

# Mould Remediation Guide



© [www.doctorfungus.org](http://www.doctorfungus.org)

*Procedures for identifying and  
remediating mould contamination  
in buildings.*



**HAZARDOUS MATERIALS ASSOCIATION**

Phone: 604-580-5889 • Fax: 604-580-5823 • [www.hazmatbc.ca](http://www.hazmatbc.ca) • e.mail: [info@hazmatbc.ca](mailto:info@hazmatbc.ca)  
12277 Industrial Road, Surrey, British Columbia, Canada V3V 3S1

Copyright © 2004  
Hazardous Materials Association  
All rights reserved.

For copies of this publication contact the  
Hazardous Materials Association at:  
12277 Industrial Road, Surrey, BC, V3V 3S1  
Phone: 604-580-5889  
Fax: 604-580-5823

*Cover photograph of Histoplasma capsulatum spores by M. McGinnis.  
Copyright © 2004, courtesy & used with the permission of [www.doctorfungus.org](http://www.doctorfungus.org)*

*The Government of Canada has contributed funding to this initiative.*



**Government  
of Canada**

**Gouvernement  
du Canada**

Typography & design

*Information* by *Design*

# About the Hazardous Materials Association

The Hazardous Materials Association is an association of professional contractors, other concerned organizations, and individuals involved in the remediation and safe handling of hazardous materials.

One of the objectives of the Hazardous Materials Association is to promote voluntary standardization of mould remediation procedures, thereby protecting the health and safety of hazardous materials workers, building occupants, the general public, and the environment.

This *Mould Remediation Guide* is intended to establish and reinforce requirements and standards for the safe handling of mould contaminated materials in the province of British Columbia. Users of this *Guide* should also be familiar with the applicable federal, provincial, and municipal regulations and guidelines that apply to the handling, transportation and disposal of mould contaminated materials.

Those who have a need to apply mould remediation standards are encouraged to use this *Guide* as a reference text whenever practicable. This *Guide* will be subject to periodic review and revision. Users of this *Guide* should contact the Hazardous Materials Association to obtain the latest edition.

We have prepared this *Mould Remediation Guide* using information sources believed to be accurate and reliable. We, however, assume no responsibility or liability with respect to the use of this information and make no representation or warranties of any kind.

The Hazardous Materials Association welcomes and encourages constructive criticism and suggestions for changes or additions to the present manual. Please address all correspondence and requests for additional copies to the address below.

## Hazardous Materials Association

12277 Industrial Road, Surrey, British Columbia V3V 3S1

Phone: 604-580-5889

Fax: 604-580-5823

E-mail: [info@hazmatbc.ca](mailto:info@hazmatbc.ca)

Web Page [www.hazmatbc.ca](http://www.hazmatbc.ca)



# Preface

This *Guide* contains only general information about identifying specific mould or fungus varieties. Mycology is a complex science and the microscopic study of fungus particles requires considerable expertise.

For contractors, it is important to have a broad understanding of mould physiology and growth in order to manage contamination. If identification of specific mould species is required, it is assumed that the contractor will consult with a knowledgeable biologist or mycologist and use the services of an competent microbiological laboratory.

## ***Language Use***

This is not a biology text. It is a guide for contractors and workers involved in mould remediation work. Part of this work involves talking to experts about mould and making sense of lab reports which use scientific taxonomy; at other times, contractors and their employees have to communicate information about mould to the general public using more everyday language. In the *Guide* we have tried to bridge the gap between the two. In doing so, we generalize and ignore details not relevant to the immediate purpose.

- In this guide, spore is used in an inexact sense to describe the primary mould propagule, no matter what sexual process went into its production. Spore and conidium are sometimes used interchangeably and inexactly.
- The term ‘mould debris’ used in the guide refers to the various microscopic particles exuded into the atmosphere by the mould organism - hyphae, spores, conidia, conidiophores etc.



# Table of Contents

<b>1. An Introduction to Mould .....</b>	<b>1</b>
The Fungi Kingdom .....	1
Mushrooms, Moulds, and Yeasts .....	2
Mould Growth .....	3
Oxygen .....	3
Moisture .....	3
Temperature .....	3
Nutrients .....	4
Inhibiting Mould Growth .....	5
<b>2. Health Effects of Moulds .....</b>	<b>6</b>
Introduction .....	6
Adverse Health Effects of Exposure to Mould .....	6
Conclusion .....	8
<b>3. Assessing Mould Contamination .....</b>	<b>9</b>
Inspection Procedures .....	9
Invasive or Destructive Testing .....	12
Sampling .....	12
Air Sampling .....	13
Surface Scraping and Swabbing .....	13
Bulk Sampling .....	14
Evaluation Criteria for Samples .....	14
Interpretation of Assessment Results .....	15
<b>4. Mould Remediation Procedures .....</b>	<b>17</b>
Moisture Control .....	17
Mould Remediation Worker Protection .....	17
Risk Assessment .....	18
Worker Training .....	18
Personal Protective Equipment .....	18
Electrical Services and Equipment .....	19
Protection of Building Occupants .....	19
Work Area Isolation and Containment .....	19
Common Requirements for all Remediation Projects .....	20



Remediation Methods and Levels .....	20
Level 1 - Small Area (10 sq. ft. or less) .....	23
Work Area Preparations and Control Measures .....	23
Personal Protective Equipment and Hygiene Facilities .....	23
Mould Remediation Work Area Cleanup .....	24
Level 2 - Mid-sized Area (10 – 100 sq. ft.) .....	24
Work Area Preparations and Control Measures .....	24
Personal Protective Equipment and Hygiene Facilities .....	25
Level 3 - Large Areas (greater than 100 sq. ft.) .....	25
Work Area Preparations and Control Measures .....	25
Personal Protective Equipment and Hygiene Facilities .....	25
Remediation Methods for Specific Building Components .....	26
General .....	26
Concrete .....	26
Carpet .....	26
Wall and Ceiling Board .....	27
Electrical Equipment .....	27
Furniture .....	28
Files and Paper .....	28
HVAC Systems Decontamination .....	29
Preparation .....	29
Cleanup .....	29
Post-Remediation Inspection and Clearance .....	30
Long-term Monitoring .....	30
<b>5. Personal Protective Equipment .....</b>	<b>31</b>
Respirators .....	31
Selection of Respiratory Equipment .....	32
Respirator Use .....	32
Protective Clothing .....	33
Protective Footwear .....	33
Hearing and Eye Protection .....	33
<b>6. Glossary .....</b>	<b>34</b>
<b>7. Standards and References .....</b>	<b>44</b>
Appendix A - Sampling Protocols (Mould) .....	45
Appendix B - Training Requirements for Mould Remediation Workers .....	49
Appendix C - Testing and Maintenance of Respirators .....	51



# 1

# An Introduction to Mould

## The Fungi Kingdom

The fungi family is a diverse and colourful collection of organisms which includes mushrooms, rusts, smuts, puffballs, truffles, morels, moulds, and yeasts, as well as many less well-known organisms. Collectively, the fungi account for one quarter of all the biomass on earth and exploit every possible ecological niche. More than 70,000 species of fungi have been identified and catalogued; however, some biologists suggest that more than a million species may exist. Along with the plants and animals, the fungi are one of the three multicellular kingdoms of life.

Although resembling plants in many ways, fungi feed by ingesting organic matter created by other life forms. Plants, on the other hand, use chlorophyll to convert inorganic substances into nutrients. Fungi can draw nutrients from living as well as dead organic material. When the nutrient source for the fungus is a living organism, the fungus may harm or kill the host organism in a parasitic relationship; or it may coexist and help the host organism in a symbiotic relationship. Most fungi break down and use the organic material in dead plants and animals as nutrient sources. Fungi are the primary decomposers of organic waste, capable of invading and digesting dead wood, leaf litter, animal feces, or any products such as paper or cloth which are made of organic material.

Biologists divide fungi into five large groupings called phyla, depending on the way in which each fungus gathers nutrients, grows and reproduces. The five phyla of the fungi kingdom are shown in Figure 1 below.

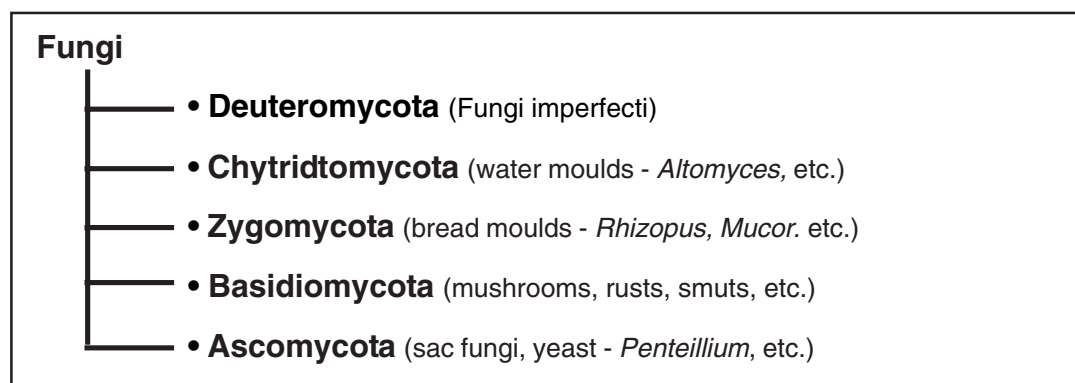


Figure 1 - The five phyla of the fungi kingdom.

Each phylum is further divided into orders, classes, genera, and species. Generally, only the last two items in this taxonomy, genus and species, are used to name a particular fungus in the same way that we use first and last names to identify people. For example, a common indoor mould is a specific *chartorum* species of the genus *Stachybotrys*. In the literature, it will be called *Stachybotrys chartorum*, using the standard genus-species naming convention.

## Mushrooms, Moulds and Yeasts

Some aspects of mould remediation work will require the use of the scientific taxonomy for classifying fungi. For example, when looking at lab reports or talking to specialists, exact scientific nomenclature will have to be used to identify the mould. For most purposes, however, a more descriptive and everyday naming convention will be sufficient. The nontechnical view of fungi divides the kingdom into mushrooms, moulds and yeasts.

**Mushrooms** are characterized by large fleshy fruiting bodies. The actual mushroom cap that we see represents only one small part of the organism, most of which is composed of a mass of hyphae growing out of sight in the substrate. The fungus we know as the field or horse mushroom, *Agaricus campestris*, may have a fibrous 'body' of hyphae that extends several metres in all directions from the eruption of the spore bearing mushroom cap. Most mushroom varieties belong to the phylum *Basidiomycota*.

The term **mould** is a common name which most of us apply to any a variety of fungi which grow as semi-microscopic organisms. Moulds tend to appear as a loose meshwork of fibres rather than the dense tissue characteristic of a mushroom. Moulds may belong to any of the five fungi phyla, and the term has no scientific relevance. For everyday purposes, the term mould is descriptive of microscopic fungi with a 'fuzzy' or 'woolly' appearance, markedly different from the large fleshy fungi we call mushrooms.

Moulds have no fruiting body. Instead, microscopic spores are formed at the ends of the growing filaments which form the characteristic fuzzy mass of the mould organism. The mass of hyphae filaments typical of mushrooms and moulds are collectively known as mycelium.

For taxonomic and reference purposes, the great majority of what we commonly call moulds belong to the phylum *Zygomycota* or *Fungi Imperfecti*.

**Yeasts** are solitary, rounded organisms which reproduce by 'budding' and splitting apart (fission). Colonies of yeast reproduce best in very moist or wet conditions. Yeasts belong to the phyla *Ascomycota*.

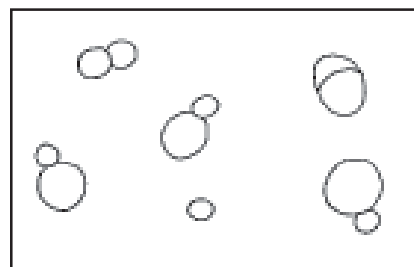


Figure 2 - Yeast spores budding.

## Mould Growth

Moulds grow whenever they encounter the right mix of moisture, temperature, oxygen and nutrients. Fungi form colonies that can reproduce in five to ten days. They reproduce by forming and broadcasting spores that range from 2 to 60 microns in size.

Moulds are demanding in their growth requirements, and different species of mould grow only under specific environmental conditions.

### Oxygen

Moulds and other fungi can grow in either normal or very low oxygen levels but none are anaerobic.

### Moisture

As much as 90% of the weight of any fungus is water. Water is necessary for mould to process nutrients and grow.

### Temperature

Most fungi grow in the temperature range between 5 - 38 °C but some species may live in extreme habitats. Mould varieties can be found growing on icy mountain tops as well as in hot springs. Some environments support a particular species of fungi and are hostile to others. Thermophilic mould species grow best in very warm environments such as compost piles. Several low temperature *Basidiomycetes* or 'snow moulds' grow directly under the snow (*Fusarium nivale*, *Sclerotinia borealis*) and blight lawns from coast to coast in Canada.

Very high temperatures can kill the mould organism, but mould spores are sometimes more difficult to destroy. All mould species grow best within quite a narrow temperature range, but many are tolerant of lower and higher temperatures. Low temperatures will generally slow mould growth; freezing temperatures will stop it completely.

