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mould guidelines for the Canadian construction industry

Canadian Construction Association

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FOREWORD

Mould, or fungi, has existed on Earth since life first began, and results in the natural decomposition (recycling) of organic materials.

In the built environment, fungi and mould damages wood, wallboard and other materials and causes them to rot. The growth of fungi on materials in the built environment can affect human health, depending on the extent of growth, the length of exposure, and the health status of the exposed personnel. Because many regulatory agencies now consider mould growth a health hazard, there has been an increase in litigation, originally limited to the United States but now being seen in Canada, against those involved in the construction and maintenance of buildings. In the absence of national guidelines or legislative remedies, courts have been left to define the extent of contractors' and other parties' responsibility concerning mould growth and exposure.

In June 2002, the Canadian Construction Association created a Mould Task Force to develop national guidelines to assist contractors in minimizing the potential for mould growth, and instituting effective remediation practices. This document is the product of that work. These national guidelines provide useful information and step-by-step instructions in the following areas:

- Insurance Considerations;
- Minimizing of Moisture Intrusion;
- Proper Building Maintenance and Operation;
- Mould Assessment;
- Mould Remediation Protocols;
- Proper Disposal of Mouldy Materials; and
- Guidelines for Selecting Mould Remediation Contractors.

DISCLAIMER

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CCA MOULD GUIDELINES
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1.0 INTRODUCTION

In recent years, the private, commercial, industrial, and institutional sectors, as well as the public at large have become increasingly concerned about the potential health risks of mould.

Because of the media's coverage of the possible health risks of mould in schools, courthouses, homes, and other public and private buildings, and the associated legal issues and insurance claims, mould has become a very hot topic.

This has placed increased pressures on building managers, safety committees, directors, contractors, consultants and owners to properly assess the effects of mould and to implement proper prevention, clean-up and remediation practices and procedures.

The scientific and public health communities agree that indoor mould contamination is a health issue for some individuals, and therefore mould growth should be removed. At the same time, both communities agree that it is presently impossible to establish safe mould exposure thresholds.

Incurring mould growth during construction can have a negative effect on scheduling, costs, client relations and occupancy.

In order to minimize mould growth and associated health risks, all aspects of a construction project should be reviewed. This includes the design, specifications, material selection and handling, construction work practices, scheduling, operations and maintenance.

Minimizing water intrusion during construction and developing a proactive plan to effectively deal with wet construction materials are also important considerations.

As construction professionals, understanding mould related issues is vital to achieving successful projects and minimizing associated liabilities.

This document is intended to provide stakeholders with information to assist them in understanding some of the issues associated with mould, as well as their own roles and responsibilities, and the decisions that can significantly increase or decrease associated risk factors.

1.1 Key Roles and Responsibilities

Design professionals (e.g. architects and engineers) are responsible for the design of a building's envelope, its heating, ventilating and air conditioning (HVAC) system and other mechanical systems and components, including design details that could potentially cause or minimize mould growth.

Construction contractors are responsible for the proper handling and storage of construction materials at the work-site, and for monitoring that their employees and subcontractors perform in accordance with the plans, specifications, and other contract requirements.

Both design professionals and building owners are responsible for the building materials and systems they select and specify.

Owners are also responsible for the usage, operation and maintenance of a building following its completion.

2.0 LEGAL OVERVIEW

Mould in indoor environments has been compared to the asbestos crises of several years ago. Whether the two are comparable remains to be seen. What is obvious, however, is the media's and legal profession's increasing interest in mould and its possible risks. As a result, people are more aware of their legal rights, and quicker to act on them. Class actions are becoming more common in Canada, as are "contingency" fee arrangements whereby lawyers charge clients based on recovery rather than on effort.

Looking at the U.S. experience with mould claims, it is likely that mould will also become a significant legal issue in Canada, and will result in a growing number of claims by owners and occupants against those involved in the construction process. Several large actions are underway involving contractors, subcontractors, design professionals, material suppliers, and maintenance entities.

The U.S. experience has resulted in multi-million dollar jury awards for clean-up costs, relocation expenses and, in some cases, personal injury damages. The insurance market has been hit hard, leading a number of insurers to no longer provide coverage for mould and its consequences. Most insurers have taken steps to limit their exposure to mould claims.

For federal/provincial regulators, mould is a significant occupational health and safety issue, as well as a public health issue. Most jurisdictions have issued alerts or bulletins concerning the hazards of mould growth in indoor environments. Employers are required to take all reasonable measures to protect the health and safety of their workers, which includes a duty to protect against exposure to potentially harmful substances such as mould. These measures require the immediate and safe removal of any mould growth in buildings, while ensuring the protection of workers, building occupants, and the surrounding environment. Although the health risks of mould exposure are not fully known, scientific and health authorities agree that exposure should be avoided.

Employers must be duly diligent and ensure that their policies and procedures demonstrate full commitment to worker safety. Due diligence is also required to protect the construction industry from the consequences of civil claims relating to mould damage and the potential health risks of mould exposure.

We believe that a proactive response to the issues surrounding mould in indoor environments is appropriate, and will assist our industry in managing the legal risks presented by the growing concerns over mould.

3.0 INSURANCE OVERVIEW

3.1 Insurance Industry's Position

Generally, the insurance industry's position is that mould is not covered under commercial insurance policies. Endorsements specifically excluding mould were added to clarify coverage under Commercial Property and Liability Policies – generally at renewal dates of policies on or after January 1, 2003.

The definition of mould was deemed too restrictive, and therefore endorsements may also use the term "fungi", which includes mould, and "spores" – the reproductive part of fungi.

Insurers recognized the need to specifically exclude mould following the outcome of a number of court cases in Canada and the U.S. The courts' interpretation of insurance policy wordings led insurers and their reinsurers to clarify the intent of policies by specifically stating that mould is excluded. Some insurers are more restrictive than others, and each policy should be carefully reviewed to confirm the extent of coverage and exclusions.

3.2 Property and Business Interruption (e.g., builder's risk, installation floaters, equipment, owned property (such as buildings and contents), extra expense).

The standard mould exclusion used by most insurers:

- Excludes loss or damage consisting of or caused directly or indirectly, in whole or in part, by fungi or spores, unless such fungi or spores are directly caused by or directly result from a peril otherwise insured and not excluded under the policy.
- Excludes costs or expenses for any testing, monitoring, evaluating or assessing of fungi or spores.
- Provides limited coverage for fungi and spores if damage results from another insured peril (such as fire).

However, not all insurers provide the limited cover referred to in the third bullet above. Some have ABSOLUTE exclusions. Each insurance policy should be carefully reviewed for mould provisions.

Some insurers may also be willing to pay for expenses incurred for testing following an otherwise insured loss to ensure that remediation work is done properly. Again, it is important to review each policy to determine whether coverage may be available.

3.3 Liability

General liability policies provide insurance to cover the insured's legal responsibility for bodily injury of other people or property damage to other people's property.

Under this type of policy, three options are typically available with respect to mould:

1. Absolute Exclusion, using wording such as the following:
   Excludes bodily injury, property damage, personal injury or medical payments or any other cost, loss or expense incurred by others, arising directly or indirectly from the actual alleged or threatened inhalation of, ingestion of, contact with, exposure to, existence of, presence of, spread of, reproduction, discharge or other growth of any fungi or spores, however caused, including any costs or expenses incurred to prevent, respond to, test for, monitor, abate, mitigate, remove, cleanup, contain, remediate, treat, detoxify, neutralize, assess or otherwise deal with or dispose of fungi or spores, or

   Any supervision, instructions, recommendations, warnings or advice given or which should have been given in connection with above, or

   Any obligations to pay damages, share damages with or repay someone else who must pay damages because of such injury or damage.

2. Limited coverage, possibly with a sublimit and/or annual aggregate limit
   Coverage may be provided with respect to products and completed operations as opposed to ongoing work, and for work or operations performed by the insured or on the insured's behalf to premises he/she owns, rents, or occupies.

3. No endorsement, that is, the policy is silent with respect to mould.

It is likely that the Absolute Exclusion will be included in policies for the construction industry.

3.4 Home Insurance

Personal insurance for homes, condominiums, or apartments has excluded mould for a number of years.

3.5 Examples of Possible Insurance Claims

- Contractor completes a building, and two years later, mould develops with no specific incident noted to cause the mould. Building owner sues contractor, and the insurance policy does not respond.
- Plumbing Contractor works in new or existing building. Work is not completed correctly (e.g., pipe joints not sealed, etc.). Mould subsequently develops because of leakage. Building owner sues for damage to building, and tenant sues for resulting health problems. Insurance policy does not respond to either claim.
- Fire occurs in a recently constructed building. Mould develops as the result of water used to put out fire or from improper clean up. Building owner seeks recovery of costs. Building owner's property policy responds because mould developed as a result of the fire (an insured peril under the policy). In the event that the building was not fully complete, the Builders Risk Policy should then respond.
  It is also important to note that if the building owner's insurer responded, that insurer might pursue recovery (subrogate) from the contractor if it could be proven that the contractor's negligence had contributed to the cause of the fire. Depending on his / her insurance policies, the contractor may or may not have coverage.
- A condominium corporation hires a building science consultant to assess and provide designs to repair a deteriorated building envelope. The consultant neither assesses for mould nor includes the costs of mould abatement in the repair budget. A contractor is retained to perform the repairs and, early in the project, when hidden mould is identified, the public health office issues orders for extensive abatement. The condominium board is sued by a class of owners over escalating repair costs and reduction in property values; the board in turn sues the consultant. The insurers for both the condominium board and the consultant refuse coverage for legal fees and damages, citing the pollution exclusion clause.

  It is important to note that if the property policy had an Absolute Pollution exclusion, the policy would not respond, and again there would be no insurance coverage.

3.6 Recommendations

- Check your policy wording, and ask your insurance representative to explain what coverage if any you may have for mould. Ask whether it is possible to obtain quotes for other options.
- Coverage may be available under the following types of policies:
  - Environmental Liability Policy
  - Directors and Officers Liability Policy
- A contractor or building owner, when hiring a mould remediation contractor or environmental consultant, should determine whether the service provider's insurance includes mould coverage. Mould inclusive insurance is recommended for all levels of mould remediation, particularly for Level 2 and 3 remediation work.

  Again, discuss your coverage with your insurance representative. He / she will assist you in determining whether these options will provide mould insurance and at what cost.

