EXHIBIT CONSTRUCTION: CONSERVATION, PRESERVATION, MATERIALS, AND DESIGN
FOCUS ON THE PRO FOOTBALL HALL OF FAME CANTON, OHIO

A Thesis
Presented to
The Graduate Faculty of The University of Akron

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts Administration

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August, 2011
EXHIBIT CONSTRUCTION: CONSERVATION, PRESERVATION, MATERIALS, AND DESIGN

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Thesis

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ABSTRACT

Standards are set by conservators as to the ideal conditions in which artifacts are stored and displayed. These standards provide for the preservation of museum objects that, if left alone and vulnerable to the environment, would deteriorate at a much faster rate. Unfortunately, using all ideal materials in storage and exhibit case construction is not within the budget for most small to medium sized museums. Therefore, adaptations from the standards should be made dependent on museum resources on a case-to-case basis. This paper is focused on the construction of exhibit cases and galleries to fit conservation standards and addresses the objects displayed, materials used to construct display cases, the role these materials play in the preservation of objects, and less expensive alternatives. For the purpose of this project, the focus is on museum objects and needs of the Pro Football Hall of Fame, National Football Museum, LLC in Canton, Ohio.

This paper is broken into five areas that cover the different concerns in the creation of conservation quality exhibits. The first chapter, “Care of Objects”, covers the different materials that make up museum objects in this museum and the specific concerns regarding the degradation of materials. The second chapter, “Environmental Control of Objects on Exhibit”, addresses safe and not-so-safe lighting options, how light is damaging to materials, interior case lighting
versus exterior case lighting, temperature and relative humidity, and dangers of airborne pollutants. A chapter on “Safe Exhibit Case Construction Materials” covers what building materials should be used and those that should be avoided. “Exhibit Case Design and Security” explains the different case styles, case access, and security principles that should be taken into account when designing exhibit cases for museum objects. “Sealed vs. Ventilated Exhibit Cases” explores the difference between these two types of exhibit cases and when each style is more appropriate. The chapter also addresses environmental control within the case, as well as forced and passive ventilation of an exhibit case. There are no citations within the text of this thesis to allow for an easier flow of information without the interruption of citations. All sources used in the research conducted for this thesis can be found at the end of the text. There is an appendix that includes further resources such as diagrams that need more clarification than can be provided within the main chapters, as well as photographs of the display cases constructed during the renovation of the Lamar Hunt Super Bowl Gallery at the Pro Football Hall of Fame.
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CHAPTER I
THE PRO FOOTBALL HALL OF FAME
NATIONAL FOOTBALL MUSEUM, LLC.

The mission statement of the Pro Football Hall of Fame located in Canton, Ohio, is: “To Honor, preserve, educate, and promote…to honor individuals who have made outstanding contributions to professional football, to preserve professional football’s historic documents and artifacts, to educate the public regarding the origin, development and growth of professional football as an important part of American culture, and to promote the positive values of the sport”. Since opening in 1963, the Pro Football Hall of Fame has grown in both size and stature. The building was expanded in 1971, 1978 and 1995; and completed major exhibit gallery renovations in 2003, 2008, and 2009. Together, these improvements have transformed the original 19,000 square-foot Hall of Fame museum into a 83,000 square-foot internationally recognized institution and travel destination.

The Pro Football Hall of Fame features seven galleries with numerous interactive kiosks to support the historic football memorabilia on display. The galleries are primarily located on the second floor of the museum. Upon ascending the ramp inside the front doors, visitors come across the rotunda
gallery which houses the story of the first century of football. This gallery includes some of the most vulnerable objects on display in the museum.

The Teams of the NFL gallery is located next to the rotunda and is sandwiched between walls of glass windows. The gallery houses informational panels and helmets representing all thirty-two teams of the NFL. The windows of this gallery are coated with a UV protective film to decrease damage from the intense light shining through the windows.

The Pro Football Hall of Fame’s permanent collection consists of approximately 19,000 artifacts relating to the origins and history of Professional Football as played by American rules. Originally and throughout the early years, the Pro Football Hall of Fame displayed artifacts by commercial building standards rather than museum standards. The galleries were lit with fluorescent lights and artifacts displayed openly without cases. Due to these factors, artifacts that were on display during that time now show visible signs of damage. Jerseys bear irreparable fading and weakness from light damage. Some artifacts displayed in the open were repeatedly touched by visitors. Over time this practice has caused wear to the artifacts such as missing letters from jersey nameplates.

In 2008, the Hall of Fame renovated the Moments, Memories, and Mementos and Pro Football Today galleries. These renovations marked the first step in updating the galleries to better preserve the artifacts on display. The Moments, Memories, and Mementos gallery features exhibit cases that are dimly lit until visitors set off motion detectors that brighten the case temporarily to allow visitors to better view the objects inside the cases. Also, the shoes, helmets, and
football on display are supported by custom made mounts to better support and preserve the artifacts.

The Pro Football Today gallery incorporates video with artifacts to support the stories of NFL Goes Global, The Pro Bowl, Career Records, and Rookie Records. All of the artifacts on display are mounted on conservation body forms, behind glass, and lit by LED strips.

The goal of the renovation of these two galleries, was to begin the process of making all of the exhibit galleries meet preservation standards in an effort to protect the artifacts on display and enhance the visitor experiences. However, the opening of the Lamar Hunt Super Bowl Gallery proved to be the greatest enhancement thus far in protecting and preserving the artifacts on display. The research conducted for this thesis was implemented in the design and display methods used in the recently opened Lamar Hunt Super Bowl gallery.
CHAPTER I

CARE OF OBJECTS

Leather Artifacts

Leather is one of the most difficult materials to preserve because it does not consist of just one material. The process of creating leather and the nature of the rawhide affect the aging process of the material. In most cases, leather objects are not made entirely of leather. Most leather objects also include materials such as metal, which can adversely affect the aging process of leather.

As with many organic materials, light and humidity can age leather dramatically over time. Exposure of leather objects to excessive dryness results in cracking, breakage, and embrittlement of the object surface. Extreme exposure to light causes similar problems to dryness, with the addition of fading in the color of the leather object subjected to the light. Also, high humidity levels will cause mold growth that will lead to an overall softening of the leather along with staining, odor, and surface distortion. All of the above mentioned conditions can increase the chances of the development of red rot.

“Red rot” is one of the greatest concerns with leather. It is an irreversible deterioration of leather caused by the tannin reacting with sulfuric acid in the atmosphere. Although these challenges exist with leather, measures can be taken to preserve objects made of leather for years to come. Red rot occurs as
the leather is exposed to airborne pollutants in the environment. Once affected, objects go through several stages before finally disintegrating. In the earliest stages of red rot the leather object will display a pinkish color that seems to darken as time goes by and cracks will start to appear in the areas that receive the most wear. Once the deterioration progresses further, the cracks widen and the tissue beneath the surface will start to soften and disintegrate into a reddish brown powder. At the end stage of red rot the leather will appear dark red and need conservation treatment or be sacrificed from the collection by a complete disintegration of the material. Red rot is irreversible but the length of time between the beginning and end stages can be prolonged with proper care and treatment such as limited handling and storage in a separate environment with air control.

The accumulation of dust is a problem with leather since dust particles can be difficult to remove from the surface of leather without damaging a fragile, painted, or decorated surface on the leather. Dust particles act as tiny abrasives on the surface of leather and can leave permanent damage if allowed to collect. In addition to dust, objects that consist of leather and metal, such as shoes, are at risk for corrosion caused by the metal interacting with the leather tannin. In cases such as these, care should be taken to insure that the metal is clean and when possible, plastic such as Mylar ® should be inserted between the metal and leather to create a barrier. Damage to leather can result when the object is folded, displayed, or rested on its side or edges. This can lead to structural damage of the object resulting in splitting and cracking of the leather. The
damage caused by resting an object on its side or edge can also make the object lose shape and alter the overall appearance.

