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AIRTIGHT, HUMIDITY STABILIZED DISPLAY CASES:
The Practical Design and Fabrication of
Sealed Exhibit Cases

by Toby J. Raphael

Abstract

Humidity "stabilized" or "buffered" case designs are a relatively simple but useful technology which has been under utilized. This type of exhibit microclimate has not been widely adopted by small museums and historical sites where overall humidity control is often unachievable. Conservators at the National Park Service have developed specially designed exhibit cases in a program aimed at upgrading the permanent exhibits in National Parks across the country. This paper outlines the conservation parameters for fabricating sealed cases and identifies a number of alternative designs for achieving passive humidity control.

Introduction

This year marks the 75th Anniversary of the National Park Service (NPS) and for much of this period it appears that "exhibit case design" has contributed unnecessarily to the deterioration of our collections. An effort is now being made to improve the long-term preservation of our exhibit objects by paying particular attention to exhibition design and construction to ensure the utilization of the highest standards possible and incorporation the most practical and current conservation technology. This effort, in conjunction with the increased involvement of conservators, have significantly lengthened the time we feel we can safely display our tremendously varied collections.

The role of the NPS is to preserve and protect both the nation's "natural" and "cultural" resources which are entrusted to its care. One of its biggest challenges has been to create an inviting and stimulating exhibition environment that does not endanger the collections on display. A systematic program for collections care has been developed by NPS curators and over the past five years conservators at the central exhibits facility in Harpers Ferry have experimented with numerous designs for passive humidity control in "low-maintenance" display cases.

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We recommend the use of humidity "buffered" or "stabilized" cases to our exhibit designers when display materials are humidity sensitive but can tolerate a slight range of relative humidity fluctuation. The principle benefits of these case designs are: 1) that they have proven to be effective in reducing the risk of unnecessary damage and deterioration to these collections, and 2) that they are an extremely cost efficient approach to climate control.

We have found that these cases can help preserve display materials in museums and at historical sites where overall climate control is impractical, enormously expensive or destructive to the building site. Their use can also allow for the exhibition of sensitive objects in places where curatorial and conservational expertise are limited or unavailable.

The annual recording of Rh at a wide variety of our exhibit sites (including those without any humidity control) has shown that in most open exhibit spaces the range of Rh is unacceptable for humidity sensitive materials, however, the "average" of Rh readings falls within the acceptable range of 40 to 60%. In these instances buffered cases can usually function very effectively. We have found some climatic exceptions, however, which generally include our sites in extremely arid and tropical climate areas.

Our experience has shown us that the effectiveness and performance of these cases depends on the cooperation and collaboration between designers, curators, conservators and exhibit fabricators. When this type of case design is selected, exhibit planners must concern themselves with the total exhibit environment created through the interplay of the exhibit building's environmental conditions, the case design and fabrication materials used, and the curatorial staff.

A Simple And Practical Solution For Some Exhibits

Tim Padfield said in 1967 that a properly designed display case is probably the greatest single aid to conservation. Over the past decade numerous outstanding ideas and technological approaches have been presented on the subject of microclimates; however, too few institutions and conservators alike, have put into practice the knowledge that our field has already developed and proven useful. Amazingly few such case designs have been developed, tested and adapted for common museum usage.

We have developed our exhibit program around the premise that practical, "low-tech" solutions are available to solve most of our museums' conservation needs. The criteria of reliability, simplicity and practicality have therefore been key objectives in our search for suitable case designs. From a conservation perspective, we are finding that our most successful exhibits maintain a "simplicity" of design while meeting our established conservation standards.

To insure successful performance, practical and reliable engineering is essential. When appropriately engineered and constructed, airtight cases offer nearly total protection from insect entry, dust and soil

accumulation, vandalism and handling, as well as damaging climatic conditions.

Special Museum Circumstances And Airtight Cases

Humidity buffered or stabilized case designs are a relatively simple technology which is particularly useful for museums which must rely on preventive conservation measures because of budgetary and personnel constraints.

