GUIDELINES FOR THE INVESTIGATION, ASSESSMENT, & REMEDIATION OF MOULD IN WORKPLACES

Workplace Safety and Health Division
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Preface

This guideline has been developed to provide general information to employers, workers, consultants, abatement contractors and others concerned with mould contamination in workplaces. This information is intended to establish minimum requirements to be considered when investigating and assessing complaint/concerns from workers and others. This guideline also establishes minimum remediation procedures that must be followed when contaminated material is to be abated.

This guideline adopts and adapts a large amount of the information from the Health Canada document, Fungal Contamination in Public Buildings: A Guide to Recognition and Management (http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/fungal.pdf), and general information from the Ontario Ministry of Labour information bulletin Indoor Air Quality: Carbon Monoxide, Moulds & Beyond, Current Issue Paper 198 (http://www.ontla.on.ca/library/c198fr.htm). Specific references contained in these two documents have not been included in this guideline. Readers are advised to refer to the original documents to view the references.

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GUIDELINES FOR THE INVESTIGATION, ASSESSMENT, & REMEDIATION OF MOULD IN WORKPLACES

A. Introduction to Mould

1. What is fungi/mould

Fungi are primitive plants that lack chlorophyll and therefore must live as parasites or feed on organic matter that they digest externally and absorb. The true fungi include yeast, mould, mildew, rust, smut and mushrooms. They usually grow best in dark moist habitats, and are found wherever organic matter is available. Some fungi can grow under extremely difficult conditions. This section discusses those fungi known as moulds (sometimes spelled molds). Humid or damp conditions in the home, school or workplace may promote the growth of moulds, as well as bacteria and dust mites. These organisms may contribute to poor indoor air quality and can cause health problems.

Fungi in indoor environments comprise microscopic yeasts and moulds, known as micro fungi, while plaster and wood-rotting fungi are referred to as macro fungi because they produce sporing bodies that are visible to the naked eye. Apart from single-celled yeasts, fungi colonize surfaces as a network of filaments, and some produce numerous aerially dispersed spores and other chemical substances such as volatile organic compounds (VOC's). The naturally occurring substances produced by fungi that bring about a toxic response are called mycotoxins, and are usually contained in the spores. Toxicity can arise from inhalation or skin contact with toxigenic moulds.

2. Health Effects

In most non-contaminated workplaces the possible mould exposure would not be expected to present a health hazard except to very susceptible individuals. In contaminated situations the risk from exposure to mould increases. Reactions are varied and complex depending upon many factors. Human factors include personal susceptibility, route of exposure, age and state of health. Mould related factors include amount and length of time of exposure, virility and viability of the organism, and whether the effect is infection, allergenic, toxigenic or some combination of these.

The effects of inhaling mould spores include allergies, infection or irritation.

- **Allergic reactions** – a significant portion of asthmatics are allergic to moulds, so that exposure can bring on attacks. Other forms of immediate and delayed allergic responses, such as hayfever (allergic rhinitis), also may occur;
- **Toxic and Irritative effects** – long-term exposure to moulds has been associated with a number of non-specific respiratory and flu-like symptoms, headaches, skin problems and impaired immune functions as well as a lung condition in infants known as pulmonary haemosiderosis; and

- **Infectious mechanisms** – in immuno-compromised individuals, exposure to moulds that would not normally cause illness can result in infection, termed mycosis.

Under certain conditions, moulds can pose a health hazard. Factors that increase the risk of illness include:

- **Susceptible individuals** – those allergic to mould, those with low immunity and babies whose lungs are not completely formed;
- **High levels of exposure** – exposure to large numbers of spores over a long period of time; and
- **Species of mould** – the more noxious moulds (high potential for mycotoxin production) pose the greatest risks.

Not surprisingly, young babies, asthmatics, and persons who have poor immune systems (such as those undergoing cancer treatment and persons with HIV) are at the highest risk if they are exposed to large amounts of mould. However, although effects of moulds on the general population are yet less well known, this does not suggest that mould growth indoors should be left alone. Mould in occupied buildings should always be kept to a minimum.

3. Moulds of Health Concern

Indoor air contains spores and filaments of many different moulds but the most common are likely to be species of *Cladosporium alternaria* and other mould typically also found in the normal outdoor environment. However in "sick buildings" one can find toxigenic or allergenic mould, including certain species of *Penicillium,* some *Aspergillus, Stachybotrys* and *Fusarium.* Most mould found in indoor air are able to obtain the nutrients they need from dead moist organic material. Wood, paper, surface coating such as paint, soft furnishings, soil in plant pots, and drywall can provide ample opportunity for mould to grow.

B. Investigating Potential Contamination

1. What triggers an investigation for mould contamination

An investigation for mould contamination can be triggered by **adverse health concerns of occupants, observations of growing mould, unusual odours, or events of water intrusion**.

A variety of symptoms or observations, such as respiratory problems, headaches, nausea, irritation of eyes, nose, or throat, tiredness, fatigue, etc may trigger an investigation into potential mould contamination. Mould may be observed on walls, pipes, ceiling tiles, window ledges, books, files, documents, etc. Musty odours and other unusual smells may indicate potential mould contamination. Also, any indication of water intrusion, flooding, condensation or high humidity, especially if chronic and or severe suggests potential mould contamination.