4.0 DEFINING MOULD

The term “mould” applies to a large group of microorganisms, which, together with mushrooms and yeast, form the Fungi Kingdom of living matter. Over 100,000 individual species of mould have been identified and biologists estimate there may be over 1.5 million species worldwide. Mould organisms grow by degrading nutrients from organic substrates such as wood and wood products, fabrics, foodstuffs, plants and plant debris, and soil. They play an essential role in the natural world. Mould is one of the principal decomposers of organic matter and through the decomposition process, essential nutrients are made available to other organisms. Mildew is a common term applied to a variety of moulds that grow on plants or household items under damp conditions.

Most moulds reproduce by forming large numbers of spores. Mould spores are always present outdoors and in buildings, and are distributed by wind, insects, floods, animal and human activity. All buildings have a background concentration of settled spores. However, these spores do not pose a hazard until the three essential conditions for mould growth are present, namely, a suitable temperature, appropriate substrate and adequate moisture. Some species of mould grow even in extreme temperatures, for example, just above the freezing point of water and up to temperatures of at least 40^{o}C. Moulds will colonize on a wide variety of construction materials and building contents, the most common being drywall, wood and wood products, ceiling tiles, wallpaper, and carpets. Exposed soil within a building (e.g., a dirt crawlspace) is another area of potential mould growth. While some inorganic materials such as fibreglass insulation or plaster and other masonry products may not themselves support mould growth they may contain dirt or have surface coatings that support growth. The presence of moisture may be due to either flooding (e.g., a rain storm or broken pipe), or conditions of relative humidity and condensation which can result in trapped moisture in a wall cavity, cold sections of air conditioning equipment and ductwork, or cool surfaces in unventilated, unheated areas. By their very nature, construction sites are prone to wetness or uncontrolled humidity.

Under the appropriate conditions, mould grows rapidly. The spores develop a root-like structure within hours of wetting and many common mould species produce visible colonization and masses of spores within 3-5 days. Mould growth on building finishes and contents normally appears as a pattern of black, green or grey spotty circular growth or as masses of fine, white, fluffy growth. Generally, once the conditions of adequate moisture have been established, many types of mould may colonize a surface. A musty, earthy odour, which results from the release of metabolic by-products, is often present as the mould grows. Mould growth may produce billions of spores per square metre of visible growth which, when airborne, may pose a potential health risk.

The wet conditions in buildings that promote mould growth can also foster the growth of other microorganisms, some of which may also pose a health risk. For example, actinomycetes are a class of bacteria that form long filaments of powdery growth of various colours on soil and other organic materials and may be mistaken for mould growth. Gram-negative bacteria are a class of bacteria that may also colonize building materials. Bacterial growth often produces a sour or rank odour. Generally, the measures outlined in these guidelines to prevent and remediate mould growth are also suitable for preventing and controlling environmental bacterial growth.

5.0 HEALTH RISKS

5.1 General

There are a number of documented cases of health problems related to exposure to indoor fungi. Both high-level, short-term exposures and lower-level, long-term exposures can result in illness. The most common symptoms from exposure to mould in indoor environments are runny nose, eye irritation, cough, congestion, aggravation of asthma, headache, flu-like symptoms, fatigue, and skin rash. People with suppressed immune systems may be susceptible to fungal infections as a result of exposure to indoor moulds.

People who are exposed to mould growth on building materials will not necessarily exhibit adverse health effects. However, the mould must still be removed. Humans are at risk from indoor mould when fungal spores, fragments or metabolites are released into the air and inhaled or physically contacted (dermal exposure).

Not everyone experiences allergic reaction; the susceptibility to exposure varies with the individual's genetic predisposition, age, state of health, and concurrent exposures. For these reasons, and because the measurement of exposure is not standardized and biological markers of exposure to fungi are largely unknown, it is not possible to establish "safe" or "unsafe" levels of exposure. However, federal and provincial policies have been written to minimize mould exposure and the elimination of mould indoors.

5.2 Susceptibility to Mould Exposure

People's reaction to mould exposure is quite varied, and although anyone can be affected, some people may be more susceptible and at greater risk, including:

- Infants and children
- The elderly
- Pregnant women
- Individuals with respiratory conditions or allergies and asthma
- Persons with weakened immune systems (e.g., chemotherapy patients, organ or bone marrow transplant recipients, and people with HIV infections or autoimmune diseases).

People with specific health concerns should consult their doctor if concerned about mould exposure. Symptoms that may appear to stem from mould exposure may be due to other causes such as bacterial or viral infections or other allergies.

5.3 Infectious Diseases

Exposure to fungi from bird and bat droppings (i.e., Histoplasma capsulatum and Cryptococcus neoformans) poses a risk of infection to any worker or building occupant when the droppings are disturbed. Although most infected persons may only experience temporary flu-like symptoms, some may develop more significant respiratory infections or blindness. All significant deposits of bird or bat droppings should be considered a hazardous substance.

5.4 Relocation of Personnel

Anyone who may be severely affected by mould exposure should be removed from the affected area during remediation. People diagnosed with fungal-related diseases should not be returned to the affected and/or adjacent areas until mould remediation and verification testing are completed. The decision to remove / return people affected by mould exposure should be based on a medical assessment.

6.0 CONSTRUCTION PRACTICES TO MINIMIZE MOISTURE INTRUSION

6.1 General

The key to dealing with mould – and with the rising tide of public concern and adverse publicity that surround the issue – lies in prevention. Many construction materials contain enough organic material to cultivate mould when wet. Stachybotrys, for example, is frequently found on wet paper used in gypsum wallboard and other materials with a high cellulose content.

Although it is not possible to completely eliminate mould spores and nutrients from the construction process, it is possible to control the other element that promotes mould growth - moisture. Mould needs moisture to grow; without excess water or humidity, mould growth will not occur. This is not an easy task; however, controlling moisture during the construction process poses significant challenges to the designers, consultants, contractors, and owners who must work closely together to successfully complete the project.

6.2 Building Design Considerations

Mould prevention is the joint responsibility of the three key stakeholders in a building project, designers, builders, and operators/owners. The failure of any stakeholder to exercise due care can result in a mould-contaminated facility, with the inherent loss of use, costly remediation, and possible long-term litigation. Guidelines for preventing mould in new construction and in the operation of building systems are discussed in later sections of this document.

Although some contractors operating in the Design-Build sector have a thorough knowledge of proper design principles, some do not. Nevertheless, builders must be aware of the importance of proper HVAC design, architectural detailing, and the selection of suitable systems and materials in the prevention of mould in a building.

It is unreasonable to expect the builder to carry the entire burden of mould prevention for a project. Builders are responsible for proper material handling and workmanship, but should never accept responsibility for inadequate detailing or specification. Designers are duty-bound to provide proper detailing, systems design, and material selection to prevent water intrusion or condensation that results in mould growth and contamination. Building operators must establish, as part of a complete Facility Operations and Maintenance Plan, detailed guidelines on maintenance and inspection for the prevention and early detection of mould.

Project or construction managers, whether or not they are part of the design team, should give careful consideration to the timing and scheduling of the project, and advise the owner of any increased risks due to accelerated schedules. It is critical to acknowledge that construction during damp / rainy seasons may result in the exposure of building materials to moisture.

Even with a weather-tight completed building envelope, concrete floor curing or plastering processes can release excess moisture within a building. Where a suitable ventilation or drying process is not specified, drywall surfaces and wood structures that are particularly sensitive to moisture absorption are likely to facilitate mould growth.

Designers who recognize the risks of exposing materials to moisture during construction or during building operation can make appropriate material choices to reduce the risk of mould.

In response to industry demands, manufacturers of interior finishing products have developed "mould resistant" materials. Wallboard manufacturers are producing moisture-resistant gypsum board faced with a glass mat instead of paper for use when exposure to moisture can occur. Some ceiling tile manufacturers now offer tiles that incorporate a mould inhibitor, and anti-microbial silver ion-based paints are available to coat sheet metal to minimize mould growth in ductwork.

Builders have the right to ask designers for details of the project mould prevention plan. If no such plan exists, the builder should inform the designers that mould prevention is a joint responsibility of the designer, builder and owner. Given the growing awareness of the potential hazards of mould contamination in buildings, owners and designers must today be acutely aware of detailing or systems engineering practices that led to mould problems in the past. In the early 1980's, for example, many buildings were made "air-tight" but without the benefit of adequate ventilation to control humidity. The resulting problems due to mould contamination are well documented in industry and legal publications.

6.2.1 Architectural Detailing and Practices

Many mould-contaminated buildings suffer from chronic leaking through exterior wall and roof systems, sometimes as a result of poor detailing of penetrations or entire assemblies. Proper "rain-screen" design principles and details are essential in the Canadian environment to permit the escape of rainwater that penetrates the exterior surface.

Progressive designers will stipulate that the builder constructs mock-ups of critical assemblies such as windows prior to installation. This is crucial to an effective Quality Management Plan and allows the designer and builder to demonstrate the validity of the design or to expose problems with detailing that might permit a leak. The mock-ups will ensure suitable flashing, insulation, caulking, and air barrier installation; the completed and approved mock-up is then left on the site to serve as the standard for all future installations.

6.2.2 Role of HVAC Designer

Proper design principles can reduce the risk of the heating, ventilation, and air conditioning (HVAC) system contributing to mould growth in a building. Various publications by respected industry bodies such as the American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE) outline good practices for ductwork design, cooling for dehumidification, and proper installation of humidification systems to reduce moisture in ductwork and the likelihood of mould growth (see, for example, the ASHRAE publication, "Humidity Control Design Guide for Commercial and Industrial Buildings-2001").

The HVAC designer should also provide input on the final Operation and Maintenance Guidelines for the specified systems and equipment, and should actively participate in the Commissioning Process, thereby ensuring that building operators understand their role and responsibility in mould prevention.

Should the project permit or require the builder to operate the permanent HVAC system during construction, it must be specified that the equipment be turned over upon project completion in clean condition.

6.3 Construction Considerations

To effectively minimize moisture intrusions, owner(s), designer(s), consultants, and construction contractors must work together. It is particularly important that all parties analyze the construction schedule because it dictates the installations for the project and when they are to occur.

Generally, the earlier the construction schedule requires a contractor to begin finishing the interior, the greater the risk of permitting water to enter or accumulate on materials that accommodate mould growth.

There are three stages of construction: the Exposed Phase, the Partially Enclosed Phase, and the Controlled Phase. If the goal is to achieve the lowest level of risk, then the single most important point in the construction schedule may be the point at which the contractor seals the building envelope.