The ideal environment for the display of leather is in an area with a humidity level in the range of 45-55% and temperature of 64°F-68°F because leather reacts to even the slightest change in humidity. Leather is a naturally acidic substance but has the potential to be damaged by pollutants in the atmosphere.

Painted and dyed leathers are highly light sensitive and should be watched carefully for cracking and splitting. Leather objects should be fully supported when displayed to help maintain shape over time, prevent cracking and splitting, and prevent stiffness. Mounts made for leather objects should provide support devices for all areas. For example, leather helmets should be displayed on an ethafoam™ mannequin head form to provide support to the entire helmet from the inside and prevent loss of shape while on display. For shoes, this means both internal support to help maintain shape and external support to prevent the shoes from tipping over. One of the greatest dangers to leather is insufficient support, both when in storage and on exhibit.

Plastic Artifacts

Plastic is becoming more of a concern with conservation care as it becomes the prime material used to create modern equipment and parts. Objects made of modern plastics can be very unstable and easily affected by plasticizers that are off-gassed from some construction and packing materials from the
surrounding environment. Deterioration of plastic objects is evident within five to twenty-five years of collection. The deterioration of plastics is inevitable and once it has started it cannot be stopped or reversed, only slowed.

Different types of plastic behave differently while deteriorating. Plastics are typically classified according to their origins: natural, semi-synthetics, and synthetics. Natural plastics include materials such as amber, wax, and rubber. Semi-synthetics include materials such as hardened rubber, casein, cellulose nitrate, and cellulose acetate. Examples of synthetic plastics include phenol formaldehyde, urea formaldehyde, polyvinyl chloride (PVC), polyethylene, polyamide, and polyurethane.

Although all plastics deteriorate in similar ways, such as crazing, cracking, and yellowing, some plastics have specific characteristics. The deterioration of cellulose nitrate based plastics occurs in three different stages. During the first stage, plasticizers in the object evaporate or migrate, which, in turn, causes the object to shrink. In the second stage, crazing and cracks begin to develop and the object begins to yellow. Once the object reaches the final stage of degradation the advanced crazing causes the cellulose nitrate to begin disintegrating. PVC plastics experience many of the same characteristics as cellulose nitrate with the addition of a tacky surface and the possible presence of crystalline material on the object surface. Casein plastics are affected mostly by the loss of moisture because water is a plasticizer in these products. The only visible degradation exhibited by casein objects is crazing due to moisture loss but casein is also vulnerable to attack from mildew. Unlike other plastics, degradation
of cellulose acetate objects is evident with the odor of acetic acid, which smells like vinegar. Environmental factors involved in causing change for all plastic objects include light (especially ultraviolet), heat, stress, oxygen, moisture and humidity, ozone and other airborne pollutants which may be off-gassed from other degrading objects close to the plastic, and direct contact with other materials.

Ideally, plastics should be protected from light at all times, which clearly is not practical for objects on display. Therefore, plastics should be under the least amount of light possible. The use of a dimmer or motion detection system on exhibit cases, for example, is ideal for the display of plastics. Light can serve as a catalyst in the degradation process by speeding the process of oxidation as well as in some cases conducting heat within the object environment. A cool environment works best for plastics. Temperatures in the exhibit area or exhibit case should be approximately 65°F. Humidity should be controlled in areas where plastic is exhibited due to the absorption of moisture and damage that would occur as a result.

Ventilation and environmental control are extremely important for objects made of plastic. Exhibit cases holding plastic objects should be ventilated for the prevention of trapped pollutants off-gassed from the object. This allows the object to breath and also serves to protect any other materials that may be part of the plastic object or displayed within the same case. For example, modern football cleats made of plastics also have shoelaces made of cloth which would be
susceptible to degradation when exposed to the acidic elements released by plastic.

Paper Artifacts and Photographs

Paper and photographs are two of the most sensitive materials in museum collections. Different airborne pollutants such as nitrogen and sulfur gases, soot, and mold spores can react with paper and increase the rate of degradation. Likewise, humidity can permanently damage paper and photographic objects by causing the material to distort or curl. Paper is highly light sensitive; therefore, light level and exposure should be kept at a minimum.

Light damage on paper is sometimes invisible until it is too late. Light damage not only leaves visible damage with fading and yellowing but also weakens the paper fibers and can turn the paper brittle. Light damage is cumulative and irreversible, so even a low level of the best lighting causes damage to paper over time. Due to the sensitivity of paper to light, it is best to display replica copies of documents and works on paper when possible and keep the originals in a dark storage room. If that is not an option, paper objects should only be left on display for very short windows of time. When paper objects are on display, there should never be a partial shadow cast by another object in the exhibit case or a part of the exhibit case as this will cause uneven fading which cannot be reversed.

Paper objects should be matted or framed while on display in tightly sealed frames. Frames should be regularly checked to insure that the seal is
intact. If the frame is not tightly sealed, moisture, dust, or pollutants can collect inside the frame and damage the object. When framing a paper document, mat board should be rigid enough to provide support and should be made of cotton rag or 100% chemically purified and buffered to a pH content of 7.5 to 10.

Paper objects should be exhibited in a cool, dry environment with a temperature around 68°F and relative humidity of approximately 40%. Climatic changes cause paper to expand and contract, which can cause documents to curl, weaken, become very brittle. Temperature and relative humidity should be kept at a steady constant range. Heat and moisture can cause paper to deteriorate more rapidly and encourage the growth of mold.

When paper objects are on display, they should be mounted in a way that is reversible. The mount should be constructed to allow the paper to expand and contract as necessary. The mat framing the paper document should provide space between the document and the protective glass or plastic. In attaching the object to a frame, adhesives should not directly touch or be added to the object. Matboard should be attached to the backing material rather than the object. Japanese paper strips with wheat starch paste has been found to be a safe material in creating hinges on mats protecting paper documents and photographs.

Photographs are vulnerable to the same risks as paper documents with the added concern of development techniques used and chemicals added. As with paper, photographs should be protected from light as much as possible and replica photographs should be used whenever applicable. Framing materials for
photographs need to have passed the photographic activity test (PAT), which is designed to determine the safety of a material when in close contact with silver photographic images. If PAT approved materials are not available, lignin free or 100% rag are safe alternatives. Due to the glossy finish of most photographs, extreme care must be taken to insure there is space between the photograph and protective glass or acrylic in the frame. If photographs are pressed too close to glass or acrylic, the chemical degradation of the photograph will cause the photograph to adhere to the protective covering. This is very hard to repair and conservation care is required.

Wood Artifacts

Wooden objects, much like those made from leather, are rarely made exclusively of wood. Most have some type of adhesive component and may also include other materials such as metal or plastic. This creates an issue when it comes to preservation because of the differences in degradation of these materials. Protein based glues typically used to joint wood furniture and products are water soluble and are sensitive to high relative humidity. Wood is an organic material and therefore naturally produces harmful acids as it ages. This can in turn be damaging to other parts of the object that are made of a different material, such as plastic or metal. For example, degradation of wood products on a trophy base may cause the metal trophy to tarnish more readily.

Due to physical, chemical, and biological deterioration, wood can change in appearance over time. Changes in temperature and relative humidity can
cause wood objects to shrink or swell and become distorted and warped. The fluctuation of relative humidity is especially dangerous for furniture or wood objects made from more than one board that are connected across grains. These objects are vulnerable to stress because the natural expansion and contraction of wood is restricted by glue, nails, or screws. The stress placed on objects of this nature can cause the wood to split.