In most instances the precipitating factors for an investigation into mould contamination are a combination of occupant adverse health symptoms combined with a history of water intrusion**. When mould is visible, maintenance or housekeeping staff normally clean it and remove it; i.e. visible mould is treated as "you see it, you get rid of it".** Odours can arise from many sources, but in the absence of supporting evidence (e.g. occupant health complaints or an IAQ investigation that excludes other options) odours alone do not a trigger a mould investigation.

2. The building history

The mould investigator examines a building's history looking at the original design, original intended use, construction (materials, workmanship, location), and any renovations or additions. This information is examined for changes that point to potential opportunities for mould (or other biocontaminants) to colonize.

Present use vs. the intended use

When the present use of a building is different from the intended use, the original building design may not be suitable. For example, a basement area that was not intended for storage is often used to store old files and documents. Since the design did not intend the basement area to be ventilated and kept dry, when water enters or the humidity is elevated the conditions are perfect for mould to grow on these materials. Similarly, when a basement not intended for occupancy is converted to office space the occupancy of that basement can generate both high humidity and nutrient material for mould to grow. Another example, when office dividers and walls are erected and then occupancy is increased, the original HVAC system may be inadequate. Condensation and poor air circulation that results can lead to conditions for mould to grow.

Probably the most significant change in building design to affect conditions fostering mould growth came from the demand over the past 25+ years for greater energy efficiency. This change resulted in many buildings having HVAC systems that were not designed to handle the excessive moisture that develops in these energy efficient buildings. The high humidity that results can lead to hidden mould growth in many parts of the building, and this growth is extremely hard to find because there may be no signs to indicate its presence.

Present state of construction or deterioration

As structures age they deteriorate; a building envelope begins to break down and if proper maintenance is not practiced the interior of the building becomes subject to intrusion of the elements, most notably water. When this occurs, biocontamination is likely to follow. An older building with apparent deterioration may require the services of a building engineer to conduct a thorough building envelope investigation. The results of this investigation can indicate where moisture may have entered and consequently where mould may grow.

The mould investigator should check the following:

Building exterior

- windows, doors, air conditioning units, dormers etc - is the paint peeling or blistering, is there rot or other damage that might allow water to penetrate
- roof – is there damage that could allow water to leak in
- exterior walls – are there breaks, cracks or other openings
- joints at corners, top sills, side jambs, and where different claddings meet must be examined for continuous caulking that seals the joint properly
- basement window wells must be examined for proper drainage (gravel and drain tube to base of wall is normal) and to be sure they don't leak
- basement walls should be examined for cracks or other damage that could indicate water intrusion sites
- drainage pipes (e.g. rain-trough down spouts) should be examined for damage or blockages that might lead to water entering the building
- pipes that penetrate the basement wall (e.g. utilities) should be checked for proper seals
- slope of ground around basement wall must provide proper drainage
- drainage holes, pipes for water that might collect behind exterior veneer must not be blocked

Building interior:

- basements should be examined for renovations that might trap condensation, evidence of leaks around pipes that penetrate the wall, leaks around windows, condensation around cold spots or on plumbing pipes, plumbing leaks (water and sewage pipes, appliances), HVAC system, standing water (e.g. sewers, sumps, and puddles) active ventilation of the area, leaks from the floor above, relative humidity, materials that might sustain growth in high humidity, expansion joints at floor-wall junctions,

Present environment of building

A building's environment provides clues to potential mould contamination – usually these clues are water related. For example, high humidity, condensation around windows, in corners or on plumbing, stained ceiling tiles, blistered paint, peeling wallpaper, rotted wood around windows or near plumbing, mildew/mould in bathrooms, water stains around sinks (kitchens, lunchrooms, janitorial storage rooms, water in crawl spaces or basements, and leaks. Also, odour may indicate mould - many moulds produce odours that are readily detectable. Activities in the building can contribute to mould growth; e.g. activities that generate moisture (fountains, showers, etc), accumulation of left over food, temperature below the dew point, and HVAC system that does not supply sufficient fresh air.

Impact of renovations or additions

Whenever an existing building is renovated or has a structure added, then opportunities occur for mould to grow. New components joined to old ones may not react to environmental changes in the same manner, and two structures may shift or settle

separately. Components can work against each other causing separation and damage. When new internal structures are erected they can impede the HVAC system's ability to provide sufficient air supply or movement thus potentially creating conditions for mould to grow.

3. Interviewing occupants

When investigating a building for potential mould contamination, adverse health effects of the occupants is both supporting evidence of contamination and a pointer to possible locations of contamination. Generally an investigation for mould contamination does not occur in the absence of occupants experiencing adverse health effects. During the investigation staff can be asked about health effects. In some instances (e.g. confidentiality concerns) this may be a role for a medical doctor. Occupants often can relate episodic or chronic health effects to events (leaks, floods, condensation, high humidity) or locations in the building. The investigator uses this information with other information to plan where, when and how to look for mould. In the absence of other evidence, a distribution pattern of occupant illness can indicate areas of high probability of mould contamination.

