

GUIDE

Investigation, Assessment and Remediation of Mould in Workplaces



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Guide for the Investigation, Assessment and Remediation of Mould in Workplaces

Preface

This guide 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 complaints/concerns from workers and others. This guide also establishes minimum remediation procedures that must be followed when contaminated material is to be abated.

This guide has been revised and supersedes Manitoba's 2001 *Guidelines for the Investigation, Assessment and Remediation of Mould in Workplaces*. It adopts and adapts a large amount of information from numerous documents outlined in the references.



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INTRODUCTION TO MOULD

What is fungi/mould?

Mould is a common term that refers to various species of fungi that are a natural part of the environment. Fungi also include yeast, mildew, smut and mushrooms. They usually grow best in dark, moist habitats and are found wherever organic matter is available. 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 include microscopic yeasts and moulds, known as microfungi, while plaster and wood-rotting fungi are referred to as macrofungi 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 (VOCs). 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.

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. Adverse health effects to mould are varied, complex and depend upon many factors. Human factors include personal susceptibility, route of exposure, age and state of health. Mould-related factors include the amount and duration of exposure, virility and viability of the organism and whether the effect is infectious, 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 irritation effects** – long-term exposure to moulds has been associated with a number of non-specific respiratory and flu-like symptoms, eye, nose and throat irritation, headaches, skin problems and impaired immune functions; 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 the very young or elderly with a pre-existing medical condition;
- **High levels of exposure** – exposure to large numbers of spores over a long period of time; and
- **Species of mould** – the more harmful moulds (high potential for mycotoxin production) pose the greatest risk since they may cause irritation and/or allergic reactions.



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 mould on the general population are 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.

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 moulds also commonly found in the outdoor environment. In addition, one can find other moulds, including certain species of *Penicillium*, some *Aspergillus*, *Stachybotrys*, *Chaetomium* and *Fusarium*. Most moulds found in indoor air are able to obtain the nutrients needed 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.



INVESTIGATING POTENTIAL CONTAMINATION

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 or fatigue, 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 are indicators of the possible presence of mould contamination. Also, any indication of water intrusion, flooding, condensation or high humidity, especially if chronic or severe, suggests potential mould contamination.

In most instances, the precipitating factors for an investigation into mould contamination are a combination of adverse health symptoms among occupants combined with a history of water intrusion. Odours can arise from many sources, but in the absence of supporting evidence (e.g., occupant health complaints or an Indoor Air Quality (IAQ) investigation that rules out other options), odours alone may not normally trigger a mould investigation.

The building history

The mould investigator examines a building's history, looking at the original design, original intended use, construction (e.g., 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.

Building use

When the current 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 often is 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 if the humidity is elevated, conditions may become favourable 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. As another example, when office dividers and walls are erected and then occupancy is increased, the original heating, ventilation and air conditioning (HVAC) system may be inadequate. The resulting condensation and poor air circulation can lead to conditions for mould to grow.

Along with the current demand for greater energy efficiency came a significant change in building design. This change resulted in many buildings having HVAC systems that were not designed to handle the excessive moisture that develops when energy efficiency is introduced. In some cases, mould may grow inside the air handling unit and ductwork. High humidity can foster mould growth and lead to hidden mould in many parts of the building. Mould can be extremely hard to find when there are no visible signs of its presence.

Building deterioration

As structures age, they deteriorate; a building envelope begins to break down and if proper maintenance is not practised, 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 where different claddings meet and where caulking is used to seal joints;
- 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 the building must provide proper drainage;
- Drainage holes and pipes for water that might collect behind the exterior veneer must not be blocked; and
- Crawlspaces must be examined for dampness, adequacy of ventilation, signs of suspect mould growth or past flooding, water damage to any sonotubes, mechanical insulation or structural members, exposed clay or soil and the integrity of existing ground covers (e.g., moisture barriers).

Building interior:

- Areas throughout the interior should be examined for renovations that might trap condensation; evidence of leaks around pipes that penetrate the wall or ceiling; leaks around windows; condensation around cold spots or on plumbing pipes; plumbing leaks (e.g., 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; and expansion joints at floor-wall junctions.

