

APPENDIX S: CURATORIAL CARE OF OBJECTS MADE FROM LEATHER AND SKIN PRODUCTS

A. Overview

1. *What information will I find in this appendix?*

You will find the National Park Service's present understanding of objects made of leather and skin products. You also will learn about preventive care for these objects including:

- agents of deterioration posing the greatest threat to these objects
- measures for preventing or minimizing the impact of these agents
- techniques for handling, marking, and cleaning these objects
- methods and techniques for improving storage and exhibit conditions
- methods for monitoring the condition of these objects

2. *Why is it important for me to practice preventive conservation with these objects?*

Advancements in the treatment of leather and skin products have not kept pace with the progress made in conserving other kinds of museum objects. The conservation field only can offer limited solutions to the problems facing objects made of leather and skin. Conservators and the scientific community have begun to focus more specifically on developing new treatment strategies for the preservation of leather and skin. While new information is provided as it becomes available, you need to practice sound preventive conservation now because:

- preventive measures stabilize objects and leave opportunity for appropriate future interventive treatments
- conservators can only offer limited treatment solutions

Conservators discourage traditional interventive treatments, such as the application of saddle soaps and dressings. *Avoid interventive conservation treatment of leather and skin objects whenever possible.*

See NPS Museum Handbook, Part I (MH-I), Chapter 3, Museum Objects Preservation: Getting Started, for a discussion of preventive conservation and conservation treatment.

3. *How can I find the latest information on care of these types of materials?*

Refer to the following sources for new information and techniques:

- NPS *Conserve O Gram* series
- e-mail NPS Museum Management Newsletter

B. The Nature of Leather and Skin Products

The skins and hides from vertebrates constitute the class of natural materials called skin products. Leather is one type of skin product that is produced by a particular tanning process. Processed and unprocessed animal skins have supplied the basic fabric for making utilitarian and decorative objects since prehistoric times. You will often find these materials in art, history, ethnology, and science collections.

1. *What is the structure of skin?*

Animal skin is a fibrous layer of living tissue that protects an organism from the elements. Figure S.1 illustrates its structure.

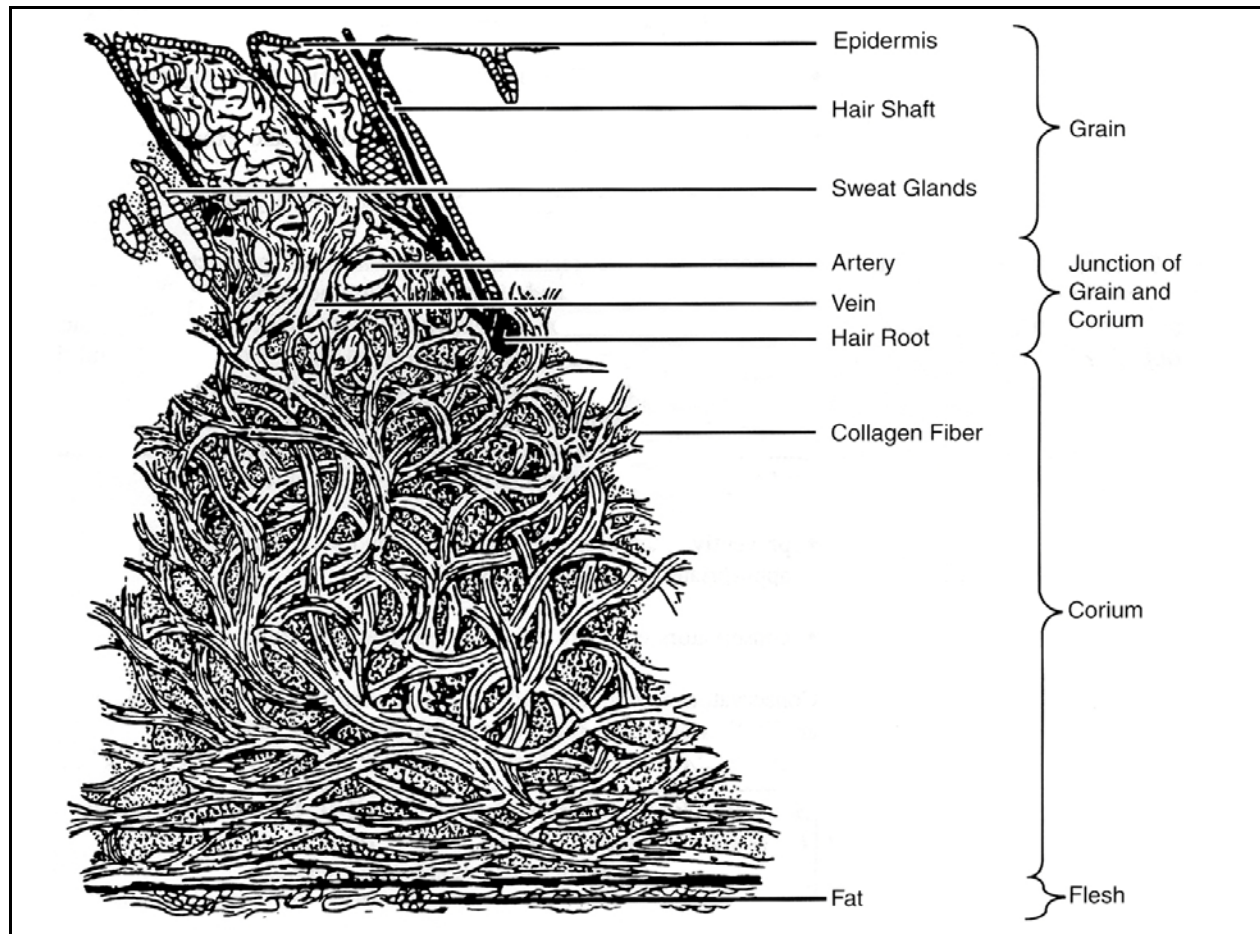


Figure S.1. The Structure of Skin

Once removed, an unadulterated skin is a proteinaceous sheet containing hair, sweat glands, fat and blood vessels, as well as its basic constituent of collagen fibers. These protein fibers are composed of coil-like molecules built of tiny fibrous strands that are twisted together, then aligned side by side overlapping one another, much like cotton fibers are arranged in a textile yarn. (To prevent separation of the cotton fibers the yarn is twisted during manufacture to produce a strong and usable thread.)

