ADVICE SHEET

Monitoring temperature and humidity in museums

Museums Galleries Scotland

Introduction

Monitoring of the museum environment is one of the basic tasks of all museums. The Museums Galleries Scotland advice sheet *What is Environmental Monitoring?* explains the reasons for monitoring the environment and its purpose. This advice sheet introduces the basics of monitoring the environmental factors of temperature and relative humidity. It will describe the equipment available, how it should be used, checked and cared for and what the results of monitoring might tell you. Further information and advice is available, details of which are at the end of this sheet.

Monitoring: how often?

You need to monitor temperature and humidity, which means measuring them regularly and frequently, to get a complete picture of the museum environment. Ideally you should measure and record both continuously, 24 hours a day. This is because the temperature and relative humidity can fluctuate frequently and dramatically on a daily, weekly or annual basis.

There are several reasons for this: natural changes of outside climate and weather conditions are often reflected inside museum buildings, add to this the effects of heating, lighting and visitors and the resulting indoor environment can be quite variable. Most museum objects are affected one way or another by extremes, or frequent fluctuation, of temperature and humidity.

Equipment: what should I use?

Temperature and relative humidity are closely related and are often measured with one instrument. Temperature is expressed in degrees Celsius (°C). Relative humidity is expressed as a percentage (%RH). There is a wide range of monitoring equipment available and the prices vary depending on the complexity, reliability and accuracy of the equipment, and on its function.

Continuous recording instruments

Recording thermohygrograph

Thermohygrographs use a bi-metallic coil to indicate changes in temperature, and a bundle of human hair, which expands and contracts depending on its moisture content (which will

change as the humidity of the air changes), to indicate changes in humidity. The changes are recorded on a chart that rotates on a drum over a fixed time period. This gives a continuous readout of the changing environment that is very easy to interpret. These instruments are best left in one place for most of the time, as moving them about may upset the calibration.

Data-loggers, telemetric sensors and hard-wired systems

These instruments have electronic sensors for both temperature and humidity. These are less vulnerable to movement and so this type of instrument can be moved frequently without upsetting the calibration. They log or record readings very frequently, storing them in the logger or on a computer. Data-loggers need to be connected to a computer periodically to download the data they gather. Telemetric (radio-linked) and hard-wired systems relay the data directly to a computer to allow it to be read on-screen instantaneously. Some of these systems can be networked to cover more than one building from a central point, and some can also help to control the museum environment by providing instructions to environmental control equipment such as radiators and dehumidifiers.

Instruments for spot reading

Whirling or aspirated hygrometer

This once commonly used instrument consists of two thermometers, a wet bulb and a dry bulb, which are used to measure the temperature and calculate the humidity. The measurement is very accurate, but human error during use and calculation can give rise to misleading results.

Electronic hygrometers

These instruments use electronic sensors that respond to air temperature and humidity. They are less quick to react than a whirling hygrometer, which can give an instant reading. They are often used for spot-readings, as they are light and easy to operate.

Dial (or "hair") hygrometer

This instrument uses a bunch of hair, like the recording thermohygrograph, indicating relative humidity on a "clock face" dial. As with the thermohygrograph, movement of the instrument can upset the calibration.

Humidity indicator cards

These cards have patches impregnated with cobalt chloride, which change colour at a certain humidity level. The cards give an indication of humidity levels but they are less accurate than the instruments mentioned above. They can be useful as a cheap and easy way to monitor the conditions inside a display case or inside a box of archaeological material in store.

Accuracy and calibration

All instruments are subject to some degree of *error*. This is usually discussed as *accuracy*. There are some important principles to remember.

1. It is only possible for any RH monitor to give a guide, within a few percent, of the actual level of humidity. Often this may be written as e.g. +/- 3%.

2. This means that there could be as much as 6% difference between two monitors that are **both reading correctly**.

3. There is nothing we can do to prevent this error, but we can make sure it remains this small by reading monitors correctly and checking calibration.

Reading RH accurately

Type of Equipment	Accuracy	Maximizing accuracy
Thermohygrograph	+/- 3%	• Place chart correctly • Check calibration monthly • Read to the nearest line
Dial hair hygrometer	+/- 5%	• Check calibration monthly • Read to the nearest mark
Whirling hygrometer	+/- 2%	• Check that both thermometers read the same before wetting • Continue whirling until readers are ready • Read as quickly as possible • Read to the nearest half-degree
Electronic hygrometer (handheld)	+/- 2%	• Check calibration annually • Wait for reading to settle (this might take up to half an hour)
Electronic hygrometer (continuous recording)	+/- 2%	• Check calibration annually

Checking and Calibration: who, how and when?

Instruments need to be correctly calibrated to read accurately. The manufacturer often calibrates new instruments but, after a period of use, they will start to drift. Calibration checking aims to find out how large the drift is. Sometimes it is possible to correct the drift but often it is better to simply note it and not try to alter the instrument. This is because altering the instrument will wear it out more rapidly and can also lead to more extreme drifting. The purpose of calibration is to check how an instrument is reading against an absolute and known standard; a poorly calibrated instrument will give results that are at best inaccurate and at worst completely misleading.

