Article: Microclimate storage for metals (and other humidity-sensitive collections): Practical solutions
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MICROCLIMATE STORAGE FOR METALS (AND OTHER HUMIDITY-SENSITIVE COLLECTIONS): PRACTICAL SOLUTIONS

GRETCHEN ANDERSON

ABSTRACT

We all know that environmental conditions for collections, either in storage or exhibition, are rarely ideal. And sometimes they are dreadful. This is particularly true for humidity-sensitive collections such as archaeological metals. It is often impossible to reach ideal conditions due to lack of funding or to limitations of the physical building. We strive to reach a balance between these issues to achieve the best possible environment for all collections, including these sensitive collections, while living within budgets and building requirements.

Practical solutions for these challenges must be sought. They must be within budget and be easily maintained. This article explores the development of microclimate containers for humidity-sensitive collections. This series of solutions was developed at the Science Museum of Minnesota over a 15-year period, each solution building on the strengths of the previous. It is hoped that the reader will adapt these ideas to their own situations.

1. INTRODUCTION

In the late 1980s, the Canadian Conservation Institute (CCI) developed the Preservation Framework to help conservators and museum professionals develop reasonable strategies to solve challenges, such as this one (Michalski 1994; Rose and Hawks 1995). The Preservation Framework, together with formalized risk assessment for collections (Waller 1995), provided a broader, more practical way of identifying and mitigating risks to museum collections. It was a different way to think about the risks, one in which the conservator could make improvements in overall collections care based on specific situations and budget constraints. The Society for the Preservation of Natural History Collections (SPNHC) helped disseminate this information to conservators and collections managers in natural history collections.[1]

At the same time as this methodology was being disseminated, The Science Museum of Minnesota (SMM) founded a conservation department and hired its first conservator. The conservator was charged with the responsibility of developing a museum-wide conservation program that crossed all division lines. The methodology as described in the framework was immediately adopted as the founding principles of the department. It was used to address challenges to collections care, and was a natural fit with the philosophy and structure of the museum. The conservator could develop reasonable solutions for the serious problems of environmental control encountered at SMM.

The Science Museum of Minnesota has approximately 1.75 million collections, of which there are about 150 archaeological metals. The majority of these are Native American copper artifacts, and a collection of Etruscan bronzes. In 1989, collections at the Science Museum of Minnesota were stored in a large basement storage area. The cabinetry, considered state-of-the-art in 1960, consisted of painted metal shells with oak drawers and polyurethane foam gaskets. There was evidence of numerous minor floods and high humidity in the form of rust formation and tide lines on cabinets and walls. The metal rolling ladders were rusted. The gaskets were crumbling. Hygrothermographs, purchased through an IMS CP funded general survey, were placed throughout the museum. One was placed on top of cabinets in storage; another was placed inside of a cabinet. The data from hygrothermographs was not surprising, given the Minnesota climate and the 1960 building that housed the collection. Relative humidity fluctuated seasonally from 10% in the winter months to over 80% in the summer, with up to 40% short-term fluctuations when storms rolled through the area. The data from inside of the cabinet demonstrated that the cabinet and wooden drawers buffered environmental changes. Relative humidity inside the cabinet fluctuated seasonally from 35% to 65%, smoothing out the short-term fluctuations. Given the age of the building and HVAC zones the only reasonable action was to create microclimates.

The archaeological metal collections were often placed directly on the wooden drawers, with no barriers. They were minimally padded with acidic and hygroscopic materials such as polyurethane foam, cotton and acidic paper. There were no supports for the fragile metals that were in storage.

At the same time, there was a desire to put more collections on exhibition. Curatorial and exhibition staff wanted to create study storage drawers in order to allow the public to see more of what is in storage, and to put behind-the-scenes activities on exhibit. SMM was experimenting with methods of putting collections storage on display. To this end the storage cabinets and drawers were retrofitted so that drawers could be opened and closed at will by the public. The collections inside had to be “bullet proof”: safe from theft and from banging drawers. They were safe from vibration and shock. These experiments brought about the first generation of microclimate drawers, and started us on the quest for improving storage for humidity-sensitive artifacts.