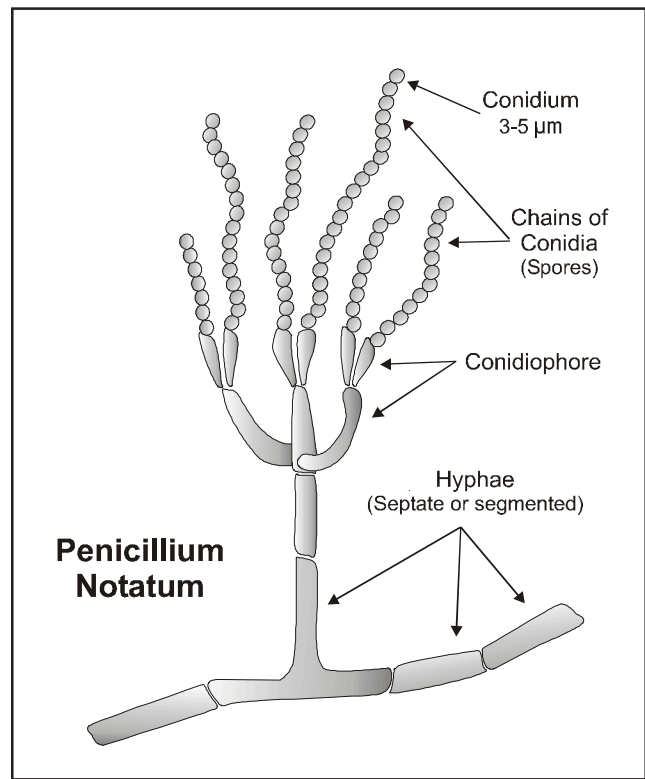


Figure 3 - Structure of a typical mould.

## **Nutrients**

Moulds and other fungi excrete enzymes to break down the substrate and then they absorb the resulting nutrients. A fungus grows into its food supply, sending out hyphae to contact, penetrate and exploit new sources of nutrients. As the nutrient source is depleted, the mould switches to reproductive mode and produces spores. Thus in most fungal colonies, there is a 'leading edge' of spore-free hyphae growth in rich unexploited substrate and a 'trailing edge' of spore producing hyphae in the nutrient depleted region colonized earlier. The 'fairy ring' phenomenon is an example of this growth pattern. The fungus causing the fairy ring depletes nutrients in the ground as it grows outward from an original infection point. After a few years, the ground at the centre of the ring is nutrient depleted and the fungus no longer grows there. Around the outside of the circle, the fungus continues to grow outward into nutrient rich ground. Just behind this ring of growth, the fungus will produce the characteristic ring of mushrooms it uses to propagate spores.

When dealing with fungus contamination and growth, it is important to remember that the growing mould organism may extend well beyond areas where spores are visible, and well into the substrate, even if that substrate appears to be impervious to penetration.

Substrates such as dust, wallpaper, paints, insulation materials, gypsum board, carpet, fabric, and upholstery commonly support mould growth. Many building materials are suitable nutrient sources for fungal growth, particularly cellulose substrates such as paper products, cardboard, ceiling tiles, and wood products. Moulds can also grow on inorganic surfaces if they are contaminated with suitable organic material such as wet dirt or sewage.

### ***Volatile Organic Compounds***

As mould grows and consumes its food, the chemical reactions of enzymes and organic compounds in the substrates produce carbon dioxide, water, and volatile organic compounds (VOCs). Mould produces many types of VOCs which will typically include aldehydes, alcohols, ketones, and hydrocarbons. Some VOCs have complex chemical structures. They are called volatile because they evaporate easily at room temperature and atmospheric pressure. When you smell a 'musty' or 'mouldy' odour, it is generally the VOCs created by mould that you are noticing. If you do smell these odours, it is a sign that mould is growing and you need to investigate.



## Inhibiting Mould Growth

As noted above, mould spores and other propagules permeate the atmosphere and cover all surfaces inside and outside buildings. Mould spores are extremely persistent and very hard to destroy. They will withstand extremes of temperature, lack of oxygen, dry conditions and chemicals that kill most other forms of life. Spores can persist in a dormant state for hundreds of years and then propagate fungus growth when favourable growing conditions return. Avoiding mould infection in the first place is not an option. Mould will appear whenever and wherever the environmental conditions are right.

Strategies for slowing or preventing mould growth include removing nutrients or establishing an environment hostile to mould growth.

- The first strategy, removing the organic substrate supporting mould growth, is only feasible in a limited number of situations. Concrete contaminated with greywater or bird feces can be washed, but paper, wood, and other porous organic material supporting mould growth must usually be removed.
- The second strategy is to create conditions unfavourable to mould growth. This usually involves identifying sources of moisture and eliminating them, denying the mould one of the necessities of life.



# 2

## Health Effects of Moulds

### Introduction

Mould can grow just about anywhere and mould spores can be found in air samples taken in the high Arctic as well as in tropical forests. When they are growing, moulds emit a constant stream of emissions into the surrounding atmosphere. Among the fungi's emissions are antibiotics, which inhibit the growth of other fungi and bacteria; volatile and often odorous compounds which spoil food; *phytotoxins* that affect plant growth; and spores containing *mycotoxins* which can affect animals and human beings. Because mould and mould spores are so widely dispersed, people and animals are exposed to mould emissions on a daily basis through inhalation, ingestion and physical contact.

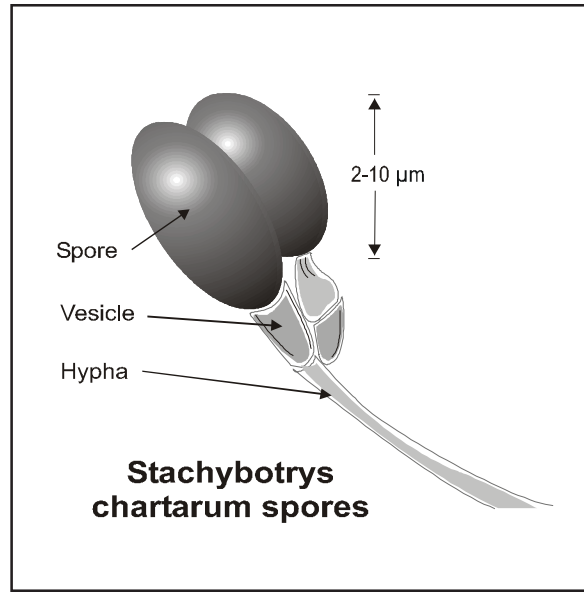


Figure 4 - *Stachybotrys chartarum* spores.

Most exposure to mould is benign and causes no adverse health effects. Under certain conditions however, mould may adversely affect those who are exposed to it in a surprising number of ways. Health hazards associated with exposure to mould range from allergens that can be dangerous to the immune system, to toxins that directly cause illness, to pathogens that directly cause infection and disease.

### Adverse Health Effects of Exposure to Mould

The adverse health effects from exposure to mould can range from mild to severe. The extent of the health effect depends on the affected person's state of health, susceptibility to disease, the particular fungi variety contacted and the duration and severity of the exposure. Some health effects disappear when the person leaves the contaminated area, while some effects may be long-term or permanent. The health effects of exposure to mould are generally categorized into the following four categories:

**Irritation** - For some people, a ‘mouldy odour’ can irritate mucous membranes and cause headaches and other symptoms. Living or working in damp and mouldy buildings has been associated with non-specific complaints such as headache, sore throat, flu symptoms, diarrhea, fatigue, dermatitis, cough, rhinitis, epistaxis, and fever. (See the entry for *sick building syndrome* in the *Glossary*)

**Allergy** - Hypersensitivity or allergic reactions are typically the most common health problems caused from exposure to mould. Symptoms may include skin irritation; headaches; memory problems; mood changes; aches and pains; nasal and sinus congestion; burning, watery or reddened eyes; dry hacking cough; nose and throat irritation; fever; respiratory problems; and difficulty breathing.

People who are allergic to moulds, or sensitive to mould infections, can acquire new allergies from even minor exposure (e.g., during building renovation).

**Infection** - There are about 100 species of mould known to cause infections in humans. Fungal infections can be systemic or opportunistic and are established most commonly through inhalation or ingestion. When a fungi passes the barriers of the human immune system and establishes an infection, the infection is classified according to the tissue level initially colonized.

**Toxicosis** - Fungi produce a wide variety of chemicals which are toxic to humans, animals and plants. More than 300 mycotoxins have been identified in over 350 species of fungi. Some mushrooms and toadstools are well known for their powerful toxic and hallucinogenic effects. For example, the fungus known as the ‘avenging angel’ (*Amanita virosa*) produces one of the most potent poisons known to pharmacologists.

Different species of the same genus or strains of the same species can produce different toxins or none at all. Mycotoxins are believed to be prevalent in living and dead spores as well as in other parts of the fungus organism. They are lipid-soluble and are readily absorbed by the intestinal lining, airways, and skin. Lab and field studies have shown these compounds to produce severe toxic effects in both animals and humans and therefore, the general recommendation is to minimize exposure to any potentially toxigenic mould. The symptoms of toxic exposure range from flu-like symptoms, skin rashes and lesions, bleeding, fatigue, difficulty breathing, and depression, to longer-term nerve and organ problems, altered immunity and cancer.

*Mycotoxicoeses* are illnesses caused by mycotoxins. Although they occur more frequently in areas with a hot and humid climate, they can also be found in temperate zones. Exposure to mycotoxins is mostly by ingestion, but also occurs through skin contact and inhalation. Because many other diseases may cause mycotoxosis symptoms, misdiagnosis of mycotoxin poisoning is common.



At high concentrations, mycotoxins may cause acute symptoms and can affect any system of the body. Exposure to the mould *Aspergillus flavus* and its toxin (aflatoxin) is known to result in an increased risk of liver cancer.

Aflatoxins are acute poisons which often occur at high concentration. Some foods that can sometimes produce aflatoxins are corn and nuts. Aflatoxins are rarely found in Canadian field crops because of our cool climate. The Canadian Food and Drug Regulations' maximum tolerated level for aflatoxin is 15 parts per billion.

Illnesses reported after exposures to mycotoxins of some fungi include the following:

- Immunotoxic - higher incidence of infection in those affected
- Dermotoxic - dermatitis, skin rash
- Neurotoxic - toxic encephalopathy: headache, memory and verbal problems, fatigue, malaise, vertigo, dizziness, depression
- Enterotoxic - nausea, vomiting, diarrhea etc.
- Vascular - fragile blood vessels and bleeding, nose bleeds, hemorrhagic lung disease (especially in male infants.)
- Respiratory - burning-sore throat, laryngitis, irritant cough, exertional shortness of breath, chest tightness, wheezing, bronchitis and pneumonitis, respiratory trachiociliary damage (clearing of airways impaired), bleeding of the lungs.

## Conclusion

Epidemiological studies have consistently detected an association between respiratory symptoms and home dampness and mould growth, but causality in these studies has not been firmly established. Until the magnitude of the population risk is known, it would be prudent, based on current evidence, to remediate indoor sources of mould growth.

### ***Penicillin: A Useful Mycotoxin***

In 1928 Alexander Fleming was annoyed that mould spores had drifted onto the bacteria culture he had prepared a few days before, spoiling his research. However he looked at the plates before he threw them out and noted that the growth of the bacterium *Staphylococcus aureus* was inhibited in those areas of the culture that had been contaminated by the mould *Penicillium notatum*. Fleming isolated the mould and grew it in a fluid medium. He found that this product was capable of killing many of the bacteria that cause disease in humans. In 1940, research workers developed an injectable penicillin agent for therapeutic use.



# 3 Assessing Mould Contamination

Potential mould contamination in an indoor environment should be investigated to determine if a comprehensive site investigation is warranted. Sometimes mould investigations are combined with the investigation of other factors that influence indoor air quality such as inadequate ventilation, the presence of pets, industrial processes, or chemical contaminants. The criteria for conducting a mould investigation may include:

1. Unusual odours
2. Presence of visible mould
3. Evidence of high humidity, condensation, water damage, or water intrusion.
4. Occupant health complaints or symptoms, which may be attributed to allergic reactions or toxic response to moulds such as headaches, eye, nose, and throat irritations, respiratory illness, nausea, rashes, and chronic fatigue.

## Inspection Procedures

Recommended procedures for the investigation of possible mould contamination may be summarized as follows:

1. Interview occupants and maintenance staff to help determine specific locations for further investigation, or past moisture or water problems such as floods, leaks, excessive humidity, or condensation.
2. Review the building's history, including the original design and intended use, workmanship, construction materials, and any renovations or additions.
3. The primary method of mould investigation is through visual inspection. A thorough building and mechanical systems inspection may reveal building envelope failures or other moisture problems that are the result of original design or construction deficiencies, renovations, lack of maintenance, or deterioration. Visual inspection is the most important initial step in identifying a possible mould contamination problem. Generally, mould proliferation occurs in buildings where there is, or has been, an excess of moisture, or water damaged material. Determining the cause of excess moisture is essential; investigators should look for the features illustrated on the following pages.



3a. Building envelope failures including but not limited to:

- inadequate site drainage adjacent to the building foundation.
- deficient, missing, deteriorated, damaged or clogged drain tiles.
- leaks at doors, windowsills, and exterior wall penetrations.
- deficient, missing, deteriorated, or damaged flashings.
- deficient, missing, deteriorated, or damaged caulking joints.
- deficient, missing, deteriorated, damaged or clogged rain water leaders (roof drains).
- roof leaks, including chimneys, fascias, dormers, and skylights.