Building environment

A building's environment provides clues to potential mould contamination – usually the 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 or 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 leftover food, temperature below the dew point and an HVAC system that does not supply sufficient fresh air.



Relative humidity

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (**ASHRAE**), Standard 62.1-2004: *Ventilation for Acceptable Indoor Air Quality*, outlines that elevated relative humidity (RH) can support the growth of fungi and associated mycotoxins. This growth will be enhanced by the presence of materials with high cellulose content such as fiberboard and drywall as well as dust, lint and skin particles. As per the ASHRAE standard, occupied spaces should be maintained below 70 per cent RH to minimize the growth of allergenic or pathogenic organisms. The 2008 *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, **New York City Department of Health and Mental Hygiene**, recommends maintaining indoor RH levels below 65 per cent to inhibit mould growth.

Impact of renovations or additions

Whenever an existing building is renovated or has a structure added, 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.

Mould growth can develop during the construction of a building if mould-prone materials are exposed to high humidity, flooding or precipitation. The Canadian Construction Guide 82: *Mould Guidelines for the Canadian Construction Industry*, offers detailed advice to minimize mould growth during design and construction of a building.

Interviewing occupants

When investigating a building for potential mould contamination, adverse health effects to the occupants are 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, due to confidentiality concerns, this may be a role for a medical doctor. Often, occupants can relate episodic or chronic health effects to events (e.g., 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.

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 such as ceiling tiles, wallpaper (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 (e.g., 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.



Destructive investigation

When mould is not visible but is suspected, one has to look for clues as to its location such as behind baseboards, within wall cavities, above enclosed ceilings and in carpets. This may require the use of a destructive investigation process, 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; and blistering paint.

Destructive sampling may require additional precautions in health care facilities, personal care homes and clinics, locations where high-risk occupants with existing known medical conditions are present.

Moisture

Moisture and dampness are primary factors to be considered in a mould investigation. Following the visual inspection, and prior to undertaking invasive and destructive investigative measures (cutting out walls, etc.), a moisture inspection should be conducted with the use of a moisture meter.

A moisture inspection can serve to help narrow a search when mould is concealed. Moisture level readings measured on gypsum board (drywall), wood, timber, roofing, plaster or brick can detect locations and conditions of humidity, which could lead to potential mould growth beneath the surface. The moisture levels will range between low, moderate and high. Moderate humidity levels detected may indicate potential mould growth. High humidity levels may indicate the likelihood of mould growth.

Sampling

Sampling of mould is not usually necessary before proceeding with remediation of visually identified mould growth or water damaged materials. It cannot be emphasized enough that, as a basic premise of this guide, the approach to visible mould is “you see it, you get rid of it.”

Appropriate remediation planning can usually be made on the basis of the building history, a methodical visual inspection, moisture level readings and a destructive investigation process, if required.

Nevertheless, there will be circumstances where mould sampling may need to be carried out. The various types of mould sampling, collection and analysis methodologies and suggested guidelines are outlined and discussed further in **Appendix 1**.

General investigation principles

The following section describes the general order of investigation and has been adapted from the 2004 Federal-Provincial Committee on Environmental and Occupational Health document, *Fungal Contamination in Public Buildings: Health Effects and Investigations Methods*.



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 safety and health 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 – 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 safety and health 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 in accordance with the **Manitoba Workplace Safety and Health Act and Regulation**. Building occupants should be kept up-to-date during the investigative, remedial and follow-up stages. 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 – 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. The relative humidity in the building/ area of concern may be elevated. 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 (e.g., paper, cardboard, wood), air filters, heat exchangers (e.g., condensation on cooling coils), humidifiers, water sumps, perimeter heating and cooling units, wet carpets, 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.