During the Exposed and Partially Enclosed Phases, to minimize the potential for mould growth, it is important to minimize the risk of water damage and wet surfaces due to external factors such as rain, snow, flooding, and high relative humidity. The installation of protective barriers or temporary enclosures across building envelope openings (walls, roof, and basement) and open areas to accommodate construction elevators/hoists, window installation, etc., is recommended. The use of water-resistant materials in areas susceptible to moisture also reduces the risk of mould growth. These decisions affect both the construction cost and schedule, and should be fully considered. Wet areas should be reported immediately and steps taken to dry the materials within 24 hours.

Sequencing of construction and fit-up materials is critical during the Controlled Phase. Concrete walls, beams and floors, wooden structural components, gypsum moldings, and other materials must be allowed to completely dry without being covered or hidden. Placing a floor or ceiling over a wet concrete floor can result in mould growth. Installation of drywall on or near concrete that is being cured, or adjacent to sprayed-on insulation, or within an area of high relative humidity, will result in water damage.

Drying techniques using fans, natural ventilation, heaters, dehumidifiers, desiccant dehumidifiers, and the HVAC system if operational have unique limitations. These methods should be reviewed and used appropriately to reduce the potential of interior mould growth during construction.

6.3.1 General Considerations

Construction contractors should consider the following to minimize the potential for mould growth:

- minimizing the exposure of interior building products to exterior conditions;
- protecting stored materials from moisture;
- minimizing moisture accumulation within the building;
- prevent spillage of water within the building;
- maintaining the integrity of the building envelope components through ongoing monitoring and inspections;
- achieving balance control of thermal comfort and relative humidity in the building;
- checking all material deliveries to validate that components are dry and clean;
- reject wet or mouldy materials, and;
- monitoring installations to ensure they remain clean and dry (including the HVAC systems).

6.3.2 Administrative Controls and Record-Keeping

Administrative controls and record keeping are useful resources in the prevention of mould growth because they provide working tools for on-site personnel. These may include:

- a written Project Environment and Safety Plan which identifies mould prevention practices and procedures;
- Incident Report forms for documenting water intrusion incidents;

- Non-Conformance Report forms identifying rejected wet materials;
- Inspection forms; and
- Tailgate meeting forms where topics for water intrusion prevention can be communicated and documented.

6.3.3 Worker Orientations

Where construction work is to be performed on any facility, it is extremely important that workers be informed of the following at worker orientation sessions:

- Exposure to mould may cause adverse health effects;
- If mould is found, work in the affected area is to be stopped and the worker is to report the mould finding to his/her supervisor immediately;
- Mould must not be disturbed because it may become airborne and contaminate or impact other areas;
- Wet construction materials must not be installed unless part of an approved process;
- Mouldy construction materials must not be installed; and
- Workers must report wet or mouldy construction materials immediately so proper corrective measures (drying, cleaning or replacement) can be implemented.

NOTE: Subcontractors who conduct their own worker orientations must provide the above information to their workers, and must document that the information has been provided.

6.4 Subcontractors / Suppliers

Contract and purchase order specifications should require that materials be delivered dry and kept clean and dry at all times, including during storage and transportation.

6.5 Drying of Wet Materials

If water intrusion occurs, every reasonable effort should be made to dry out wet materials within 24 hours (48 hours maximum) from the time when it is reasonably practical to stop the water intrusion. It should be determined whether materials can remain on site or must be removed and replaced. Some materials such as absorbent ceiling tiles or fiberglass insulation cannot be effectively dried and should be immediately discarded and replaced. All incidents of wet materials should be documented as part of due diligence.

A moisture meter will detect hidden wetness and moisture under carpets and between interior and exterior walls. Both pin and pinless meters are readily available and can be used to compare wet and dry areas. Sometimes a carpet “feels” dry to the touch but the underpadding or floor is saturated. A wall may have a wet core or wet fibreglass insulation behind it. Materials such as drywall, carpet, wood, concrete, etc., have an established “equilibrium” moisture content that will not support mould growth.

Where water is introduced as part of a construction process (e.g., forming drywall curvatures), every reasonable effort should be made to dry out wet materials within 24 hours (48 hours maximum).

These guidelines apply to clean water intrusion incidents only. If the water source is contaminated with sewage, or chemical or biological pollutants, a qualified consultant or contractor should be contacted immediately for advice and/or assistance.

7.0 BUILDING OPERATION AND MAINTENANCE

In addition to the Handover and Acceptance Procedures, it is extremely important that the Manufacturer's Operational and Maintenance Procedures for the HVAC system (part of handover package to owner) are reviewed with the owner (for each occupancy) and documented as well. Proper humidity moisture control and good housekeeping within a building are critical to minimizing mould growth.

The HVAC system serves several functions, including providing required ventilation, maintaining desired temperatures, adjusting indoor humidity and establishing desired pressure relationships (air flows) within different portions of a building. The HVAC system components can become a source or disseminator of airborne contamination throughout the building. Figure A shows the general layout of a HVAC system.

Mould may also be introduced through improper positioning of outdoor air intakes. Upwind cooling towers, sanitary vents, and bird-nesting sites are possible growth sources for influx. Stagnant water, soil, plant and animal waste near or in an air intake can support the development of mould, which may subsequently enter a building. It is also important to monitor bird, bat, rodent and other animal infestations in the area, as animal droppings and waste materials harbour pathogenic species. The presence of a particular species depends on the geographic location of the building. For example, Cryptococcus neoformans and Histoplasma capsulatum are found in Ontario and Quebec.

Filters are traditionally used to protect the heating and cooling coil(s) within the HVAC system, and may become damp when an air intake is not adequately protected from rain or snow. Consequently, mould may grow on a damp filter or on the collected dust. The common filters in building HVAC systems will not remove all particles from the incoming air stream. These particles contain organic matter that can gather on surfaces within the HVAC system, and support mould growth in the presence of moisture.

The air supply is cooled and heated by coils (tubes and fins) within the air-handling unit. Debris and moisture collected on the coils can result in microbial growth and contamination of the HVAC system and occupied space. Condensation on the cooling coil and spray from the humidification system can wet system components such as mixing plenums, dampers, floors, fans, and supply ducts. Wet porous insulation and stagnant water can be especially problematic and must be remediated.

Moulds can grow in stagnant water that results when drain pans are not properly sloped toward an outlet or when a drain is blocked. The pressure differential between the inside and outside of a ventilation system may also affect drainage. The presence of a film or foam in standing water is a good indication of microbial growth or other contamination. However, some type of mechanical disturbance is required to create airborne contaminants from infested water.

Sumps for air washers and humidification devices that use recirculated cold water are easily contaminated by micro-organisms and consequently require regular cleaning and maintenance. Because these devices generate aerosols, they should always be considered a potential problem. Growth may also occur in a heat-exchange plenum if the surfaces are sufficiently cool to allow condensation. Although steam humidification systems are preferred over water spray systems, condensation and related microbial growth may still be problematic.

Supply air ducts and return plenums are often lined with glass fibre to reduce noise and minimize heat exchange with surrounding materials. Return air ceiling plenums and risers will also have accumulated dust and debris. Any surface within the air supply system can accumulate dirt, which, in the presence of adequate moisture, will promote mould growth. Moisture sources such as condensation on cold air supply ducts and pipes, and leaking drains and roofs must be remediated. Improperly operated and maintained fan-coils, induction units, and heat pumps above the ceiling or along the building perimeter can also be a source of moisture for mould growth.

In most office and institutional buildings, air exits from the occupied space by passing through a common return plenum or an open space above a suspended ceiling. The return air then goes through an air-handling unit for reconditioning. If not effectively filtered, mould contaminants produced in an occupied space may be circulated to other parts of the building. Pressurization, leakage, or backflow from a return or exhaust air system could re-aerosolize particulates and mould. Any water leak in the return air systems can result in mould contamination of the occupied space and HVAC system.

The decontamination of an HVAC system is often costly and time consuming. The key to avoiding remediation is proper system control. Table 1 presents some measures for reducing the risk of mould growth in key HVAC system components.

Figure A.
General HVAC System Layout

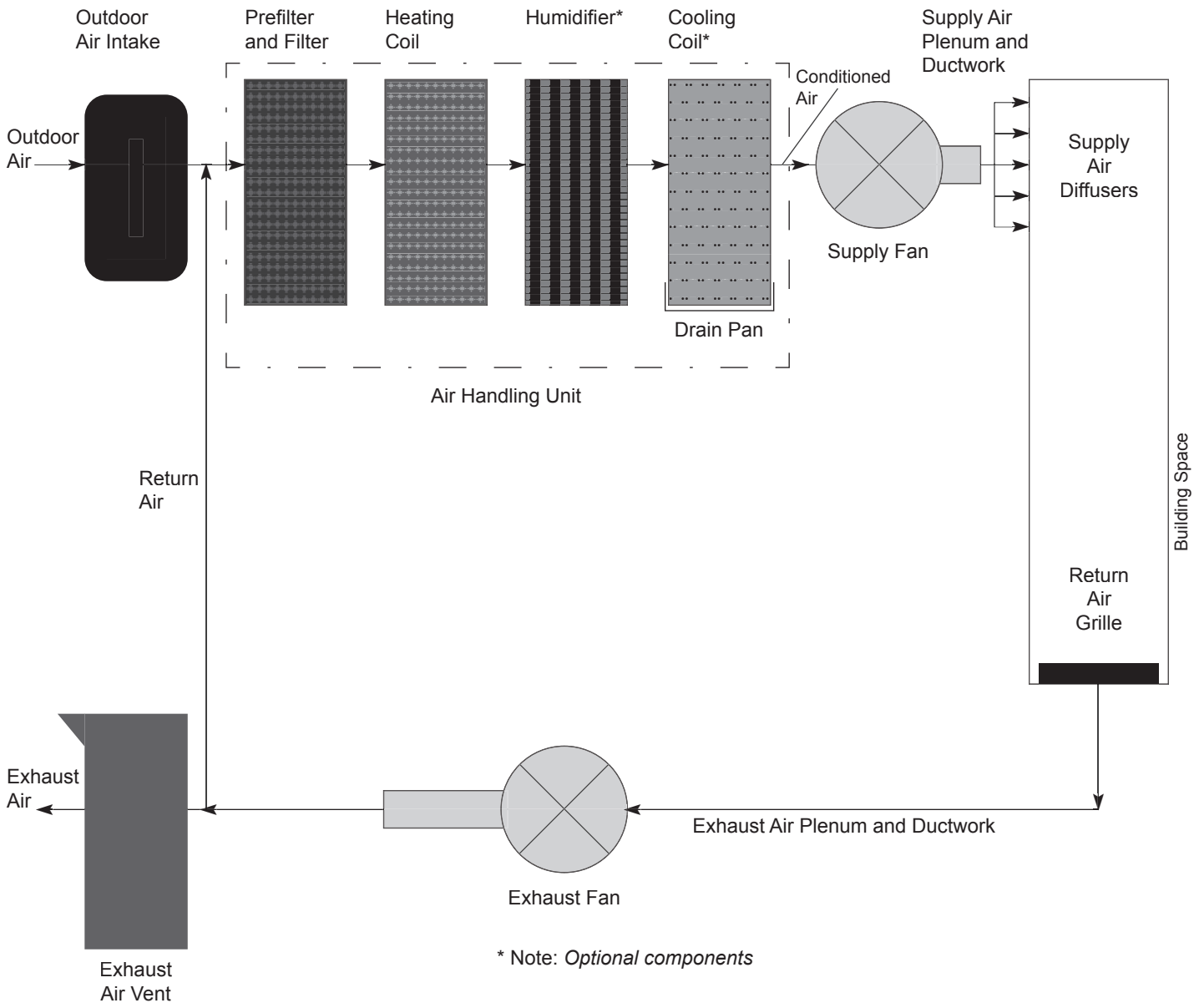


Table 1. Measures for Reducing Mould Growth in HVAC Systems.