4. Visual inspection

The visual inspection of the site must include examination of any areas identified as "potential" from occupant interviews, building history, or building environment information. A visual inspection should look at many parameters e.g. ceiling tiles, wall paper (especially if vinyl and peeling), breaks or cracks in the wall, window sills (condensation) carpets (stains), surfaces of materials that may provide nutrients, bathrooms, showers, toilets, basement expansion joints, plumbing pipes and appliances, and HVAC systems (ducts and air handling units). In those areas where "potential" contamination is possible the baseboard should be pulled away from the wall and the wallboard behind examined for mould growth.

5. Sampling

Primarily, there are three forms of sampling commonly used in mould investigations; **bulk, swab and air**. Less commonly used sampling procedures include vacuum of a surface area, contact plates, settle plates, and lift tape with direct microscopy and bio-organism analysis.

Interpretation of the analytical results will depend upon several factors, including; the location of the sample, any material the sample was a part of, environmental conditions at the time of sampling, the method used to collect the sample, the method used to analyze the sample, and the format and units used to report the results.

Analysis of either **bulk or swab samples** normally requires dilution of the sample and distributing a specific volume (aliquot) over a sterile growth medium. After a suitable growth period (usually 7 days for mould) colonies are identified and counted. Generally, two results are reported: organism identification (either to general level or to species level), and total colony forming units (CFU) and percentages of each organism type. Results are reported as CFU because each colony may not have grown from only one

single spore or other reproductive form of the organism. Thus, whatever number of spores initiated a colony, it is counted as only one CFU. Most analytical laboratories report bulk samples as colony forming units per gram of material (CFU/g), and swab samples as colony forming units per square centemetre of area sampled (CFU/cm^2) – a minimum of 100 cm^2 is normally recommended. These units are consistent with most of the literature reports as well.

Air sampling requires the use of a devise to impinge organisms from a specific volume of air onto a sterile agar growth medium. The sample is then incubated for a specified period of time (usually 7 days). The colonies are then counted and the results reported as CFU/m^3 air. When testing the air of a potentially contaminated area it is necessary to have comparative samples of air from both the contaminated area and the air outside of the potentially contaminated building. A sample of inside air from an uncontaminated area of the same building should also be obtained.

The sterile agar growth medium used in mould analysis will impact upon the CFU count. If the medium used does not support the growth of certain species then there will be no CFU of those species, i.e. a false negative for the species identification and a false low CFU count. If the medium provides preferential growth nutrients for certain species then these may grow faster, overwhelm the slower growing organisms, and result in false negative results as well. Generally, most analytical laboratories use a standardized medium (maltose extract agar with rose bengal added to inhibit bacterial growth). Some laboratories will use multiple agar growth media to get a more accurate analysis of the CFU and of the species present.

All sampling, whether swab, bulk or air, requires knowledge of specific analytical methods and techniques. Sampling and testing for mould generally requires the services of a technically qualified professional who uses an accredited laboratory for the analysis. Extensive testing is not advised as a method to locate mould contamination. Sampling and testing is useful however for confirming that a problem exists or to assist medical diagnosis by relating patient symptoms to a source of exposure. Air sampling has value when confirming the mould has been remediated and the site can be re-occupied.

When mould is not visible, but is suspected, then one has to look for clues as to its location e.g. behind baseboards, on ceiling tiles, in carpets, etc. This may require the use of **destructive visual or bulk testing**, such as breaking into walls or cutting out pieces of carpet. Before proceeding to any destructive testing, the possible existence of a mould problem should be supported by sufficient evidence. Clues to look for include: historical or present moisture problems (e.g. floods, condensation and plumbing leaks), people complaining of illness and/or musty odours, staining on carpets or ceiling tiles, or blistering paint.

Additional information on sampling and analytical methods may be obtained from;

Macher, J., Ed.: *Bioaerosols: Assessment and Control.* Cincinnati, OH: ACGIH, 1999.

Dillon, H.K.; Heinsohn, P.A.; and J.D. Miller, Eds.: *Field Guide for the Determination of Biological Contaminants in Environmental Samples.* Fairfax, Virginia: American Industrial Hygiene Association, 1996.

National Institute of Occupational Safety and Health, *NIOSH Manual of Analytical Methods J: SAMPLING AND CHARACTERIZATION OF BIOAEROSOLS* (http://www.cdc.gov/niosh/nmam/pdfs/chapter-j.pdf)

6. Preservation and transportation of samples

The manner in which samples of materials suspected to contain mould are handled (i.e. preserved and transported) will impact upon the results. It is very important to carefully follow the analytical laboratory's prescribed procedures for sample handling. Improper sample handling can lead to false positives and false high values if the conditions allow contamination or growth of the sample while in transit. False negatives and false low values will occur if the organisms are damaged in transit. Laboratories normally request investigators to keep samples dry and cool, to transport the sample to the laboratory by the fastest available method, and to have the sample arrive at the laboratory within 24 hours of being obtained.

