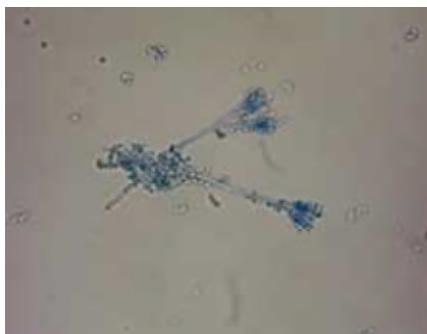


Mould Outbreak – An Immediate Response



Conidia and conidiophores of a *Penicillium* species

Introduction

The following information outlines a general course of action to deal with a mould infestation in a heritage collection – be it an archive, library, museum, or gallery. It is intended as a guide to help with immediate decisions and first steps to control the infestation and to protect people and the collection. The information is appropriate for small (<0.3 m² of visible mould growth) to medium-sized (0.3–3 m² of visible mould growth) outbreaks of mould. However, if the mould growth is large (3–10 m² of visible mould growth) or extensive (>10 m² of visible mould growth), or toxic mould is suspected or known to be present, additional measures and outside expertise will be required.

The information presented here is based on [Mould Prevention and Collection Recovery: Guidelines for Heritage Collections](#) (Technical Bulletin N^o 26). Although directed to heritage collections, this information is also appropriate for use by the general public.

The First Steps

Protect staff

Take preventive measures to protect staff working in the facility. [Information on appropriate personal protective equipment (PPE) is provided below.] People with allergies or those with asthma should not be in contact with affected material or where the mould infestation is located.

Isolate artifacts

It is important to isolate the mould contamination. If only one or a few artifacts are contaminated, isolate them. If many artifacts are involved, isolate the entire collection area. This will prevent mould spores from dispersing into clean areas of a collection and the rest of the building. Artifacts can be isolated by placing them in a sealed box or bag. If large, they can be wrapped in plastic sheeting. If

the artifacts are wet or damp, this should be a temporary measure until they can be dried. If the artifacts are dry, they can stay in containers or wrapped in plastic until they are cleaned of visible mould growth. If the collection area must be isolated, seal the entrance and return air intake vents with tape and heavy gauge plastic/polyethylene sheeting. This will prevent mould spores entering clean areas of a building.



Covering books and shelves to prevent the spread of spores

Isolate and control access to affected artifacts or contaminated areas to reduce exposing people to mould. People entering the isolated area or opening sealed objects should always wear the appropriate PPE.

Determine the extent of the mould infestation, consider the available resources, and determine whether the infestation can be handled in-house or outside help is required.

Identify and eliminate the causative agent

Determine the cause of the mould outbreak and take immediate action to correct it. This may include measures to lower the relative humidity, to increase air circulation, to lower room temperature, and to remove any standing water. If necessary, employ a company that specializes in desiccant drying to dry the affected facilities and furnishings, such as carpets and drapes.

Deactivate the mould

The mould is actively growing if it feels damp and smears when brushed or if a mouldy smell is present. Deactivating the mould will stop its growth and prevent further damage to the artifacts. This can be done either by air drying or by freezing, as discussed below. Once the artifact is dry, mould can be removed. Keep the dry artifact isolated and in a sealed container until it can be cleaned. This will prevent any inactive, but still viable, spores from dispersing.

Air drying

Artifacts can be air dried by lowering the relative humidity and increasing air circulation. Because the mould spores of most species are easily airborne, it is important to conduct air drying in a way that

does not disperse mould spores and to take measures to prevent the spores from dispersing throughout the building. Seal the return air vent and, if possible, open windows to vent air outdoors. Select an isolated room, with a minimum of furniture, that is easy to clean afterwards. Allow artifacts to air dry naturally or use fans. If using fans, place them so the airflow is directed away from the artifacts. This will limit spore dispersal and keep the drying process slow enough to reduce physical distortions, such as fine checks or cracks that can result from an abrupt decrease in the object's moisture content. Objects made of a thick layer of organic material, or objects that are composed of different elements (such as inlays or veneers) joined together, are the most likely to undergo high physical stresses leading to damage during air drying.

If air drying indoors cannot be accomplished without dispersing mould spores, it is preferable to either freeze the material, air dry a few at a time in a fume hood, or dry the material outdoors. Air drying outdoors should be done on a clear day, in a sheltered spot out of direct sunlight. Be sure to keep the objects away from people and building air-intake systems, and bring them in at night.

