Report of Microbial Growth Task Force

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REPORT OF MICROBIAL GROWTH TASK FORCE

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION
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AIHA Press
American Industrial Hygiene Association
2700 Prosperity Avenue, Suite 250
Fairfax, VA 22031

Tel.: (703) 849-8888 • Fax: (703) 207-3561
http://www.aiha.org • email: infonet@aiha.org

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Preface

Many AIHA members and other public health professionals are increasingly having to evaluate the potential health hazards of microbial contamination in buildings, to make decisions regarding abatement of those potential hazards, and to communicate their findings and recommendations effectively to building owners and occupants, workers, and other stakeholders.

This is no easy task. The evaluation and remediation of these potential hazards is extremely difficult in the real world for many reasons. The scientific challenges alone can be daunting, because the available science is incomplete and sometimes controversial. Although there are several available guidance documents, there is no accepted national standard. Validated methods to measure contamination are still in their infancy, and even when measurement techniques are available, there are no clear benchmarks or standard values against which to compare the results. Similar scientific uncertainties exist in the medical diagnosis of mold-related health effects.

The scientific complexities alone would be a huge challenge, but the truth is that other difficulties dwarf them. The intense public and media attention on this topic often creates emotionally charged circumstances that make scientific judgment and reasoned dialogue difficult. In some instances, building owners tend to ignore or dismiss potentially serious problems. In other instances, building occupants or public officials can react with excessive alarm to potential threats, complicating the scientific component of the evaluation and making risk communication very difficult. While experts and practitioners disagree as to which of these trends are of more concern, it is clear that both are real and sizable. The worst obstacle, however, is that a lot of money can be involved in these disputes. As a result, the issue is increasingly clouded by the acrimony and distorted partisanship of mushrooming liability battles in the legal arena. It is not a pretty picture.

Aware of this challenge to our members, the AIHA convened an expert workshop three years ago to review the available guidance documents, identify any gaps, and recommend action to address them. The workshop was followed by the creation of a Task Force of experts from several AIHA technical committees. The Task Force has been working diligently for many months to fulfill their charge. This document is the result of their deliberations.

We believe that this document helps to fulfill the AIHA's obligation to assist our members and other professionals to better address these challenges. The document is a consensus statement by a group of experts about important aspects of the "state of the science." The guidance in this document offers a wealth of very practical information to AIHA members and others concerned with the proper assessment and remediation of microbial contamination in buildings. It is intended to help professionals make the tough decisions they often face in the absence of complete data.

Consensus is not unanimity, however, and the document also contains a minority position by one member of the Task Force. We are comfortable with this outcome, although it is uncommon in AIHA documents, because we know that advances in science will prove wrong some of the statements in both the consensus and the minority documents. The document does not, therefore, purport to be a definitive or comprehensive position statement on the issues. It addresses some but by no means all the gaps that were identified in existing guidance. Because it is not comprehensive, it should *always* be used in conjunction with other existing guidance documents, as well as professional judgment.

Public and occupational health practice is rarely an exact science. Prevention always poses the challenge of making tough and often costly decisions with incomplete information or understanding. The decision may be action or inaction, with resulting human and financial costs, or both. But decisions have to be made. We believe that this consensus document, despite its probable imperfections, will help our members and other professionals make those decisions better and with more wisdom.

Donna Doganiero, CIH, U.S. Army CHPPM
Board Coordinator for Task Force and Treasurer

Manuel R. Gómez, DrPH, MS, CIH
Director, Scientific Affairs

Margaret Breida, MS
Manager, Technical Committee Support

Table of Contents

1. EXECUTIVE SUMMARY

Industrial hygienists frequently find it difficult to obtain reliable advice regarding microbial growth remediation[1] and associated worker protection. The difficulties and confusion arise because of several factors: a) there are no clear-cut regulatory requirements; b) insufficient scientific knowledge and hence controversy about some aspects of the association between microbial growth and health effects among building occupants or remediation workers; c) the scientific debates include disputes concerning potential liability for building owners and others; and d) although several useful guidance documents are available, it is difficult for them to fully encompass the wide variety of situations where microbial contamination of buildings may be encountered. Therefore, none of the available documents are truly comprehensive, and all suffer from some gaps in areas that are important to practicing industrial hygienists.

The AIHA convened a Microbial Growth Task Force to assist industrial hygienists in *locating, effectively applying, and supplementing* existing guidance concerning microbial contamination in buildings. In this report, the Task Force briefly reviews key aspects of existing guidance documents, identifies important gaps in those documents, and provides recommendations to address those gaps whenever possible.

This document is neither a comprehensive treatment of issues concerning microbial contamination in buildings, nor a stand-alone resource. It is intended to be used by the practitioner together with existing guidance documents and other information resources. This caveat is especially important because scientific and practical knowledge in this area are rapidly accumulating and evolving.

The major recommendations and findings of this report are presented for each question considered:

1. When Should Microbial Contamination Found In Occupied Buildings Be Remediated?

   All the currently available consensus guidance documents agree that amplification, i.e., "growth" of mold on building surfaces, requires remediation.

   Microbial growth (or amplification), regardless of species, in a building should be remediated as rapidly as possible, along with the sources that have led to its generation (moisture/water damage).

[1] Throughout this document, *remediation* is used to refer to a broad range of possible removal techniques for microbiological contamination, including simple cleaning (i.e., scrubbing surface with a surfactant), vacuuming, removing selected portions of wall board, or major structural changes that may release large amounts of dust.

With the current level of knowledge, it seems prudent to consider hidden microbial growth as an indicator for remediation given the potential for exposure and given the potential for the decay of building materials.

2. What Amount(S) Of Mold Should Indicate What Degree of Remediation?

The question of whether the density and extent of fungal growth should be factors in indicating the need for remediation has not been answered. However, the Task Force did agree that density and extent of growth determine the degree of remediation and the containment procedures during remediation (see Section 8—How Should Remediation Work Areas Be Isolated?).

The question of whether material (e.g., the inside of a wall) contaminated with fungal propagules should be an indicator for remediation has not been answered.

3. What Remediation Methods Should Be Used?

The guiding principles in remediation are as follows: a) identify and correct the original moisture problem(s) that caused the fungal growth; b) remove semi-porous and nonporous materials whose integrity has been compromised; c) clean contaminated surface layers of otherwise sound semi-porous materials; and d) remove the remaining dusts. Specific techniques are addressed in Section 5.

The value of duct cleaning is in question. It is suggested that ducts should be cleaned only if there is substantial mold growth or dust accumulation. A fine layer of dust is not a reason to clean ducts.

As more epidemiological data are collected, the use of a formal risk assessment model and cost-benefit analysis to indicate remediation and to determine extent of remediation may eventually become warranted.

4. Should Biocides Be Used In Remediation?

The use of bleach or other biocides is questionable in most instances.

The effectiveness of bleach in reducing allergenic and toxigenic materials in remediation work has not been demonstrated. There are some instances when industrial hygienists with work experience in mold remediation may consider, with proper precautions, the use of bleach and other biocides such as when the mold contaminated materials to be remediated are not responding to treatment with water and detergents.

The goal of remediation is removal of mold and the moisture source because: a) biocides do not alter mycotoxins or allergens; b) it is generally not possible to get 100 percent kill with biocides; and c) because of (b), the newly deposited spores, re-growth will occur after the biocides if moisture returns.

5. Under What Circumstances Should Buildings Be Evacuated and Work Areas Isolated?

The following excerpts from the NYC DOH guidelines (2000) offer a meaningful basis for making a decision on the evacuation of a building or work area:

> "Except in cases of widespread fungal contamination that are linked to illnesses throughout a building, a building-wide evacuation is not indicated."
>
> "Infants (less than 12 months old), persons recovering from recent surgery, or people with immune suppression, asthma, hypersensitivity pneumonitis, severe allergies, sinusitis, or other chronic inflammatory lung diseases…should be removed from the affected area during remediation. Persons diagnosed with fungal-related diseases should not be returned to the affected areas until remediation and air testing are completed."
>
> "A trained occupational/environmental health practitioner should base decisions about medical removals in the occupational setting on the results of a clinical assessment."

The OSHA General Duty Clause, which directs employers to provide a safe and healthy work environment for their employees, should also be used as a guide for industrial hygienists in making decisions on evacuation.

6. How Should Remediation Work Areas Be Isolated?

The industrial hygienist (or other environmental health professional with relevant education and/or experience) should use professional judgment to ensure the containment of dusts and the protection of remediation workers.

Innovation should be encouraged rather than strict adherence to NYC DOH guidelines.

The professional should keep in mind the practical significance of the "square-footage" guidelines given by NYC DOH and not focus on the specific number.

7. How Should Water-Damaged Content Items Be Treated?

Water-damaged nonporous content items in fungally contaminated areas can be reliably tested for contamination, and contamination can be efficiently removed.

Consistent with the primary sources of remediation methods, visibly contaminated porous items should be discarded, except in rare cases where the value of the item warrants extraordinary means of decontamination and restoration, e.g., works of art or valuable records.

8. What Quality Assurance Principles Should Be Followed To Ensure That Mold Remediation Is Successful?

The principal quality assurance performance indicator is documentation that **the precipitating water or moisture sources have been identified and eliminated,** and all affected areas have been physically inspected to ensure that mold has been removed.

Other recommended **key QA performance indicators** are:

Documenting appropriate containment protocol.

Documenting that cleaning was performed according to specifications.

Documenting that mold removal has been in accord with the approved remediation plan.

Documenting that the remediated areas were checked for any remaining unremediated mold/water damage that may have been revealed during the demolition/cleaning process.

Documenting that the amount of surface dust does not indicate a need for recleaning.

Documenting that the remediated space has been vacuumed with devices equipped with high-efficiency air particulate (HEPA) filters.

9. What Personal Protective Equipment (PPE) Are Recommended During Bioremediation?

The ACGIH guidelines should be followed. These guidelines include specific recommendations, but also allow decisions to be made about PPE based on factors (potential for exposure, dust generation, etc.) that vary from one case to the next.

In many circumstances, a disposable N-95 NIOSH-approved respirator should offer adequate respiratory protection provided that the facepiece fits tightly, ensuring that contaminants do not enter through leaks between the respirator and a wearer's face.

Some environments may require sophisticated PPE due to the concentrations of specific microbial agents and their disease potential. Work practices and PPE selection guidelines (Lenhart et al., 1997) have been developed for remediation workers involved in the removal of material potentially contaminated with *Histoplasma capsulatum* and similar organisms.

A Certified Industrial Hygienist (CIH) with relevant experience or similarly qualified professional should be consulted during the decision process based upon the need to protect workers from the irritating and allergenic effects of bioaerosols during mold cleanup. Protection from these effects should also protect workers from putative toxigenic effects from molds or other bioaerosols.

Some situations may allow cleanup to occur with optional PPE use. The published guidelines do not address situations where the amount of visible mold is very small (e.g., $\ll 10\ ft^2$ of contamination) or where remediation does not require removal of materials (e.g., wiping a nonporous surface).

10. Is Personal Air Sampling Appropriate To Determine Worker Exposure During Mold Remediation?

The routine determination of personal exposures of remediation workers to biocontaminants is not appropriate based on existing information. In addition, occupational exposure limits or guidelines do not exist for microorganisms or agents derived from these organisms, so that comparisons to airborne levels are not interpretable.