COMPONENT		DISCIPLINE	MEASURE	
1	Outdoor Air Intakes	M	*	Maintain clean surfaces to prevent the accumulation of moisture or debris.
		M	*	Protect intakes and surrounding area from infestation of birds, bats, rodents, or other animals.
		M	*	Promptly remove all stagnant water, soil, plant, animal, and other debris from adjacent areas.
		D	*	Avoid positioning any intake down wind from possible mould sources (e.g., cooling towers, sanitary vents, building exhausts, large bird nesting or roosting sites).
2	Filters	D/M	*	Protect filters from direct wetting via rain, snow, water leaks or flooding to avoid microbial growth on the filter medium. Replace filters periodically so they perform to design specifications.
		D	*	Locate duct humidifiers at least 4.6 m (15 ft.) downstream of the final, high-efficiency filters.
		M	*	Promptly discard wet filters and insulation from HVAC air-handling and fan-coil units.
3	Condenser Units and Vicinity	D	*	Avoid the use of porous materials on airstream surfaces in persistently wet areas of HVAC systems.
		D/M	*	Design and operate cooling coils and spray humidifiers to minimize carryover of water droplets.
4	Drain Pans	D	*	Slope pans to drain completely (e.g., a drop of –0.2 cm for every 10 cm of pan length (0.25 in/ft.)). The slope should direct water toward a drainage point, preferably from the bottom of a pan. Do not insulate pan with porous materials.
		D	*	To allow water to drain properly, isolate the pressure difference between an air-handling unit under negative pressure relative to a mechanical room by installing a water trap in the drain line. The effect height of the water trap should be 40% greater than the expected peak static pressure of the supply air fan (i.e. 1.4 times the peak static pressure in centimeters or inches or water gauge).
		M	*	Keep drain pans clean to avoid extensive microbial growth. Physically remove growth that develops. Biocide treatment without removal of microbial growth is inadequate.
		M	*	HVAC components, subject to wet or damp conditions, should be inspected monthly and cleaned, if necessary.
5	Humidifiers	D/M	*	If steam is used, supply “clean steam.” Raw steam from a central boiler may be contaminated.
		A	*	Discourage the use of console humidifiers or vaporizers in the workplace because they must be fastidiously cleaned and disinfected to eliminate all growth.

COMPONENT		DISCIPLINE	MEASURE	
		A	*	Avoid water-spray humidifiers and air washers in non-industrial HVAC systems because they require frequent maintenance to prevent microbial growth.
		D/M	*	Avoid exposed insulation and air cleaners (e.g., filters) in HVAC plenums or ductwork downstream of humidifiers within the absorption distance recommended by manufactures to allow complete entrainment of humidifier moisture by the ventilation airstream.
6	Plenums and Ducts	D/M	*	The airstream surfaces of HVAC equipment and ductwork should resist the accumulation of dirt (or be readily cleanable or replaceable), moisture absorption or retention, and biodeterioration.
		M	*	Maintain all surfaces within the HVAC plenum to prevent the accumulation or moisture or debris.
		D/M	*	Surfaces in the vicinity of moisture-producing equipment should be smooth and non-absorbent. Keep porous insulation in these areas free of dirt and moisture or protect surfaces with a layer that is impermeable to water (e.g., sheet metal).
		A D/M	*	Check for obstructions or proper operation of HVAC system if areas are poorly ventilated.

Discipline Legend:
D = *Design*
M = *Maintenance*
A = *Administrative*

8.0 MOULD ASSESSMENT

Prior to tendering a construction project involving an existing building, an investigation should be conducted to assess and identify the areas or probable areas of mould growth within the building and HVAC system. Simple inspections can be performed by design professionals, building owners, or construction managers, while more complicated or extensive investigations should be performed by qualified environmental professionals. The extent of the review will depend on the circumstances of the project and building, but will most likely include the following:

- Collection of any available background information (e.g., history of water damage, sequence of renovations or operations, reports of odours or adverse health effects).
- Walkthrough evaluation of the project area and HVAC systems.
- Intrusive inspections into walls or other cavities to detect the presence of hidden mould growth, where information or observations suggest the possibility of mould.
- In some circumstances, collection and testing of air and/or surface samples may be useful to correlate the visual findings and to document current conditions.

8.1 Visual Inspection

A thorough inspection of the project areas and HVAC systems is the most important element of a mould assessment. See Appendix A for a checklist for visually determining the presence of mould in an existing building.

Investigators who may have prolonged exposure to elevated mould concentrations during their inspections and sampling should wear a suitable respirator (minimum of N95 half-facepiece). Disposable coveralls should be used for work in areas that pose a significant risk of contact with mouldy materials or other contaminants (e.g., investigations in a crawlspace or attic with extensive visible mould growth).

8.2 Intrusive Inspections

If the building inspection reveals no obvious mould growth, there may still be growth within the walls, ductwork, or at other hidden locations. Where risk factors for possible hidden mould growth are present (e.g., history of water damage or building envelope failure, surface staining, mouldy odours), an intrusive inspection is necessary to determine the full extent of contamination. Intrusive inspections may involve peeling back areas of baseboard or vinyl wallpaper, removing sections of carpet or ceiling tiles, cutting holes into wall or ceiling cavities, or inspecting HVAC systems, components, and ductwork.

Before performing an intrusive inspection, the investigator should consider and plan for the possible impact on those performing the inspection, and the other building occupants and elements. It is advisable to remove occupants during an intrusive inspection, if possible. The use of dust-controlled tools with exhaust ventilation to a high efficiency particulate air (HEPA) filtered vacuum are useful options in controlling the spread of contamination. An intrusive inspection should never be performed where building occupants are particularly susceptible to mould (e.g., infants, asthmatics, persons with environmental sensitivities and comprimized immune systems). In such cases, the inspection should be performed under isolated conditions and possibly within HEPA- filtered negative pressure enclosures. In addition, the investigators should be protected by disposable coveralls, and suitable respiratory protection. In occupied buildings, the affected area should be cleaned after inspection and holes sealed with tape or other suitable material.

8.3 Surface Testing

Mould growth can often be identified by raised, dusty deposits, often in rings or in a spotty leopard-like pattern. Where contamination is evident, it is seldom necessary to test mould-suspect materials. However, where mould growth is suspected and not visible, or where the presence and types of mould must be confirmed for health or legal reasons, then bulk, surface, or air samples should be obtained for laboratory analysis. The collection process should minimize the release and dispersal of any contaminant.

The most common surface samples are bulk or substrate samples, tape-lift samples, and swabs.

- Bulk or substrate samples are collected by cutting out a section of mould-suspect material. The sampling tool should be cleaned with a disinfectant wipe prior to obtaining each sample. The material is sealed in a sturdy zip-lock bag and transported to the laboratory.
- Tape-lift samples are useful where the investigator does not want to cut out the mould-suspect material. A piece of clear (not translucent) adhesive tape is pressed lightly against the mould-suspect surface and then stuck onto the surface of a piece of plastic (a clean zip-lock bag is suggested) or waxed paper, with the adhesive side to the bag surface. The adhered tape-lift sample is then placed in a clean zip-lock bag for transport to the laboratory.
- Swab samples are taken with medical-type swabs or sterile cotton swabs by rolling the swab head against the mould-suspect surface. The sample is returned to a clean container and transported to the laboratory.

It is best to consult the laboratory, prior to sampling, for advice on the best type of sample to collect to meet the specific requirements, and for details on sampling methods, handling, and transport.

8.4 Air Sampling

The collection and interpretation of fungal air samples should be performed by environmental or health and safety professionals experienced in fungal and indoor air quality investigations. Air sampling is not typically required in mould investigations, particularly if the extent of mould is readily determined by inspection. Air sampling may be useful in cases where hidden mould growth is suspected and the investigator would limit destructive testing, in cases where mould growth may be present in ventilation units, or for purposes of litigation. Air sampling can also provide information on exposure levels, although the interpretation is complicated by the limitations of short sampling periods, high variability in indoor concentrations, and a lack of standardization in sampling methods and equipment. Air sampling is sometimes performed after mould remediation is completed, to confirm that an acceptable condition has been met before the containment barriers are removed.

8.5 Laboratory Support and Sample Submission

Prior to mould sampling, it is important to identify a microbiology laboratory with experience and demonstrated performance in the identification of environmental mould. The laboratory can provide advice and references towards the development of the sampling strategy, including test methods, equipment and media, sampling time, transportation, and analysis and reporting period.

When selecting a laboratory, the Health and Safety Professional/Consultant who is experienced in performing microbial investigations shall ensure it meets the following criteria:

- The analytical staff should have training and experience in the identification of environmental mould and bacteria and should be able to identify mould to the species level.
- The laboratory should follow current best practices for environmental microbiology.
- The laboratory should be able to demonstrate successful participation in an external proficiency testing program, wherein the laboratory periodically analyses test samples.
- The laboratory should have a comprehensive quality assurance program and designated quality assurance officer.

The person submitting the samples must complete a chain of custody form to accompany all samples. A unique identifier is assigned to each sample and clearly marked on the sample's packaging. Where available, the laboratory's own form should be used. Ensure that all applicable fields are completed, including sample number, type of analysis requested, date of collection and the date by which results are required. The form should be signed and dated every time the sample changes hands.

