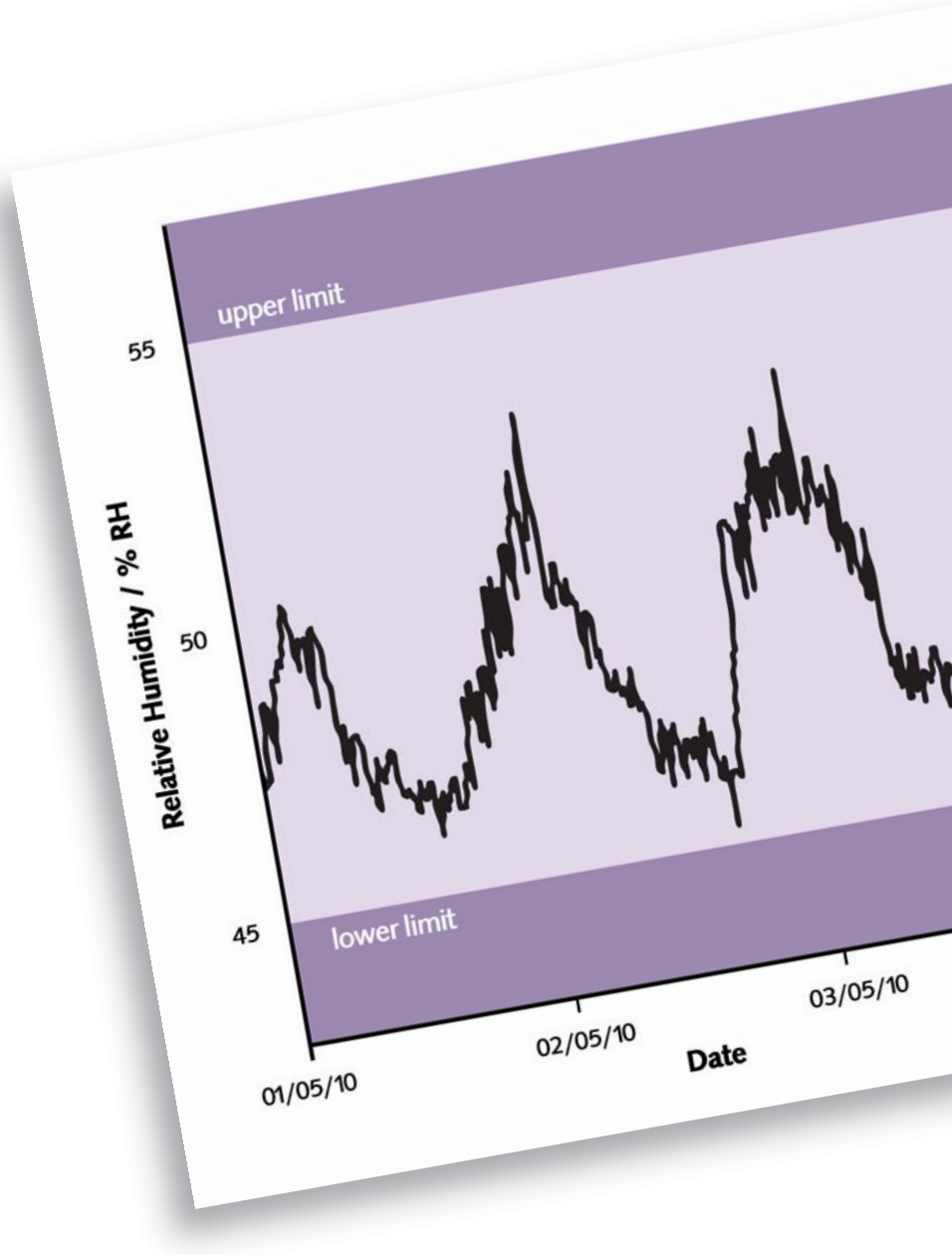
BRITISH LIBRARY

Preservation Advisory Centre

Environment



The Preservation Advisory Centre has been awarded the CILIP Seal of Recognition based on an independent review of the content of its training courses and its engagement with the CILIP Body of Professional Knowledge.

