

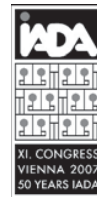
FLUFFY STUFF

INTEGRATED CONTROL OF MOULD IN ARCHIVES

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This publication is a translation of *Pluis in huis, geïntegreerde bestrijding van schimmels in archieven*, first published by the Instituut Collectie Nederland in 1999.

Compared with the Dutch original, this English version contains a few small changes and some up-dated information.



This special English edition has been published on the occasion of the 50th Anniversary of the International Association of Book and Paper Conservators (IADA).

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INTRODUCTION

The Regional Archive Inspectorate, the Dutch National Archives and the Netherlands Institute for Cultural Heritage (ICN) are regularly approached with inquiries about the control of moulds in archives. In most cases, the solutions offered require much time and expense. The archive collection managers need a simple method of disinfection. However, the only mass disinfection method available is actually damaging for archive materials. Symptom control is an incorrect approach. In nearly all cases, the mould problem proves to be linked with incorrect storage conditions or water damage. Regardless of the method of disinfection, storage conditions must be improved in order to prevent a rapid reoccurrence. Had this measure been taken earlier, the problem most probably would never have occurred.

In order to reduce the chance of a mould outbreak to a minimum, one can use the 'integrated control of mould' approach. Integrated control is a strategy with which one strives to limit the use of harmful control substances and methods to a minimum by applying correct preventive measures and collection care. Should mould be detected somewhere despite prevention measures, a treatment is sought which is safe for materials and humans while radical (mass) treatment is considered only as a last resort.

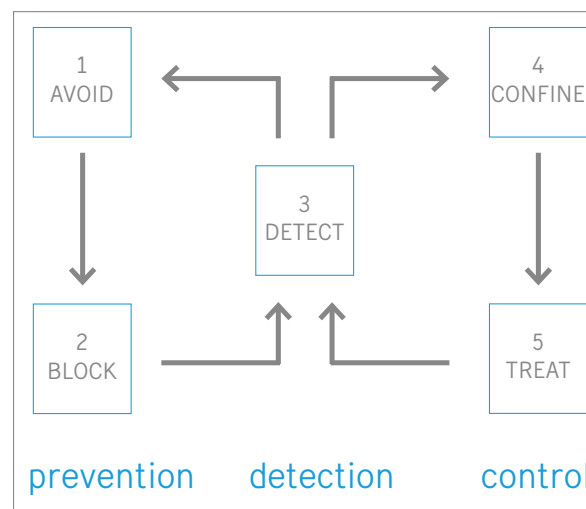
Integrated control comprises five logically consecutive steps. The program is based on preventive measures and detection: active control measures are taken only in the last instance. (See diagram on next page).

To successfully carry out the integrated approach, it is important that the co-ordination is in the hands of one person who is authorised to impose the measures. In addition, every person who is involved in the care and use of the archive must be informed of the procedures. Explicit agreements should be made with staff and external partners such as cleaners and maintenance personal. Integrated control of mould would appear in the first instance to create more work, but, in practice, it means a healthier work environment for the archive personnel

and a reduction in work that would otherwise be spent in disinfection and mitigating the material damage caused by control treatments.

After a short introduction about moulds and their control, this book describes the five steps of integrated control of mould. The actions required for each step are accompanied by commentary. Further information about specific subjects or actions that require more extensive explanation are given in the appendices.

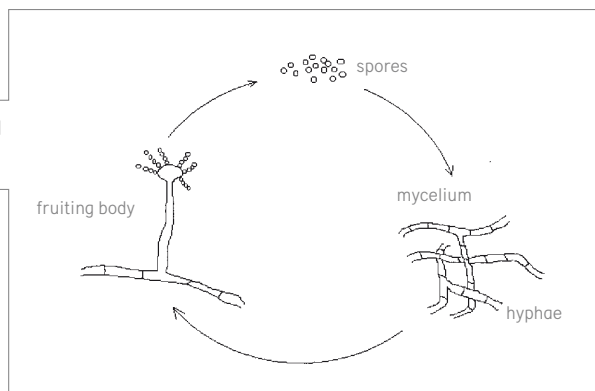
With this publication, the authors hope to provide managers of archive collections with a helping hand in the prevention and mitigation of mould infection in the collections. Although written for archives, the approach and recommended working procedures also apply to other collections. In this publication the standards referred to for storage conditions are those required by the Dutch Archives Act (1995) with regulations from 2001.



MOULDS

Moulds are micro-organisms which form a separate kingdom from animals and plants. They are an essential link in the chain of decomposition and recycling of organic material in nature. At the same time, they form a threat for archives because they can also affect the organic material in the collections. Most moulds comprise a fungus floccule or mycelium, the fluff that we see growing on surfaces. The mycelium is made up of mould threads or hyphae. Fruiting bodies in which spores are formed develop on the hyphae ends. The spores are the means by which the mould propagates and disperses itself. These are tiny particles (1-10 micrometres) that are easily distributed by air. If the circumstances are favourable, the spores germinate and form hyphae that then grow into a new mycelium. The types we encounter in collections are the surface moulds.

