Storage Facilities

Collections are stored in all manner of facilities: barns, basements, attics, closets, the second floor of historic houses and offsite storage facilities. Some storage areas share a building with other museum functions, such as exhibits or offices, while others share space with non-museum functions such as rental apartments, cafeterias or garages.

Ideal storage space has stable relative humidity and temperature, no dust nor fumes, light, pests, leaks nor fire hazards. It is easily accessible, and the collection is organized, well labeled and easy to retrieve. Finally, the space is expandable to fit the needs of an ever-growing collection. OK, so the ideal never exists. Some museums get pretty close, but even the best have the occasional dripping sprinkler head, mouse incursion, or forgotten corner piled with artifacts. Storage improvements are a process. The Detroit Institute of Arts talks about "shifting up." As improvements are made to one space, every other space is improved a little as well. For example, buying expensive cabinets frees up pretty good metal shelving that will replace really rotten wood shelving in another storage space. Using a planned approach, with an overall goal of ideal storage, these yearly advances contribute to the overall improvement of preservation.

Planning Collection Storage Space

The National Park Service suggests using an outside contractor to survey your storage area and write a collection storage plan. The U.S. Institute of Museum and Library Services (IMLS) has promoted hiring contractors to conduct general condition surveys for the past 25 years through their Conservation Project and Conservation Assessment Program grants. IMLS provides money for these surveys, but requires that staff at a museum that receives funding write the long-range conservation or preservation plan. An outside contractor is recommended because he or she brings fresh eyes to situations that you may no longer notice. For example, one museum, noted for its innovative storage improvements, has neglected its large-artifact storage barn for 20 years because the problem is so immense none of the staff has the energy to tackle it or even devise an implementation plan. It has become a classic case of out of site, out of mind. The Park Service suggests that a collection storage plan takes three to six weeks to complete. IMLS suggests five days to visit and write a conservation assessment report for a small institution, but allows six weeks for the process to be completed. The IMLS report covers all preservation aspects of the museum; storage is one component. The Park Service collection storage plan should include a determination of the space and equipment needed, a floor plan with recommended equipment layout, and a summary of current storage techniques with suggested improvements. Finally, the plan should provide solutions for urgent problems. The contractor's report may also include a brief overview of the collection and compare existing storage areas with generally accepted standards. The report may also include a synopsis of funding and staffing resources, if alternative storage is recommended.

However, an outside contractor cannot commit your museum to a project. Plans are useless if they sit on a shelf. As a contractor to museums, it is frustrating to put in significant amount of time and thought on a report and then find it gathering dust years later, with nothing changed. On the other hand, the majority of museums embrace these reports, discuss them and use them to raise money for implementing improvements to their storage – and make the contractor happy. Wright County Historical Society, a relatively small regional museum in Minnesota, has used its Conservation Assessment Program, or CAP, report to implement major changes, including installing compactor and other metal shelving in the archives and artifact storage areas, removing wood shelves and eliminating piles on the floor. Wright County quoted from the contractor's report to apply for funds from local, regional and national agencies. Doing so helped justify the time and expense required for improvements.

You can do some self- assessment. However, a self-assessment is only as good as the staff's understanding and training in the problems that might occur within their storage area. An archive storage area, as part of a small NEH preservation grant, did a self-assessment (CALIPR) before an outside contractor came to review the situation. The self-assessment turned out to be useless because the staff felt everything was pretty good and didn't see any place for major improvements. However, the contractor found a number of areas that did need improvement. This created unnecessary friction between the staff and the contractor.

Determining Space Needs

When planning storage improvements, plan for 20 years of collection growth and the requisite furniture needed to support that growth. This seems like a long time, but consider that a museum professional's career often exceeds 40 years. In reality, your time frame may be condensed further if expanded storage is included in a new building. The Minnesota Historical Society found that building a gorgeous, highly visible new museum (it overlooks a major freeway), resulted in a significant increase in collection donations. Thus, the time that MHS expected to have for filling storage areas was halved for some collections. Those areas filled up too fast and forced the museum to start searching for alternatives. Thus, any prediction made during planning may be altered by reality.

When determining storage needs, accept that every item will eventually spend time there. It is better to design a unique spot for each artifact than to juggle storage space to fit everything when exhibits change. Providing space for all objects also helps staff see collection losses: gaps show up in storage. As part of the planning process, staff must generate three different lists about the collection. First, know the general size and quantity of each type of collection item. For example, there are 500 buttons (average size 1-inch diameter), 20 wagons (average size, 60 square feet). Secondly, objects also should be categorized by curatorial subdivisions. There are 5OO Native American items, 50 modern art sculptures, 400 costumes, etc. Finally, the collection should be categorized by its composition. There are 500 wood and iron pieces (includes axes and wagons), 400 copper alloy pieces, 600 silk textiles. There may be special environmental needs for certain collections. For example, in an arid desert region, storing iron is less of a concern than in a temperate rain forest. By understanding different ways that your collection can be subdivided, you can decide which subdivision is best for preserving the collection while still making it accessible.

The following equation helps determine your storage needs. You need to know:

- The cumulative square footage of all current storage (SF)
- The number of all objects in your collection (C)
- The average number of objects acquired annually (D)

If you collect vastly different materials at vastly different rates, you may wish to break down each storage area by type of item. For example, you have vehicles stored in a large barn and you acquire an average of one vehicle every five years, or 0.20 vehicles per year. On the other hand, you have a large and rapidly growing photograph collection stored elsewhere in the museum. You may wish to determine space needs for each collection separately. However, the equation works pretty well if you lump the entire collection together, too. The large amount of space required by one vehicle might be equaled in five years by the speed at which the photographs are acquired.

Divide the square footage (SF) by the number of objects (C) to determine the current space you allocate per artifact (S). This number may surprise you. Often it is tiny, 3 square inches to 6 square inches (5 to 10 square cm). This is because before improvements, objects are not stored for optimum preservation. Rather, they are stacked, crammed into boxes or otherwise too close for comfort. After storage improvements, the average space for objects in a mixed collection is about 1 square foot (0.25 m). For a closer approximation, add the third dimension of height, especially if your planned storage area and current storage area have vastly different heights. In this case, take the cubic area allocated for storage and divide by the number of objects. Again, the average in improved storage areas is 1 cubic foot per object.

Now, to determine how much growth you might need, take the average number of yearly acquisitions (D) and multiply by 20. This gives you the projected number of objects that will be added to the collection in 20 years (F). Many small museums collect an average of 300 to 500 objects per year. Thus, in 20 years they will be caring for an additional 6,000 to 10,000 artifacts. Some institutions will base the growth rate on past experience. Other institutions can predict growth from planned archaeological and natural history research projects. Study your scope of collections. Are you planning to fill gaps or add to existing strengths? Have you committed to collecting only items smaller than a breadbox? One small museum in Iowa, with scarcely any storage room, decided to collect only small things. Thus it became a museum of miniatures, eyeglasses and toys. If you have an active loan program, consider outgoing and incoming loans and temporary transfers. These items will also need to be housed in your storage area.

By adding the current number of collection items (C) to the projected additional collection items (D), the projected size of the collection in 20 years is determined. Now multiply this figure by the average current area provided for each artifact, and you have an idea for the amount of space needed in 20 years – with no improvements to storage.

However, most items need improvements. Wright County Historical Society found that recent storage improvements – boxing, padding, providing storage mounts – doubled the amount of space the small artifact collection required. Consider an acid-free box for costumes. Many museums stack as many as 12 costumes in one box. However, with padding and interleaving, each box can comfortably hold only one or two. This would expand required storage for boxed textiles six times the current amount. Therefore, you must plan for increased storage space needed to implement storage improvements. To determine this, multiply the storage space required if no improvements occur by 2 or 4 (or 6) to determine how much storage space you reasonably need in the future. For most general museums, multiplying by a factor of 4 proves adequate.