The production of this booklet has been supported by Collections Link **www.collectionslink.org.uk**

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ISBN 978 0 7123 4999 4

Design The British Library Design Office

First published February 2007
Revised December 2010

Managing the library and archive environment

Introduction

The life expectancy of collections is significantly affected by the environmental conditions in which they are stored. Environmental problems in buildings can cause significant damage to collections. These can be quite easy to ignore, building up slowly over time until they reach crisis point. The economics of environmental damage are stark. Poor conditions can lead to damage to hundreds or even thousands of items at one time, each of which may need expensive individual repair. Conservators can often repair damage to books and documents, but this is rarely a cheap process and there are many other negative consequences. Books and documents that are being treated are not available for study, and regardless of the quality of the conservation work, something of the original is lost during treatment. This can lead to a less useful or less valuable item.

Knowing the environmental conditions in a library or archive is essential for planning the best strategy for the preservation of collections and for targeting your resources effectively. With good recordkeeping, the information collected will provide evidence of good stewardship for funders, professional bodies and future donors. Compliance with relevant standards and professional guidelines, and the requirements of government agencies and funding bodies are additional reasons to implement a programme of environmental management. Collecting and acting on data does take time but is impossible to do on a retrospective basis. Good environmental records will mean that evidence of good stewardship of collections can be produced should it be requested, as a condition of a grant, or as evidence of need to support applications to fund improvements.

This booklet provides guidance on environmental management to help you to preserve your books and documents for as long as possible. Although a range of environmental factors can affect library and archive collections this booklet will concentrate on temperature and relative humidity (RH).

Terminology

- **Environment**
  The qualities of the atmosphere in which collections are housed.

- **Environmental conditions**
  Describe a range of factors such as temperature, humidity, light, and pollution that contribute to the overall environment.

- **Environmental damage**
  The damage that can be caused by incorrect humidity or temperature and by light, pollution or a pest infestation that results from a poor environment.

- **Environmental monitoring**
  This is the process of capturing evidence about environmental conditions. Monitoring can be carried out on a continuous basis or as spot readings. A wide range of instruments is available to monitor different environmental factors.

- **Environmental records**
  These are the outputs from monitoring activity and take the form of handwritten lists, charts or databases.

- **Stewardship**
  This term is used to describe a wide range of practices used to ensure the well-being of a collection. It includes the management of environmental conditions and general collection care but also activities such as documentation and security.

Environmental factors

A range of environmental factors can affect collections:

- Radiation in the form of light, and especially ultraviolet light, will cause paper to yellow and inks to fade. The energy from this radiation can also cause structural damage to paper, parchment and leather. Levels of visible light should be set to ensure the most effective balance between the needs of readers and the need to minimise light damage to the collections. Ultraviolet light should be eliminated wherever possible. Light levels can be monitored using a light meter. The amount of damage caused by light is proportional to the intensity of the light (lux) multiplied by the length of exposure (hours)[1].
- *Pollution* monitoring can be complex. Setting it up usually requires specialist advice. Air quality measurement usually includes assessment of levels of particulate matter (dust) and atmospheric pollutants. Even without monitoring, much pollution can be controlled by good building maintenance, housekeeping and the careful selection of materials used for cleaning and storage.
- *Vibration and particulate pollution*. If the collection is to be relocated or if extensive work is planned on the building, additional specialist monitoring for vibration or particulate pollution (dust) may be required. Moving collections can subject them to vibration damage during transit, and in the loading and unloading phases. Good training and handling procedures along with careful selection of equipment and materials can reduce these risks[2].
- *Insect* pest levels should be monitored with a view to reducing levels of damaging pests to zero[3].
- *Temperature and relative humidity.* These factors can have a significant impact on the condition of library and archive collections, and therefore will be dealt with in more detail. It is important, however, to be aware that libraries and archives, the buildings that house them and the documents they contain, are whole systems and that environmental factors are often interrelated.