Nevertheless, area air samples, bulk samples, and surface samples taken before remediation might assist in the development of a remediation strategy, in the appropriate selection of personal sampling equipment, to determine the extent of contamination of an HVAC system or as a useful QA performance indicator after remediation as described in Section 10- What Quality Assurance Principles Should Be Followed To Ensure That Mold Remediation Is Successful?

11. What Medical Evaluation Is Recommended For Remediation Workers?

The Task Force recommends that the NYC DOH 2000 guidelines regarding medical evaluation and removal be followed for all workers engaged in the remediation of microbial growth.

2. BACKGROUND

Creation of Task Force

The AIHA Board of Directors approved the formation of a Microbial Growth Task Force (henceforth Task Force, see Appendix 1) in August 1998. The Task Force was asked to review the currently available guidelines on microbial growth remediation and develop any necessary recommendations for industrial hygienists. The impetus to create the task force arose from an expert workshop held at AIHA headquarters in March 1998. The workshop participants purposefully spanned a wide range of scientific opinion. Yet they agreed that it was possible to address many practical gaps in the available guidance documents, despite the differences of opinion that still exist among experts regarding the hazards of various microorganisms and the variety of methods available for remediation and associated worker protection.

Task Force Procedures

At its first meeting in March 1999, the Task Force developed a list of questions (Appendix 2) to be used as a guide in reviewing six currently available guidelines (Appendix 3). The Task Force divided into groups that would focus on two major areas: remediation and worker protection issues. Over the next several months, including meetings in June and September 1999, the Task Force reviewed the current guidance documents to identify any discrepancies or important gaps and to seek consensus on practical recommendations to address them.

The Task Force identified gaps and made technical recommendations for each of the specified questions:

1. When Should Microbial Contamination Found In Occupied Buildings Be Remediated?

   Two important issues are not addressed comprehensively in existing guidelines:

      "Hidden" versus visible mold, or mold growth that may be present in visually inaccessible spaces but may still pose potential exposure risks; and

      Remediation of dusts that may contain microorganisms, spores, hyphal fragments, toxigenic substances, or other antigenic materials.

Much of the concern regarding hidden mold is based on the assumption of the dissemination of mold reservoirs, i.e., infiltration, from “hidden” sinks, areas in ventilation systems, or from indoor reservoir materials. More research is needed regarding the potential for infiltration and the estimation of infiltration rates.

2. What Amount(S) of Mold Should Indicate What Degrees of Remediation?

There is a need to address in a more comprehensive manner several questions related to existing guidelines that still complicate decision-making when microbiological growth is found in buildings. These questions are listed in Section 4 and include the issues of hidden mold, density and extent of contamination, settled dusts as reservoirs of fungal propagules, cost-benefit analysis, and risk assessment.

There is a need for clearer guidance regarding buildings with unusual occupants, such as health care facilities.

3. What Remediation Methods Should Be Used?

There is a need to investigate the utility of air blowing, which is commonly employed on larger remediation projects as a final step in the cleaning process.

There is a need to address whether there are any options available for porous materials other than removal, or to address more comprehensively the means by which items might be cleaned and demonstrated to be clean.

The Task Force recommends further study on how to handle mold behind vinyl wall covering (mold between gypsum and vinyl wall covering).

More research is needed to assess the value of duct cleaning.

4. Should Biocides Be Used In Remediation?

More empirical testing is needed to provide sufficient details on the advantages, disadvantages, or effectiveness of the use of biocides during remediation, and to provide more information on the relative merits of one biocide over another.

5. Under What Circumstances Should Buildings Be Evacuated and Work Areas Isolated?

There may be a need to develop a comprehensive risk assessment model for remediation of fungal contamination to minimize the subjectivity involved in a decision to evacuate a building. However, professional judgment by a qualified medical/environmental health team will likely always be required.

6. How Should Remediation Work Areas Be Isolated?

   Innovation in devising isolation techniques is encouraged rather than strict adherence to the NYC DOH guidelines.

7. How Should Water-Damaged Content Items Be Treated?

   There is a need to investigate existing methods further and possibly to devise others to determine if a porous content item is contaminated when mold growth is not visible and to clean contaminated items effectively, if possible.

8. What Quality Assurance Principles Should Be Followed To Ensure That Mold Remediation Is Successful?

   In documenting that the amount of surface dust does not indicate a need for recleaning, the proposed gravimetrically based criterion needs further assessment.

9. What Personal Protective Equipment (PPE) Are Recommended During Bioremediation?

   More research is needed to determine what minimal level of fungal contamination would justify optional PPE use.

   Guidelines for remediation should address the need for PPE in the cases where biocides are used.

10. Is Personal Air Sampling Appropriate To Determine Worker Exposure During Mold Remediation?

   Research to assess the need for and to select appropriate methods for personal sampling is encouraged to facilitate the assessment of individual risk.

   Research also is needed to determine if methods other than air sampling (such as swabs on protective clothing) may also be appropriate during mold remediation.

11. What Medical Evaluation Is Recommended For Remediators?

Additional research is needed to determine microbial exposure to remediation workers (i.e., personal sampling methods) in order that accurate medical tests can also be developed to assess the biological effects of exposure and to determine the causative link between exposure and disease.

The Task Force also recommended that this report be made available on the AIHA Web site, and that one or a combination of AIHA's technical committees (e.g., IEQ or Biosafety) be charged with the task of continuing to address knowledge gaps by reviewing and/or developing new guidelines and educational materials for AIHA members and others.

3. WHEN SHOULD MICROBIAL GROWTH FOUND IN OCCUPIED BUILDINGS BE REMEDIATED?

Review of Current Guidance

All the currently available consensus guidance documents agree that amplification, i.e., "growth" of mold on building surfaces, requires remediation. They also agree that the sources of moisture/water damage that permitted the growth of mold must also be eliminated.

The New York City Department of Health (NYC DOH, 1993 and 2000) Guidelines, International Society of Indoor Air Quality and Climate (ISIAQ, 1996) document, and the American Conference of Governmental Industrial Hygienists (ACGIH, 1999) book specify the quantities of microbial growth (in terms of affected building surface area) which can be remediated by routine building maintenance personnel, and those which require specially trained personnel, isolation techniques, and personal protective equipment. The clear implication is that all microbial growth and their causes (moisture/water damage) require remediation. The guidance documents generally agree that the selection of specific remediation methods should be based on factors specific to each situation. Key among these factors is the extent of microbial contamination (see Section 4, What Amount(s) of Mold Should Indicate What Degree of Remediation?), the types of occupancy (e.g., residential, office, public buildings), and the potential for exposure. These factors will affect the degree of control employed (including engineering controls and personal protective equipment) needed to minimize exposure to building occupants and/or remediation workers.

Information Gaps

Two important issues are not addressed comprehensively in existing guidelines:

- "Hidden" versus visible mold, or mold growth that may be present in visually inaccessible spaces but may still pose potential exposure risks; and
- Remediation of dusts that may contain microorganisms, spores, hyphal fragments, toxigenic substances, or other antigenic materials.

The Health Canada (1995) document is the only one to devote any specific attention to the issue of searching normally inaccessible spaces to identify the potential presence and extent of mold growth. This document includes discussions on how to check behind wall cavities and within ventilation ducts. Other guidance documents only address *visible* mold on furnishings and/or building materials or in heating, ventilating, and air-conditioning (HVAC) systems.

None of the current guidance documents address the dissemination mechanisms for potential hidden mold impaction that could result in occupant exposures to fungal propagules within a building. Specifically, there is no discussion of building pressurization relationships that could produce air movement resulting in the development of dissemination pathways from hidden microbiological reservoirs and an occupied area. Moreover, these documents do not address the “sink” theory of exposure, which postulates that a low rate of infiltration from contaminated wall cavities may result in migration of mold spores into porous indoor surfaces such as carpets and furnishings. The concern with this migration is that, over time, significant accumulation of spores may occur, and disruption of the reservoirs may result in occupant exposures.

Discussion/Recommendations

Frequently, it is within the wall cavity that filamentous molds first begin to grow. This is particularly true when the source of moisture is leakage through the building’s envelope. When moisture conditions permit, staining and/or mold growth may penetrate through to the interior side of the wall. Other times, mold growth may be undetected indoors. Epidemiological studies suggest that one of the best predictors for health impact in damp buildings is the *quantity* of mold present, both visible and hidden within walls (Dales et al., 1997).

The types of building materials and construction techniques affect the susceptibility of a micro-environment to support mold growth. These factors may retard or enhance the growth of mold within wall cavities, i.e., hidden mold. One significant factor is the particular susceptibility of the building materials to biological degradation. Fibrous glass-surfaced exterior gypsum wallboard will be more resistant to mold growth than exterior rated gypsum wallboard, which itself is more resistant to mold growth than interior rated gypsum wallboard. Gypsum wallboard is more susceptible to mold growth than lath and plaster due to its hygroscopic nature. The presence of vapor barriers may retard mold growth by isolating certain wall components from moisture. However, or under different conditions, these barriers may trap water and allow it to accumulate, exacerbating mold growth. As one example, the presence of interior molding may provide sufficient resistance to evaporation from the wall system to the interior of the building that the space between the interior molding and the gypsum wallboard may be the first interior space to permit the growth of filamentous mold.

A careful visual inspection of the interior portions of a building suspected of in-wall mold growth is the first step in the assessment process. The investigation must pay close attention to the presence of staining, particularly at corners and at floor level. In addition to visual surveys, moisture meters calibrated for gypsum wallboard may be used. However, the investigator must exercise caution, since the meter will not find current growth with limited moisture microclimates.

The visual inspection of suspect locations within wall cavities based on hypotheses generated by the above techniques can be useful in definitively documenting the existence of mold contamination and its extent. An example of a detailed protocol that may be useful has been included as Appendix 4. Inspection alternatives include the application of a boroscope, the use of an inspection mirror with an illuminating light source to view the back of gypsum wallboard, or the simple removal of wallboard. The applied technique is determined by the wall construction, e.g., boroscopes may prove impractical with insulation present, and the cooperation of the building manager/owner. However, it should be noted that these actions are invasive (i.e., destructive to the wall surface) and allow for the possibility of fungal spore release into the occupied areas.

In-wall sampling of mold spores has been suggested, using a small hole and tubing attached to a vacuum pump. It is difficult to interpret such tests, as the sensitivity and specificity under various conditions are unknown. What effect might the presence of insulation or a vapor barrier within the wall have on results? If the access hole is made through a section of wallboard with mold on the surface opposite of the interior exposed side (i.e., hidden), can this result in a positive bias, and if so, by how much? Most important, is there any correlation between the findings from such a test and the quantity of mold present in the wall? Because a positive finding in such a test will require opening the wall for inspection, what would be the purpose of such testing?

These concepts, which are consistent with Health Canada's “extraordinary physical search” approach for hidden mold, deserve greater discussion in current guidance documents. There is a need to identify when it is necessary to search normally inaccessible spaces to identify the potential presence and extent of hidden mold growth. Additionally, much of the concern regarding hidden mold is based on the assumption of the dissemination of mold reservoirs, i.e., infiltration, from “hidden” sinks, areas in ventilation systems, or from indoor reservoir materials. More research is needed regarding the potential for infiltration and the estimation of infiltration rates.