2. GENERATION 1: 1991

The drawers used were the actual drawers used in collections storage, placed in an actual storage cabinet (fig. 1). In addition to fluctuating relative humidity, we were attempting to overcome the following challenges: acid contamination from the drawer, object support, vibration mitigation, and security. As is typical in these situations, there was only a little bit of money available to do the work.

Construction instructions:

1. The oak study storage drawer (as it was called) was lined with Marvelseal, an aluminium plastic laminate, to mitigate acidic off-gassing from the oak drawer. The effect was tested using potassium permanganate and found to be successful.[2] Holes for the drawer pulls at the front and back of the drawer were sealed with a block of wood that was also covered with Marvelseal.
2. The bottom of the drawer was lined with polyethylene foam. An upper layer of foam was cut with cavities customized to fit the metal artifacts. The artifacts were held in place through pressure. Embroidery floss was used to secure any object that would not stay in its pressure-fit cavity.
3. Silica gel was conditioned to be as dry as possible and placed in muslin tubes. The tubes were pinned into place. A humidity strip was placed in the drawer to monitor conditions.
4. The drawer was sealed with a Plexiglas lid that was screwed into the wood and the seam was taped closed with clear packing tape.
5. A 2-inch pad of Ethafoam was attached to the back of the cabinet to buffer the shock when the drawer was slammed shut by the public.

Fig. 1. 1991: The first generation of microclimate container consisted of wooden storage drawers modified to reduce acidic contamination with Marvelseal (Photograph by Gretchen Anderson)

This method was crude but effective. The copper artifacts were held securely in place, the volatile acids off-gassing from the wood were reduced significantly, and a low relative humidity (about 20%) was maintained throughout the year. The objects were secure from theft behind Plexiglas. The silica gel had to be reconditioned every two years. The objects were completely visible yet secure behind Plexiglas. One drawer was prepared in this manner.

There was one major drawback. It was extremely difficult to access the artifacts. To remove an individual object for research or to remove the silica gel for reconditioning, the cover had to be completely removed. Since it was held in place with at least 20 screws, this was a tiresome and time-consuming activity. This made the method unacceptable for use on a collection that was actively being studied. To solve this problem we modified the drawer by cutting a channel into which the Plexiglas cover was slid. However, this modification could not be easily sealed against off-gassing and it was not tight enough to maintain the desired relative humidity.

3. GENERATION 2: 1994

Given the drawback of difficulty in accessing the collections and the fact that many of the Etruscan artifacts were too deep to enclose in a drawer, we took a slightly different approach for collection storage. Inexpensive polypropylene and polyethylene plastic tubs were purchased and put through Oddy testing[3] to ensure that they were inert (fig. 2). After the container was altered, it was tested again using potassium permanganate.

Construction instructions:

1. The bottom of the box was covered with conditioned silica gel. The volume of the specific box determined the amount of desiccated gel (Canadian Conservation Institute

1984). Small quantities of indicator gel were mixed in to quickly and easily monitor relative humidity.
2. The second layer consisted of polystyrene lighting grid, cut to size. This was set on blocks of Ethafoam so that it rested above the silica gel. The grid served a double purpose. The holes allowed for the air in the box to be desiccated and the structure was adequate to provide a base on which to construct a storage mount.
3. A storage mount made of Ethafoam and backer rod was lined with acid-free tissue, which was later upgraded to Tyvek. Each mount was made custom for the object, and could be adapted to best protect the piece.
4. A humidity strip was placed inside the container to monitor relative humidity (fig. 3).
5. The lid snapped on the box, but the seal was not adequate to maintain the desired relative humidity. This was improved by adding a silicone gasket, backed with acrylic adhesive. This material was purchased from a local hardware store. Clear 3M packing tape was used to further improve the seal. Several clear packing tapes were tested for chemical stability and for the ability to remain attached to the plastic container. Oddy tests were also done on the adhesive. The 3M packing tape was the most stable and had the best long-term adhesion to the plastic box. It begins to yellow after 10 years - about the time the silica gel requires reconditioning.
6. A photograph of the artifact was placed on the exterior of the lid for identification.