2. *How is animal skin processed?*

Animal skin can be tanned and untanned. Examples of untanned skin include rawhide, parchment, and vellum. Stable skin is processed by chemically binding fibers together, commonly referred to as tanning. The amount and type of bonding that occurs within a skin establishes its "degree of tannage." The term "leather" refers technically only to the fully tanned skin products. Figure S.2 describes degrees and types of tannage of most skin and leather objects in park collections.

Un-tanned	Semi-tanned	Native-tanned	Fully-tanned
rawhide parchment vellum	oil tannage alum tannage	smoke tannage brain tannage oil tannage	vegetable tannage mineral tannage combination tannage

Figure S.2. Degrees and Types of Tannage

People have preserved or "tanned" skin products in many ways to render them strong, insoluble, and more resistant to temperature and moisture. Nearly all of the methods of skin processing techniques used by skin and leather workers throughout the ages achieve some degree of tannage. Many of these procedures rely on mechanical properties more heavily than chemical tanning, such as the softening that results from introducing oils.

Unfortunately, determining an object's original manufacture requires considerable study. While laboratory treatments vary for different types of skins and leathers, *preventive conservation procedures are similar for most of these materials*. Your familiarity with the general skin processing categories can be very useful since these methods are responsible for many of the object's functional characteristics. See Figure S.3 for physical characteristics of these products.

3. *How do I recognize different species?*

The skin or hide of each animal species is recognizable by its physical characteristics. The principle variations among animal types are the size, density, and distribution of the animal's hair, which gives rise to a distinctive grain pattern.

The relative thickness of hide and skin products is traditionally measured in "ounces." Each ounce represents 1/64 of an inch. The black solid lines in Figure S.4. represent the thickness of leather being measured.

CHARACTERISTICS OF LEATHER AND SKIN PRODUCTS							
	RAWHIDE	OIL TANNAGE	ALUM TANNAGE	SMOKE TANNAGE	BRAIN TANNAGE	VEGETABLE TANNAGE	MINERAL TANNAGE
TANNING MATERIAL	No Tannage Applied	Cod Liver Oil and Other Oils	Alum or Aluminum Sulphates or Chlorides	Aldehydes from Wood Smoke	Animal Brains	Extracts of Wood Chips, Bark, Leaves, Roots, Fruit	Chromium Sulphates or Chlorides
COLOR AFTER TANNAGE	White to Yellow	Dull Yellow	White	Yellow to Yellow/Brown	White to Yellow	Yellow/Orange to Light Brown	Bluish White to Pale Green
EFFECT OF WATER	Stiffens, Dissolves, Turns Transparent	Water Absorbed, Tan Stable	Stiffens, Water Removes Tan	Water Resistant	Stiffens, Water Absorbed	Water Absorbed, Water Removes Tan Slowly	Water Absorbed, Tan Stable
TYPICAL USES	Saddle Trees, Drumheads, Scabbards	Gloves, Wettable Leathers	Gloves, Pelts and Furs, Book Bindings	Native American Clothing, Lodges	Native American "Buckskin" Clothing and Objects	Shoe Soles, Saddles, Book Bindings	Clothing Shoe Uppers

Figure S.3. Characteristics of Leather and Skin Products

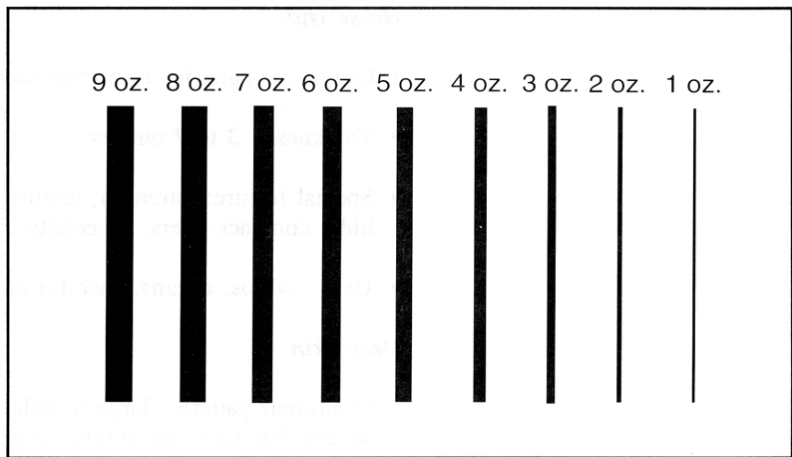


Figure S.4. Thickness of Skins and Hides

The characteristics and uses of common animal skins and hides are listed below.

Cow Hide

- Grain/hair pattern: pebbly, pronounced with large, equidistant hair spacing
- Thickness: 2 to 20 ounces
- Processing note: often split into several pieces
- Special feature: very durable, excellent for tooling and carving
- Uses: shoe soles, belting, trunks, clothing

Calf Skin

- Grain/hair pattern: same as cowhide only smaller
- Thickness: 1.5 to 4 ounces
- Special feature: greater uniformity and fineness than cowhide
- Uses: upholstery, shoe uppers, clothing, bookbindings

Bison Hide

- Grain/hair pattern: similar but less uniform than cattle
- Thickness: 5 to 20 ounces
- Special feature: loose-knit fibers on flesh side; very large hide size; stiff hump between shoulders
- Uses: 19th century boots, sleigh blankets, Native American shields, robes, clothing, tipis

Horse Hide

- Grain/hair pattern: resembles cow hide but less dense
- Thickness: 3 to 7 ounces
- Special feature: strength, texture and thickness are inferior to cow hide; compact fibers, especially in butt region
- Uses: whips, aprons, base for enameled leathers, trunks