Here is how it looks as an equation:

Current storage square footage (SF)
Number of objects in collection (C)
Average number of yearly donations (D)
SF / C = Current space per artifact (S)
D x 20 = projected items in collection (F)
(F+C)xS = Space needs (no improvements) (NI)
NI x 2 or 4 = Space needs with improvements

Let's plug in some numbers:
Your current collection numbers 100,000 objects housed in 5,000 square feet of storage. You annually acquire about 300 objects.

Current storage (SF) : 5,000
Nos. of objects (C): 100,000
Average yearly donations (D): 300
SF / C = (S) = .05 sq. feet (about 2 1/2 sq. in. or 4 cm.)
D x 20 = (F) = 6,000
106,000 x .05 = (NI) = 5,300 sq. ft. for storage in 20 years without improvements
NI x 4 = 21,200 sq. ft. (10 in. per artifact or about 17 cm. per artifact) storage in 20 years WITH improvements. (Note: By adding compactor moveable shelving, the required storage space could be halved or cut down to one-third.)

Storage Location

The physical location of storage is critical to shelter and protect your collection. Ideally storage should be above ground and have no exterior walls or roofs. Make sure it is not "under water." In other words, don't put storage below bathrooms, roof drains, sewage and water pipes or air conditioner lines. Storage also must be located above sea level and 100-year flood levels.

Storage doors should not open into public access areas. Build in a buffer zone: a short corridor, a research area or a workspace. However, storage should be located so that artifact movement to and from exhibits, the loading dock and research areas is simple. Wide, smooth corridors, double doors (or larger) and clutter free routes are essential for safe artifact movement. Too often architects design storage areas with sharp angles from loading docks, requiring tight turns that are awkward with large crates or objects.

If you have special high risk areas, such as dermestid colonies, a conservation laboratory, workshop, aquarium, staff break room, kitchen, cafeteria, janitorial supply closet, sinks or recycling or trash collection points, try to locate storage as far away as possible. These areas draw pests and often cause chemical, dust and water problems.

Modern storage areas use the "box within a box" concept, even with new construction. Storage areas are the heart of the museum, located in its protected center. The new Plains Art Museum in Fargo, N.D. retrofitted an old, brick industrial building downtown by placing offices, public reception and other non-collection areas along outer walls. The center of the building became the storage areas and galleries. This central core eliminated many environmental problems by avoiding exterior walls. Only the central core requires full climate control, which cut heating and cooling costs. Objects rarely leave the protected core areas. They move up or down for exhibits and storage, but never enter the less controlled periphery. The core is separated by vapor barriers, insulation and firewalls.

The Illinois State Museum followed a similar philosophy when it retrofitted a former shopping mall into offsite storage. The collection is stored in three internal pods, each with its own climate control system. The pods are surrounded by corridors and offices. None has an external wall, nor are they located close to external doors. Everything is on one level, so the pods have external roofs, but water entering through any of the building entrances would have to travel quite a distance before reaching a storage area. The pod walls are insulated and have vapor barriers. Each also has fire protection from the rest of the building. Pod environment is monitored constantly and fluctuations that exceed pre-determined amounts ring alarms at a manager's home and office.

The "box within a box" concept was first publicized by the National Park Service when it was trying to develop adequate storage in inadequate buildings. The Park Service promoted insulated containers with vapor barriers and individual climate controls inside historic structures such as barns. The historic landscape is retained, but the collection is protected.

Finally, storage location should depend on collection use. For example, are certain items always in demand for loans, exhibits or research? Then they should be as close as possible to the people who handle them regularly. It would not make sense, absent strong environmental preservation concerns, to place oft-used items in offsite storage. Location also may affect how some items are stored. Handling can be minimized by placing items on supports or in padded trays. This will be discussed in detail in the chapter on **mounts**. Popular collections should have the best storage supports possible to reduce damage from constant movement and handling. Ideally, these function as exhibit, storage and shipping supports, so the object is never removed from the support.

Separate Functions

Storage areas should only hold collections. Non-collections material, such as Christmas ornaments, museum publications, gift shop inventory, museum business records, cleaning supplies, light bulbs, maintenance supplies – ANYTHING THAT IS NOT ACCESSIONED INTO THE COLLECTION – does not belong in collection storage. Planning must include separate storage spaces for these items. They do not require stringent climate controls, so storing them in expensive space is a waste of money. Furthermore, they increase risks to the collection by their presence in storage.

Maintenance panels are another common sight in storage areas, including telephone switches, computer network hubs, fuse boxes, sprinkler controls, alarm panels and water lines. They increase the risk of accidents and theft. Again, design the current and future storage to exclude maintenance panels. You may lose some current storage areas as a result.

Often, the storage climate controls (HVAC) are located within the storage room. This is due to a lack of knowledge by engineers and architects of the rigorous requirements for collection storage. A collection storeroom is different from any other storage area, thus equipment that must be maintained and may leak, such as an HVAC, must be located outside collection storage. Sometimes a closet is built around the unit. However, maintenance staff must traverse the storage room to reach the closet, making this a poor solution. Ideally, equipment requiring regular maintenance should be located outside secure storage areas.

Constructing the Ideal Space: Physical Requirements
The best storage space follows principles of good design. It should be cost effective to build and cost effective to use and maintain. It should protect the collection. Good climate controls have the single largest impact on collection longevity. Climate control also is among the first sacrifices by penny-pinching architects.

Well-designed storage should be easy to monitor and clean. My father, an architect, suggested that the most efficient room was round – cleaning was quick because it had no corners. How will staff keep floors clean? This includes the area under storage shelves and cabinets? Compactor units may allow easy cleaning of the entire floor. So, too, may rolling cabinets or cabinets raised high enough to allow cleaning. One museum developed an innovative room for storing wet collections. It incorporated a grillwork floor so broken jars and alcohol could flow out of the space. However, shoes stick in the holes, carts vibrate excessively, the grill cannot be lifted for easy cleaning (after a couple years the floor under the grill is disgusting), and many of the collection items, even in containers, are small enough to fall through. What seemed a smart, innovative, storage solution has turned into a maintenance nightmare.

The storage design team should include museum professionals along with non-museum professionals such as the architect, mechanical and structural engineers, security consultants and fire suppression consultants. Museum staff should include a curator, conservator, collection manager and the heads of security and facilities and maintenance. Examine blueprints carefully. Pay attention to the placement of windows, doors, ventilation ducts, sprinklers and plumbing. Notice what spaces are next to each other. Does a staff break room or a bathroom share a wall with a storage area? This would increase pest, water and fire risks in storage. Where are public spaces, and where are private spaces? Where are fire escape corridors? Question everything on the floor plan and the elevations. What is the useable ceiling height once the ducts, sprinklers, lights and emergency signs are installed? Insist on meetings throughout the design and build phase of the project. As-builts (the building plan that reflects all the changes since the original designs) are often different from the original blueprints. Often the electrician, plumber or pipe fitter installing the equipment will approximate its location rather than sticking to the drawings. This can result in wasted wall space and/or low ceilings.

Some museums write pre-construction manuals and require the architect to follow it. This should list all non-negotiable building components that must be provided. When construction begins, architects usually encounter cost overruns and want to cut expensive environmental control and filtering systems. Staff can bring out the pre-construction agreement and point out that the architect promised specific environmental controls. Architects often do not want to cut less important items such as expensive finishes – doing so alters their creative vision.