Changes in relative humidity, natural weathering, and human abuse are all causes of physical deterioration of wood objects. Light can also speed the deterioration of wood objects. Light damages the cellular structure of wood and bleaches the color. It is especially damaging to include interior case lighting when displaying an object made of wood. The light will change the natural color and make light wood appear darker and dark wood appear lighter. Light can also embrittle finishes and fade stains on wood objects.

Wood should be exhibited in an environment with a temperature of 68°F as this will stop mold growth. Fasteners, such as nails, screws and bolts, often made of metal, will corrode in high relative humidity. The corrosion of fasteners can spread and damage both the appearance and structure of the wood object. Elements in the metal fasteners can discolor the wood and degrade the chemical stability of the object. If the metal fasteners become severely corroded, it will expand and cause the surrounding wood to split.

Much like plastics, as wood goes through the aging process it produces acids that can be damaging for the wood and surrounding objects if not properly ventilated. Cases displaying wood objects should be well ventilated or have an
environmental chamber to absorb any off-gassing. This should be determined on a case by case basis dependent upon other elements of the object. Wood objects are also at an increased risk for pest infestation and therefore should be encased at all times when on display. Dust is abrasive to wood and also attracts mold and insects. Wood objects should be carefully dusted on a regular basis to prevent any infestations or mold growth.

Textile Artifacts

Textiles are one of the most light-sensitive objects in museum collections. Light damage on textiles is irreversible and causes the objects to weaken tremendously. Textiles will deteriorate at a faster rate if in contact with acid-releasing materials such as cheap mount board, certain woods, and some metals. Textiles absorb water very easily. The absorption of water causes textile fibers to swell and become longer. As the fibers dry they shrink and become shorter. This can cause deterioration of the textile and can occur due to high moisture content in the air.

High relative humidity, above 65%, is conducive for mold and pests. Conversely, low relative humidity reduces the moisture content in textiles and can leave them brittle and dry. Rapid change of humidity in the air can cause textile materials to separate and lift. For example, painted detail on banners may lift from the unpainted portion of the textile from humidity fluctuations over time. Relative humidity should be kept no lower than 45% and no higher than 65% for
90% of the time. Temperatures should be kept at around 68°F when displaying textiles.

Light damage on textiles is permanent and irreversible. Often, textiles damaged by light need conservation treatment just to be strong enough for display. However, conservators are unable to restore faded colors or return textiles to original strength. Damage to textiles from light begins with a loss of flexibility. Textiles will slowly become weak and brittle until they break into tears and eventually turn to dust in extreme cases. Throughout the degradation process, the textiles become discolored and take on a yellow or brown hue.

Textiles should be on rotation for exhibit and should not be displayed permanently. All light at any level is damaging and can cause degradation over time. It is not advisable to display an object that is already in poor condition because the condition will worsen from being on display. If a textile is crucial to an exhibit, use a photograph or digital image of the object instead.

Textiles on display should be supported by a mount to avoid damage. Textile mounts should be constructed in a way that physical damage such as tearing and stretching can be avoided. When on display, creasing and wrinkling the textiles should be avoided. This can cause a weakening of fibers at the points where the fabric is creased or wrinkled. Textiles should not be put on open display. Textiles on open display are vulnerable to damage from human contact, pests, moisture, and dust. Once dust becomes embedded between the textile fibers it is extremely difficult to remove. Dust can disfigure and wear on the fibers
of the textile. Textiles should be displayed within an exhibit case with proper ventilation.

Metal Artifacts

The biggest concern with most metals is corrosion. Gold and silver are the two exceptions and do not corrode within the museum environment although silver can experience sulfide related tarnishing. Unfortunately, the majority of metals found in museums are alloys, a mixture of more than one metal, which easily corrode. Corrosion can occur due to airborne pollutants in the environment, as a result of reactions with other nearby materials, and by human touch. Handling of metal should always be done with gloves. The natural oils in skin corrode metal and over time fingerprints are visibly imprinted into the surface of the metal objects.

Light and temperature is not as great of concern with metals as it is with most other materials. However, relative humidity can impact the amount of corrosion or tarnishing metal objects experience. Ideally, iron objects should be stored at a relative humidity of 40% or less whereas for most other metals, a relative humidity of 50-55% is permissible. If relative humidity levels are too elevated, iron and copper alloys will corrode. The greatest environmental danger to metals is from airborne pollutants.

Acetic and formic acids produced in the deterioration of other materials can cause corrosion and salt formation on metals. Some metals will tarnish because of the effects of acetic acid. These acids can also be off-gassed from
improperly sealed wood products used in the construction of exhibit cases.

Nitrogen oxides from cooking appliances can damage metals. Metals should not be exhibited in areas close to food service. Ammonia and aluminum hydroxide from cleaning agents and paints can tarnish and cause corrosion to metals. It is not a good idea to routinely polish or clean metal pieces because each time metal is polished, a layer of the surface is ground off or dissolved away by cleaning solutions. Therefore, it is imperative that metals on display are encased in a sealed environment with pollution scavengers such as activated charcoal cloth or pacific silvercloth.

Metal should not be exhibited in a shared case with objects experiencing cellulose nitrate degradation because the degradation causes corrosion and tarnishing of the metal. Sulfur gas released by wool in carpeting or textiles is also damaging in proximity to metals and will cause corrosion. Certain interior paints in exhibit cases will also tarnish metals and should be avoided. Exhibit cases housing metal objects should be well sealed with an environmental chamber and pollution scavengers to prevent corrosion and tarnish.
CHAPTER III

ENVIRONMENTAL CONTROL OF OBJECTS ON DISPLAY

Lighting

All wavelengths of light, including all visible light, cause significant damage to most objects. Ideally artifacts should be exposed to light only while in use and at the lowest level possible. The Law of Reciprocity states that limited exposure to a high-intensity light will produce the same amount of damage as long exposure to a low-intensity light. Therefore, an object’s exposure to 10 footcandles for 5 hours would cause the same damage as when exposed to 5 footcandles for 10 hours. Light levels should be measured as the light falling on the object. Measurements should be taken at the time of lighting installation in an exhibit space and again whenever a change in lighting occurs.

Visible light is a necessary evil when exhibiting objects. Although the light is damaging, it is necessary in order for visitors to see objects on display. In the museum setting, visible light levels ideally should be set at 5 footcandles for the most sensitive objects and a maximum of 10 footcandles for those objects that are slightly less sensitive. Items made of multiple media and those with unknown light sensitive should be treated as very sensitive. Many times, because of visitor
comfort, this is easier said than done. To address this concern, dimmers and timers can be utilized to limit the time objects on display are illuminated. Another possible design is to structure the gallery so the least sensitive objects are at the beginning where light can be slightly stronger and gradually dim the lights as visitors move further into the gallery. This allows visitor eyes time to adjust and the decreased light level to go unnoticed.

Ultraviolet radiation (UV) is one of the most harmful aspects of light damage on objects. UV raises the temperature of objects because of high energy levels and energy absorbed from infrared light. Some of the most damaging sources of light include the sun, tungsten-halogen lamps, mercury or metal halide high intensity discharge lamps, and fluorescent lamps. UV filters should cover any windows within an exhibit gallery and objects should be placed in areas where the sun cannot shine directly on them. Natural light should be avoided at all cost and exhibit areas should be lit only with artificial light. When objects begin to fade it is only a small indication of the deterioration caused by light.

Damage from light is cumulative and irreversible. Light causes paper to yellow, bleach or darken, and can cause the fibers to weaken. Light also can cause organic materials to break down at a faster rate due to extended exposure. Signs indicating the reason for low light levels might help explain why displays appear so dark and also underscore the fact that the objects being displayed are fragile and precious.