The cycle of mould development.



Mould spores are present everywhere; the creation of a sterile archive is impossible. However, spores can not germinate and grow just so: a number of growing conditions must be met. First and foremost they need a growth medium. In contrast with plants, moulds have no leaves with chlorophyll and must derive their nutrients from the material on which they grow. Organic materials such as paper, leather, glue, wood and textiles offer sufficient nutrition. In addition, moulds need oxygen for the metabolism of the nutrients. The temperature at which moulds can

develop lies between about 4 and 40°C with an optimum between 24 and 30°C. By far the most important growing condition is moisture. For their development, moulds need a water activity of 0.7 to 1.0 at the surface of the material. Generally this correlates with a relative humidity (RH) of 70-100%. Some mould species can germinate at a lower RH once their first colonies have formed because they can supply their own water requirements. It is generally accepted that no mould growth occurs at a RH below 65%.

Maintaining the RH below 65% is the most effective manner to prevent mould growth!

Moulds cause damage to archival documents in different ways. First of all, they cause direct damage by their growth. Mould that grows on a surface conceals the underlying text or drawing and thereby makes a document unreadable. Furthermore, hyphae can damage the structure of the material by forcing their way through it. In addition, they decompose the material by using enzymes to extract nutrients from it. Mould can also cause indirect damage by excreting acidic waste products and colouring substances during their growing process that are left behind in the material. Last but not least, moulds can form a danger for our health. The complaints vary from allergies, skin and respiratory tract irritation to diseases.

Most collection managers regard the damage on archive objects caused by moulds as a serious problem. This is particularly because moulds, under suitable conditions, are able to spread and damage a great deal of a collection relatively quickly. Detection of mould often leads to light panic and the reaction to disinfect the whole collection as soon as possible. Such an approach comes up against a number of drawbacks. First of all, the disinfection of the whole collection is a great deal of work that may be partly unnecessary because not all objects are affected. Secondly, there are few methods available to disinfect mouldy archive material and these methods have negative effects on the material. Methyl bromide, a much used insect fumigant in the past, is not effective against mould

DAMAGE CAUSED BY MOULDS

CONTROL OF MOULDS

and with the banning of the use of ethylene oxide in the Netherlands already in the late 1980s and the lack of an effective alternative, fumigation is no option. Other fumigants that are used by cleaning and disinfection companies do destroy insects or bacteria but not moulds. Consequently, only gamma radiation remains as a method for mass disinfection. But this method is known to accelerate the ageing of materials. Paper especially is very sensitive to the influence of gamma radiation. Above all, these negative effects accumulate which means that every successive treatment accelerates the ageing even more. Lastly, the total cost of a disinfection treatment (packing, transport, treatment, cleaning, returning to the collection) are high.

All in all, dry mechanical removal with a fine brush into a vacuum cleaner nozzle or vacuuming directly using a suitable attachment is the most appropriate method to remove mould from archive objects. This method does not eradicate mould, but removes it so that the chance of new mould growth will be limited as much as possible after the object is returned to correct storage conditions. This method has hardly any negative effect on the material and can be carried out in-house. It may seem to be a labour intensive method but in fact it is just part of the whole process that is carried out with a disinfection treatment. After killing the mould the treated objects need to be cleaned in any case. So not only does mechanical removal require no extra effort, it leads people to be more selective and clean only those objects in the collection that are actually affected. Mass control treatment makes sense when there is a large or actively growing infection and one needs to buy time for mould removal.

After disinfection and/or removal of the mould growth, the storage conditions must be optimised before the objects are returned. After all, mould can renew its growth under bad storage conditions. Considering that conditions must be optimized, it is much more efficient to improve storage conditions before a mould outbreak can occur than afterwards. The emphasis in the preservation of archive material must therefore lie on prevention: prevention of mould problems instead of the control of mould outbreaks.

THE 5 STEPS OF INTEGRATED CONTROL OF MOULD

Prevention	1 > Avoid
	2 > Block
Detection	3 > Detect
Control	4 > Confine
	5 > Treat

STEP 1 AVOID

First and foremost, the environment in the archive should be such that mould spores cannot germinate.

- A Keep RH below 65%.
- B Provide sufficient ventilation.
- C Avoid the formation of microclimates.
- D Maintain a clean and dust free area.

General information: see Margry (1991), Nationaal Archief (2001), and BSI 5454 (1989)

COMMENTARY

A
Climate requirements for paper according to the Dutch Archives Act are RH 49-55% and T 15-18°C; other materials may have other requirements.

RH and T must be continually measured with a thermo-hygrograph: hair hygrometers that cannot be calibrated are forbidden by law (Margry: 7.0, Nationaal Archief, 2001).

