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Environmental Monitoring: A Library Case Study

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by Kazuko Hioki

MOST LIBRARIANS UNDERSTAND the effects of environmental conditions on collections. However, do you know how much the daily and seasonal temperature and relative humidity (RH) fluctuate in your facilities? Is the existing climate level acceptable? Is the mechanical system performing as it was designed? How can we quantify the effect of environment on the natural aging rate of organic materials? The University of Kentucky (UK) Libraries Preservation Department launched environmental monitoring projects in several library buildings over a year ago.

Storage Facilities and Environmental Concerns

The UK Libraries consist of 15 branch and associate libraries with holdings of over 3.4 million volumes, 6.4 million microfilms, and 32,000 current periodical subscription titles. Six facilities were selected for this project because of environmental concerns and the impact on materials housed there.

HOBO data logger

Because mold-infested items are never sent to the storage according to Library policy, the mold had likely grown while in storage.

Three of the six are closed stacks environments and are outlined below.

1. Underground Storage: "The Cave"

Since the 1990s, the UK Libraries have contracted with a commercial underground storage facility that consists of a one-acre stack area within a 32-acre limestone cavern.

A couple of years ago, the interlibrary loan department noticed evidence of mold on materials housed in this storage facility. The Libraries consulted with a university mycologist who took samples from the site. His examination found detritus of an inactive, non-toxic mold species. Because mold-infested items are never sent to the storage according to Library policy, the mold had likely grown while in storage. Since we had no data to verify temperature and RH levels, the Libraries began to investigate the infestation.

Fig. 1

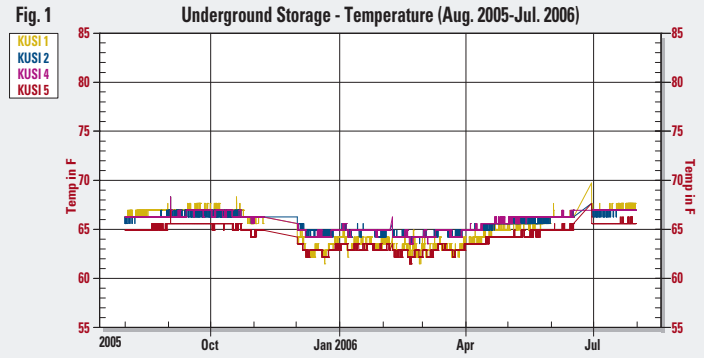
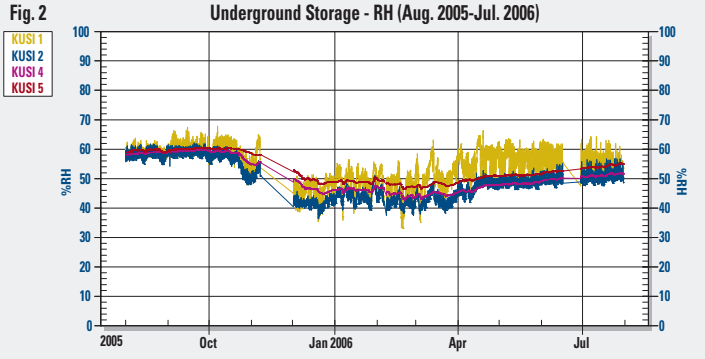


Fig. 2



2. King Library Special Collections Closed Stacks: "The Core Stacks"
Built in early 1930s, the King Library houses Special Collections and Archives which includes rare books, manuscripts, photographic materials, acetate films and other artifacts. A "core" of closed stacks, including a basement and five floors, form the middle of the building. The stacks environment has been controlled by two independent Liebert units, which run 24 hours/day, 365 days/year. According to spot checks, the desirable environment was inconsistently achieved in the Core Stacks. The rest of the King building that surrounds the Core Stacks is controlled by a central HVAC system, which is shut down at night, on weekends and holidays.

3. Basement Storage Room: "The Vault"
Some of the most vulnerable materials in Special Collections and Archives such as nitrate and acetate films, videos, broadcast archives and photographic materials are kept in a closed stack in the Fine Arts Library basement. This space is a large, L-shaped room with compact shelving units. One independent Liebert unit runs 24 hours/day and 365 days/year but the humidification function was disabled in the past. The staff has expressed concern about the room's uneven temperature distribution, poor air circulation and warmer temperature settings. The deteriorating acetate films are already exhibiting the irreversible deterioration known as "vinegar syndrome."

Monitoring Method

Data loggers are used to record temperature and RH. A data logger with electronic sensors and a computer chip inside a matchbook-sized container continuously records temperature and RH with reasonable accuracy. We placed 17 HOBO data loggers at six library facilities and uploaded the data to a computer every 2-3 months. A software program, *Box Car® Pro*, is used to extract the data from the loggers and then *Climate Notebook®*[1] is used for graphs production and data analysis. The UK Libraries were chosen to participate in the Image Permanence Institute's (IPI) grant project, entitled "Training and Implementation for Effective use of Environment in Collection Preservation." This project provided four highly accurate data loggers called Preservation Environment Monitors and data analysis services.