Dimmers used in galleries allow for some control of the amount of light illuminating an object. Dimmers can include a visitor operated button, motion
sensors, or light triggered by sound. When applicable, light should be diffused and not direct, therefore less light will be needed. Although spotlights are commonly used to create visual interest in a particular object, they should never be directly on an object. The use of indirect and low lighting will provide some protection of the object. This technique also allows for less adjustment of the eye which then allows the use of lower wattage lamps throughout the entire exhibit space.

Fiber Optics

Fiber optic lighting is an excellent and energy efficient way to provide display lighting. It is useful for lighting spaces that are difficult to access. Fiber optic lighting consists of light transmitted from a light source through glass fibers. Fiber optics are ideal for exhibit case lighting because they do not cause a buildup of heat within the case. When used in internal light chambers, low level light can be piped directly into the case while maintaining a seal on the exhibit case. By doing this, the light injector can be located outside the display case which prevents heat buildup within the case. The benefits of fiber optics include system versatility, reduced maintenance, exhibit security, heat isolation, fixture size, control, and design effect opportunities.

Fiber optic systems, although ideal, can have some drawbacks. Challenges involved with fiber optic systems include efficiency, confusing photometric data, and post installation maintenance. Some fiber optic systems are made with
acrylic fibers rather than glass, which is less durable and the light is not as safe as that carried by glass fibers. The drawback to fiber optics is that it is difficult and costly to spotlight large objects.

Light Emitting Diode (LED)

Light Emitting Diode (LED) lighting has a long lifespan. This type of lighting is compact, requires low energy consumption, and do not give off heat. LED lighting can also produce dynamic lighting effects. There is no maintenance required for LED lighting, although illumination decreases by 30% after five years. LEDs are directional lighting and can be dimmed. Along with fiber optics, LED is the preferred lighting method for exhibit galleries.

The challenges faced when using LED lighting include white light, white efficiency, clarity, light management, packaging, and cost. The light beam itself has no heat or IR but the fixture itself will generate heat. When placed in a lighting chamber of an exhibit case, the light bay must be properly ventilated. If heat is not ventilated, the internal temperature of the exhibit case can increase by as much as 2°. While this is still better than other lighting systems, it should be avoided. Most LED systems have a lifespan of 50,000 hours. It is difficult to mount LED lighting close together when trying to achieve uniformity in a small exhibit space. LEDs are difficult to use in track lighting due to competition between light output and uniformity. Since LEDs will produce light indefinitely, depreciation of light quality is the determinant for lifespan.
Incandescent

Incandescent lights illuminate colors well, and compared to other light sources, are less expensive and easier to install. Incandescent lamps produce an appearance similar to candlelight or the illumination of a kerosene lamp. Incandescent lighting includes lamps such as mirror reflector (MR) and Tungsten-Halogen. MR lamps have a reflector made out of glass coated with a transmissive film coating to reflect all visible light. This allows the infrared and UV rays produced by incandescent lights, to go through the reflector. Over 60% of the infrared and UV rays are reflected through the back and sides of the lamp rather than forward and on the path of the light beam.

Tungsten-Halogen lights can be dimmed, but give off significant amounts of UV. If used, UV filters must be employed. Incandescent lights have an adverse effect on the moisture content of sensitive materials due to heat build-up. Use of these lights can create surface heating which results in cracking and splitting. These lights should not be mounted close to objects on display.

Fluorescent

Fluorescent lamps produce high levels of UV radiation. The exact amount of UV produced by fluorescent lamps varies by brand. Typically, fluorescent lamps emit anywhere from 0.5% to 12%. If fluorescent lights must be used, museums should only use those that emit no more than 2% UV. Due to the strong amounts of UV produced, if used in an exhibit gallery objects should be located at least 24 inches from the light source with a UV filter.
Fluorescent lamps consist of mercury vapor inside a glass tube painted with white fluorescent powder on the inside. When electricity is passed through the tube, mercury vapor emits UV radiation which is absorbed by the powder and emitted as visible light. Fluorescent lamps are more damaging than incandescent lamps due to the high levels of UV emitted. Although UV filters are available for fluorescent lamps, the filters are expensive and require replacement after a certain amount of time. Fluorescent lights cannot be dimmed and are a disadvantage for exhibit areas. Fluorescent lights should be avoided unless budget and means prevent the purchase of better systems.

Interior and Exterior Case Lighting

Interior case lighting can be accomplished by the use of a lighting chamber within an exhibit case as shown in appendix A. This way, maintenance to the lighting system can be accessed through a separate door than the display chamber. Lighting should be separated from the display chamber to protect the display from any accidents. Light chambers inside exhibit cases should be ventilated and filtered to prevent heat buildup and dirt deposits. Freestanding or built-in display cases usually house lighting chambers in the overhead of the case. Display cases that are only seen from one direction typically have a partial lighting chamber just above the display that slants upward to disappear from view. Display cases that are seen from all sides require a full lighting chamber that is the same size as the top of the case.

When possible, lighting should be installed outside of the exhibit case. Certain types of objects need exterior lighting due to issues with degradation.
Some lighting fixtures produce a greenhouse effect of heat within the case. Heat filters and reflector lamps should be used to reduce the amount of heat projected into an exhibit case. Temperature directly determines relative humidity and therefore its control is critical. When temperature rises, humidity falls, and when it cools, humidity rises.

**Temperature and Relative Humidity**

Temperature and relative humidity are extremely important environmental factors in the preservation of objects on display. Sudden changes in temperature or relative humidity can cause objects to expand and contract. When a room is heated, the level of humidity falls and when it cools, the humidity rises. This being said, relative humidity and temperature directly effect and are affected by each other and are important part of environmental control in an exhibit gallery or case. Sporadic changes in relative humidity or temperature can cause irreparable damage to materials.

Relative humidity should not exceed 40% ± 5%. If relative humidity gets too high, objects are susceptible to mold outbreaks and pest infestations. Relative humidity that is 35% and lower can cause the embrittlement of some objects and dry out materials such as leather and textiles. The relative humidity set in a museum should accommodate for seasonal variations and the transfer from heat to air conditioning. For example, the air feels noticeably drier in a heated room during the winter and more damp when it is cooler. Museums located in regions that experience seasonal change must accommodate these
natural changes in humidity. These changes in relative humidity should not be more than 5% per month to allow objects to easily adjust.

Temperature should not exceed 72°F and should not be less than 68°F. Temperatures above 80°F can cause a considerable amount of damage to objects on display. When temperature changes are necessary, there should not be more than a 2°-3° change within twenty-four hours. For every 18°F increase in temperature, the rate of chemical degradation in an artifact doubles.

Temperature should remain constant twenty-four hours a day all year long. This means that the temperature settings in the building should not be lowered at night, weekends, or when the building is closed.

Airborne Pollutants

Airborne pollutants are a danger to objects on display as they can cause increased degradation in organic materials and corrosion of metals. These pollutants are drawn into museums from outdoor air, office equipment, construction materials that have not been given proper time to off-gas, paints, and cleaning products. Airborne pollutants include sulfur dioxide, nitrogen dioxide, ozone, acetic and formic acids, and volatile organic compounds (VOC). When these pollutants collect in exhibit cases, acid can form on objects and cause damage. Exposure to even low concentrations of pollutants is as damaging as exposure to high levels of pollutants over a short period of time.

Construction materials used in the renovation of an exhibit gallery or construction of exhibit cases can give off harmful pollutants such as dust, solvent fumes, and moisture. Even after surfaces of displays appear dry to the touch,
volatile compounds can still be secreted. Many times the presence of volatile compounds and pollutants are evident by scent but some damaging pollutants cannot be as easily detected until damage to the object displayed is evident. It is imperative that exhibit cases are given proper time for off-gassing prior to the installation of museum objects. The ideal off-gassing time varies depending on materials used in the construction of galleries and cases.