Deer Skin

- Grain/hair pattern: large follicles form definite single rows; closely spaced fine hairs are similar to goat skin
- Thickness: 2 to 9 ounces
- Processing note: hairs are sometimes left on
- Special feature: loose structure (like sheep) results in a very stretchy leather
- Uses: parchment, gloves, clothing; Native American clothing, moccasins, containers

Sheep Skin

- Grain/hair pattern: linear groupings of large and small groups
- Thickness: 1.5 to 3 ounces
- Special feature: weaker, less durable skin (loose interweave of fibers); loosened texture (fibers run parallel to skin surface)
- Uses: suede leathers, bookbindings, jackets, gloves, chamois

Goat Skin

- Grain/hair pattern: groupings of three coarser hair follicles with closely spaced fine hair follicles
- Thickness: 2 to 3 ounces
- Special feature: close-knit collagen fibers; more durable and stronger than sheep skin
- Uses: linings, billfolds, shoe uppers

Pig Skin

- Grain/hair pattern: very coarse hairs are sparsely distributed in groups of three
- Thickness: 3 to 4 ounces

- Special feature: high fat cell content produces tough but spongy leather; very rough surface; limited water resistance
- Uses: shoes, bags, gloves, pants

Exotic Leathers

Reptile

- Special feature: surface patterns distinguish reptile type: crocodile, alligator, snake, or lizard
- Special feature: light, thin, grainless leathers often are made from bellies

Fish

- Special feature: structure is different from mammals but scales are comparable to hair on mammals

Seal

- Special feature: proportionally stronger than other leather materials; fur is left on for coats, fur is removed from base for enameled leather

C. Agents of Deterioration

The ways that skin products deteriorate can be identified and categorized. The interdependency of these mechanisms cannot be overstated. For example, temperature changes directly affect a skin or hide's moisture content, the rate at which chemical deterioration proceeds, and the object's susceptibility to biological infestation.

1. *What is the threat of biological infestation?*

A great variety of biological organisms are attracted to skin and hide products making these materials subject to quick and irreversible damage or total destruction. For example, insects are frequently attracted to the oils present in skin products as well as surface soils. Also, poorly cleaned materials are particularly attractive as a nutrient material for insects and microorganisms, as are all items made from rawhide.

Most insects prefer skin products made from fur and unborn animal skins. The most frequent infestations involve dermestid beetles and clothes moths, but other beetles and moths also attack skin and fur on occasion, as do silverfish and cockroaches.

<p><i>Insect development usually relies on higher levels of humidity and temperature.</i></p>

Since skin products are acidic in nature, microbic deterioration of skin products is generally limited to molds and occasionally bacteria. This deterioration is primarily due to environmental factors such as high humidity (above 65% RH) and a wide temperature range (in most cases 10°-40°C [50°-104°F]). These organisms produce organic acids and enzymes that bleach and stain the skin. Fungal growths are often

characterized by a white, gray, or green fuzzy appearance. These growths occur most commonly on objects made from rawhide and on those skin products that have become heavily soiled.

2. *How do I prevent pest problems?*

Here are some measures to prevent or minimize biological infestation:

- Monitor all areas of the museum continually and systematically to identify insect and microbial problems at an early stage. Use insect monitoring traps and routinely inspect objects for frass, nesting materials and damage. See *MH-I*, Chapter 5, Biological Infestations, for guidance on developing a museum Integrated Pest Management (IPM) Program.
- Identify dead or living pests that you suspect of attacking skin objects.
- Develop a pest control program that includes a designated staff coordinator, with guidelines for preventive and emergency measures. Its focus should be pest control through good housekeeping and modifying the environment.
- Minimize microbiological attack of skin products by keeping relative humidity below 65% and by keeping areas clean.
- Never apply insecticides and fungicides directly to hide artifacts because they can damage the objects, complicate long term preservation, and contaminate the material for future handling and study.
- Gaseous fumigation methods available for skin and hide materials are few and require coordination by a conservator. In addition, contact the park, center, or your IPM coordinator prior to pesticide use. Technology is constantly changing and the coordinator will have access to the latest and most appropriate solutions. Your IPM coordinator must authorize and approve all pesticide use before application.

Non-toxic means of extermination such as freezing are preferable. See NPS Conserve O Gram 3/6, An Insect Pest Control Procedure: The Freezing Process, for guidance on the technique of freezing for controlling pest infestations.

3. *What about the loss of hair and fur?*

The loss of hair and fur from skins and hides not only devalues an object, but also can destroy its potential usefulness. The causes of hair or fur loss are complex and usually depend on the form and structure of the animal, the hide's original processing techniques, and the environmental conditions to which it has been subjected.

There are numerous types of hair loss:

- Epidermal slippage: hair is lost as the epidermal layer separates from the dermal layer.
- Deterioration of the individual hair follicles: hair roots become loose and hair falls out.

- Hair shaft breakage: mechanical damage weakens the hair and it breaks at its base.
- Biological attack: insects feed on the hair itself or epidermal layer, resulting in the hair being severed.

You can't do much about hair loss that is due to insufficient fixing during processing, but you can control many of the other causes, such as high temperatures, low relative humidity, photochemical degradation, and insect damage.

4. *How can I stop hair and fur loss?*

To limit the loss of hair and fur:

- Minimize the exposure of fur or hair products to lighting; illuminate only to the minimum level necessary to see the object. Recommended levels are 50 lux (5 footcandles) or less.
- Minimize handling.
- Stabilize the relative humidity and temperature to which hides with hair and fur are exposed. Don't expose them to rapid changes of either temperature or humidity and protect them from desiccation.
- Routinely inspect hair and fur products for insect damage. Remove loose or broken hair by brushing and vacuuming, and store materials in insect-proof containers such as metal museum storage cabinets with door gaskets.