Fig. 2. 1992: The second generation container was a polyethylene/polypropylene storage container, purchased off the shelf at Target (Photograph by Gretchen Anderson)

This was a highly successful experiment. The original materials are inexpensive, inert, and provide full support for even the most fragile object. Relative humidity was held at the desired level, and was extremely stable for 10 years.

Nothing is perfect. It was hard to see the object. At the time, the only containers available were cloudy. Photographs were placed on the tops and sides of the boxes to identify the objects in the container. Today, many clear containers can be found which would partially solve this drawback. However, even with the clear containers, it is impossible to see the entire object without removing it from the microclimate box. While it was easier to get into than the study storage drawers, access was not ideal.

The objects placed in this system were a small collection (approximately 30 pieces) of Etruscan and Roman bronzes, and two metal bowls from Peru. That left the Native American copper artifacts without proper storage. This was a collection that was actively being researched and curators did not want them to be inaccessible in either system that had been prototyped. An attempt was made to make Marvelseal bags with Mylar windows; unfortunately it was almost impossible to make the bag completely tight so that humidity was maintained. No matter how carefully the bags were made there would be tiny holes, and a low relative humidity could not be maintained. It was also difficult to see the artifacts. Today, there is a wider range of plastic laminate materials that might be used to create a viable clear package.

Fig. 3. A humidity strip was placed inside the container for ongoing monitoring (Photograph by Gretchen Anderson)

4. GENERATION 3: 2001

Fast forward to 2001. The Science Museum of Minnesota had just opened a new museum facility with a state-of-the-art collections storage area in December 1999. SMM holds a relatively small natural history collection (1.75 million objects) and it was decided to maintain the tradition of placing all collections in one large, climate-controlled storage room. Delta Design cabinets placed on compactor units were used to fully maximize space in the storage facility (fig. 4). Conditions in storage are maintained at 68°F ± 2° variance and 45% RH ± 5% variance. This was a definite improvement over the previous storage facility in a damp basement.

But, what to do with smaller collections that should be stored at lower (or higher) relative humidity levels for their long-term preservation? SMM does not have a large enough collection of archeological metals requiring specialized environmental conditions to justify the expense of a special room. A specially adapted cabinet was the ticket. All the archaeological metals could easily be placed within a single cabinet. An active system was briefly considered, but determined to be more prone to failure than passive systems.

Fig. 4. 2003: The third generation of microclimate drawer is a customized Delta Design drawer (Photograph by Gretchen Anderson)

A conservation team consisting of the conservator (Anderson), assistant conservator (Rebecca Newberry), and a volunteer who happens to be a retired engineer (Ron Voelker) discussed methods to adapt the new Delta Design drawers along the concept of the 1st generation study storage drawer. The challenges were different than with the old wooden drawers. The powder-coated surfaces of the cabinets and drawers were already inert. However, the folded metal drawers have gaps in them that had to be filled. The biggest problem was how to provide a leak-proof seal around the Plexiglas cover.

We tested a few systems and came up with the following method:

1. The drawers have gaps and holes in them. These gaps were with filled with silicone caulk (ammonia free). The caulk was allowed to cure fully for a month.
2. A silicone gasket with an acrylic pressure-sensitive adhesive was applied to the flange on the top of the drawer. This acts as a seal (if silicone gasket is not available, Volara foam cut into strips and attached with 3M pressure-sensitive adhesive 968 works well). The gasket that was used had a solid, rectangular cross section, although other profiles could be used. Testing the sealing capability of each profile prior to use is recommended. The

gasket used was chosen after discussion with Delta Design engineers and extensive Oddy testing.