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[1] For further information on acceptable light levels and damage caused by light see BS 5454:2000. *Recommendations for the storage and exhibition of archival documents* and Chapter 3 of *reCollections* **www.collectionsaustralia.net/sector_info_item/3**

[2] Refer to the Preservation Advisory Centre booklet *Packing and moving library and archive collections* **www.bl.uk/blpac/pdf/moving.pdf**

[3] For further information on Integrated Pest Management and pest control strategies refer to the Preservation Advisory Centre booklet *Basic preservation for library and archive collections* **www.bl.uk/blpac/pdf/basic.pdf**

Temperature and relative humidity

Types of damage

Incorrect temperature and relative humidity (RH) can cause significant damage to books and documents. Decay reactions such as the breakdown of cellulose in paper constitute chemical damage. The rate of these reactions is affected by temperature and humidity levels. Warm, damp conditions provide more energy and so increase the speed of decay. The rate of change for many chemical reactions is doubled for each increase in temperature of 10°C, and for some unstable materials may double with an increase of only 5°C . Library and archive materials are hygroscopic, readily absorbing and releasing moisture. They respond to diurnal and seasonal changes in temperature and relative humidity by expanding and contracting. Dimensional changes accelerate deterioration and lead to such visible physical damage as cockling paper, flaking ink, warped covers on books, and cracked emulsion on photographs. Vulnerability to the physical damage caused by human activities, such as poor handling or packing, is increased in hot dry conditions. Biological damage is caused by organisms such as mould or insects, and is much more common when conditions are damp and warm. It is worth noting that the impact of changes in temperature and RH are buffered by certain types of storage enclosures and by books being packed closely together.

Temperature

Temperature can damage some materials directly. High temperatures can cause wax seals to soften or even encourage the combustion of cellulose nitrate film. At lower temperatures, some organic materials, including plastics, will become brittle, making them prone to physical damage if handled. However, one of the most significant consequences of incorrect temperature is the incorrect relative humidity that can result.

Relative humidity

Relative humidity (RH) is a ratio (expressed as a percentage) of the amount of water vapour actually 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 and pressure. When saturated, the relative humidity of air is 100% and condensation becomes inevitable. The higher the temperature, the more water vapour the air can hold. When the air is cooled, it can hold less water and relative humidity rises.

Since temperature has a direct effect on RH, these two factors must be considered together. Raising the temperature will decrease the RH and vice versa. Switching heating on and off with no change in available moisture will lead to fluctuating RH. To illustrate this, consider a storage area with conditions of 21°C and 50% RH. If the temperature drops to 10°C the RH level will rise to 100% making condensation inevitable.

Some materials such as metal or glass are unstable above or below specific humidity levels. For inorganic materials such as metal, glass or stone there are 'safe' and 'dangerous' levels of RH. However, most library and archive collections are made of organic materials such as leather, wood, paper or parchment and these materials respond to RH much more directly. RH that is too high, too low or that fluctuates widely damages organic collections.

High RH encourages mould and pest activity. Low RH leads to desiccation, shrinking and cracking of organic materials. Extreme changes in RH will result in the objects adsorbing and desorbing water, causing them to expand and contract. If the material is restrained, for example the leaves of a book stitched into their bindings, changes in RH can cause deformation. Large changes in RH can cause permanent damage to most organic materials, for example, splits, warping or cracks. Hot dry conditions can result in collections cracking and splitting. Paper may turn yellow and break, especially when handled. Damp conditions will lead to paper absorbing moisture and as a result it will expand. Books can be badly damaged by this process as individual leaves will warp and the book will swell.

If RH is high mould is likely to form. When RH rises above 65% the threat of mould becomes significant and if there is no air movement the risk increases. The higher the RH rises above this level the more likely mould is to grow and the quicker it will spread. Mould is a form of biological damage which will consume materials like paper and textiles by digesting them. Materials will become weakened by mould and then crumble or collapse. In the process of digesting books and documents, moulds excrete acidic by-products that can damage other surrounding materials such as metal. They can also cause stains which discolour surrounding materials. Moulds can be harmful to humans, so staff and users need to be protected if they handle affected collections[4].

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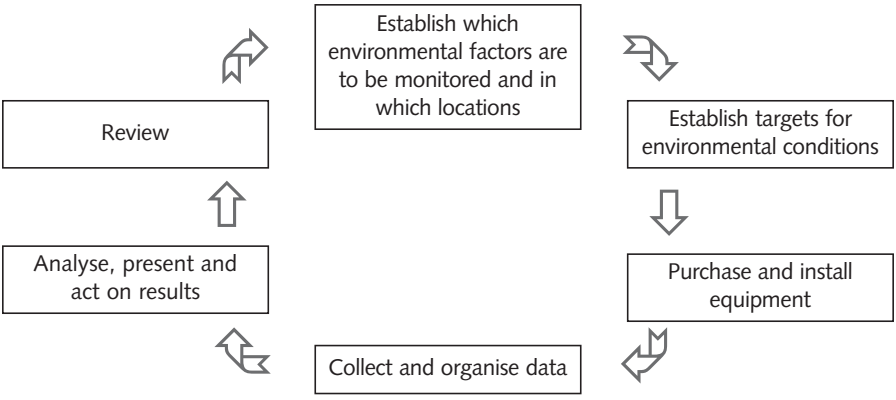
[4] Refer to the Preservation Advisory Centre booklet *Prevention and treatment of mould outbreaks in collections* **www.bl.uk/blpac/pdf/mould.pdf**

