper overalls can be used. Full: Mold-impervious disposable head and foot coverings, and a body suit made of a breathable material, such as TYVEK®, should be used. All gaps, such as those around ankles and wrists, should be sealed (many remediators use duct tape to seal clothing).

Clearance Testing

We have developed Post-Remediation Evaluation Criteria for Mold Contamination, based on non-cultured sampling. All the procedures have been laid out for a post-remediation evaluation in a six-step chart.

STEP 1: Visual Inspection

Were the specifications followed? Was the moisture source identified and corrected? Were the contents and debris removed? Was the work area white-glove dust free?

To start, a **visual inspection** is conducted prior to the collection of any samples. The visual inspection is conducted to determine if the project specifications were followed, the moisture source was identified and corrected, and that the work area is dust free (white glove test). Only after the area passes a visual inspection are non-cultured samples collected.

STEP 2: Total Spore Concentration

Is the total spore concentration less than 2,000 c/m³ (typical of a normal fungal ecology)? If less than 800, go to Step 4.

Initial interpretation of the sample data compares the total fungal **spore concentration** to the set number of 2,000 spore counts per cubic meter of air (c/m³). Several studies agree that this value is typical of an environment that is not impacted by adverse interior fungal growth, in essence, a "normal fungal ecology". The data also shows that very low total counts are possible based on seasonal variability or location. Our experience is consistent with that expressed by many other authors: when comparing samples from various areas the reliability of a gross comparison (i.e., total fungal spores) drops off considerably at low spore concentrations. Therefore, an exemption from step 3 is provided for samples from inside the contained area that have a total spore concentration of less than 800 c/m³.

STEP 3: Comparison to Make-up Air Source

Is the total spore concentration on the inside sample below that on the comparison sample? Comparison sample collected from out-of-doors or inside building but outside work area, depending on location of containment entry point.

The evaluation of the remediation process continues with a **comparison of the total spore count** inside the work area to the total spore count in the makeup air source, based on the location of the containment entry point.

STEP 4: Rank / Order Comparison

Is the level of each fungal type (and hyphae) recovered inside less than 100c/m³ above the level of the same fungal type (and hyphae) in the comparison sample?

Subsequently, a **rank/order comparison** of the fungal types (to the genus level only) and concentrations, including hyphal fragments inside the work area, are compared to the types and amounts naturally occurring in the comparison sample. At this point, we also recommend that the levels of hyphal fragments be reviewed. Hyphal fragment is a term that many laboratories use to describe fragments of fungal organisms that are not spores. Since hyphal fragments generally do not have enough characteristics to allow them to be correlated with a specific genus of fungi, they are recorded as a separate item. Our experience indicates that when concentrations of hyphal fragments found inside are higher than those found out-of-doors, an indoor source of fungal growth is usually present. As such, we have included this secondary comparison in step 4.

The levels of fungal spores and hyphal fragments recovered in the work area sample(s) must be not more than 100 c/m³ higher than the levels of corresponding fungal spores or hyphal fragments in the comparison sample. This limit is based on the principle that all analytical methods have a limit of detection that must accommodate the limitations of the equipment used in the laboratory and for sample collection. In an indoor environment with a normal fungal ecology the ranking of the spores types found inside the work area should reflect the ranking of the comparison sample. For example, if Cladosporium was the most common spore type identified in the comparison sample, one would expect to find Cladosporium as the top ranking spore type inside the work area, only at a significantly lower level.

STEP 5: Indicator Organisms

Was Aspergillus/Penicillium on the inside sample less than 200 c/m³?

At this point in the process, **indicator fungal types are considered**. Fungal types are designated as "indicator" if they are associated with water damage to building or indoor finish materials. Keep in mind that these fungi may also come from out-of-doors and make up a natural part of the existing flora. While several molds are discussed as potential indicators of water-damaged environments, Aspergillus/Penicillium types are mentioned frequently.

Aspergillus and Penicillium spores are lumped together when analysis is performed by direct microscopy because the spores are indistinguishable from one another. Oddly, this turns out to be a benefit for the post-remediation evaluation process. Certain species of both Aspergillus and Penicillium are early colonizers of water-damaged materials that grow quickly and disperse many spores. When these growth properties are matched with the negative health effects associated with these spores, their value as an indication of acceptable mold remediation procedures is enhanced. A conservative but achievable goal for indicator fungal types (e.g., Aspergillus/Penicillium) should be at levels below 200 c/m³ post remediation.

STEP 6: Target Organisms

Was the inside sample free of target fungal types, both counted and observed? Zero tolerance of Stachybotrys sp., Fusarium sp., Trichoderma sp., Memnoniella sp., Chaetomium sp

The final step in evaluating a mold remediation project is to **consider target organisms**. Target organisms are identified by their characteristic need for high moisture content and/or water activity to grow, their ability to naturally produce toxins, and their common degradation of cellulose-containing materials. Spores from these target organisms are not typically found in clean indoor environments so the criterion for target organisms is zero tolerance. The presence of target organisms in a cleaned work area indicates ineffective remediation and can result in continued issues with the structure or ill-health effects for the occupants of the space.

Any time one of the steps in the evaluation process exceeds the criteria, the area must be re-cleaned and retested as many times and as thoroughly as needed to meet the criteria for that step before moving on to the next step. When the work area has met the criteria in all six steps, it is considered to be clean with a normal fungal ecology, and the project has been successfully completed.

For more information check out the EPA guidelines online at www.epa.gov/mold/moldresources.html

“The key to mold control is moisture control.”

In addition to a plan to remediate the mold problem a remediator should also provide a plan for fixing any moisture problems.