B
The air must be circulated day and night with an air exchange rate of 2 per hour and a fresh air intake of 10%. (Nationaal Archief, 2001).

C
Microclimates are locally varying climatic conditions. They can occur due to local sources of moisture or cold spots, at outer walls, in places where insufficient air circulation takes place and in packaging. In order to avoid microclimates, sources of moisture and temperature gradients must be removed and an optimum air circulation must be provided. Cupboards and storage racks must stand free from walls, floor (20 cm) and ceiling (30 cm) (Margry: 5.3.3.3, Nationaal Archief, 2001). Additionally, this simplifies cleaning under and behind cupboards and storage racks.

D
See De Bruin et al. (1996).
Cleaning comprises tidying (everything that does not belong in the room or storage area must be removed) and the removal of dirt and dust. It is recommended to vacuum and mop (sweeping is useless) the storage areas at least once every three months. Vacuum cleaners should have P3 or HEPA-filters that must be regularly replaced or cleaned. Dusters (electrostatic types) can be used on shelves. See Appendix 1: *Cleaning and disinfection of the area.*

STEP 2 BLOCK

Clean collection areas without mould contamination must remain so. Mould must therefore be prevented from entering these areas. The most important sources of contamination are contaminated archive materials coming in from external sources and air treatment systems (HVAC).

- A Find out how and where mould could enter the building and take measures to prevent it occurring.
- B Inspect newly arriving archive material for signs of mould infection (preferably at the point of departure).
- C Place contaminated and suspicious material in quarantine; isolate and treat contaminated material (see steps 4 and 5).
- D Examine suspicious material for active mould growth.
 - if not: clean and admit into the archive (step 5);
 - if so: isolate and treat (see steps 4 and 5).
- E Monitor and replace filters in air treatment systems regularly.
- F Clean air channels, heat exchangers and drip trays regularly.

COMMENTARY

A This usually concerns construction issues. Direct contact between external air and the inside must certainly be avoided. Ensure that cracks, holes and slits are sealed and that doors close well. A buffering zone between the storage area and the outside is preferable.

B Inspect newly arriving archive material visually. Do not carry this out in the storage area but in another room or preferably at the very beginning of the transfer chain at the archive donor's premises. Look for damage, fluff or stains on boxes, covers and archive objects. Mouldy smells, rusty staples and paperclips, and damp paper are a first indication to look closely and carefully.

C When there is no quarantine area at one's disposal, suspicious material can be packed in a well sealed box or plastic

bag. Never place wet material in a plastic bag. If there is no other option, then at least store it cool. (See step 4 d).

D Wait about five days and see if the fluff or stain becomes larger. If it is not mould, it could still be important to know what it is before proceeding with removal. In that case, seek advice from a conservator/restorer or other expert.

E See Appendix 4: *HVAC systems*.

F Regularly check for the presence of dust in the intake opening of the air treatment system. Dust indicates that the filters must be changed. The method and frequency of the internal cleaning of the ducts should be decided in consultation with the maintenance team. During periods that the air treatment system is not working, ensure that the climate is temporarily regulated with independent climate control units.

STEP 3 DETECT

Regular visual inspection and sampling of areas and archive material is necessary in order to check whether the measures taken in step 1 and 2 are sufficient to prevent mould infection.

- A Perform random inspections of archive objects throughout the storage area.
- B Inspect returning loans.
- C Regularly inspect the collection areas.
- D Determine whether the encountered damage, fluff or stain is caused by mould;
 - if not: clean and replace in the archive (step 5).
 - if so: take a sample of the mould and isolate the object for treatment (step 4).
- E Note all observations in a logbook for future comparison.

COMMENTARY

A
Regular visual spot checks provide the most useful information. During such inspections, look out for damage and fluff or stains on packaging/covers, on and in archive objects.

In particular, inspect vulnerable objects and places: recently arrived material and that near cool outside walls and pipes. Tighten up inspection in periods in which the outside climate is the most beneficial for mould growth: summer and autumn, when the warm outside air contains a large quantity of moisture.

B
Provide guests with a list of instructions on the handling of materials and also invite their co-operation in the inspection; it takes little extra trouble to detect and report signs of infection.

C
1. All staff that enter the collection areas, from archivist to cleaners, should be alerted to keep their eyes open. Instruct everyone to look out for insects as well as mould and identify the co-ordinator to whom all finds should be reported.

2. The presence of viable mould spores in the area can be determined by taking swab samples (ARA-kit), plate samples (Rodac) or air samples (RCS sampler). See Appendix 2: *Spore viability and spore counts*.

D
Whenever something suspicious is observed, one must first determine whether it is indeed mould. Fluff or stains can also be dust or efflorescence of salts, oils or fats. See Appendix 3: *Identification of fluff or stain*.

E
When mould is discovered, note which area and which objects are affected, location, climatic conditions and date. Also note the results of identified samples. In the same logbook, note when and in which manner both the area and the particular archive objects were cleaned. Should a spore count determination have been carried out, report these results as well.

