Specifying Storage Environments in Libraries and Archives

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Introduction

When new or renovated collection storage areas are to be built in a library, museum, or archive, it is necessary for the institution to decide on environmental requirements (temperature and RH conditions) for the new spaces. Usually, a team of professionals is given the task to work out together, and in most cases the architect and engineer start by asking of the collections and preservation staff, “What conditions do you want?

It’s easy to get agreement on the general goals for this process:

- Obtain the maximum ‘preservation quality’ (ensure the longest life for the collections).
- Minimize capital and operating costs.
- Achieve minimal inhibition of staff workflows.
- Be environmentally responsible in choice of materials and energy use.

Once past the generalities, however, the specifics raise many questions that are difficult to resolve. As the process unfolds in real life, administrators, curators, architects, design engineers, mechanical contractors, building operators, and conservators all have their own concerns. Ideally, each professional contributes expertise to an overall satisfactory result that makes sense to each participant and meets as many of the general goals as possible.

Unfortunately, the ideal is not often reached. Tim Padfield, one of the most experienced scientists and consultants in the field of museum climates, describes his disappointment with the specification process in his 2005 publication, “How to Keep for a While What You Want to Keep Forever.”

> My experience of these groups, which should have the superhuman group intelligence that comes from mixing different professions, has not been happy. I identify the problem as the lack of enough shared education for synergy to happen.[1]

In this presentation today, I will offer my thoughts on what that ‘shared education’ might consist of, touching on issues of standards, how deterioration really works (and therefore what general

[1] http://www.padfield.org/tim/cfys/phdk/phdk_tp.pdf

rules of thumb can guide the specifications process) , and suggestions on saving energy in the HVAC operations of collection environments.

Standards and Precedents

Architects and engineers—as well as conservators—quite naturally expect that others have faced this task and that standards have been published which will guide the choices of environmental conditions. There are, in fact, standards (or guidelines for practice) from organizations such as NISO, ISO, ASHRAE, NARA, and BSI concerning various aspects of environments for cultural institutions. While standards can be helpful in some circumstances—especially when 'authority' is needed to convince reluctant parties to the process—more often than not they disappoint architects and conservators who were looking for simple answers to complicated questions. To quote Tim Padfield once more from the same 2005 publication, "The standards we have in conservation are particularly unconvincing and the evidence that supports them is shaky and controversial."

Architects and engineers are often shocked at the lack not only of relevant, accepted standards, but the general absence of off-the-shelf guidance on how to create a museum and library environment that is suitable for particular collections. Unfortunately, many conservators are equally surprised at the lack of directly relevant standards and even worse, are poorly equipped to answer the question "what do you want" based on their own ability to figure it out from scratch. Other potential sources of help are precedents in the form of existing buildings. Certainly, many precedents exist, some of them innovative and energy-efficient. Ideas may come from existing precedents, but simply copying other designs is usually not feasible, because local conditions and collection contents vary hugely from institution to institution. Some precedents are also unworthy of imitation, and it can be challenging to know the difference.

Targets and Ranges for Temperature and RH

Engineers and architects often ask the 'client' in the design process for a specification of environmental conditions in the form of a target temperature and RH, with specified tolerances around the targets. The conservator and curator representing the client are thus put on the spot to determine what the ideal condition should be for each collection space. The problem is not that the architect and engineer would ask such a question—they indeed will need some kind of range to design to—but that environmental specifications in the form of targets and ranges are often adopted without a deeper analysis of their wisdom in the form of a process to broker trade-offs that affect cost, preservation quality, sustainability, and operating simplicity.

Environmental specifications in the form of targets and ranges (for example, 70°F +/- 2°F, 50% RH +/- 5% RH) beg the question of what it means to be out of range, or whether the chosen targets are equally ideal for all collection materials (they're likely not, whatever they may be). Also, targets cannot help determine the degree of risk or benefit that conditions present to collections. If specifications are settled upon at design time without a shared education and understanding of all the trade-offs, it comes back to haunt the institution once the building is built, when it falls to the operators to face difficult choices between energy consumption, human comfort, and preservation quality.

Understanding Deterioration
The appropriate basis for setting environmental specifications and a key piece of the shared understanding that all parties to the specification process should have is a basic understanding of how collections deteriorate. One must know the nature of one's collections, and act accordingly. Deterioration occurs through three basic modalities:

- Chemical change
- Biological processes
- Mechanical (physical) damage

Chemical change is a form of deterioration that arises from spontaneous chemical reactions occurring in collection objects in response to heat energy (i.e., temperature) and available moisture. One form of chemical change is metal corrosion, which is primarily driven by the environmental condition of high RH. For libraries and archives, in which most collection objects are organic in nature (paper, plastics, leather, dyes, etc.), another form of chemical change is of paramount concern. Spontaneous chemical change leading to discoloration, embrittlement, and fading of organic materials is the biggest environmental threat. The essential fact is that temperature and RH combine to control the rate of such undesirable chemical reactions. Temperature matters more than RH in the sense that great benefit and great harm can result from very cool and very warm temperatures, respectively. The warmer it is, and the higher the moisture content of collections, the faster they deteriorate. Some change occurs at every environmental condition; what matters most are the long-term average temperature and RH. Chemical change is a slow process in which short-term fluctuations are not usually significant, nor does any harm result from transitioning from one rate of change to another (in other words, there is no penalty for variations *per se*).