Steps for achieving a good environment

The actions needed to achieve a good environment can be seen as a series of steps that should be reviewed as part of a regular cycle. The necessary stages are set out below:



Target conditions for RH and temperature

It is essential to establish targets for your environmental conditions in order to allow assessment of performance in achieving them. Targets can be based on fixed standards or on making improvements to current conditions. Examples of the latter might be to reduce the number of extreme environmental events, or to raise the average winter RH in a reading/search room by slightly decreasing the temperature.

Fixed targets

BS 5454: 2000[5] provides the most familiar target parameters for the preservation of library and archive collections. It contains specific guidelines for the storage of paper and parchment. For frequently-handled material, it recommends that temperature should be kept at a fixed point between 16°C and 19°C with a fluctuation of only 1°C on either side, for example between 16°C and 18°C, or 17°C and 19°C. Infrequently-handled material, which will be less subject to movement from storage areas to reading/search

[5] *BS 5454:2000 Recommendations for the storage and exhibition of archival documents*, London: British Standards Institution, 2000.

rooms, should be kept at a fixed point between 13°C and 16°C with a fluctuation of only 1°C on either side. Relative humidity should be at a fixed point between 45% and 60% with fluctuations to a maximum of 5% on either side. Rapid changes should be avoided. The standard also contains guidelines for the storage of modern media such as photographs, microfilm and moving images. The targets quoted in BS 5454:2000 reflect the results of research into specific decay mechanisms and factor in human comfort requirements for temperature. If the collection is particularly uniform i.e. all black and white safety film, or highly vulnerable, it is possible to set very specific targets for storage conditions that significantly reduce decay rates for that type of material. For mixed collections or open access storage this can prove more difficult. In these situations a more general target that is comfortable for people but limits decay rates becomes most suitable. However, keeping conditions cooler in storage areas, where people are not working or studying, will extend the life of collections.

Matching collections and locations

The simplest form of environmental management is to identify conditions throughout your building and to try to match collections to the conditions most suited to them. A monitoring program could reveal that one storage area is cooler and drier than another. It would then be possible to prioritise using the cooler store for more significant or vulnerable collections and/or those which are less frequently handled. This may well seem 'easier said than done' but informed changes could be built into the general plans for the development of the organisation and over time environmental factors could become important criteria in space allocation. In this situation targets are based on establishing a 'best fit' of your collections to existing conditions.

Combining RH and temperature

Research has been undertaken into the total energy supplied by both temperature and humidity, considering the impact this has on decay processes. Graphs that show lines of constant stability for specific types of materials (known as isoperms) can be drawn up. These show that conditions of 20°C and 50% RH will cause chemical decay in materials such as paper and leather at the same rate as conditions of 25°C and 30% RH or 15°C and 85% RH. Whilst extreme conditions should always be avoided in libraries and archives, the principle can be used to allow more flexibility in setting target conditions. As a general rule lower temperature and lower humidity conditions are most beneficial for infrequently-handled collections. In addition, an increase in either temperature or RH can be offset in terms of the lifetime of collections, by a decrease in the other.

Adapting to external conditions

Recent research in preservation suggests that stable internal climates provide the best conditions for the survival of collections. However, there is increasing concern about the environmental impact of air conditioning systems used to create 'perfect' conditions. Accordingly, some researchers are investigating systems that are based on slight adaptations to external environmental conditions. These researchers also use isoperms as a basis for targets. Buildings and equipment are designed to create conditions that require the least change from external environmental conditions and a reasonable environment for collections. The results tend to be stable buildings, with minimal plant and equipment, which are less prone to disastrous changes if power supplies are lost for any reason. Much of the pioneering work for this has been carried out in Denmark by Tim Padfield[6]. The principle is not very dissimilar to the 'conservation heating' approach taken by the National Trust. Some historic buildings without air conditioning tend to be cool and damp, especially in winter. In such buildings heating systems can be activated by relative humidity levels. Collections will benefit from increased chemical stability as temperatures slowly drop, but if the RH rises above a safe level the heating comes on and the RH falls[7].

