

TEMPERATURE AND HUMIDITY

Stable environmental conditions are amongst the most important factors in the preservation of museum collections. Temperature, humidity, light levels and air quality all need to be controlled. This factsheet deals with the effects of temperature and humidity. The effects of light levels and air pollution are discussed in two separate factsheets.

HUMIDITY

Organic materials

Plants and animals contain a high proportion of water, and it is therefore not surprising that their products - organic materials, such as wood, paper, cotton, linen, wool, silk, parchment, leather, fur, feathers, ivory, bone and horn - also retain moisture. These materials are **hygroscopic**. They can and will absorb or give off moisture until they reach a state of equilibrium with the air that surrounds them.

When the surrounding air is very **dry**, organic materials will **give off** some of their moisture: they become brittle and may shrink, warp, split or crack.

When the surrounding air is **damp**, the materials will **absorb** some of the moisture from the air: they may swell, cockle, warp, change shape and/or lose strength. Dampness can also cause mould and fungal growth on organic materials.

Inorganic Materials

Inorganic materials (glass, ceramics, metals and minerals) are also affected by high or low humidity. Materials that have a natural salt content may suffer from **efflorescence** when the air is dry. The salts in deteriorated glass, porous ceramics and some geological material are carried to the surface by moisture (which may have entered the pores during a period of higher humidity). The moisture evaporates and the salts crystallise on the surface.

Other inorganic materials are affected by high humidity: metals (particularly iron and copper alloys) **corrode**; dyes and pigments **fade** more readily; and geological material can suffer from **pyrite decay**.

Physical Damage

If the humidity of the air changes frequently, hygroscopic materials will swell and shrink repeatedly. This causes **internal stress** and **damage**, and can particularly be a problem in composite objects where the different materials have different rates of shrinkage. The expansion of one material may force changes in the dimensions of another, causing considerable tension and eventually damage (eg: skins on drums, paintings on wooden panels).

Moisture can also start or speed up the damaging effect of air pollutants and other harmful substances on many museum items. (Refer to factsheets *Air Pollution* and *The Effects of Storage and Display Materials on Museum Objects*).

TEMPERATURE

Although most objects are not **directly** sensitive to temperature, there are good reasons for controlling the temperature in areas with collection items, as temperature changes do affect the items **indirectly**.

Changes in temperature cause changes in the **humidity** of the air. Objects can be very sensitive to changes in humidity, and it is therefore important to maintain humidity at a stable level. **This is the main reason for controlling the temperature.**

Chemical processes and **biological activity** can be sped up when the temperature increases. Some materials **expand and contract** when the temperature changes. For composite objects whose parts expand at different rates an unusual change in temperature may be particularly damaging.

The temperature levels are also affected by the needs of museum workers and visitors, who require a comfortable ambient temperature.

HOW DO TEMPERATURE AND HUMIDITY WORK TOGETHER?

As mentioned above, the **humidity** of the air depends on the **temperature** of the air:

- one cubic metre of air can hold 10g water at 10°C

BUT

- the same cubic metre can hold more than 30g water when the air is heated up to 30°C

Measuring the **absolute humidity** (the amount of moisture in grams) would not be very useful, because 10g water makes air feel very damp at 10°C but it leaves air still quite dry at 30°C. This is why **relative humidity** (RH) is used to measure the dampness or dryness of the air. Relative humidity is expressed as a percentage of the maximum amount of water the air can hold at that temperature:

- at 10°C, 10g water is the maximum amount the air can hold, so the RH is 100%
- at 30°C, 10g is about one-third of the maximum amount, therefore the RH is approximately 33%

This means that a change in temperature causes a change in relative humidity. If the temperature fluctuates between daytime and nighttime, the relative humidity will also fluctuate. This principle is an important factor in the control of the relative humidity (see **Controlling Temperature and Humidity**).