Moisture meters/thermal imaging cameras

A moisture meter can be used to detect elevated moisture in walls, floors, timber and carpets. In addition, thermal imaging cameras using infrared technology allow the investigator to detect cooler areas inside walls, above ceilings and below floors. This technology, in combination with a moisture meter, can help to narrow the search for damp mould-prone areas in the building without causing damage. 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 – Destructive investigation:

Destructive investigation occurs when certain structures of the building have to be taken apart in an attempt to locate the source of suspected contamination or the contamination itself. During this phase, the contamination status of the building is expected to be altered by the actions taken by the investigative team, through exposure of previously hidden contaminants and redistribution of such contaminants via the HVAC system or by other means. Precautions must be taken to prevent all individuals within the building from a potential exposure during a destructive investigation.

Inspecting wall cavities

Wall cavities can be observed by drilling small (typically four-inch) holes between structural members in the interior wallboard. A vacuum equipped with a HEPA filter should be kept nearby to collect any wallboard dust or biological particulate which might be released during drilling or from the open hole in the wall. The holes can be inspected with a flashlight, boroscope and mirror to identify the presence of mould, staining or moisture. Following the observation, each hole can be patched with the removed plug and repaired so that no air pathway remains from the cavity into the occupied space.

PHASE V – Sampling:

There are circumstances when sampling will be required to confirm or dispute the nature of a concern. Air sampling is not appropriate unless a thorough building inspection is done either on a concurrent basis or before sampling. Common methods include:

- transparent tape surface sampling
- scrapings of contaminated materials
- bulk sampling
- routine air sampling.

During this phase, the contamination status of the building is not expected to be altered by the actions taken by the investigative team. Sampling practices are outlined in **Appendix 1**.

PHASE VI – Remedial actions:

Removal of contaminated material may include:

- Decontamination of the HVAC and other systems as required; and
- 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 workers, possibly through disturbance of newly exposed heavy concentrations of contaminants and redistribution of such contaminants via the HVAC system if appropriate remedial measures are not adopted as outlined in the following section.



MOULD REMEDIATION PROCEDURES

Introduction

In all situations, the underlying cause for the presence of mould, for example, water intrusion or accumulation, must be rectified or fungal growth will recur. Remediation performed without first identifying and rectifying the cause of the biocontamination will result in 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 recur. 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, the relative humidity (RH) should be maintained at levels below 65 per cent to inhibit mould growth.

Porous materials

Porous materials such as furniture, ceiling tiles, plaster/lath, gypsum wallboard, insulation and carpet that have become wet on an ongoing basis or left wet for an indeterminate amount of time (due to floods, building and roof leaks, sewage backup or groundwater infiltration) are usually discarded.

Only in exceptional cases, and within 24 to 48 hours, should porous materials be considered for drying. 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.

Drywall and other wall material, such as insulation, should be removed up to a point that is no longer wet. The rule of thumb is to remove approximately 40 cm (16 inches) above the visible mould or high water line, whichever is higher.

The effectiveness of any remediation of contaminated porous material must be evaluated as a standard procedure in all abatement activities. Surface sampling can be carried out 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 (e.g., plaster, drywall, roofing material, etc.) should also be assessed. A followup evaluation should be performed in the remediation area after approximately three to six months to ensure that the growth of mould has not recurred. This followup evaluation may be visual initially and ultimately could include air testing and/or surface testing, if required. The results of the followup tests can be compared with the suggested guidelines presented in **Appendix 1**.



Biocides and disinfectants; controlled products

The goal of the remediation is to remove microbial growth. This is generally accomplished by physical removal of materials supporting active growth, including porous materials, and thorough cleaning of non-porous materials. Therefore, application of biocides would serve no purpose that could not be accomplished with soap/detergent and water.

Soap and water is recommended for cleaning **non-porous** materials. This approach has been adopted by various jurisdictions and organizations, including, but not limited to, British Columbia, Ontario, Canada Mortgage and Housing Corporation, New York City Department of Health and Mental Hygiene, the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and the American Industrial Hygiene Association (AIHA).

In the event that biocides are required, a risk assessment, safe work procedure and worker training program must be developed and coordinated by the employer to address the hazards outlined by all information available for the product (e.g., Material Safety Data Sheets (MSDS) and/or labels).