5. *What is the threat of thermal reaction?*

Skin and leather products are thermosensitive. Skin tissue has a heating threshold, or point of thermal contraction, which is referred to as its shrinkage temperature. For newly processed skins and hides, this point is frequently between 60°-75°C (140°-167°F). However, the shrinkage temperature of degraded hides of aged objects can be considerably lower.

Heating dries out, embrittles, and deforms skin and leather objects. Changes in temperature also can destabilize relative humidity levels. Exhibit lighting, direct sunlight, and proximity to heating registers and radiators can easily damage leather and skin objects, which also become more sensitive to heat as they age.

Elevated temperatures cause eventual damage not only by speeding up the chemical deterioration processes, but by causing unstable fats and oils to come to the surface where they often deposit as unsightly spews. Spews (also spelled spues) are surface deposits of solidified fats and oils that exude from the interior of the leather/skin material. They appear as a white crystalline deposit or as a whitish bloom. Desiccation can also result from over-heating.

6. *How can I minimize the threat of thermal reactions?*

Try these preventive measures to minimize thermal reaction:

- Safeguard skins from exposure to warm, moist air. The acceptable minimum and maximum temperature levels are from just above freezing to 20°C (70°F).

- Reduce the damaging effect of heat cycling by placing objects away from external building walls, exterior doors and windows, exposed pipes, heating and air conditioning vents, direct sunlight, exhibit lighting sources, and locations such as hot attic spaces.

7. *What about water and moisture damage?*

While skin materials have a great affinity for water, inappropriate levels of atmospheric moisture or direct wetting usually cause serious damage. The direct wetting of skin products initiates deterioration because these materials have only a limited degree of water resistance. Rawhide, parchment and vellum are most prone to damage. Aged objects made of full-tanned leather are also highly susceptible to stiffening and darkening from wetting.

All animal materials readily absorb moisture from the air. Excessive moisture (levels above 65% RH) causes swelling of the skin's fibers and encourages biological infestation. Excessive dehydration (humidity levels below 22% RH) forces the skin to give up moisture permanently, which results in shrinkage and deformity.

Dehydration reduces the skin's ability to take up and hold moisture, thus weakening it and dramatically decreasing its flexibility. Repeated exposure to moist and dry cycles will, eventually, physically stress the hide's fibers enough to induce mechanical damage and increase its susceptibility to chemical deterioration. The hide's soluble components are frequently displaced, leached, or deposited on the surface resulting in the alteration of physical characteristics.

When skin material is subjected to either excessive moisture or high humidity in conjunction with heat and acid conditions, its chemical structure is attacked, causing shrinkage and embrittlement. If allowed to continue, the skin will lose its structure and become gelatinous. The boiling of skin to produce gelatin or hide glue is an example of this process.

8. *What are the measures for limiting water and moisture damage?*

To minimize water and moisture damage:

- Keep hide materials dry by protecting them from wetting and exposure to relative humidity levels above 65%. House objects in water-resistant containers, such as storage cabinets and exhibit cases. Whenever possible, include moisture absorbing materials to buffer enclosed spaces against extreme fluctuation of RH. These materials may include commercially-available buffers such as cotton or linen cloth, acid-free paper products, or silica gel. See *MH-I*, Appendix I, Curatorial Care of Archeological Objects, for a discussion of the use of silica gel.
- Control the relative humidity to conform to the recommended levels suitable for the collection's circumstances. Stabilize humidity fluctuation to the recommended range of 40-60% RH. Normally, you will regulate humidity through the central air-handling system, but you also can use localized and portable sources of humidification/dehumidification to protect objects from unnecessary damage.
- If you discover mold on objects made of leather or skin, consult a conservator regarding vacuum cleaning and disinfectant procedures.

9. *What is the threat of prolonged exposure to oxygen?*

For organically-based materials like skin products, prolonged exposure to oxygen is one of the more serious and avoidable chemical factors that causes deterioration and is responsible for altering both the skin's chemical structure and many of its tanning compounds.

Its long-term effects include the hardening of skin and hide material, embrittlement, cracking and crazing of the skin surface and overall yellowing or darkening as well as a number of serious internal structural changes. Oxidative degradation is caused by high temperatures and humidities and exposure to light radiation.

10. *How can I minimize these oxidation reactions?*

By taking the following preventive measures:

- While it is impractical to keep most of these materials from being exposed to oxygen, if an object is extremely rare, consult with a conservator about storage and display in a hermetically sealed container filled with inert gas (such as nitrogen or helium).
- Don't expose hide materials to excessive humidity or heat. Use air conditioning, storage design and exhibit design to eliminate the detrimental effects of these environmental stimulants of oxidation.
- Reduce the level of visible light to the minimum required and eliminate exposure to ultraviolet light.

11. *What about pollutants?*

The threatening forms of pollutants to skin products are particulate and gaseous pollutants. Particulates are solids that are suspended in air and range in composition from inorganic to organic. Because skin has such a porous and absorbent surface, these solid foreign materials easily work their way into the fibrous network of skin products causing soiling, staining, and eventual stiffness.

Little data is available regarding the effect of gaseous pollutants on skin but it is probable that oxidant, acidic and sulphating gases play some role in the deterioration process. Native-tanned and semi-tanned materials seem relatively more resistant than do commercial, vegetable-tanned leathers. It is likely that pollutants promote oxidation, hydrolysis and overall discoloration.

12. *How can I minimize the effects of pollutants?*

To minimize their effects:

- Modify the building's central air conditioning and filtering system. Various filters can trap different size particles, and effectively remove gaseous contaminants.
- Exhibit and store your objects in tightly sealed enclosures constructed of the highest quality inert materials. Install specialized pollutant absorbers with individual storage cabinets.

13. *What harm can light cause?*

Light is an important factor in the process that degrades skin products. Its damage is cumulative and irreversible.

Certain wavelengths break down polymeric bonds and are detrimental to all skin materials. The ultraviolet range of light is one of the most dangerous wavelengths for skin products; however, visible light also causes structural damage and color change.