The majority of pollutants are released immediately after application during construction but volatile organic compounds from paints and coatings can still be released for at least fifteen months after installation. Materials used in construction of walls and floors such as vinyl, foam insulation, textiles, linoleum, rubber, and some furniture can all bring airborne pollutants into the museum environment. Museum visitors are also a source of pollutants in the museum environment. Fibers from clothing and skin flakes produce dust and are damaging in contact with museum objects. No object on display should be in the open due to the damaging effects of pollutants in the environment. Museum objects stored in the same case as other objects may also cause damage from off-gassing due to the degradation of materials such as plastic and wood. This is why plastic and wood objects should be monitored closely and displayed in cases that allow air exchange.

Dust, both that caused from visitors and that left from construction, can cause scratches and surface damage to objects on display. Dust can enter into display cases and soil the surfaces of the display and the encased object. Typically these particles are acidic because they are absorbed from other
degrading objects or absorb airborne pollutants from off-gassing of construction materials or ozone. Dust can cause organic materials to deteriorate at a faster speed. Good ventilation or the use of pollutant scavengers can help control the amount of dust that collects on objects.

Airborne pollutants and dust are impossible to eliminate entirely. To reduce the amount of pollutants in the environment, construction materials should be made of inert materials rather than those with a high rate of off-gas. A physical barrier around polluting materials can guard the object on display from the damaging effects of the construction material. Objects should always be enclosed when on display and out of reach of visitors. It is imperative that when an object is displayed in a well sealed case that only inert materials are used in the construction of the case. Ventilation systems should be filtered to dilute the concentration of airborne pollutants that have access to the case. Typically, the greatest damage and concentration of pollutants is due to poor ventilation within enclosed cases. The speed and level of degradation of an object on display is a direct result of the accessibility to airborne pollutants. A newly constructed exhibit space should not be filled with objects until emissions from pollutants are at a safe level.
CHAPTER IV
SAFE EXHIBIT CASE CONSTRUCTION MATERIALS

Wood

Although inexpensive, wood has drawbacks as a construction material for exhibit case construction. Some woods such as oak, Douglas fir, teak, red mahogany, yellow pine, sweet chestnut, cork, and western red cedar have a tendency to off-gas natural acids. These woods should not be used in case construction due to the corrosive qualities of the natural acids they produce. Wood based products such as Masonite, chip board, particle board, interior plywoods bonded with urea formaldehyde and C grade plywood should not be used because they produce formic acids, acetic acids, and peroxides from both the wood and adhesives.

If wood is being used as a case construction material, well-seasoned air-dried spruce, mahogany, walnut, basswood, poplar, and balsa are all safe to use. Before any wood is used in case construction it should be thoroughly aerated. Cases made of wood should include pollutant scavenger materials such as activated charcoal to control the effects of pollutants on the objects displayed. Wood that has been treated with fire retardants should not be used inside cases because fire retardants pose a risk to museum objects. There should also be a barrier covering the wood and preventing direct contact with the exhibited object.
Protective films such as aluminum sign blank, formica, sintra, and marvelseal® are all preferred and serve as a much more effective barrier than liquid coatings.

Woods naturally produce acids and formaldehydes which can damage objects if the wood is not properly sealed and ventilated. Once the wood used for cases is sealed, nailing, stapling, or drilling of holes will destroy the effectiveness of the barrier films and coatings. Although typically not in direct contact with objects, edges of boards should be sealed because the edges emit vapors at a higher rate than the broad side of the wood. Thickly applied paraffin wax will effectively seal end grains on wood boards. Knot holes naturally occurring in wood are also sites for higher rates of vapor emissions. Wood with knots and exposed wood joints should be avoided when selecting materials for case construction. During construction, sawdust should be limited and avoided when possible. When wood is rendered into sawdust, the maximum evolution of organic acids occurs.

Metal

Metal is the most desirable material for exhibit case construction. Metal is inert, non-flammable, and does not emit harmful vapors. However, not all metals are safe to be used near museum objects. Baked enamel metals are harmful because the process involves alkyd resin paint, urea or thermosetting polymers like melamine formaldehyde. These materials continue to evolve acids over time.
and are harmful to artifacts. Powder coated steel or aluminum is the ideal material and safest metal for exhibit display case construction.

Unlike liquid coatings that need solvents to assist with the application, powder coating is applied in a process that does not require a solvent and provides a protective layer to prevent rusting should humidity become a problem. The solvents used in liquid coatings release vapors as the coatings dry and even though the rate of emission decreases over time, it does not happen quickly. Even though powder coating is safe, it is imperative to give enough time for coatings to dry in order to allow harmful emissions to dissipate before adding museum objects in the environment.

Plastics

Many plastics off-gas over time and produce plasticizers that can damage certain materials. Plastics such as PVC, chlorinated rubbers, cellulose nitrate, cellulose acetate, or rubbers with sulfur vulcanizing agents should not be used because they contain chlorine and are a danger to museum objects. Plexiglas, lucite, polyethylene, polypropylene, polyester, polystyrene, acrylic, and polycarbonate plastics are all safe to use.

Plastics such as Plexiglas and acrylic are a good choice as barriers to prevent visitors from touching objects on display. Vitrines made of these materials are useful for protecting objects from dust and airborne pollutants. Plexiglas and acrylic are also effective barriers for security of objects from theft or physical damage.
Textiles

Fabrics are frequently used as lining in exhibit cases, backdrops, reproduction clothing, or as a barrier between an unsafe material and museum object. Not all fabrics are safe for use with museum objects. Wool, jute, foam or adhesive backed fabrics, and anything coated with fire retardants are all unsafe. These fabrics give off harmful vapors that can cause damage and corrosion of objects. Wool will damage silver and other metals by direct contact or oxidation. Fabrics that contain phosphates, adhesives, resins and dyes can cause harmful degradation similar to that of plastics.

Undyed and unbleached cotton and linen fabrics are safe to use as long as they are thoroughly washed and rinsed prior to installation. The ideal fabrics for case design are those held together by thermal/spin bonding or needle punched. Textile surfaces should not have surfaces that can stick to the surface of the objects being displayed.

Some textiles are made to control the air quality of exhibit cases. Pacific Silvercloth ® prevents tarnishing on silver and silver plated objects. It consists of 100% cotton fabric that is impregnated with silver nitrate. Activated charcoal cloth absorbs the organic acid vapors and other airborne pollutants that are harmful to objects. Activated charcoal cloth needs to be checked on a yearly basis and replaced to insure that the cloth is still absorbing pollutants and not producing secondary off-gassing. Activated charcoal cloth is available in both cloth and pellet forms depending on object and case need.
Coatings and Sealants

Coatings and sealants are necessary to protect objects from the construction materials such as wood that will off-gas over time. When sealing wood, one or two additional layers of coating should be applied to the edges of wood boards to establish a safe barrier as these sections of wood tend to off-gas more. These barrier materials should be given proper time to off-gas before objects are placed in the environment because they tend to produce harmful vapors for quite some time after installation. There are many building materials on the market for commercial use, but not all of these are safe for museum use. Only materials that have a low volatile organic compound (VOC) emission rating should be used. These materials tend to off-gas tremendously, which is a concern for paper documents. Regardless of the VOC emission rating, a drying period of four weeks should be allotted for coatings inside cases to properly aerate. Even after coatings and sealants have been applied, a proper barrier such as acid free paper or plastic sheeting should be applied between the case and the object being displayed.