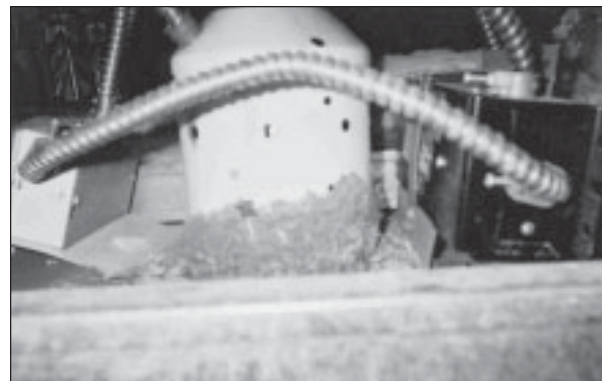


3b. Evidence of building interior moisture problems including but not limited to:

- Mouldy, damp odours, standing water, previous floods or water leaks.
- Mouldy dirty or wet carpet, plaster, gypsum board, and ceiling tiles.
- Condensation on windows, cold spots, or plumbing pipes and fixtures.
- Peeling or blistering paint, and water stains.
- Uncontrolled or high humidity.



- Building service moisture problems including condensation and leaks related to heating, ventilating, air conditioning, plumbing systems, and appliances, examples include:
  - Inadequate venting of moisture generating appliances such as dryers.
  - Condensation or leaks at air intakes, filter units, cooling or heating fans and coils, humidifiers, reservoirs, ducts, insulation, induction and fan coil units, drain and condensate pans and sumps that are either dirty or wet.
4. Identify problem areas (mould habitat)
- i. locate mould whether visible or concealed (using destructive or invasive inspection methods if required).
  - ii. determine physical condition of mould - wet or dry.
  - iii. measure area(s) affected.



## Invasive or Destructive Testing

Non-invasive or non-destructive surveys are conducted without damaging building components or finishes. A visual inspection of window sills, frames, wall and ceiling surfaces, inside of cabinets, carpet stains, tub surrounds etc. may be all that is required to determine the presence of moulds.

Invasive or destructive surveys may require the destruction of building finishes like gypsum board or floor coverings in order to inspect floor, wall, and ceiling cavities. During this type of destructive investigation, it is possible that concealed moulds could be disturbed allowing the migration of mould spores to previously uncontaminated areas of the building. It is strongly recommended that qualified professionals be retained to perform invasive or destructive investigations. It is extremely important that invasive or destructive surveys are performed in a manner that minimizes the potential spread of contamination and ensures the safety of the survey personnel and building occupants. A detailed step-by-step protocol to assist professionals investigating a site with a potential mould amplification problem is available from Health Canada. This protocol covers investigation of building history, visual inspection, sampling and culturing of airborne propagules, examination and culturing of materials and assays for ergosterol and mycotoxin.

## Sampling

In some circumstances, sampling strategies for moulds are employed to supplement visual inspections. Sampling strategies may include the following:

- Non-aggressive and aggressive techniques to obtain information on mould debris present in settled dusts that could become airborne during normal occupancy.
- Air sampling for total mould spores using spore traps to obtain information on mould spores that may be present but not culturable.
- Bulk dust samples cultured on at least two types of media to obtain information on a broad range of mould propagules present in settled dusts. These propagules could become airborne into the breathing zone when disturbed or become active when sufficient moisture occurs.
- Fungi debris found in settled dusts provides a history of fungi that have been present in the past and have deposited on interior surfaces.



## Air Sampling

Air sampling is difficult because the number of spores that are airborne at any time varies dramatically during the cycle of the mould colony growth. Changes in air movements can also influence the sampling. The prevalence of fungi debris in the air is quantified by the measure of colony forming units per cubic metre (CFU/m<sup>3</sup>) of air. The measure is developed by sampling the air for suspended particles and culturing them on some type of agar medium. Mould propagules in the suspended material will grow into colonies of mould and they can then be counted.

Air sampling may be required if there is evidence from visual inspection or bulk sampling that a building's ventilation systems may be contaminated. The purpose of such air sampling is to assess the extent of contamination throughout the indoor environment. If air sampling is chosen as a method of assessment, the personnel conducting the sampling must be trained in proper air sampling methods for microbial contaminants.

Air sampling for mould should not be part of a routine assessment because air sampling methods for mould are prone to false negative results and therefore cannot be used to rule out contamination.

## Surface Scraping and Swabbing

Surface dust sampling produces large volumes of matter for fractional analysis. As some materials can store spores for extended periods of time, samples taken by this method can produce a history of mould activity. There are some drawbacks to this procedure, as some spores are viable for a few weeks only, while others remain viable for years. Also spores from certain species will not grow colonies that can be counted, yet they may still cause adverse health effects.

Surface scraping of mould colonies can be used when dealing with a mould such as *Stachybotrys chartorum*, whose spores do not easily become airborne. Analysis of surface scrapings cannot be used to identify many toxigenic moulds as their spores may be semi-transparent (hyaline) and too unremarkable in appearance for reliable species identification.



## Bulk Sampling

Bulk sampling is used to identify species of mould growing on contaminated material. A properly collected large sample of contaminated material can allow for identification of some moulds.

Bulk samples should only be used to document the presence and extent of toxic moulds if extensive areas are affected. For example, if visible mould occurs on areas larger than one gypsum board panel and water damage is a chronic problem, or if occupants are experiencing symptoms which may be related to exposure to mould, then the need for bulk sampling is indicated.

If only a limited area is affected (<30 sq. ft.) the water damage is the result of a known occurrence, and occupants are not experiencing symptoms, then bulk or other sampling is not required. Remediation should proceed without further evaluation, under the assumption that mould contaminants are present.

When bulk sampling is required, qualified personnel should collect bulk samples from appropriate areas (e.g., damp, mouldy, cellulose-derived material) by scraping surface materials into a clean Ziploc™ plastic bag or by stripping the suspect surface with vinyl acetate tape.

## Evaluation Criteria for Samples

Bulk and air samples must be sent to a qualified microbiological laboratory for analysis. It is important to determine if the lab is competent to perform the analysis and that it has a documented quality control program. Some species of mould are easily missed if other species are present and microscopic identification of the spores requires considerable expertise. Samples should also be analyzed for the presence of other common indoor microbial contaminants.

- a. **Bulk sampling:**
  - i. sampling results in excess of 1 Colony Forming Unit (CFU) per gram are generally considered to be positive.
- b. **Air monitoring:** (Both indoor and outdoor air samples should be collected and compared.)
  - i. concentrations of mould in indoor air, which significantly exceed concentrations in outdoor air, should be considered positive.



## Interpretation of Assessment Results

Since 1989, the American Conference of Governmental Industrial Hygienists (ACGIH) Bioaerosols Committee has recommended rank order assessment as a means of interpreting air-sampling data. The presence of one or more species of fungi indoors, but not outdoors, suggests the presence of an amplifier in the building. Species identification is critical to the analysis.

- 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. Some of these species cannot be measured by air sampling techniques.
- The persistent presence of significant numbers of toxigenic fungi (e.g., *Stachybotrys atra*, toxigenic *Aspergillus*, *Penicillium* and *Fusarium* species) indicates that further investigation and action should be taken accordingly.
- The confirmed presence of one or more mould 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 mould amplifier. Appropriate action should be taken.
- The normal mycoflora is qualitatively similar (comparable fungi) and quantitatively lower (lower CFU/m<sup>3</sup>) than that of outdoor air.
- More than 50 CFU/m<sup>3</sup> of a single species (other than *Cladosporium* or *Alternaria*) may be reason for concern. Further investigation is necessary.
- Up to 150 CFU/m<sup>3</sup> 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.
- Up to 150 CFU/m<sup>3</sup> 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.
- The visible presence of fungi in humidifiers and on ducts, mouldy ceiling tiles and other surfaces requires investigation and remedial action regardless of the airborne spore load.
- There are certain kinds of mould contamination not readily detectable by the methods discussed here. If unexplained sick building syndrom symptoms persist, consideration should be given to collecting dust samples and having them analyzed for mould species.



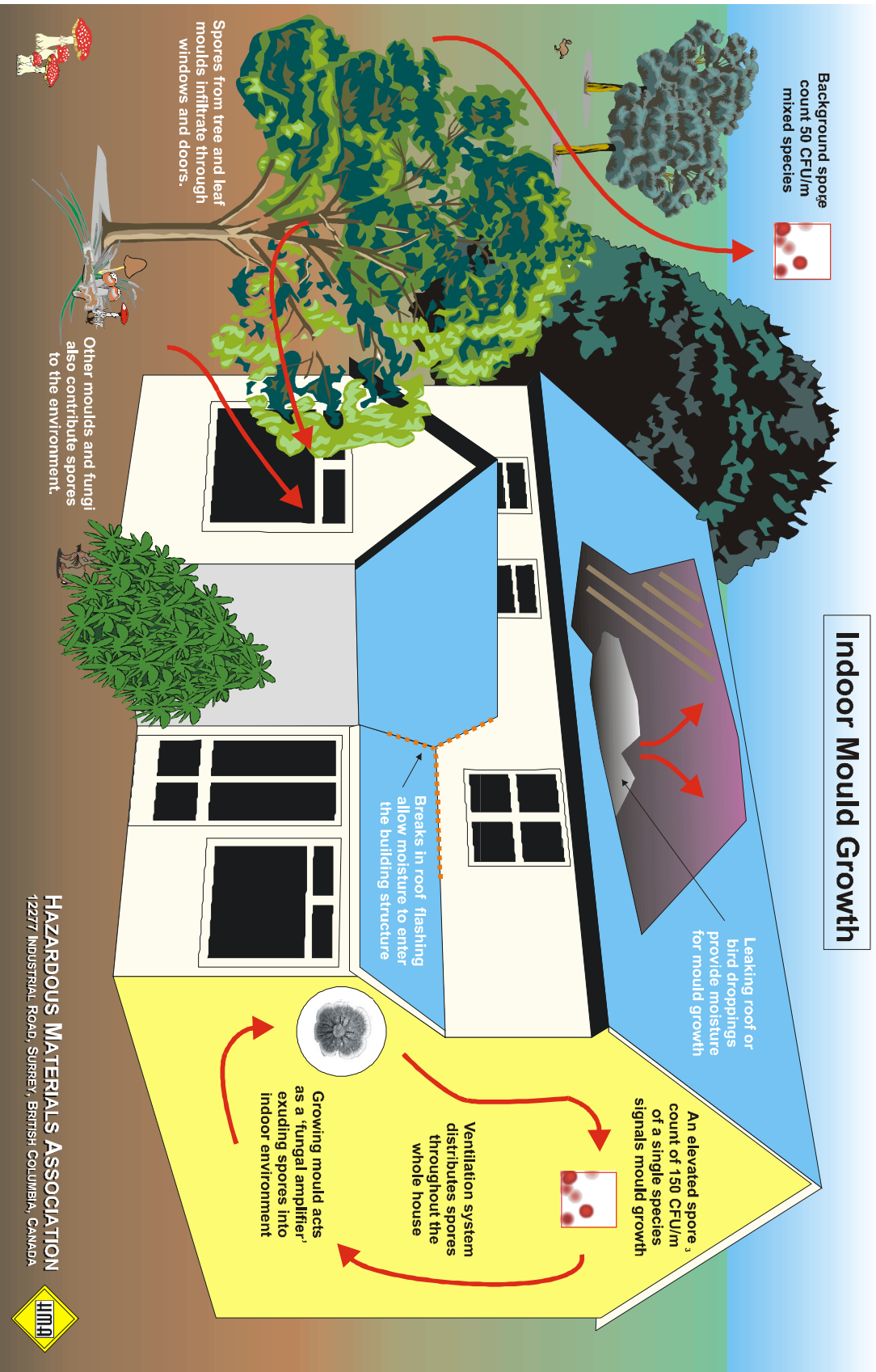


Figure 5 - Indoor mould growth.



## **4 Mould Remediation Procedures**

Successful mould remediation requires correction of moisture or water infiltration problems, and the removal, disposal, and cleanup of mould or mould contaminated materials in a manner that prevents the spread of mould materials beyond the remediation work area. It is imperative that mould remediation be performed in a manner that protects the health and safety of the workers, and the building occupants, while inhibiting future mould growth.

### **Moisture Control**

Mould cannot exist without a source of moisture; therefore, the first step in a mould remediation project is to determine the source of moisture and either eliminate or control it. There are numerous possible sources of moisture and climatic conditions that may contribute moisture that will support mould growth in an indoor environment. Typically moisture is the result of an infiltration of water from a plumbing or mechanical system leak, flooding, a leaky building envelope, or an indoor environment problem such as high humidity or condensation. Building repairs and or engineering controls to eliminate excess moisture should be performed in conjunction with, or prior to, mould remediation.

A fast response to water infiltration, within 24 to 48 hours, and thorough cleaning, drying and removal of water damaged materials will help prevent or limit mould growth. Relative humidity should be maintained at levels below 60% to inhibit mould growth. Canada Mortgage and Housing Corporation (CMHC) recommend maintaining a relative humidity level of 30 – 50%.

### **Mould Remediation Worker Protection**

Controls to reduce worker exposure to mould during a remediation project include a risk assessment and exposure control plan, worker training, personal protective equipment, appropriate work area preparations, specialized work procedures, and worker decontamination facilities.



## Risk Assessment

Prior to starting work on a mould remediation project, ensure that a qualified person conducts a site inspection, and site-specific risk assessment of all workplace hazards that may be detrimental to the health and safety of the workers or building occupants. Assess the potential exposure hazard whenever proposed work activities may expose workers to a hazardous substance or conditions. The exposure assessment must consider all routes of exposure such as inhalation, ingestion, and skin contact.

Assess the extent of mould growth, and the types of affected building materials. The presence and extent of visible mould growth can be checked by direct observation and measuring the area of coverage. It may be necessary to use specialized equipment such as a boroscope to view spaces in ventilation ductwork or inside floor, wall, and ceiling cavities for mould growth or water damage. Document and incorporate the information obtained during the risk assessment into a site specific Exposure Control Plan. A change in site conditions, equipment, or work procedures may require a reassessment.