STEP 4 CONFINE

Whenever an infection is detected at step 3, its dispersal must be prevented as soon as possible. First it must be determined which objects are infected. Then the direct vicinity of the infected objects must be inspected. Next the infected objects must be isolated. Finally the cause or source of the mould growth must be found and removed.

- A If necessary, shut the air treatment system down to prevent dispersal of the spores.
- B Locate all infected objects.
- C Take a sample of the mould for eventual identification.
- D Isolate the infected objects.
- E Remove the infected objects to the treatment area.
- F Determine whether the mould is active or not.
- G Determine the cause and rectify it.

COMMENTARY

A See Appendix 4: *HVAC system*.

B Inspect the direct vicinity of the infected objects: the neighbouring objects on the shelf; in racks objects on the backing shelves as well; in compactor storage the objects on the shelves in front also. Should it concern recently arrived objects, other parts of the same lot placed in other locations may also be infected. Determine what was in the same lot, where they are stored, then check them.

C Identification of the detected mould can give an indication of the cause of the problem and the scale of risk formed by the infection. Especially when no obvious cause of infection can be determined it becomes important to identify the mould species to explain its presence.
See Appendix 6: *Taking an adhesive tape sample*.

D Isolation can best be achieved by removal to a quarantine area (not connected to the air treatment system) where the objects can be kept until treated. In the absence of a

quarantine area, the infected objects can be packed in a well sealed box, wheeled container or plastic bag. Be very careful with wet material in closed bags or boxes as mould growth can occur there even more vigorously.

In the case of a water incident, wet archive material can be frozen at -20°C. This treatment retards the mould growth but does not kill the spores. First seek advice from an expert.

With a large infection, part of the storage area can be shielded off from the rest using plastic sheeting on a slat frame. Ensure that the air treatment system is excluded. A second tent can be made for the treatment of infected objects in order to avoid moving them through an area that is still clean.

E Avoid spreading mould spores during the transport to the treatment area. Isolate the passageway from the rest of the area with plastic sheeting or stretch shrink-wrap plastic sheeting over the wheeled container or trolley. Always follow the same route.

F The fluff of actively growing mould usually has a soft or turgid appearance in contrast with inactive mould that is often dry and powdery. Active mould must be disinfected immediately. The danger of spreading spores throughout the rest of the archive is much less in the case of inactive mould. In case of doubt, one should remove the mould and wait two weeks to see if new growth has been formed. Alternatively, the viability of the mould can be determined with a swab test or by sending a sample to an institution that cultures and identifies mould (see comment c).
See Appendix 2: *Viability and spore counts*.

G Check to see if there is a source of dampness. Is the RH too high or has it been high recently? Are there water leaks? Are microclimates occurring? Is the infection coming from outside? If no cause can be found, identification of the mould may provide a clue about the circumstances and origin of the problem.
See Appendix 5: *Checklist of causes*.

STEP 5 TREAT

In the control of an infection, both the archive objects and the area must be treated. Mould must be removed whether or not it has been killed first.

The simplest and least damaging method for the objects is dry, mechanical removal over suction. Alternatively, removal with 70% alcohol (ethanol) can be tried. For large quantities mould growth can be stopped by storing the material in a freezer at -20°C. As a last resort the mould can first be killed by gamma radiation. Before placing disinfected objects back in storage, the area must be thoroughly cleaned with a disinfectant.

- A Unpack the isolated objects and dry them if they are wet.
- B Determine whether the infection can be removed mechanically.
- C If not: stop growth by freezing the objects or kill mould and spores with gamma radiation and remove the dead remains.
- D Disinfect and clean the area.

Go back to step 1
Make adjustments to meet requirements
Return objects to their place

COMMENTARY

A Dry documents that are wet using natural ventilation at a low RH, if needed under forced ventilation, in a vacuum cupboard under suction or even by freeze-drying. In all cases, prevent spores from being blown into the room. Do not use warmth for drying: that just stimulates mould growth!
See Appendix 7: *Personal protection*.

B 1. Whether infections can be removed mechanically or not depends on their magnitude, degree of activity and danger of further spreading of the infection, time pressure and the total costs. As disinfection using fungicides or gamma radiation must always be followed by the removal of the

remains of the mould, the amount of work required plays no role in the decision process. However the availability of personnel does, as the fewer there are available, the more time is required for such treatment and active mould can continue developing should no disinfection have been carried out.

2. The mechanical removal of mould is carried out by suction with a vacuum cleaner or another suction system. Should the mould be firmly attached to the substrate, then it must be loosened with a brush moving toward the vacuum mouth piece that is held close by. Freezing mouldy objects for at least a day kills off the mycelium and facilitates mechanical removal, but does not kill the spores. The mould particles and spores must not be blown into the room via the air outlet of the vacuum cleaner. Use a device with a HEPA filter or let it blow the outlet air directly outdoors. A layer of gauze can be laid over the object to prevent loose object parts being sucked up.
See Appendix 7: *Personal protection*.