Paints and Adhesives

Paints and adhesives used in the construction of exhibit cases should be chosen carefully. Many materials that seem fitting for display purposes to make an exhibit aesthetically pleasing can cause corrosion, discoloration, and
deterioration of objects. Paints are useless as a barrier against harmful vapors and may actually add to the harmful emissions already presented by construction materials. If paint is used, casein, alkyd, polyurethane, and oil-based paints and varnishes should be avoided. Quality acrylic latex with a low VOC emission and epoxy-resins are safe to use once enough time is permitted for the paint to dry thoroughly and aerate. Paints and adhesives must be given proper time to aerate, especially water-based emulsions. These products form a skin that is dry to the touch hours before the water has completely escaped. If not properly aerated and enclosed inside a case, the humidity level within the case will rise and damage objects as a result.

Adhesives are similar to paints as to materials to avoid. Adhesives should be checked for formaldehyde, acetic, formic, and sulfuric acids, chlorohydroxide, and ammonia gas prior to use in exhibit case construction. Hot melt glues, dense polyurethane, and Tyvek are safe adhesives to use. Epoxies and urethanes should be avoided because of the damaging pollutants they produce.
Case Access

Case access is a very important part of the protection and security of museum objects. The need of curatorial staff to access objects on display should be considered in the construction and design of exhibit cases. Objects that may need to be accessed on a regular basis should be relatively simple to get to without putting the object or staff member at risk. The case should also require the least number of staff possible to access objects. Cases should take the least amount of time possible to access while still providing security for objects on display. The security component should make it difficult for the public to access the case, but allow simple maintenance for curatorial staff. Also, the cases should be easily re-secured once staff is done accessing the object. Lock location should be placed in a convenient location for staff and hidden from the public. Security hardware such as spanner screws and other security derived fasteners should be used when possible. The case access should not weaken the stability of the case in any way.

Lift-off style case access involves a vitrine that surrounds the object and must be lifted for case access. One person should be able to lift vitrines when
possible. Vitrines of this style should be made so that they can be safely and easily lifted over objects for removal, should never be larger than 30” x 30” x 30” and should weigh no more than 75 pounds, the maximum for two people to lift safely. Vitrines made of glass are double the weight of those made of acrylic or polycarbonate.

Another option for display case design is hinged doors. These doors should be accessible by only one person whenever possible. Hinged doors should be designed so as not to disturb the stability of the case. These cases can be troublesome in use with a well-sealed case because it is difficult to properly seal the hinge area as hinges tend to pinch nearby gaskets.

Security

Different levels of security can be achieved through case design. Cases should provide protection of the object from theft and visitor damage as well as environmental protection. The structure and design of an exhibit case determines its capability of protecting the object on display.

The case should keep the object out of reach from visitors, prevent structural damage, and protect the object from theft while on display. Locks should be designed to allow easy access for staff but deny access to the case by an intruder. Hardware used to secure cases should be concealed and if visible, tamper resistant security screws should be used.
Case Style

There are two main styles of exhibit cases found in museums, free standing cases and wall cases. The decision as to which design should be used in a gallery is decided according to space availability, object need, and the shape and design of the existing space. Regardless of which design is chosen, the enclosures must be designed to provide a protective microenvironment for the object displayed. The case must control the level of airborne pollutants that come in contact with the object, and should reduce the amount of instability in the temperature and humidity surrounding the object.

Free standing cases are those which are not built or attached to a wall. These cases can have a hinged door or lift off style access. Structural frames on free standing cases can provide strength and physical security but they also increase the potential for penetration of outside air and pollutants. If structural frames are used, gaskets and caulk sealants will be needed if the case is to be well sealed. Free standing cases with vitrine tops provide limited security but are light weight and easy to seal.

Another case style option is the wall case. These cases are built to fit on or as part of a wall in the gallery space. As with free standing cases, structural frames are useful in terms of physical security but will require the use of gaskets or caulk sealants if the case is to be well sealed. Wall cases should be easily accessible to staff while providing a secure and safe environment for the object.
CHAPTER VI
SEALED EXHIBIT CASES VERSUS VENTILATED EXHIBIT CASES

Macro and Micro-Environments

Objects in a museum vary in regard to whether they should be in a sealed or ventilated exhibit case. Objects such as metal should always be presented in a sealed case to prevent corrosion and tarnishing whereas plastic and wood objects need to be displayed in ventilated cases because of the gasses produced naturally by the materials. In some cases museums have a controlled environment with a steady temperature and humidity with their Heating, Ventilating, and Air Conditioning (HVAC) system. In situations such as these, museums are equipped to provide a macro-environment with controlled temperature and humidity in the museum as a whole rather than in individual cases. When this is possible, the concern is the control of pollutants and stagnant air in the exhibit cases. In museums where a macro-environment is not within the budget or will not work, a microclimate should be created for each case.

A microclimate case requires an environmental chamber to control the level of pollutants and relative humidity inside a case. For a microclimate case to be successful it is necessary to seal the case with gaskets and limit the air
exchange between the inside of the case and the rest of the exhibit gallery. If left unsealed, the air exchange makes the pollution scavengers and humidity controlling materials relatively useless. Microclimates cannot be created within an already existing “off the shelf” exhibit case. Microclimate cases must be specially made, which can be costly because they take longer to construct and have tighter design specifications. Cases must also have a strict adherence to the safe and unsafe construction materials in order to provide the safest environment for the object to be displayed. Depending on the object being displayed, it may be necessary to display the object in a microclimate case. For example, the Declaration of Independence is stored in a microclimate case due to its high value, role as a national treasure, and the sensitive nature of archival paper documents.

In order for microclimates to work efficiently, the conditions within the case must be uniform. Air should be able to pass freely over pollutant absorbers in order to be effective and allow the conditions within the case to balance quickly. There are two commonly used ways to allow air circulation within the case. A perimeter gap placed on all sides of the display chamber can be created. The perimeter gap allows for air movement into the environmental chamber. The other way to allow for air circulation is through the use of a perforated deck. The perforated deck sits behind or below the object with a barrier of permeable inert fabric. The fabric allows the perforations to breath and air to flow from the display chamber to the environmental chamber and vice versa. Metal or plastic should be used to create the perforated deck as it is not advised to drill into wood.
products because of the dangerous vapors that will be released to the
environment.

In museums with a building-wide room-specific HVAC system, the
temperature and humidity in the entire space can be controlled. This provides the
greatest protection for objects on display but is not always practical due to cost of
installation, operation, and service. These systems can also have potential for
damage to buildings when humidity levels are elevated during the winter months.
When these systems are in place, a macroclimate can be established.

Macroclimates allow for the use of ventilated exhibit cases that are more
cost effective than well-sealed cases with environmental chambers. The most
common case styles allow for ventilation through unsealed joints and gaps.
Unfortunately, although this style for ventilation is easy to construct, it is
uncontrolled and does not protect the object from dust or chemical pollutants. It is
preferred to have a moderately sealed case with controlled ventilation through
filtered vents either at the top or bottom of the case.

The biggest difference between using a micro or macroclimate is the size
and resources for the conservation features. It is ideal to control the environment
throughout the entire exhibit space because everything on display will be under
the same conditions. The main goal is to provide additional support for objects
that are more sensitive and protect those objects further from sources of
deterioration. If both macro and microclimates can be created, that allows for the
least amount of staff time and maintenance over the course of the exhibit.
Seal of Exhibit Cases

Well sealed cases are used to protect objects that are most sensitive to the environment and airborne pollutants. The level of seal is determined by the material being displayed. The degree of seal is the rate of air exchange between the case interior and the environment of the exhibit gallery. There are four degrees of case seal: unsealed, moderately sealed, well sealed, and hermetically sealed.

Most museums use cases that are unsealed or moderately sealed. Well-sealed cases must be tested for performance and attention must be paid to design and construction to ensure that the case will provide appropriate protection of the object being displayed. Each degree of seal has its own characteristics as to the construction and performance with air circulation.