Respiratory protection

Respiratory protection is required in all mould remediation projects. The extent of respiratory protection is established based on the degree and extent of the contamination. In all cases, **respiratory protection must be NIOSH-approved (National Institute for Occupational Safety and Health) and be properly fitted to the individual worker(s) by personnel competent in the practice of respirator fit testing** in accordance with the most recent Canadian Standards Association (CSA) standard: *Selection, use and care of respirators Z94.4-11*.

Procedures for removal of mould

Procedures to be followed for removing mould-contaminated material will vary according to the size of the contaminated area: **small, medium or large**.

Small area: less than 1 m²

Medium area: between 1 m² and 3 m²

Large area: greater than 3 m²



Applicable to all areas of mould removal – small, medium and large:

- The work area should be unoccupied.
- Eating, drinking, chewing and smoking are prohibited in the work area.
- Respiratory protection, the selection of which is dependent on the extent of the contaminated area, gloves and eye protection (goggles are preferred) are required.
- All respiratory protection must be properly fitted according the current CSA Standard: *Selection, use and care of respirators Z94.4-11*, by personnel trained and competent in the task of respirator fit testing.
- Compressed air must not be used to clean up or remove contamination from any contaminated surface.
- Prior to removal, all surfaces of material to be removed must be gently misted (not soaked) with a suitable solution, soap or detergent and water, to minimize the spread of mould or spores prior to removal.
- The spread of contaminated debris from the work area must be controlled by placing 6-mil polyethylene plastic sheeting under the contaminated material to be removed.
- To avoid cross-contamination with adjacent unaffected areas, all contaminated debris must be bagged in 6-mil polyethylene plastic bags or wrapped in the sheeting. The bags and sheeting must be sealed immediately and removed from the area for disposal as soon as possible.
- Sharp items capable of puncturing the polyethylene material should be packaged in such a way as to prevent them from puncturing the material before being bagged or wrapped.
- Any plastic sheeting used in the process must be disposed of with the contaminated debris upon completion of the removal.
- The sealed polyethylene bags should be removed from the building as soon as possible. The bags may be disposed of in a licensed landfill. There are no special requirements for the disposal of mouldy material.
- The worker transporting the sealed bags to the exterior of the building must be informed of the content and be trained on the procedures to follow in the event of puncture (e.g., donning personal protective equipment (PPE), securing the area and clean-up).
- An assessment of risk is to be conducted for any controlled product used in the removal process. An associated SAFE work procedure must be developed to include, but not be limited to, outlining the appropriate PPE for its usage and handling.
- Washing facilities for hands and face must be made available to workers in the work area and workers must wash before leaving the work area.

Small area – less than 1 m² of mould

- Small area procedures can be considered when fewer than three patches of mould are present in the same room, provided the sum total of all mould present does not exceed 1 m².
- All workers performing the removal of materials contaminated by mould must be provided with a minimum of N95 respiratory protection or a half-mask with P100 filters, gloves and eye protection. Appropriate respiratory protection must also be evaluated for any wetting agents that are to be used during the remediation.
- All mechanical ventilation (HVAC and duct openings) in the immediate area must be disabled and sealed to prevent any contamination (e.g., mould spores) from entering the ventilation system.
- Electrical circuits in proximity of the contaminated area(s) must be deactivated unless equipped with ground-fault circuit interrupters.