3. Plexiglas was cut to cover the top of the drawer. Quarter-inch Plexiglas was chosen because it was thick enough not to deflect over the surface of the drawer and there happened to be a supply from a prior exhibition that could be reused. It was scratched, but acceptable for use in storage. It was secured with two clamps made of Plexiglas on the front of the drawer and metal clamps on the back. The metal clamps were made from aluminum U channel (figs. 5–7). After much experimentation, it was found that two simple clamps on the back were adequate to maintain a seal. The metal clamps have a setscrew that can be slightly tightened as needed. Do not over tighten the screws or wing nuts. This will stress the seal and break it, allowing the modified environment inside the case to equalize with the ambient atmosphere (fig. 8).

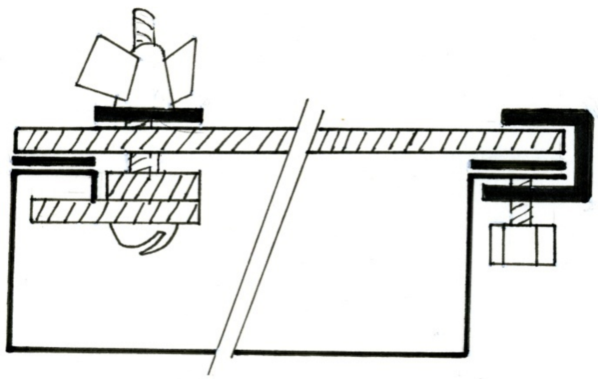

Fig. 5. The diagram illustrates the systems used to clamp the Plexiglas on to the metal drawer. There is a flat silicone gasket between the drawer and the Plexiglas.

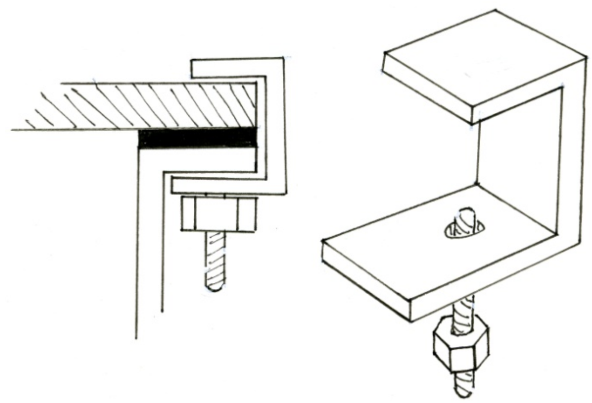

Fig. 6. The clamp on the back of the drawer is made of an aluminum U channel with a threaded rod and nut. The black line on the diagram is the flat silicone gasket. The pressure applied by the clamp is minimal.

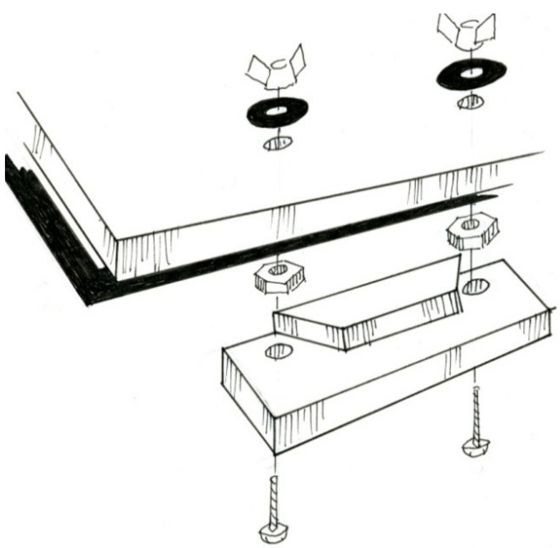

Fig. 7. The front clamp is made of a series of Plexiglas pieces that fit over the lip of the drawer. Threaded bolts, nuts, ring gaskets and wing nuts are finger-tightened to apply pressure needed to seal the container.