Ventilation

Ventilation is a requirement for any area where people work or study. The Health and Safety Executive requires that workplaces are 'adequately ventilated' with 'fresh, clean air' that is 'uncontaminated' and is 'circulated through workrooms' (HSE, 2003)[8]. BS 5454:2000 recommends that any air circulated should contain at least 5–10% fresh air. In storage areas stagnant air is often associated with neglected and damp areas. In these spaces mould and pest infestations can take hold, leading to extensive damage to collections and a health and safety hazard for staff. Even in reasonably good storage areas, pockets of damp stagnant air can build up near cold surfaces or beside walls where maintenance failures have gone unnoticed. As a general rule it is best to ensure that air circulation is possible behind and around

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[6] See **www.padfield.org/tim**

[7] See Staniforth, S. et al., 'Appropriate technologies for relative humidity control for museum collections housed in historic buildings' in Roy, A. and Smith, P. (Eds) *Preventive Conservation: Practice, Theory and Research: Pre-prints of the Contributions to the Ottawa Congress,12-16 September 1994*, London: International Institute for Conservation, 1994

[8] *Workplace, health, safety and welfare: a short guide for managers*, London: HSE, 2006 **www.hse.gov.uk/pubns/indg244.pdf**

stacks and shelves. BS 5454:2000 recommends an air gap of at least 150mm between collections and the building fabric, and 50mm between collections and the shelf above. Regular inspections should be built into your collections management regime. The implications of air circulation for the dispersal of the volatile organic compounds, which are a product of paper decay, are the subject of current research[9].

Choosing monitoring equipment

In order to measure the levels of RH and temperature, appropriate equipment is needed. The choice will depend on the level of detail required, the budget, and how much effort can be put into collecting and interpreting the results. The first step in choosing monitoring equipment is to consider the amount of information (data) that you want. More is not always better. The data collected should be limited to information that staff:

- have some idea how to use
- have time to interpret
- can make plans to act on
- need to satisfy some external requirements.

Some equipment will continue to display conditions on a dial or strip. However, unless the results are noted manually the information is lost. This can be categorised as spot reading equipment. Continuous recording equipment allows a full record of environmental changes to be retained. It may be recorded automatically at a central point or it may have to be downloaded from sensors. Each type has advantages and disadvantages, and these are summarised below:

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[9] See 'Volatile Organic Compounds in Books – Research Project Outline' on the British Library website, **www.bl.uk/aboutus/stratpolprog/ccare/projects/voc/**

Continuous recording equipment

- ✓ Allows you to find out what happens when you are not there
- ✓ Allows a more thorough analysis of conditions
- ✓ Provides data for past conditions that a lender may request
- ✓ Often requires no day-to-day action
- x Amount of data may be overwhelming
- x Needs more work to interpret
- x Usually more expensive
- x Maintenance costs may be higher to ensure data collection is continuous and accurate

Spot reading equipment

- ✓ Data easy to collect (usually)
- ✓ Data easier to manage
- ✓ Often cheaper
- ✓ Normally easier to understand results
- ✓ Can take readings in different places on same day
- ✓ Maintenance does not interfere with readings
- x Results only tell you about conditions when you are there
- x Not a full picture – hard to diagnose complex problems
- x May not be enough data for indemnity, insurance or lenders
- x Needs manual intervention

Many organisations install a continuous monitoring system backed up by a high quality hand-held monitor with a calibration kit. The continuous system helps build a picture of the general environment and the spot meter can be used to check other locations and to confirm calibration.

Accuracy

The total cost of the equipment may not reflect the quality of the actual component that records conditions. Do not assume that because a piece of equipment is expensive that it is accurate. The quality of environmental monitoring equipment can vary widely. The quality of the sensors can be assessed by looking carefully at the accuracy quoted in the product literature and comparing it with other equipment on the market. Most equipment will record temperature with an accuracy of ± 1°C, which should almost always be sufficient. The figures quoted for the accuracy of RH monitoring equipment can be quite confusing. As a general rule an accuracy of ± 2% is very good and an accuracy of ± 5% may be sufficient for basic applications. If very precise information

is required, performance should be discussed with the supplier. Some equipment is more accurate within moderate temperature and humidity conditions than at extremes. The performance should be matched to conditions, budget and need. The precision of the display should not be confused with the precision of the meter. A meter may read 55.2% RH but if the equipment is only accurate to ± 5% then the true conditions may be somewhere between 50.2 and 60.2% RH.