Freezing

Freezing is a quick method of killing actively growing mould. However, although a mould's vegetative growth will freeze and break down, the spores are able to withstand the cold temperatures and remain viable.

Freezing is a good option when there are numerous water-damaged or mouldy objects as this method eliminates the urgency to safely dry all wet artifacts within a short time frame. But freezing is not appropriate for all artifacts. In general, it is safe for textiles, furs, feathers, leather, paper, and wood. However, it is not recommended for glass plate negatives, oil paintings, or acrylic paintings. If in doubt, check with a conservator first. Before freezing, seal the object in a clear polyethylene bag or wrap with polyethylene film and seal with tape.

Household horizontal chest freezers, which generally operate between -18°C and -28°C , can be used for a small number of objects. Freezing on a large scale requires a larger freezer. Large walk-in freezers can be rented. Freezer trucks can also be rented and brought to a site. The labour-intensive drying process can then be postponed until the staff is fully organized and has secured the space, time, resources, and people to deal with the artifacts.

Should the Mould be Identified?

In general, identifying mould is not required in order to respond to an outbreak in a heritage collection, to remove visible mould from heritage material, or to treat artifacts damaged by mould. Identifying mould is done for specific reasons, e.g. if there is a health hazard concern or if some staff have health problems.

Health Effects

Mould is ubiquitous. Normal background concentrations of mould do not usually affect healthy individuals. In contaminated environments, however, the risk of health effects from exposure to mould increases. Reactions are varied and depend on the nature of the species involved, the metabolic products produced by these species, the amount and duration of exposure to mould and mould products, and the susceptibility of the individual. As well, people with asthma or respiratory problems, those suffering from allergies or an allergy to mould, those with compromised immune systems, and anyone taking steroids may be affected.

Generally, health effects fall into the following categories: irritation, allergy, toxicity, and infection (Ammann 2003). Symptoms that result from exposure to abnormal levels of indoor moulds, including toxigenic moulds, may include the following (Johanning and Landsbergis 1999):

- nasal irritation, burning, itchiness, stuffiness and congestion, bloody nasal discharge, throat irritation and soreness
- cough, shortness of breath, wheezing, chest congestion and tightness
- severe headaches, concentration problems, irritability, dizziness or lightheadedness, fatigue
- burning, irritated, blurry vision
- burning rash on skin
- low-grade fever, flu-like symptoms

People experiencing any of the above symptoms that may be related to exposure to abnormal levels of indoor moulds should consult their physician.

Personal Protective Equipment (PPE)

Mould is a serious health concern, so every effort should be made to limit human exposure to it. PPE that should be worn when handling mouldy artifacts or when working in mould-contaminated areas is described below. There is no conclusive research that specifies a level of personal protection that is appropriate at a certain number of square metres of contamination (Environmental Protection Agency 2001). If in doubt regarding the appropriate level of PPE, consult health and safety experts.

Respiratory protection

For mould infestations in heritage collections, particulate filters from the N series (N for not resistant to oil) are generally appropriate. Filters described as N100 offer the greatest protection against particulate matter. These filters are also referred to as HEPA (high-efficiency particulate air) filters.

Some fungi produce volatile organic compounds that cause unpleasant odours, including the characteristic mouldy smell associated with damp areas or materials. The health effects of exposure to microbial volatile organic compounds (MVOCs) have not been well-studied. They may be responsible for headache, dizziness, and eye and mucous membrane irritation (Levetin 1995). When a mould smell is present, a filter that combines HEPA and organic vapour cartridges is

recommended. Some particulate disposable respirators incorporate nuisance-level organic vapour relief and may be appropriate for some circumstances. Half-face and full-face respirators and some powered air purification respiratory systems (PAPRs) can be fitted with combination HEPA and organic vapour cartridges that protect against MVOCs.

Respirators, including disposable respirators, should be test fitted by a qualified individual to ensure a proper fit. Respirators should always be stored in a clean area or in a bag to avoid buildup of particulate matter on the respirator. At the end of each day of use, respirators should be cleaned according to the manufacturer's instructions. Used respirator filters will support mould growth. To prevent this, allow the respirator (and filters) to air out before storing them in a sealed bag.