Light can act as a catalyst when oxygen, water vapor and various pollutants in the atmosphere combine to increase the rate of deterioration. The rate of degradation is generally related to the intensity and length of light exposure. Fading of smoked and pigmented hides is a particular problem where prolonged light exposure is involved.

14. *How can I minimize the effects of light?*

Take these preventive measures:

- Minimize the exposure of skin materials to visible light; illuminate only to the minimum level necessary to see the object. Recommended maximum levels are 150 lux (15 footcandles) for most materials and 50 lux (5 footcandles) for painted skins and hides with fur.
- Eliminate ultraviolet (UV) radiation through the use of UV absorbing filters installed between the light source and the artifact or on the light source itself. Select lighting systems with low proportions of UV radiation. The maximum acceptable proportion of UV radiation is 75 microwatts per lumen.
- Maintain stored objects in darkness. Ensure that unfiltered light does not reach stored skin and hide materials.
- Monitor and adjust lighting fixture locations and light bulb wattage individually. Use timers and dimmers for controlling light in exhibits.

See MH-I, Chapter 4, The Museum Environment, for general guidance on temperature, relative humidity, light, and pollution.

**D. Preventive Conservation:
Guidelines for Leather
and Skin Object Care,
Handling, and Storage**

The most successful method of preserving leather and skin products is a good preventive conservation program. This program needs to include systematic collection care, handling and storage practices, and regular inspection and condition evaluation. This approach replaces the traditional practices and remedies of the past that have been found to be detrimental to museum objects.

For longer life of skin and leather objects follow these general guidelines:

- Identify the general category of the skin product correctly.
- Understand the product's basic characteristics, as well as its deterioration features.
- Upgrade the general environment that includes controlling climatic conditions, minimizing light exposure, providing physical support, and protecting from mishandling, soil accumulation, and pest infestation.

- Inspect, evaluate, monitor, and document an object's condition, periodically; record the urgency for conservation treatment.
- Provide specialist care for those objects requiring complex or considerable conservation treatment.

And follow these specific guidelines:

1. *How do I provide a stable and appropriate humidity?*

Use enclosures such as exhibit cases or storage cabinets to stabilize humidity and reduce handling, soil accumulation, and attack from microorganisms and insects.

Set relative humidity to an acceptable range: less than 5% RH change within a 24-hour period and an annual change of no more than $\pm 8\%$ fluctuation from the set point.

Humidity parameters are frequently 40%-60% RH; however, the specific set points will vary according to:

- climatic considerations
- an object's state of deterioration
- your facility's air handling capability
- requirements of any composite and associated materials present
- the relative humidity with which the object has reached equilibrium

2. *How do I monitor the condition of objects?*

Inspect objects for deterioration regularly. If you do not regularly evaluate and document their state of degradation, deterioration of leather and skin objects can go undetected and unchecked. Evaluate the condition of objects thoroughly when they are acquired. Then, inspect the objects periodically to identify progressive damage, such as lengthening of tears, increases in surface or pigment loss, and evidence of biological attack. Finally, use a conservator to assist in periodic surveying of significant objects in order to establish conservation treatment needs. See *MH-I*, Chapter 3, Museum Objects Preservation: Getting/Started, for guidance on Collection Condition Surveys.

3. *How do I clean objects?*

The degree to which each soiled object can be cleaned is a function of the nature of the soil and the sensitivity of the object. Clean an object only as necessary to remove airborne soil accumulation.

Don't directly apply chemical reagents such as cleaners, dressings, waxes, and coatings: they are not beneficial and will complicate future conservation treatment.

You can't remove some surface soils by simple cleaning methods, and other soils are not removable at all. Highly deteriorated objects cannot be cleaned by routine procedures so degraded surfaces should be noted and protected so that cleaning will be avoided.

When decorative elements on an object are extensive and very delicate, refer cleaning to a professional conservator. Surfaces that have specialized finishes also may require exemption from cleaning. Figure S.5 describes cleaning techniques that can be considered for objects in good condition.

4. *How do I handle skin and hide materials?*

Much of the damage caused to leather and skin products is due to improper handling. Therefore, you need to train staff in proper handling techniques. See *MH-I*, Chapter 6, Handling, Packing, and Shipping Museum Objects, for general handling rules.

In addition to the general rules there are a few essential rules for the safe handling of these objects:

- Be prepared before handling these objects by having a clean area ready to receive the object. Arrange for assistance from others when necessary.
- Consider the weight of the entire object before lifting; aged and deteriorated fibers cannot tolerate much physical stress. Avoid suspending, creasing, and folding items.
- Move leather and skin artifacts on a tray support, in a drawer, or in a box; if direct handling is necessary, use both hands and support the object from underneath, not from original handles and straps.
- Accommodate the special handling requirements of appendages and decorative elements such as beadwork and dangles.
- Handle skin and hide materials only while wearing clean, cotton gloves; if hand contact is required, wash hands just before handling.

See MH-I, Appendix I, Curatorial Care of Archeological Objects, for a discussion of support trays for objects.

5. *What about catalog labeling?*

Marking and labeling leather and skin artifacts for cataloging purposes can present a number of preservation problems:

- The porous, absorbent nature of all skin products can cause labeling inks, paints and varnishes to be absorbed into the skin tissue causing irreversible staining and stiffening.
- The adhesives associated with commercial labeling tapes have poor long-term stability.
- Pressure sensitive tapes and embossed plastic tapes tend to fall off in time, and their adhesives are generally not removable from the skin.
- Any type of metal tag (including aluminum) or metal ringed tag can cause corrosion. Aluminum in contact with skin and hide materials causes dark spots on the surface of the object.