Here are some problems that have been built into new museum storage areas:
- Low ductwork or ducts that take up wall space.
- Low-hanging emergency signs that make it impossible to bring in cabinets.
- Wall-mounted emergency lights, fire extinguishers and motion detectors that eliminate efficient use of walls for storage.
- Low sprinklers.
- Low lights.
- Lack of vapor barriers in walls, floors and ceilings that make it impossible to maintain relative humidity levels year round.
- Wall openings for ducts, electrical wiring or water lines that breach the fire resistant capacities of walls or allow pests to enter.
- Metal exterior roofs without adequate vapor barriers and insulation, so high relative humidity causes storage areas to rain.
- Concrete floors without vapor and water barriers that allow in excessive moisture resulting in mold on the lowest shelves.
- Columns in awkward places.
- Strange corners.
- Doors that open to block other doors or cabinets. Or doors that can't open fully because they are partially blocked.
- Emergency exit corridors that run through a storage area. The door cannot be locked since it is an emergency exit (This is surprisingly common).
- Intake air for the HVAC low on the building, in the loading area, where trucks park with their motors running.
- Inconsistent door sizes and corridor widths between the loading dock and the storage area, freight elevator and exhibit galleries, creating bottlenecks.

- Small doors that make it difficult to bring cabinets into the room.
- Environmental control equipment located below the flood plain – high water eliminates the HVAC.
- HVAC placed inside the storage area instead of outside, as originally planned.
- No lip around or drain next to the HVAC.
- Water condensation tubing running from an air conditioner through the storage area to a floor drain across the room.
- Windows. Architects love windows. (My younger sister, another family architect, received a low grade in college for designing a museum with no windows. Her professor had never heard me rant about windows in museums. Unfortunately for my sister, she HAD heard me rant all too often. She now designs college buildings and hospitals and won't touch a museum.)
- Floors that won't support a sufficient load. Catherine Hawks, a natural history conservator, suggests storage floor loads should be 350 pounds per square foot (psf). She recommends that rating for storage, exhibits and access corridors between them and the loading dock. That makes the floor strong enough for a forklift. The National Park Service recommends 250 psf for storage. As a point of reference, most homes have floors rated at 100 psf and office buildings are required to have 150 psf.

Storage areas do not need to be pretty. But they do need to be neat and clean. Walls should be painted and floors sealed. Most modern storage areas have concrete floors and cinderblock walls. Depending on the value of your collection, you should build so that it is nearly impossible to cut through storage walls and doors. Although concrete contributes moisture and alkaline salts to the atmosphere for a number of years, wood will emit volatile organic chemicals (VOCs) for far longer. Also, concrete is more flame resistant than organic materials. Carpets are not recommended. They can hide pest infestations and provide habitat and food. Carpets also emit volatile chemicals. The floor, walls and ceiling should have vapor barriers and insulation – especially if storage areas have separate climate controls. Wide doors, access corridors and interior room corridors make moving big artifacts and storage cabinets much easier. Keep ceilings open. Drop ceilings provide pest habitat and disguise leaks.

Although pipes and ductwork should not be in storage, if present, they should be clearly labeled. Duct linings should be external, not internal. Make sure duct openings are sealed where they pass through walls, floors and ceilings. Internally, ducts may need a fire damper to preserve the fire retardant properties of the storage room walls.

Use white acrylic emulsion latex paint on the interior walls and ceiling. To improve the fire retardant properties of non-masonry walls, use intumescent fire-retardant paint on the non-collection room side of the wall. Intumescent paint foams up when heated to form a fire barrier. Also, construct the wall using metal studs rather than wood. Avoid oil-based paints and polyurethane, single-component epoxies and alkyd paints. Coat cured concrete floors with solvent-borne epoxy sealer, topped with a moisture-cure epoxy sealer.[1]

Construction Checklist (based on Catherine Hawks, John Hilberry, NPS, and CCI publications)

- Floor load: 350 psf – storage, exhibits, and access corridors between all and loading dock (C. Hawks)
- Doorways, hallways, routes of travel: large enough for full-unit cabinets and large objects (in both width and height). No bottlenecks.
- Make sure door hinges are to the inside of the storage room. Storage doors should open out into the corridor.
- Doors as large as adjacent corridor. Between seven to eight feet high and five to eight feet wide. Add a transom above the door for additional height when needed. Double doors should have one fixed and one operating leaf for general use.
- Door frame should be reinforced steel.
- Two key locks on storage areas – requiring two people to access.
- Make sure entrance to storage is clear and easily visible from staff offices.
- Smooth transitions, no bumps in corridor floors or level changes, elevators have smooth floors and do not have bumps or large gaps
- Corridors within storage area, at least 48 inches (4 feet) (NPS) between cabinets.
- No drop ceilings (pest habitat and disguise leaks)
- Label all pipes and ductwork.
- No pipes/ductwork except sprinklers over storage areas
- Seals around all duct and pipe chases where they pass through walls, floors or ceilings of store rooms
- External, not internal, duct linings (noise control/reduce condensation)
- Paint walls and ceilings white using acrylic emulsion latex (interior or exterior, vinyl acrylic, or acrylic urethane coating. (Tetreault 1999)
- DO NOT USE: oil-based paints, single-component epoxies, alkyd paints, or oil-modified polyurethane coatings.
- Coat concrete floors (after curing) with solvent-borne epoxy sealer, topped with a moisture-cure epoxy sealer.
    - Beware of Volatile Organic chemicals (VOCs) coming from carpet backing and adhesives

[1] Catherine Hawk, "Storage Design for Object and Specimen Collections", unpublished paper, 2000.

  - The most inert carpets are olefin (polypropylene) and solution dyed nylon (6 or 6.6).
  - For tiles, use linoleum, not PVC tile or sheet flooring.
  - Carpet backings: avoid natural latex and PVC. Use synthetic latex (styrene-butadiene rubber) and woven polyester or polypropylene
  - Adhesives: water-based acrylic resins with CRI of 0.5 mg/m2-hr. or less for total VOCs.
  - Look for CRI IAQ "Green Label." Indicates the manufacturer voluntarily participates in the CRI testing programs. Developed for people with allergies.
  - Use tackless strip installation if possible
  - Install exactly to manufacturer specifications
  - No anti-microbial treatments on carpets (ineffective and damaging)
  - 4 weeks for off-gassing and RH equilibrium before installing artifacts
  - Do not carpet below grade or where there is danger of water accumulation
- Install polypropylene fiber mats outside the doors to storage rooms.
- Include adequate outlets for vacuum cleaning and use of temporary electrical equipment.
- Install lighting adequate for area inspections. C. Hawks recommends a high CRI, for lower light levels. Others recommend yellow filters to eliminate damaging blue light.
- Battery powered emergency lighting.
- Back-up generator to run HVAC, sump pump, alarms, electric locks and other essential collection protection.
- Separate storage areas: permanent collection, loans/traveling exhibits, exhibit crates, storage supplies, holding room for in-coming objects near shipping and receiving.
- Ceiling height adequate for stored collection. Too high is a waste of space, too low makes use difficult.
- All walls and partitions made of fire and light proof masonry that is difficult for a burglar to penetrate.
- Elevators open outside storage areas, never within secured space.
- Elevators large enough to hold cabinets and largest collection objects (Vehicles? Totem poles?)
- Smooth floor to elevators to decrease vibration.
- No electrostatic precipitators to clean the air – they produce damaging ozone.
- Mechanical equipment in a separate room.
- Raised curb at mechanical room door. Drain in floor.

Research Space

Researchers need a climate-controlled place to examine collections safely. This should not be inside secure storage. Instead, provide a dedicated research room. It should be large enough to accommodate the needs and equipment of researchers using the collection now or in the future. For example, if you have many requests to examine quilts, you need a table large enough to unroll a quilt. You may need a wall rack for temporary rolled quilt storage. You may need a large metal shelving unit for quilt boxes. A lockable temporary storage cabinet inside the room can keep objects safe, especially before and after researchers use the room. Ideally, only one item would be in a research room at a time, but a researcher may want to make comparisons. Research space should be convenient to staff offices, collection storage spaces, the researcher staging area, restrooms, curatorial work area and/or the conservation laboratory. The space should be accessible to people with disabilities. Since researchers may need to use portable computers and other equipment, the space should have electric outlets, phone service and other utilities to meet researchers' needs and local building codes. These may include a sink and a fume hood, depending on the nature of your collection and the research. Other useful additions are a small reference library, microfilm and microfiche readers, video and DVD players with TV screens, a typewriter and a computer with a modem. The room should have a small bulletin board for posting policies and procedures. The room should be staffed; someone from the museum must be present when the collection is out of storage. A researcher should never be left alone. No matter how often you see this person, he or she is not part of your staff. Their work should be monitored 100 percent of the time. A desk for a staff person in the research area might be necessary. An alternative is to place an office next to the research area. Have a large window between the office and the research area. Video surveillance with tape backups also is recommended.