3. Mould can be found 1) on the boxes or covers, 2) on the outside of archive documents or 3) inside the archive documents. In the first case, one can consider replacing the packaging. Otherwise, it is sufficient to vacuum the outside surfaces or clean them with 70% alcohol or a disinfectant. In the second case, the objects themselves must be vacuumed with particular attention being paid to the spine, inner joint and cover of bindings. In the third case, the documents must be vacuumed page by page. Objects that prove difficult to clean may have to be packed and removed for disinfection with gamma radiation.

C The least intrusive manner to halt mould growth is freezing. This does not kill the spores but it can buy time for mechanical removal of the mould. If complete kill of the mould is required, the objects need to be treated with gamma radiation.
See Appendix 8: *Gamma radiation*.

D See Appendix 1: *Cleaning and disinfection of the area*.

APPENDICES

- 1 Cleaning and disinfection of the area
- 2 Viability and spore counts
- 3 Identification of fluff or stain
- 4 HVAC system (heating, ventilation and air conditioning)
- 5 Checklist of causes
- 6 Taking a mould sample using adhesive tape
- 7 Personal protection
- 8 Gamma radiation

Cleaning and disinfection of the area

APPENDIX 1

The cleaning (tidying and vacuuming) of archive areas is of great importance as a preventative measure in making the surroundings unattractive (step 1). The removal of dirt and dust is achieved by vacuuming so that it is immediately taken off site. Sweeping is useless because it merely moves dust around.

When routine cleaning of storage and archive areas is contracted out to a cleaning service, it is best to make clear arrangements about the method and frequency of cleaning. Above all, it is useful to engage the cleaners in the inspection of the area. With good instructions on signalling the presence of mould and insects they can become the extra eyes of the collection keeper in the building.

Tidying

- ⋮ Everything that is superfluous and does not need to be in the area must be removed.

Vacuuming

- ⋮ Use a vacuum cleaner with a HEPA-filter or P3-filter.
- ⋮ Work from top to bottom
 - . top shelves of a storage rack
 - . rest of the rack from top to bottom
 - . idem for neighbouring racks
 - . first vacuum the walls, plinths and edges
 - . lastly the floor around and under the racks
- ⋮ Work in blocks from a distant corner towards the entrance/exit.

Once an infection is observed, disinfection must follow a good cleaning. This is carried out with a disinfectant solution in water. Popular products are based on quaternary ammonium compounds. One example is Sumabac D10, a cleaning agent and disinfectant from the food industry. Its use is allowed in places where food is prepared. The concentrate and solutions in water can affect the skin and irritate the eyes, therefore it is advised to wear safety gloves and glasses during disinfection.

1

CLEANING

2

DISINFECTION

Before applying a watery solution, the consequences of introducing water into the area for the RH should be considered.

- ⌘ Make a 1% dilution of Sumabac (10 ml Sumabac in 1 L water).
- ⌘ Remove loose dirt.
- ⌘ Apply Sumabac solution to the surface with a cloth, brush or mop; spraying is also possible.
- ⌘ Allow the solution to work for 5 minutes.
- ⌘ Remove by rinsing with water or a moist cloth.
- ⌘ Remove moisture with a dry cloth.
- ⌘ Work from top to bottom as with vacuuming.
- ⌘ Work in blocks from a distant corner towards the exit.
- ⌘ If mould has established itself in the waxed finish of the floor, the top layer must be removed and the underlying layer disinfected and rinsed off. When the floor has dried a new wax finish can be applied.

Frequency

A frequency of at least once every three months is recommended for the vacuuming and mopping of storage areas. A preventive disinfection should take place twice a year in which the exposed fronts of shelves, empty shelves, sides and tops of archive racks are wiped and rinsed off. A general cleaning and disinfection of the storage areas, including the packaging material should take place once every three or four years. This includes the vacuuming of the outside surfaces of boxes and archive documents, the dry or wet cleaning of storage racks, shelves and floors with disinfectant and the vacuuming and mopping of floors.

See also:

Bruin, G. de, Steemers, Th., Teuling, A.J.M. den, Zanen, B. van, (1996)
Margry, P.J., (ed.), (1991)

APPENDIX 2

Viability and spore counts

It is important to know if a mould is active (produces viable spores). If that is the case, the chance exists that an infection will spread. If a mould is no longer active, there is more time to plan and carry out treatment. In that case, identification of the mould is not really necessary. Whenever presented with an active infection, health problems appear or mould returns after treatment, it is advisable to contact a specialist to identify the mould. Knowing whether it is one particular species or a mixed population helps in determining the cause of the infection. Information on the species aids in estimating the risks for collection and staff.