Museums which were initially built for the purpose of exhibition and major museums in urban / metropolitan areas have a reasonably good chance of achieving overall climate control in their display galleries. The museums and historical settings with which we routinely deal in the NPS, however, are often in rural areas or unconventional environments and generally have no realistic means for controlling humidity and other mechanisms of deterioration. The special exhibit circumstances we find are much like those of many smaller museums and include the following:

- Inadequate control of relative humidity (Rh) within exhibit halls: both unacceptable levels and rates of fluctuation.
- Temperature swings which occasionally fall outside of recommended parameters due to lighting and seasonal change.
- Dust and airborne soil entry present a serious maintenance and conservation challenge.
- Insect entry is difficult, if not impossible, to control: due to geography, visitor traffic and building configuration.
- Few trained curatorial staff are on site and the extent and quality of exhibit maintenance may vary tremendously.
- Exhibits are usually considered permanent installations: the site may request a new exhibit every 10 to 20 years.

When faced with these circumstances at NPS sites we find we select closed case designs more and more frequently. Airtight cases have proven most suitable not only because they make excellent microenvironments - air exchange is greatly reduced and relative humidity can be effectively stabilized with less moisture absorber for longer periods of time - but because of their added protective features regarding insects, pollutants and temperature swings.

Special Design Considerations

We have identified four special design and fabrication considerations which play a very important role when sealed exhibit cases are being designed and built. The following points should be considered when these displays are specified:

Inert Materials

Particular attention must be paid to assure that sealed cases employ materials that are inert and of high quality. Low quality fabrication materials can be hazardous when exposed within case interiors because

they can damage objects by subjecting them to volatile substances which build up to dangerous levels within sealed cases.

Isolation of Harmful Materials

Potentially hazardous materials which are exposed to the case interior can be isolated to some degree with barrier coatings or certain laminate materials.

Reducing Air Leakage

Sealed cases need to employ design features and fabrication techniques which minimize the air exchange between the case and the general exhibit space. Tolerances between joints should be more restrictive than normally required for unsealed exhibit casework. All openings including glazed openings and doors require sealing with gasketry or caulk.

Heat From Exhibit Lighting

Sealed cases are particularly susceptible to overheating as a result of inappropriate exhibit lighting. Case interiors can experience temperature rise due to convection and infrared radiation which is made more dramatic because of the "green house" effect. Lighting fixtures and bulbs must be carefully evaluated to ensure their effect on the case's atmosphere is not destabilizing. Exterior, ceiling lighting does not present the threat that attached, above case lighting does. Double glazing and infrared reflecting glass can be used, for example, to isolate from the display area lighting systems which are attached to cases.

Humidity Control And Airtight Cases

The relative humidity of the air in a traditional, non-absorbent display case will approximately follow the average, daily Rh of the exhibit room. When cases are made airtight and a moisture absorbing material is added, daily humidity fluctuation is eliminated and weekly and even monthly fluctuations are drastically reduced. It is possible to stabilize yearly Rh levels to plus or minus 5%, even when ambient humidity is uncontrolled.

In our experience it is rarely necessary to consider the use of anything other than the passive approach to humidity control (as opposed to a mechanical method, such as the use of a micro climate generator). Our cases are not engineered to "fix" relative humidity but rather to stabilize or buffer the interior environment from the more rapid changes occurring outside of the enclosure. The humidity levels in these cases are, by design, self regulating between seasons and will ultimately reflect the yearly average of the exhibit room at large. We find we can maintain an annual interior range of 40 - 60% Rh, with the rate of seasonal change-over not exceeding 5% Rh per month.

Airtight cases do not constitute hermetically sealed enclosures; however, their design and fabrication do require that the structures be as airtight as possible, incorporating gasketry and sealant caulk to greatly reduce the rate of air leakage. Technical evaluation procedures are now available to pinpoint case leakage and measure the rate of air

exchange in a given exhibit case. This technology is steadily becoming more affordable and will undoubtedly be widely used in the future.