You also should have a staging area for researchers. This area should contain a hat and coat rack or lockers and equipment stands for storing and securing garments, bags, packages and containers. Purses, backpacks, overcoats, bulky sweaters and briefcases should not be allowed inside research areas. Any of these can be used to sneak collection items out of the museum.

Within the room, provide safe handling tools. Insist researchers use pencils, not pens. Do not allow sticky pads. Provide gloves, bone folders, microspatulas, padded supports or cradles and acid-free paper. Post informational signs on the tables and bulletin board. Ask researchers to read your handling guidelines or view a video on handling collections. There are two cartoon publications, one by Rob Waller and one by Nancy Odegaard, that make transmitting handling information much more pleasant. I always kept Nancy's book by the door to storage for visitors and researchers to peruse. (They are listed in your bibliography under **Handling.**)

Holding Area

In-coming collections should not be placed directly into storage areas. They need to acclimate to your environment slowly. They may contain a pest infestation. Isolate new items in a holding room. The holding area should be a climate controlled, secure storage space near your loading dock. Here you can inspect, bag, freeze, clean and prepare incoming materials for storage. This room should have shelves, locked cabinets, a low temperature freezer, plastic tubing and bag sealer. Storage supplies and gloves should be located just outside the door.

Environmental Controls

The museum should specify the best environmental control unit it can afford. Ideally the unit should provide between 90 percent and 95 percent particle filtration of all new and recycled air and filter gaseous pollutants using activated charcoal filters or potassium permanganate filtration beds (if the museum is filthy rich). Filters should be changed regularly. Take care that they fit tightly. Fan belts and motors should be inspected twice annually. Moving parts should be oiled as recommended by the manufacturer. The equipment should maintain a non-fluctuating, moderately dry and cool environment.

Choose an environmental engineer who is familiar with recent changes to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) handbook. Until recently, the handbook barely mentioned museums, libraries or archives, providing only a paragraph to guide engineers. But in the last few handbooks, Chapter 21 "Museums, Libraries and Archives" – a whole chapter – covers museum environmental control in detail.[2] Many engineers design mechanical systems with which they are comfortable. Thus, an engineer may use heating systems designed for homes in a small historical society storage area. Or another engineer may use a variable air volume system, popular in the energy-crunched 1970s, to provide cost savings. Make sure that everyone, from the director on down, understands that energy setbacks, while cost effective in office buildings, quickly destroy the collection. The engineer must understand that climate control must be 24/7/365 – 24 hours each day, seven days a week, 365 days a year. It cannot fluctuate during fall and spring or from day to night. To ensure continuous control, the climate control machinery must have a backup generator that maintains control during power outages. The generator should be serviced regularly.

As noted in the previous chapter, fluctuations in relative humidity causes cracking, warping, flaking paint, tears, glass crizzling or sweating, mold and metal corrosion. Temperature and relative humidity are inversely related. Thus in a closed environment,

[2] 2003 ASHRAE Handbook — HVAC Applications, can be ordered from their website, http://www.ashrae.org/template/EducationLinkLanding/category/1553

a decreasing temperature raises relative humidity and vice versa. Controlling relative humidity so that it fluctuates slowly over a limited range greatly increases collection longevity and stability. Some museums control relative humidity by allowing the temperature to fluctuate in a 10 degree range. This is accomplished through humidistatically, not thermostatically, controlled heat. In general, fluctuations in temperature cause minimal damage if relative humidity is constant. However, some materials also are temperature sensitive: plastics, photographs and film deteriorate rapidly at high temperatures.

Historically, conservators have recommended relative humidity ranging between 45 percent and 55 percent at 65 to 68 degrees Fahrenheit (20 degrees Celsius). This was based on Gary Thomson's pioneering book, The Museum Environment. However, more recently, conservators have recommended lower temperatures (the rate of degradation reactions slows more with lower temperatures) and non-fluctuating, relatively low, 35 percent to 40 percent RH. In these recommendations, temperature lower limits are set for human comfort when necessary. Rochester Institute of Technology, in its research on film preservation, found that at Gary Thomson's recommended environmental levels, acetate films started to produce acetic acid, "vinegar syndrome" in 50 years. However, by lowering the temperature, longevity could be extended thousands of years. Rochester Institute of Technology developed a wheel (on line at http://www.climatenotebook.org/MSQR/MSQR_home.html) that tells how long acetate and other photographic media last at different relative humidity levels and temperatures. In recent years, the Institute has worked on a datalogger and software that collates RH and temperature fluctuations over time and provides a preservation index (PI) number.[3] This number would tell you the longevity of your film collection given your current environmental fluctuations. Because of the Institute's research on plastics, conservators generally recommend cooler storage temperatures as long as the relative humidity doesn't rise above 40 percent.[4], [5] Temperatures just above freezing

[3] Preservation Environment Monitor (PEM) and Climate Notebook (CNB) software, project announcement at http://www.rit.edu/~661www1/sub_pages/8page21.htm and http://palimpsest.stanford.edu/byform/mailing-lists/cdl/2001/0574.html. The software works with most popular museum dataloggers. PEM and CNB can be purchased from Rochester Institute of Technology's Image Permanence Institute.

[4] Because relative humidity and temperature are inversely proportional if temperature lowers in a fixed container of air, the relative humidity rises. A generalized rule of thumb is that for every degree Fahrenheit the temperature lowers, the relative humidity rises two percent. And vice versa. For every degree the temperature rises, the relative humidity drops two percent. (For those of you who operate in Celsius, I have not converted this rule for you.) Please note that although temperature changes affect relative humidity, the opposite is not true. Relative humidity changes do not affect temperature.

[5] Cold storage will damage collections if it does not incorporate RH controls. The Anchorage Museum of Art placed their fur collection in a cold storage room. In under a year, the entire collection was covered in

are excellent for organic materials – except waxes and possibly some plastics. Glass and ceramics might be damaged by thermal shock if temperatures vary too much between exhibit and storage. CCI recommends defining correct relative humidity and temperature for different stored materials. In the chapter on **Specific Collections**, I have given some guidelines. However, most museums cannot afford to store more than a few items in special climate conditions. In general, it is better for the relative humidity to be stabilized rather than the temperature. Most HVACs are better at controlling temperature than they are at controlling RH. Discuss this problem with your environmental engineer. You could fluctuate the temperature within a 10-degree Fahrenheit range, to lessen relative humidity fluctuations, using humidistatically controlled heat[6] with thermostat backups. Some historic house museums control internal environments with this simple solution. Remember, it is OK to go down in temperature, but not to go up. Above 68 degrees Fahrenheit, the rate of deterioration increases exponentially.

Regional climate determines feasible temperature and relative humidity for your building. Arid northern areas of the American plains cannot achieve 50 percent relative humidity in the winter without severe damage to older museum buildings. The moist air hits the cold exterior air somewhere within the walls, causing ice to damage the outer surface. Rigid adherence to 50 percent relative humidity could destroy the collection's protective building! This is an important concept for those building a new museum to understand. Even with insulation and a vapor barrier, the maximum winter relative humidity may only be 35 percent. Any higher, and you will see moisture pooling on windows, eventually rotting out sills. For northern museums, a buffer zone (offices, theaters, gathering spaces) between the high RH central storage and exhibit areas and the exterior walls, may make it possible to maintain a high, constant relative humidity year round where the collection is housed and displayed.

