SECTION 2:
WHAT YOU NEED TO DO

ACHIEVE THE LEAST RISK TO COLLECTIONS AND THE BEST ENERGY SAVINGS POSSIBLE

Section Two includes four chapters:

- Chapter 3: Document the Current Storage Environment
- Chapter 4: Document Each Storage Facility's Mechanical System
- Chapter 5: Understand the Role of Dew Point
- Chapter 6: Analyze Collected Data

These chapters introduce the primary steps involved in achieving an optimal and sustainable preservation environment. Armed with an understanding of the environment, its effect on material decay, and the factors that shape the storage environment, you are ready to dig deeper into the reality of your own situation.

Section Three – Institute Sustainable Preservation Practices – will cover the activities required to maintain an optimal and sustainable preservation environment, including the development of an Environmental Management Team and suggestions for investigating opportunities for energy savings in your institution.

3

CHAPTER 3:
Document the Current Storage Environment

Environmental monitoring is undertaken in order to understand how the storage environment is affecting the preservation of collections. Historically, this task resulted in handwritten logs of temperature and RH or weekly charts made by hygrothermographs. How much could this data tell us about the preservation quality of the space and the long term effect on collections? With a focus on "flat line" temperature and "ideal" RH ranges, the short-term data available could identify any deviations from targets and set points. Unfortunately, this short-term perspective worked against the consideration of more significant trends such as seasonal variation and equilibration rates.

Today, we have the ability to collect data electronically and to use computer programs to do extensive calculations on collected data. Computers can quickly condense a whole year of data onto one graph and provide a long-term, statistic based evaluation of the preservation quality of the storage space.

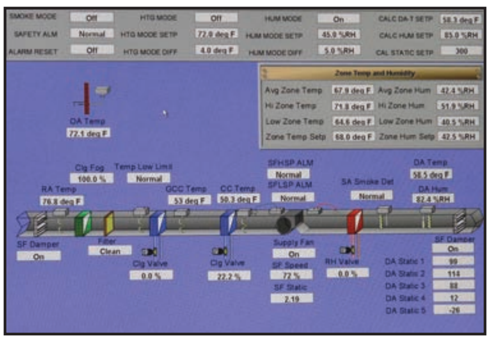
3A Collect Appropriate Data

Regular monitoring of environmental conditions will provide you with accurate statistical information, which should form the basis of both long and short term plans for collection care and preservation. It will enable you to document the actual environment in the storage area, and to illustrate how well the HVAC system is performing. Informed data analysis will allow you to head off potential preservation problems and see clearly how environmental conditions are impacting the life of the collection. Reliable data can be used to develop strategies to improve the storage environment and identify whether those strategies are actually working.

Determine Who Will Monitor the Storage Environment

IPI's experience shows that environmental management usually works best when the collections care staff (conservators, curators, archivists, preservation professionals) does its own independent monitoring of the environment in collection storage and display spaces. Collections care staff are responsible for determining whether the collections are well served by the environment they exist in. To fulfill that basic professional responsibility, they need temperature and relative humidity data from monitored spaces that reflect the conditions experienced by the collections (in some instances even inside objects or showcases), rather than just in ducts and on walls where building control sensors are placed. This data should be continuous, accurate, and in a form that allows for convenient organization and interpretation. When weighed against the importance of the environmental management task and the high cost of creating special climates, the time and expense of deploying dataloggers for use by preservation staff in fulfilling their basic professional responsibilities is small. Having 'their own' data is essential if collections care staff are to engage constructively with facilities staff in the effort to improve environments and manage risks to collections that arise from facility management and sustainability activities.

Building Management Systems

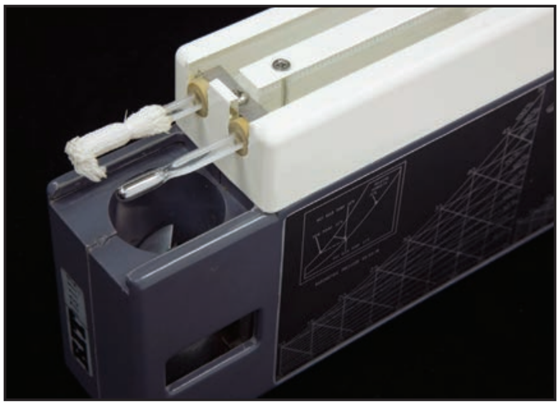


In some cases, data from BMS or EMS (Building Management Systems or Energy Management Systems) can also be used with moderate success. Modern building management systems are computerized and include centralized controls for mechanical systems and other devices used in facilities management. BMS sensors are placed to allow Facilities to monitor for control of specific equipment, not for long-term analysis of the storage environment. These systems may offer the capacity to 'trend' (store and graph data from control sensors in spaces) and export that data to other software for further analysis. However, in many real-world situations it becomes too time-consuming and cumbersome for facilities staff to perform comprehensive monitoring using the BMS. The BMS is a tool for control and is not designed for extensive data analysis. In addition, BMS system designs are secure and proprietary, and they can be quite complex to program.