A review of the history of water intrusion may be very valuable in determining that the level of remediation should be applied prior to initiation of the remediation activity. This information may result in escalation of the level of remediation warranted for the project.

4. WHAT AMOUNT(S) OF MOLD SHOULD INDICATE WHAT DEGREES OF REMEDIATION?

Review of Current Guidance

All the current consensus guidance documents recommend that microbial growth be eliminated, along with the sources that led to its generation (moisture/water damage). A set of guidelines developed by NYC DOH in 1993 was the first to recommend a 30 square feet (ft^2) surface area (approximately the size of a single gypsum board panel) as an approximate "indicator" indicating a need for special abatement personnel and isolation techniques. Microbiological contamination covering less than 30 ft^2 is suggested to be addressable by appropriately trained maintenance personnel. Health Canada (1995) and the ISIAQ (1996) later adopted essentially this same approach. The New York City Department of Health reiterated it in 2000.

ISIAQ (1996) states that "The urgency with which cleanup is accomplished is greatest if the molds present on contaminated surfaces are toxigenic (e.g., *Stachybotrys atra, Aspergillus versicolor, or Fusarium moniliforme*)." The ACGIH Bioaerosols Manual (1999) also suggests that materials contaminated with potentially toxigenic fungi should be given the highest priority for removal (i.e., they should be removed before other work begins). The NYC DOH Guidelines (2000) have been expanded to include all fungi (not just known mycotoxin producers) because of the presence of mycotoxins in many fungi other than *Stachybotrys chartarum,* because of the risk that remediation personnel may develop organic dust toxic syndrome (ODTS) from a single heavy exposure, and because fungi can cause allergic reactions.

ISIAQ (1996) further asserts that containment precautions are warranted if persons who are immuno-compromised or have asthma or other respiratory conditions reoccupy the area. ISIAQ (1996) also emphasizes the presence of visible mold on HVAC systems as potentially more serious than in occupied spaces because the contamination is hidden from view and spores can be directly transmitted to occupant breathing zones.

For residential environments, the potential for exposure occurs 24 hours per day and may include very sensitive people (e.g., the elderly and infants); while typical workplace exposures are 8 to 10 hours. Additionally, residences are not typically equipped with ventilation systems that introduce a predetermined amount of outdoor air (as per ASHRAE recommendations for buildings) that could result in an increase in the indoor contaminant concentration over time.

Public buildings may create exposures of very minimal duration for the client population, but also serve as workplaces. The NYC DOH (2000) and ACGIH (1999) documents do not specifically address these differences, nor do they distinguish the general population from healthy workers. The Health Canada document is presumably applicable only to public buildings, based upon its title. The AIHA (1996) document discusses individuals at risk, distinguishing susceptible persons from persons simultaneously exposed to other toxic agents. AIHA (1996) suggests that atopic persons react more intensely to bioaerosols. If an immune-mediated response is postulated, then the duration of exposure may be less significant.

The NYC DOH (1993) document emerged as a *de facto* standard, although it has no formal risk-derived basis. Except for some very general comments, the square footage recommendations from the New York City Health Department did not discuss factors such as the degree of accessibility of the mold growth area to building occupants or the presence or absence of mold particles in the air stream.

The revised NYC DOH (2000) document allows increased flexibility in the interpretation of the "indicator," but warns, "Any changes to the remediation methods listed in these guidelines, however, should be carefully considered prior to implementation."

Information Gaps

Health care facilities are special cases, and guidelines appropriate for other environments may not be applicable to hospitals due to the sensitivity of patients to pathogenic fungi such as *Aspergillus fumigatus.* Many of the documents intermingle these issues. For example, AIHA (1996) talks about house dust endotoxins and worker protection. The Veterans Administration has recently developed a set of guidelines (VA, 1999) regarding recognized and emerging infectious nosocomial diseases and design considerations given to the built environment. However, this document is not commonly available to the general public.

The Task Force identified numerous questions related to existing guidelines that still complicate decision-making when microbiological growth is found in buildings. Some of these questions are:

- How should visible and hidden mold growth be included in "indicator" criteria for the extent of remediation?
- Should the "denominator" (i.e., the total square footage of wall area) be considered along with the "numerator" (i.e., the mold-contaminated surface area)? Should the density of mold coverage be considered?
- Are there any conditions under which mold within wall cavities can be allowed to remain? Would this be affected by such factors as building pressurization and construction details such as the presence of a vapor barrier?

- Would criteria for inside-the-wall materials change if those materials were mold propagules from a secondary source rather than direct mold growth within the cavity?
- To what extent should cost be considered in justifying the conduct and degree of dust removal?
- To what extent should current criteria be required to rely on more formal risk-based factors in order to prevent unnecessary abatement?
- Since it is costly to remove such dusts, removing them needs to be justified.
- Guidance is needed for situations in which interim measures may be needed if remediation costs must be phased in over time.

Discussion/Recommendations

Fungal growth (or amplification), regardless of species, in a building should be eliminated as rapidly as possible, along with the source of the water. With the current level of knowledge, it seems prudent to include hidden mold growth as an indicator given the potential for exposure and given the potential for the decay of building materials. The question of whether the density and extent of fungal growth should be factors in indicating remediation has not been answered; however, the Task Force did agree that density and extent of growth determine the containment procedures during remediation (see Section 8-How Should Remediation Work Areas Be Isolated?).

The question of whether material (inside a wall) that is contaminated with fungal propagules from a secondary source should be an indicator for remediation has not been answered. Some of the other identified questions related to existing guidelines have been addressed, in part, in Section 3-When Should Microbial Growth Found In Occupied Buildings Be Remediated? Other points can only be addressed on a case-by-case basis. For example, questions based on the cost to conduct certain remediation activities can ultimately only be decided upon by the individual(s) providing the funds, which could include the owner and/or the insurance carrier. Regardless, additional research is needed to enhance the basis for remediation decision-making (which should include some form of a cost-benefit analysis) in the field for industrial hygienists and others. As more epidemiologic data are collected, the use of a formal risk assessment model may eventually become possible.

The Task Force agreed that surfaces that have supported previous mold growth require a lesser amount of moisture/water for growth to resume, when compared to surfaces that have not experienced mold growth (Adan OCG, 1994). Thus, previously contaminated surfaces are more vulnerable to consequent mold growth following remediation than original surfaces of identical material.

The collection of settled dust samples can be useful in identifying hidden "sinks" and reservoirs of contamination, i.e., carpets. Many practitioners may be confusing samples of settled dust on surfaces or in carpets with samples of micro-environments conducive to mold growth. The difference between them must be clear. Settled dust samples provide information as a “passive sampler” might, reflecting airborne concentrations over a period of time. While not ideal, such samples avoid some of the false negative problems associated with air sampling. They provide more information than air sampling alone. Samples of micro-environments conducive to mold growth, on the other hand, should not be interpreted as indicative of building contamination by fungal propagules. This mistake could occur, for example, when samples are taken at the base of windows where localized condensation might occur, or on a leaky ceiling tile, or under a leaky water heater. These would not be equivalent to settled dust samples. Microscopic examination of cellophane tape samples taken on porous materials is useful in distinguishing fungal colonies from phylloplane spores that normally settle on surfaces (Morey, 1999).

Healthcare Environments

There is a need for clearer guidance regarding buildings with unusual occupants, such as health care facilities. Studies conducted by the Centers for Disease Control and Prevention have estimated the national rate of nosocomial infections (all patients admitted to hospitals for reasons other than infections) to be approximately 5 percent (CDC, 1970). Designing the patient environment to reduce the ambient microorganism concentration has been shown to reduce the incidence of nosocomial *Aspergillus* infections. The effective management and control of bioaerosols in these types of environments (e.g., hospitals) requires a comprehensive understanding of the possible antigenic or infectious nature of microorganisms, the susceptibility of the host, and the ability of the investigator to predict dissemination pathways based on the available information.

The diversity of health effects (immunogenic or infectious) of microbiologic agents in the hospital environment dictates a multidisciplinary control approach that includes infection control personnel, biosafety officers, and industrial hygienists. Infection control personnel focus primarily on nosocomially acquired infections through the activities of an infection control program. At times issues related to chemical or biological hazards other than nosocomial control are coordinated through the biosafety officer and/or industrial hygienist. Responsibilities of the various disciplines may overlap in certain situations. A typical example includes the recognition, evaluation, and control of microbiological contamination in a hospital ventilation system. In this example, an epidemiologic assessment may indicate a cluster of cases of aspergillosis among patients. Environmental investigation confirms the presence, amplification, and dissemination of microbiological reservoirs. Subsequent interaction with the engineering staff can then foster solutions that (1) protect the workers and patients during remediation activities and (2) prevent the recurrence of similar events.

5. WHAT REMEDIATION METHODS SHOULD BE USED?

Review of Current Guidance

Almost all of the current guidance documents agree on the following goals of microbial remediation:

1) Correct the original moisture problem(s) that precipitated the microbial problem;
2) Remove moldy materials (i.e., frank, or visible mold growth); and
3) Remove dusts that may contain accumulated microorganisms, spores, and toxigenic materials.

The AIHA document does not address remediation methods. In addition, most of the documents recommend that filtration be improved in HVAC systems as a preventative measure.

According to ACGIH, the "identification of the conditions that contributed to microbial proliferation in a building is the most important step in remediation." All the documents agree that correcting the problem is essential to prevent reoccurrence. This may involve repairing leaks or infiltration, improving the operation of the HVAC system, pressurizing the building, and/or correcting drainage problems.

All of the current guidance documents agree that moldy materials should generally be removed, although, in some cases, they suggest cleaning as an alternative. The ACGIH (1999) document notes that semi-porous materials, the primary example being wood, can be cleaned effectively if the integrity of the wood has not been compromised. Morey *et al.* (1999) state that "wood that is sound with the exception of colonization of the outer layers of wood cells (approximately 1 mm depth) may be sanded, planed, refinished, and reused." The NYC DOH (2000) document asserts, "moldy materials that cannot be cleaned be removed," but it does not provide guidance on what or how to clean. Health Canada (1995) asserts that carpet, insulation, and porous wall and ceiling panels cannot be effectively cleaned because "there is no way to determine if fungal growth has been eliminated." ISIAQ (1996) recommends discarding soft furnishings (carpet, insulation, paper products, clothes, and upholstered furniture) because even after cleaning and disinfection, allergens and toxic debris may remain. Each of the documents, with the exception of NYC DOH (2000), offers comparable advice on specific materials (e.g., OSHA [1995] on carpet and ceiling panels, and ISIAQ [1996] on wood).

There is consensus that nonporous surfaces that may have been affected by microbial growth should be thoroughly cleaned; however, opinions differ regarding how to clean such surfaces. NYC DOH (2000) and ISIAQ (1996) recommend that nonporous surfaces near the removed materials or inside a containment structure be HEPA-vacuumed, wet wiped, and wiped with a 10 percent bleach solution. ACGIH (1999) and Health Canada (1995), however, recommend against the use of bleach or other biocides (see section on biocides), except in unusual circumstances. Several of the documents suggest encapsulation of remaining surfaces as a preventative measure; however, none suggest encapsulation as a substitute for a thorough cleaning. There is at least one product currently marketed as an encapsulant designed for use on hard surfaces that have not been cleaned and on porous materials, but the effectiveness of this product is unknown to the Task Force.