Disposable particulate respirators

Disposable respirators are inexpensive and maintenance free, but proper use requires carefully reading and closely following the manufacturer's instructions. In order to get a good fit from a disposable respirator, follow the instructions on the package. Disposable respirators are not appropriate for every individual. If improper facial contact is made with the respirator, it may actually increase the concentration of mould spores being inhaled. These devices, therefore, are not appropriate for people with facial hair. If a disposable respirator is used more than once, be sure to air it out after use and store it in a clean environment. Stuff the inside of the respirator with clean tissue to ensure it remains clean. If the respirator becomes damaged, soiled, or breathing becomes difficult, discard it.



Conservator is wearing an N100 disposable particulate respirator, lab coat, and gloves while conducting a survey of a potentially mould-infested collection

Half-face respirators

A half-face respirator consists of an assembled face piece worn over the mouth and nose. Cartridges selected to protect against a hazardous environment are attached to the face piece. Particulate and combination cartridges are available. Half-face respirators are more expensive than disposable respirators, but are re-usable because the cartridges can be replaced. Half-face respirators are available in different shapes, styles, and sizes. They are not appropriate for people with facial hair.

Full-face respirators

A full-face respirator consists of an assembled face piece worn over the mouth, nose, and eyes. Cartridges selected to protect against a hazardous environment are attached to the face piece. Particulate and combination cartridges are available. Full-face respirators can be re-used by replacing the cartridges as required. Full-face respirators are available in different materials, styles, and sizes. They are not appropriate for people with facial hair.

It is not necessary to wear protective goggles with a full-face respirator, but the seal of the respirator may be compromised if the person wears prescription eyeglasses. It may be necessary to consult with a reputable technical consultant of respiratory equipment to select the most appropriate full-face respirator. Full-face respirators or PAPRs are recommended when dealing with extensive mould growth.

Powered air purification respiratory systems (PAPRs)

PAPRs are positive-pressure airflow respirators that deliver a steady supply of filtered air. Filtered air passes through the breathing tube and into the headpiece. PAPRs protect individuals with facial hair and do not require test fitting.

Goggles

Protective goggles must also be worn when dealing with mould. The appropriate, recommended goggles are not ventilated and must accommodate a disposable or half-face respirator. If the user wears prescription eyeglasses, tight-fitting yet comfortable goggles may be difficult to locate. In this case, full-face respirators or PAPRs may be an option.

Gloves

Protective gloves should be worn when handling mouldy material. Due to concerns about latex allergies, vinyl (PVC) or Nitrile gloves are recommended. Disposable gloves should be replaced as required. Torn gloves should be replaced immediately. Hands should be washed with soap and water after handling contaminated material, even when gloves have been worn.

Protective clothing

When dealing with mouldy material, protective clothing must be available for all personnel and it must be properly worn and fastened. Coveralls and protective hair and shoe covers should be used when significant amounts of mould spores might be released into the air. Disposable clothing is recommended, but re-useable protective clothing (lab coats or coveralls) may be appropriate for small and medium-sized levels of contamination. Protective clothing must not be worn outside the contaminated area. It should be removed on-site and washed in hot water and bleach.

Discarded disposable PPE

There are no special requirements for discarding contaminated PPE. However, it is important to exercise caution when handling and discarding these items. Place disposable clothing, gloves, etc., in thick (6 mil) plastic garbage bags or two layers of thin plastic garbage bags. Seal and discard the bags in an outdoor garbage container.

Recommended Personal Protective Equipment (PPE)				
PPE	Level 1: small isolated areas ($< 0.3 \text{ m}^2$)	Level 2: medium-size isolated areas ($0.3\text{—}3 \text{ m}^2$)	Level 3: large isolated areas ($3\text{—}10 \text{ m}^2$)	Level 4: extensive contamination ($> 10 \text{ m}^2$)
Acetic acid	N95 or N100 disposable respirator	half-face N100 respirator	full-face N100 respirator	full-face N100 respirator or PAPRs with HEPA filter
Other	disposable gloves and protective goggles	disposable gloves, protective goggles, and protective clothing	disposable gloves and protective clothing with head and boots covered	disposable gloves and protective clothing with head and boots covered
Additional protection	appropriate respiratory, eye, and hand protection for any wetting or cleaning agents (e.g. high concentrations of bleach)			
Additional comments	disposable respirator with nuisance-level organic vapour relief for MVOCs may be appropriate	organic vapour cartridge for MVOCs may be appropriate		<ul style="list-style-type: none"> organic vapour cartridge for MVOCs may be appropriate professional help likely required for collection recovery on this scale
	half-face respirator, gloves, goggles, and protective clothing are recommended for collection recovery at any scale where toxigenic fungi are known or suspected			

Summary

The information presented here will allow you to take the first steps to address a mould infestation. It will enable you to protect staff by selecting the appropriate PPE, to isolate contaminated artifacts, and to prevent the dispersion of mould spores to non-contaminated artifacts or the rest of the building. It

describes ways to deactivate the mould by air drying or freezing the contaminated material. These are the first steps in coping with a mould infestation in a collection.