7. Interpreting the laboratory results

Interpreting laboratory analysis of biological samples is not an exact science at the best of times. No matter how precise and accurate the analytical procedures are in the laboratory, there are many factors that impact upon interpretation of the results; e.g. sample site, sampling methods, environmental conditions, sample handling, growth media used, and viability of the organisms.

Air samples are interpreted in the context of: outside air reference samples, inside air reference samples from an uncontaminated area, the building structure, air handling system, activities in the building, occupancy load, etc.

In general air samples from suspected contaminated areas are compared to **outside reference samples** on the basis of kinds and amounts of the organisms detected. In a building with a normally functioning and maintained air handling system the kinds of mould in the indoor air should be relatively the same as those found in the outside air. Also, the rank order and proportion of organisms found in inside air compared to outside reference air should be about the same. If the air handling system uses air filters then the number of organisms inside compared to outside will be 20-40% lower i.e. expect the filter system to remove 60-80% of all organisms but to leave the kinds and relative percentages the same.

Any organisms found in inside air but not in outside air must be suspected as coming from an amplification site within the building. This assumption should be assumed correct until sufficient evidence makes the assumption unlikely.

The procedures presented in the Health Canada document, Fungal Contamination in Public Buildings: A Guide to Recognition and Management (http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/fungal.pdf) should be reviewed for recommendations on what action should be considered if the results of air sampling suggest the presence of an amplification situation within the building.

8. Suggested guidelines

There is still considerable controversy over the acceptance of an appropriate standard for a "safe" exposure to mould. There are many factors that must be considered in the establishment of such a standard. However, it is necessary that guidelines be established for the purpose of providing direction for the handling of mould contamination.

The standard for airborne concentrations recommended for use in this guideline are those accepted by a Federal-Provincial Working Group on Indoor Air Quality, and reported in Indoor Air Quality in Office Buildings: A Technical Guide and Fungal Contamination in Public Buildings: A Guide to Recognition and Management. The following are the recommendations presented.

"Canadian guidelines were published in Indoor Air Quality in Office Buildings: A Technical Guide in 1993. As described in that document, the guidelines are based on a large data set gathered over a period of several years using a Reuter centrifugal sampler with a four-minute sampling time. These guidelines have been found useful by workers in the field and are used on a regular basis."

1) Significant numbers of certain pathogenic fungi should not be present in indoor air (e.g., *Aspergillus fumigatus*, *Histoplasma* and *Cryptococcus*). Bird or bat droppings near air intakes, in ducts or buildings should be assumed to contain these pathogens. Action should be taken accordingly. Some of these species cannot be measured by air sampling techniques.

2) The persistent presence of significant numbers of toxigenic fungi (e.g., *Stachybotrys chartarum* (= *atra)*, toxigenic *Aspergillus*, *Penicillium* and *Fusarium* species) indicates that further investigation and action should be taken accordingly.

3) The confirmed presence of one or more fungal species occurring as a significant percentage of a sample in indoor air samples and not similarly present in concurrent outdoor samples is evidence of a fungal amplifier. Appropriate action should be taken.

4) The "normal" air mycoflora is qualitatively similar to and quantitatively lower than that of outside air. The number of fungal isolates in outdoor air is affected by the

sampling technique, the season, weather conditions, activities, etc. Published data on the range of "normal" values in different parts of Canada are not available, and those that are available may be based on sampling techniques unlikely to be applied in modern indoor studies.

5) More than 50 CFU/m^3 of a single species (other than *Cladosporium* or *Alternaria*) may be reason for concern present. Further investigation is necessary.

6) Up to 150 CFU/m^3 is acceptable if there is a mixture of species reflective of the outdoor air spores. Higher counts suggest dirty or low efficiency air filters or other problems.

7) Up to 500 CFU/m^3 is acceptable in summer if the species present are primarily *Cladosporium* or other tree and leaf fungi. Values higher than this may indicate failure of the filters or contamination in the building.

8) The visible presence of mould in humidifiers and on ducts, mouldy ceiling tiles and other surfaces requires investigation and remedial action regardless of the airborne spore load.

9) There are certain kinds of mould contamination not readily detectable by the methods discussed in this report. If unexplained sick building syndrome symptoms persist, consideration should be given to collecting dust samples with a vacuum cleaner and having them analyzed for fungal species.

Recommendations have also been established for bulk samples of the inside of **ventilation ducts**. The University of Minnesota, Department of Environmental Health & Safety, Indoor Air Quality has recommended guidelines for the interpretation of bulk analysis from the inside of ventilation ducts in an article entitled Mycological Aspects of Indoor Air Quality (http://www.dehs.umn.edu/fungus/mycoglos.html). The following is a section of that report.

"For duct insulation, the following numbers are rough rules of thumb used to assess fungal contamination using a dilution sample."