The principal means by which Rh escapes from these enclosures is through diffusion and permeation of the exhibit case materials. Additional forces at work are convection, thermal pumping and barometric pressure change. Although diffusion is a serious concern when trying to maintain a constant Rh it occurs very slowly and acrylic glazing as well as glass is acceptable for use in humidity controlled case design. Convection, on the other hand, works to drive vast quantities of air out one small gap or hole and in another, taking moisture with it. CCI Conservator Stefan Michalski has explained that the effective stabilization of RH in sealed exhibit cases therefore depends on the successful limitation of convection losses and this can be accomplished by ensuring that:

- 1) all gaps are sealed effectively with gasketry or caulk and,
- 2) whenever possible, to reduce convection, lateral case entry design should be used (such as five sided acrylic vitrines).

Moisture Absorbers

Airtight display units should be designed to incorporate a humidity "buffer" or moisture absorbing and releasing materials. The term "buffer" has been used to denote any material which resists or helps to buffer a change in the Rh of the air surrounding it, whether this change is caused by a leakage of air at a different RH or by a change in temperature. If the Rh of the air falls, then the buffer, in order to keep in equilibrium with the air, will give out some moisture. This moisture will cause the Rh to rise thus counteracting the change, and vice versa. So much more water is locked up in moisture absorbent materials than in air that the short-term effect of the buffer is actually to compensate for a change in Rh caused by a temperature change or air infiltration.

All organic materials have a moisture absorbing quality, however certain substances have the capacity to absorb more moisture or to pick it up faster. Within airtight cases we have successfully used buffers in the form of natural products (such as cotton batting, wood and paper cellulose fiber) or man-made products (such as regular density of hybrid silica gels).

Within each display case a maintenance chamber should be included to contain the quantity of the absorber which is calculated to protect the case throughout the year. The quantity of buffer is substantially less than that which is recommended for leaky cases, and as a rule, should not require maintenance, under most circumstances. Only under emergency conditions would a small amount of moist or dry silica gel need to be added to "boost" the permanent buffer. We frequently have added a small maintenance door (ie. 4' X 4") for this purpose.

The buffer is usually located under the display deck or plinth and air circulation is encouraged by allowing for 15 to 20% communication through or around this platform.

Silica gel products have proven the most reliable, however, they differ in their effectiveness within varying ranges of humidity. Certain, new hybrid gel compounds have been shown to absorb and release moisture more efficiently within the range useful for most of our museums. Artsorb and Arten Gels are appropriate commercial products which are available from conservation suppliers. In most instances, we use 1/3 lb. of these gels per cubic foot, or roughly 9 lbs. per cubic yard.

Silica gel used within airtight cases should be contained in a standardized enclosure or container for quantity control and maintenance purposes. We have used inert plastic tiles, tubes or fabric bags and impregnated paper and foam products which are commercially available. Economical containers can also be fabricated to suit the needs of an exhibit case. Standard sized, pleated nylon bags and custom panels are made in-house and have proven to be the most successful and cost effective.

Exhibit Case Gasketry and Sealant Caulk

Gaskets serve to control interior case humidity and temperature as well as the entry of unwanted pests, airborne soils and pollutants. Gasket characteristics, design and location must, therefore, be carefully selected since gasketry plays a fundamental role in sealed exhibit cases.