Subsequent to these measures a cleaning methodology should be devised and the collection recovery phase of the mould infestation can begin. Mould spores do not have to be viable to retain allergenic or toxigenic properties; therefore, exposure to dormant mould is a health concern. The conscientious removal of mould and the reduction of spores from contaminated artifacts is necessary. For more information on collection recovery of mouldy artifacts, refer to [Mould Prevention and Collection Recovery: Guidelines for Heritage Collections](#) (Technical Bulletin N° 26).

Suppliers of Personal Protective Equipment (PPE)

(including respiratory protection, goggles, gloves, protective clothing, head and shoe coverings, ear protection, back support belts)

Canadian Standards Association (for more information regarding respirators)

- CSA Standard Z94.4-02 "Selection, Use, and Care of Respirators"
- Telephone: 416-747-4000 or 1-800-463-6727

Fisher Safety Canada

- Telephone: 1-800-243-7437 (customer service in Canada)
- Telephone: 1-877-676-3639 (safety customer service in Canada)
- Telephone: 1-800-772-6733 (customer service in the United States)
- [Fisher Safety Canada website](#)

Lab Safety Supply

- Telephone: 1-800-356-0783 (Canada and the United States)
- Telephone: 1-800-356-2501 (technical assistance)
- Telephone: 608-754-7160 (International)
- [Lab Safety Supply website](#)

Other Sources of Information

General Information

Health Canada

- [Contamination of Indoor Air](#)

Canada Mortgage and Housing Corporation (CMHC)

- [Indoor Air Quality](#)
- [Fighting Mold](#)
- [Canadian Centre for Occupational Health and Safety \(CCOHS\)](#)

U.S. Environmental Protection Agency (EPA)

- [Biological Pollutants in Your Home](#)
- A Brief Guide to Mold, Moisture, and Your Home
- [Mold Resources \(EPA\)](#)
- [Mold Remediation in Schools and Commercial Buildings](#)

American Industrial Hygiene Association (AIHA)

- [Mold Resources \(AIHA\)](#)

Guidelines for Mould Remediation

Health Canada

- Fungal Contamination in Public Buildings: A Guide to Recognition and Management

Manitoba Department of Labour, Safety & Health Division

- Guidelines for the Investigation, Assessment & Remediation of Mould in Workplaces

New York City Department of Health, Bureau of Environmental & Occupational Disease Epidemiology

- [Guidelines on Assessment and Remediation of Fungi in Indoor Environments](#)

Hiring a Conservator

- [Canadian Association of Professional Conservators](#)
- [American Institute for Conservation of Historic and Artistic Works](#)

Laboratories

- [AIHA Accredited Labs](#)
- [Aerotech Labs](#)
- [Environmental Microbiology Laboratory, Inc.](#)

Paracel Laboratories Inc.

- [Paracel Laboratories Inc. website](#)
- [Canadian Council of Independent Laboratories](#)

References

- Ammann, H. Is Indoor Mold Contamination a Threat to Health? (June 2003).
- Environmental Protection Agency. "Table 2: Mold Remediation Guidelines." In **Mold Remediation in Schools and Commercial Buildings** . Washington, D.C.: Office of Air and Radiation, Indoor Environments Division, 2001, pp. 12–15.
- Johanning, E., and P. Landsbergis. "Clinical Findings Related to Indoor Fungal Exposure – Review of Clinic Data of Specialty Clinic." In **Bioaerosols, Fungi and Mycotoxins: Health Effects, Assessment, Prevention and Control** (edited by E. Johanning). Albany, New York: Eastern New York Occupational & Environmental Health Center, 1999.
- Levetin, E. "Fungi." In **Bioaerosols** (edited by H.A. Burge). Boca Raton, Florida: Center for Indoor Air Research, CRC Press Inc., 1995.