To monitor the presence of mould in a space one can determine the spore count. This number indicates how many viable spores are present from which mould colonies can develop under suitable conditions. By taking samples and culturing the captured spores on a growth medium, the average number of colony forming units (CFUs) can be determined. A high spore count indicates the possible presence of active mould and can coincide with health problems for personnel, but is not necessarily an immediate danger for the collection. Only when conditions for germination are met, which in most cases means that the RH exceeds 65%, can mould growth take effect. A high spore count thus indicates the potential danger to the collection and the magnitude of the infection. The spore count provides a snap shot of the total biological load in a space. This number can provide no definite information on the risks for collection or staff without further determination of the mould species present. Nevertheless, these quantitative measurements are particularly useful when they are carried out regularly as part of the monitoring of the storage conditions or as a control for a cleaning operation, where the situation before and after cleaning can be established.

Spore viability can be determined by archive staff while spore count and identification are usually carried out by laboratories for air quality testing. These laboratories often

only provide quantitative results, the proper interpretation of which is not always possible without qualitative information on the mould species present.

1 SWAB TEST (ARA KIT)

To establish if a mould is active, the Dutch National Archives has developed a simple test kit: the ARA kit. This comprises two plastic test tubes. One test tube is half filled with a growth medium that is specific for the moulds in archives that prefer dry conditions (DG18). The other test tube contains a cotton swab moistened with sterile water. The swab is used to collect about 10 cm² of surface dust that is then swabbed over the growth medium in the medium tube. The moisture left behind on the surface of an archive object must first be allowed to evaporate before closing or storing it. The test tube with the sample is then left in a warm place at a temperature of 25-30°C, preferably an incubator. The test tube is checked daily for mould growth. If no growth is observed after five days incubation, it can be concluded that there is no viable mould on the tested material. To be absolutely certain, an incubation period of 10 days should be held as some slowly growing and dry loving species only appear after 10 days. A swab from a suspicious area should always be compared to one of a clean area.

2 PLATE TEST (RODAC PLATES)

A Rodac plate is a Petri dish of 65 mm diameter holding a convex formed growth medium. This plate is suitable for making contact prints. The lid is removed from the plate and the plate with growth medium facing down is laid on the surface to be tested. The plate is pressed down without twisting, lifted off the surface and closed with the lid. The plate is incubated for five days at 25-30°C. The number of mould colonies are counted on the third, fourth and fifth days. The Dutch National Archives uses the following quantification assessment:

<i>Number of colonies on the plate</i>	<i>Assessment</i>
0-15	good
15-50	moderate
50-150	bad

3 AIR SAMPLING (RCS AIR SAMPLER)

The RCS air sampler is one of several instruments for detecting the microbial content of air. The instrument draws in air through a rotor in the front and airborne spores and microbes are impacted onto an agar strip through centrifugal force. A DG18 medium is used in collections. The agar strip is incubated and after five days the number of mould colonies are counted. An incubation period of 10 days is held in order to also give slow growing species a chance. The final result is an airborne spore count giving the number of colony forming units per m³ of air. Despite the fact that the Dutch National Archives has already been working with this method for years, no standard for archives has yet been established. However, there are empirical figures that can be applied in practice.

Number of colony forming units per m³ of air:

<i>Air</i>	<i>Assessment</i>
0-25	no expected problems
25-100	possible presence of source, further testing needed
100-1000	source present, mould often observed on objects
> 1000	active mould growth in area

These quantities apply to mixed flora. If there is only one species found, then quantities of 25-100 already indicate the presence of an infection.

Mould spores are not spread homogeneously in a space. In places with a high air movement the spore count can be lower than in places where the air is fairly still. The airborne spore count is the result of a random sampling. To achieve a reliable result, generally three measurements are taken diagonally across the space at 20 cm, 90 cm and 240 cm above the floor.

See also:

Bruin, G. de, et al., (1996)
Samson, R.A. and Hoekstra, E., (eds.) (1994)

APPENDIX 3 Identification of fluff or stain

For those who are not familiar with recognizing mould under a microscope, ruling out other options may lead to the correct conclusion. The following tests can help in the identification of fluff or stains. If necessary they can be carried out on the archive object itself but it is better to remove some fluff or stain and test it separately on a microscope slide or glass plate.

- EQUIPMENT**
- ⋮ microscope slide or glass plate
 - ⋮ scalpel or tweezers
 - ⋮ magnifying glass or microscope
 - ⋮ drop bottle containing distilled water
 - ⋮ drop bottle containing 85% lactic acid in water
 - ⋮ drop bottle containing 96% alcohol
 - ⋮ incandescent light source or lighter (heat source)

- TEST PROCEDURE**
- 1 Examine fluff or stain with magnifying glass.
Are the threads lying loosely, randomly distributed and unconnected with each other on the surface?
YES = dust
NO = go to 2
 - 2 Scrape a little of the fluff or stain onto a microscope slide or glass plate. Place a drop of lactic acid (85%) or water on the scraping or eventually directly on the fluff or stain on the archive object.
Does the fluff effervesce in acid or dissolve in water after 5 minutes?
YES = salt
NO = go to 3
 - 3 Dab water away then add a drop of alcohol to the fluff or stain.
Wait five minutes; does the fluff or stain dissolve?
YES = organic compound or salt
NO = go to 4

- 4 Place a warm lamp just over the fluff or stain or heat the glass plate from underneath with a lighter.
Wait five minutes; does the fluff or stain melt?
YES = fat or oil
NO = probably mould

If the fluff or stain is not mould it can still be important to know what it really is before treatment commences. In that case, seek advice from a conservator, the archive inspection or experts from a conservation institution. Be aware that remains from old pesticides may be blooming on the surface of objects.