Medium area – between 1 m² and 3 m² of mould

- Medium area procedures can be considered when there are one or more isolated patches larger than 1 m² in the same room, provided the sum total of all mould present does not exceed 3 m².
- Clearly visible signs warning of the remediation must identify the area where the removal is being performed.
- Where a removal is conducted and where walls do not already enclose the contaminated area, the spread of contamination from the area must be prevented by the construction of a small walk-in negative pressure enclosure.
- Movement of personnel and removal of waste to and from the contaminated area shall be controlled via the construction of an attached, single-stage airlock.
- The negative pressure enclosure and the attached airlock must be constructed of, at minimum, one layer 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 an exhaust ventilation unit equipped with a HEPA filter and vented to the outside of the building.
- All mechanical ventilation in the contaminated area, except that required to maintain the negative pressure, must be disabled and blocked to prevent any contamination (e.g., mould spores) from entering the ventilation system.
- At least one layer of 6-mil polyethylene must be placed over all openings in the contaminated area including the ventilation system components in the area.
- Electrical circuits inside the contaminated area must be deactivated unless equipped with ground-fault circuit interrupters.
- Only persons wearing protective clothing, eye protection, gloves, a minimum of a re-usable half-mask with P100 filters for respiratory protection and any appropriate protection for wetting agents, as determined by the assessment of risk, are allowed to enter the contaminated area.
- All contaminated debris must be cleaned up frequently and immediately upon completion of the work.
- All contaminated debris must be 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 solution of soap or detergent and water before being removed from the area or negative pressure enclosure for disposal. Alternatively, the initial bag of waste can be placed in a second (clean) bag, by a second worker located inside the adjoining airlock/waste transfer chamber, prior to the work being removed from the work area. The choice of procedure will depend on the building occupancy at the time of remediation and the risk of exposure to occupants and contamination to surroundings areas in the event that a bag should break open while exiting the building. Many contractors will prefer the two-bag method for efficiency over wet wiping.
- 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 solution of soap or detergent and water prior to dismantling the enclosure.
- All polyethylene sheeting used to receive contaminated materials, to form the negative pressure enclosure and to cover all openings inside the contaminated area, must be folded to contain any remaining debris and bagged in 6-mil polyethylene bags, sealed and disposed of or properly decontaminated 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 solution of soap and water after completing the work and before leaving the contaminated area.
- Contaminated protective clothing that will not be re-used must be disposed of with the mould-contaminated waste.



Large area – greater than 3 m² of mould

- 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. A contact person can be identified on the signage for worker or occupant questions.
- 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 a minimum of two layers of 6-mil polyethylene or other suitable material, with reinforced polyethylene on the floors.
- The negative pressure enclosure must have at least four 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 pass 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 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 one layer 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 separate worker and waste 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 from street clothes and for storing clean clothing and equipment; and
 - an equipment room suitable for removing the protective clothing and for storage of the contaminated equipment.
- The waste decontamination unit must consist of two interconnecting rooms including:
 - a clean room suitable for cleaning any equipment to be removed or for double bagging of waste; and
 - a hold room suitable for the storage of waste until it can be removed by a second worker accessing the room from the exterior of the contaminated work area.
- The worker and waste decontamination units 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 and waste decontamination units must be arranged in sequence and constructed so that every person, or any waste or equipment, entering or leaving the work area must pass through each room of the corresponding 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 to follow; 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 mask and P100 or HEPA filters, respiratory protection and appropriate protection for any controlled products are allowed to enter the contaminated area.
- Movable contaminated non-porous equipment within the work area should be cleaned either with an appropriate solution of soap or detergent and water and then removed from the work site.
- Fixed contaminated non-porous equipment within the work area must be cleaned with an appropriate solution of soap or detergent and water and protected from further contamination during the remediation.
- 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;
 - remove all debris from the work clothing with the use of a vacuum cleaner equipped with a HEPA filter and then remove all clothing and store it in a suitable manner;
 - place disposable clothing in 6-mil polyethylene plastic bags to be disposed of with the contaminated 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 contaminated material must be cleaned up frequently and immediately upon completion of the work, 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 waste decontamination unit.
- Bags of waste and contaminated protective clothing must be sealed and removed from the work area by the following procedure:
 - remove visible contamination on the outside of the bags in the work area;
 - transfer the bags to the container clean room and place the bag in a second bag;
 - transfer the bagged waste to the adjoining hold room and then out of the decontamination unit for disposal as soon as possible;
 - bags are to be removed by the most direct exit route (e.g., a window or exterior door connected to the decontamination unit); and
 - workers disposing of bags must be aware of the contents, take measures to avoid ruptures and be trained in how to deal with such an event.