Cleaning Techniques	Tools	Caution
VACUUMING - This is the safest cleaning method, if carefully executed.	Use fine plastic screening and a vacuum cleaner with adjustable suction or a rheostat and a small standard nozzle attachment.	Screening between the leather and the nozzle protects the leather, but movement of the screen can also cause abrasion. Flaking surfaces and loose parts may be accidentally removed.
DUSTING - This is the most frequently used technique. It can be combined with vacuuming.	Use camel hair brushes.	Dust acts as an abrasive; each time a material is brushed, surface material may be removed. Brushing also increases the danger of knocking off delicate pieces.
FORCED AIR - Compressed air cleaning must be done outside the collection area or dust will simply be redistributed.	Use a compressor, air hose, and broad compressed air nozzle.	Loose or fragile pieces can be blown off if too great a pressure is used; 40 pounds/square inch is maximum.
ARTIST'S ERASER - This method can occasionally remove stubborn surface deposits from the grain side of firm, intact leathers and skins.	Use artist's block or powder eraser. (Testing has shown "Magic Rub" block and "Scum X" powder to be the least damaging.)	This technique is not useful on deteriorated surfaces or where skin or decorative layers may be susceptible to flaking. Remnants of the eraser may become deposited in textured surfaces and require vacuuming.

Figure S.5. Cleaning Techniques for Leather and Skin Objects in Good Condition

You can determine the specific labeling technique you will need by considering the individual object. Maintain consistency throughout the collection and use the least damaging method. Consider both indirect and direct labeling.

- Indirect labeling allows you to avoid irreversibly damaging the hide material with ink. The two recommended methods of indirect labeling are tie-on tags and fabric labels.
 - Make tie-on tags from high quality, acid-free paper products or inert plastic materials. Corners should not be sharp. Attach tags in a manner that does not cause undue stress, such as to an orifice, strap or handle. Use soft cotton string or a non-abrasive plastic loop for attachment.
 - If you can't label an object with a tie-on tag, use a fabric label, such as those made from cotton twill tape or non-woven spun-bonded polyester; these can be sewn to soft skin products using a beading needle and single strand, white cotton thread. You can usually attach these labels without passing completely through the skin, and you can limit stitches to the upper edge of the label. Attach at a seam or inconspicuous area of the skin or hide material, or loop to a permanent strap.
- Direct labeling on skin products can be recommended only for firm leathers and rawhide. You can apply a barrier coating or ground of clear Acryloid B-72 resin to a small, inconspicuous area

(approximately 1 cm x 3 cm in size). When dry, apply the catalog number directly. The ink should have different solubility than that of the ground resin, so it may be changed if necessary.

See NPS Conserve O Gram 1/4, Use of Acryloid B-72 Lacquer for Labeling Museum Objects and the Museum Handbook, Part II, Chapter 3, Cataloging. In addition to normal health precautions, exercise additional caution when using solvents around leather and skin products because excessive amounts can cause deterioration.

Label the object neatly in the most inconspicuous place possible. Your labels should be small yet clearly readable from a distance of one foot. Use a high quality and iron-free ink, such as India ink.

6. *How do I provide adequate physical support for objects?*

Most organic materials lose their structural integrity as they age. Collapsed, creased, or folded materials will develop local weaknesses and damage if not protected by custom mounts and supports.

Use high quality, non-reactive materials:

- rigid acrylic sheeting
- acid-free matboard and unbuffered paper tissues
- washed and undyed cotton and linen fabrics
- polyester batting
- polyethylene foam products

Attached components can cause deterioration when in contact with other materials (such as metal parts). Separate components by a barrier of polyethylene sheeting or layers of acid-free tissue.

7. *How do I store objects properly?*

Store skin and leather objects in a space that is dedicated to the storage of museum collections, where climate control and security can be adequately controlled. Although storage requirements vary somewhat for individual leather and skin materials, basic conservation principles recommend that you provide a spacious and secure storage area, appropriate cabinets and containers, an area that is as free as possible from environmental threats, and individual storage supports. See MH-I, Chapter 7, Museum Collections Storage, for guidance on storage of museum collections.

The storage needs of tanned and untanned materials can be discussed at two levels. The first level addresses the overall collections storage facility with its system of shelving, cabinets, drawers, and trays. The second level focuses on individualized object supports. The following discussion provides more guidance based on these basic principles.

- ***Provide Appropriate Cabinets and Containers***
 - Protect objects made of skin products within cabinets or on shelving with dust covers. Items should not be piled, folded, squashed or leaned. Use cabinets and storage furniture made of

metal with a baked enamel finish. Don't use wooden cabinets and shelving, because wood products emit damaging vapors.