## Worker Training

Prior to starting remediation work ensure that all personnel, including supervisors and authorized visitors, have received training in the potential hazards of mould exposure, the safe handling of mould contaminated materials, the selection use maintenance and limitations of respirators and protective clothing, the use of decontamination facilities, work area entry and exit procedures, emergency/evacuation procedures, and the use of specific equipment and tools.

## Personal Protective Equipment

Workers on all mould remediation projects must use personal protective equipment that is appropriate for the level of remediation.



## Electrical Services and Equipment

During remediation work, all electrical equipment operated inside the work area, or whenever there is danger of electrical shock, must use power sources with ground fault circuit interrupters (GFCI) or equivalent protection against electrical shock. All existing electrical circuits or lighting must be locked out or physically disconnected to prevent the unintentional start up of electrical equipment or electrical shock. Written lock out policy and procedures must be followed whenever remediation activities involve working on or about a machine; process or system that presents an electrical or start-up hazard.

## Protection of Building Occupants

An important requirement for all mould remediation projects is that building occupants and users are not put at risk.

- Building occupants should be alerted to the ongoing work so that they can take the necessary precautions to avoid the mould remediation work area.
- Children and sensitive adults should be evacuated before remediation starts as it is likely that some exposure has already occurred by the time the problem is recognized.
- Controls must be in place before remediation starts in order to reduce or eliminate contamination of other areas in proximity to the work site.
- Building occupants, and persons not involved in the remediation process should not be allowed back into the remediation work area until a qualified person has certified the area as clean and suitable for re-occupation.

## Work Area Isolation and Containment

The mould remediation work area should be contained and isolated from adjacent, uncontaminated areas of the building. Where it is practical, the entire work area should be fully enclosed within an airtight containment. For effective containment the following conditions apply:

- All containments should be airtight. Polyethylene sheeting (minimum 6 mil.) or similar impermeable material should be used. The polyethylene sheeting should be supported by suitable framing as required, and be held in place and sealed with duct tape.
- Mouldy carpets should be removed and floors should be covered with polyethylene sheeting (minimum 6 mil.) which should be fastened a minimum of 300 mm (12 inches) up the wall (where possible). The intention is to provide a watertight, airtight seal.



- A negative pressure ventilation system should be used in the containment to ensure that air flows from clean outside areas into the mould remediation work area. Exhaust air must be discharged outdoors through a HEPA filter. D.O.P. (Dioctyl phthalate) testing should be performed on each piece of equipment which uses HEPA filters, including negative pressure ventilation systems and HEPA vacuums.
- Where it is practical, electrical, plumbing or ventilation services must be excluded from the work area containment.
- Warning signs identifying the existence of mould materials within the remediation work area must be placed at all access points to help prevent unauthorized personnel from entering the work area. The warning signs must identify the hazards, and the appropriate precautions to be taken to avoid exposure.
- If a complete containment cannot be achieved, the windows, doors and openings to other areas of the building must be sealed with polyethylene sheeting and duct tape to prevent the migration of mould into the surrounding building environment. Where possible, all air handling systems must be shut down and sealed. If this is not possible, heating and ventilation ducts must be sealed and dampers closed to halt airflow.

## **Common Requirements for all Remediation Projects**

- A competent supervisor must be on site during all mould remediation work.
- Workers must wear appropriate personal protective equipment (PPE) during intrusive and non-intrusive investigations, remediation work and demolition work.
- Procedures must be specified for the prevention of potential contact with all electrical sources.
- The electrical supply to equipment in damp or wet locations must be protected by a ground fault circuit interrupter (GFCI).

## **Remediation Methods and Levels**

In general, non-porous (metals, glass, and hard plastics) and semi-porous (wood and concrete) materials that are structurally sound with visible mould growth can be cleaned with a detergent solution and then reused. Porous materials such as ceiling tiles, insulation, gypsum board, and carpets with more than a small area of contamination should be removed and discarded. All materials to be reused must be, clean, dry and visibly free from mould.

The first guidelines for the remediation of mould contamination in indoor environments were based on protocols for asbestos abatement. Generally accepted mould remediation guidelines were developed and distributed by the New York City Department



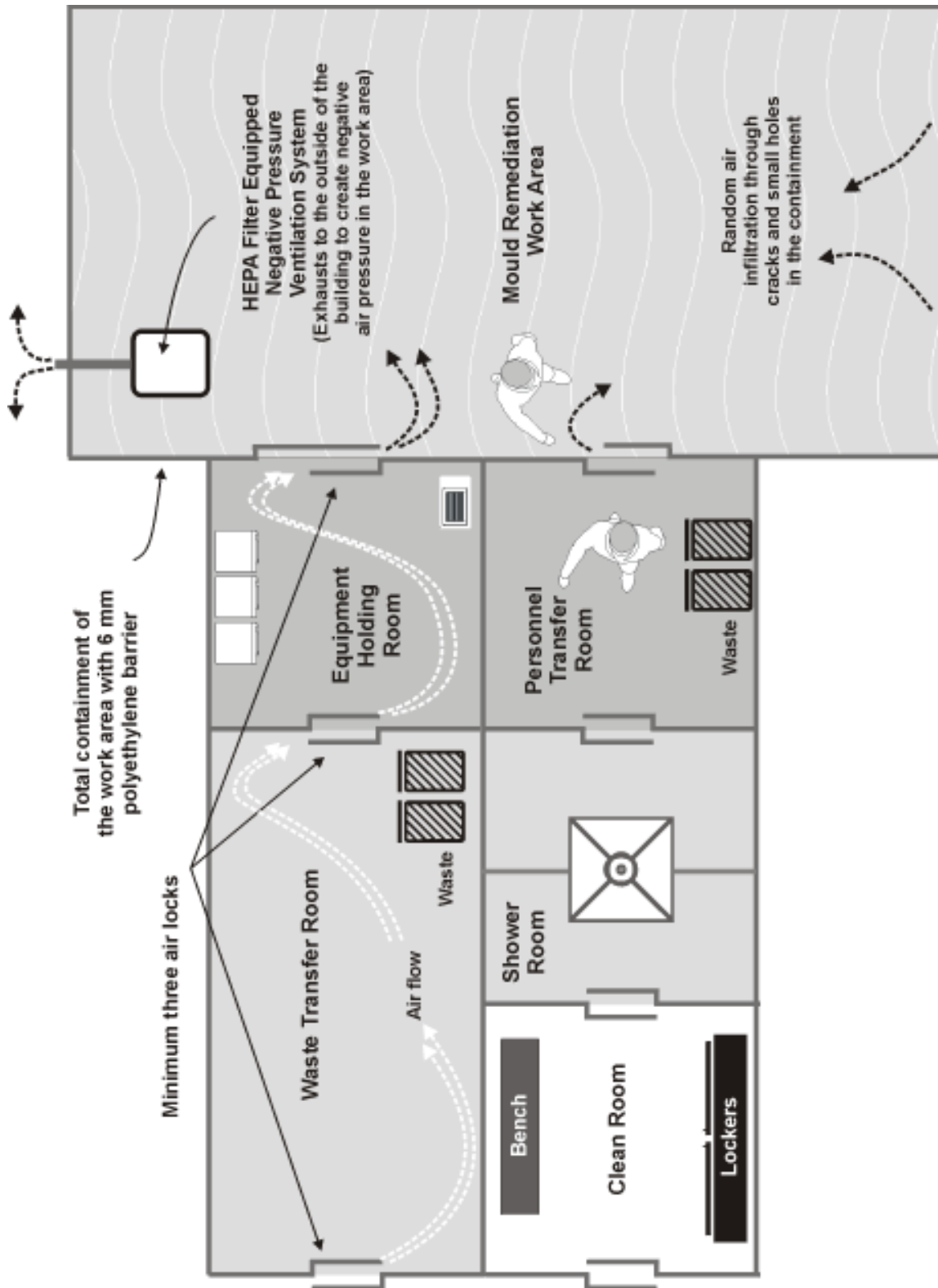


Figure 6 - Contained work area and decontamination facility for mould remediation work.



of Health, the Mount Sinai Medical Center, the N.Y Department of Occupational and Environmental Medicine, and the American Industrial Hygiene Association (AIHA). The following remediation methods and procedures have evolved over time based on practical experience and the procedures from these sources.

The size of the area and the extent of the mould contamination primarily determine the level of remediation. The following remediation methods are suggested, but it is the responsibility of the personnel performing the remediation to ensure the methods enacted are adequate. These methods are not meant to exclude other similarly effective methods, but any changes should be carefully considered prior to starting work.

Typically, remediation procedures depend on the size or extent of mould growth. The extent of mould growth and the corresponding level of remediation procedures have been classified as follows:

- Level I    Small Area (less than 10 square feet)**
- Level 2    Mid-sized Area (10 – 100 square feet)**
- Level 3    Large Area (greater than 100 square feet)**

It must be emphasized that these Remediation Levels are arbitrary guidelines. Individual mould remediation projects often have unique circumstances that will require amending these guidelines; it is recommended that a qualified mould remediation specialist be consulted to determine the necessary procedures for mould remediation projects. Mould remediation projects must be performed by a well-trained, well-equipped and experienced work force.

### **To Bleach or Not to Bleach?**

The use of biocides during mould remediation remains a controversial practice. The Hazardous Materials Association does not recommend the use of biocides or chlorine bleach during routine mould remediation projects. However, the Association recognizes there may be instances when a qualified professional recommends these products or finds that it is necessary to use them.

If chlorine bleach or a biocide is used, it is imperative that the area be well ventilated by exhausting the work area outside the building, while drawing in fresh make up air. Appropriate personal protective equipment including respiratory protection must be worn when applying or working in close proximity to these products. Procedures on manufactures' instructions, specification data sheets and material safety data sheets must be followed exactly.

Chlorine bleach should never be mixed with cleaning products which contain ammonia because the combination may produce highly toxic vapours that are potentially fatal if inhaled.



## Level 1 - Small Area (10 sq. ft. or less)

### ***Work Area Preparations and Control Measures***

- The Mould Remediation work area should be unoccupied. Evacuating people from areas adjacent to the work area may not always be necessary but is recommended in the case of infants, persons recovering from recent surgery, or persons with suppressed immune systems, respiratory ailments (e.g., asthma) or allergies.
- Containment of the work area may not always be necessary but dust suppression methods are recommended such as misting, *not soaking*, surfaces prior to and during remediation procedures
- Shutdown and isolate all heating, ventilating, and air conditioning (HVAC) system components, that are within, or adjacent to the work area. Seal all HVAC system openings including but not limited to diffusers, vents, and grills with polyethylene sheeting and duct tape.
- Clean all movable non-porous objects within the work area using HEPA filtered vacuum equipment and damp wiping methods as appropriate. After cleaning, these objects should be removed from the work area and stored in a non-contaminated location.
- Use drop sheets beneath mouldy materials to be removed to help prevent the spread of mould contaminants.

### ***Personal Protective Equipment and Hygiene Facilities (minimum requirements)***

- Workers shall wear a half-face piece air purifying respirator equipped with NIOSH 100 series (HEPA) filter cartridges.
- Protective clothing consisting of disposable coveralls, suitable gloves, eye protection, and footwear that is easily cleaned such as laceless rubber boots should also be worn.
- Provide hygiene facilities for washing hands and face and cleaning of respiratory equipment upon completion of work.



### ***Mould Remediation Work Area Cleanup***

- The work area, and areas used by remediation personnel for egress, should be thoroughly cleaned with a damp cloth or mop and detergent solution. Always use cleaning techniques designed to minimize potential dust and spore dispersal.
- Contaminated materials that cannot be cleaned (such as porous materials) must be removed from the area in sealed polyethylene bags for disposal.
- Thoroughly clean all equipment and tools that were used in the remediation work using HEPA filtered vacuum equipment and damp wiping methods as appropriate.
- Upon completion of work area cleanup, all surfaces within the designated work area are to be left dry and visibly free from contamination and debris. Dispose of waste material in accordance with federal, provincial, and local regulations.

## **Level 2 - Mid-sized Area (10 – 100 sq. ft.)**

Level 2 Remediation requires all of the procedures and precautions outlined in Level 1, with the addition of the following requirements:

### ***Work Area Preparations and Control Measures***

- A qualified health and safety professional with experience performing mould investigations and mould remediation projects should be consulted to oversee the project, and determine the adequacy of the required level of remediation, and corresponding procedures and precautions.
- Isolate the work area by constructing a temporary containment consisting of minimum 6 mil polyethylene sheeting sealed with duct tape (supported by suitable framing materials where required).
- Install HEPA filtered exhaust equipment, such as a HEPA filtered vacuum cleaner for small containments, or a portable HEPA filtered negative air cabinet for larger containments to establish and maintain a negative air pressure differential in the work area.



### ***Personal Protective Equipment and Hygiene Facilities (minimum requirements)***

- Workers shall wear as a minimum, a half mask air purifying respirator equipped with NIOSH 100 series (HEPA) filter cartridges. Significant concentrations of mould growth may require upgrading of respiratory protection to a Full Face Powered Air Purifying Respirator equipped with NIOSH 100 series (HEPA) filter cartridges.
- Workers shall wear impermeable gloves, and full-bodied impermeable disposable coveralls with attached head and foot coverings designed to fit snugly at the neck, wrists, and ankles.
- Provide an enclosed change area at the entrance to the work area containment, for donning and removing coveralls. The change area should incorporate the hygiene facilities for washing hands and face and cleaning of respiratory equipment upon completion of work. Significant concentrations of mould growth may require upgrading the change area and hygiene facilities to a full workers' decontamination facility as illustrated in Figure 6.