Information Gaps

None of the current guidance documents address a procedure that is commonly employed on larger remediation projects as a final step in the cleaning process: air washing. This procedure entails the use of aggressive air movement (such as the use of leaf blowers) to move settled dust into the air column so biogenic materials can be filtered out by the HEPA-filtered negative air system.

None of the documents, alone or in concert, adequately address whether there are any options available for porous materials other than removal, or the means by which items might be cleaned and demonstrated to be clean.

Although there is consensus on the need to clean contaminated HVAC systems, not all of the documents specifically address HVAC components. ACGIH (1999) and NYC DOH (2000) recommend removal of all contaminated porous materials in HVAC systems. ISIAQ (1996) recommends that nonporous components of air handling units be cleaned by mechanically scrubbing with a detergent, treating with a biocide, and removing the biocide before the area is reoccupied.

There are conflicting recommendations regarding the use of biocides in the available guidance documents.

Recommendations

The guiding principles in remediation are as follows: a) identify and correct the original moisture problem(s) that caused the fungal growth; b) remove moldy porous materials and remove semi-porous and nonporous materials whose integrity has been compromised; c) clean contaminated surface layers of otherwise sound semi-porous materials; and d) remove the remaining dusts that may contain accumulated microorganisms, spores, and toxins. Correcting the moisture problem may involve repairing leaks or infiltration, improving the operation of the HVAC system, pressurizing the building, and/or correcting drainage problems. Fungally contaminated surface layers of otherwise sound wood should be removed mechanically—sanding, planing—and refinished. Nonporous surfaces that may have been affected by microbial growth should be thoroughly cleaned by HEPA vacuuming and scrubbing with water and a surfactant. Biocides need not be used in many circumstances where hand scrubbing with a damp cloth and surfactant is effective. However, a 10% (at the maximum) bleach solution may be considered carefully by the industrial hygienist for those surfaces where the hand scrubbing is not effective in removing the mold growth. The remediation strategy must avoid the dispersal of contaminated materials to occupied areas of a building (see Section 8—How Should Remediation Work Areas Be Isolated?). All fungally contaminated materials should be sealed in plastic and disposed of in a sanitary landfill.

If the structural integrity of a material has been compromised, replacement is the only recourse. Small, localized patches of fungal growth that affect only the surface layers of the material may be amenable to effective cleaning. For example, a six-square-inch patch of mold on painted gypsum board created through water condensation resulting from thermal bridge issues could be easily remediated with damp wiping. This is supported by the NYC DOH (2000) guidelines which state, "The goal of remediation is to remove or clean contaminated materials in a way that prevents the emission of fungi and dust contaminated with fungi from leaving a work area and entering an occupied or non-abatement area, while protecting the health of workers performing the abatement."

NYC DOH (2000) also recommends "Porous materials such as ceiling tiles and insulation, and wallboards with more than a small area of contamination should be removed and discarded." In the case of wood structures, sanding may also be an appropriate supplemental technique. More widespread contamination would require material removal.

The Task Force recommends further study on how to handle mold behind vinyl wall covering (mold between gypsum and vinyl wall covering, i.e., one example of hidden mold).

The value of duct cleaning is in question. It is suggested that ducts should be cleaned only if there is substantial mold growth or dust accumulation. A fine layer of dust is not a reason to clean ducts for mold growth.

6. SHOULD BIOCIDES BE USED IN REMEDIATION?

Review of Current Guidance

The current guidance documents offer diverse and sometimes conflicting recommendations regarding the use of biocides. They only agree that biocides should be used only, if at all, after all moldy materials and settled dusts are removed.

NYC DOH (2000), ISIAQ (1996), and OSHA (1995) recommend wiping all affected nonporous surfaces with a 10% bleach solution following removal of moldy materials and surface cleaning. ACGIH (1999), on the other hand, asserts that “application of a biocide would serve no useful purpose that could not be accomplished with a detergent or cleaning agent.” Elsewhere, however, ACGIH (1999) indicates that growth that has occurred in a surface layer of condensation on painted walls or nonporous surfaces (including wood) can sometimes be cleaned by washing with a dilute solution of biocide and detergent. Health Canada (1995) recommends that the use of biocides is “generally discouraged because of the potential toxic effects…however…[it] may provide a valuable adjunct to cleaning procedures.” ISIAQ (1996) also recommends that biocides be used in air handlers following a thorough cleaning of nonporous components.

Information Gaps

None of the documents provide sufficient details on the advantages, disadvantages, or effectiveness of the biocides, nor do any provide information on the relative merits of one biocide over another.

Recommendations

The use of bleach or other biocides is questionable in most instances. The effectiveness of bleach in reducing allergenic and toxigenic materials in remediation work has not been demonstrated. Also, the effectiveness of bleach in reducing viable fungi is highly dependent on concentration, residual chlorine levels, and contact time, and these factors can seldom be controlled effectively. Finally, the use of bleach involves a potential occupational risk that must be addressed through engineering controls, work practices, and personal protective equipment. These factors severely limit the applicability of bleach in remediation projects.

Some practitioners recommend the application of chlorine dioxide to remaining semi-porous surfaces such as concrete, but the risks posed by the application of this highly hazardous material suggest strongly against this approach. Also, it is not known to what extent chlorine dioxide removes the risks posed by residual biogenic materials. Chlorine dioxide should be viewed as a disinfectant with very limited applicability, if any, in microbiological remediation.

7. UNDER WHAT CIRCUMSTANCES SHOULD BUILDINGS BE EVACUATED AND WORK AREAS ISOLATED?

Review of Current Guidance and Information Gaps

Most of the current guidance documents provide a general recommendation for evacuating or isolating affected areas of a building based on the principles that: (a) occupants must be protected from the higher airborne levels of fungal materials that may arise during a remediation (ACGIH [1999], NYC DOH [2000], and Health Canada [1995]); and (b) occupants who experience adverse health effects caused by exposure to fungal materials should be removed from the area immediately, until remediation is complete (OSHA [1995], NYC DOH [2000]). The means by which (a) is achieved are discussed under Section 8—How Should Remediation Work Areas Be Isolated?

Only NYC DOH (2000) provides specific guidance on when a building should be evacuated as follows:

1. "Except in cases of widespread fungal contamination that are linked to illnesses throughout a building, a building-wide evacuation is not indicated."

2. "Infants (less than 12 months old), persons recovering from recent surgery, or people with immune suppression, asthma, hypersensitivity pneumonitis, severe allergies, sinusitis, or other chronic inflammatory lung diseases…should be removed from the affected area during remediation. Persons diagnosed with fungal-related diseases should not be returned to the affected areas until remediation and air testing are completed."

3. "A trained occupational/environmental health practitioner should base decisions about medical removals in the occupational setting on the results of a clinical assessment."

A comprehensive risk assessment model for remediation of fungal contamination would remove a portion of the subjectivity of a decision to evacuate a building. However, professional judgment by a qualified medical/environmental health team will likely always be required.

Information Gaps

- Previous documents have not addressed issues with liability of the remediation contractor for occupant health effects resulting from release of contaminants during contractor activities when the occupants were not removed from the area.

Recommendations

The NYC DOH (2000) guidelines as delineated above offer a meaningful basis for making a decision on the evacuation of a building or work area. The professional judgment of an occupational/environmental health care practitioner and an environmental health professional, both experienced in the recognition of risk factors associated with exposure to fungal aerosols in dusty environments, are of paramount importance in correctly applying these guidelines. The OSHA General Duty Clause, which directs employers to provide a safe and healthy work environment for their employees, should also be used as a guide for industrial hygienists or other environmental health professionals with relevant experience in making decisions on evacuation.

8. HOW SHOULD REMEDIATION WORK AREAS BE ISOLATED?

Review of Current Guidance and Information Gaps

The AIHA Field Guide for the Determination of Biological Contaminants in Environmental Samples (1996) document does not address isolation of remediation areas. The other guidance documents recommend that remediation work be performed so as to minimize the spread of fungal materials outside the vicinity of the work. NYC DOH (1993) took this concept and articulated several "levels of abatement" (i.e., degrees of containment) based on the amount of moldy materials and whether or not the HVAC system is contaminated. The 1993 NYC DOH guidelines had four levels, and the 2000 NYC DOH guidelines have 5 levels: I; II; III; IV; and V. The 1993 NYC DOH guidelines appear to have been endorsed by ISIAQ (1996) and ACGIH (1999), with a caveat indicating that professional judgment should be used in categorizing affected spaces. Health Canada (1995) and OSHA (1995) are silent on the issue of containment.

According to the NYC DOH (2000) protocols, as the amount (surface area) of moldy materials increases, the degree of containment should increase. This approach provides specific procedures for containment based on the amount of microbial growth present (measured as surface area of microbial growth-contaminated material). It has been suggested that this approach may limit the ability of the industrial hygienist or building professional to apply professional judgment which in turn could result in a greater degree of care and expense than would be sufficient to solve the microbial contamination problem and to protect the occupants and workers, particularly when more than 30 square feet of surface area are affected.

Containment of dusts is the primary goal of the various types of containment systems. Engineering controls such as critical barriers, polyethylene sheeting on horizontal surfaces, and negative pressure systems should be recommended based on the nature of the contamination, the use and configuration of the space, and occupancy considerations. ACGIH (1999) seems to support a flexible approach by recommending that the level of containment should also be based on the fungal taxa, the type of contaminated material, and the location of the affected area.

Information Gaps

- Specific guidance is needed to decide whether full abatement procedures can be safely waived (e.g., the area is vacant and/or enhanced dust control or expanded cleaning is used).

Recommendations

The industrial hygienist (or other environmental health professional) should use professional judgment to ensure the containment of dusts and the protection of remediation workers. Innovation should be encouraged rather than strict adherence to the NYC DOH (2000) guidelines. The professional should keep in mind the practical significance of the "square-footage" guidelines and not focus on the specific number. Level I (10 ft^2or less) applies to objects that can easily be removed with minimal disturbance of the environment, e.g., ceiling tiles, small areas on walls. Level II (10-30 ft^2) applies to the removal of objects as large as individual wall panels, which offer the potential for the generation of significant aerosol levels. Level III (30-100 ft^2) applies to the removal of several wall panels, greatly enhancing the potential for the generation of aerosol, but on a scale that can be controlled by simple containment and dust control. Level IV (>100 ft^2or activities that are expected to generate heavy dust levels) calls for measures similar to those used in asbestos abatement. This classification may be used in smaller areas where remediation activities include, for example, abrasive cleaning of contaminated surfaces or demolition of plaster walls or where mold blankets the surface of building materials). Level V is reserved for remediation of HVAC Systems and is divided into two groups: a small isolated area (10 ft^2 or less); and areas of contamination (> 10 ft^2).

9. HOW SHOULD WATER-DAMAGED CONTENT ITEMS BE TREATED?

Review of Current Guidance and Information Gaps

None of the consensus guideline documents specifically address the issue of the treatment of water-damaged content items. Content items within a commercial building typically include furniture, fixtures, paper records, books, or similar items. In a residential environment content items may also include clothing, art, kitchen equipment, and both small and large appliances. These items could become mold-damaged via two mechanisms, direct and indirect.