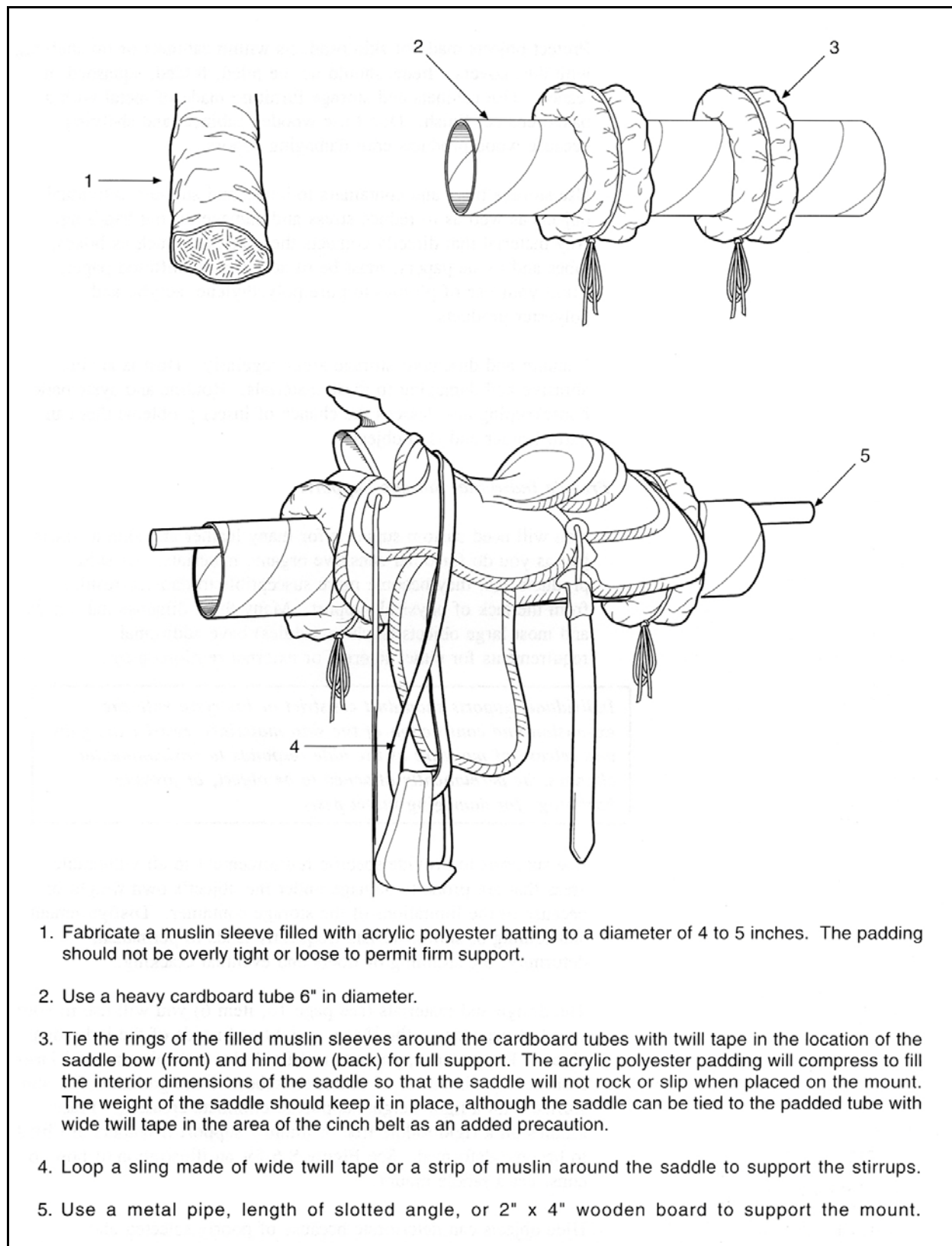
- Use storage trays and containers to house and support individual objects as well as to reduce stress and damage during handling. Any material that directly contacts the specimen, such as boxes, tubes and tissue papers, must be of acid-free unbuffered paper. Limit your use of plastics to pure polyethylene, acrylic and polyester products.
- Vacuum and dust your storage areas regularly. Dust is acidic, abrasive and damaging to these materials. Routine and systematic housekeeping also lessens the chance of insect problems that can harm leather and skin objects.

- ***Provide Individual Storage Supports***

- You will need custom supports for many leather and skin artifacts just as you do for other sensitive organic materials. As skin products age, they become more susceptible to damage resulting from the lack of physical support. Many three-dimensional objects and most large objects (such as saddles) have additional requirements for either internal or external reinforcement.

Individual supports shouldn't constrict or interfere with the expansion and contraction of the skin materials, restrict the gain and release of moisture as the hide responds to environmental changes, be permanently attached to the object, or provide harborage for damaging insect pests.

- Use supports to provide specific reinforcement to all vulnerable areas that are prone to damage under the object's own weight or because of the limitations of the storage container. Disfigurement and folding of skin materials frequently leads to permanent deformity, the straining of fibers and eventual cracking.
- The design and materials (see page 16, item 6) you will use in your supports depends on the shape, weight and needs of the individual object. For instance, you can roll flat hides and robes around large diameter (minimum of 6" diameter) tubes. Store garments flat and stuffed with a light weight support to eliminate creasing. Place saddles on a rigid saddle tree or dummy support if fenders are likely to become deformed. See Figure S.6 for an illustration of how to construct a saddle mount.
- Hide objects can deteriorate because of poorly selected and inappropriate support materials. Harmful materials are those that emit damaging vapors and organic compounds.



1. Fabricate a muslin sleeve filled with acrylic polyester batting to a diameter of 4 to 5 inches. The padding should not be overly tight or loose to permit firm support.
2. Use a heavy cardboard tube 6" in diameter.
3. Tie the rings of the filled muslin sleeves around the cardboard tubes with twill tape in the location of the saddle bow (front) and hind bow (back) for full support. The acrylic polyester padding will compress to fill the interior dimensions of the saddle so that the saddle will not rock or slip when placed on the mount. The weight of the saddle should keep it in place, although the saddle can be tied to the padded tube with wide twill tape in the area of the cinch belt as an added precaution.
4. Loop a sling made of wide twill tape or a strip of muslin around the saddle to support the stirrups.
5. Use a metal pipe, length of slotted angle, or 2" x 4" wooden board to support the mount.

Figure S.6. Constructing a Saddlemount

E. Summary: Leather and Skin Product Deterioration and Preventive Care

The previous two sections discussed deterioration, the causes of deterioration, and ways to limit deterioration through preventive conservation efforts. Figure S.7 summarizes some of this information.