Calibration

Equipment will not retain its accuracy and will need to be recalibrated. Calibration can be carried out in situ, by staff or the supplier under contract, or by returning it to the manufacturer. The decision may depend on local technical expertise, budget and convenience. Whichever method is used, it is vital to ensure that calibration can be matched to recognised standards. Calibration kits or services should adhere to NAMAS[10] traceable standards. For more details of calibration techniques see the Museums Galleries Scotland advice sheet *Monitoring temperature and humidity in museums* published on the Collections Link website at **www.collectionslink.org.uk**.

Suitability

It is almost inevitable that today's hi-tech electronics will be superseded by smaller, quicker, more versatile versions. So the choice of equipment should focus on current needs and the organisational capacity to manage the equipment. Ensure that staff have time to learn to use the software associated with any new monitoring system. Manufacturers advertise a range of features for any piece of equipment, but they may not all be needed. Some systems do a very basic job of measuring conditions, others can be expanded, or become part of a larger multi-function scheme. The following features should be assessed:

- Is the equipment small enough to fit the allocated space?
- Is it robust enough for its intended application?
- Is use tied to a dedicated computer?
- Does any software supplier provide outputs that you want to use?
- Can data be exported for use in other applications?
- Is it sufficiently attractive or tamper-proof to go into a public area?
- Can it be fixed down?

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[10] National Accreditation of Measurement and Sampling

- Is it easy to use?
- Is it easy to maintain and can the batteries be changed without sending it back?
- Can it be calibrated and if so by whom?
- Will there ever be time to read the instructions and use all of the features?

Cost

The amount that is spent on environmental monitoring equipment will be governed by the quality and flexibility of the products and should be in proportion to the use that will be made of the results. For monitoring a brand new air conditioning system significant investment may be justified. If, on the other hand, the equipment is to monitor simple improvements, such as installing cloakrooms separate from reading/search rooms, then it is not necessary to collect a great deal of precision data. Equipment and spending should be proportional to the task in hand.

Spot readings	Cost per unit	**Continuous recording**	Cost per unit
Mechanical/Simple			
• RH indicator cards • Dial hygrometers	• Very cheap • Cheap	• Thermo-hygrographs	• Moderate
Digital			
• Max-Min units • Hand-held meters	• Cheap • Variable from cheap to moderate depending on accuracy	• Radio telemetric system and loggers • Data loggers	• High set up costs, moderate cost per unit • Low set up costs, moderate cost per unit

Recording and measurement

Placing the data loggers

The location of the data loggers must be planned. Obviously, the more loggers there are the more choices there are. Some simple concepts to consider are:

- Monitor where the collections are i.e. place the logger at the same height or on the same shelves.
- Even if the air handling plant has a monitoring system built-in, it may be advisable to take independent readings, especially if the sensors are in the return vents.

- Use the loggers to answer questions, such as: Is there a cooler store? Is the shelving nearest the rear wall damper than others? What is the difference in conditions between the reading/search room and the storage area/s?
- Consider whether the logger is in a location that is representative of the rest of the room or distinct from it.
- Consider future plans. Are collections going to be moved to a new external store? Are renovations planned or might the organisation borrow or acquire a new collection? Will there be a need to monitor storage areas before collections are moved into them or to match conditions in your new building to those in the place of origin?
- Is the logger affected by draughts from doors and windows?
- Is it near a radiator or other source of heat?
- Does direct sunlight fall on the sensor?

It may be advisable to try out several monitoring locations before settling on a more permanent arrangement. Wherever the loggers are placed, it is essential that a good record is kept of their location and that this record is stored with the logged data.