In warm, moist, tropical climates, you will be lucky to lower temperature to 70 degrees Fahrenheit (20-21 degrees Celsius) or decrease humidity to 55 percent RH. If the environmental control units fail regularly, these fluctuations may be more damaging than no environmental control at all.[7]

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mold. Although cold, the room did not have humidity controls. Lowering the temperature had raised the relative humidity above 65 percent. Even in cool temperatures, mold grows. (Just look in my refrigerator.) Clean up was costly and posed a risk to human health as well as the fur collection.

[6] Brenda L. Long. "Humidistatically Controlled Heating and Ventilation Systems: Alternative Methods for Relative Humidity Control." CRM OnLine, No. 7. 1999. http://crm.cr.nps.gov/archive/22-7/22-07-o2.pdf

[7] Preserving Collections in Tropical Countries
http://www.getty.edu/conservation/publications/newsletters/12_2/news2_1.html

Note that most collections have acclimated to your area. Items that have been perfectly stable at 20 percent relative humidity, winter and summer, may be severely damaged if they are suddenly stored at "optimum" levels. As the caretaker of your collection, it is critical that you know your environment. The U.S. National Weather Service has data for your area. Do you live in a humid area such as Washington State? Or a semi-arid desert such as eastern Montana? Do you have high humidity during summer and arid winters? (Or are they only arid within heated structures?)[8] Whatever your climate, work with an environmental engineer to ensure that relative humidity does not fluctuate within your building. Be sure to emphasize *relative humidity* when working with an environmental engineer. This is different from absolute humidity (the actual amount of water held in the air). If you must change relative humidity between seasons, make the change gradually, at the rate of 2 percent RH per week for a maximum change of 10 percent RH.

In the tropics, high temperature and RH lead to increased pest and mold infestations. If your museum cannot keep RH below 60 percent, you must try a different approach. Many museums in the tropics open their buildings. Airflow and rigorous staff inspections and monitoring may work better than closed spaces. I am always shocked when I visit Mexico's National Museum. Every gallery has open exterior doors. It is, frankly, a lovely way to see a museum. The museum maintains positive air pressure inside the building AND displays primarily inorganic archaeological objects on the lower levels.

In tropical areas, reduce all clutter in storage – including use of boxes and acid-free tissue paper. If your main concerns are pests, especially termites, eliminate all organic materials. Use metal shelving and metal cooking trays instead of wood or cardboard boxes. Inspect thoroughly twice a day (termites cause damage quickly). Keep collections well off floors and away from walls. Keep padding minimal – it can provide pest habitat. Use screens and sticky barriers at openings, including drains and ducts.

Heating, air-conditioning, humidification and dehumidification systems are available independently or in combination. The entire system is referred to as HVAC. Some

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[8] Recent work by Helen Alten of Northern States Conservation Center and Rebecca Thatcher Ellis of Sebesta Blomberg, Inc., found that relative humdity did not fluctuate drastically in unheated log buildings at Old World Wisconsin, a living history museum. The relative humidity was high year-round, making the spaces ideal habitats for pests and mold. Wood furniture was in excellent condition, except for the surface finishes. Varnishes seem to have been damaged by the high relative humidity. The surprising conclusion was that the environmental fluctuations were not the primary cause of damage in unheated structures. Pests, dust, light and high relative humidity levels were more damaging than environmental fluctuations.

museums successfully control small enclosed storage areas with used equipment, which may be available from businesses that are upgrading computer rooms. Whether components are integrated or operated separately, it is important that they be monitored, recorded and controlled centrally. If your system has internal monitors, double-check them with external monitors. It is common for a system to think it is providing optimum conditions when it is really too hot, cold, dry or humid. Balance the system after installation, and calibrate all sensors at installation and recalibrate them every six to 12 months. Calibration means taking a relative humidity and temperature reading with a psychrometer right next to the sensor and comparing results with the sensor's readings.

Rebecca Thatcher Ellis, a ventilation engineer in the Twin Cities has published “Getting Function from Design: Making Systems Work” (http://www.nedcc.org/plam3/tleaf23.htm) an article that should be read before you begin retrofitting your HVAC or begin planning a new storage facility. Ms. Ellis has worked with a number of museums and conservators and is well aware of our special needs for environmental control. Make sure your HVAC system and the mechanical room that houses it are designed for easy maintenance. (For example, steam pipes should be high enough that you can enter the mechanical room without hitting your head. You should not have to be a contortionist to change filters or maintain the equipment.)

Monitor storage environment using thermohygrographs, dataloggers, temperature monitors and alarms linked to central controls. Monitor close to exterior walls and near the floor and roof, as well as in the center of the storage room. There may be a noticeable difference between air near cold surfaces and air in the middle of the room. Use fans, install insulation and vapor barriers to help correct unevenness. In some cases you may need to use portable heaters or air conditioners to moderate local areas. Be careful, these are fire and water risks. Air conditioners in windows can cause permanent damage, rotting out windowsills and running moisture down walls.

Much more detail, discussing climate and light control in museum, is given on Tim Padfield’s delightful web sites:
http://www.padfield.org/tim/cfys/
http://www.natmus.dk/cons/tp/

There is also a lengthy list of excellent articles in your additional readings. Some of you are planning new construction. Familiarize yourself with terms and concepts so you can speak intelligently with the architect and engineer.

Pollutants and Particulates

HVAC also should clean and filter air. Filtration systems promote adequate ventilation and reduce pollutants by removing dust, particles and harmful gasses.

Gases and particles are the two components of air pollution. Particles from burning fuel are sooty and tarry, contain sulfuric acid and trace metals such as iron that start degradation. Dust is abrasive, unsightly and may absorb acidic fumes or moisture from the air. Absorbed water damages glass and metals. Abrasive particles act as little saw teeth, cutting organic material when it expands and contracts from humidity fluctuations.

Acid corrodes metals and destroys organic material. Sulfur dioxide, a common acidic gas, is formed from burning fossil fuels. It turns into sulfuric acid in the presence of water and can rapidly disintegrate carbonate materials such as chalk, limestone, marble and alkaline sandstone. It also embrittles and yellows plant fibers such as paper, cotton, linen, rayon and wood, may instigate "red rot" in leather, attacks paints and pigments; breaks down synthetic materials such as nylon and rubber; and corrodes metal.

Oxidizers, primarily ozone and nitrogen dioxide, are produced when oxygen breaks down. Ultraviolet rays in the upper atmosphere, sunlight on car exhaust fumes (photochemical smog), or certain lamps and electrical equipment such as electrostatic precipitators and photocopy machines, create ozone or nitrogen dioxide (neither should be located near collections storage). Oxidizers react with all organic materials causing structural breakdown. They attack dyes, pigments, inks, cotton, basketry paper and polyesters. Nitrogen dioxide also forms nitric acid in the presence of high relative humidity causing damage similar to that caused by sulfuric acid.

If your museum is housed in a large city or on a busy street, or if your air intake is in the loading dock where trucks and car fumes are concentrated, consider filtration that absorbs gaseous as well as particulate pollutants. Even in the country, you may need to filter outside air. Are there sulfur fumes from natural hot springs? Are nearby fields treated with chemical fertilizers? Are you near a rail line that transports chemicals?

Localized air pollution can be produced inside your museum from photocopiers, woodshops or acidic storage materials. In an enclosed area, fumes produced by products containing oils, sulfur and formaldehyde rapidly corrode metal, yellow and embrittle many organic materials, and fade some dyes and pigments. See the Chapter on **Materials** for information on safe storage materials. The source of some of these damaging fumes may be other collection pieces. Rubber tires, plastic dolls, wood sculptures may all produce fumes that damage themselves and/or other materials.