- Contaminated equipment, tools and other items used in the work area must be cleaned with an appropriate solution 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 solution of soap or detergent and water.
- Final air clearance testing inside the negative pressure enclosure should be performed before the enclosure is removed if and when susceptible individuals (e.g., those allergic to mould, those with low immunity, babies whose lungs are not completely formed, etc.) will reoccupy the area.
- 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 and waste decontamination units, and the covering of all openings inside the contaminated area must be bagged in 6-mil polyethylene bags, sealed and disposed of.
- The sealed polyethylene bags containing contaminated material may be disposed of in a licensed landfill or by incineration.
- Washing facilities for hands and face must be made available to workers in the work area and workers must wash before leaving the work area.



APPENDIX 1: MOULD SAMPLING

Sampling of mould is not usually necessary before proceeding with remediation of visually identified mould growth or water-damaged materials. It cannot be emphasized enough that, as a basic premise of this guide, the approach to visible mould is **“you see it, you get rid of it.”** The reader should keep in mind that **all wet porous materials would support the growth of mould if they were not dried thoroughly within 24 to 48 hours.** These materials should be discarded if they cannot be dried within the times specified.

Nevertheless, there will be circumstances where mould sampling may need to be carried out.

1. Sample collection and analytical methods

Primarily, there are three forms of sampling commonly used in mould investigations: **bulk, swab and air.**

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.

Current industry practice for **bulk or swab** sampling are to use Direct Microscopic Examination of surface samples (tape-lift, bulk, swab) to examine for mould growth. Culture-based analysis of bulk materials is rarely called for.

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 centimeter of area sampled (CFU/cm²) – a minimum of 100 cm² is normally recommended. These units are consistent with most of the literature reports as well.

For **air sampling**, the most commonly used method is Direct Microscope Examination of spore trap fungal air samples. Advantages of this method include no need for cold shipping, no wait for culturing and the possibility of next day results.

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.

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.

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

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

***Field Guide for the Determination of Biological Contaminants in Environmental Samples, Second Edition*, American Industrial Hygiene Association, 2005, Dillon, H.K.; Hung Ling-Ling and J.D. Miller**

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



2. Preservation and transportation of samples

The manner in which samples of materials suspected to contain mould are handled (e.g., preserved and transported) will affect 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.

3. 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 affect 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 similar. If the air handling system uses air filters, the number of organisms inside compared to outside will be 20-40 per cent lower (e.g., expect the filter system to remove 60-80 per cent 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.

Procedures presented in *Fungal Contamination in Public Buildings: Health Effects and Investigation Methods*, 2004, Health Canada, provide recommendations on what action should be considered if the results of air sampling suggest the presence of an amplification situation within the building.

4. Suggested guidelines

There is still considerable controversy over the acceptance of an appropriate standard for a "safe" exposure to mould. As explained in Health Canada's bulletin *Mould in Indoor Air – Environmental and Workplace Health*, 2012, Health Canada does not have any numerical exposure limits for mould. Health Canada states that "since people have different sensitivities, it is not possible to establish a safe limit for mould." In addition Health Canada "recommends removing any mould found growing indoors and fixing the underlying moisture problem."

The Health Canada publication *Indoor Air Quality in Office Buildings: A Technical Guide*, 1995, presents numerical spore counts (in CFU/m³) that were typically observed by the author in federal government buildings over several years. The numbers are based on a large data set gathered using a Reuter centrifugal sampler with a four-minute sampling time. The observations that were made at that time were meant to help guide investigations in office buildings where mould is suspected but not visible.



The findings presented in the Health Canada publication (below) are not meant to be presented as “safe levels” of mould. They are not intended as Health Canada guidelines or recommendations; however, some of them have been found useful by workers in the field. Note that the concentrations cited in e), f) and g) make no reference to background or outdoor levels that can be higher than these concentrations. The concentrations cited in e), f) and g) cannot be adopted as guidelines in the assessment of health risk. Today, it is primarily important and relevant to compare sampling results to background or outdoor levels.