TABLE 1

Concentration	Qualitative Assessment of Contamination
less than 10,000 CFU/g	Low
10,000 to 100,000 CFU/g	Medium
100,000 to 1,000,000 CFU/g	Medium to heavy
>1,000,000 CFU/g	Heavy

The recommendations above were establish specifically for ventilation ducts. There is still considerable disagreement amongst technical experts as to whether a standard can/should be established for other types of porous building materials. The most notable of these building materials is carpeting. Those experts who do not believe that a "universally applicable standard" can be recommended argue that there has not been enough scientific study to allow for the setting of a standard at this time. They suggest that each case must be assessed independently and that action be justified on the basis of occupant complaints and the water history of the building. Certainly any concerns identified from these two areas must be addressed appropriately. In the process of establishing this guideline however, there is an expectation that specific criteria will be provided on when to deal with building materials that have become wet due to floods, roof leaks, sewage backup and groundwater infiltration.

The reader should keep in mind that all wet porous materials would support the growth of mould if they were not dried thoroughly within hours 24 to 48. These materials should be discarded if they cannot be dried within the times specified. **Where bulk samples of porous materials are analyzed for microbial contamination, the results should be either compared to those criteria developed for duct insulation (see TABLE 1 above) or compared to similar uncontaminated materials from the same building to evaluate their level of contamination.**

General recommendations also exist for classifying the degree of mould contamination of **non-porous surfaces**. These recommendations listed in Table 2, below, are based on sampling an area of 100 cm^2.

TABLE 2

Concentration	Qualitative Assessment of Contamination
less than 200 CFU/ cm^2	Low
200 to 500 CFU/ cm^2	Medium
> 500 CFU/ cm^2	Heavy

9. General Investigation Principles

The following section describing the general order of investigation has been adapted from the Federal-Provincial Committee on Environmental and Occupational Health document Fungal Contamination in Public Buildings: A Guide to Recognition and Management.

Procedures for the investigation of possible mycological contamination in indoor air can be grouped broadly into the following six phases:

PHASE I - Assessing the magnitude of health problems and taking the building history:

An estimate of the prevalence and severity of health problems may be obtained from discussions with managers, employees, union representatives, joint occupational health and safety committees, and building maintenance staff. Advice should be sought from knowledgeable health professionals. Health questionnaires are sometimes used as a tool to assemble more comprehensive information. The value of such data is reduced by the fact that in so-called healthy buildings, a significant minority of occupants will describe symptoms that they attribute to the building environment. During this phase, the contamination status of the building is not expected to be altered by the actions taken by the investigative team.

PHASE II - Identifying problems in the building environment:

Fungi require water and nutrients for growth and proliferation. They are most often found in buildings in which there is excess moisture, often in the presence of water-damaged material. Humidity may be high. There may be visible condensation on windows. Colonization of walls and other exposed surfaces may be visible. There may be a distinctive fungal odour. Investigators should look for areas in building where moisture and substrates may encourage fungal growth - for example, areas containing cellulose material (paper, cardboard, wood, etc.), air filters, heat exchangers (condensation on cooling coils), humidifiers, water sumps, perimeter heating and cooling units, wetted carpet, porous lining materials, etc. An attempt should be made to correlate these conditions with high-symptom areas and to designate possible hot spots of contamination. During this phase, the contamination status of the building is not expected to be altered by the actions taken by the investigative team.

PHASE III – Sampling:

- Transparent tape surface sampling.
- Scrapings of contaminated materials.
- Routine air sampling.
- Bulk sampling.

During this phase, the contamination status of the building is not expected to be altered by the actions taken by the investigative team.

PHASE IV - Risk communication:

Risk communication has been defined as "the act of conveying or transmitting information between interested parties about the levels of health or environmental risks; the significance or meaning of such risks; or decisions, actions or policies aimed at managing or controlling such risks." Lines of communication between building occupants, workplace health and safety officials, building managers and owners, employers, union representatives, and safety and health committee representatives should be established as soon as health complaints related to indoor air quality are received. Steps for investigation of the source of the problem should be presented and agreed to by all parties involved. If fungal contamination is detected, discussions should occur on the health hazards and remedial measures to be carried out. Individuals involved in the investigation and remediation should have received

appropriate training as required by the Workplace Safety and Health Act and WHMIS. Building occupants should be kept up to date during the investigative, remedial, and follow-up stages. Detailed information on effective communication strategies for dealing with indoor air quality problems is available. During this phase, the contamination status of the building is not expected to be altered by the actions taken by the investigative team.

PHASE V - Destructive testing:

Destructive testing occurs when certain structures of the building have to be taken apart in an attempt to locate the source of suspected contamination. During this phase, the contamination status of the building is expected to be altered by the actions taken by the investigative team, possibly through exposure of previously cryptic contaminants and redistribution of such contaminants via the HVAC system or by other means. All individuals within the building should be protected from exposure.

PHASE VI - Remedial actions:

- Removal of contaminated material.
- Decontamination of the HVAC and other systems as required.
- Repair or replacement of damaged materials and/or structures.

During this phase, the contamination status of the building is expected to be altered by the actions taken by the investigative team, possibly through disturbance of newly exposed heavy concentrations of contaminants and redistribution of such contaminants via the HVAC system.