3B Environmental Monitoring Tools

The choice of monitoring hardware depends on your institutions monitoring goals and how you intend to use collected data. Monitoring devices vary in size, accuracy, data capacity, ease of use, battery life, and of course, cost. There are spot measuring devices as well as continuous recording devices. Some devices have displays and some do not. Monitors may be connected to computers via radio signals or network cables and can therefore collect data in real time. Standalone dataloggers store data internally until it can be retrieved and uploaded to a computer for graphing and analysis. This data transfer can be done with a USB cable or portable memory card. Commonly used environmental monitoring tools are described below.

Psychrometers



Psychrometers are used to make daily readings, spot recordings, and to calibrate dial hygrometers and hygrothermographs. Psychrometers give you a relative humidity reading by comparing the temperature between a "dry bulb" and a "web bulb." The dry bulb is a mercury thermometer. The wet bulb is an identical thermometer covered with a wetted cotton wick. The cooling effect of evaporating water causes the wet bulb to read lower than the dry bulb. The drier the air, the faster the water evaporates and the lower the reading. There are two types of psychrometers—sling and aspirating. The sling psychrometer has to be whirled around in the air for one minute and the results recorded immediately. The process should be repeated until you get the same readings twice in a row. The aspirating psychrometer uses a battery powered fan to blow air over the bulb at a set speed. According to ISO technical report 18931, the accuracy of wet-bulb/dry-bulb thermometers is +/-5% if all the variables are managed correctly. The thermometers that measure temperature have good long-term stability, so the problems with psychrometers usually arise from operator error or problems with the cotton wick.

Hygrometers

Both dial and electronic hygrometers measure relative humidity. Dial hygrometers have a hygroscopic material, usually paper, attached to a hand on the dial. As the material absorbs or gives off moisture it expands and contracts, causing the hand to move across the dial. These instruments are inaccurate below 40% RH or above 80% RH and are difficult to calibrate. Digital versions have built-in temperature monitors. They are often calibrated with saturated salt solutions provided by the manufacturer.

Hygrothermographs

Hygrothermographs provide a continuous record of temperature and relative humidity over a set period of time. These units include a temperature-sensitive element, usually a bimetal strip, and a hygroscopic element, usually a human hair bundle or a polymer membrane. A spring or battery operated drive rotates a paper chart which has been wrapped around a cylindrical drum. Recording pens attached to linkage arms rest on the revolving chart, moving up and down as the temperature and humidity sensitive elements react to changes in the environment.

When properly calibrated, hygrothermographs are accurate within +/-3% to 5%. They are most accurate within the 30% to 60% RH range and require frequent calibration—every few months ideally. Charts must be removed at the end of each recording cycle and pens require frequent maintenance.

Data can be assessed on a short-term basis by looking at the hygrothermograph chart. It is labor intensive, but the data can be typed into a data management program in order to see long term trends.

Electronic Dataloggers

Electronic dataloggers measure temperature and relative humidity continuously and store the data for later graphing and analysis. The most common electronic humidity sensors use technology based on electrical resistance or electrical capacitance. When the relative humidity of the environment changes the sensor registers the change. Data collected by these devises is more comprehensive and more accurately reflects the actual environment experienced by collections.

There are many electronic dataloggers on the market that measure temperature and relative humidity data and make it available as graphs for analysis. The main types are standalone battery-operated units, and units that are hard-wired to an Ethernet or radio frequency units that include transmitters and a base station. The standalone units are the most popular and practical in most institutions. Individual units can range in cost from $65 to $800 (plus ancillary costs), depending on a range of variables including operating range, accuracy, data retrieval method, memory, battery life, etc. Design specifications and calibration standards vary greatly.

The accuracy of the most common devices can be as refined as ±2% RH or as high as ±5% RH depending on the accuracy of its calibration. The stability of electronic sensors also varies greatly. Under benign environmental conditions they can be very stable, but can drift over time, causing their readings to fall outside of their original accuracy range. The tendency to drift can increase if the sensor is exposed to extreme levels of temperature or humidity for prolonged periods of time. To ensure the most accurate readings, follow the recalibration schedule recommended by the manufacturer.