A variety of gasket designs and elastomer materials are commercially available, however, not all are appropriate for use in exhibit cases. From our experience we have formulated the following recommendations which are aimed at insuring both successful performance and the selection of safe gasket materials:

1. Appropriate gasket materials should be employed to seal all doors, removable panels and exhibit case glazing. Extruded or sheet elastomers are available.
2. Only high quality and chemically inert gasketry materials should be selected, thus assuring that the gasket itself will, in no way, contaminate the interior exhibit space.
3. Gasket design should be suitable for its particular application and its short and long range performance thoroughly considered i.e. a routed channel can be employed, whenever possible, to allow for additional compression space.
4. Ideally, proposed gaskets should be tested for chemical stability and effectiveness of design application. When testing is not possible, product data and specifications should be reviewed by an exhibitions conservator. We have found the material cellular silicone sponge (dimethyl-poly-siloxane) to meet all of our criteria.

To further assure that display cases are as tightly sealed as possible it is an acceptable practice to finish interior or exterior seams and joints with caulking. Acrylic and silicone caulk can be used both effectively and safely, however, both require a cure time of several weeks before object installation can occur. Certain caulking products are neutral curing and do not emit acetic acid during their curing, such as the caulking product manufactured by General Electric #2501.

Selection of Construction Materials

To ensure the long-term preservation of objects exhibited in sealed cases, we have found that all materials used within the exhibit enclosure must be carefully selected.

Unsafe or low quality materials can encourage both chemical and biological damage of objects when these materials are enclosed with objects within an exhibit enclosure. For this reason it is very important that case materials be selected on the basis of their inertness; i.e. substances that will not present a hazard to the exposed objects. Ideally, all unknown fabrication materials should be tested to identify the presence of organic acids or other harmful components. Careful consideration, therefore, must not only be given to the selection of the case's structural materials but the adhesives, paints, finishes and laminate materials used as well.

From a conservation perspective, it is preferable to construct exhibit case structures from non-reactive materials such as metals since they are dimensionally stable and are not known to emit any harmful vapors. Aluminum, steel, and brass have been successfully incorporated into a variety of case designs. For reasons of cost and aesthetics these materials are often excluded as fabrication materials, and traditionally, more problematic materials, such as wood and wood products, have been the construction materials most commonly used.

We try to follow four basic guidelines regarding fabrication materials:

1. All construction materials which comprise a part of the "interior" case environment should be free of acid or harmful volatile chemicals.
2. New and previously untested materials should be tested to identify the presence of organic acids or other harmful components. Testing services are available commercially and our conservation laboratories can perform some less complex testing.
3. Before objects are installed within an enclosed case all surfaces and construction materials must be absolutely dry and fully cured: paints, adhesives and caulks generally require a minimum of three weeks. Objects should not be placed immediately into newly constructed cases.

4. Only inert materials should be in direct contact with display objects. Unknown materials, reactive materials, dyed, painted or abrasive surfaces must be isolated from contact with artifacts by an appropriate, conservation-approved isolating layer (i.e., linen, cotton or polyester fabric, polyester or polyethylene film, acid-free paper or paper boards).

Use of Wood Products For Case Construction:

From a conservation perspective, wood and wood products are not ideal materials for exhibit case construction, particularly in the instances of sealed cases. Wood emits corrosive vapors (acids and compounds) which can be harmful to many objects and certain precautions must be enforced if wood is used with exhibit cases. Free acetic and formic acid are contained in all wooden materials and more acid is generated over time by the hydrolysis of the acetyl groups of both soft and hard woods. Elevated temperatures and high humidity increase dramatically the release of gaseous vapors.

We try to substitute non-wood products whenever possible and select safe and chemically inert materials whose composition and characteristics are known. Excellent wood substitutes includes: acrylic or polycarbonate sheeting and extruded paneling, such as Plexiglas or Lexan thermoclear panels; aluminum honeycomb paneling, such as Hexcel honeycomb sandwich; and paper honeycomb board, such as Tycore paneling.

In constructing cases, we make an effort to use the least corrosive wood products possible. In a study of the corrosive potential of wood toward metal (lead), Honduran mahogany was found to be the least corrosive because of its inherent lower acid content and low permeability characteristics. Try to limit woods used to; (soft woods) poplar, basswood, and spruce; (hardwoods) mahogany, walnut, birch and balsa wood.