+RECOMMENDED LEVELS FOR TEMPERATURE

In Australia a *temperature range of between 18 - 22°C is generally recommended*. It should be noted however, that museum collections will not be put at risk by temperatures cooler than 18°C. It is people's comfort (both museum workers and visitors) that dictates the lower levels of the temperature range. Below 10°C it can become more difficult to maintain recommended humidity levels and problems with condensation may occur. Degradation processes will take place increasingly quickly the higher the temperature level. So for both the comfort of people and the safety of collections the band of 18 and 22°C has been determined.

For areas that are not frequented by staff and/or visitors (such as stores), the temperature may be kept lower. However, it is important that items are allowed to acclimatise gradually when they are moved from storage to display areas, and vice versa, and this can be more of a problem for small museums than maintaining the same levels throughout all collection areas.

RECOMMENDED LEVELS FOR RELATIVE HUMIDITY

The maximum level for relative humidity is determined by the point at which mould and fungal growth starts. Mould and other fungi need a humidity of at least 70% RH, therefore *the recommended maximum level for relative humidity is 70%*.

Below 40% humidity-sensitive items can become unacceptably dry and brittle, therefore *the recommended minimum level for relative humidity is 40%*.

Within these outer limits, **some materials require more specifically controlled levels** of relative humidity. A table listing recommended conditions for the storage, display and transport of museum objects is included in *Museum Methods* sheet 4.3 *Recommended environmental conditions for museum objects*. This table has been included at the end of this factsheet for your reference and use.

MONITORING TEMPERATURE AND HUMIDITY

In a naturally ventilated building in sound condition, it can be expected that the indoor conditions will respond to the outdoor conditions. However, there are many factors that can affect the temperature and humidity inside a building, in a display room, or even around one particular object.

The indoor conditions may be affected by the following **external** factors:

- **water penetration** or **rising damp** can cause high humidity levels if the building is in poor condition or badly maintained
- **sudden weather changes** can cause dramatic fluctuations if the building

is not insulated

- **direct sunshine** on metal roofs and glass skylights can cause considerable heat gain and day-night variations inside

The indoor conditions may be affected by the following **internal** factors:

- **poor air circulation or ventilation** can cause local conditions (*microclimates*) that differ from the ambient conditions
- **air conditioning or cooling systems** run for people's comfort only (eg: on at 8am, off at 5pm) can cause day-night fluctuations
- **visitors** produce moisture, particularly when it rains (wet coats and umbrellas)
- **spotlights or in-case lighting** directed at objects, can create local pockets of high temperature and low RH
- **air conditioning vents** blowing air directly onto or near a museum item can create pockets of RH that are higher or lower than in the rest of the room
- **display cases**, generally used to provide a more favourable environment, can also have the opposite effect and an adverse microclimate can develop

Continuous Monitoring

To gain an understanding of the temperature and humidity levels in the museum, it is essential that they are **monitored continuously**. Once conditions have been monitored over a period of at least 12 months, the results give a picture of the environmental conditions within the building. They will indicate which areas are suitable for what type of items, which need additional control equipment to make them suitable for museum items, and which are unsuitable.

FLUCTUATIONS

As can be seen above, there are many causes for fluctuations in temperature and humidity. These fluctuations can cause damage to museum items and should therefore be avoided or minimised.

In particular, fluctuations that occur **repeatedly** over a period of between a few hours and a few days are potentially damaging. The changes take place slowly enough for the objects to adjust to them, but fast enough to cause frequent movement, stress and fatigue in the material.

Occasional very rapid fluctuations (within 1 or 2 hours) will have a less damaging – though by no means negligible – effect on items. **Very gradual** fluctuations will give the items enough time to acclimatise slowly.

Some types of items are more affected by fluctuations than others. In general, when transporting items to an area with different environmental conditions, it is a good idea to keep items well packed in boxes and wrapped in buffering material, such as: acid-free tissue and washed cotton or linen. This will ensure that acclimatisation to the new conditions can take place gradually.