Electronic dataloggers require an associated software program that allows you to produce data graphs and tables. The software may be included or available for an additional charge. The features and capabilities of the programs vary a great deal as well. Some only produce data graphs, others allow you to manipulate data in a number of ways to generate reports, analyze trends, or extract information useful for collection preservation or HVAC management. When investing in environmental monitoring tools it is important to consider the initial cost of both hardware and software, as well as the time and effort required to upload and retrieve data, and to organize and analyze the data once you have it.

> ***Full Disclosure:***
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> *IPI developed an electronic datalogger based on our preservation research specifically for use by cultural institutions. IPI also has sophisticated collection management software. You can read more about IPI's Environmental Monitoring Products in Section 4 of this guidebook.*

IPI strongly recommends managing environments using data in electronic form. Computers are absolutely vital tools for organizing, analyzing and reporting on environmental conditions. Non-computerized data gathering tools such as dial hygrometers and hygrothermographs are unsatisfactory because they do not allow for overviews of long-term trends or easy statistical analysis, and they preclude any use of more modern computational approaches such as IPI's Preservation Metrics™ (see Section 6B). Electronic dataloggers and other sensors connected directly to computer systems are usually more accurate, more effective, and less time-consuming to use than the other alternatives.

3C Determine Where to Locate Environmental Monitors

We are often asked how many monitors are needed and where they should be placed. It is not as simple as saying use one logger per room or that one logger will cover so many cubic feet of storage space. Other factors should be considered depending on your goals for data collection and analysis. You may want to gather data from:

- Storage locations that hold the most important or valuable collections
- Storage locations that house the most vulnerable collections
- Storage areas that have different environments from others because they are served by different HVAC equipment
- An area where the HVAC system does not seem to be working properly
- Storage locations that have had environmental problems in the past—you may need data to justify the need for improvements

In a historic house consider monitoring north and south facing rooms which may receive differing amounts of heat from the sun. Basement storage locations may be effected by high humidity levels from open drains or soil moisture that produce higher dew points than above-grade spaces in the same building.

Place loggers on a shelf or near the cabinets where collections are stored. You may want to place loggers midway between the floor and top shelf or ceiling, unless you have very tall bays of shelving and stratification is a concern. Avoid placing loggers near outside doors, air vents, radiators, cold walls, fans, and other sources of heated, cooled, dehumidified or humidified air.

It is important to measure temperature and humidity routinely, although in most cases it isn't necessary to download the data daily or even weekly – every few months is usually fine. It is important however to gather data from each location for at least one year so that the data you analyze covers the change of seasons (both heating and cooling seasons). Assign each monitor to a single collection area and leave it in place for a full year. Data collected over a short period of time has limited value for analysis.

3D Additional Considerations when Selecting Environmental Monitoring Devices

Desirable characteristics in an environmental monitoring device include simplicity of use, accuracy, overall expense, and the ease of data transfer to the computer where interpretation and graphing of the data will take place. The overall expense factor includes the cost of associated software, the cost and frequency of recalibration, and the time needed to set up, deploy, and periodically collect data from the loggers.

In June 2008, IPI developed a datalogger comparison table, which is available for review at https://www.imagepermanenceinstitute.org/environmental/datalogger-comparison. In 2011, conservator Rachael Perkins Arenstein researched the most commonly used data management tools and produced a document comparing dataloggers for museum monitoring for the National Park Service which is available at http://www.nps.gov/museum/publications/conserveogram/03-03.pdf.

Finally, consider how you will use and interpret the data you collect. Too often people focus on the price of the monitoring hardware and assume that once they have environmental data, its meaning will magically become clear. The reality is that making sense of data and putting it to practical use has always been the most difficult part of monitoring. See Chapter 6, Analyze Collected Data for more information on getting useful information from the data you have collected.

CHAPTER 4:
Document Each Storage Facility's Mechanical System

To achieve an optimal and sustainable storage environment it is very important to develop a clear understanding of the HVAC equipment that serves your storage areas. Work with facilities staff to create floor plans identifying the AHU that serves each storage area and an associated list of the areas served by each AHU. It is also instructive to prepare schematic diagrams which follow the air stream loop from the point it leaves the storage space by passing through the return air grills, moves along the return air path to the AHU, and then returns through the supply air ducts to re-enter the storage space via the supply air grills.