C. Biocontamination Remediation Procedures

1. Introduction

In all situations, the underlying cause of water accumulation must be rectified or fungal growth will reoccur. Remediation performed without first identifying and rectifying the cause of the biocontamination will result in a regrowth of the mould. Emphasis should be placed on ensuring proper repairs of the building infrastructure so that water damage and moisture buildup does not reoccur. Water infiltration should be stopped and cleaned immediately. An immediate response (generally within 24 to 48 hours) and thorough clean up, drying, and/or removal of water damaged materials will prevent or limit mould growth. If the source of water is elevated humidity, relative humidity should be maintained at levels below 40 - 60% to inhibit mould growth.

It must be clearly understood that porous materials, such as furniture, ceiling tiles, plaster/lath, gypsum wallboard, similar building materials, and carpet, that have been become wet due to floods, roof leaks, sewage backup and groundwater infiltration should be discarded.

Only in exceptional cases, and within 24 to 48 hours, should these materials be considered for drying and disinfecting. Special procedures are required for the restoration of books and paper. Professional conservators should be contacted for information on handling these types of wet products.

The effectiveness of any remediation of contaminated porous material must be evaluated as a standard procedure in all abatement activities. Surface sampling is advisable on porous material adjacent to the removed contaminated material. All positive results in excess of background levels should be evaluated by a technically qualified person to determine whether additional remediation is warranted.

The effectiveness of any remediation of contaminated building materials (plaster, drywall, roofing material, etc.) should also be performed. A follow-up evaluation should be performed in the remediation area after approximately three to six months to ensure that the growth of mould has not reoccurred. This follow-up evaluation may be air testing and/or surface testing, as appropriate. The results of the follow-up tests should be compared against the suggested guidelines presented in Section 8 of this guideline.

2. Procedures for removal of less than 0.3 m^2 of mould

- Eating, drinking, chewing or smoking is prohibited in the work area.
- All surfaces of material to be removed must be misted (not soaked) with a suitable material to minimize the spread of mould or spores prior to removal.
- All contaminated debris must be double-bagged in 6-mil polyethylene bags, and securely tied immediately.
- The spread of contaminated debris from the work area must be controlled by placing plastic sheeting under the contaminated material to be removed.
- The plastic sheeting mentioned above must be disposed of with the contaminated debris upon completion of the removal.
- The plastic bags containing contaminated material and the plastic drop sheets must be double-bagged in 6-mil polyethylene bags, seal immediately and disposed of as soon as possible.
- The sealed polyethylene bags containing contaminated material may be disposed of in a licensed landfill or by incineration.
- All workers performing the removal must be provided with a minimum of N95 respiratory protection (and appropriate protection for any wetting agents or disinfectants), gloves, and eye protection.

- Washing facilities for hand and face must be made available to workers in the work area, and workers must wash before leaving the work area.

3. Procedures for removal of between 0.3 m^2 and 3 m^2 of mould

- Eating, drinking, chewing or smoking is prohibited in the work area.
- Clearly visible signs warning of the remediation must identify the area where the removal is being performed.
- Compressed air must not used to clean up or remove contamination from any contaminated surface.
- Where a removal is conducted and where walls do not already enclose the contaminated area, the spread of contaminated from the area must be prevented by the construction of a small walk-in negative pressure enclosure.
- The negative pressure enclosure must be constructed of two layers of a minimum of 6-mil polyethylene, or other suitable material, with reinforced polyethylene on the floor.
- The negative pressure enclosure must be kept at a minimum pressure differential of at least −5 Pa (- 0.02 inches of water gauge) relative to the air outside of the enclosure at all times during the operation by use of a vacuum cleaner equipped with a HEPA filter or similar ventilation unit.
- All mechanical ventilation in the contaminated area, except that required to maintain the negative pressure, must be disabled.
- At least two layers of 6-mil polyethylene must be placed over all openings in the contaminated area.
- Only persons wearing protective clothing, eye protection, appropriate gloves, and a minimum of half face N99 respiratory protection (and appropriate protection for any wetting agents or disinfectants) are allowed to enter the contaminated area.
- All surfaces of material to be removed must be misted (not soaked) with a suitable material to minimize the spread of mould or spores prior to removal.
- All contaminated debris must be cleaned up frequently and immediately upon completion of the work.
- All contaminated debris must be double-bagged in 6-mil polyethylene bags.

- The outside surface of all polyethylene bags must be either vacuumed with a vacuum equipped with a HEPA filter, or wet wiped with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water before being removed from the negative pressure enclosure.

- All surfaces inside the negative pressure enclosure must be either vacuumed with a vacuum equipped with a HEPA filter, or wet wiped with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water prior to dismantling.

- All polyethylene sheeting used to form the negative pressure enclosure and covering all openings inside the contaminated area must be folded to contain any remaining debris and double-bagged in 6-mil polyethylene bags, securely tied and disposed of, or disinfected prior to reuse.

- All persons must decontaminate their protective clothing, eye protection, gloves, and respirators by using a vacuum cleaner equipped with a HEPA filter, or by wet wiping with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water after completing the work and before leaving the contaminated area.

- Contaminated protective clothing that will not be re-use must be disposed of as contaminated waste.

- The sealed polyethylene bags containing contaminated material may be disposed of in a licensed landfill or by incineration.