APPENDIX 4 HVAC system (heating, ventilation and air conditioning)

PREVENTION Regular inspection of the dust and mould filters in the HVAC system falls under the responsibility of the maintenance company. Ensure that the maintenance contract states that the filters are checked, and if necessary replaced, at least once a year. Ensure that the filter fittings are cleaned with a disinfectant. During the period that the HVAC system is switched off for servicing, it may be necessary to regulate the climate in the archive with stand alone mobile units. (A proper building should have enough buffering capacity to maintain a relatively stable climate over 24 hours without HVAC.)

DETECTION Inspect the ventilation grills for accumulated dust and soiling. This indicates that the filters are no longer effective and may eventually even form a growth medium and source of mould.

CONTROL When the space in which an outbreak is found is connected to a central HVAC system, one must prevent the infection from spreading through the rest of the building by closing off the affected area from the central system or even by shutting down the system altogether. Meanwhile the climate may have to be maintained using stand alone mobile units. If this is impossible then re-circulation of air must be prevented by venting directly to the outside in combination with a 100% fresh air intake.

If it appears that the origin of the infection is in the HVAC itself, the system needs to be disinfected while the climate is controlled by stand alone mobile units.

Checklist of causes

RH

What was average; minimum; maximum
Has the RH been above 65%? How high and for how long?

Temperature

What was average; minimum; maximum
Has there been a high RH due to a low temperature?

N.B.: check that the measuring instruments are correctly calibrated.

- ⌘ leakages
 - . floor: pools of water; damp areas
 - . pipes: water pipes; heating conduits; flues
 - . ceiling: ring marks; dampness; drips
 - . walls: damp areas; water stains; rusty anchors; bad joints; iron wall fittings; rising/seeping damp
 - . windows: cracks; open
 - . gutters: blocked
- ⌘ drains
- ⌘ vents
- ⌘ fire hoses, sprinkler installation
- ⌘ cleaning (wet mopping)
- ⌘ coat rack (wet coats, rain coats)
- ⌘ wet incoming objects

- ⌘ insufficient ventilation/stale air
- ⌘ insufficient circulation/racks against the wall
- ⌘ condensation on cold surfaces
 - .on cold (outside) walls and floors; insulation
 - .on windows (single/double glazing)
 - .on (steel) doors
 - .on water pipes and flues

- ⌘ openings or cracks in wall, ceiling, floor
- ⌘ windows and doors closed, especially if it is wet outside

APPENDIX 5

1

INDOOR CLIMATE

2

SOURCE OF MOISTURE

3

MICRO-CLIMATES

4

FROM OUTSIDE

- ⌘ elevator
- ⌘ HVAC system: filters; ducts; vents; inlet grills
- ⌘ arrival of infected archive materials from external sources
- ⌘ infected packaging in the storage area
- ⌘ living plants

A mould infection is often due to a water incident. Rapid action after a calamity can strongly reduce mould problems. This is why it is important that the institution has an emergency preparedness plan stating who does what and how and when.

See also:

Roelofs, W.G.Th. & Mosk, J.A. (eds.) (1992)

Mosk-Stoets, L.H. (1992)

Emergency Response and Salvage Wheel

www.heritagepreservation.org/catalog/Wheel1

Taking a mould sample using adhesive tape

APPENDIX 6

The simplest way of taking a mould sample is to use adhesive tape.

- ⌘ transparent adhesive tape, ± 5 cm long
- ⌘ pen or pencil
- ⌘ microscope glass slide, glass plate or piece of Melinex sheet

EQUIPMENT

Hold the adhesive tape by the ends and lay it with the adhesive side on the surface to be sampled. Softly press the adhesive tape with the end of the pen or pencil against the tape (to avoid making fingerprints). Carefully pull the adhesive tape away from the surface. The mould is now transferred to the tape. With the adhesive side down, apply the adhesive tape to the glass slide, plate or Melinex.

METHOD

An adhesive tape sample can be examined under the microscope to determine whether it is indeed mould, whether it is one particular species or a mixed population, and which species it is.

A laboratory specialising in the identification of mould should carry out the identification of the sample. This must take place as soon as possible after taking the sample, so avoid sending in samples just before the weekend or public holidays. Make arrangements with the specialist and send off the well-packed adhesive tape sample.