The analysis of biocontaminants other than moulds [e.g., Legionella bacteria, (gram negative from water sources) hantavirus (from mouse droppings), etc.] requires specialized analyses that may be available from only a few laboratories.

9.0 MOULD REMEDIATION GUIDELINES

9.1 General

The following Mould Remediation Guidelines have been developed to assist the construction industry in the effective removal of mould growth while maintaining the safety of the workers performing the removal and the occupants of the affected building. In selecting the appropriate abatement measures, it is important to consider the extent and location of the mould growth, and any particular sensitivities of the occupants. These three factors are interdependent; therefore, they must be considered collectively when determining the appropriate abatement measures.

Two primary principles underscore mould remediation: universal precautions and controlled conditions.

Universal precautions assume that an exposure hazard exists, unless proven otherwise. Therefore the use of respiratory protection, gloves and eye protection is recommended. (Note: bird and bat droppings are pathogenic and require special precautions.)

Controlled conditions include isolation or containment of the affected area to prevent the dispersion of mould to other areas within the building and into the HVAC system.

The successful remediation of mould contamination includes the following:

- Identification and rectification of the underlying cause;
- Use of reputable and proven resources;
- Development or use of an established remediation methodology; that is, a "Standard Operating Procedure" that includes the use of personal protection, employee training, method of containment, repair, cleaning and disposal, equipment use and decontamination, and isolation of the air-handling system;
- Proper hygiene practices - working clean and safeguarding against the spread of dust and debris;
- Use of detergents and chemicals that are approved for the specified use;
- Establishment of criteria for documentation, task completion and quality assurance; and
- Selection of a "contact person" and development of a communication strategy.

Each remediation project has its own unique challenges that may require deviations from these guidelines. Changes to these guidelines should only be made by qualified personnel experienced in microbial investigations and remediation. Health Canada, Public Works and Government Services Canada (PWGSC), the U.S. Environmental Protection Agency (EPA), the American Industrial Hygiene Association (AIHA), and the American Conference of Governmental Industrial Hygienists (ACGIH), have published documents on this subject.

9.2 Remediation Levels

Remediation depends primarily on the scale, or size, of the mould growth. Mould growth is classified as small (Level l), medium (Level II), or large (Level III), with appropriate measures or procedures established for each level.

For building finishes and components (e.g., drywall, ceiling tile, carpet, etc.) the levels are as follows:

- Level 1 (Small Scale): Areas less than 1 square metre (10 square feet)*
- Level ll (Medium Scale): Areas between 1-10 square metres (10-100 square feet)*
- Level lll (Large Scale): Areas greater than 10 square metres (≥100 square feet)*

When determining the appropriate remediation level, it is important to consider both the total area affected (the perimeter of affected materials) and the density of the mould growth.

*These are arbitrary thresholds and are offered as guidelines only. Again, it is recommended that a qualified remediation specialist be consulted to determine the specific requirements of the project.

9.2.1 Remediation of HVAC Systems

- See Section 9.3

9.2.2 High-Risk Facilities

Mould remediation poses a greater potential risk in facilities such as hospitals, infant daycare centres, medical clinics, and chronic care facilities because of the high proportion of occupants with heightened sensitivities to mould. The remediation manager should consult with the facility operator regarding potential sensitivities to mould. Where sensitivities exist, Level II remediation measures should be used, and susceptible occupants should be kept well away from the perimeters of the remediation containment areas.

In health care facilities, Infection Control personnel should review, approve and monitor the mould remediation procedures. As a minimum, the requirements of the following Health Canada standard must be followed: "Construction-Related Nosocomial Infections in Patients in Healthcare Facilities – Decreasing the Risk of Aspergillus, Legionella and Other Infections," Canada Communicable Disease Report, Volume 2752, July 2001. The Health Canada standard can be accessed through the CCA Mould website at: www.cca-acc.com/mould.

9.2.3 Special Risks of Mould Linked to Contaminated Water

If mould growth is linked to water sources containing potentially high levels of harmful microorganisms (e.g., sewage, river floods), the remediation worker has the added risk of infectious disease. In such cases, specific restoration protocols must be followed and additional measures, including isolation, personal protection, and disinfection, are required. These projects require the assistance of a qualified restoration contractor or consultant. For more information, see "Remedial Procedures for Water Damage in Buildings," Public Works and Government Services Canada, 2001, which can be accessed through the CCA Mould website at www.cca-acc.com/mould.

9.2.4 Remediation of Small-Scale Mould Growth (Less than 1 m²)

Remediation may be performed by regular building maintenance staff; however, only properly trained workers should perform mould abatement. Workers should be well informed about the hazards of mould abatement, and their training should include the use of personal protection and proper clean-up methods. Eating, drinking or smoking is prohibited in the work area.

1. Occupants should not be present within the remediated area. The project authority (remediation supervisor) should consider whether occupants should be removed from the adjacent work areas. The determining factor is usually the presence of susceptible occupants, including, but not limited to, infants less than 12 months old, persons recovering from surgery, the elderly, and people with suppressed immune systems or chronic inflammatory lung diseases. Consultation with the facility operator is recommended.

2. Workers must be medically fit to work with potential mould exposure. Workers with a history of significant allergic disease (asthma, hay fever, hives, etc.) or other medical concerns should consult with an occupational physician to determine the health risks associated with mould removal and restoration activities. Mould abatement workers who risk infectious disease from unsanitary water sources (sewage, river floods, etc.) should consult with an occupational physician regarding appropriate immunization.

3. Workers performing Level I mould remediation shall wear a half-face piece air-purifying respirator fitted with replaceable filters (N95 minimum) or a filtering facepiece respirator (N95 minimum) and suitable eye

protection. The selection, fitting, maintenance, and monitoring of the respirator shall meet the requirements of CSA Standard Z94.4, as amended. Workers shall be fit-tested with the assigned respirator, prior to the initial use and yearly thereafter. The seal of the respirator to the wearer's face shall not be compromised by any facial hair. Filters shall be disposed of daily due to the potential growth of mould spores on damp filter media.

4. Workers shall wear disposable coveralls and dust-impermeable gloves appropriate to the work being performed, and water-impermeable gloves when applying detergent or disinfectant. Workers can wear disposable boot covers or they should clean their boots before leaving the remediation area. Refer to the Material Safety Data Sheet (MSDS) for the selection of appropriate detergents, disinfectants, and gloves.

5. Turn off HVAC systems and seal over all system openings (e.g., diffusers and return air openings) within or immediately adjacent to the work area.

6. Movable non-porous items within the work area shall be cleaned with a HEPA vacuum, followed by a suitable cleaning solution, and then removed from the work site. Fixed non-porous items within the work area shall be first cleaned by vacuuming and wet wiping, and then sealed under polyethylene sheeting, taped in place during remediation work.

7. Wherever possible, place a drop sheet below the mouldy materials to be removed.

8. Do not use compressed air mechanical devices to clean up or remove contamination.

9. Dust suppression methods should be used where possible, prior to disturbing mouldy materials. Tape a section of plastic sheeting or duct tape over the mouldy material, or, lightly mist the mouldy material with water. Do not dry sweep or dry whisk. Power tools fitted with dust collection bags will reduce airborne particulates.

10. Remove any porous substrate materials (ceiling tiles, drywall, etc.) well beyond the immediate areas of visible contamination; the minimum recommended distance is 30 cm in all directions.

11. After bulk removal, clean all exposed surfaces within the work area. Begin by cleaning with a HEPA vacuum and appropriate tools. Do not use any other type of vacuum. If a HEPA vacuum is not available, wet wiping is adequate for Level I work.

12. Remove all waste created by the remediation work, including, but not limited to, building debris, disposable coveralls, respirator cartridges, and plastic sheeting. Seal all waste into 6 mil nominal disposal bags. Wet wipe or clean the bags with a HEPA vacuum and finally double-bag in a second clean 6 mil nominal bag or suitable sealed container.

13. Clean all equipment used in the remediation work (e.g., vacuum cleaner, knives, saws) using a HEPA vacuum and by wet wiping. Equipment that cannot be readily cleaned (e.g. vacuum hose or wire brushes) shall be HEPA vacuumed and sealed in 6 mil polyethylene bags or suitable sealed container before removal from the work area.

14. Dispose of the waste material in compliance with local, provincial, and federal regulations.

15. Wash face and hands, and clean and maintain respirator after completion of mould abatement.

16. Leave all areas dry and visibly free from contamination and debris, and ensure that surfaces are adequately dry prior to installation of new materials.

9.2.5 Remediation of Medium-Scale Mould Growth (Areas between 1 m² – 10 m²)

Level II includes all items in Level I together with the following requirements:

1. A health and safety professional experienced in performing microbial investigations should be consulted prior to starting remediation to provide oversight and inspection of remediation activities.

2. A competent supervisor must be present during all decontamination work.

3. Workers shall wear full-body dust-impervious coveralls, with attached hoods, secured with tape at the ankles and wrists.

4. Isolate the work area with an enclosure constructed of fibre-reinforced polyethylene sheeting or 6 mil polyethylene sheeting, taped and supported as required. Provide a temporary roof where an existing ceiling does not complete the temporary enclosure. Use fibre-reinforced polyethylene sheeting for covering floors.

5. Provide a negative pressure within the enclosure by drawing air from the work area and exhausting it out of the enclosure, by using an exhaust fan (to outdoors), a HEPA vacuum or a HEPA air filtration device (negative air machine). Provide a minimum negative pressure of 5 Pascals (0.02 inches of water column). Where possible, discharge the filtered air outside the building and away from people.

6. Consider providing a change space at the entrance to the containment area, for workers to don / remove coveralls and for storage of clean supplies. Provide double-overlapping or slit and covering flaps at both ends of the change room, and ensure that the space is under negative pressure with respect to the occupied areas of the building, and under positive pressure with respect to the mould removal area.

   Appoint a competent person to inspect the work area for defects in the enclosure, barriers, and change room.

7. The project authority should document the abatement work in writing and maintain records in the project file, supported by inspection reports or other relevant documents.

9.2.6 Remediation of Large-Scale Mould Growth (Areas greater than 10 m²)

Level III mould abatement includes all Level II measures, as well as the following:

1. A health and safety professional (HSP) experienced in performing microbial investigations must be consulted prior to commencing remediation. The HSP must determine whether the following procedures are applicable to the specific remediation project, and identify any required changes. In addition, the HSP will provide periodic hands-on monitoring of all associated mould removal activities.