CONDITION	PROBABLE CAUSE	PREVENTIVE ACTION
Deformation (contraction, cockling, cupping, shrinkage)	Physical alteration during use, storage or exhibition	Support in unconfined space
	Desiccation	Raise & stabilize ambient RH
	Alternate wetting or drying	Use container to protect against humidity extremes
	Excessive heating	Lower ambient temperature
	Photochemical reaction	Filter UV radiation, lower visible light
Embrittlement (rigid, inflexible, brittle)	Disuse, absence of flexing	None available
	Desiccation	Raise and stabilize ambient RH
	Soil impregnation	Use container, filter air
	Deterioration, loss of fat	Filter UV radiation, lower visible light
	Detanning	Use container
	Photochemical reaction	Filter UV radiation, lower visible light
Low cohesive strength (weakened, powdering, separating, fibrous)	Poor manufacture	None available
	Mechanical abuse	Use container, eliminate handling
	Chemical air pollution	Use container, filter air
	High acidity	Use container, filter air, stabilize ambient RH
	Oxidation	None available
	Loss of fat or water content	Stabilize ambient RH
	Photochemical reaction	Filter UV radiation, lower visible light
Physical Damage (abrasion, tearing, splitting, holes, missing parts, disjoined section)	Historic usage	Support, limit handling
	Inherent stress	Support, limit handling
	Dimensional movement	Stabilize ambient RH
	Handling	Use container, limit handling
	Stitching failure	Use container, limit handling
	Adhesive failure	Use container, limit handling
	Biological attack	Inspect, initiate control program
Soil or stain accumulation (oiliness, water staining)	Use during historical period	Document, identify using remaining characteristics
	Improper handling	Instruct staff in proper handling, limit handling
	Unprotected storage or display	Use container, filter air
	Unstable fat spew formation	Stabilize ambient temperature
Discoloration (fading, darkening, lightening)	Soiling or staining	Use container, filter air
	Excessive fat content	None available
	Acid deterioration	Use container, filter air
	Photochemical reaction	Filter UV radiation, lower visible light
Loss of grain layer or exterior surface	Morphological feature of skin	Use container, limit handling
	Poor manufacture	Use container, limit handling
	Mechanical abuse	Limit handling
	Uneven consolidation	None available
Loss of fur or hair (slippage, breakage)	Morphological feature of hair	Use container, limit handling
	Poor manufacture	Use container, limit handling
	Desiccation	Stabilize RH
	Insect attack	Initiate periodic inspection and control program

Figure S.7. Leather and Skin Product Deterioration and Preventive Care

F. Conservation Treatment Issues

Curators, collectors, and conservators alike have been guilty of relying on old treatments to preserve skin materials, and far too frequently they accepted the promotions of commercial products designed for contemporary leathers. This history of haphazard treatment and unsystematic evaluation of skin products has resulted in considerable damage and loss. Common criticisms of past treatments of skin and leather products are that preservation attempts have not differentiated among the distinct categories of skin materials and have relied too heavily on the application of "preservatives."

The traditional remedies and reagents once routinely used in museum collections are now being carefully scrutinized by museum conservators. With the aid of scientific investigation and the assessment of the results of past treatment, several important new directions are being taken. The findings on past treatments have not been encouraging.

The routine application of preservatives (such as saddle soaps and leather dressings) is discouraged.

1. *What are the perils of saddle soap?*

There are many problems associated with the use of "saddle soap" on historic and artistic objects made from animal skin products. With the best of intentions, this commercial product has been inappropriately applied to just about every form of skin material in the past.

"Saddle soap" was not developed as a cleaner, but as a 19th century leather conditioner. Its basic components of neatsfoot oil and cod or sperm oil were emulsified with soap in water to produce an emulsion fat-liquor introduced during early tanning. As a conditioner, saddle soap is considered obsolete by tanners today.

Its application has caused considerable permanent damage to skin and leather objects since its components cannot be easily rinsed out and adequately removed (as manufacturer instructions often suggest). Saddle soap effectively softens and emulsifies surface oil and dirt, however it usually distributes them deeper into the material. The mixture's high moisture content presents a hazard to aged skin materials that should not be wetted, as well as light colored vegetable and/or alum tanned leathers.

Commercial formulations of saddle soap differ in their ingredients, some containing abrasives and even colorants. Saddle soap quality fluctuates greatly among manufacturers.

Perhaps most importantly, conservators now suspect that the surface cracking on many older skin and leather objects may well be due to past "saddle soap" application. Avoid it.

2. *What are the drawbacks of leather dressings?*

The care of skin and leather goods has traditionally involved the routine use of leather dressings, solutions of fats and oils that lubricate skin products to increase flexibility. Modern research has shown, however, that the haphazard use of dressings has been the cause of considerable deterioration within museum collections.

These solutions should never be applied to Native-tanned materials or objects comprised of untanned or semi-tanned skin products. Avoid the use of leather dressings on museum objects.

Numerous drawbacks are associated with dressing of skin products. For example, dressings frequently:

- darken lighter colored leathers
- encourage biological attack
- form fatty spews at the surface
- oxidize over time and stiffen the material
- wick into surrounding materials
- soften original finishes and decoration
- cause dust to accumulate
- impede future conservation treatment
- contaminate the material for future analysis

3. *What about neutralization of acids?*

The chemical decay and disintegration of leather resulting from exposure to acids is a well-known problem and its solution for older leathers remains unresolved. Vegetable-tanned leathers produced since the mid-19th century frequently exhibit a condition of internal fiber degradation known as "red rot." The color of the leather actually reddens as the deterioration progresses. In its advanced state, affected leather will disintegrate into a powdery form.

This condition is most always associated with sulfuric acid, introduced either during the tanning process or from atmospheric contact with the contaminant sulphur dioxide. (Leather readily absorbs acid from the air.) Sulphur dioxide, when absorbed, becomes sulphur trioxide, which unites with water to form sulfuric acid, resulting in a devastating effect on collagen fibers. Certain vegetable tannages (the ones categorized as condensed tannins) have been identified as being much more susceptible to this mechanism of deterioration.

Modern leathers are fortified against acid formation by incorporating buffering salts that repress acid formation and action. Some of the museum preservation literature during the last decade recommended that older leathers be treated with similar buffering salts, such as potassium lactate and potassium citrate, to protect them from acid attack.

The problem that museum curators face is that there is no easy and safe method for long-term neutralization of acids that are present in historic leather objects. There are three drawbacks associated with the treatment of leather with standard buffering salt solutions:

- The salts must be introduced in an aqueous solution yet water can be very damaging to historic leather causing stiffening, color change and disruption of applied finishes.
- Salt solutions are meant only for vegetable-tanned leather and will de-tan and damage mineral-tanned materials; the applicator must, therefore, be able to distinguish between them, which is not an easy task.
- The addition of buffering salts will do nothing for leathers that have already begun to deteriorate from acid exposure.

The conservation field is looking at other methods of deacidifying leathers; vapor phase reagents and non-aqueous chemicals are being investigated. The importance of this conservation issue is clear to those involved, and acceptable procedures should be available to museum staffs in the near future.

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