Building Management Systems

With a Building Management System (BMS) the monitoring and control of the environment may be carried out by an estates or buildings department. It may be necessary to explain the environmental requirements for the collections to ensure that the system delivers the best possible conditions. Discussions with colleagues with responsibility for a BMS should focus on the importance of RH, the calibration regime for the sensors, the location of sensors, how data is created and whether it is permanently recorded. Problems that may arise include:

- Temperature controlled for human comfort at the expense of RH.
- Sharply fluctuating RH that is within the guidelines but is not ideal.
- Sensors located in return air ducts not accurately recording conditions experienced by the collections.
- Inaccuracies in sensors that both record and control conditions.
- Data collected as strings of numbers.
- Data kept for very short time periods and then deleted.
- Difficulty in obtaining data if building management is contracted out.

Setting up a monitoring programme which is separate from the control system or BMS will overcome many of these problems.

Collection and storage of data

In order to ensure the consistent collection of data it is best to establish protocols for how it will be collected, presented and stored. A regime for collecting and organising your findings must be developed. The amount of effort must relate to the questions that the organisation needs to answer. Unless the data can be interpreted it is essentially worthless.

For spot readings a standard routine of collecting data should be created. This regime will be informed by staffing levels and time available. Spot readings taken twice a day in each type of space would be a reasonable level to aim for. Readings could be taken at the start of the day before the building is opened to the public and again in the afternoon. If there is an exceptionally busy time or unusual activity an extra reading should be taken.

Digital data should be backed up and may be printed off monthly or quarterly as hard copies of charts. For digital data it is also important to ensure consistency in file naming so that information can be traced. A simple procedure is to store all the data in a raw format by a unique number such as the ID number of the logger and then copy and store it again under a friendly file name such as 'reading room'. This file should be used for data manipulation and interpretation and the numbered file kept as a backup. The first time data is downloaded, a brief inspection of the results should be made for extreme conditions or obvious problems. The staff member in charge of organising the files should have a reporting procedure for notifying any significant concerns. At the filing stage it is essential that supporting information such as weather conditions, events, user numbers, location of loggers and calibration dates is collected and filed in such a way that it can be matched back to the data. Do not be afraid to annotate charts. Notes such as 'floor washed here' 'leak from roof' or 'school visit' will significantly increase the value of the data for those trying to interpret it. A routine for a more detailed inspection of the data should be established. Inspection every six or twelve months should be sufficient in most medium-sized organisations operating under normal conditions. Events such as construction work or moves will call for a closer inspection of results.

Interpreting and using the results

Most systems present RH and temperature data in graphical format against time. Charts can be weekly, monthly or yearly. Setting different time periods will allow investigation of different features. For example, a weekly chart helps identify the impact of switching on the lights in the morning and a yearly chart highlights seasonal trends. Probably the most common chart is the monthly chart as it shows a sufficiently long time period to illustrate trends but more detailed daily information can still be extracted. When looking at these charts an important factor to consider is the relationship between temperature and humidity. Since raising the temperature will lower the RH, the tracings on the chart will often move in opposite directions (see Fig. 1). In this case stabilising the temperature will stabilise the humidity. If temperature and humidity are not moving in opposite directions then moisture is being introduced or lost from the room (see Figs. 2-3). In these circumstances the amount of moisture available needs to be considered and changed if RH falls outside target conditions. In some circumstances the two lines follow each other. Usually this occurs in a fairly well-sealed space with something acting as a 'buffer'. Wood, paper and other moisture-absorbing material can give out moisture when temperature rises and RH falls so they compensate for changes in environmental conditions. The collection is, in effect, self-buffering. More advice on interpreting RH and temperature charts can be found in the *Relative humidity and temperature pattern book*, published on the Centre for Sustainable Heritage website at **www.ucl.ac.uk/ sustainableheritage/ RH_pattern_book.pdf** . It may be necessary to consult a conservator or environmental specialist, as charts can sometimes be difficult to interpret.

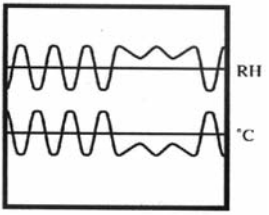

Fig. 1. Temperature and Humidity mirroring each other.

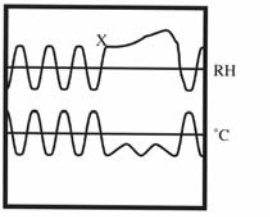

Fig. 2. Extra water into air at point X – perhaps wet weather.

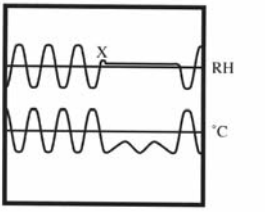

Fig. 3. De-humidifier takes water out of the air at point X.