There are four ways to address damaging fumes in your collection:

- Avoid them
- Block them
- Absorb them
- Dilute them

Avoid pollutant fumes by segregating collection materials by composition, building with inert materials, and testing regularly to ensure clean air. For example shells, lead and pyrites should be separate from wood, rubber and plastic objects. Some objects contain materials that damage each other: nicknamed “inherent vice.” The classic example is little Arctic ship models, made of wood, dried animal gut and furs. The figures in these models have lead hands, though these usually are gone. If still present, they are covered in white deterioration products, indicating their rapid disintegration from the presence of organic acids. Occasionally sealing the lead with wax or lacquer extends its longevity.

Block fumes produced by wood cabinetry by sealing the interior surfaces with aluminum foil, Marvelseal, Formica or other laminates that completely block acids in the wood from migrating into the air. Paints and varnishes and most plastic films (such as Mylar and polyethylene sheeting) do not completely block acidic fumes. There is more in the chapter on **Materials**.

Absorb fumes entering the museum or within storage cabinets using either activated charcoal filters or potassium permanganate filters. The Minnesota History Center and the new J. Paul Getty museum use both. The activated charcoal filters are placed perpendicular to incoming air. The potassium permanganate lies in flat beds parallel to incoming air. Charcoal filters are significantly less expensive than replacing used potassium permanganate. A shock to museums using potassium permanganate filters is their maintenance cost. You must budget replacement on average every five years. Charcoal filters are easily found in any hardware store. They are the filters used in fans placed over kitchen stoves. You can buy the filter material in large rolls. The Illinois State Museum segregated all of its plastic dolls, placing them in enclosed cabinets lined with activated charcoal filters.

Dilute fumes by adding clean air to a cabinet. If your region’s air is not clean you cannot dilute with incoming air. It must be filtered. Dilute cabinet air by opening vents at the bottom and top of the cabinet. Vents should be filtered so dust doesn’t enter. This can be done with cotton batting or fine cotton fabric. If there are concerns about pollutant vapors in the room, add a charcoal filter over the vents. Vents need to be staggered, one higher than the other, to create natural airflow. If vents are on the same level, air will not move.

When constructing a new facility, avoid locations with high pollution, dust or local emissions such as truck routes. Test building materials, preferring those designed for high-sensitivity, allergy-prone people. They may release fewer gases with age. Eliminate smoking. If that is not possible, eliminate smokers (Provide smoking areas with separate vent systems. Similarly, parking facilities should be separately ventilated.)

As with temperature- and RH-sensitive materials, some materials are more sensitive to gaseous pollutants than others. Make a list of the most sensitive materials. Monitor them closely, check their environment regularly, and try to improve their storage area so it has no problematic vapors. Some of the more sensitive materials are lead, calcium carbonate (shells, limestone, marble), pyrite, silver and other metals.

Make sure staff ALWAYS wears gloves when handling collections. Monitor dust levels, tarnish and patina color changes. If you see a problem, test further with A-D strips, dosimeters and metal coupons. Maintain cleanliness in storage. Use HEPA or ULPA filtered vacuum cleaners so dust is not re-deposited on objects. Do not manually sweep or mop storage areas – vacuuming should be sufficient.

Storage Illumination

As noted in the previous chapter, three forms of light damage collections: visible, ultraviolet and infrared. In general, light acts as a catalyst for most degradation reactions, causing, embrittlement, yellowing, and discoloration.

In storage, reduce ultraviolet radiation to below 75 microwatts per lumen (mW/l). The ideal is 0 mW/l. The Wright County Historical Society installed yellow plastic light filters over fluorescent lights. The polycarbonate cover absorbs most of the UV radiation, while the yellow eliminates the damaging blue part of the visible spectrum. This lighting takes some getting used to. It ensures researchers and staff remove collections to separate examination rooms located outside of storage. Interestingly, another conservator, Catherine Hawks, recommends lighting with a high CRI (color rendering index) because one can see clearly with low intensity light. Remember, you need to regularly monitor for pests, dust and other problems. Although light damages collections, staff also have to be able to see storage areas well enough to see problems.

For years, conservators recommended that visible light levels in exhibits remain below 5 footcandles (fc) for light sensitive materials and below 15 fc for less sensitive materials.

Experiments by the Canadian Conservation Institute, quantified on their light slide rule, have shown that fading occurs in light sensitive materials in one year if they are exposed to 15 fc of light for eight hours a day, seven days a week. Remember, *ALL light damage is irreversible and cumulative.* In other words, deterioration will continue and multiply every time the material is exposed to any type of light. Therefore, it is critical that light-sensitive items be stored in cabinets, boxes or otherwise kept in the dark. Light sensitive materials include all organic items and anything with organic colors applied to it – dyes, watercolors, some paints.

Reduce light levels in storage by wiring banks of lights to separate switches, covering light sensitive material, having brighter lights only in work, and/or controlling lights with a timer. Incandescent lights produce heat, which dries collections stored or exhibited close to them. Fluorescent bulbs, fiber-optic lights or incandescent dichroic bulbs (which direct heat out the back of a lamp) are cooler options.

Most modern storage areas use fluorescent lights. Reduce ultraviolet light levels in storage by using florescent bulbs with a UV filter coat applied by the manufacturer. Otherwise, UV screening may be slipped over a fluorescent bulb or may be slipped inside a plastic light cover. Because the ends (ballast) of fluorescent bulbs get hot and can melt plastic sleeves, it is best to place the UV screens on the fixture cover. Most clear, rigid, plastic fixture covers are made of polycarbonate, a natural UV absorber. These covers filter UV light although they are not designed to do so. Therefore, fluorescent lights in storage areas must have covers. Do not use bare bulbs. Polycarbonate covers are available from hardware stores. UV screening filters are available from suppliers listed in NPS' Conserve O Gram (http://www.cr.nps.gov/museum/publications/conserveogram/uvfilms3-10.pdf). UV screens may need to be changed periodically. Check manufacturer specifications. See http://www.nedcc.org/plam3/tleaf24.htm for more information on light, UV screens and monitoring.

Paint storage areas with latex paint that contains Titanium dioxide. It is a natural UV absorber and will keep UV from bouncing off your walls. Some museums use this property to lower UV levels by bouncing fluorescent lights off the walls and ceilings rather than having it pointing down onto the storage furniture and collection.

Monitor light levels in your storage area. Depending on what kind of meter you buy, it will give you a reading in lux or footcandles. Light meters are available from photo suppliers. If a light meter is not readily available, a camera can be used to measure light levels.9 Ultraviolet monitors are expensive. Every museum should have its own light meter, but UV meters may be an unnecessary luxury if a large museum or regional laboratory is willing to loan one. Check light levels behind curtains – are they really providing complete filtration? Put blue wool fade cards on storage tables and near artifacts stored near lights. How quickly do the cards fade? Often, I've found cards in storage areas fade more rapidly than in exhibit areas. If this is the case, everything in storage must be covered with light-barrier fabric, placed in cabinets or boxed.

RECOMMENDED VISIBLE LIGHT LEVELS FOR OBJECTS ON EXHIBIT:
*Below 5 footcandles (fc)** for watercolors, textiles, dyed leathers, prints, color or hand tinted photos and maps.

*Below 15 footcandles (fc)** for oil paintings, plain leather, painted wood, black and white photos, charcoal and graphite drawings

**Note: 1 footcandle is about 10 lux.*

RECOMMENDED ULTRAVIOLET LIGHT LEVELS FOR OBJECTS ON EXHIBIT:
Below 75 microwatts per lumen (mW/l) for all artifacts. (0 mW/l is ideal.)

Security

Security includes regular staff training on theft and safe handling practices, regular collection inventories, and a comprehensive system of alarms.

Theft

Theft, internal and external, and accidental damage are major causes of collection loss. Isolate, secure and control access to all storage areas. Storage areas should not be multiple-use areas. Keep storage areas locked at all times, electronically linked to a central security system, and limit the number of keys. Ideally, no more than three keys should be made for storage areas. Two are held by staff who do not have keys to the building, and one is kept in a lock box for emergencies. Key control is essential. Keys should be signed in and out. Staff should not take museum keys out of the building. However, no staff person should have access to storage room keys and the main building entrance keys. Especially not the security staff.