Whenever possible, we avoid the use of plywood and particleboard. If plywood must be used in exhibit case construction, we specify:

- 1) the highest grade (Type 1, Grade AA or BB exterior plywood) with phenol-formaldehyde adhesive, or,
- 2) interior grade plywood with hard wood veneer using phenolformaldehyde adhesive (check with major lumber suppliers or contact the Hardwood Plywood Manufacturer's Association), or,
- 3) particle Board using phenol-formaldehyde adhesives.

Special protective coatings or laminates must be used to isolate all raw wood and wood product surfaces and edges that are exposed to the interior of exhibit cases. These materials should be sealed to reduce the outgassing of harmful, volatile substances. Remember that only certain laminates and sealants provide an effective barrier.

We use a variety of products which we have evaluated to isolate wood products. These laminates and sealants fall into the following categories:

- metal foil (such as aluminum)
- metalized plastic film (such as aluminized mylar)
- high pressure laminates (such as Formica, Micarta)
- epoxy (certain 100% solid, two part coatings)
- moisture cured polyurethane

Use of Adhesives In Case Construction

A wide variety of glues and adhesive systems have commonly been used in the assembly of exhibit cases. We have found that most adhesives emit vapors during their drying or setting phase and many continue to outgas throughout their serviceable lifetime. Research has shown that some of the most damaging construction adhesives fall into the categories of "contact" and "pressure sensitive" adhesives. New and complex formulations are available on the adhesives market at an increasing rate and many of these materials have the potential to harm sensitive display materials. In our experience careful scrutiny of these products is necessary in order to maintain a protective microenvironment.

We try to follow the following guidelines regarding adhesives:

1. Use mechanical fastening and avoid the use of adhesives altogether, whenever possible.
2. Depending on the placement of an adhesive it may or may not be exposed to the interior display environment. Utilize the design of exhibit case and construction techniques to inhibit the possible entry of volatile adhesive components. Utilize acceptable laminates and caulking of joints as effective barriers.
3. Use known adhesive systems which have a track record and include acceptable chemical components, i.e. acrylic resins, polyvinyl acetate and silicone adhesives.
4. Allow sufficient time for the curing and setting of adhesives before display materials are enclosed in the exhibit case. A minimum period of three weeks is recommended during which case doors should be open.

Use of Decorative Fabrics, Case Liners and Paints

We use a wide range of fabrics to line exhibit case interiors to achieve a variety of decorative objectives. It is extremely important, however, to systematically review these materials and their installation techniques in order to avoid introducing a source of potential damage to the display objects. Textiles are frequently used to line the interiors of sealed display cases yet only certain textiles are considered safe for this function. Both the fiber composition and dye used must be

examined to reduce the risk of contaminating the exhibit environment or risking dye transfer to objects. Wool fabrics (including felts containing wool), for example, should not be used because of the fabric's emission of volatile sulfur compounds. Pure cotton, linen, silk and even polyester fabrics are suitable. Fabrics containing other fibers should be tested as should dyed textiles to identify dye fastness in water.

Paint systems that our exhibit designers select for use within display cases require similar care in selection. Alkyd or oil based paints are a poor choice since they are known to outgas for long periods of time. Acrylic and acrylic latex paints have shown to be the most compatible paint system for internal exhibit use. The longer the curing time the better.

We try to follow three recommendations regarding case interiors:

1. Select safe fabrics for use within exhibit cases and prewash and dry them before installation to remove sizes and finishes and to preshrink the fabrics.
2. Attach liners by mechanical means whenever possible. It is recommended that adhesives not be used. Double sided adhesive tapes are not considered permanent yet the archival quality tapes can be useful in this function. Rust proof staples and tacks are also available for the attachment of fabric liners, while sewing is considered the safest option.
3. Review the composition of commercial wall paints and use only conservation-approved paints; allow sufficient cure time before installing objects.