See also:

Samson, R.A. and Hoekstra, E., (eds.) (1994)

APPENDIX 7 Personal protection

One must be protected when working with mouldy objects and in infected areas. Only a few species of mould are directly harmful to our health but exposure to large quantities of harmless mould can lead to irritation of the respiratory tracts and skin, over-sensitivity and allergy. The basic equipment for safe working comprises the following:

LAB COAT A white lab coat is generally the most suitable because any adhering soil is visible. A lab coat should contain a high percentage of cotton because cotton absorbs moisture and dissolved dirt while nylon or polyester allows it to pass through to the clothing or skin under the coat.

GLOVES Latex or nitrile surgical gloves are very suitable for handling infected archive objects. They offer sufficient protection against mould spores and may be discarded after use as they are inexpensive.

Neoprene or rubber household gloves can best be worn when using disinfectants such as Sumabac.

FACE MASKS Face masks can be divided into dust masks and filter masks (half or full face masks that can also filter out chemicals as well as dust). A P2 filter (fine) is sufficient for working with dust; filter quality P3 (finest) is required for working with moulds. Discard masks after use.

See also:
Bruin, G. de, et.al1996)

Gamma radiation

APPENDIX 8

Gamma radiation is high energy, electromagnetic radiation with a high penetration that is able to kill micro-organisms such as moulds and bacteria by destroying their essential life supporting molecules. The rays are similar to UV-radiation but contain more energy. The radiation is beamed from a radiation source, usually a Cobalt source (^{60}Co) that is radioactive itself but does not cause radioactivity in the radiated material. Gamma radiation treatments are carried out by licensed commercial companies. This radiation is used, amongst other things, for the sterilization of hospital and laboratory equipment and for the disinfection of cosmetics, agricultural products and certain food products.

As gamma radiation has a deep penetration, large quantities of mouldy material, still packed, can be treated at once. Therefore the costs remain relatively low. The treatment is very effective, takes little time and as far as is known, no residues are left behind. However the treatment has one great disadvantage: research has shown that paper is very sensitive to gamma radiation. The cellulose chains are broken which leads to the accelerated ageing of the paper. With a treatment of 10kGy (kiloGray) the ageing process is accelerated by at least 50%. Above all, the damage is accumulative so that each following treatment adds to the further acceleration to the ageing process. Thus gamma radiation treatment can only be seen as a last resort and one that is used only once.

1 Pre-treatment

The confined infected objects should be documented, packed and made ready for transport in a special room.

A clear registration of the objects to be treated is desirable to prevent later problems with damage, loss and replacement.

PROCEDURE

Pallets can be used for packing. They are 100 x 180 x 120 cm in size (Gamma radiation firms may have size restrictions: check first). 144 Standard sized boxes (30 x 40 x 12 cm) fit on one such pallet. Using 'collars' (side panels) the pallets can be built up to a height of six layers. Stacked pallets can be sealed with plastic wrap for transport. Loose archive objects can be placed in a plastic bag. Use the full capacity of the pallet because hiring is expensive. Instead of a scoop pallet, flight boxes may be used. These are closed on all sides and have a lid, but one must climb inside to fill them and they are expensive. Wheeled containers may not be accepted. It may be necessary to confirm the order before sending a load to be radiated.

2 *Transportation to the treatment site*

Usually, the transport company is also the supplier of the pallets. A strategy must be formulated in consultation with the transport company. It is best for the transport company to make delivery arrangements with the treatment plant and the archives manager. Then the infected archive material can be picked up from the archives and delivered to the radiation plant in one trip. In this way the danger of bad weather and other damage is limited. After transport the transport company is responsible for the cleaning of the truck to prevent the spread of the infection and later re-infection.

3 *Radiation*

The treatment is the full responsibility of the treatment plant. The desired dosage of 10 kGy must be noted on the order and the order confirmation. Eventually, the dosage can be measured with a perspex dosimeter that turns blue under the influence of radiation. Always ask for a certificate of the radiation treatment on which the details of the treatment are given.

4 *Transportation to the archives*

The re-infection of the archive objects must be avoided during the transport back to the archives. To achieve this,

clear agreement must be made with the transport company on the procedures to be followed. Even if the disinfected material is still packed and the chance of re-infection small, the truck must still be clean. The transportation must be well co-ordinated with the treatment so that the material does not have to stand waiting unnecessarily long at the radiation plant.

5 *Post treatment*

During the absence of the infected archive objects, the quarantine/treatment areas must be disinfected so that the returning archive objects can be unpacked in a clean area. Should the archive objects have previously been vacuumed then they may be returned to storage after unpacking. Otherwise, the mould remains must first be removed before the objects are returned. Document which objects have been treated, the date and their condition. In the future, colleagues will want to know what has happened with the objects, even more so because repetition of the treatment is most inadvisable. N.B: before replacing the disinfected objects the storage area must be disinfected and cleaned.

See also:
 Brokerhof, A.W. (1989)
 Wellheiser, J.G. (1992)

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