9 "Measuring Light Levels for Works on Display," in The Exhibition Alliance Technical Note. 1990. http://exhibitionalliance.org/pdf/light_levels.pdf
Also in: "Protection from Light Damage" NEDCC Technical Leaflet, Section 2, Leaflet 4, http://www.nedcc.org/plam3/tleaf24.htm

At one museum a security guard publicly bragged that he spent his nights wearing collection items. He was fired immediately. At another institution, a number of expensive pieces of equipment vanished. Security couldn't find how. After three years, it suddenly came to light that the security staff was pilfering easily fenced items from the museum after hours. At some museums, staff have been caught removing collection items after hours and "trading" with collectors.

Another suggestion is to require two different keys, held by two different people, to open any collection storage area. Even with electronic access, this principle could be used. Staff would have to buzz security before their access card worked.

Have guests, staff and volunteers sign a register whenever they enter storage. Staff should always accompany visitors. Many museums with recently upgraded storage areas use electronic card systems that generate reports listing who entered and when. You should always know who has been in your storage area. For extra security, storage cabinets may be separately locked. At the University of Alaska Museum in Fairbanks, the compactor units are locked in sections according to curatorial expertise. Thus, one curator does not have access to collection material under the control of another curator. Lock firearms separately and do not store ammunition nearby. Some museums run a padded chain through trigger guards of all guns. Others keep firearms locked in cabinets and – in some cases – use trigger locks.

Storage should have a window in the door to permit inspection from the outside of the room. Storage room light switches should be located outside the storage room door.

The museum building should be well maintained. It should have good exterior lighting. There should be no bushes or debris near exterior walls. Make sure windows, doors and skylights are locked and alarmed and connected to a central system that notifies police or fire departments. Check that telephone, power and emergency lines are tamper-proof. Make sure exterior doors and frames are solid wood, steel or aluminum alloy. Doorframes, window frames, keyholes and locks should be resistant to prying, twisting or cutting. Seal or screen windows so people cannot drop materials out. And finally, lock the most valuable collection items in separate cabinets, cages or vaults.

More and more museums are fingerprinting staff and running background checks. Limit the number of people with access to storage by building research rooms for examining collections. At some museums, collection handlers pull items for staff and non-staff researchers, limiting the number of people in storage.

Security Log

An accession file disappears from your records. The curator insists it was returned. The registrar has not seen it. It is not in the collection workroom, and there is no record of it being taken. It is later found improperly filed in the curator's office.

All too often objects cannot be found and have either been misplaced or stolen. Records do not show when, how or why they were moved. While security logs will not eliminate theft or misplacement of collections or records, tracking the movement of objects and the people who have access to them are invaluable tools for finding lost or stolen items.

It is also important to keep records of the people who come to your museum to use the collection. Records can be as simple as a paper log or more complicated and expensive, including surveillance cameras and access badges. Whichever method is used, the following information should be recorded: date, time, who has access, what is moved or taken, where the object is taken and why.

Paper records or logs are as simple as a notebook kept at the door of storage or the records room, with the requirement that anyone entering the space sign in and out. Paper logs of this sort are dependent on people remembering to sign in and out. Human error is the weak point in this system.

Electronic systems remove human error from the security system. The lock is unlocked by a card swipe. Each card is programmed with an individual name. There are card reader systems that include a code to be punched in. These systems are expensive but provide an accurate and detailed list of who is opening the door when. Electronic records will not tell you why, so a researcher log (either on paper or on computer) also should be kept. Security cameras can be added.

An additional log is recommended to keep track of objects and paper files. A notation must be made when an object is removed from storage or a paper file is removed from the records room. The information on the note should include date, individual (full name), reason for removal and temporary location of object or file. Keep notes on a computer or on paper, though using both is preferred. The simplest system is a note card put in the spot of the artifact or file. This provides a quick visual reference as to why the object is missing from its designated place and where it is now. This also reminds the diligent staff member that there is an object that belongs in that specific place, so no other object is put there. Enter the temporary location in your computer database or on an object location card.

Logs show who is using the collection, how often they are accessing it, and the type of research being done. This is good data to use in grant proposals and to justify the expense of keeping collections to your board or governing body.

Collections Inventories

Theft is hard to spot if you do not know what is in your collection. It is a good policy to perform a regular inventory. For larger collections, a monthly spot inventory where cards are picked out at random and the object is located may be best. For smaller collections, try an annual inventory. If your collection has not been cataloged, doing so should be a high priority. Identify valuable materials. To make inventories easier, include an area for collection photography near the main storage area. Ideally, cataloging should include a dated photograph of every item in the collection. If photography is not possible, include a clear, detailed description of each item. If you are computerized, place a computer terminal near the storage area for easy access to collection records.

Alarms

Any area that houses collections should be protected with alarms. Storage areas should have motion detectors and 24-hour contact alarms on all doors. Storage areas should not have windows. If there are windows, wall them over. (Work with an architect to ensure you do not damage the building.) Until then, place bars over windows and alarm the room with a shattering glass sensor. Block with thick curtains. Alarms should be monitored 24 hours a day by a fulltime security company or museum security staff.

Emergency Preparedness

Although I hope one won't strike you, disasters do happen. Be prepared. There is a lot information available on writing a disaster plan and staff emergency planning.[10] Emergency preparedness for storage includes fire protection, fire and water alarms and preparation of a disaster recovery plan.

Fire Protection

Fire suppression in storage areas has always been controversial. Water often causes far more damage than the actual fire[11], and sprinkler systems are known to leak or malfunction. Until recently, an expensive alternative was Halon 1301 fire suppression. Halon puts out fires by eliminating oxygen in a closed room. It does not leave a residue, as do chemical fire suppressants. Its popularity is waning, however, for three reasons:

[10] See Northern States Conservation Center's website section on Emergency Preparedness http://www.collectioncare.org/cci/cciep.html and planning http://www.collectioncare.org/cci/cciepgp.html.

[11] Although without water to put out the fire damage can be extensive – as was proved when the Oshkosh Public Museum in Oshkosh, Wisconsin burned in the mid 1990s..

(1) It suppresses fire by eliminating oxygen. Any person trapped in the shut storage room will be asphyxiated; (2) It is no longer possible to refill spent tanks given the harm Halon does the ozone layer; and (3) Halon is released forcefully, acting like a small tornado within the storage room. Halon "dumps" can occur accidentally. In Alaska, a state with approximately 60 museums, most of the storage areas had Halon 1301 fire suppression and accidental dumps occurred twice in six years. Items stored on top of cabinets and papers loose on tables are thrown about during a dump. Loose dust and particles from cinderblock walls become abrasive powders and sandblast everything in the room. Because Halon was the preferred fire suppressant for computer rooms, manufacturers are experimenting with other non-residue fire suppressants. To date, none are recommended. Halon will not put out electrical or chemical fires. Today, most conservators recommend against gas fire suppression systems because they are too damaging to staff and collections.

Most major museums recommend combining early smoke detection with a sprinkler system. "Dry-pipe" sprinkler systems are preferred by some conservators because water is not stored in the pipes, reducing the potential for leaks. However, if the system has been tested there may be water left behind. This results in corrosion and leaks. Leaks also have occurred in dry pipe systems if the sprinkler heads are faulty. Some conservators recommend against dry pipe systems. "Wet-pipe" systems contain pressurized water. Any fault in the sprinkler head or plumbing will cause a leak. However, water-based, automatic fire suppression systems that are regularly maintained may be our best option. Whichever system you choose, it should have individually activated heads. Experiments have been underway at the St. Paul Companies headquarters, a major property insurance company, to determine the minimum amount of water required to eliminate a fire. Initial work with water mist systems have been very encouraging, although, to my knowledge, no one has strongly recommended them for museums. Mist systems put out a mist of water, moistening everything in the area and using far less water. However, they may not meet your local building codes.