Content items that have become water-damaged or have sustained extended exposure to high humidity environments may support fungal and/or bacterial growth. Such items provide a hospitable environment for biological growth, including food and moisture necessary for growth and sporulation. For discussion purposes, this will be referred to as direct biological contamination. Indirect biological contamination may also occur to content items from the presence of these items in indoor environments adjacent to water-damaged building materials. Under these conditions, release of fungal propagules or other biological particulate that settle on content items would potentially cause indirect contamination.

The ACGIH (1999) Guidelines suggest that portable, handheld moisture meters can be employed during the walk-through investigation to identify potential biological growth areas. However, it appears that the intent was to apply these devices specifically on water-impacted building materials. General recommendations subsequent to flooding include the drying of water-damaged materials within 24 to 48 hours and the discarding of sewage-contaminated porous materials. These recommendations could be applied to content items as well as building materials. Like ACGIH (1999), the ISIAQ (1996) document takes a generic approach to the treatment of water-damaged content items but includes them under the categorization of soft porous materials. Water damage alone is not sufficient to effect remediation protocols; however, these impacted materials must show evidence of fungal contamination as well.

Materials damaged by sewage-contaminated water are not addressed satisfactorily in any of the consensus guidance documents. However, the Institute of Inspection, Cleaning, and Restoration (IICRC) published the second edition of the *Standard and Reference Guide for Professional Water Damage Restoration* (IICRC, 1999). This document was intended to establish a procedural standard for the restoration of water-damaged materials, including materials damaged by sewage-contaminated water, based on research and experience. The standard is applicable to residences, buildings, and other structures.

The commentary presented for the treatment of moldy materials in the Remediation Methods section also applies to the treatment of mold-damaged content items. As stated in Remediation Methods, ISIAQ (1996) specifically recommends that soft, porous furnishings that are microbiologically contaminated be discarded. ISIAQ (1996) contends that cleaning and disinfecting cannot ensure the removal of allergens and potentially toxic debris. Health Canada (1995) also contends that fungally contaminated porous materials cannot be effectively cleaned because the remediation of fungal growth cannot be verified. Despite recommendations against it, cleaning contractors routinely treat porous content items.

The cleaning methods for nonporous items that are recommended by ISIAQ (1996) would also apply to nonporous content items. The materials are to be HEPA-vacuumed, wet wiped, and wiped with a 10 percent bleach solution. However, ACGIH (1999) and Health Canada (1995) recommend against the use of bleach or other biocides. NYC DOH (2000) recommends cleaning using a detergent solution.

Another issue that has not been specifically addressed by the primary sources of remediation methods is the determination of whether or not a porous content item is contaminated when mold growth is not visible. If for example an item is contaminated indirectly with fungal propagules, some test of the extent of contamination would be necessary to allow a decision to be made by the remediator as to whether the content item can be returned without "re-contaminating" the building. The re-introduction of contaminated content items that have not been adequately cleaned may introduce fungal propagules and other allergens into an area previously released for reoccupancy.

Upholstered items, clothing, and other porous items cannot be reliably evaluated for indirect contamination by either a swab or tape-lift approach. Use of liquid-based recovery systems for recovering fungal propagules from porous items has not proven to be reliable in field collection assays. Agitation of porous content items within a clean environment followed by air sampling has been used by some remediators to determine contamination status of content items, as has dust (vacuum) sampling. Quantitative dust protocols usually involve vacuuming dusts from a surface either into an air sampling cassette or into a small bag, i.e., thimble, filter designed to be used with a standard vacuum cleaner (AIHA, 1996). These techniques are described in Appendix 5.

Discussion/Recommendations

In both direct and indirect contamination conditions, direct skin exposure of occupants to biological materials could occur as a result of handling these items; airborne exposure could occur as a result of agitation and release of biological particulates from these items consequent to use or handling. The uncertainty that surrounds health effects of exposure to fungal and/or bacterial contamination in environments with moisture-damaged building materials carries through to exposures resulting from content contamination. Exposures within the micro-environment surrounding an individual resulting from their personal activities may represent higher exposures than are typically indicated by area monitoring. In the case of content items, such exposures might be associated with bouncing on an upholstered couch, or other common activities such as holding a stuffed animal close to the face.

Water-damaged nonporous content items in fungally contaminated areas can be reliably tested for contamination, and contamination can be efficiently removed. Surface sampling on content items is a practical method of testing nonporous surfaces. Swab sampling a known area of a nonporous surface followed by culture analysis is probably more sensitive than the use of tape lift samples because the area swabbed can vastly exceed the area covered by a tape sample. The AIHA (1996) Field Guide discusses the issues of limits of detection and quantitation. Quantitative dust sampling by vacuuming as described in Appendix 5 may also be used. If an investigator/remediator uses surface sampling to assess an indoor environment, then it would follow logically that the criteria used to judge the extent of contamination could be similarly applied to nonporous content items to assess contamination. It would also follow that any criteria established for surface cleanup following remediation (see "Quality Assurance Following Mold Remediation") could be used for evaluating nonporous content items, assuming a similar mechanism were postulated for the contamination of both surfaces and content items. Remediation of nonporous surfaces is straightforward. The materials should be HEPA-vacuumed and wet wiped. A wet wipe with 10 percent bleach is unwarranted although a surfactant may facilitate cleaning.

Consistent with the primary sources of remediation methods, visibly contaminated porous items should be discarded, except in rare cases where the value of the item warrants extraordinary means of decontamination and restoration, e.g., works of art or valuable records. Porous items that may be contaminated with fungal propagules but do not show visible contamination present an enigma in that the reliability of detection and removal of contamination is suspect. Such items may be better evaluated using a quantitative dust protocol, or by measuring liberated biological dusts following aggressive agitation of the content item within a biological particle-free containment. (See Appendix 5.) However, the reliability of these techniques for nonporous content items has not been firmly established and should be further evaluated.

10. WHAT QUALITY ASSURANCE PRINCIPLES SHOULD BE FOLLOWED TO ENSURE THAT MOLD REMEDIATION IS SUCCESSFUL?

Review of Current Guidance Documents and Information Gaps

Although the guidance documents that address remediation (ACGIH [1999], ISIAQ [1996], NYC [2000], and Health Canada [1995]) offer some guidance on ensuring that mold remediation is conducted properly, basic remediation quality assurance (QA) principles are not thoroughly discussed. The remainder of this section is a recommendation on the guiding principles that should be used to govern quality assurance and specific recommendations on procedures that can ensure that a remediation has been successful.

Discussion/Recommendations

Basic Remediation Quality Assurance (QA) Principles

The primary method to assure that a mold remediation has been done properly is confirmation that **the precipitating water or moisture sources have been identified and eliminated** thoroughly, and that all of the affected areas have been physically inspected for mold. For example, if there has been a pipe burst, flood, fire, or storm, all areas where water has been documented can be reasonably suspected to have mold damage. Following physical inspection, air samples and other techniques can also be useful in determining the extent and nature of mold contamination before remediation.

Typically, all materials on which there has been active fungal growth are removed. Solid wood surfaces that have sustained active fungal growth but are not easily removed can be sanded and treated to prevent the release of particles. For other surfaces, case-specific cleaning methods can be devised to ensure physical removal of the material containing fungal growth. “Sinks” of settled spores, including carpets and ceiling tiles, may also need to be removed if they cannot be suitably cleaned. **Appropriate containment** to prevent the increases in settled dusts from fungal spores and debris in the affected and adjacent areas is necessary during remediation. Documenting appropriate containment is a **key QA performance indicator.**

Remediation typically must include a thorough cleaning of accumulated dust or particulates, conducted by appropriately trained crews. It is necessary to **monitor the performance** of the cleaning crew to ensure that every area is cleaned according to the remediation specifications. Documenting that cleaning is performed according to specifications is a **key QA performance indicator.**

Quality Assurance Before Remediation "Build-Back"

Documenting that mold removal has been in accord with the approved remediation plan is a **key QA performance indicator**.

Documenting that the remediated areas were checked for any remaining un-remediated mold/water damage that may have been revealed during the demolition/cleaning process is a **key QA performance indicator**.

Documenting that the amount of surface dust does not indicate a need for re-cleaning is **a key QA performance indicator**. One method to accomplish may be to determine whether the mass of surface dust per unit nonporous surface area is <100 mg/m^2 on representative surfaces, with sufficient replication to make a statistically valid decision. The National Air Duct Cleaning Association (NADCA, 1992) considers the 100 mg/m^2 level to indicate a clean nonporous surface. ACGIH (1999) cautions that a gravimetric measurement gives no information about the content of the dust, but mycological analysis may also be conducted as described in the next paragraph. Alternatively, one can ensure that residual dust levels are comparable to levels found in a similar but uncontaminated workplace.

Mycological analyses of collected settled dust is secondary; the necessity to do this must be judged on a case-by case basis. Such analyses can be made by dilution or direct plating of the samples on malt extract agar and/or DG-18 (AIHA, 1996 and Dillon *et al*.,1999). The acquisition of such data will be useful to the industrial hygienist or building/engineering proposal community by providing additional benchmarks of contamination for possible use in the future. For example, such analysis may in the future be able to give information on whether mold-damaged materials have been removed in an appropriate way (e.g., if the moldy material was carried out in bags or exposed).

In circumstances when less than an entire floor or building is remediated, it may be useful to take air samples to determine whether any additional sources of mold contamination may have been missed during the initial investigation.

Quality Assurance After Remediation "Build-Back"

Documenting that the remediated space has been HEPA-vacuumed is a **key QA performance indicator**.

Documenting the results of air sampling one to two weeks after the ventilation system has been running normally may be a useful QA performance indicator, by reflecting the status of the remediated areas. Air samples should be done according to the AIHA (1996) Field Guide.

Summary of Recommendations

The principal quality assurance performance indicator is documentation that **the precipitating water or moisture sources have been identified and eliminated** thoroughly, and that all of the affected areas have been physically inspected for mold.

Other recommended **key QA performance indicators** are:

Documenting appropriate containment;

Documenting that cleaning was performed according to specifications;

Documenting that mold removal has been in accord with the approved remediation plan;

Documenting that the remediated areas were checked for any remaining unremediated mold/water damage that may have been revealed during the demolition/cleaning process;

Documenting that the amount of surface dust does not indicate a need for re-cleaning; and

Documenting that the remediated space has been HEPA-vacuumed.

11. WHAT PPE ARE RECOMMENDED DURING BIOREMEDIATION?

Review of Current Guidance Documents

The 2000 NYC DOH and 1999 ACGIH guidelines contain specific requirements for personal protective equipment (PPE). Both documents recommend obtaining professional help for all but the smallest cleanup jobs. These guidelines appear to have been developed on the premise that remediation is always a large project and involves removal of mold-contaminated materials. It does not address PPE for peripheral activities, for example, vacuuming and wiping surfaces as part of a remediation, or as a follow up to a project involving removal of mold-contaminated materials. The ACGIH (1999) document presents a general guide (Chapter 15) for PPE selection, with the caveat that other factors may need to be considered, and professional judgment is required. The discussion of PPE selection also refers back to the 1993 NYC Guidelines. The document is helpful because it begins with an N-95 respirator for small jobs. However, ACGIH (1999) suggests earlier in the document that for the investigator evaluating and sampling small, localized patches of fungal growth, it is possible that PPE may not be required. This same logic may be applicable to small remediation projects conducted by maintenance personnel. The NYC DOH (2000) guidelines recommend consulting with 20 CFR 1910.134 for PPE requirements (OSHA Respirator Standard).