### **Level 3 - Large Areas (greater than 100 sq. ft.)**

Level 3 Remediation requires all of the procedures and precautions outlined in Level 2, with the addition of the following requirements:

#### ***Work Area Preparations and Control Measures***

- Install a sufficient number of HEPA filtered negative air cabinets to establish and maintain a negative air pressure differential in the work area.

### ***Personal Protective Equipment and Hygiene Facilities (minimum requirements)***

- Workers shall wear as a minimum a Full Face Powered Air Purifying Respirator equipped with NIOSH 100 series (HEPA) filter cartridges.
- Provide a full workers' decontamination facility consisting of a clean room, shower room, and transfer room at the entrance to the work area as illustrated in Figure 6. The worker's decontamination facility must be constructed in a manner that ensures that all personnel entering or exiting the work area must pass through each room of the decontamination facility in sequence.



## Remediation Methods for Specific Building Components

The following are general guidelines to be followed when dealing with specific surfaces that have been contaminated with mould.

### General

- An inventory of all water damaged areas, building materials and furnishings should be compiled. Identify carpet under cabinets, furniture etc. Use a moisture meter if necessary to identify the extent of water damage to gypsum board and other porous surfaces.
- Cleaning or disinfecting the surface of the contaminated material may remove or kill the mould on the surface, but mycelium within the substrate will often survive and grow again.
- Mycotoxins may also grow in accumulated material. Removing the contaminated material is usually the best option.
- Remove and dispose of all mould contaminated ceiling tiles within hours of water damage.

### Concrete

- All hard surfaces such as concrete block walls, concrete, and steel sheeting must be scrubbed with mild detergent followed by a rinse of the surface. After the cleanup is complete, increase the heat and use a dehumidifier, if required, to completely dry out the work area.

### Carpet

- Carpet that has been contaminated over a large area with sewage backup must be discarded under controlled conditions and the entire area disinfected. Small areas of carpet contaminated with sewage backup may be cleaned using the procedure listed for other sources of water.
- Carpet that has become wet from floods, roof leaks, potable water leaks and ground water can be treated as per the following:

#### **Carpet wet less than 48 hours**

- Remove all materials (e.g., furniture, file cabinets) from the carpet. Extract as much water as possible from the carpet using wet vacuums. Shampoo the carpet with a dilute surfactant. It is preferable to not use a biocide but if one is used, consult a microbiologist first, as some people may have adverse reactions to biocides.



- Rinse and extract the carpet with clean water to remove any detergent residues. Commercial steam cleaning of carpeting can be used in place of bleach as the vacuum system is housed in a truck. The water used to clean the carpet is also heated above the boiling point.
- Dry the carpet within 12 to 24 hours of treatment. After work is completed, increase the room temperature and use commercial dehumidifiers, floor fans or exhaust fans to aid in drying the carpet.

### ***Carpet wet more than 48 hours***

- If carpet is soaked with relatively clean water during the winter, extract and dry the carpet within 12 to 24 hours of treatment. After work is completed, increase the room temperature and use commercial dehumidifiers, floor fans or exhaust fans to aid in drying the carpet.
- Drying carpet is usually more difficult in summer, especially if the carpet is not in an air-conditioned space or dehumidifiers are not available. Water damaged carpets in humid environments often do not dry adequately. In humid environments, disposal of water damaged carpets is often the best option.

### ***Wall and Ceiling Board***

- Remove and replace all mould contaminated, water damaged gypsum board and insulation within 24 hours. If the gypsum board is not removed within 24 hours or if previous water damage has caused microbial growth, then extensive controls may be necessary for the remediation process. Use a moisture meter and cut gypsum board at least 300 cm (1 foot) beyond the moisture mark.
- Water on plaster walls may cause minerals to leach from the surface and leave a chalky residue. This loose material will need to be removed from the surface under controlled conditions and the surface allowed to dry.
- If a plaster wall develops a strong, mouldy odour—with or without visible mould growth—eliminate the source of moisture and replace the damaged plaster.

### ***Electrical Equipment***

- All wet wiring and electrical fixtures must be considered as an electrical hazard until a qualified electrician inspects, services as required, and certifies them as operational. Circuit breakers, GFCIs (ground fault circuit interrupters) and fuses that have become wet must be replaced.



## ***Furniture***

Upholstered furniture damaged by steam leaks or direct-contact with potable water must be dried within 24 hours and monitored for fungal growth and odours.

Dispose of upholstered furniture that has become wet due to floods, leaky roofs, sewage backups and ground water incursions.

Hardwood furniture or laminate furniture whose laminate is intact must be air dried and cleaned with a mild detergent. Laminate furniture whose laminate has delaminated must usually be disposed of because the pressed wood under the laminate absorbs water readily and does not dry easily.

Furniture which has become wet due to a steam leak can be dried and monitored closely for fungal growth or odour. Particle board or pressed wood furniture must usually be discarded.

## ***Files and Paper***

Remove and dispose of non-essential wet files and paperwork.

If the moisture was due to a steam leak, paperwork can sometimes be dried instead.

Wet paper that is to be salvaged must be removed to a location where it can be dried, photocopied and then discarded if possible. Professional conservators must be contacted for information on handling these types of wet products.

If large amounts of files and paperwork cannot be dried within 24 to 48 hours, essential files and paperwork may be rinsed with clean water and temporarily frozen until proper drying can be completed. Any paper products that do develop mould will need to be discarded.



## **HVAC Systems Decontamination**

Evidence of mould or micro-organism growth in or on HVAC system growth should be taken very seriously. A qualified professional with experience performing mould investigations and mould remediation of HVAC systems should be consulted to perform an assessment, oversee remediation activities, quality assurance, and acceptance.

Personnel performing investigations and cleanup must be protected with appropriate HEPA filtered (P100) respiratory protection and protective clothing as required.

### ***Preparation***

- Shut down, isolate, and lockout all HVAC system components that are suspected of supporting the growth of mould or other micro-organisms. Protect all motors, controls, bearing assemblies, and belt drive assemblies within the HVAC unit with taped on polyethylene sheeting.
- Seal off ends and openings of all ductwork not being immediately worked on.
- Isolate duct section to be worked upon, using protective seal barriers within the ductwork to prevent loose dirt and debris from contaminating cleaned sections of the system.
- Any ductwork entered by personnel must be suitably braced and supported. Remove and replace interior insulation if required. Existing duct access panels must be used wherever possible.

### ***Cleanup***

- Preliminary cleaning and decontamination of all supply, return and exhaust ductwork, diffusers, grilles and registers.
- Remove and dispose of contaminated internal duct lining where possible, dispose and replace ductwork in situations where contaminated duct lining can not be removed. Where feasible, replace internal duct lining insulation with external insulation.
- Remove and replace contaminated flexible ducting.
- Remove and dispose of all visible dirt, debris, and other contaminants working in sequence following the direction of the air flow from the supply fan to the diffuser, always working from clean ducting toward the un-cleaned ducting. Never allow un-cleaned ductwork to be upstream from clean ductwork.
- Use high pressure washing, damp wiping, and/or vacuum and rotary brush techniques for the cleaning of HVAC system components as required.
- Vacuum clean all pressure washed surfaces. Vacuum collected wash water must be disposed of outside of the HVAC unit.



## Post-Remediation Inspection and Clearance

At the completion of mould remediation and cleanup procedures, a qualified mould remediation professional must perform a thorough quality control inspection to ensure the adequacy of cleanup. The post-remediation inspection consists of a thorough and meticulous visual inspection, and in some instances testing. A remediation work area is acceptable for reoccupation when the visual inspection verifies that that remediation and cleanup work has been completed, and that all surfaces in the work area are free of mould contaminants, dust, or debris. In some circumstances mould testing and sampling is performed to help confirm that the work area is free of mould contaminants and suitable for re-occupation. Types of post remediation testing and sampling include but are not necessarily limited to air samples, vacuum dust samples, swabs, and tape lift off samples. Sampling and testing may be considered if there are concerns about unsuccessful remediation.

Sampling results from post remediation work areas are compared to samples collected from clean reference areas, and or outdoor locations. Evidence of successful remediation is supported when air or surface sampling reveals no significant elevation in mould particulate over the levels in the reference samples. Sampling and testing for mould, and interpreting the results is a complicated procedure that should only be performed by a qualified professional.

### Long-term Monitoring

After the remediation work is completed, routine inspections should be conducted to confirm the effectiveness of the remediation.



# 5 Personal Protective Equipment

## Respirators

Assess and identify potential respiratory hazards in the work place during the pre-project risk assessment to establish criteria for selecting the appropriate respiratory equipment for use on the project. Respirators approved by National Institute of Occupational Safety and Health (NIOSH) and the Workers' Compensation Board of British Columbia must be worn if workers are, or may be, exposed to an oxygen deficient atmosphere, or air borne contaminants. All personnel must wear respiratory protection whenever a work activity has the potential to disturb mould or mould contaminated materials.

Single use or disposable respirators are not acceptable for use when working with, or in close proximity to, mould or mould contaminated materials. Approved respirators for protection against airborne contaminants fall into two categories: air purifying respirators (APRs), and air supplied respirators (ASRs).

Air purifying respirators (APRs) equipped with 'NIOSH 100 series' filter cartridges that are designed to remove dust, mists, fumes, and particulate, including mould spores, from the air by filtering the air prior to inhalation. Air purifying respirators may be either a half-facepiece model or a full-facepiece model. A full-facepiece air purifying respirator provides better protection than a half-facepiece air purifying respirator.

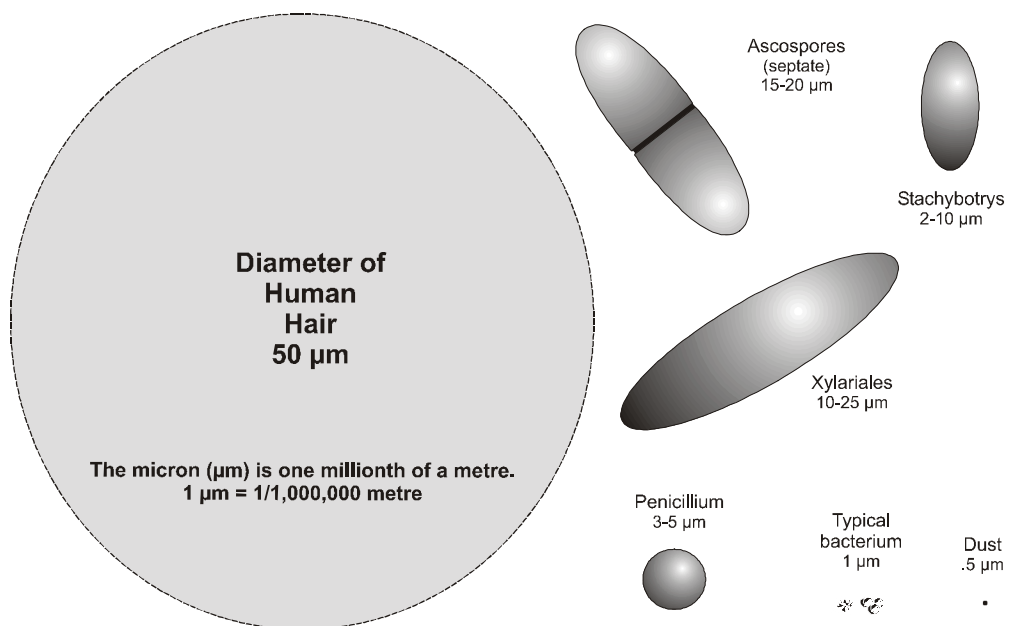


Figure 7 - Comparison of spore size.

Powered air purifying respirators (PAPRs) utilize a battery powered blower assembly to draw air through 'NIOSH 100 series' filter cartridge(s) and maintains a positive air pressure in the facepiece which provides greater protection than a non-powered air purifying respirator.

APRs and PAPRs are air purifying respirators. They do not supply clean air. Instead they use filters to remove specific contaminants from the ambient air. Never wear an APR or PAPR respirator in a potentially oxygen deficient atmosphere.

There are two categories of air supplying respirators, the air supplied respirator (ASR), and the self contained breathing apparatus (SCBA), both of which provide a source of breathing air. Supplied air respirators supply clean breathable air to the facepiece by means of an air hose connected to an air tank or air compressor. SCBA units supply clean respirable air from a cylinder usually carried as a backpack. Air supplying respirators provide protection from toxic air contaminants or oxygen deficient atmospheres.

## **Selection of Respiratory Equipment**

The selection of appropriate respiratory protection equipment is a critical employer responsibility. Serious adverse health effects or even death may occur if the wrong type or insufficient respiratory equipment is used. Comprehensive knowledge of respiratory hazards and respiratory protection equipment is essential to ensure the appropriate selection of respirators. The selection of appropriate respirators must consider the nature, concentration, and toxicity of all potential air borne contaminants and hazards.

Always make respiratory selection decisions based on consultations with the workers who will be performing the work, and in accordance with *CSA Standard CAN/CSA-Z94.4-93, Selection, Use, and Care of Respirators*, and the Workers' Compensation Board of British Columbia manual *Breathe Safer – How to use respirators safely and start a respirator program*.

The WCB manual *Breathe Safer: How to use respirators safely and start a respirator program* contains a *Respirator Selection Guide - Flow Chart* that assists with the selection process.

## **Respirator Use**

Provide all personnel that are required to wear respiratory protection with personally issued, individually marked and identified respirators suitable for protection against the anticipated airborne contaminants. All personnel are to receive training in the maintenance, use, and limitations of the respirators that they are required to use.