Museum staff or volunteers can carry out some calibration tests, but some checking has to be done by NAMAS registered laboratories, which can check against national standards.

Type of equipment	Who?	How?	How often?
Recording thermohygrograph	Museum staff	By comparing with a whirling hygrometer or calibrated electronic monitor	Once a month
Hair hygrometer	Museum staff	By comparing with a whirling hygrometer or calibrated electronic monitor	Once a month
As above	Museum staff	By wrapping in a damp cloth and checking that monitor reads above 95% RH.	Every 6 months

Type of equipment	Who?	How?	How often?
Hand-held electronic monitor, some dataloggers and electronic sensors	Museum staff	By using saturated salt solutions, according to the suppliers instructions	Every 6 months
As above	Supplier / NAMAS lab	By conducting a NAMAS check against a standard	Every year (or every other year if also doing self-checks)
Saturated salt solutions	Supplier / NAMAS lab	By conducting a NAMAS check against a standard	Every other year
Whirling Hygrometer	Museum staff	By checking that both thermometers read the same before wetting one for use	Before every time it is used

If you find during your checking that the instrument is so poorly calibrated that you are not confident that it can tell you anything useful about the environment you can either send it away for a service or repair or think about replacing it with another instrument.

Many electronic instruments have a limited lifespan as the equipment and its software can become obsolete and the manufacturers cease to provide support even if the system still works effectively. It is best to plan for systems to be replaced after about 10 years. Some manufacturers will offer part-exchange on their old radio-telemetry sensors and equipment.

Where to monitor?

You should aim to monitor in all areas of your museum where collections are housed: both stores and display areas. The locations to choose will depend on a variety of factors, but bear in mind that your monitor will only give you information about the local environment it is in. Try to make sure that the sensor (the part of the instrument that reacts to the environment) is somewhere that is in the centre of the space that you want to monitor. You should avoid putting instruments on the floor, near a heat source, near a humidifier / dehumidifier or beside a door or window. Also, try not to place an instrument somewhere where it may be tampered with or accidentally knocked or moved.

Keeping a record

Some equipment, such as the recording thermohygrograph or a data-logger, will provide you with a graphed summary of data over a period of time. If you are taking daily spot readings, you can summarise these graphically too, either drawing by hand or using a computer. Daily records can be very useful and provide you with a lot of information, so don't dismiss this method of monitoring. A sample of a recording table that might be used for this is given below.

Environmental record
Location: gallery one, near entrance
Year: 2008

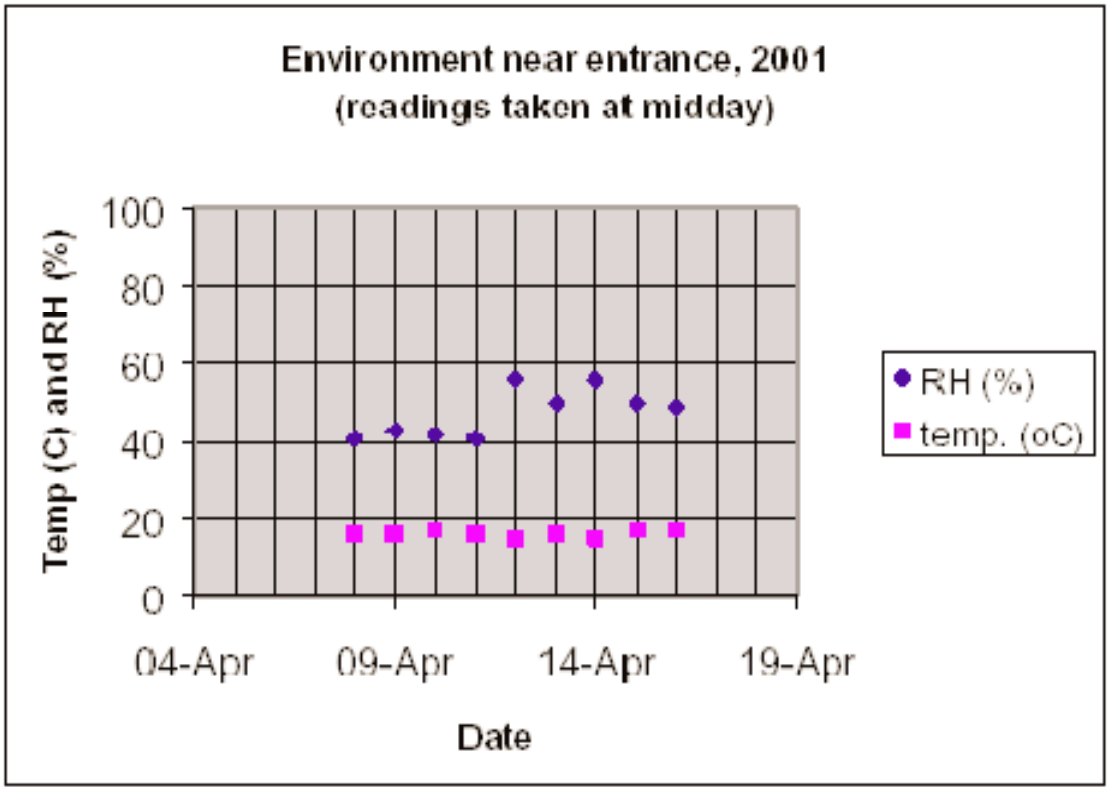
Date	Day	Time	RH (%)	Temp. (°C)	Dehumidifier on? Y/N	Heating on? Y/N	Notes	Weather	Outside temp (°C)	Initial
8/4	S	12.30	41	16	n	y	Setting up exhib.	rain/sun	9	EH
9/4	M	12.30	43	16	n	y	"	rain	11	EH
10/4	T	12.45	42	17	n	y	"	rain/sun	12	EH
11/4	W	12.00	41	16	n	y	"	sun	10	EH
12/4	T	12.00	56	15	y	y	Press photos	rain/sun	12	EH
13/4	F	12.00	50	16	y	y	Open for season	sun	11	EH
14/4	S	12.45	56	15	y	y	Busy day!	rain/sun	12	JR
15/4	S	12.15	50	17	y	y	Easter	sun	13	JR
16/4	M	12.30	49	17	n	y		rain/sun	12	JR
17/4	T									
18/4	W									
19/4	T									
20/4	F									
21/4	S									