For Levels I through II, from small, isolated areas ($\leq$10 ft^2) to mid-sized areas (10 to 30 ft^2), the NYC DOH (2000) guidelines require gloves and eye protection, and specify that respiratory protection should be selected in accordance with 29 CFR 1910.134. For Level III (large isolated areas of 30 to 100 ft^2), the recommendation is to consult a health and safety professional with experience performing microbial investigations prior to remediation activities to provide oversight for the abatement project. NYC DOH (2000) guidelines also recommend, at a minimum, “personnel trained in the handling of hazardous materials and equipped with respiratory protection (e.g., N-95 disposable respirator), in accordance with 29 CFR 1910.134. Gloves and eye protection should be worn.” This leaves the respirator question open, since 29 CFR 1910.134 states:

> **(d)(1)(i) The employer shall select and provide an appropriate respirator based on the respiratory hazard(s) to which the worker is exposed and workplace and user factors that affect respirator performance and reliability.”**

The respiratory protection standard requires that PPE be determined by the hazard(s) present, and that a hazard evaluation may be needed. Not until Level IV, for areas of extensive contamination and higher (greater than 100 contiguous

ft^2 in an area and remediation of HVAC systems), large areas with high dust potential, are HEPA-filtered full-face respirators and full body covering specified under the OSHA rule.

The minimum specific PPE recommendations are in the ACGIH (1999) guidelines, which start out with an N-95 respirator and gloves for “minimal” fungal growth, adding eye protection and full body covering for “moderate” and “extensive” fungal growth. The reader must rely on “professional judgment” to determine what the level of contamination is and what kind of PPE is needed. These guidelines direct the reader to consult a professional to determine the respiratory protection requirements.

ISIAQ (1996) suggests that cleanup may be conducted by “building personnel provided with proper respiratory protection.” When contaminated surfaces are larger than around 30 ft^2, full containment similar to that used during abatement of hazardous materials is recommended.

The Health Canada (1995) document urges precautions during removal of contaminated materials “should be similar to those followed for cleaning activities” (citation of the 1993 NYC Guidelines). They recommend that “appropriate protective equipment should be used, and removal of contaminated material should be done by trained individuals.” These terms are not defined.

Information Gaps

The guidelines do not address situations where the amount of visible mold is very small (e.g., a small area that can be wrapped and removed) or where remediation does not require removal of materials (e.g., wiping a nonporous surface). This may be because the guidelines were written with experience from, and expectations of, large-scale cleanup projects. Considering that the ACGIH (1999) guidelines provide an exemption to inspectors from having to wear PPE during small-scale sampling (based on professional judgment), it is also reasonable to suggest that very small areas may be cleaned up without PPE. Otherwise, the guidelines for 10 ft^2 (or less) dictate the PPE requirements, i.e., consulting CFR 1910.134 and/or using an N-95 respirator.

The guidelines fail to specifically address the need for PPE in the cases where biocides are used. Although a qualified professional should know when respiratory protection is needed in these cases, notation of the guidelines would be useful for documentation purposes and for the education of other interested parties.

Discussion/Recommendations

Remediation of microbially contaminated building surfaces may reasonably result in the disruption of microbiologic reservoirs. The airborne dissemination of these bioaerosols can result in significant exposures to remediation workers. These aerosols can also spread to uncontaminated areas of a building, pose hazards to occupants and add to the difficulty of cleanup. Therefore, it is important that all remediation activities be conducted with an awareness of the potential bioaerosol exposures and with minimal disturbance of contaminated materials. Specifically, controls must be instituted that protect both the *worker* and the *adjacent environment*.

Remediation workers should use PPE appropriate for the hazards to which they may be exposed. Such decisions require *a priori* awareness of potentially hazardous agents, significant exposure routes (e.g., inhalation, dermal contact, or ingestion), and possible concentrations of the biological materials. For example, disturbance of obvious fungal growth and large accumulations of organic matter (bird, bat, or rodent droppings) can be a significant exposure risk for remediation workers. Even the inspection and/or collection of water samples from operating cooling towers in legionellosis investigations can place investigators at risk of exposure. The first step in risk assessment is a visual evaluation of the possible type and extent of contamination, subsequently leading to a determination of the level of protection needed. For example, remediation work on small, localized patches of mold growth on ceilings or walls may be conducted with appropriate respirators, eye protection, and gloves. The professional judgment of the industrial hygienist reviewing the remediation work will be the determinant on the use of PPE in these cases. In contrast, investigators entering an attic with large accumulations of bird or bat droppings may need full-face, powered air-purifying respirators, disposable protective clothing with hoods, gloves, and disposable shoe coverings.

NIOSH (1994) recommends the selection of an appropriate respirator for protection against particulates consider the following conditions:

- The identity and concentration of the particulates in the workplace;
- The OSHA or MSHA permissible exposure limit (PEL), the NIOSH recommended exposure limit (REL), or other occupational exposure limit for the contaminant;
- The hazard ratio, HR (i.e., the airborne particulate concentration divided by the exposure limit);
- The assigned protection factor (APF) for the class of respirator (APF should be greater than the HR);
- The immediately dangerous to life or health (IDLH) concentration, including oxygen deficiency; and
- Any service life information available for combination cartridges or canisters.

For infectious agents, the identity of the etiologic agent of disease may be known but the determination of the airborne concentration is subject to the existence of an air sampling method. For most infectious agents, methods are not available.

However, technology is evolving. NIOSH published a method (NIOSH Manual of Analytical Methods, Method 0900 [1994]) for the identification of *Mycobacterium tuberculosis* using genetic probes (polymerase chain reaction) collected from air on PTFE filters. The Centers for Disease Control and Prevention (CDC) has periodically employed culturable air sampling techniques to document the dissemination of *Legionella pneumophila* from contaminated water systems. The remaining NIOSH recommended selection conditions are difficult to apply. Exposure limits for infectious agents generally do not exist. However, knowledge of specific parameters of the etiologic agent (such as infectious dose, particle size, and organism viability outside of the host) may be able to be used to establish the health risk of exposure. Subjective decisions may then be applied to determine the appropriate respirator recommendation. A current example is the CDC (1994) specification of filtration performance criteria for protection against occupational exposure to tuberculosis in the health-care industry. Current OSHA policy for occupational exposure to tubercle bacilli permits the use of Part 11 HEPA filter or any Part 84 particulate filter.

For noninfectious concerns, i.e., allergic responses or toxicosis, the available scientific literature regarding the identification of specific etiologic agents and their health outcomes are more limited. As with infectious agents, exposure criteria do not exist. Individuals engaged in microbial remediation projects may be exposed to a variety of agents and concentrations each possessing different health risks that could act individually or synergistically to produce a response in the exposed individual. Additionally, for allergic health endpoints, the genetic predisposition of the exposed person will have an impact on the development of disease. All airborne exposures to microbial agents should be considered to have the potential to initiate an allergic response in the susceptible individual. Without definitive determination of susceptibility, prudent practice dictates the wearing of appropriate PPE whenever known or suspected microbial reservoirs are encountered. The selection of appropriate respiratory protection by a qualified industrial hygienist should consider all potential health outcomes. Consideration of dermal effects associated with exposures to specific microbial agents should be addressed with the use of appropriate protective clothing.

In most circumstances involving mold remediation, a disposable N-95 NIOSH-approved respirator should offer adequate protection provided that the facepiece fits tightly, ensuring that contaminants do not enter through leaks between the respirator and a wearer's face. (The N-95 designation indicates that the filter material has been shown to remove 95 percent of particles greater than 0.3 µm.) The size of airborne fungal spores generally ranges from 1 to 50 µm. Other bioaerosols generally fall within a similar size range. A relatively intense exposure is usually necessary to affect non-sensitized individuals. However, some environments may require a higher level of PPE due to the concentrations of the microbial agents and their disease potential. Lenhart *et al.* (1997) have developed a work practice and PPE selection guideline for remediation workers involved in the removal of material potentially contaminated with *Histoplasma capsulatum*.

The ACGIH (1999) guidelines should be recommended for use by industrial hygienists when they are involved in PPE selection for indoor mold-related problems. They include specific recommendations, but also allow decisions to be made about PPE based on factors (potential for exposure, dust generation, etc.) that vary from one case to the next. A Certified Industrial Hygienist or similarly qualified professional should be consulted during the decision process based on the need to protect workers from the irritating and allergenic effects of bioaerosols during mold cleanup. Protection from these effects should also protect workers from putative toxigenic effects from molds or other bioaerosols. Other factors that can impact the decisions about PPE include consideration of the size and other physical characteristics of the cleanup site, and the availability and use of dust suppression methods. Some situations may allow cleanup to occur with optional PPE use.

The ACGIH guidelines for “minimal” mold contamination do not include eye protection; however, eye protection (preferably goggles) is desirable during any project requiring removal of materials.

12. IS PERSONAL AIR SAMPLING APPROPRIATE TO DETERMINE WORKER EXPOSURE DURING MOLD REMEDIATION?

Review of Current Guidance Documents/Information Gaps

No information is provided by the current guidance documents on the use of personal air sampling during remediation (ACGIH [1999], ISIAQ [1996], NYC DOH [2000], Health Canada [1995]). In response to the "Penny for Your Thoughts" section of the *Synergist*, several industrial hygienists have reported taking personal samples during remediation of fungal contamination in buildings. Primarily, air samples have been taken with filter cassettes or with the Air-O-Cell (Zefon Analytical Accessories, Ocala, Fla.) for microscopic counting of fungal propagules. Apparently, this information has not appeared in peer-reviewed publications. One NIOSH health hazard evaluation reports the personal sampling of ergosterol as a measure of exposures to fungal mass (Weber and Martinez, 1996).

Recommendations

The routine determination of personal exposures of remediation workers to biocontaminants does not seem justified based on existing information. Occupational exposure limits or guidelines do not exist for microbial organisms or agents derived from these organisms, so that comparisons to airborne levels are not interpretable. Nevertheless, fungal spore levels during remediation of heavily contaminated buildings are likely to be high and can approach 10^8 propagules per cubic meter of air (Morey, 1995). As has been stated in the discussion of PPE, the degree of worker protection recommended is not based on measurements of personal exposure but on the potential for exposure. Recommendations appear to be justifiably based on the extent of contamination and on the potential for the generation of dust during remediation activities (ISIAQ [1996], NYC DOH [1993], ACGIH [1999]).

Personal monitoring may not be justified at this time for another reason. Few existing air sampling and analysis methods available are appropriate for personal sampling. A review of methods reports that only a few are sensitive enough for the air volumes that can be sampled with battery-powered personal sampling pumps (Dillon *et al*., 1999).

Filter cassette samples can be examined by several analytical approaches. Microscopic spore counts and ergosterol and perhaps 1,3-beta-D-glucan determinations provide a measure of exposure to fungal biomass. An *in vitro* protein translational assay provides a measure of compounds that interfere with protein synthesis, a primary biological effect of exposure to trichothecenes, potent mycotoxins produced by several fungi including *Stachybotrys chartarum.* However, in the absence of guidelines of exposure to fungal mass or mycotoxins, the concentrations found by these techniques cannot be interpreted. Bacterial endotoxin can be determined by the *Limulus* amebocyte lysate (LAL) methods or by GC/MS. Guidelines for exposure to endotoxin have been proposed for biologically active endotoxin (ACGIH [1999], Rylander [1995]); however, lack of agreement of determinations among laboratories participating in proficiency testing brings the accuracy of the LAL method into question.