All personnel that are required to wear respiratory protection must be clean-shaven where the respirator seals with the face. Personnel who wear prescription eyeglasses may need to obtain special frames for use with a full-facepiece respirator to ensure that the arms of the glasses do not interfere with the respirator to face seal. Most respirator manufacturers have specially designed corrective lens holders that fit inside the respirator facepiece.



Facial injuries, scars, broken bones, skin irritations or skin disease, impaired sense of smell, or health problems such as asthma, emphysema, or bronchitis, epilepsy, diabetes, high blood pressure and heart disease are only a few of a number medical conditions that may prevent some individuals from wearing a respirator. If there is any doubt of an individual's ability to wear a respirator, they should be examined and receive clearance from a physician before performing work activities that require respiratory protection.

## Protective Clothing

The employer shall provide all personnel with appropriate protective clothing, gloves and personal protective equipment whenever they are performing work activities which are at risk of disturbing mould or mould contaminated materials. All personnel working in close proximity to mould or mould contaminated materials will wear full-bodied impermeable disposable coveralls or other full-bodied clothing that resists penetration by air borne contaminants. The clothing should have attached head and foot coverings which are designed to fit snugly at the neck, wrists, and ankles. Immediately repair or replace torn or damaged protective clothing.

## Protective Footwear

Workers shall wear appropriate work footwear with toe protection and metatarsal protection on all jobsites in accordance with CSA Standards CAN/CSA-Z195-M92, *Protective Footwear*. Non-skid, laceless rubber boots meeting these requirements are required in all contaminated work areas.

## Hearing and Eye Protection

The employer will provide, select, and maintain hearing protection in accordance with the Workers Compensation Board of British Columbia, Occupational Health & Safety Regulation and *CSA Standard Z94.2--94, Hearing Protectors*. All personnel must participate in the Workers' Compensation Board 'Audiometric Testing Program' the employer will provide hearing test within six months after the initial start of employment, and annually thereafter. Industrial audiometric technicians must be authorized by the Worker's Compensation Board of British Columbia in order to administer audiometric hearing tests.

Adequate eye protection shall be required and worn whenever there is a hazard to the eyes. The employer must provide, select and maintain eye protection in accordance with the Workers' Compensation Board of British Columbia, Occupational Health & Safety Regulation and *CSA Standard CAN/CSA-Z94.3-92, Industrial Eye and Face Protectors*.



## 6 Glossary

<b>Aerobic</b>	Having the ability to grow in the presence of oxygen or requiring oxygen for life.
<b>Air Exchange Rate</b>	Whether natural and mechanically induced air flow, the number of times that the air volume inside an area is replaced, usually expressed as air changes per hour.
<b>Airlock</b>	An apparatus designed to allow personnel to enter and exit a contaminated work area while restricting air movement between the contaminated area and a non-contaminated area. An airlock is typically constructed by using polyethylene sheeting to create weighted self closing curtained doorways over existing or temporarily framed doorways. Two curtained doorways that are sufficiently spaced form an Airlock.
<b>Allergy</b>	A sensitivity to chemical, physical or biological agents.
<b>Allergen</b>	A chemical or biological substance (e.g., pollen, animal dander, or house dust mite proteins) that induces an allergic reaction.
<b>Allergenic</b>	Having the tendency to cause allergic reactions.
<b>Ambient Air</b>	Air from spaces surrounding a mould contaminated room or building. In the case of a mould contaminated building, ambient air would be outside air.
<b>Amplification</b>	The process of indoor growth which results in an increased indoor spore (conidia) concentration compared with the immediate outdoor environment (ambient air).
<b>Amplifier</b>	An indoor fungal growth which is adding mould spores or other exudents to the interior of a building.
<b>Andersen Sampler</b>	A sieve type air sampling device that uses a vacuum pump to draw air through a radial pattern of 300 small pores. Spores and other impacting particles in each of the small streams of air are blown onto the surface of microbial growth medium plates. Andersen samplers with two or six stages separate particles by size and deposit each size class onto a separate growth medium plate.
<b>Antimicrobial</b>	Substance used to kill or control microbes such as bacteria and viruses.



<b>Air Handling Unit</b>	The term refers to equipment for moving or treating air: blowers or fans; heating and cooling coils; controls; condensate drain pans; and air filters. It does not include passive elements such as ductwork; registers or grilles; or boilers and chillers.
<b>Anaerobic</b>	An organism or process which can or must exist without oxygen from the air. Opposite of aerobic.
<b>Antigen</b>	A chemical substance which is attacked by the immune system of an organism. For example, a cell wall protein or glycoprotein from a fungus spore may be recognized as an foreign invader and attacked by the organism's immune system. The organism that has been invaded forms antibodies which bind to the antigens of the invading fungus spore.
<b>Aspergillus</b>	(pl. <i>aspergilli</i> ) A genus of mould fungi containing over 100 species, approximately 15 of which are commonly encountered in Canadian dwellings. All naturally occurring <i>aspergilli</i> species are toxigenic.
<b>Aspergillus fumigatus</b>	A fast growing thermotolerant mould that may cause opportunistic infection in persons with compromised immune systems or those suffering from asthma. <i>Aspergillus</i> is both <i>toxigenic</i> and <i>allergenic</i> . It may also cause lung disease in chronically or heavily exposed individuals, and nonspecific respiratory symptoms in moderately exposed individuals. Its habitats are compost, dung, and other organic matter, especially in warm areas with relatively high nitrogen content. This species is thermophilic and grows well at temperatures up to 55 °C.
<b>Aspergillosis</b>	Disease caused by a variety of <i>Aspergillus</i> .
<b>Bacterium</b>	(pl. bacteria) A single-celled microorganism. Some can have <i>pathogenic</i> potential while others may cause problems in indoor air quality, especially when their mode of transmission is through the respiratory route (e.g., <i>Mycobacterium tuberculosis</i> the pathogen responsible for Tuberculosis or <i>Legionella pneumophila</i> responsible for Legionnaire's Disease).
<b>Bioaerosol</b>	An airborne dispersion of microbiological particles containing whole organisms or parts thereof. Bioaerosols may include bacteria; viruses; fungi; fecal elements or body parts of dust mites or cockroaches; animal fur; skin; scales; dander; hair; saliva; or urine.



<b>Building Related Illness</b>	Medically recognized diseases which can be attributed to exposure to airborne bioaerosols or chemical pollutants within a building. (e.g., Legionnaire’s Disease, Pontiac Fever, carbon monoxide poisoning, and <i>Aspergillosis</i> ).
<b>Biocide</b>	A chemical agent that kills biological entities. Some common biocides are sodium hypochlorite, quaternary ammonium compounds, formaldehyde, hydrogen peroxide, alcohols, phenolics, and glutaraldehydes.
<b>Bronchial</b>	Relating to the airways of the lungs below the larynx that lead to the alveolar region of the lungs.
<b>Bulk Sampling</b>	Samples of building materials and building contents taken during the hazard assessment and identification phase of mould remediation work.
<b>Building Envelope</b>	The outermost enclosing element of a building.
<b>Ceiling Plenum</b>	The space above the suspended ceiling which accommodates the mechanical and electrical equipment. If the space is also used as part of the air distribution system, it will usually be kept under negative pressure.
<b>Chronic</b>	Occuring over a period of time; persistent. A <i>chronic</i> exposure to allergens take place on a regular basis over a period of time. <i>Acute</i> exposure, on the other hand, is a single significant exposure event.
<b>Clean Room</b>	One of the rooms in a worker’s decontamination enclosure facility (located adjacent to the shower room). The clean room allows workers to remove and store street clothing and dress in protective clothing and respiratory equipment in an uncontaminated area prior to entering a contaminated work area.
<b>Conidium</b>	A term referring to the asexual spores of most types of mould. These are much more common in air than the more specialized sexual spores released by some of the same fungi. (pl. conidia)
<b>Conidiophore</b>	The specialized branch which produces the conidia (spores) of a mould. Seeing conidiophores in a direct microscopic examination of indoor samples indicates the mould is actually growing and reproducing in the site sampled.



<b>Contact Plate</b>	A plate of microbiological growth medium (e.g., fungal or bacterial medium) designed to be pressed directly onto a surface in order to detect mould spores, hyphae, or other parts of the organism which are capable of growth (propagules). Such propagules will ideally grow on the medium in proportion to the degree of surface contamination.
<b>Containment</b>	A safe condition brought about by creating a barrier to the spread or transmission of contamination. Containment is achieved when engineering controls have been put in place to keep biohazardous agents from escaping. Containment may be needed for a stand-alone piece of equipment, a facility within a building, or the entire building.
<b>Cryptococcus neoforma</b>	A pathogenic yeast growing in accumulated bird (usually pigeon) or bat dung and causing cryptococcosis in people who are heavily exposed or in those with compromised immune systems.
<b>Decontamination Facility</b>	A series of rooms constructed in such a way as to allow persons to enter and leave a contaminated area without spreading the contaminants beyond the work area.
<b>Direct Slide</b>	A slide for microscopic analysis prepared from materials removed directly from contaminated surfaces without being subjected to culturing or other amplification techniques.
<b>Disinfectant</b>	One of three groups of antimicrobial agents registered by EPA for public health purposes. The EPA considers an antimicrobial agent to be a disinfectant if it destroys or irreversibly inactivates infectious or other undesirable organisms, but not necessarily their spores.
<b>D.O.P. Testing (dioctyl phthalate)</b>	A method for testing the integrity of a HEPA filter by using aerosolized liquid dioctyl phthalate particles for assessing the filter capability and effectiveness at removing particles greater than or equal to 0.3 microns in size from the air with 99.97% efficiency.
<b>Dust Mites</b>	Microscopic anthropoid species common in the indoor environment. Mites and their feces have been identified as important indoor allergens.
<b>Emphysema</b>	A chronic pulmonary disease characterized by loss of lung function after many alveolar walls have been destroyed, with resulting enlargement of the air space. As a consequence, emphysema patients have trouble breathing.



<b>Epidemiology</b>	A branch of medicine that investigates the causes and control of epidemics; a study of all the elements contributing to the occurrence or non-occurrence of a disease in a population; the ecology course of a disease.
<b>Etiology</b>	The science of causes or origins; the cause of a specific disease.
<b>Exfiltration</b>	Air leakage outward through cracks and holes in the ceilings, floors, and walls of a space or building. Contrast with infiltration, leakage into a space or building.
<b>Filament</b>	A threadlike growth characteristic of certain moulds; a hypha of a fungus.
<b>Fungal Spores</b>	An everyday term for differentiated fungal reproductive structures such as conidia, chlamydospores, ascospores etc. These reproductive structures are generally more resistant to adverse conditions than the fungus that produced them.
<b>Fungus</b>	(pl. fungi) The kingdom of multi-celled organisms known variously as moulds, yeasts, and mushrooms. Fungi may cause indoor air quality problems through the dissemination of conidia, spores, toxins, or cell wall constituents. (Fungi are defined technically as a parasitic or saprobic, filamentous or single-celled eucaryotic organism, devoid of chlorophyll and characterized by heterotrophic growth and the production of extracellular enzymes.)
<b>Fungicide</b>	Biocides used to control, prevent or kill fungi.
<b>Genus</b>	(pl. genera) In the scientific system for the naming of organisms, a group of related species are known as a genus. For example, the genus <i>Aspergillus</i> comprises several related species such as <i>Aspergillus fumigatus</i> and <i>Aspergillus flavus</i> . In the literature, a reference to <i>Aspergillus sp.</i> is a general reference to all species in the genus.
<b>HEPA Filter</b>	A High Efficiency Particulate Air filter capable of trapping and retaining particles greater than or equal to 0.3 microns in size at 99.97% efficiency.
<b>Hypersensitivity</b>	The immune system's exaggerated response to an allergen.
<b>Hypersensitivity Diseases</b>	Diseases characterized by allergic responses to animal antigens. The hypersensitivity diseases most clearly associated with indoor air quality are asthma, rhinitis and hypersensitivity pneumonitis.



<b>Hypersensitive Pneumonitis</b>	A chronic respiratory distress syndrome characterized by a delayed allergic response to an allergen (immunosensitizing substance). Usually prolonged heavy exposure to the allergic stimulus precedes development of the syndrome in susceptible individuals. Other equally heavily exposed individuals may fail to develop the syndrome, despite manifesting a strong immunological response to the prevalent antigens.
<b>Hazardous Material</b>	Substances that can pose a substantial or potential hazard to human health or the environment when improperly managed. Hazardous waste has at least one of five characteristics: corrosiveness, reactivity, toxicity, flammability or adverse effects on the environment.
<b>Impactor</b>	A sampling instrument employing impactor plates to collect airborne particles of different sizes (inspirable, thoracic, or respirable particulate matter). The impactor is based on the principle that in a moving air stream, different-sized particles have different acceleration and removal rates.
<b>Indoor air pollutant</b>	Undesirable additions to the air: dust, fibres, mists, bioaerosols, vapours and gases.
<b>Indoor Air Quality</b>	The physical, chemical, and biological characteristics of indoor air in non-residential workplaces with no internal industrial processes or operations that can affect the comfort or health of the occupant.
<b>Micron</b>	A micrometre is 1/1,000,000 (one millionth) of a metre.
<b>Mitigation</b>	Measures taken to reduce adverse effects on the environment.
<b>Mould</b>	Mould is a non-scientific term which normally refers to any fungi with a filamentous growth form. Moulds may belong to any of the four major phyla of the fungi kingdom and the term is descriptive only. To reproduce and propagate, moulds produce microscopic conidia or spores which are small enough to be carried by air currents.
<b>Mycelium</b>	A mass of hyphae derived either from a single fungal colony or from a group of associated fungal colonies.
<b>Mycology</b>	The branch of biology that deals with the study of fungi.



