



Preservation and Conservation (PAC) Programme Frequently Asked Questions

How to apply efficient preventive conservation strategies in your climate

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Q: What is the physical relation between temperature and relative humidity?

A: Library materials are prone to damage caused by excessive water in its liquid or gaseous phase, due to the ability of organic components such as paper, parchment, boards and leather, to absorb moisture from the surrounding environment. When water is in its gaseous phase, its particles are present in the air in the form of water vapour, which is the component that makes air humid. When speaking about humidity we must differentiate between two different measurement units, **Absolute Humidity, and Relative Humidity.**

Absolute Humidity is the total mass of water vapour present in a given volume of air, it is usually expressed as grams per cubic meter of air (g/m^3). The calculation to determine absolute humidity does not take temperature into consideration. **Relative Humidity (RH)** is the ratio (expressed as a percentage) of the amount of water vapour held in a specific amount of air compared to how much water vapour that same amount of air could potentially hold at the same temperature when RH reaches 100% when the air is completely saturated with moisture before condensation occurs..

The relation between Relative Humidity (RH) and Temperature (T) is an inverse relation. If we take an example of a closed storage room with no change in the water vapour content (absolute humidity), increasing temperature will increase the capacity of air to hold more water vapour and therefore decreases the RH. Lowering the temperature will decrease the capacity of air to hold water vapour and RH will rise. This relation must be understood and taken into consideration when taking actions that alter indoor temperature such as introducing colder outdoor air, heating or cycling on-off the air conditioning in the library

To understand the relation better, take a look at Figure 1, which shows the psychrometric chart. If we look at the blue line, we see that when we have approximately 11 grams of water vapour in the air at a temperature of 20 °C the resulting RH is 60%. If temperature drops to around 12 °C RH reaches 100%, which means the air is fully saturated with water vapour and water will start to condense on surfaces. This saturation temperature is known as **Dew Point.**

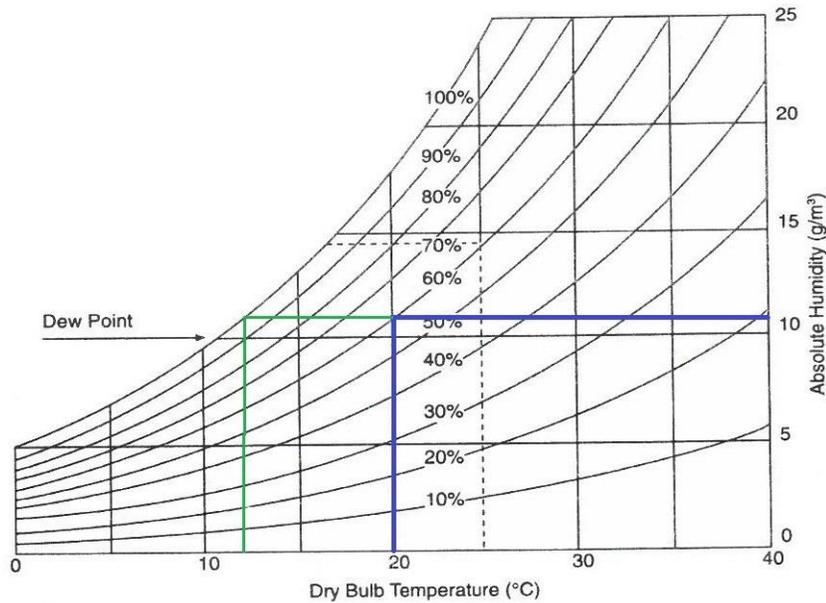


Figure 1: Psychrometric Chart

Q: What are the recommended temperature and relative humidity set points for library collections?

A: As a rule of thumb for most organic materials, the lower the temperature the better as the rate of deterioration slows in cooler environments. theoretically doubling the life of an object with every 5 °C decrease in storage temperature. Obviously, there are practical limits to the reduction of temperature therefore we compromise between the best conditions for library items and human comfort. Special environments such as targeted freezers or highly insulated storage rooms can be considered for collection formats that will suffer unacceptable damage without the use of extremely cold or freezing temperatures to slow their deterioration rate.

Library collections include a mix of composite materials, which complicates the choice of set-points for temperature and relative humidity. As there is no single ideal set point for all library materials. However, based on most experimentation, it is more or less safe to recommend a temperature range of 18 – 20 °C for most mixed collections provided that achieving this temperature range is practical considering the necessary natural and financial resources to achieve and maintain these conditions, does not result in excessive relative humidity in humid climates, and does not pose risk to the building envelope. For many years a target range of 45% – 50% RH was commonly recommended. In more recent years, research from many countries has looked at the consequence of an intentional relaxing relative humidity standards to accommodate seasonal fluctuation. Many libraries now identify the minimum and maximum safe RH levels for their collections which may widen the acceptable range while promoting more sustainable operations.