Monitoring is only valuable if the data is collected, interpreted and acted upon. Unfortunately some organisations commit significant resources to monitoring conditions but little to using the results. This represents a significant waste of capital expenditure and staff time. There is no point filling folders and cabinets with charts if no one hears about them. Not many people will find a folder of charts fascinating or informative, so it is sensible to distil the information down into key facts. If conditions are compared with the environmental targets that were set, the report can comment on progress in achieving or maintaining these targets. Reports may comment on the percentage of time that a room falls outside target conditions or the number of such events. This should be followed up by an analysis of why this has happened and suggestions for a future course of action. Improving the environment should start with the building and the wider environment. Changes made from the outside will make the biggest difference and will be the most sustainable. They may be costly, but in the long term are most effective. For example, if a reading room is damp a dehumidifier could be installed. However, if the root of the problem is blocked guttering then fixing this would be the most effective action in the long term. It is vital to identify and cure the problem, not just treat the symptoms.

Preservation Index and Time-Weighted Preservation Index

The Preservation Index (PI) was developed by the Image Permanence Institute as a means of assessing how benign or aggressive an environment is for vulnerable organic materials, such as paper and parchment. Based on research into the effects of the storage temperature and relative humidity on the deterioration of a specific type of photographic film, it gives the time in years for a just noticeable change in appearance. It is not a predictor of the useable lifespan of any item, but it is a convenient comparative measure, using materials that are known to be unstable as a yardstick. This makes target setting easier and aids decision-making when trying to balance user and collection needs. For example, the Preservation Index (PI) of a reading room at 21°C and 45% RH is 44 years but the PI of a storage area at 15°C and 45% RH is 95 years. If 44 years is considered too short a lifespan for some material in the reading room, either it can be moved to the storage area, or the temperature and humidity in the reading room dropped to 19°C and 42% RH, raising the PI to 62 years. The attraction of the system is that it allows a quick and easy assessment of the costs and benefits of different solutions and measures improvements in very understandable terms. A small program for calculating the PI from ambient temperature and relative humidity levels can be downloaded from the IPI website at **www.imagepermanenceinstitute.org** .

The calculation of the PI assumes that the storage conditions are constant and unchanging. In reality, temperature and relative humidity fluctuate. The Time-Weighted Preservation Index (TWPI) attempts to account for the effects of variations, calculating when deterioration is rapid (high temperature or relative humidity) and when it is lower (low temperature and relative humidity). The Image Permanence Institute markets the Preservation Environment Monitor® and Climate Notebook® software that can calculate the TWPI from environmental data.

Online resources

A list of environmental monitoring and control resources is available at Conservation Online, **http://cool.conservation-us.org/bytopic/environment**

Free downloads and Information on environmental monitoring can be found on the Image Permanence Institute website: **www.imagepermanenceinstitute.org**

The following Scottish Museums Council (SMC) advice sheets are all available through Collections Link, **www.collectionslink.org.uk**

- What is environmental monitoring?
- Air Pollution
- Monitoring Light and UV radiation in museums
- Monitoring temperature and humidity in museums

Additional reading

BS 5454:2000 Recommendations for the storage and exhibition of archival documents, London: British Standards Institution, 2000

Cassar, M. & Hutchings, J., Relative humidity and temperature pattern book: a guide to understanding and using data on the museum environment London: Museums and Galleries Commission, 2000
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Preservation guidance booklets

The following booklets can be downloaded free of charge at **www.bl.uk/blpac/publicationsleaf.html**.

Free printed copies are also available.

Basic preservation for library and archive collections

Building blocks for a preservation policy

Cleaning books and documents

Damaged books

Good handling principles and practice for library and archive materials

Guidance for exhibiting library and archive materials

Managing the digitisation of library and archive materials

Managing the library and archive environment

Managing the preservation of library and archive collections in historic buildings

Packing and moving library and archive collections

Photocopying of library and archive materials

Preparing funding applications for preservation and conservation projects

Prevention and treatment of mould outbreaks in collections

Preservation of photographic material

Specifying library and archive storage

Understanding and caring for bookbindings

The Preservation Advisory Centre promotes the benefit of good preservation practice and provides support in the form of information services, training and preservation management tools.

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