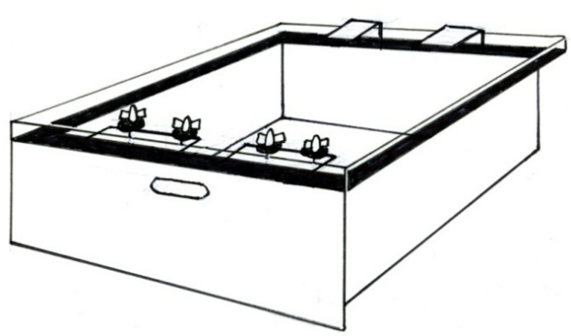

Fig. 8. The finished drawer.
For figures 5–8: Design by Ronald Voelker
(Illustration by Verne J. Anderson)

4. Student interns were instructed to created modular cavity mounts for each individual object. In this way the artifacts could be organized according to the archaeologist's needs. The cavity mounts were made with a corrugated plastic (polypropylene) base, polyethylene foam, backer rod/tri-rod supports and padding. Tyvek was used to line the mounts. They fit into the drawer like a puzzle. Magnets were used to keep the mounts from sliding on the slick surface of the drawer.
5. Bulk silica gel was packaged in cotton stockinette and conditioned to be as dry as possible. To condition, the tube is simply placed in an oven at 50°C and baked for 3-4 hours. The cotton stockinette was tested prior to doing this and was not damaged by the process.
6. A humidity monitor was placed in each drawer.

The test drawer held 10% relative humidity for five years (as of 2009). The collections are easy to see in the drawers. Curator or researcher can do all preliminary examination through the Plexiglas using catalog information. If further work is needed, the artifact can be easily and quickly removed from the drawer with minimal impact on the environment. The silica gel can be easily removed for reconditioning when necessary.

The museum's metals are now stored in a low relative humidity environment that is very stable. There is no contamination from the drawer or from storage materials. All of the microclimate drawers are currently stored in a single cabinet, and not integrated into the traditional organizational system. The reasoning behind this was that it would be easier to monitor the microclimate if all drawers were grouped together, and it was a more efficient use of space.

5. VARIATIONS ON A THEME

Other uses for the drawers have been found. Like many natural history collections, SMM has a collection of historic bird study skins and taxidermy. These date to the early days of the 20th century, and it was no surprise to find that they are laced with arsenic. The microclimate drawer system was used to isolate and contain the contaminated specimens (fig. 9).

It took some convincing to get the collections manager to agree not to integrate the birds into the usual taxonomic organization of the collection. In the old facility the historic collection had been segregated in a mobile storage cart. When the collection was moved to the new facility, the collections manager began to integrate the arsenic-laden specimens into the taxonomic order with modern study skins. Conservation expressed concern of cross-contamination. This was demonstrated by testing the specimen adjacent to the contaminated specimens, as well as testing the foam liner. The presence of arsenic was tested using the standard arsenic spot test.[4]

Once the possibility of cross contamination was clearly demonstrated, the collections manager was satisfied to segregate the historic collection. The arsenic is now contained and not in danger of contaminating other specimens. The collection is easy to find and easy to view, and there is no doubt as to what specimens are contaminated and should be handled with care.

Fig. 9. This method has other uses beyond creating controlled relative humidity containers. The same system has been used to contain bird study skins that are laced with arsenic. In this manner the skins are isolated, preventing cross-contamination with specimens not treated with arsenic, and a healthier environment for researchers working with the collection is provided. (Photograph by Gretchen Anderson).

6. CONCLUSION

Each one of the microclimate drawers worked. They did the job, and were all reasonable and affordable. Our solutions were for Kewaunee and Delta Design cabinets. However, the methods can be adapted for use with other types of drawers and cabinets.

As conservators we are faced, sometimes daily, with seemingly impossible tasks. There is almost always a reasonable solution to the problem. This is good to remember on those frustrating days when everything seems to backfire. Take a deep breath. Look at the Framework for Preservation (or your problem solving tool of choice) and work it out. Be practical about the solution. With a little ingenuity, imagination and creative help we can solve almost any storage challenge.