Air sampling and analysis methods for *culturable* fungi and bacteria have the sensitivity for personal sampling but cannot be operated by personal sampling pumps and are, in general, too heavy and bulky for mounting on an individual. The primary advantage of these methods is that they can often provide identification of the predominant organisms to which remediation workers are exposed (Dillon *et al*., 1999) and may indicate the presence of hidden mold. Consequently, area air samples taken before remediation might assist in the development of a remediation strategy and also in the appropriate selection of personal sampling equipment. The culturing of bulk samples, including settled dust, may provide similar information. Fixed-point air sampling may also help to determine the extent of contamination of an HVAC system, if visual inspection or bulk sampling have determined that fungal amplification or reservoirs occur in the system. Furthermore, air sampling may be a useful QA performance indicator after remediation as described in Section 10—What Quality Assurance Principles Should Be Followed To Ensure That Mold Remediation Is Successful?

Although there is currently little justification for performing personal sampling during remediation activities, research involving personal sampling is encouraged. The determination of personal exposure doses to biological agents during remediation is necessary to perform epidemiological studies for the assessment of risk. It is only after the assessment of risk that the most appropriate sampling methods can be selected and that the interpretation of exposure measurements can be achieved. Research also is needed to determine if methods other than air sampling (such as swabs on protective clothing) may also be appropriate during mold remediation.

13. WHAT MEDICAL EVALUATION IS RECOMMENDED FOR REMEDIATORS?

Review of Current Guidance Documents

The 1993 and 2000 NYC DOH guidelines discuss specific requirements for medical evaluation and removal of anyone with medical problems that may be aggravated by exposure to microbial contamination. It is implicit that this recommendation applies to remediation workers.

The NYC DOH document notes that individuals with “persistent health problems” should be referred to occupational/environmental physicians with specific knowledge about microbial contamination exposures. The 1993 NYC DOH guidelines contain a discussion of the use of “biological markers” (e.g., in blood samples) for Stachybotrys Atra exposure. However, it was noted that these tests were not readily available or interpretable and should not be used routinely. The 2000 NYC DOH guidelines, in contrast, indicate that “medical tests are not currently available that can document exposure or, except for allergic reactions, causative effects.”

The Medical Removal sections of both NYC DOH guidelines contain a list of the types of individuals who need to be removed from the ‘affected area’ until the remediation and clearance testing have been completed. They recommend that the evaluation be conducted by a “trained occupational/environmental health practitioner.” These individuals include: infants less than 12 months old; persons recovering from recent surgery; and people with immune suppression, asthma, hypersensitivity pneumonitis, severe allergies, sinusitis, or chronic inflammatory lung diseases.

The AIHA *Field Guide for the Determination of Biological Contaminants*, Chapter 2 on “Diseases Caused by Bioaerosols” contains a section on “Prevention” (page 31), which discusses medical recommendations for remediation workers. It notes, “Personal protection also comprises pre-employment medical screening, routine medical surveillance, and education and training programs.” The pre-employment screening is defined as “medical testing” that can be utilized to identify individuals at risk or with potential health problems. The medical tests to be used to identify these individuals are not defined.

Information Gaps

The 2000 NYC DOH guidelines indicate that “medical tests are not currently available that can document exposure or, except for allergic reactions, causative effects.” Additional research is needed in order that accurate medical tests can be developed to document microbial exposure for remedial workers.

Recommendations

The Task Force recommends that the 2000 NYC DOH guidelines regarding medical evaluation and removal be followed for all workers engaged in the remediation of microbial growth. According to these guidelines, the following classes of individuals should not be employed as remediation workers: individuals recovering from recent surgery; and people with immune suppression, asthma, hypersensitivity pneumonitis, severe allergies, sinusitis, or chronic inflammatory lung diseases.

An occupational/environmental physician would make the medical evaluation of the remediation workers and indicate on a written form whether the worker is capable of performing the remediation work.

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APPENDIX 1—AIHA MICROBIAL GROWTH TASK FORCE

Remediation

H. E. Barney Burroughs, CIAQP
IAQ/Building Wellness Consultancy Inc.

Thomas Hall, PhD, CIH (Occupational Epidemiology Committee)
University of Oklahoma Health Sciences Center, College of Public Health

David E. Jacobs, PhD, CIH
U.S. Department of Housing & Urban Development, Office of Lead Hazard Control

J. David Miller, PhD (Biosafety Committee)
Carleton University

Bradley Prezant, MSPH, CIH, CPE (IEQ Committee)
Prezant Associates Inc.

Patrick J. Rafferty, CIH (IEQ Committee)
Clayton Group Services, Inc.

Chin S. Yang, PhD (EMLAC)
P&K Microbiology Services Inc.

Worker Protection

Kenneth Dillon, PhD, CIH (Biosafety Committee)
University of Alabama at Birmingham, School of Public Health

Kenneth F. Martinez, MSEE, CIH (EMLAC)
NIOSH

Coreen A. Robbins, PhD, CIH (Toxicology Committee)
GlobalTox

Linda D. Stetzenbach, PhD (Biosafety Committee)
University of Nevada Las Vegas

Donald M. Weekes, CIH, CSP (IEQ Committee and Task Force Chair)
Abacus Environmental

Staff Contacts: Margaret A. Breida, MS and Manuel Gómez, DrPH, MS, CIH
Board Coordinator: Donna Doganiero, CIH, U.S. Army CHPPM

APPENDIX 2—QUESTIONS DISCUSSED BY TASK FORCE

Microbial Remediation

1) Should microbial growth found in occupied buildings be eliminated (remediated)? Visible vs. hidden mold should be considered. Microbial needs to be defined.

2) If so, which of the following factors should be considered in selecting the method of remediation?

   - Type of occupancy (e.g., daily, infrequent, etc.)
   - Health status of occupants
   - Potential for exposure
   - Extent of contamination (e.g., square footage)
   - Type of mold or other microbial contamination
   - Cost and effectiveness (how long does the remediation last?)
   - Building systems (HVAC)
   - Substrate and location
   - Structural considerations
   - Regulatory and legal context

3) What methods should be used to remediate the microbial growth?

4) Is there a minimum amount of microbial growth (e.g., square footage per building) that should indicate mold remediation? If so, what is the level? What other factors should be considered? How?

   - Consider dissemination pathway

5) Should biocides or other cleaning/disinfecting agents (such as bleach) be used in microbial remediation? If so, which agents should be used and under what circumstances? Is there a need for research on biocides? It was noted that biocides may be registered with EPA for a certain purpose, but not necessarily for microbial remediation.

6) When should microbial remediation work areas be isolated from adjoining occupied areas? What isolation method should be used? When should a building be evacuated prior to remediation? When should it be evacuated during remediation?

7) When should negative air pressure be applied to mold remediation project areas? When used, what negative air pressure is acceptable?

8) Are visual inspections sufficient to "clear" an area that has undergone mold remediation? If not, what are the alternatives and when are they appropriate? Discuss work practices, visual inspections, and testing.

9) Should swab and/or spore trap sampling be used to "clear" the area? Tape lifts and electron microscopy should be considered.

10) What parameters should be utilized to determine if an area following mold remediation is "clear" for reoccupancy? What clearance criteria are appropriate? Do the criteria vary for the types of mold that are remediated? Do the criteria vary due to the background outside air concentrations? Other factors? Who does the clearance to evaluate the quality of the work? Do we need a new name for clearance?

Worker Protection

1) Is there basic personal protective equipment (PPE) that should be used by workers on all remediation projects? The response to the biocide question above should be considered since different PPE are required.

2) If so, is the same PPE required for all sized mold remediation projects? For all types of microbial growth?

3) Is personal air sampling appropriate to determine worker exposure during mold remediation? If so, how is this sampling to be accomplished? What criteria should be used to interpret the results of worker exposure measurements?

4) Is any other method of sampling to determine worker exposure (such as swabs on protective clothing) appropriate during mold remediation? If so, how is this sampling to be accomplished? What criteria should be used to interpret the results of worker exposure measurements?

APPENDIX 3—GUIDELINES REVIEWED BY THE TASK FORCE

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APPENDIX 4—INSPECTION OF WALL CAVITIES

Wall cavities can be observed by drilling small (typically 4-inch) diameter holes between structural members in the interior gypsum wallboard (GWB). During drilling and observation, a HEPA equipped vacuum is utilized to capture gypsum dust and any possible biological particulate, including mold spores, which might be released by drilling. In addition, a negative air machine equipped with a HEPA filter is located near the hole in the room during inspection activities to capture any dusts that might have resulted from the presence of the open hole in the wall. These precautions are taken to ensure that investigation activities do not result in additional mold spore exposures to building occupants. Following observation and measurement, each hole is patched with the removed GWB plug, drywall tape, and drywall “mud” such that no air pathway remains from the wall cavity into the occupied building.

Inspection holes are examined visually using a flashlight, boroscope, and mirror to identify the presence of mold, water, moisture, or staining. A boroscope is a fiber optic light source with a wide-angle telescope, both of which are housed in a 3-inch long and 7/8-inch diameter steel shaft. It provides the ability to see around corners and into areas difficult or impossible to directly observe or observe with the mirror and flashlight. Moisture measurements are taken with a probe-type moisture meter. Utilize the observation holes to determine sources of water leakage into the building and also the presence of mold.

It is possible to observe areas above and below a hole until a structural component prevents visual access. Typically, horizontal visibility is limited by steel studs located 32 inches apart. Fibrous glass insulation is typically present in the exterior wall cavities and can be pushed aside to facilitate observation. Other building components in walls can limit vertical visibility. It is typical to be able to see the exterior side of the interior GWB as well as the interior side of the exterior GWB. It is not possible to observe the exterior side of the exterior GWB or the interior side of the Styrofoam insulation of the exterior of the building, except when the exterior GWB is penetrated. Spores on the exterior side of the interior GWB and the interior side of the exterior GWB are of particular interest because of the possibility that they could migrate through penetrations in the interior GWB into the occupied building, driven by positive pressure on the outside of the building relative to the interior of the building. Such pressures could be created by wind or by the building’s ventilation system creating a “vacuum” within the building. Migration of spores inward could potentially result in exposures to occupants which could result in undesirable health effects.

Observation beyond the interior side of the exterior GWB is judged to be less significant in terms of potential exposures to mold spores. This is because spores located on the exterior of the building would be less likely to enter the wall cavity between the interior and exterior GWB and from there to migrate into the occupied building.

When observed, details seen from each access hole including the quantity of mold and type of water damage present, if any, as well as the building components present and their condition are recorded. Also record the location of each inspection hole relative to the architectural grid lines present on the blueprints. Multiple holes are typically made in the exterior walls of each room investigated.