Many library materials can tolerate a wider range of RH. Cabinets and individual boxes provide some degree of buffering against short fluctuations depending upon the cabinet or box materials and how tightly it closes. For many library collection formats extended storage at extremely dry or humid conditions is more damaging than short fluctuations so long as the minimum or

maximum RH is not extreme. Damage caused by the expansion and shrinking of material due to RH fluctuation can be mitigated or lessened by housing strategies.

This is given usually for temperate countries and must be calculated cautiously in hot and humid areas. And it is always recommended to consult an expert on this matter.

Q: How can we maintain optimum conservation conditions for library collections in hot and humid areas?

A: External climate of a library building introduces most of the thermal energy and relative humidity to the building interior. This presents a huge challenge for conservators in hot and humid climates when planning and implementing environmental management plans for their collection, taking into consideration the comfort of the occupants. To maintain the optimum T and RH in your library, some air conditioning systems or heating, ventilation, and air conditioning (HVAC) units with no relative humidity control functions will not be able to control RH. As explained above, cooling through air conditioning without dehumidification or removing absolute moisture will result in an increase in RH which may be damaging to collections. If you have the financial and natural resources and staff to purchase, operate and maintain them specialized climate control units (CCU) which include humidification and dehumidification systems can be installed for optimum control. Such systems are different from the traditional AC and HVAC unit in their ability to control RH in addition to T, and can vary in size from small units used to control the environment inside a single showcase, or large unit that can control RH and T inside multiple showcases or a small storage space., Specialty equipment can be procured through companies who serve the museum and cultural heritage communities.

In case of power-outages or failure of air conditioning or climate control units, keep the windows and doors closed at all times to maintain T and RH. During this type of malfunction closing outdoor air intakes that feed air conditioning systems is often a good strategy to keep unconditioned and unfiltered air from entering the building, while During outages if possible maintain air circulation or natural ventilation between rooms to avoid pockets of stagnant air that can promote biological growth in humid conditions. Keep window blinds closed to reduce thermal load from the sun. Consider if it is possible and worth the risks of handling to relocated sensitive materials to a more controlled and stable environments if the malfunction cannot be resolved for an extended time period and/or the conditions in the impacted space are extreme.

If the library building is not equipped with air conditioning units and does not have the resources to purchase any climate control equipment determine the natural climate within the building and assess the risks to specific collections. First, it is important to implement a thorough plan to classify the collection based on the type of materials they are composed of (e.g. newspapers, posters, parchment, photographs), to evaluate the condition of items, and identify known risks. When resources are limited focus first on immediate risks such as high RH levels that promote germination of biological growth.

When planning the storage and display of library materials it is important to not place shelves near an exterior wall or window. Leave some space between the wall and the shelves to avoid condensation or other exaggerated risks. Do not place high value items or sensitive items at the bottom shelves near the floor to prevent damage should water enter the space Place the most

sensitive materials in rooms without exterior walls if possible, or avoid placing sensitive materials on shelves near exterior walls. Avoid storing materials in damp basements or hot attics. Perform periodic condition check for the materials. Isolate items that show signs of damage that can spread to other materials.

The next step is to understand the library building and monitor the environmental conditions in each room/area. After analysing and understanding the building a number of measures can be taken to control the environmental conditions including but not limited to: controlling air circulation and exchange (this will help control T and RH, it will also reduce the risk of biological deterioration), installing window blinds or curtains to block sun, insulating external walls, insulating window glass, installing exhaust fans, weather-stripping doors and windows, keeping doors and windows closed, roof insulation. Consider the use of ceiling fans to circulate air. Minimize the use of water for cleaning storage and display areas to avoid puddles which could damage collections or raise RH in the space

Q: What are the different methods for measuring and monitoring temperature and relative humidity? (a question that will introduce each method, traditional, mechanical devices, digital data loggers)

A: There are different types of instruments to measure temperature and relative humidity, ranging from simple thermometers and hygrometers to sophisticated environmental monitoring data loggers. Regardless of what equipment you use look for a devices with high accuracy since the data that you collect will help you understand the building environment and develop environmental control plans. When setting up a measuring or monitoring system, it is important to make sure that the units are calibrated before use. Learn how often the units must be calibrated, and perform the calibration according to the manufacturer's instructions.

It is important to monitor temperature and RH within the storage room or exhibit space as data collected from sensors within an air conditioning system or dehumidifier may not reflect conditions in the collection space.