2. Workers shall wear a full-facepiece air purifying respirator fitted with P100 filters, or preferably, a tight-fitting positive-pressure full-facepiece Powered Air Purifying Respirator with high-efficiency particulate filters.

3. Workers shall wear impermeable gloves and full-body dust-impervious coveralls, with attached hoods, tightly secured with tape at the ankles and wrists.

4. Workers shall wear disposable boot covers or separate work boots that can be effectively cleaned with a HEPA vacuum or wiped clean prior to removal from the work area.

5. Isolate the work area from adjacent spaces using temporary hoarding, tape, and polyethylene sheeting, etc. Cover all walls that form part of the enclosure perimeter with one layer of polyethylene sheeting, taped in place. Where temporary walls form part of the enclosure perimeter, provide two separately sealed layers of polyethylene sheeting, one on each side of the temporary wall.

6. Provide a negative pressure within the enclosure, by using portable, HEPA-filtered exhaust fans (negative air machines). Provide a minimum negative pressure of 5 Pascals (0.02 inches of water column) and a minimum of four air changes per hour. Where possible, discharge the filtered air outside the building and away from people.

7. A competent person must regularly inspect the work area and record, in writing, any defects in the enclosure, barriers, and change room, at the beginning of every shift, at the end of every shift where no shift immediately follows, and at least once daily on days where there are no shifts. These inspections should be documented in writing.

8. Provide a Worker Decontamination Facility, to include a Clean Change Room and a Dirty Change Room. (see Figure B for a schematic layout of these rooms). Install flap doors at each opening into and within the Decontamination Facility. Provide a wash station consisting of, at a minimum, a basin, fresh water, soap, and toweling in the Clean Change Room. Consider providing a shower for worker comfort. Construct and arrange the worker decontamination rooms in such a way that everyone entering or leaving the work area must pass through each room of the decontamination unit.

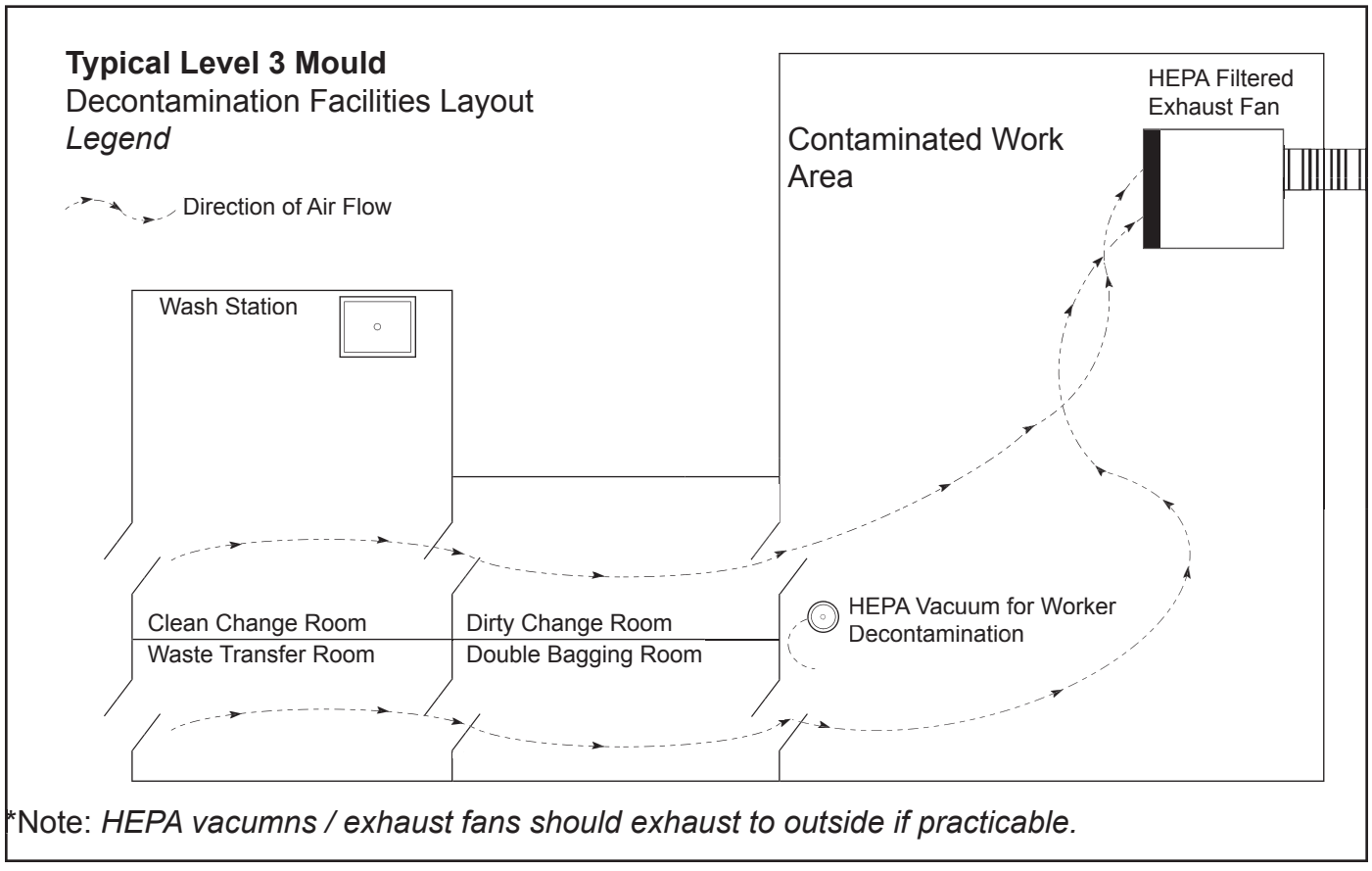
9. Before entering the contaminated work area, workers must first put on clean coveralls and a respirator in the Clean Change Room. When exiting, workers must use a HEPA vacuum in the work area to remove gross contamination from coveralls and boot covers (or separate work boots). Workers must then enter the Dirty Change Room and remove dirty coveralls and boot covers, the latter are to be used and then disposed of. Work boots used without boot covers must be removed and stored in the dirty change room. On leaving the work area, workers must then clean their face and hands in the wash station.

10. A separate Waste Decontamination Facility, consisting of a Double Bagging Room and a Waste Transfer Room, should be provided where large volumes of waste will be removed. Seal the waste into bags in the contaminated work area, and wipe the exterior of the bags or other suitable sealed containers. Transfer the bags to the Double Bagging Room and place in a second bag or sealed container. Transfer the double-bagged waste or container into the Waste Transfer Room for removal by workers entering from outside the decontamination facilities.

11. Upon completion of removal and cleaning, the Health and Safety Professional shall inspect the Level 3 work area for acceptable completion, through a combination of careful visual inspection, and possibly, testing. A site will be considered acceptable and clean when a thorough visual inspection shows that all the removal work has been completed and that all surfaces in the work area are free of any dust or debris. In addition, mould measurements (air samples, swabs, tape-lifts, or vacuumed dust samples) can be taken to demonstrate that the work area is no longer impacted by the mould contamination and removal process.

    Generally, air samples are collected from the work area and compared to samples taken in reference areas (areas adjacent to where the work area make-up air is being drawn, or outdoor locations). An acceptable condition is indicated when concentrations of airborne fungal particles in the work area are not significantly elevated when compared to concentrations in the reference samples, and the types of fungal particulate present in the work area do not differ significantly from those present in the reference samples. The samples may so be compared to any similar measurements taken in the work area prior to the remediation work Again, the sample results should be interpreted by a qualified professional.

Figure B.
Layout of Decontamination Facilities for
Level III Mould Remediation



9.3 Remediation of HVAC Systems

HVAC systems include central or main systems, rooftop and compartmental units, ventilators, heat pumps, induction, convection and fan-coil units (within the occupied space or ceiling), air supply ductwork, variable air volume (VAV) boxes, and the return air system. Internal HVAC system components that become contaminated with active mould growth, spores, associated contaminants or must be cleaned or replaced.

HVAC contamination can occur during various stages of the building life cycle:

- during building construction and system installation, where there is water intrusion/damage and wet interior components are not properly restored;
- through cross-contamination during remediation of other areas within the building where proper isolation and containment applications were not utilized;
- through improper system design, operation or maintenance practices; and
- by catastrophic events such as a flood, fire, or water leak.

Mould (and bacteria) can grow on any HVAC system component, porous or non-porous, that is continuously wet. The system design, operation, and maintenance must ensure that there are no areas of stagnant water or sustained wetness. Professional organizations such as ASHRAE and Public Works and Government Services Canada publish guidelines for avoiding moisture.

The underlying cause of microbial contamination must be rectified before remediation begins.

Contaminated system components, such as dampers, mixing plenums, enclosures, filters, cooling/heating coils, humidifiers, fans, insulation, grills and deflectors, etc., should be cleaned by an appropriate method such as HEPA-vacuuming, wet-wiping, pressure washing, or other mechanical means, using suitable cleaning equipment and products. The remediation process must not damage or degrade any components.

Damaged and non-functioning components discovered prior to remediation should be reported to the building owner/manager. Verify that there are no asbestos-containing materials that may become damaged during remediation or that may need to be replaced. If any additional or hidden contamination is found during remediation, the contractor must notify the manager in charge.

As in the remediation process within the building, Universal Precautions (assume an exposure hazard exists and use personal protection) and Controlled Conditions (isolate the affected area to contain the contamination) must be followed.

Prior to starting remediation, it is important to determine the extent and objective(s) of the work.

9.3.1 Small contamination areas, under 3 m²

The following procedures may be utilized in remediating small areas within the HVAC system:

- Remediation can be conducted by regular maintenance staff or contractors trained in proper removal and containment methods, personal protection, and potential health hazards. Personnel should also be familiar with Occupational Health and Safety regulations and policies.

- Respiratory protection (N95 disposable mask or better), gloves, and eye protection should be worn.
- The HVAC system should be shut down during remediation.
- Avoid the spread of dust and debris from the work site to non-contaminated adjacent areas. Isolate the zone, cover clean components, and protect motors, bearings, sensors, electrical components, etc.
- When cleaning air-handling units within an occupied space, seal the return grills. Use drop cloths to protect carpets and furnishings. Building occupants should be removed from the cleaning area. (Remediation is normally done during the evenings.)
- Clean filters inside the air-handling unit can be removed or protected before remediation. Contaminated porous materials must be discarded; and sealed in plastic bags or a suitable sealed container.
- When removing insulation, the underlying metal surface should be cleaned of debris and dust prior to installing new insulation. Closed-cell foam or metal-bonded insulation is preferable.
- Do not transport contaminated materials through occupied spaces. Where this is not feasible, the debris should be sealed in bags or containers in the work area, and then removed.
- Heavily contaminated or damaged components that are difficult to clean, such as coils, reservoirs and condensate pans, may need to be replaced.
- All tools and equipment used during decontamination must be cleaned prior to removal from the work site.
- After remediation, there should be no visible dust and debris in the HVAC system nor in the mechanical room.