Data Analysis

We used *Climate Notebook*® for data analysis which has more features than basic graphing. For instance, with this software we can compare various storage environments and quantify collection storage environments by using preservation metrics such as the Time-Weighted Preservation Index (TWPI) and the Mold Risk Factor (MRF). Below are examples of an analysis using *Climate Notebook*®.

The Cave

In order to identify areas with less stable environmental conditions, four data loggers were placed throughout the underground storage. The temperature and RH of those locations were compared (Fig. 1 and Fig. 2).

A comparison shows no significant differences in temperature and RH among those locations. These graphs also show the temperature and RH level was never high enough to encourage mold outbreaks. (In general, mold growth is inevitable in an RH of 70% or higher for a sustained period.) We also analyzed the risk of mold growth by using the *Climate Notebook*® metric, Mold Risk Factor (MRF[2]). Based on a number derived from temperature and RH data over a period of time, MRF expresses the likelihood and severity of mold growth on organic materials such as paper, textile and plastics. During the period of monitoring, MRF was zero, which means mold was probably not a problem at that time. However, the current RH level at the Underground Storage is very close to the threshold for mold growth. One logger recorded RH 68-69% for a sustained period. It is likely that an extended hot, humid summer or fall, a prolonged rainy season and/or a dysfunction of the dehumidifier in the past prompted the mold growth. Similar conditions could prompt another outbreak.

The Core Stacks

Two data loggers were placed in the basement and on the 5th floor of the Core Stacks. The temperature and RH were compared (Fig. 3 and Fig. 4). The temperatures ranged from 61°F to 74°F with the higher temperature occurring in the winter and lower temperature occurring in the summer. The high temperature in winter is possibly the influence of the ambient environment of the King Library Building which surrounds the Core Stacks. The RH of the stacks fluctuates drastically with a range from 19% in winter months to 73% in August and September in the basement. The *Climate Notebook*® metric,

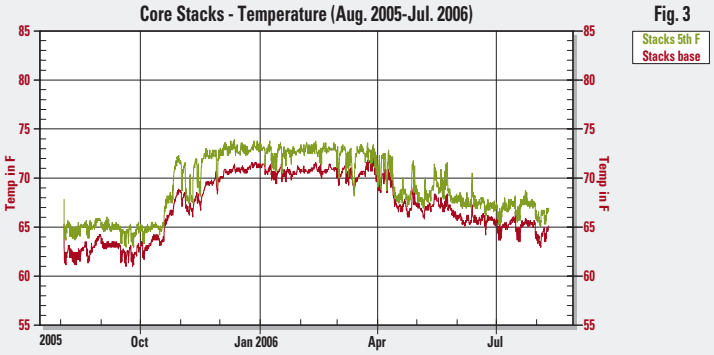


Fig. 3

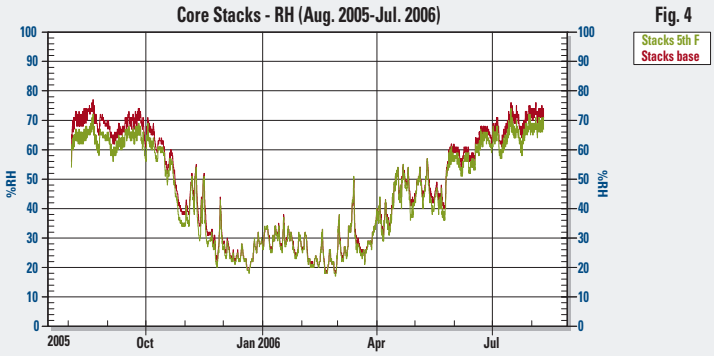


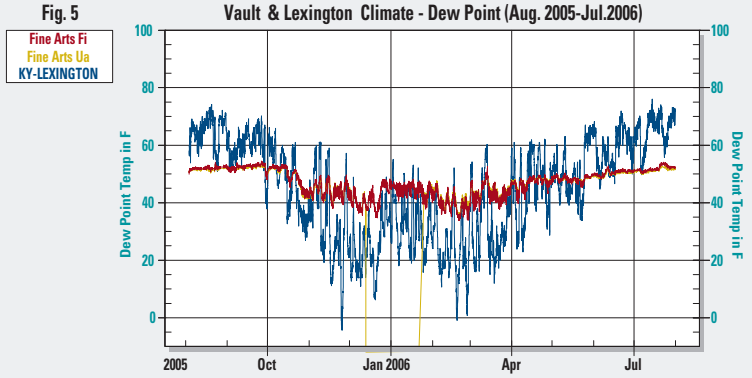
Fig. 4

Dimensional Change Max (DC Max),[3] measures the potential for physical change in organic material caused by gain or loss of moisture. During the period of monitoring, DC Max numbers for stacks were close to 2.5%, which represents a risk of a dangerous dimensional change in objects. Laminate and composite materials such as illuminated manuscripts and photographs are particularly

vulnerable to mechanical deterioration caused by that level of fluctuation.