Some of those measuring and monitoring instruments are:

- 1- **Bulb Thermometers:** This is a low budget option to measure temperature and keep an eye on temperature readings throughout the day.
- 2- **Electronic Thermometers:** Those can be more practical than the traditional bulb thermometers as they can be smaller in size and easier to read when for example they are placed inside a showcase.
- 3- **Psychrometer:** also known as sling psychrometer or "wet and dry bulb hygrometer". Is a hygrometer that uses two thermometers, one dry (dry bulb) and one covered in a fabric saturated with distilled water (wet bulb). Air is passed over both thermometers, either by a fan or by swinging the instrument, as in a sling psychrometer. A psychrometric chart can then be used to calculate humidity by using the dry and wet bulb temperatures. This is the simplest hygrometer yet very accurate and easy to use.
- 4- **Humidity Indicator Cards:** a card with moisture-sensitive chemical that will change colour when the indicated relative humidity is reached. These cards can be used to give a general sense of environment but do not provide precise information. Tracking trends or change in RH with these cards is very hard to do.

- 5- **Hygrometers:** Such as the dial hygrometers or electronic hygrometers, different options can be found in the market but as mentioned before, it is very important to use a hygrometer with high accuracy. There is also the option of thermo-hygrometer, which is good to take spot readings of temperature and relative humidity. There is a wide variety of options for such instruments and this can be useful for display cases monitoring.
- 6- **Data loggers:** are electronic devices that records temperature and relative humidity data over time. This is the best option to keep track of your environmental data over time without having to check it and record it manually. There are different options of data loggers available in the market: 1) standalone data loggers, which you will have to connect to a computer to download and view the data. 2) Wireless data loggers that are connected to a computer via radio signal or via WI-FI that allows you to view and download the data real-time without having to move the device.

Q: What are the different types of damage caused by inadequate/incorrect and/or fluctuating temperatures and relative humidity?

A: Different types of damage can occur to the library collection as a result of inadequate T and RH, which can be listed under three main categories Physical, chemical, and biological.

1- Physical:

The library collection is mostly made of organic materials such as paper, parchment, leather, textiles, those materials are hygroscopic, meaning that they absorb moisture. When RH is high these materials will adsorb the moisture from the surrounding air causing them to expand, when RH drops, the moisture content within the structure of the materials will evaporate causing them to shrink. Physical damage occurs mostly from the repeated fluctuations of T and RH which causes dimensional changes resulting in damage such as warping of paper, breaking of fibres, flaking of ink, cracked emulsions on photographs, and dislocating components of a book as a result of the different rate of expansion and contraction and different physical strength

Chemical:

Chemical damage is caused by chemical reactions within the material which are influenced by, temperature, humidity, reactive pollutants and light. One major form of chemical damage is the acidification of papers made from mechanical wood pulp. In hot and humid climates, High T and RH increases the risk of chemical damage due to increasing reaction rates.

2- Biological:

High T and RH creates suitable conditions for bio-deterioration, mould growth and most insect pests are active in temperatures above 25 °C and RH of around 65%. The time of exposure to inappropriate T and RH is also important as this will determine the time of germination in micro-biological deterioration causes

Q: Do we need to take the buffering effect of books and archival materials into consideration when designing the set points of temperature and relative humidity within the library spaces?

A: Buffering effect of hygroscopic materials (i.e. most materials in library collections) must always be taken into consideration when planning for design set points of climate control units or even when planning to store those materials in separate showcases or moisture-proof boxes to create a micro-climate for items that requires specific storage conditions and/or are infected and need to be isolated.

Materials such as paper of books and gelatine of photographs are hygroscopic objects, which means they adsorb and/or desorb water vapour. These materials take longer time in the evaporation of their water (desorption) than the adsorption.

When studying the environmental conditions in a library it is worth considering that each book has, in normal conditions, approximately 10% of his weight of water content. When considering a large number of books which may be in a closed room, hundreds or maybe thousands, a significant portion of their volume is water (in liquid form but temporarily fixed within the cellulose matrix). This 10% of water is not all free to desorb in case of dry environment, but it represents a huge mass of water which buffer and react with the climate condition inside the room. This mass of water plays a role in buffering the atmosphere. At such point we arrive to a paradoxical situation where actually the books and their water content has a greater effect on the environment than other factors.

For example, a room of 200 m³, may have 6000 books which contain around 500 liters of water (8.5 grams of water at 20 °C and 50% RH). Even if a part of this water could be desorbed, not being fixed permanently to the cellulose, it is a substantial mass in respect to the 8.5 grams of water vapour present in the air (at 20 °C and 50% of RH). The heritage professional can share information about the composition of library materials with engineers who calculate loads when designing climate control systems.

Q: What about audio-visual materials collection?

A: Most audio-visual materials usually require low T and RH in their storage (<10 °C and 40% RH) since they are often more vulnerable to damage caused by incorrect temperature and humidity than older materials. Coloured photographs, films, and magnetic media can show significant signs of decay in less than a human life time, which is a very short time period compared to books and manuscripts that survived for hundreds of years. Audio-visual materials are also subject to physical, chemical, and biological deterioration. High temperature and relative humidity can cause physical damage such as: deformation, fractures, and blocking damage. Chemical damage caused by acid-hydrolysis, and biological damages caused by mould.

Further Reading:

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