9.3.2 Larger contamination areas (3 m² or more)

Larger contamination areas within the HVAC system or in the mechanical room may require the services of a professional restoration / remediation firm and should include, in addition to the above, the following measures:

- A qualified professional with experience in mould remediation and HVAC systems should be consulted to provide project management services. These services may include assessment of the problem, the development of a Scope of Work (Standard Operating Procedure), remediation management, oversight, quality assurance, and acceptance testing.
- Workers must wear a full-face respirator with HEPA cartridges or a powered air purifying respirator, disposable clothing with head and foot covering, gloves, and eye protection.
- Isolate the contaminated area and place under negative pressure. Restrict access and post hazardous materials warning signs at entry points. Provide air locks, a decontamination room, and washing and clean-up facilities.
- Negative air pressure greater than 5 Pascal (or 0.02 in. WC) should be maintained between the remediation area and the occupied workplace, and greater than 2 Pascal should be between the cleaning area and the adjacent mechanical space.
- All contaminated materials should be cleaned or removed in an established sequence following a controlled air flow path proceeding from clean to dirty areas.
- Insulation should be removed from air supply ducts with water-damaged contaminated porous internal insulation (usually unbonded fibreglass). Contaminated fibreboard ducts should also be discarded. Where feasible replace with external insulation.
- Dirty, contaminated flexible ducts should be replaced.
- Contaminated materials must be double-bagged or placed in sealed containers in the work area; the external surface must then be cleaned by hepa-vacuuming or by washing prior to transport through a clean workplace. Combustibles must be removed daily.

9.4 Conclusion

The objective of fungal remediation is not to disinfect or sterilize interior surfaces and components, but rather to restore surfaces to 'normal' conditions. For example, the presence of settled dusts containing spores from outdoor sources is not a problem, while the colonization by any fungus and the predominance of species that do not normally occur outdoors are indicators of unsuccessful cleaning or remediation.

If the occupied space is undergoing mould remediation, the dedicated HVAC system should be inspected and possibly cleaned after this remediation as part of a final commissioning process. While it is good practice to avoid cross-contamination of the HVAC system by sealing off the air return and isolating the remediation zone, it is prudent to verify that both the remediated area and the air supply system are clean before the space is occupied.

The primary response to fungal contamination in buildings must be prompt remediation of contaminated material and infrastructure repair. The simplest and most expedient remediation methods that properly and safely remove fungal growth from buildings should be used. In all situations, the underlying cause of water accumulation must be rectified or the fungal growth will recur. The focus should be on preventing contamination, through proper building construction practices, maintenance, and prompt repair of water-damaged areas.

10.0 COMMUNICATION

If not properly planned, implemented, monitored, and documented, communicating the potential hazards of fungal contamination can become a contentious issue.

When Level 2 or 3 remediation is required, there should be a meeting of the major stakeholders, which may include the building owner's representative(s), the general contractor's representative(s) and the remediation contractor's representative(s). This meeting should establish what is to be communicated and to whom, a timetable for implementation, a monitoring and feedback plan, follow-up meetings, and a completion report, all of which are to be documented, circulated to affected stakeholders, and maintained as part of the project file.

External comunication to tenants should include a description of remedial measures to be undertaken and a timetable for their completion. The following outlines the responsibilities of the various stakeholders, with regard to building occupants, construction workers, public notification, security, meetings / documentation, joint Health and Safety committees, and regulatory compliance.

Building Occupants

The owner is responsible for advising the building occupants of the reasonable risks of microbial exposure and remediation activities, and for notifying individuals with persistent health problems associated with bioaerosol exposures to seek medical advice.

Construction Workers

Contractors are responsible for notifying workers of the remediation activities, the precautions that should be taken, and the personal protection equipment requirements. Contractors must also advise workers of remediation work areas, routes of travel, location of restricted areas, and observance of posted warning signs.

Public Notification
Building owners are responsible for posting warning signs at strategic locations to inform the public of remediation activities and necessary restrictions. Through contractual arrangements with the contractor(s), the owner may assign responsibility for public notification to the contractor.

Security
Building owners are responsible for security in the remediation work areas - it is particularly important that no unauthorized personnel enter the remediation areas after work hours. Again, this responsibility can be assigned to the contractor(s) through contractual arrangements.

Meetings / Documentation
Building owners and contractors are jointly responsible for scheduling and attending Communication meetings, documenting all action and completed items, and circulating the minutes of these meetings to the appropriate stakeholders.

Joint Health and Safety Committees
Each stakeholder is responsible for notifying their workplace Joint Health and Safety Committee (if this is a jurisdictional requirement) of remediation activities and for submitting the applicable report of findings and procedures.

Regulatory Compliance
Communicating the potential hazards of fungal remediation is a requirement of federal / provincial Health and Safety Acts and Regulations.

11.0 DECOMMISSIONING / DEMOLITION CONSIDERATIONS

Prior to the decommissioning or demolition of a building, an environmental site assessment or audit is required to establish the presence of hazardous materials, such as lead (e.g., in paint), asbestos, PCBs, and other materials that require unique handling and disposal procedures. Currently, mould-contaminated materials are not classified as hazardous waste. However, certain precautions should apply to the handling, disposal, recycling, and transportation of mouldy materials.

Two principles underlie these precautions - the need for worker protection and the avoidance of cross-contamination to neighbouring spaces.

The demolition contractor should inspect the site for visible mould contamination and signs of hidden mould contamination. The latter includes musty odours, visible water damage or dampness, a history of water damage, roof, window, or building envelope failures, and years of non-occupancy, vandalism, and neglect.

When workers enter a mould-contaminated building to disconnect services, prepare the facility for demolition, or to salvage items, industrial hygiene practices similar to Level III remediation measures, specifically respiratory, eye, and clothing protection, must be followed. During this process and during demolition, it is important to follow work and dust control procedures that eliminate or reduce dust generation.

During demolition, it is advisable to first remove contaminated materials whenever possible. Mouldy materials should be double bagged or placed in a closed container on site. To reduce airborne dust, carefully mist or wet dust the debris before removing by broom and shovel, or use a HEPA-filtered vacuum. Truck-mounted vacuum systems can be used to remove large amounts of contamination. Mist or wet walls prior to cutting and removing them. It is also a good practice to use power equipment with exhaust filters.

Small items can be double bagged for disposal in a waste container, while larger items can be placed directly in closed drums or hoppers. Transportation of these items to an outdoor container, dumpster, or vehicle, should again minimize the possibility of cross-contamination. The containers should also be covered and secured to avoid exposure to the elements (rain and wind) and scavengers. A delay in removing debris will increase the risk of microbial growth and exposure.

Expert advice should be sought regarding the removal of contaminated materials prior to demolition, taking into consideration the size of the building and effectiveness of dust suppression techniques, the quantity and location of the contaminated materials, the structural integrity and soundness of the building, weather conditions, and the proximity to other buildings, building type and population (exposure risk factors).

The application of biocides and other disinfectants to treat contaminated materials before removal is not recommended. These chemicals are not totally effective and may have adverse health risks. Formaldehyde saturation has proven effective in treating soil contaminated with bird or bat droppings; however, it is advisable to seek expert advice. Lead-contaminated soil is considered hazardous and is costly to remediate and dispose of.

Dust containing contamination and potentially hazardous substances can be aerosolized during construction, excavation, or demolition. However, it is important to be aware that air currents can easily carry spores over long distances; therefore, not only are people at the work site at risk, but others can also be infected. Contaminants entering the ventilation system intakes of adjacent buildings (possibly “high risk” facilities such as schools, retirement homes and health care facilities) can cause a serious outbreak of disease.

During windy periods, demolition, removal or disposal of contaminated or dusty materials outdoors should be stopped. The cabs of earthmoving equipment and trucks should be equipped with air conditioning and the filters on these units should be maintained and replaced using respiratory protection. Trucks carrying contaminated soil or debris must be covered and should pass through a wash station before leaving the site. At the dumpsite, the driver should ensure that everyone is safely away from the area where the truck is emptied so they will not be exposed to aerosolized dust.

Educating and training contractors and workers in good work practices will minimize both the risk of exposure and cross-contamination during demolition and handling of mouldy materials. Companies should develop written internal Standard Operating Procedures that mirror the established regulations, standards and guidelines developed by governments and recognized, professional authorities.

12.0 DISPOSAL OF MOULDY MATERIALS

Mouldy construction materials may be disposed of as regular garbage in approved landfills, with no special considerations generally required. However, federal, provincial, and local regulations must be followed. Debris and waste should be stored in a secure location and transported in a closed container to minimize the possibility of cross-contamination or exposure. Where local legislation requires recycling of materials, mouldy construction materials debris, especially porous materials such as carpets, textiles, insulation, and drywall, should not be included.

Non-porous materials such as metal, glass, stone, and plastics, and some semi-porous materials such as wood beams and framing, brick and concrete, can be recycled or salvaged for re-use. A professional restoration specialist should be consulted to determine the appropriate cleaning methods and precautions to prevent the spread of contamination. Cleaning methods include vacumning, abrasion, and the use of liquids.

13.0 GUIDELINES FOR SELECTING MOULD REMEDIATION CONTRACTORS

13.1 General

The method(s) used to remediate mould growth depends on the cause and extent of the growth, and often a variety of techniques and cleaning procedures are required to control the situation and minimize health risks due to exposure and the spread of contaminants. The materials subject to mould remediation also vary and include porous materials (e.g., furniture, carpet, etc.), structural elements (e.g. tile, insulation, etc.), and HVAC system components (e.g., air handling units, ducts, etc.). There is no one single Canadian body that provides training in mould remediation nor is there a definitive list of selection criteria for choosing a remediation contractor. The following section provides some guidelines for choosing a mould remediation contractor. However, these are general guidelines only. There are unique situations that require special consideration, and these are beyond the scope of the guidelines presented here.