<b>Mycotoxigenic</b>	Producing mycotoxins or toxins derived from fungus growth. Most mycotoxins are small, nonvolatile molecules such as polyketides, amino acid derivatives, or alkaloids. The production of mycotoxins is stressed in indoor air mycology only when the toxins are known to adversely affect humans and other mammals.
<b>Mycotoxin</b>	A class of fungal metabolites that have a toxic effect on animals and humans. Penicillin, alcohol and LSD are mycotoxins.
<b>Negative Air Cabinet</b>	Low-velocity, high-volume portable exhaust fans in sealed cabinets equipped with HEPA filters that exhaust filtered air to the outside of the building for the purpose of establishing and maintaining a constant negative air pressure differential in a contaminated work area relative to adjacent non-contaminated areas.
<b>Particulate</b>	A state of matter in which solid or liquid substances exist in the form of aggregated molecules or particles. Airborne particulate matter is typically in the size range of >.01 to 100 microns.
<b>Pathogenic</b>	Capable of causing disease.
<b>Pathogens</b>	Microorganisms that can cause disease in other organisms, humans animals or plants.
<b>Personnel Transfer Room</b>	One of the rooms in a worker's decontamination enclosure facility. Some times referred to as the 'Dirty Room,' the Personnel Transfer Room is considered a contaminated room adjacent to the contaminated work area, and has provisions for storage of contaminated clothing and equipment.
<b>Propagule</b>	Any airborne part of a fungus that can give rise to new growth; e.g., spores or hyphae.
<b>Qualified Person</b>	A qualified person must "be an occupational health and safety professional" with extensive experience in mould remediation. Suitable qualifications or credentials for persons performing risk assessments and project supervision include: Certified Industrial Hygienist (CIH), Registered Occupational Hygienist (ROH), Certified Safety Professional (CSP), Certified Registered Safety Professional (CRSP) or Registered Professional Biologist (RPBio) with experience in the practice of occupational hygiene as it relates to mould remediation; or other combinations of education, training and experience, such as, persons with extensive past experience mould remediation projects who have also attended recognized education and training courses on the subject of mould remediation.



<b>Reuter Centrifugal Sampler.</b>	A centrifugal air impaction device for quantitatively sampling microbial propagules. It uses an impeller fan to impact propagules onto the agar-filled wells of a moulded plastic strip lining the inside of the sampler. It is highly portable and hence may be easier to use than other equivalent vacuum-culture devices. Blank strips can be purchased to accommodate any special mycological media as required. Some newer models allow for quantity calibration of the air samples.
<b>Settle Plate</b>	A petri plate filled with microbial growth medium and left open for a prescribed period of time so that <i>bioaerosols</i> can settle on it. It is then closed up and incubated to allow the growth of colonies of fungi or bacteria.
<b>Shower Room</b>	One of the rooms in a worker's decontamination enclosure facility. The shower room separates and isolates the clean room from the personnel transfer room. The shower room is equipped with a walk through shower facility; hot and cold running water controlled and regulated at the shower head to facilitate complete showering for the purpose of personnel decontamination. The shower room also serves as an airlock between the contaminated and clean area.
<b>Sick Building Syndrome</b>	According to World Health Organization's definition, SBS consists of a group of nonspecific symptoms related to chemical, particulate or biological exposure that cannot be related to a specific cause, but are alleviated when the occupant leaves the building. Individuals report symptoms such as eye, nose, or throat irritation; a sensation of dry mucous membranes; dry skin, rash; mental fatigue; headache; nausea; dizziness; coughing; hoarseness; wheezing; or itching and nonspecific hypersensitivity reactions.
<b>Slit-to-agar Sampler</b>	An air sampling device for testing spore concentrations in the air over a period of time. The Bourdillon slit-to-agar sampler draws air through a narrow slit onto the surface of a rotating petri dish filled with agar. As only one position on the agar surface is under the slit at one time, some idea of the temporal variation in propagule intake can be obtained by examining the plate. This in turn gives an idea of the degree of homogeneity of propagule distribution in the air itself.
<b>Spore</b>	A reproductive propagule that forms either following meiosis or asexually by a cleavage process. Also called a conidium.



<b>Stack Effect</b>	Airflow produced by convection as heated air rises, creating a positive pressure area at the top of a building and a negative pressure area at the bottom of a building. The stack effect can overpower mechanical systems and disrupt ventilation and circulation in a building.
<b>Static Pressure</b>	Condition that exists when an equal amount of air is supplied to and exhausted from a space. At static pressure, equilibrium has been reached.
<b>Substrate</b>	The substance or material upon which a fungus grows. When it is fragmented or porous, a great deal of the fungus growth occurs within the substrate.
<b>Thermophilic</b>	Organisms that prefer a temperature above 37 °C for growth and survival. Such agents can grow in temperatures up to 58 °C and are isolated in hot springs, soil, compost piles, gas furnace humidifiers etc. This may be an important group causing indoor air problems in buildings.
<b>Thermotolerant</b>	Organisms that survive at temperatures above 37 °C.
<b>Total Suspended Particulate</b>	The mass of particles suspended in a unit volume of air when collected by a high volume air sampler.
<b>Toxigenic</b>	A substance or biological entity that harms humans or other animals.
<b>Trichotecene</b>	A class of toxins produced by certain fungal species such as <i>Fusarium sporotrichoides</i> and <i>Stachybotrys chartarum</i> . These mycotoxins cause severe health effects in humans and other animals.
<b>Upper Respiratory Tract</b>	Structures that conduct air into the lungs, including the nasal cavity, mouth, pharynx and larynx.
<b>Vacuum to Culture Technique</b>	Air samplers that sample mould propagules by means of a vacuum drawing airborne matter onto culture media.
<b>Variable Air Volume System</b>	Air handling system that conditions the air to a constant temperature and varies the outside airflow to ensure thermal comfort.
<b>Ventilation Rate</b>	The amount of outside air that is supplied to the interior space.
<b>Volatile Organic Compounds</b>	Some VOCs are of industrial origin, such as compounds that evaporate from housekeeping or maintenance products used or in storage. Others are produced by certain microorganisms.



**Vapour**

A substance in gas form, particularly one near equilibrium with its condensed phase, which does not obey the ideal gas laws; in general, any gas below its critical temperature.

**Vector**

A transmission mechanism for mould or bacterial infection. For example, mould spores and yeast buds can be carried about by an insect or rodent.



# 7

## Standards and References

### **CSA Standards**

Z94.4-02 *Selection, Use and Care of Respirators*

Z94.3-02 *Eye and Face Protectors*

Z94.2-02 *Hearing Protection Devices – Performance, Selection, Care, and Use*

### **Workers Compensation Board of British Columbia**

*Occupational Health & Safety Regulation*

### **Ontario Ministry of Labour**

*Hazard Alert – Mould in Workplace Buildings (December 2000)*

### **Reliable Internet Resources**

#### **Workers' Compensation Board of British Columbia**

*Guideline G4.79 Moulds and Indoor Air Quality*

<http://regulation.healthandsafetycentre.org/s/GuidelinePart4.asp#SectionNumber:G4.79>

#### **United States Environmental Protection Agency (USEPA)**

*Mold Remediation in Schools and Commercial Buildings*

[www.epa.gov/iaq/molds/index.html](http://www.epa.gov/iaq/molds/index.html)

#### **New York City Department of Health.**

*Guidelines on Assessment and Remediation of Fungi in Indoor Environments (April 2000)*

[www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html](http://www.ci.nyc.ny.us/html/doh/html/epi/moldrpt1.html)

#### **Canada Mortgage and Housing Corporation.**

*Fighting Mold (1999)*

[www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose\\_ce08.cfm](http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_ce08.cfm)

#### **Construction Safety Association of Ontario.**

*Moulds: Controlling Exposure is Essential*

[www.csa.org/uploadfiles/magazine/vol10no2/moulds.htm](http://www.csa.org/uploadfiles/magazine/vol10no2/moulds.htm)



## Sampling Protocols (Mould)

*US Micro Solutions Inc.*

### I. Air Sampling - Viable

Viable sampling is used to determine airborne concentrations of mould and bacteria that are living and can grow on media.

The Anderson N6 or Aerotech 6 single stage bioaerosol samplers are 2 samplers available for rental to perform this type of sampling. In such sampling, air is drawn at high velocity through a multi-holed orifice plate where inertial forces cause the impaction of the airborne particles onto a nutrient agar surface. The selection of agar depends on the sampling objective and the incubation temperature of the agar depends upon the microbial under investigation. Once the media is selected and the incubation temperature is determined, the colonies are allowed to grow. As they mature, they are quantified and identified to the genus level for fungal and bacterial isolates and speciated when possible. The concentrations are expressed as colony forming units per cubic meter (CFU/m<sup>3</sup>).

A few guidelines when viable air-sampling:

1. Samples should be collected for compliant and noncompliant areas.
2. Sampling procedures should include a representative outdoor to provide a reference for determining whether certain genera and species are being amplified in the indoor environment.
3. Sampling durations of 1-2 minutes, 28.3-56.6 total litres, are commonly used. Areas with visible fungal growth may be sampled for a lesser time and likewise, remediated areas may be sampled for a longer duration.
4. A sufficient number of blanks or control samples should be submitted to establish the quality of the data collected.
5. Duplicate samples are recommended for each culture used at each location to characterize exposures at individual test sites.

### II. Air Sampling – Non-Viable

Total spore and particle sampling methods are used to evaluate the presence of viable and nonviable mould spores, hyphal fragments and pollen.

In commercially particle sampling devices such as the Zefon Mini Pump, particles are drawn through a tapered slotted orifice and impacted on an adhesive-covered cover slip.



The cover slip is mounted on a microscope slide with stain and examined at 400x and 600x magnification. Both spores and hyphal fragments are counted on a fraction of the collection surface (5%) using horizontal traverses. The count is then converted to a concentration based on volume of air sampled and expressed as spores or structures per cubic meter. (CTS/m<sup>3</sup>).

A few guidelines when nonviable air sampling:

1. Samples should be collected for complaint and noncompliant areas.
2. Sampling procedures should include a representative outdoor sample to provide a reference for determining whether certain genera and species are being amplified in the indoor environment.
3. The flow rates recommended for total mould spore sampling are in the range of 10-15 L/min.
4. Seventy-five total litres is recommended as a benchmark for representative sample volume.
5. In dusty or heavily polluted areas, particle overloading may occur and sampling times and volume should be adjusted accordingly.

### III. Bulk Sampling

Bulk sampling provides information regarding whether environmental materials may be contaminated beyond background levels and possibly serve as sources of biological agents that may be disseminated as bioaerosols. Bulk sampling is conducted on mould-infested materials to identify mould or bacteria types as well as their relative abundance.

Bulk samples are cut or otherwise aseptically removed from a source and placed in a sterile container. A segment of the sample is selected from an area that is least likely to have been handled and most likely to recover representative microbials. The selected sample segment is weighed and dispersed in a sterile liquid, diluted as necessary and inoculated on nutrient agar media. The selection of agar depends on the sampling objective and the incubation temperature of the agar depends upon the microbial under investigation. Once the media is selected and the incubation temperature determined, the fungal and bacterial colonies are allowed to grow. As colonies mature, they are quantified and identified to the genus level and speciated when possible. The concentrations are expressed in terms of colony forming units per gram of material (CFU/g).

A few guidelines when bulk sampling:

1. As a rule of thumb, aseptic techniques should be strictly adhered.
2. Bulk samples should be delivered to the laboratory as soon as possible and protected from temperature extremes during transport.
3. Bulk samples should include a representative cross section of the area sampled.



## IV. Dust Sampling

Dust sampling provides information about possible sources of biological agents in buildings as well as the composition and relative concentration. Dust, house dust or settled dust are terms used to describe the material that collects on horizontal surfaces in textiles, upholstered furniture and carpets.

Dust samples can be collected using a suction device, filter for full size vacuum cleaner or particle sampling devices fitted with specially designed filters. The dust sample is weighed and dispersed in a sterile liquid, diluted as necessary and inoculated on nutrient agar media. The selection of agar depends on the sampling objective and the incubation temperature of the agar depends upon the microbial under investigation. Once the media is selected and the incubation temperature determined, the fungal and bacterial colonies are allowed to grow. As colonies mature, they are quantified and identified to the genus level and speciated when possible. The concentrations are expressed in terms of colony forming units per gram of material (CFU/g) or colony forming units per area sampled (CFU/g/units of area sampled).

## V. Swab - Surface Sampling

Surface samples provide information similar to that obtained by bulk samples regarding whether environmental materials may be contaminated beyond background levels and possibly serves as sources of biological agents that may be disseminated as bioaerosols. Often, surface sampling is preferred over bulk sampling when a less destructive method of sample collection is desired.

Surface samples are collected by washing, rubbing or brushing a swab over a prescribed area. Swab samples are suspended in liquid and diluted as necessary. Aliquots of the sample are inoculated on nutrient agar media. The selection of agar depends on the sampling objective and the incubation temperature of the agar depends upon the microbial under investigation. Once the media is selected and the incubation temperature is determined, the colonies are allowed to grow. As they mature, they are quantified and identified to the genus level for fungal and bacterial isolates and speciated when possible. The concentrations are expressed in terms of colony forming units per swab or colony forming units per area sampled.