Unsealed exhibit cases are exactly as they sound. There is no use of gaskets or caulking to control the penetration of air through case seams or doors. Unsealed cases are not required to have air-tight fasteners or permeable construction materials. Objects in unsealed cases should not be those that are sensitive to environmental pollutants as these cases cannot maintain a microclimate. These cases have an air exchange rate of one per hour or less. Unsealed cases are the least expensive and are commercially prefabricated and available.

Moderately Sealed cases utilize gaskets or caulking to reduce air exchange in all of the seams in glazing, panels, and doors. There is no requirement for air-tight fasteners at doors or permeability of materials used in
construction. Moderately sealed cases have an air exchange rate of one per twenty-four to thirty-six hours.

Well sealed cases must use only construction materials that are air tight and waterproof. These cases have an air exchange rate of one per seventy-two hours or more. Well sealed cases are more expensive than unsealed and moderately sealed because of the work that must be done to create an adequate microclimate for the object to be displayed.

Hermetically sealed cases are typically only built for extraordinarily significant objects, such as the Declaration of Independence, because of cost and technical difficulty. The case is designed to prevent any air exchange and is made of gas impermeable materials with seals. Hermetically sealed cases have a mechanism to counteract pressure change and maintain an inert gas environment.

Well-Sealed Frames

When works on paper and documents are to be displayed, a microclimate for two dimensional objects can be created. A well sealed frame can protect works on paper by providing a microclimate that can be within a case that is only moderately sealed. This tends to be a more affordable way to protect two dimensional objects without creating an entire macro or microclimate case.

A well sealed frame provides a low air exchange rate for the object enclosed. These can be created to meet strict conservation needs and allow the most sensitive objects to be displayed. Without the use of a well sealed frame,
the object may be too sensitive and not safe to exhibit under the existing environmental conditions. A well sealed frame that is properly designed can reduce the objects interaction with dust, pests, and airborne pollutants. These frames can also block UV with a glazed glass. Well sealed frames can control the relative humidity inside the frame and protect against changes in humidity from the outside environment. The well sealed frame can also protect the object in case of a disaster by providing some waterproofing capabilities. Sealed frames should be used for two dimensional or three dimensional objects that are relatively shallow. Sealed frames can be created by using a pre-sealed display package or by sealing a frame and creating a microclimate.

The use of a display package that is well sealed and set into a frame has some advantages. This method allows for objects to be interchangeable and replaced in the frame as the exhibit changes or as the object needs to be taken off display for preservation reasons. Display packages are sealed on all sides with a vapor barrier adhesive. This adhesive should be applied to the glazing and backing board to provide a complete seal. Display packages can be inserted into any type of frame including original historic frames if still intact.

Sealing the entire frame is another option when a sealed package is not desired. If sealing a historic original frame, some changes may have to be made to make the frame well-sealed. In sealing a frame, a gasket should be placed between the rabbet of the frame and glazing. Air gaps should be prevented and the glazing should be set to the frame. This may involve alterations to the inside of the frame and sealing the wood surfaces. Sealed frames can provide
protection and a solid seal for a very long time whereas display packages are only intended to last for a few years.

To provide environmental control to sealed frames and display packages, silica gel and pollutant scavengers can be inserted into the package between the support and backing board. Hygroscopic mat board can add additional support for the control of relative humidity. In general, only materials that are inert and safe should be used to construct a sealed package or complete a sealed frame.

Gaskets

Gaskets are used to prevent or control air exchange within an exhibit case. They seal gaps between two case doors or panels. Gaskets are made of rubbery material that is applied to the interface of the surfaces to be joined. They should be used for both the lighting and display chambers. Gaskets not only provide a control for the air exchange, but also support environmental control, keep out airborne pollutants and pests, and protect the object on display from entry of water.

Some gaskets can produce harmful gases that can react with objects in a display case. Polyurethane foam gaskets can deteriorate over a few years because oxidation and UV break down the foam which then disintegrates. Likewise, neoprene gaskets can out-gas sulfur which is unsafe for museum objects. Gaskets made of these materials along with pressure adhesives with unknown adhesives. The adhesives can off-gas volatile organic compounds.
Gaskets should be selected carefully for exhibit cases to insure that they are safe for use around museum objects. The elastomer type should be proven to be stable so it does not affect the interior of the exhibit case. The preferred elastomer is silicone rubber. It is the most stable, resistant to temperature changes, most chemicals, oils, oxygen, and airborne pollutants. Cellular silicone sponge is a silicone that has been foamed into a uniform unicellular structure and is shaped by cutting. Ethylene propylene diene monomer (EPDM) is resistant to UV, ozone, oxidants, heat, and compression. Ethylene vinyl acetate closed-cell elastomeric seal (EVA) has a soft flexible quality with a low resistance to heat and solvents and resistance to airborne pollutants.

The shape of gaskets is important in selecting which is appropriate for the individual exhibit case. Prefabricated gaskets, extruded sponge, and formed foam are all shapes of gaskets. The prefabricated gaskets are formed by cutting, extruded sponge looks smooth and shiny, formed foam is cut into shapes with two open sides. The most useful shape for gaskets is rectangular, round, and hollow “O” or “I” shapes. The shape of a gasket for a display case should be determined by the case design and case materials.

The size and thickness of the gaskets should be determined to allow the access door or panel open and close flush with the gasket to control air exchange. The gasket thickness should be equal to the gap size plus 25% with solid gaskets, and 40% for hollow. If the gasket is too thick, stress can be placed on the door and panel hinges causing them to bind. If the gasket is too small, it can leave gaps at corners and irregular places in the surface, permitting air
exchange. The gasket density should be such that it can spring back into shape when not being pressed but soft enough to completely cushion the other surface. Gaskets should not be used that have an adhesive backing. If the adhesive is preexisting, it can be removed with a solvent. If adhesive must be used, a pressure sensitive backing, archival double-sided tape, or acrylic adhesives should be used.

How to Create an Environmental Chamber

An environmental chamber allows for the control of the air quality inside a display case. Environmental chambers are only utilized within a sealed climate control case. It is much more difficult to control the environment of large cases than small vitrines. Environmental chambers should have either a mechanical system with dehumidifiers and humidifiers, or a system that uses silica gel, hygroscopic materials, or saturated salts. If used, Environmental chambers should have appropriate air exchange with the display chamber, equipment that monitors the relative humidity, and a way to access the equipment for maintenance. An example of a well executed environmental chamber with air exchange can be found in appendix A. It is imperative that adequate air exchange be possible between the environmental and display chambers. If this does not occur, spots of differences in relative humidity can form.

A display deck constructed with a perforated material that is at least 40% open and covered with fabric can provide the adequate air exchange necessary to have a successful environmental chamber. Another option to provide
exchange of air within a case is to create a floating deck with a perimeter gap approximately 5/8" to 1" wide which allows for the circulation of air on all four sides. These two designs both allow for the exchange of air and the ability for the environmental chamber to function properly by pollutants in the air passing over the scavengers. These case designs should also allow access to the maintenance chambers without releasing the conditioned air when access doors are opened.

The most commonly used pollutant scavengers used in exhibit cases are activated charcoal and potassium permanganate. Activated charcoal comes in two forms, loose pellets and paper or fabric impregnated with the charcoal. The charcoal absorbs the pollutants in the air, which means that after a certain amount of time, it absorbs the maximum it can hold and can become a pollutant itself by off-gassing what was absorbed. There is no physical or visible change in activated charcoal to indicate when it has reached maximum capacity for pollutants absorbed. The charcoal should be replaced at least once every twelve months. Activated charcoal is most effective in absorbing ozone, sulfur dioxide, nitrogen dioxide, hydrogen sulfide, and formaldehyde. Activated charcoal is an excellent choice for environmental chambers because it is inexpensive and performs well as long as it is replaced regularly.