- a) 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 fungi cannot be measured with air sampling techniques.
- b) 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.
- c) 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.
- d) 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 is not available and data that is available may be based on sampling techniques unlikely to be applied in modern indoor studies.
- e) More than 50 CFU/m³ of a single species (other than *Cladosporium* or *Alternaria*) may be reason for concern. Further investigation is necessary.
- f) Up to 150 CFU/m³ 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.
- g) Up to 500 CFU/m³ 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.
- h) The visible presence of mould in humidifiers and on ducts, ceiling tiles and other surfaces requires investigation and remedial action regardless of the airborne spore load.
- i) Certain kinds of mould contamination are 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 or tape-lift and having them analyzed for fungal species.



Ventilation ducts

Some rules of thumb for the interpretation of bulk analysis from the inside of ventilation ducts have been documented by the University of Minnesota, Department of Environmental Health & Safety, Indoor Air Quality, in the university-based article *Mycological Aspects of Indoor Air Quality*. This reference is also published in the *Worldwide Exposure Standards for Mold and Bacteria with Assessment Guidelines for Air, Water, Dust, Ductwork, Carpet and Insulation*, 8th Edition.

Carpeting

There is still considerable disagreement among technical experts as to whether a standard can/should be established for other types of porous building materials such as carpeting. References for micro-vac and bulk dust assessment in carpeting have been documented in the *Worldwide Exposure Standards for Mold and Bacteria with Assessment Guidelines for Air, Water, Dust, Ductwork, Carpet and Insulation*, 8th Edition. The referenced concentrations are intended to assist with a qualitative assessment for the level of cleanliness of carpeting.

Additional guidelines

Construction

The Mould Guidelines for the Canadian Construction Industry (CCA-82, 2004) provide useful information and instructions for insurance considerations, minimizing of moisture intrusion, proper building maintenance and operation, mould assessment, mould remediation protocols, proper disposal of mouldy materials and guidelines for selecting mould remediation contractors.

Heavily contaminated buildings

The Calgary Health Region of Alberta Health Services has produced a number of documents on the issue of mould contamination and remediation following the use of a structure to grow operations. *The Fungal Air Testing, Investigating and Reporting Requirements for Extensively Mould-Contaminated Buildings*, 2011, provides a comparative guideline, based on current and convenient testing parameters, to identify when mould is elevated relative to background.



APPENDIX 2: 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 yourself. If this is the case, you will need to bring in experts to help you resolve your biocontamination problem.

As there are no legal restrictions on who can offer their services as a biocontamination investigator, it will be up to you to ensure they are qualified to do the work before you hire them. The following is intended to help you 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, but are not limited to, the Canadian Registration Board of Occupational Hygienists, the American Board of Industrial Hygiene, the American Industrial Hygiene Association and the Manitoba Association of Consulting Engineers. Another useful source can be the consultant listings in local directories such as the Yellow Pages. Following the site assessment, restoration companies that have training and certification by the IICRC (Institute of Inspection, Cleaning and Restoration Certification) will be knowledgeable of the onsite requirements outlined by a well-prepared remediation plan. Finally, there may be a laboratory, university, college or hospital in your area that has an occupational or environmental health program. Its 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) 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
- b) For how many years have you been professionally active in biocontamination investigation and remediation?
- c) 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.)
- d) 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?
- e) What professional associations do you belong to? What is your present grade of membership and length of time in that grade for each association?



- f) What equipment do you have for conducting biocontamination investigations?
- g) Can you refer me to engineering firms capable of installing appropriate controls? Do you have any business connection with these firms?
- h) Please indicate your fee structure. Do you work by hourly charges, estimates for the total job, retainer charges or any of these?
- i) In your charges, how do you treat such expenses as travel, subsistence, shipping, report reproduction and computer time?
- j) Can you supply a list of typical laboratory analytical fees?
- k) What insurance and bonding do you have?
- l) What restrictions are there on the use of your name in our reports or in litigation?
- m) What are the character and extent of reports that you prepare? Can you supply an example?
- n) How many staff do you employ? 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 factor in 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 the 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 according to 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.



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SAFE Work Manitoba
204-957-SAFE (7233)
1-855-957-SAFE (7233)
information@safeworkmanitoba.ca
safemanitoba.com