A few guidelines when swab surface sampling:

1. Aseptic techniques must be strictly applied.
2. Prior to collection, swabs should be wetted with sterile water to enhance particle collection.
3. Swabs should be delivered to the laboratory as soon as possible and protected from temperature extremes during transport.



## VI. Tape – Surface Sampling

Transparent tape samples of infested buildings provide a quick and easy method to identify the presence of major fungal general.

A small piece of transparent tape is touched or pressed to a prescribed or infested area and affixed to a microscope slide containing a drop of stain. The slide is examined at 600x magnification and the fungal spores, elements and hyphal fragments are identified and quantified.

A few guidelines when tape sampling:

1. One to 2 inches of crystal clear transparent tape should be used and fixed to a slide.
2. Tape should not be wrinkled, overlapped or torn.

© 2002 U.S. Micro Solutions Inc.



# Training Requirements for Mould Remediation Workers

## Pre-Employment Training

All mould remediation workers must receive pre-employment training before starting work on a mould remediation project. Upon completion of pre-employment training, the trainee should be able to:

- Recognize the variety of health effects, symptoms and allergic reactions which may result from exposure to mould.
- Explain the general employer and worker responsibilities as required by the Workers' Compensation Board of British Columbia, *Occupational Health & Safety Regulation*.
- Identify other health and safety hazards in addition to mould exposure, including but not limited to, electrical hazards, slipping or tripping, fall hazards, heat stress and exposure to hazardous substances.
- Explain and demonstrate electrical and equipment isolation and lockout procedures for various worksites.
- Demonstrate the safe use and limitations of access equipment, including ladders, scaffolding, powered platforms and self-propelled elevated work platforms.
- Discuss the necessity for observing good personal hygiene practices at the work site prior to eating or drinking.
- Discuss emergency planning and contingency plans for fire, serious injuries and emergency evacuation procedures.
- Discuss the selection, use, maintenance and limitations of personal respiratory protection equipment and protective clothing.
- Describe and demonstrate procedures, configurations and construction requirements for the erection of work area containments and isolation hoardings.

- Describe the engineering and environmental controls required for containment and control of airborne contaminants at the site including the installation and maintenance of negative pressure ventilation systems to maintain a negative air pressure differential in the mould remediation containment and decontamination facility.
- Describe and demonstrate procedures, configurations and construction requirements for a workers' decontamination facility, including entry and exit procedures and the use of airlocks and showers.
- Describe and demonstrate procedures for HEPA vacuuming and final cleaning of mould remediation work area and the handling of contaminated and hazardous waste.
- Demonstrate the procedures for the safe handling and disposal of mould contaminated wastes.
- Demonstrate remediation techniques and the use of remediation equipment and tools including hand tools, power hand tools, power wash units, spray misters and HEPA filtered vacuum equipment.
- Describe the purpose and procedures for D.O.P. testing of HEPA filters
- List the documentation that must be posted on each mould remediation site.

## **Additional Training and Upgrading**

Due to inevitable technological change and the rapid evolution of mould remediation techniques, it is the responsibility of employers and employees to keep pace with new developments within the hazardous materials industry.



## Testing and Maintenance of Respirators

### Respirator Seal Check & Field Checks

Inspect the respirator to ensure that all components are in place and that the respirator is in good operational condition. All personnel must perform a positive, a negative or both seal checks every time the respirator is worn. Perform the positive and negative seal checks in accordance with the respirator manufacturer's instructions. Positive and negative seal checks should take place while wearing all other required protective equipment such as protective clothing, hard hats and safety goggles as required. General seal check instructions for various respirator types are described below.

#### *Air purifying respirators*

- **Negative Pressure Seal Check**

Block off the inlet openings of the filter cartridges with the palms of the hands. Inhale slightly to create a negative air pressure in the facepiece and hold for approximately 10 seconds. When there is a good seal, the facepiece will collapse slightly and remain collapsed. There should be no air leakage past the respirator to face seal. If the facepiece does not collapse and remain collapsed, there is a leak. Check the exhalation valve and try repositioning the facepiece on the face and readjusting the head straps. Repeat the negative pressure seal check. If there is still a leak, try a respirator of a different size or a respirator from a different manufacturer. Repeat the negative pressure seal check with other respirators until a satisfactory facial seal is confirmed.

- **Positive Pressure Seal Check**

Block off the exhalation valve with the palm of the hand. Exhale slightly to create a positive air pressure in the facepiece and hold for approximately 10 seconds. When there is a good seal, the facepiece will bulge out from the face. There should be no air leakage past the respirator to face seal. If the facepiece does not bulge outwards, there is a leak. Check the inhalation valves and try repositioning the facepiece on the face and readjusting the head straps. Repeat the positive pressure seal check. If there is still a leak, try a respirator of a different size or a respirator from a different manufacturer. Repeat the positive pressure seal check with other respirators until a satisfactory facial seal is confirmed.

### **Powered Air Purifying Respirators (PAPRs):**

- **Flow Check** In addition to the negative pressure and positive pressure seal checks, test the powered air purifying respirators for adequate airflow in accordance with the manufactures instructions prior to every use. General powered air purifying respirator flow check instructions are as follows:
  - a) Remove blower assembly or hose from the facepiece.
  - b) Connect a fully charged battery onto the blower unit.
  - c) Install the appropriate filter cartridge(s) onto the respirator blower unit.
  - d) Test the PAPR airflow using the airflow indicator supplied by the manufacturer; ensure that the airflow indicator is in a vertical position while performing the test.

Do not enter a potentially contaminated environment with a PAPR that is unable to produce and maintain the minimum airflow recommended by the manufacturer. An inadequate airflow (below the manufacturer's specifications) usually indicates any one or a combination of all three possible problems:

- a) The battery is not fully charged or is defective. Install a fully charged battery and repeat the flow test procedure.
- b) The filter cartridge(s) are plugged, wet or restricted. Dispose of the filter cartridge(s) as contaminated waste. Install new filter cartridge(s) and repeat the flow test procedure.
- c) The blower unit itself may be defective. Replace the blower unit and repeat the flow test.

### **Air Supplied Respirators:**

- **Air Supplied Respirator Check** In addition to the above referenced negative pressure and positive pressure seal checks, thoroughly check air supplied respirator systems for proper operation prior to every use. Generally, ensure that each facepiece receives the minimum required airflow (4 cubic feet of air per minute or as recommended by the manufacturer). Make certain that the maximum hose length does not exceed 90 meters (300 feet). Ensure that the breathing air is of acceptable quality and is not subject to contamination from dust, oil, vapours and toxic or noxious fumes or gases. Breathing air must meet the requirements of *CSA Standard CAN3-Z180.1-M85, Compressed Breathing Air and Systems*. Refer to the manufacturer's instructions for pre-use inspection and maintenance of supplied air respirator systems.



## **Respirator Qualitative Fit Testing**

### ***Irritant Smoke (Stannic Chloride)***

In addition to the positive and negative seal checks, everyone required to wear a respirator for protection against exposure to airborne contaminants, must ensure that a qualitative fit test has been completed and documented prior to using the respirator.

Detailed qualitative respirator fit test procedures are in *CSA Standard CAN/CSA-Z94.4-93, Selection, Use and Care of Respirators*. The following procedures provide a general overview of the qualitative fit test protocol.

The qualitative fit test using irritant smoke can be used for fit testing air purifying respirators (with replaceable filter cartridges) and supplied air respirators. Air purifying respirators that are to be tested must be equipped with NIOSH 100 series (HEPA) filters. The test agent or irritant smoke is produced by air flowing through a ventilation test tube containing stannic chloride. This qualitative fit test relies on the test subject's response to the irritant smoke in order to detect a leak in the respirator to face seal.

Stannic chloride smoke can be irritating to the eyes, lungs and nasal passages. The test conductor conducting the test shall take all necessary precautions to minimize the test subject's exposure to the irritant smoke. Sensitivity varies and certain individuals may respond to a greater degree to the irritant smoke.

Perform the fit test procedure in an area that has adequate ventilation to prevent an accumulation of irritant smoke and exposure of the test conductor.

The person being fit tested (test subject) shall put the personally issued individually identified respirator on and successfully perform the required positive and negative seal check(s). The test subject may not proceed with the qualitative respirator fit test if a satisfactory facial seal is not confirmed with the positive or negative seal check. The test subject should wear the respirator for a short period of time prior to undergoing the fit test procedure. During this interval, the test conductor should review the specifics of the qualitative fit testing procedure with the test subject.

The test conductor must advise the test subject that the smoke can be irritating to the eyes and instruct them to keep their eyes closed during the procedure.

The test conductor shall break both ends of a ventilation smoke tube and attach one end of the smoke tube to the aspirator squeeze bulb. Cover the other end of the smoke tube with a short piece of tubing to prevent potential injury from the jagged end of the smoke tube.

The test conductor shall direct a stream of irritant smoke from the smoke tube around the perimeter of the respirator to face seal. Begin at least 30 cm (12 inches) from the facepiece directing the smoke stream around the entire perimeter of the respirator. The test conductor shall then make two more passes around the perimeter of the respirator, gradually moving to within six inches of the actual respirator to face seal.



Proceed with the test exercises if the test subject wearing the respirator has not had an involuntary response or detected the irritant smoke during the initial procedure.

The test subject will perform each of the following test exercises for at least one minute while the tester is challenging the respirator to face seal by directing the irritant smoke around the perimeter of the facepiece:

- a) Normal breathing
- b) Deep breathing
- c) Turning head from side to side, taking care not to bump respirator on the shoulders.
- d) Nodding head up and down, taking care not to bump the respirator on the chest.
- e) Talking aloud by reading the ‘*Rainbow Passage*,’ or counting backwards from one hundred, (which will result in a wide range of facial movements)
- f) Normal breathing

### **Rainbow Passage**

*“When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colours. These take the shape of a long round arch, with its path high above and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but none ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow. (From CSA Standard CAN/CSA-Z94.4-93, Selection, Use and Care of Respirators).*

If the irritant smoke produces an involuntary reaction or cough during the test exercises, the test is suspended. The test subject should then readjust the respirator straps as necessary to obtain a satisfactory facial seal. If the test procedure does not confirm a satisfactory facial seal, do not use the respirator. Repeat the test with another model or size of respirator.

The respirator may be assigned to the individual once a satisfactory facial seal is verified with the irritant smoke fit test. Do not assign a respirator if a satisfactory facial seal is not confirmed with the positive and negative seal checks and with the stannic chloride irritant smoke fit test.

Record the results of the qualitative irritant smoke fit test on the subject’s individual *Respirator Fit Test* Form and in the *Daily Respirator Log*. Ensure that the respirator has been individually marked or identified so that the test subject can identify his or her own respirator.



Perform the qualitative fit test at the beginning of each project and repeat after every 120 hours of use thereafter for the duration of the project. Qualitative fit testing must also be performed following repair or maintenance of the respirator. Do not use the qualitative fit test procedure as a maintenance check on the respirator or components.

## **Respirator Cleaning and Sanitizing**

Clean and sanitize respirators regularly to kill bacteria and prevent the build up of dirt. The employer will give the workers sufficient time and provide the materials and equipment to ensure thorough cleaning and sanitizing of respiratory equipment. Respirator cleaning and sanitizing must be performed in accordance with the manufacturers' instructions. Clean and sanitize respirators after each use if more than one person will wear them.

General respirator cleaning and sanitizing procedures are summarized as follows:

- a) Disassemble the respirator by removing the cradle suspension, cartridge connector, inhalation valve and exhalation valve assembly. Remove the inhalation valve from their respective matching components. If filter cartridges are wet or heavily loaded replace them.
- b) Wash the facepiece and other components in warm water that contains a mild detergent, using a soft scrub brush as necessary.
- c) Sanitize respirators by submerging all components for at least 2 minutes in a sanitizing solution (2 tablespoons of household bleach to 4 litres of warm water) or a sanitizing agent approved by the manufacturer of the respirator.
- d) Remove the components from the sanitizing solution, rinse thoroughly and hand dry with a lint free cloth or allow to air dry.
- e) Reassemble the respirator once it is dry. Inspect the respirator and components for wear, defects, damage or deterioration during reassembly. Replace defective respirator or components immediately. Always refer to the respirator instruction manual for detailed information. Do not use defective respirators or respirator components.



## Respirator Inspection and Maintenance

Inspect respirators for damaged or deteriorated components prior to each use.

- a) Respirator facepieces shall be inspected for dirt, cracks, tears or holes, warped surfaces, broken or worn fittings, proper installation of components and cracked or scratched lenses on full-facepiece models.
- b) Inspect inhalation and exhalation valves for soap or dirt residue on the valve or valve seats and for cracks, tears, warping or curling of valves or valve seats, as well as missing or damaged valve covers.
- c) Ensure that the filter cartridge holders and filter cartridges, are installed properly and are not damaged or deteriorated. Ensure that the appropriate filter cartridges have been selected for protection against the anticipated hazard or hazards.
- d) Powered air purifying respirators (PAPRs). In addition to the above listed maintenance checks, ensure that the battery is in good condition, is adequately charged and that the blower unit is in good repair. Test the PAPR airflow with the appropriate filter installed using the airflow indicator supplied by the manufacturer.
- e) Air supplied respirators in addition to the above listed maintenance checks, ensure that supply hoses, attachments, couplings, regulators and control valves, alarms and monitors and other system components are in good operating condition. Test the air pressure and flow rate prior to each use to ensure that the manufacturer specified flow rates are maintained. Ensure that breathing air from compressors or cylinders meets the breathing standards established by *CSA Standard CAN3-Z180.1-M85, Compressed Breathing Air and Systems*. Refer to the manufacturer's instructions for pre-use inspection and maintenance of all supplied air respirator systems.