ACKNOWLEDGEMENTS

A good team is vital for a creative project like this. The best team should have a broad range of experiences and expertise. An interesting and successful design comes only after experimentation and creative thought. The success of this project came about because of creative discussion and experimentation, and the willingness to change. The author would like to thank the following individuals for their invaluable input: Rebecca Newberry, assistant conservator, Ron Voelker, retired engineer and volunteer (every conservation lab should have access to a retired engineer to build the ideas conservators come up with), Verne Anderson, volunteer and artist (an artist who can clearly render constructions is invaluable - all of the drawings in this paper are by Verne Anderson), Jim Krache, conservation volunteer, who constructed mounts and helped to make enclosures, and interns (who seem to do the bulk of the work): Malcom Collum (1991–1993), Tracey Bredehoft (1991–1993), Kristine Hansen (1996–1997), Megan Emery

(2000–2001), Margaretta Kuesch (2002–2004), Giovanna Fregni (2004–2007), and LeeAnn Barnes Gordon (2006–2007).

NOTES

1. The matrix is no longer available on line. However, CCI has published a series of excellent articles (www.cci-icc.gc.ca/caringfor-prendresoindes/articles/10agents/index-eng.aspx), providing methods and information to systematically mitigate risks to collections through the use of layered strategies.

2. The use of potassium permanganate pellets (Carusorb) can be used as a quick "spot" test to determine if an enclosed area, such as a cabinet or exhibition vitrine, has organic contamination (Ballard and Erhardt 1990). A few beads are placed on a watch glass. The area is closed and left for 24–48 hours. If the bright purple beads turn a dull brown there is contamination. This will not tell you what the contaminant is – just that there is contamination. All enclosures have been tested using this method along with testing using A-D strips (Nicholson and O'Laughlin 1996; Alten 1997).

3. The Oddy test referred to in the text is the accelerated aging test originally developed by Andrew Oddy for the British Museum. The methodology Anderson uses was learned at the 1990 Display Materials Workshop at the then Conservation Analytical Lab Smithsonian (Ballard 1990). Since that time she has used it to test the suitability of many materials for storage and exhibition.

4. The Conservation Department at the Science Museum of Minnesota has traditionally used the arsenic test first published in Leather Conservation News (Hawks and Williams 1986).

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SOURCES OF MATERIALS

3M Packing Tape, 3M Jet-melt hot melt ATG (924, 926, 969, 987) and Double stick tape (415) (when purchasing these products look for acrylic adhesive, and polyester carrier).
3M Shop
www.shop3m.com

Aluminum U channel, screws and other hardware, silicone caulk (ammonia free), silicone gasket with 3M adhesive backing [No particular brand name is specified. Choose the profile that works best and run Oddy tests on it. One option is to use Volara or other closed-cell, conservation-grade foam and apply 3M acrylic adhesive tape (986)].
Grainger
www.grainger.com

Carusorb
Museum Services Corporation
385 Bridgepoint Way
South St. Paul, Minnesota 55075
(651) 450-8954
www.museumservicescorporation.com/index.html

Cotton Stockinette
Mountain Medical Equipment
9262 Old River Road
Marcy, NY 13403
(888) 687-4334
www.mountainside-medical.com/products/Cotton-Tubular-Stockinette,-Non-Sterile.html

Plexiglas, Acid-free cardboard, Coroplast, Ethafoam, Zotefoam, BackerRod, Tri-Rod, Cotton Stockinette, Tyvek, Relic cloth, Humidity Indicator cards, Silica gel, Marvelseal, Volara
University Products Inc.
517 Main Street
Holyoke, MA 01040
(800) 628-1912
www.universityproducts.com/

Polypropylene/polyethylene boxes, Polystyrene lighting grid
Home Depot
www.homedepot.com

Powder-coated drawers (the system described in this paper used Delta Design Drawers, however it could be adapted for any type of museum grade storage cabinet).
Delta Design Ltd.
P.O. Box 1733, Topeka
Kansas USA 66601
(800) 656-7426
www.deltadesignsltd.com

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