- Washing facilities for hand and face must be made available to workers in the work area, and workers must wash before leaving the work area.

4. Procedures for removal of greater than 3 m^2 of mould

- Eating, drinking, chewing or smoking is prohibited in the work area.

- Before starting any remediation, suitable barriers and clearly visible signs warning of the remediation work must be set up at a distance from the work site.

- Compressed air must not be used to clean up or remove debris from any contaminated surface.

- Movable contaminated nonporous equipment within the work area should be cleaned either with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water and then removed from the work site.

- Fixed contaminated nonporous equipment within the work area must be cleaned with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water and protected from further contamination during the remediation.

- Where a remediation is conducted where walls do not already enclose the operation, the spread of contaminated debris from the work area must be prevented by the construction of a negative pressure enclosure.

- The negative pressure enclosure must be constructed of two layers of a minimum of 6-mil polyethylene or other suitable material, with reinforced polyethylene on the floors.

- The negative pressure enclosure must have at least 4 air changes per hour and a minimum pressure differential of at least − 5 Pa (- 0.02 inches of water gauge) relative to the air outside of the enclosure must be maintained.

- The negative pressure enclosure must be kept under negative pressure for the duration of the operation.

- All air exhausted from the negative pressure enclosure must passed through a HEPA filter and then be vented to the outside of the building.

- All mechanical ventilation in the contaminated area, except that required to provide the negative air pressure, must be disabled and a barrier of at least two layers of 6-mil polyethylene placed over all openings in the contaminated area.

- All openings in the contaminated area, including windows and doors, must be adequately sealed with adhesive tape or isolated by two layers of 6-mil polyethylene sheeting.

- All entry points to the work site must carry prominently displayed warning notices that identify a remediation activity, and forbid entry to anyone not wearing appropriate respiratory protection and protective clothing.

- A worker decontamination unit must be connected to the work site.

- The worker decontamination unit must consist of two interconnecting rooms including
  - a clean room suitable for changing into or from street clothes and for storing clean clothing and equipment; and
  - an equipment room suitable for changing into protective clothing and for storage of contaminated protective clothing and equipment.

- The worker decontamination unit must be constructed such that overlapping curtains of polyethylene sheeting or other suitable material are fitted to each side of the entrance and exit to each room.

- The worker decontamination unit must be arranged in sequence and constructed so that every person entering or leaving the work area must pass through each room of the decontamination unit.

- A competent person must inspect the work area for defects in the enclosure, barriers, and worker decontamination unit
  - at the beginning of each shift;
  - at the end of a shift where there is no shift beginning immediately following the shift that is ending; and
  - at least once each day on days when there are no shifts.

- Any defect found on inspection must be remedied immediately, and no work, other than necessary repair work, shall be performed in the contaminated area until the repair work is completed.

- Only persons wearing appropriate protective clothing, eye protection, appropriate gloves, and a minimum of full-face N99 respiratory protection (and appropriate protection for any wetting agents or disinfectants) are allowed to enter the contaminated area.

- At the end of work workers must
  - remove gross visible contamination from their protective clothing and respiratory protection in the work area;
  - enter the equipment room of the worker decontamination unit and remove all debris from their respiratory protection equipment with the use of a vacuum cleaner equipped with a HEPA filter and
  - where the protective clothing will be reused, remove all debris from their work clothing with the use of a vacuum cleaner equipped with a HEPA filter, then remove all clothing, and store it in a suitable manner; or
  - where the protective clothing is not intended to be reused, bag it in plastic bags and dispose of it as waste; and
  - pass into the clean area remove and thoroughly clean the respiratory protection equipment, store it appropriately, dress and leave through the clean area door.

- Electrical circuits inside the contaminated area must be deactivated unless equipped with ground-fault circuit interrupters.

- All surfaces of material to be removed must be misted (not soaked) with a suitable material to minimize the spread of mould or spores prior to removal.

- All contaminated material must be cleaned up frequently and immediately upon completion of the work and double-bagged in 6-mil polyethylene bags, sealed, and disposed of.

- All bags of waste and contaminated protective clothing must be removed from the work area through the decontamination unit.

- Bags of waste and contaminated protective clothing must be removed from the work area by the following procedure
  - remove visible contamination from the bags in the work area;
  - transfer the bags to the equipment room and clean the bags with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water, place the bag into a second 6-mil polyethylene bag, and seal the outer;
  - transfer the double-bagged waste to the clean room and then out of the decontamination unit;

- Contaminated equipment, tools, and other items used in the work area must be cleaned with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water prior to removal from the negative pressure enclosure.

- All surfaces inside the negative pressure enclosure must be vacuumed with a vacuum cleaner equipped with a HEPA filter, or wet wiped with an appropriate disinfectant or a solution of 1 part household bleach to 9 parts water.

- Final air clearance testing inside the negative pressure enclosure
  - should be performed before the enclosure is removed and the area is reoccupied; or
  - must be performed before the enclosure is removed where susceptible individuals (those allergic to mould, those with low immunity and babies whose lungs are not completely formed) will reoccupy the area.