The location and number of the holes are to be determined by the hypothesized source of moisture. Holes are generally located in areas thought to be at or below water leak points in the exterior wall. No attempt is made to observe each wall cavity between studs in a given room. Some holes can also be made in areas thought not to be points of water leakage in order to verify that additional sources of leakage are not present. Access holes can be created in each room when a reasonable understanding of where moisture and/or mold is present in the exterior. It is possible that these procedures will not identify all moisture and/or mold present in a given wall; however, this sampling approach can be considered to be a reasonable estimate of the extent of moisture and/or mold present.

The discussion in the Health Canada document on techniques of wall cavity evaluation needs significant revision. A revised version should include specific tools and techniques for opening and closing wall openings. Specifically, the use of hole saws, boroscopes, and mirrors and the use of control technologies during such procedures including HEPA vacuums, negative air machines, and glove bags should be addressed. The use of protective equipment by the evaluator is also an appropriate topic for inclusion. Inspection of a building's interior wall cavities is often accompanied by an inspection of building components such as window mullions, exterior wall sealant joints, etc., by a specialty architect to determine the sources of moisture.

APPENDIX 5—TESTING PROTOCOLS FOR FUNGAL CONTAMINATION

Quantitative Dust Sampling

Surface dusts on nonporous surfaces for “clearance” sampling of remediated areas have been collected by many practitioners as follows: Mark off one square meter (or significant fraction thereof). Connect a 37-mm open-faced cassette with a pre-weighed PVC filter to a 20-L/min sampling pump. Holding the cassette so that one edge of the open rim just barely contacts the surface and the opposite edge is less than 1 cm above the surface, traverse along one edge of the square. Repeat until all surface area has been covered. Repeat sampling in a perpendicular direction. No data are available on the efficiency of dust collection by this technique.

ASTM Method E1973-99 describes the collection of house dust for lead determination (Ref: *Standard Practice for Collection of Surface Dust by Air Sampling Pump Vacuum Technique for Subsequent Lead Determination*, Method E1973-99, American Society for Testing and Materials, West Conshohocken, Pa., 1999). This method also appears to be appropriate for sampling fungally contaminated dust from surfaces. The dust over a 100-cm^2 or 1-ft^2 surface area is drawn through a 37-mm, 0.8-µm pore size cellulose ester membrane filter in a plastic cassette equipped with a stainless steel or acrylic nozzle or a short section of Tygon tubing cut at a 45-degree angle on its end. The method recommends a sampling rate of 2.5 L/min; however, Kim et al. have determined that a volume flow rate of 4.0 L/min increases soil dust collection efficiencies to >85 percent on nonporous or roughened surfaces (Kim, S.Y., Que Hee, S., and Froines, J. *Optimized Portable Cordless Vacuum Method for Sampling Dry, Hard Surfaces for Dusts*. Appl. Occup. Environ. Hyg. 15(6): 503-511 (2000)). Efficient dust collection from carpet (and consequently other porous surfaces) requires volumetric flows as high as 16 L/min. (Ref: Emond, M.; Lanphear, B., Watts, A., Eberly, S.: Measurement Error and Its Impact on the Estimated Relationship between Dust Lead and Children’s Blood Lead. Environ. Res. 72: 82-92 (1997).)

Dust sampling with electric-powered portable vacuum cleaners using Dupont Hysurf™ has been described in the AIHA Field Guide (1996). High sampling efficiencies are reported for dust mite, cat, and dog allergens, but the recovery of fungal propagules has not been determined.

Vacuum bags can result in cross-contamination of the vacuum unit. Individual cassette vacuum samples have been successfully used in place of vacuum bags.

The dust collected on a filter or in a bag is analyzed by either direct microscopic exam or culture methods to identify the types and quantities of fungal propagules (and/or possibly bacterial cells or spores) present. Culture methods are more sensitive than direct microscopic examination of recovered spores, but excessive desiccation of the spores may reduce viability of the collected dusts (page 53, AIHA's Field Guide for the Determination of Biological Contaminants in Environmental Samples). Interpretation of quantitative dust samples requires professional judgment and research is needed to establish suitable guidelines. One approach is to follow an internal control comparison or use databases established by others for dusts in residences or commercial buildings.

Clean Environment Testing of Content Items

This involves creating a clean environment, typically by operating a negative air machine equipped with HEPA filtration, such as is used in asbestos abatement, in a 6-mil polyethylene enclosure. Following HEPA vacuuming of the interior surfaces of the containment and a required minimum number of air changes to remove suspended particles, the content item is placed inside, the HEPA unit turned off, and the content item agitated. Air sampling for spore counts and/or viable analysis using an Anderson N-6 is then performed inside the chamber. As noted above for quantitative dust sampling, interpretation of sample results requires professional judgment because no guidelines have been established.

APPENDIX 6—MINORITY REPORT

Respectfully Submitted by: Coreen A. Robbins, PhD, CIH
April 3, 2001

Based on my review of the current Task Force report, it is my belief that this document should be peer-reviewed further and then reevaluated by the AIHA BOD based on the following issues:

1. The document was not originally intended nor developed for wide distribution; it was intended as an advisory document for the AIHA board.
2. Factual information about existing guidelines segues, without clear distinction, to unsupported professional opinion and practice recommendations.
3. Although circulated to some members for comment, this document did not undergo a standard peer-review process.
4. The document implies that all molds should be treated as hazardous substances, and this implication should be addressed further.

A discussion of major issues and specific examples of problematic statements follow.

Background

Microbial growth in buildings is not new to the industrial hygiene profession, but it has recently been transformed into a high profile, controversial public issue. Many practitioners now assume that the mere presence of mold growth can be toxic to building occupants. Such assessments are often based on detailed sampling strategies despite the lack of health-based standards to determine risk, and no accepted method of determining if data show levels above background. Cleanup of building mold under this approach follows procedures developed for hazardous materials. Although the Task Force did not directly address the toxic mold issue, they accepted findings from other guidelines based on assumed toxic effects of building mold (Health Canada, ISIAQ, NYCDOH 1993 & 2000, AIHA Field Guide), without examining the basis for those assumptions. It should be noted that these documents, along with the Task Force Report, are not primary literature, nor have they been produced with the use of the rigorous, double-blind, peer-review that is associated with credible scientific journals.

Some practitioners continue to take a more traditional approach, assuming health risks due to elevated mold exposures are generally limited to allergic responses or infection in immunocompromised individuals. Control of exposures to minimize or eliminate allergic symptoms is adequate protection from potential exposures including putative effects from mycotoxins. Environments with immunocompromised individuals are an exception and must be dealt with on a case-by-case basis. This approach prioritizes the response to an indoor mold problem by assuming a dose/response relationship. Remediation under this approach emphasizes common building hygiene measures, not practices developed for hazardous materials.

AIHA policies suggest that the risk assessment process should have been used to evaluate building mold before public policy is developed, resulting in recommendations consistent with current science. The building mold issue has avoided this scrutiny, with public policy developing in a manner similar to the course initially followed by EPA for occupant exposure to asbestos. The EPA recently announced its intent to issue mold guidelines, once again without AIHA input. The AIHA should be taking a leadership role in the development of this policy, emphasizing science-based risk assessment. Lack of a systematic, science-based approach will inevitably lead to more "mold hysteria," and the continued use of arbitrary and non-validated field practices for sampling and remediation.

Some Issues Not Addressed By Task Force

The narrow scope of the Task Force Report does not contribute to the resolution of the current mold controversy. Among the critical questions not addressed by the Task Force are:

→ What health effects have been demonstrated in building occupants and cleanup workers from exposure to mold?

→ Based on demonstrated health effects, what mold controls are appropriate?

→ How should controls for building mold compare to building hygiene measures typically recommended for other allergens?

→ Should worker protection requirements for mold compare to hazardous materials or nuisance dusts?

→ How should buildings be assessed for mold contamination and its relationship to health concerns? Does sampling play a role?

→ How should mold sampling data be interpreted in regard to health risks and relationship to normal background?

→ Who is qualified to remediate mold and how does this relate to Respiratory Protection Program requirements?

→ What interim measures can be taken when moisture or mold cannot be controlled immediately?

→ Can control procedures such as encapsulation be used where mold growth cannot be removed?

→ When can mold be remediated without full containment?

→ When is HEPA filtration during wall cavity inspection justified?

→ What roles can biocides effectively play in the remediation process?

Sampling and Interpretation

Recent interest in mold has resulted in unprecedented testing of buildings. Lacking neither generally accepted sampling strategies, health-based standards nor a formula that differentiates contamination from normal background; interpretation of mold test data is likely to produce false positive or false negative conclusions.

In the “real world,” assessment of IAQ health concerns is now increasingly streamlined as follows:

- Assume all health complaints are mold-related
- Test for mold
- Interpret all findings as contamination (even if normal background)
- Conduct full-scale remediation
- Retest, re-clean, retest, etc.

This approach has encouraged many non-industrial hygienists to enter this lucrative field as “mold consultants.” Lacking guidance to the contrary, an alarming number of practitioners describing themselves as industrial hygienists, are following such simplistic, test-based approaches to building environmental assessment. Although fundamental questions regarding the role of sampling and how to interpret data are raised by the current situation, the Task Force does not provide any additional guidance.

Remediator Qualifications

The trend toward treatment of building mold as a hazardous material has led to significant changes in who performs remediation. In the past, these tasks were integrated into general building maintenance, but they have now become the domain of specialized contractors, often with a background in asbestos abatement, raising significant cost and questions regarding the quality of work. One factor determining who remediates mold is the requirement of full Respiratory Protection Programs for small-scale or isolated mold clean ups, unnecessarily restricting who can perform the work. This is another important industrial hygiene issue not considered by the Task Force.

Other Issues

Examples of statements that may be misinterpreted and have potentially far-reaching results follow. This is not an exhaustive list.

Hidden Mold

Statements that hidden mold is associated with ill effects, and that this is supported by epidemiological studies, are overstated. The single study cited involves self-reported symptoms on questionnaires, with no objectively measured symptoms or health effects. These statements are likely to cause uninformed practitioners to conduct extensive physical searches for hidden, possibly nonexistent, mold. As this is already occurring, this language would only encourage such activities.

Respiratory Protection

This section in the document includes the following statement: **"All airborne exposures to microbial agents should be considered to have the potential to initiate an allergic response in the susceptible individual. Without definitive determination of susceptibility, prudent practice dictates the wearing of appropriate PPE whenever known or suspected microbial reservoirs are encountered."** The statements are out of place in this section, and much too broad. A strict interpretation would have the vast majority of us in PPE 24/7. It seems that one could never know when they might encounter a moldy bit of drywall, or a moldy bit of cottage cheese, and be certain they were not, nor could ever be, susceptible to whatever was growing there.

Recommendations

1. The AIHA Board of Directors should direct that an expedited and comprehensive health risk assessment be conducted by a new Task Force of building mold based on the available scientific evidence. The new Task Force should be constituted to include representation of all major viewpoints and fields of expertise on the building mold issue.

2. The new Task Force should also conduct a thorough review of critical issues as directed by the AIHA Board of Directors.

3. Once the new Task Force has completed its work, a peer review process shall be conducted which will allow AIHA Technical Committees the opportunity for comment on its findings and recommendations.

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American Industrial Hygiene Association
2700 Prosperity Ave., Suite 250
Fairfax, VA 22031
(703) 849-8888
(703) 207-3561 fax
internet: infonet@aiha.org
web: www.aiha.org
Stock No. 458-EQ-01