CONTROLLING TEMPERATURE AND HUMIDITY

Stable internal conditions can only be achieved if the building is providing an effective barrier against external environmental conditions. This can be achieved by ensuring that the building is in sound condition. A building survey will indicate whether any parts of the building need maintenance or repair, and should ideally be carried out once every five years. An energy efficiency survey will indicate whether the insulating properties of the building or the building services need improvement.

The aim is to keep the temperature and humidity levels as stable as possible, and although specially designed air conditioning systems can be installed this is **not** a recommended first approach. The cost of its installation, coupled with running and maintenance costs, and the damage that often results if it does not operate correctly, means that its use is most warranted in most small museums.

In temperate weather zones¹, such as Victoria, the following steps will help reduce the adverse effect of the external conditions on the indoor environment without the need for full air-conditioning:

- keep all windows closed at all times
- keep the entrance door closed as much as possible (or alternatively install double doors – an air-lock - or a revolving door)
- apply solar control film to windows and skylights to reduce the effect of direct sunlight
- re-organise the use of space within the museum to make the best use building's existing features (eg: internal rooms will be the most environmentally stable, attics will be dry but may be hot, basements will be cooler but usually damp, external walls can be prone to condensation and west-facing walls have greatly fluctuating temperatures)

In addition, control equipment such as room-based humidifiers or dehumidifiers may be needed to create and maintain a stable environment. To ensure that pieces of control equipment work efficiently, it is important that they are installed to complement, rather than work against, each other.

As a stable relative humidity is the main aim when controlling temperature and humidity, the temperature can be allowed to fluctuate moderately in favour of the stability of the relative humidity. It is possible to stabilise the relative humidity by allowing the temperature to increase and decrease. This can be achieved by controlling the heating system with a humidistat rather than a thermostat. However, in situations with large fluctuations in humidity the use of humidifiers or dehumidifiers can be more cost-effective.

It cannot be stressed enough that **stability** is the most important factor when determining and maintaining desired humidity levels. Preference should be given to maintaining a stable level **approximating** the desired level **all of the time**, rather than maintaining the exact desired level only part of the time.

¹ In more tropic weather zones in Australia it is important to note that air circulation is needed to prevent mould growth. So steps that can be used to help create stable environmental conditions by closing windows and installing airlocks in temperate zones are not recommended for museums in tropical zones.

Micro-climates

In some situations it can be difficult or financially unviable to control the environment of an entire building. In those situations control on a smaller scale may be more practical.

For items on display the conditions can be improved by using air tight display cases in which the environmental conditions can be controlled with silica gel, or even with humidifiers and dehumidifiers if the budget allows. They can also be used to create microclimates for items that need different environmental conditions (eg: very low humidity for archaeological objects). If air tight display cases are used, it is important that the conditions inside the case are continuously monitored, to prevent the development of adverse microclimates. Small display cases can be fitted with humidity-indicator strips, dial hygrometers or small electronic hygrometers. Large cases can be fitted with a thermohygrograph, or with an electronic sensor if an electronic data logging system is used.

For stored items the conditions can be improved by using enclosures. Each enclosure around an object will act as a physical buffer, and will **slow down** the damaging effects of adverse conditions. In this way conditions around individual items can be greatly improved by using acid-free tissue, Melinex sleeves or cotton covers, inside boxes or trays with lids, inside cupboards, wardrobes, plan chests, chests of drawers etc. It is also important that doors of storerooms are kept closed at all times, and that storage areas are not used as corridors.

FURTHER INFORMATION AND ADVICE

Further information on temperature and humidity can be found in *Museum Methods* (Museums Australia (NSW) Inc) and in *ReCollections* (Heritage Collections Council). *ReCollections* is available on-line www.amol.org.au/reollections

Museums Australia (Vic) can provide assistance with the location of further information on collections care and conservation for small museums. Contact: 03 8341 7344 or mavic@mavic.asn.au

Further conservation information can be found on the Australian Institute for the Conservation of Cultural Materials (AICCM) website www.aiccm.org.au

This factsheet has been adapted for use in Australia by Sarah Slade for Museums Australia (Victoria) with kind permission from the Scottish Museums Council.