- The concentration of mould inside the negative pressure enclosure determined from the air clearance testing should be qualitatively and quantitatively similar to that of outside air or a background sample obtained from an uncontaminated area of the building before the enclosure is removed.

- All polyethylene sheets used to form the negative pressure enclosure, the worker decontamination unit, and covering all openings inside the contaminated area must be double-bagged in 6-mil polyethylene bags, securely tied and disposed of, or disinfected prior to reuse.

- The sealed polyethylene bags containing contaminated material may be disposed of in a licensed landfill or by incineration.

- Washing facilities for hand and face must be made available to workers in the work area, and workers must wash before leaving the work area.

Appendix1: Hiring a Consultant to Help

It is possible that, after evaluating the information in this document, you will not be able to resolve the situation by yourself. If this is the case, you will need to bring in some expertise to help you resolve your biocontamination problem.

As there are no legal restrictions on who can offer their services as a biocontamination investigator, and it will be up to you to ensure that they are qualified to do the work before you hire them. The following is intended to assist you to find a qualified consultant.

1. Where Do You Look?

There are several sources one can check for information and the names of consultants available locally. Contacting professional associations and public service organizations related to occupational safety and health is a good place to start. These organizations include the Canadian Registration Board of Occupational Hygienists, the American Industrial Hygiene Association, and the Manitoba Association of Consulting Engineers. Another useful source can be the consultants listing in the Yellow Pages of your phone book. Finally, there may be a university, college, or hospital in your area that has an occupational or environmental health program. Their staff professionals are often available for consultation.

2. Evaluating a Consultant's Qualifications

Once you find a consultant who claims to be able to perform an assessment, you will need to evaluate his or her qualifications. The best protection against an unqualified consultant is to question the prospective consultant yourself. A series of questions is provided below for your consideration. They should not be given equal weight, as some are minor in importance. (The list is organized roughly in descending order of importance.)

a) For how many years have you been professionally active in biocontamination investigations?

b) Please supply a list of recent clients for whom you have performed biocontamination investigations. (Be sure to call a few of these references to obtain their opinion on the consultant's services.)

c) Have you carried out this work on a full-time or part-time basis? If part-time:

- Who is your chief employer, or in what other business ventures are you involved?
- May we contact your employer concerning you?

- What restrictions does your employer place on you as a part-time consultant?

d) Are you associated with the manufacture or sale of a product that could create a conflict of interest in your activities as a consultant?

e) What degrees or diplomas have you received and when? (Preferably the consultant's educational background will be in occupational hygiene or mechanical engineering.)

f) What special conferences, seminars, symposia, or short courses have you attended (especially recently) to stay up to date with current developments in biocontamination investigations?

g) What professional associations do you belong to? What is your present grade of membership and length of time in that grade for each association?

h) Are you certified or registered by any of the following?
   - Canadian Registration Board of Occupational Hygienists
   - American Board of Industrial Hygiene (specify area of certification)
   - Environmental Engineering Intersociety Board (as an occupational hygiene engineer)
   - the provincial professional engineering association

i) What equipment do you have for conducting biocontamination investigations?

j) What laboratories do you use for the analysis of your exposure measurement samples? Does the American Industrial Hygiene Association or other similar accreditation body accredit them? Do they participate in the National Institute for Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program or similar program and for what materials?

k) Can you refer me to engineering firms capable of installing appropriate controls? Do you have any business connection with these firms?

l) Please indicate your fee structure. Do you work by hourly charges, estimates for the total job, retainer charges, or any of these?

m) In your charges, how do you treat such expenses as travel, subsistence, shipping, report reproduction, and computer time?

n) Can you supply a list of typical laboratory analytical fees?

o) What insurance and bonding do you have?

p) What restrictions are there on the use of your name in our reports or in litigation?

q) What are the character and extent of reports that you prepare? Can you supply an example?

r) What is the size of your staff? What are their qualifications? Who will be working on this project?

3. Defining the Work to Be Completed

Once you have found one or more consultants who can do the work, you will need to define the type of work to be completed. One of the best tools to accomplish this task is to have the consultants prepare a project proposal for your review.

Often, in a larger job, proposals from several points of view are evaluated and used as one of the bases for the final selection of the consultant. In this case, answers to pertinent questions in the preceding section may be sought in the proposal rather than in the interview.

Aside from background qualifications of the consultant, the proposal should answer the following questions:

a) How much is the service going to cost? Smaller jobs are often bid on an hourly basis, typically with a minimum of one-half day's work, plus direct expenses commonly specified. Larger jobs are usually bid at a fixed amount, based on the work steps described.

b) What is the consultant going to do? The answer to this question may range from a simple agreement to study the problem to a comprehensive step-by-step plan to solve it.

c) What will be the end result? The answer to this question is all too often not clearly understood; the result is usually a report that specifies the consultant's recommendation. If you do not want to pay for the preparation of a written report, and a verbal one will do, specify this in advance. As recommendations often call for construction to be carried out by others whose work is not subject to the consultant's control, results usually cannot be guaranteed. Rather, an estimate of the results to be attained is all that can be expected.