13.2 Approved Remediation Plan

The mould remediation contractor must have a written remediation plan approved by a qualified professional. The plan should include the scope of work to be completed, and must define the objectives of the remediation, the areas and components to be remediated, the procedures to be followed, the chemicals, and waste disposal methods to be used, and the criteria which will determine whether remediation has been successfully completed. The remediation plan should also include a work schedule outlining the sequence of events and the documentation and inspection procedures. Environmental control requirements must be clearly stated, including containment, airflow, humidity and ventilation control strategies. The remediation plan must specify the remedy of the underlying cause of the mould growth, and verification cleaning and testing protocols for quality assurance. Finally, there should be procedures for modifying the remediation plan (change orders) and for reporting additional contamination.

13.3 Continual Training Requirements

The goal of mould remediation is to remove or clean contaminated materials and building components using proper work practices and isolation techniques so that no one's health is compromised and the contaminants are contained. Unfortunately, there is no single body that provides mould remediation certification. However, the practitioner should be familiar with current public and occupational health requirements, as well as the proper techniques for restoring materials, structural elements, and HVAC system components. Practitioners who continually upgrade their skills, maintain membership in relevant industry associations, and can provide solid references for work on similar projects, will most likely have the skills and knowledge required for mould remediation work.

APPENDIX A
Checklist for Visually Determining the Presence of Mould in an Existing Building

1. Occupied Space

Number of floors: _____

General Uses: _____

Problematic? Yes ❑ No ❑ N/A ❑

Use of attic, if applicable: _____

Dirty, malodours, signs of animals/birds/insects, growth sign, water marks? Yes ❑ No ❑ N/A ❑

Use of basement or crawlspace, if applicable: _____

Dirty, malodours, animal/bird/insect indication, growth sign, water marks? Yes ❑ No ❑ N/A ❑

Presence of water features (e.g. fountains, sprays, indoor waterfalls, etc.): _____

Sign of abnormal water movement? Yes ❑ No ❑ N/A ❑

Malodours? Yes ❑ No ❑ N/A ❑

Location(s): _____

Visible microbial growth? Yes ❑ No ❑ N/A ❑

Location(s): _____

History of water damage? Yes ❑ No ❑ N/A ❑

Location(s): _____

Evidence of water damage (stained or discoloured ciling tiles, walls, floors, carpeting etc.)? Yes ❑ No ❑ N/A ❑

Location(s): _____

Condensation or mildew on walls and windows? Yes ❑ No ❑ N/A ❑

Location(s): _____

Foul* window air conditioners? Yes ❑ No ❑ N/A ❑

Location(s): _____

Foul evaporative air coolers? Yes ❑ No ❑ N/A ❑

Foul sump pump? Yes ❑ No ❑ N/A ❑

Foul fan coil and induction units? Yes ❑ No ❑ N/A ❑

Potted plants with visible microbial growth? Yes ❑ No ❑ N/A ❑

Portable air cleaners for odour control? Yes ❑ No ❑ N/A ❑

Location(s): _____

Foul console humidifiers? Yes ❑ No ❑ N/A ❑

Location(s): _____

Console dehumidifiers? Yes ❑ No ❑ N/A ❑

Location(s): _____

Typical RH greater than 60%? Yes ❑ No ❑ N/A ❑

2. Heating, Ventilation, and Air-Conditioning System

A. General Characteristics

Type of ventilation system: _____

Location of air-handling units: _____

Cooling method: _____

Heating method: _____

Locations served by individual air handlers: _____

B. Outdoor Air Intake (OAI)

Location(s): _____

Compromised bird screen?	Yes ❑	No ❑	N/A ❑
Feathers or bird droppings near or in air intake?	Yes ❑	No ❑	N/A ❑
Other organic matter near or in air intake (e.g., leaves, plant down, insects)?	Yes ❑	No ❑	N/A ❑
Air intake unprotected from rain, snow, fog?	Yes ❑	No ❑	N/A ❑
Standing water or evidence or standing water near or in air intake?	Yes ❑	No ❑	N/A ❑
Cooling tower within 7.5 m (25 ft.)?	Yes ❑	No ❑	N/A ❑
Exhaust air outlet within 7.5 m (25 ft.)?	Yes ❑	No ❑	N/A ❑

C. Filters

Filter with organic debris and sign of microbial growth?	Yes ❑	No ❑	N/A ❑

D. Mixing Chamber of Air-Handling Unit

Mixing area dirty, with debris and sign of microbial growth?	Yes ❑	No ❑	N/A ❑
Malodours?	Yes ❑	No ❑	N/A ❑
Evidence of water damage or intrusion?	Yes ❑	No ❑	N/A ❑

E. Heating and Cooling Coil Area

Coils with organic material and sign of microbial growth?	Yes ❑	No ❑	N/A ❑
Foul condensate pan and drain (i.e., standing water, biofilm, or residue)?	Yes ❑	No ❑	N/A ❑
Corrosion on pan?	Yes ❑	No ❑	N/A ❑
Malodours?	Yes ❑	No ❑	N/A ❑
Evidence or water transport from coil area to other areas?	Yes ❑	No ❑	N/A ❑

F. Stray Humidifiers, Evaporative Coolers or Air Washers

Type of unit: _____

Chemicals or additives used: _____

Maintenance schedule: _____

Type of medium, if any: _____

Microbiological growth found in previous water sample?	Yes ❑	No ❑	N/A ❑

If yes, details: _____

Recirculated water used with foul indiation?	Yes ❑	No ❑	N/A ❑
Biofilm, dirt or microbial growth in sump area?	Yes ❑	No ❑	N/A ❑
Malodours?	Yes ❑	No ❑	N/A ❑
Water leakage from humidifier into duct system?	Yes ❑	No ❑	N/A ❑
Water pooled near unit?	Yes ❑	No ❑	N/A ❑
Unit enters airspace directly (or ducted to other areas) with sign of unusual water movement?	Yes ❑	No ❑	N/A ❑

G. Supply Side or Air-Handling Unit

Where do ducts enter building (e.g., ceilings, below floor):_____

Type of supply ducts (lined or unlined):_____

Supply area with debris and sign of microbial growth?	Yes ❑	No ❑	N/A ❑
Malodours?	Yes ❑	No ❑	N/A ❑
Evidene of water damage or intrusion?	Yes ❑	No ❑	N/A ❑

H. Return Side of Air-Handling Unit

Type of return (ducted or plenum):_____

Porous lining on ducts or plenums with foul indication?	Yes ❑	No ❑	N/A ❑
Return area with debris and sign of microbial growth?	Yes ❑	No ❑	N/A ❑
Malodours?	Yes ❑	No ❑	N/A ❑
Evidence of water damage or intrusion?	Yes ❑	No ❑	N/A ❑

3. Plumbing Fixtures/Piping/Accessories

Evidence of water leakage from:

Bathtubs?	Yes ❑	No ❑	N/A ❑
Urinals?	Yes ❑	No ❑	N/A ❑
Showers?	Yes ❑	No ❑	N/A ❑
Toilets?	Yes ❑	No ❑	N/A ❑
Basins?	Yes ❑	No ❑	N/A ❑
Sinks?	Yes ❑	No ❑	N/A ❑
Laundry tubs?	Yes ❑	No ❑	N/A ❑
Washing facilities?	Yes ❑	No ❑	N/A ❑
Gang hand-wash stations?	Yes ❑	No ❑	N/A ❑
Fire suppression systems?	Yes ❑	No ❑	N/A ❑
Piping (supply/drainage)?	Yes ❑	No ❑	N/A ❑
Roof vents?	Yes ❑	No ❑	N/A ❑
Grease interceptor traps?	Yes ❑	No ❑	N/A ❑
Ice-making machines?	Yes ❑	No ❑	N/A ❑
Floor drain back-ups?	Yes ❑	No ❑	N/A ❑

Vacuum breakers?	Yes ❑	No ❑	N/A ❑
Relief valves?	Yes ❑	No ❑	N/A ❑
Blowdown valves?	Yes ❑	No ❑	N/A ❑
Building envelope penetration?	Yes ❑	No ❑	N/A ❑
Valve stems?	Yes ❑	No ❑	N/A ❑

4. Refuse Areas

Check for microbial growth in:

Garbage cans?	Yes ❑	No ❑	N/A ❑
Garbage bins?	Yes ❑	No ❑	N/A ❑
Garbage storage rooms?	Yes ❑	No ❑	N/A ❑
Garbage chutes?	Yes ❑	No ❑	N/A ❑
Recycle bins?	Yes ❑	No ❑	N/A ❑

***Foul :** *Refers to Unusual Appearance and/or Odour*

NOTE:

A "Yes" response indicates a potential problem, and requires effective remedial action.

APPENDIX B
Mould Remediation Resources

* American Society of Heating, Refrigerating and Air Conditioning Engineers Inc., (ASHRAE)
  - Atlanta, Georgia (www.ashrae.org)
  - Standards and handbooks for system design, operation and maintenance. Ventilation and thermal comfort standards.

* Canada Mortgage and Housing Corporation (CMHC)
  - Ottawa, Ontario (www.cmhc.schl.gc.ca)
  - Procedures and guides for inspection, repair, maintenance, mould cleanup, and rehabilitation of homes.

* Health Canada
  - Ottawa, Ontario (www.hc-sc.gc.ca)
  - Occupational health and safety, indoor air quality and microbial assessment and remediation guidelines.

* Institute of Inspection, Cleaning and Restoration Certification (IICRC)
  - Vancouver, Washington (www.iicrc.org)
  - Standards for inspection, cleaning and water damage restoration

* National Air Duct Cleaners Association (NADCA)
  - Washington, DC (www.nadca.com)
  - Standards and specifications for assessment, cleaning and restoration of HVAC system

* North American Insulation Manufacturers Association (NAIMA)
  - Alexandria, Virginia (www.naima.org)
  - Practice codes for dealing with cleaning, moisture in building insulation and air transmission systems

* Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
  - Chantilly, Virginia (www.smacna.org)
  - Practice codes and construction standards for building and HVAC system works
  - Guidelines for indoor air quality of occupied buildings under construction, duct cleanliness for new construction

* Public Works and Government Services Canada (PWGSC)
  - Ottawa, Ontario K1A 0S5 (http://source.tpsgc.gc.ca/rps/aes/es/content/wwa_units_iaq_pub-e.html)
  - Building design, operation and maintenance guidelines, IAQ assessment strategy, flood restoration and mould avoidance and remediation practices

* U.S. Environmental Protection Agency (EPA)
  - Washington, DC (www.epa.gov/iaq)
  - IAQ and mould guidelines for homes, buildings and schools