Potassium permanganate is another successful pollutant scavenger for sealed exhibit cases. It is used commercially in HVAC filters but is also used in loose pellet form. Pellets of both potassium permanganate and activated charcoal can be used within exhibit cases when placed inside a permeable and
inert fabric. Potassium permanganate is more expensive than activated charcoal but has additional benefits. It reacts with the pollutants rather than absorbing them and changes color from pink to brown as it nears the end of use. Once the potassium permanganate changes from pink to brown it should be replaced because it is no longer having an effect on the environment in the case.

Pollutant scavengers can be placed in a case in a few different forms and styles as shown in appendices D through I. A contaminant tray located below the display chamber, pellets of absorbers placed behind large objects, impregnated fabric covering the exhibit case floor or walls, or inside a sealed frame. If used as a floor or wall covering, the absorbers should not have direct contact with any objects. Regardless of which technique is chosen, the case should be made airtight to ensure the success of the pollutant absorber. If used in a case that is not well-sealed, a sufficient quantity of pollutant absorbers should be used.

Silica gel is a material that can be used to control the relative humidity within a range of 40-60% relative humidity inside a display case. The amount of gel used should be determined upon the level of humidity desired. Silica gel is available in many different forms including tiles, cassettes, panels, plastic and fabric tubes, and bags. Containers housing silica gel should be permeable for moisture and inert. The conditions within a case using silica gel should be checked on a regular basis.
Ventilation of Cases

Ventilated cases should only be employed if the building has a macroenvironment that is controlled for pollutants, temperature, and humidity. Most cases allow air exchange through unsealed joints. This type of case is easy to construct but does not control the exchange of air or protect the object from airborne pollutants. Ventilated cases therefore, should not be constructed to have free air exchange through joints and gaps, rather the ventilation should be controlled through filtered vents. Examples of proper ventilation methods can be found in appendix B.

A case with filtered vents still shares the temperature and humidity of the entire gallery space but the air is filtered so that dust and pollutants do not gain access to the case. Typically, exhibit galleries use both filtered ventilated cases and well-sealed cases. Since well-sealed cases are more expensive to construct, they are reserved for use with objects that require strict environments. Vents in filtered cases can be placed inconspicuously in decorative areas of a case, recessed kick space, in graphic panels, and on the top or bottom of cases.

The location of the filtered vents can determine how the air exchange inside the case is executed. Vents should be placed to achieve appropriate circulation of air and objects should not be placed near the vent. Vents placed horizontally on the same plane will prevent the exhausting of air from a hole in the top. Vertically placed vents will attract warmer air to pass through the higher vents and cooler air to come in at the lower vent. Vents should always be placed on opposing case walls. When filtered vents are used, there should always be at
least two, one for air to enter and one for air to exit. If vents are inadequate, stagnant air can allow off-gassing to build and create zones with different temperature and humidity within the case.

There are two types of ventilation in exhibit cases, forced and passive. Forced ventilation is used best when the museum has a macroclimate established. Fan systems placed in large exhibit cases help the case regulate the air flow around the object on display. Fans should be low noise and low vibration and compatible with filters to guard against airborne pollutants penetrating the case. These filters should be replaced after a few years depending on the airborne pollutant contents of the exhibit gallery. If only one fan is to be used, it should send air out of the case. If there are two fans, one should remove air as the other pulls air in. Fan placement is not as important as the location of vents in the passive system. Passive systems use natural convection to provide air exchange through vents. This form of ventilation should only be used when the exhibit gallery has a macroclimate established.
CHAPTER VII
CONCLUSION

Lamar Hunt Super Bowl Gallery

The Lamar Hunt Super Bowl Gallery, renovated in 2009, incorporates several display techniques that had previously not been used by the Pro Football Hall of Fame. The display cases incorporate secluded light attics, environmental control compartments, and well sealed cases with gasketing where applicable. The decision to use the aforementioned styles of display cases was based partially on the research conducted in this thesis. Photographs demonstrating these techniques can be found in the Appendices.

The techniques researched and implemented as a result of the research and findings of this thesis successfully updated the Lamar Hunt Super Bowl gallery. The research allowed the Pro Football Hall of Fame to improve the preservation of objects while on display by implementing the best practice techniques to cut down on the exposure of environmental pollutants and visitor contamination of the artifacts while on display.

The decision to use the selected display case styles and techniques was based on both budget restrictions as well as the preservation needs of the artifacts stored in a particular case. For example, the Lombardi trophy is housed
in a display case that utilizes a hidden environmental chamber containing activated charcoal because the trophy is made of silver. Silver is a material that easily oxidizes when exposed to the pollutants in the air caused by the presence of visitors in the museum.

Wall cases that now house the Super Bowl Decades display do not have gaskets because they would cause more difficulty in gaining access to the artifacts for routine maintenance and artifact rotations. Since there are no gaskets, there are environmental chambers beneath the artifact decks to regulate the amount of pollutants that gain contact with the artifacts in those cases.

The recessed wall cases that display artifacts representing the first four Super Bowls have gaskets along the edges of the doors to the artifact deck. There is also an environmental chamber beneath the artifact deck. The artifact deck was constructed with perimeter gaps to permit for the air flow in the case over the pollutant scavenger materials located beneath the deck. The recessed cases have a lighting chamber above the artifact deck that separates the heat of the lamps and dust from any maintenance to the light fixtures from contaminating the artifacts.

These three display case styles are implemented throughout the gallery. Images of the cases as they appear in the Lamar Hunt Super Bowl Gallery can be found in the appendices J,K, and L. The research conducted in this thesis will be used in future planning for the museum and additional gallery modifications throughout the building to further improve the preservation standards implemented in the various galleries of the Pro Football Hall of Fame.
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APPENDICES
APPENDIX A

ANATOMY OF A DISPLAY CASE

Diagram showing the Anatomy of a Display Case:
- Lighting Chamber
- Display Chamber
- Environmental Chamber
APPENDIX B
PASSIVE VENTILATION METHODS

Small air duct filters with activated charcoal or potassium permanganate

Case Wall Vent
APPENDIX C

LIGHTING CHAMBER VENTILATION

Filtered air can circulate into the lighting chamber

Place fans to evacuate heat from the lighting chamber
APPENDIX D

AIR CIRCULATION: PERFORATED DECK

Perforated deck is shown in gray with permeable fabric in blue

Wall Case Example

Free Standing Case Example
APPENDIX E

AIR CIRCULATION: PERIMETER GAP

Wall Case Example

Free Standing Case Example
APPENDIX F

PREFABRICATED ACCESS DOOR
APPENDIX G

SLIDING ACCESS DOOR
APPENDIX H

REMOVABLE ACCESS PANEL
APPENDIX I

HINGED ACCESS DOOR
The cases on the far left and far right that contain two jerseys have an environmental pollutant scavenger compartment hidden by a hinged access door beneath the bottom ledge of the case to preserve the textiles on display.
APPENDIX K

CONSTRUCTED RECESSED CASE WITH GASKETS

“FIRST FOUR SUPER BOWLS”

These cases have a separate lighting chamber above the artifact deck and environmental pollutant scavenger compartments beneath the artifact deck that are accessed by unscrewing the front panels. The environmental scavengers access the artifact deck by way of a perimeter gap along the lower caption shelf.
APPENDIX L

FREE STANDING CASE

“LOMBARDI TROPHY”

The free standing display case housing the Lombardi Trophy has a hidden pollutant scavenger compartment inside the base that contains activated charcoal to limit the oxidation of the silver trophy by visitors in the gallery.