Some simple rules of thumb for planning or operating a space from the point of view of chemical change are:

- Make it as cool as you can while avoiding mechanical or biological damage.
- Keep summertime dew points as low as possible.

Biological Decay is caused by living creatures, most notably mold and insects. At heart, of course, living organisms depend on biochemical processes, so there are some similarities in the kinds of environments that promote chemical change and those that drive biological decay. Temperature does help determine the likelihood and severity of biological attack, but the major environmental factor here is RH. Both molds and insects thrive at moderate temperatures and elevated RH. Biological decay is an opportunistic threat, so it is best to avoid the environmental conditions that would allow organisms to thrive.

Some simple rules of thumb for planning or operating a space from the point of view of biological decay are:

- Minimize risk by avoiding high RH at moderate temperatures.
- Keep excursions above 65% RH to a few days or less.
- Keep summertime dew points low.

Mechanical (physical) damage is a form of decay that affects hygroscopic organic materials (those that absorb significant amounts of moisture). Relative humidity is the environmental factor that governs the moisture content of collection objects. At low moisture contents, objects shrink and become brittle. At high moisture contents, they swell and soften. Both dryness and dampness can lead to stresses and deformations, cracks, tears and delamination. Another type of mechanical damage risk is excessive excursions back and forth from dryness to dampness, causing microcracks to widen with each cycle. For fine and decorative arts collections mechanical decay is often considered the most important risk, but because many objects and finishes are made of organic materials, chemical change should also be considered a major risk.

Some simple rules of thumb for planning or operating a space from the point of view of mechanical decay are:

- Keep excursions below 20% RH or above 70 % RH as short and infrequent as possible.
- Keep wintertime dew points from being too low and summertime dew points from being too high.

Overall, here are some general rules of thumb for operating or designing collection spaces:

- The most significant drivers of mechanical decay are seasonal: short-term events are usually less important than the extremes of seasonal dryness and dampness.
- Short-term events are usually insignificant because objects take considerable time to equilibrate fully to a change in room RH.
- Room temperature is too warm for safe storage of organic objects that are vulnerable to rapid chemical change (paper, leather, dyes, film).

How to Make Intelligent Preservation Compromises

Making the best choice of environmental conditions for a collection begins by knowing the nature of the collection objects themselves, and from there deciding what forms of deterioration will be of primary concern. Cool temperatures matter more to a library than to a furniture collection; tight control of RH matters more to a furniture collection than a library. A rare book storage area with human comfort temperatures, but with tight RH control, would be very good from the mechanical point of view, but poor from the chemical. Considering the great variety of many collections, it's obvious that no one condition would be equally good for everything, and that choices have to be made based on the primacy of certain objects and forms of deterioration.

One helpful aspect of this situation is that all the modalities of decay can be modeled and measured. The Image Permanence Institute has developed algorithms that can start with temperature and RH data (either real or simulated) and calculate the risks and benefits to collections posed by chemical, mechanical, and biological decay. These algorithms, referred to as *decay metrics*, have been used successfully in many institutions to manage and plan storage environments. IPI has produced both hardware (Preservation Environment Monitor® datalogger) and software (Climate Notebook®) for this purpose. Metrics allow genuine risk assessment and mitigation approaches to be used with preservation environments because they yield quantitative estimates of the rate of the major forms of decay. One cannot manage what cannnot be measured. Metrics add the missing quantitative aspect to the specifications process and allow for degree of risk and degree of benefit to be weighed against other factors, such as cost and sustainability.

Energy Saving and Environmental Responsibility
Another set of considerations in the specification process—as well as later on, during building operation—revolve around energy efficiency and environmental responsibility in the choice of technologies and materials. IPI has worked closely in several large projects in libraries and museums with Herzog/Wheeler & Associates, an energy-efficiency consulting firm in St. Paul, Minnesota. Through these projects, a number of simple considerations regarding energy efficiency in design and operation of collection storage spaces have emerged. At design time:

- Design equipment to be efficient at low loads (i.e., the majority of the time, when it isn't the warmest or most humid outside).
- Design to keep outside air to code minimums.
- Plan to keep collection storage separate from human occupancy spaces.
- Design ducts to reduce fan energy.
- Minimize pressure drops (and consequent fan energy costs) due to particulate and gas phase filtration.

Once a building has been designed and built, operating savings become the central issue. In our experience, significant opportunities to reduce energy costs and provide improved preservation quality for collection environments almost always exist if one knows how and where to look for them. Operational savings pay the highest dividends in reduced energy consumption and reduced harm to the general environment. Some simple suggestions for operational savings follow:

- In collection storage areas, don't heat to human comfort temperatures in winter.
- Control for a safe RH and coldest feasible temperature.
- It's o.k. to move around in the envelope of safe operating conditions.
- Monitor collections and use preservation metrics to identify underperforming spaces and opportunities to consume less energy.
- Watch for unnecessary subcooling and reheating.

Conclusion
In summary, engineers and architects must understand the rudiments of deterioration mechanisms and explore with their clients the underlying issues affecting collection preservation. Conservators, curators, and preservation specialists must understand the rudiments of HVAC operations and explore with architects and engineers the design of a safe operating envelope that maximizes preservation quality while being kind to operating budgets and to the planet. Finally, everyone in the specification process should also consider the building operator who must make complex designs and equipment function the way it was designed. Simplicity and functionality go hand in hand for a successful overall result.