In addition to mechanical deterioration, chemical deterioration (natural aging) is among our chief concerns for preservation. How fast is the collection aging? Time-Weighted Preservation Index (TWPI)[4] is a metric to measure how temperature and RH affect the rate of natural aging in organic collection materials. The higher the TWPI value, the better the storage environment. Both the basement and 5th floor have a TWPI below 50. Is that a problem? Although TWPI is not a precise predictor of the useful life of materials and TWPI 50 does not mean that the photographs, for instance, will decay in 50 years, it is a convenient comparative measure. According to IPI, purpose-built controlled storage environments (e.g., Library of Congress's remote storage) often have a TWPI value of 200 or more. Therefore, we can project that some of Kentucky's collections will have a four times shorter lifespan than those in the Library of Congress.

Fig. 5



The Vault

Since uneven temperature distribution was reported, two data loggers were placed in the Fine Arts Basement Storage to examine this problem. Two monitored spaces showed some degree of variation within the room (an average of 5°F difference in the summer and 2-3°F in the winter), but it is not clear why the difference exists.

The other concern is if the Liebert's humidification function is working. A comparison between indoor and outdoor[5] dew point graphs answers this question. Dew point[6] is a measure of the absolute amount of water in the air. Unless the mechanical systems add or remove water from the air, the outdoor dew point and the indoor dew point are the same. In other words, any variation between the outdoor and indoor dew point is the result of the mechanical system. The graph (Fig. 5) shows the outdoor (blue) and the indoor (red and yellow) dew point. Lexington's outdoor dew point was downloaded from IPI's website and incorporated to the Vault data by using *Climate Notebook*®. The red and yellow trends indicate that the Vault is dehumidified during the summer because the room's dew point is lower than the outside dew point (blue), and in the winter, the red and yellow trends show humidification.

The RH drifted, but stayed between 30% and 50% most of the year. The temperatures remained relatively steady between 65°F and 73°F through the year; however, even with an average of temperature 69°F, the Vault is too warm for the nitrate and acetate films and photographs[7].

Taking Action

First, we analyzed the collected data. Now we are in the process of defining the optimal environment, finding options to correct problems, and developing action plans for improvement. These steps are not easy or simple. They require some understanding of highly technical architectural and mechanical engineering concepts. They also require broad collaboration among preservation, collections and facility experts. Our achievements to date have been modest, but they have been cumulative which bodes well for future improvement. For instance, at the Underground Storage facility, we shared the findings with the company's management. Immediately they began to continuously

monitor temperature and RH. While not yet implemented, our proposal to achieve an RH lower than 50% by increasing the dehumidification potential of the current and/or additional equipment was well-received.

In the near future, we will present our findings to the Libraries. Following that, we want to work strategically with our facilities personnel to achieve more optimal and consistent environments in all storage areas. Monitoring will continue in these sites, and other diagnostic surveys may commence.

What We Learned

A systematic monitoring has provided data to understand the existing climate, and *Climate Notebook*® has helped to evaluate the performance of current mechanical systems and to define the optimal environment. Effective environmental management requires an understanding of technical issues such as the relationship of temperature and RH and the engineering of environmental systems. This knowledge also helps to develop better communication with facilities management staff. Developing a successful collaboration with facility staff is a key to the effective management of the environment, however, it takes time and some effort to build trust and good team work. I have frequently stopped by the Libraries' physical maintenance office to ask questions, share my findings and just to chat. There may be limited options for correcting the existing mechanical or architectural problems, but the information we've accumulated helps us move beyond adjusting the thermostats or applying for grants to install new HVAC systems. We are starting a new conversation with our facilities management and we are better prepared to state our case. Hopefully as more institutions carry out monitoring projects, information is shared with us.

1. *Climate Notebook®* is a software application developed by IPI with funding from the Mellon Foundation. Information is available at http://www.imagepermanenceinstitute.org/shtml_sub/cat_hardsoft_cnb.shtml.

2. MRF: the higher the mold risk factor, the worse a mold problem is likely to be. MRF 0 to 1: Progress toward mold spore germination has been made. MRF above 1 : Mold has most likely germinated. When the MRF is greater than 1, the number represents how bad the problem is likely to be.

3. DC Max: 1 % DC Max indicates a controlled environment, and 2.5% or more represents a risk of dangerous dimensional change in objects.

4. TWPI: tells how good or bad an environment is on average over a long period of time. TWPI values below 50 may signal inappropriate conditions for vulnerable materials such as paper and photos.

5. Outdoor climate: outdoor climate greatly influences indoor climate. *Climate Notebook®* can incorporate outdoor temperature and RH collected from National Oceanic and Atmospheric Administration (NOAA) weather stations in more than 1000 cities including Lexington, KY.

6. Dew point: helpful information on dew point, temperature and RH is available at "Step-by-Step Workbook" p.11-15, http://www.imagepermanenceinstitute.org/shtml_sub/cnbworkbook.pdf.

7. Film storage: ISO recommends storage conditions for nitrate based film at a Max. temp of 36°F and RH of 20-30%. For acetate based film at a Max. temp. of 45°F and RH of 30%.

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