General Notes:
12 April: press photos for new exhibition first thing – many more people than we thought and had to leave front doors open for ages while they brought their equipment in!
13 April: Opening of new exhibition for friends and volunteers and families in the evening.
14 April: Very busy first day! Doors open a lot. Many people brought wet coats into the museum…

What does it mean?

Remember that record summaries are just that: you will still need to provide a commentary to explain what they mean for your museum. By making notes of events, weather, etc, it is far easier to start to interpret what you are seeing.

From collected data, you can start to see patterns. In the sample table above, it is relatively easy to see the effect that opening the doors of the museum to visitors (or the press) can have on the RH inside. On rainy days it is also easy to see that there is a greater rise in RH indoors. If the data in the table were translated into a graph it might start to look something like this:



Because it is often easier to see patterns on a graph than in a table, graphing data can be very helpful for interpretation purposes. With practice, you will get used to reading charts and commenting on relationships. In the table there is a 24-hour interval between readings. By joining the dots on the chart the information would be presented in the same way as a thermohygrograph chart, but this might be misleading. The thermohygrograph records continuously and the data from spot readings cannot inform you about the full range of environment in the museum.

In environmental monitoring you are not just collecting single charts, you can be collecting a number of these over months and years. You need to identify the longer term patterns too, through analysis of large amounts of raw data. Analysis is more-or-less the same thing as interpretation, but done quantitatively - with numbers and statistics. Strictly speaking we interpret information and analyse data.

How you interrogate the data will depend on what you are trying to achieve. If this is the first time you have monitored and you are not clear about this, there are some basic first questions to ask yourself. These include:

- How much of the time is RH outside the recommended band?
- How much does temperature and RH vary each week (month / year)?

With computer–based systems this sort of analysis can be done directly but you can use computer spreadsheet packages or drawn graphs to analyse raw data that you input by hand.

Reporting – what and how?

This stage of the monitoring process is vital, because it is by reporting on what you find that you are able to use the gathered information to make improvements. Your findings should be used to plan improvements and this means that you need to report to the people in your organisation who make decisions on forward planning and budgets.

Preparation of an annual report is a useful exercise and will help others to see how the environment is improving over time. However, short-term monitoring projects that have been done to find out about problems should also be reported as soon as the findings have been interpreted.

It can help to make some recommendations in a report that will guide those reading it towards solutions. For example, if your monitoring report notes that the RH in the museum is always too high, winter or summer, it would make sense to prepare a list of possible options for improving the situation, such as increasing heating or installing a dehumidifier, and to list the pros and cons of each.

The final analysis

Monitoring of temperature and humidity in a museum should never be seen as an end in itself. It is a means to an end and a vital step in environmental management.

Successful monitoring of temperature and humidity will:
- protect collections
- reduce museum running costs
- train staff and volunteers in conservation skills
- support funding applications
- inform improvement projects.

Further reading

Cassar, M. and Hutchings, J.
Relative Humidity and Temperature Pattern Book
2000, Museums and Galleries Commission
– a guide to understanding and using data on the museum environment

Cassar, M.
Environmental Management: Guidelines for Museums and Galleries
1995, Routledge
ISBN 0-415-10559-5

Further information and advice

This is one of a series of factsheets, advice sheets and guidance notes produced by Museums Galleries Scotland on common collections care and preventive conservation issues. For more details, signposting to further sources of advice or information on how to contact a conservator, see our website at: www.museumsgalleriesscotland.org.uk

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