Because of the propensity of sprinkler systems to leak, it is important that you install water alarms on the floor and on top of cabinets under pipes. Battery operated water alarms are available from most hardware stores. Water alarms can also be wired into your central alarm panel for 24-hour monitoring. Protect collections vulnerable to water with good cases, frames, fireproof cabinets, boxes made of corrugated plastic or polyethylene bags. Ideally, all collection items should be stored 10 to 12 inches (15-20 cm) above the floor, though most published literature suggests 3 to 6 inches (5-10 cm).

Note that sprinkler heads are a primary annoyance when trying to organize storage areas. Each region has different code requirements, but your fire department may require as much as 20 inches (32 cm?) of free space around each sprinkler head. If the heads are close to the ceiling and high above your shelving or cabinets, this isn't a problem. In many instances, ceilings are low. Or the piping is low. Or sprinklers along walls under low ductwork make top shelves unusable for collections storage. Another area of friction is the requirement that the sprinklers be able to soak everything beneath them. Some museums have been required to use open mesh shelving even though it may be completely inappropriate for stable artifact storage. Museums that drape shelving units with plastic may be required by a local fire inspector to remove it. Many museums in this situation return the sheeting as soon as the inspector has left. In short, staff has made a risk analysis, determining that the chance of a fire is much less than that of a leak within the storage area. In my experience, every museum storage area will suffer a leak. Only a few suffer fires. The four main causes of museum fires in the Upper Midwest have been: (1) coffeemakers, (2) coiled extension cords, (3) roof repairs (soldering metal flashing), and (4) poor wiring. In general, most storage areas have none of these factors, except, perhaps, poor wiring.

Keep handheld fire extinguishers serviced and in all appropriate areas. They should be of adequate size for the area. Consult fire authorities for recommendations and ask for help with a museum-wide fire safety program as well. Make sure the entire staff is trained annually to use fire extinguishers. Extinguishers are labeled according to the type of fire that they will extinguish. A-B-C extinguishers are most versatile, but leave residue that is difficult to remove. Extinguishers that contain water (Class A: common combustibles) may be sufficient for storage areas, but bear in mind they will be of no use on an electrical fire.

Fire alarms should be installed as part of your central system and should be continually monitored. Smoke detectors and heat detectors may be necessary. Test fire detection systems often. One Minnesota museum tests daily. Establish an emergency call list and procedures for fire. Keep fire doors closed. Limit chaos and debris. Make sure aisles are kept clear and uncluttered.

Construct storage areas to minimize the impact of a fire. Build fire retardant walls, using metal studs, thick walls and intumescent paint (foams with heat, providing fire retarding properties). Make sure there are firewalls between storage areas and the rest of the museum. Use fire-resistant cabinets with fire-resistant bulkheads in shelving. Leave adequate space (5 feet or 1.5 m) between walls and shelving to block spread of fire.

Eliminate the source of fires by regularly inspecting and maintaining wiring, properly storing paints and chemicals in vented metal cabinets, good housekeeping, keeping close watch on contractors (especially anyone doing welding or soldering), banning smoking and smoking materials within the building, installing lightening rods, and writing and practicing an emergency plan.

Preventing Water Damage

Staff at one museum were diligent about keeping drains located in front of their emergency exit cleared of debris. However, one evening, a storm blew leaves off the trees, clogging the drains. An unexpectedly large amount of water came down in a short period of time, flooding the area. The result was a foot of water swirling through storage. Water entered the bottom drawer of a file cabinet and tipped over chairs and trash containers. By the time staff returned to work the next day, water levels had dropped to less than an inch, but the collection, walls and furniture had tide marks showing how high the water had reached.

In general, I recommend floor drains wherever water could collect. If you have a sprinkler system, you should have floor drains. However, floor drains can back up, causing water problems. Insects and other pests, such as snakes and rodents, can get into storage using a floor drain. Even lining the interior of the drain with a slippery or sticky substance won't completely eliminate access. All drains should have metal screen covers screwed into place. The covers should be fine enough to block insects, but not so fine that water will flow over them instead of down into the drain.

When building the museum, try to avoid flood plains and designing storage below ground. Your roof should be solid, without numerous levels (always the site of leaks). Install and maintain gutters. Make sure gutters drain directly into storm sewers or deposit water at least 3 feet (1 m) from foundations. Route all water through a service corridor. (The best example of this is the South Dakota Historical Society's building – a subterranean museum with a service corridor for all water pipes, keeping them out of the rest of the museum.) Make sure mechanical rooms have dams around them. Install a sump pump, with a backup generator, for areas that may be prone to water accumulation. Store collections in water-resistant cabinets with a watershed above the top shelf and a drain channel from the water shed. Note that most commercial museum-quality cabinets ARE NOT waterproof. They have holes in their top that would allow moisture access to the collection. Be wary of metal roofs and metal girders for storage areas. Humidity can condense on them and rain on the collection. Or roof leaks can travel along the metal rods, eventually falling on the collection.

Disaster Recovery Planning
The one thing you can be sure of as you plan your storage area is (to paraphrase Will

Rogers) *a disaster!* There is no doubt that at some point in the future, something will negatively affect this area of your facility: a fire, the collapse of your shelving, an explosion, roof problems, boiler problems, water leaking into the walls from somewhere … who knows?

So while you're planning to properly store your collection, you might also want to plan to save it when disaster does strike. You might, for example, install water sensors, smoke and fire detectors, emergency lights, fire extinguishers, telephones to allow people to call for help, exit signs, and other emergency and warning equipment. You might invite your local fire marshall to visit before you begin filling the area to get his or her point of view. And you might consider other measures to prevent emergencies, such as re-routing water pipes, installing floor drains, or adding motion detectors.

If you want more help planning for a disaster, several good resources are listed in the bibliography.

Housekeeping and Maintenance
Prevention is worth its weight in gold. It is inexpensive and invaluable. Keeping dust off collections reduces risk of abrasion, pest infestation and mold. A clean, neat storage area encourages users to maintain it and shows you value the collection. Careful maintenance prolongs equipment and specimen life. Therefore, it is well worth the museum's time to develop a housekeeping plan. In it daily, regularly performed tasks and special instructions for specific materials should be detailed. Storage area floors and furniture should be vacuumed with HEPA or ULPA filtration once a week. There should be no wet cleaning in storage. Keep everything lifted off the floor, so that it is easy to vacuum clean beneath shelving, cabinets and rolling carts. Keep curatorial supplies, a big part of storage room clutter, out of storage areas. There is more information on housekeeping in the section on **Pest Control**.

Building Inspections
Your building is the first line of defense against the agents of deterioration. It blocks out the elements, helps prevent infestations and provides security for your collection. If you manage a historic house, the building also is your first and largest object. It is your responsibility to maintain and preserve it.

Make a list of what needs to be checked and create a schedule. Break it down into a reasonable workload and make it sensible for the season. Decide what needs to be checked at what interval. Some items may need daily maintenance, others weekly, monthly, quarterly, seasonally or annually. For example, you may decide to walk through the building daily. This will alert you to immediate concerns, such as a burst pipe. Keep good written records and supplement them with photographs or video. In this way, you can track the problems as they occur.

Quarterly inspections of the building exterior will document changes such as settling foundations, evidence of pest activity, plant growth around building perimeter, or the need to replace weather stripping. Systematically work through the property. Look at both the physical structure and the systems (environmental, electrical, water, waste, etc.). Examine the grounds. Develop a set of questions that relate to what you are looking at. For example: Is the surface I am looking at in good condition? Are there holes or breaks in it? Is the paint in good condition or is it peeling? Is there anything unusual about the surface or area?

Then move on to the interior. Begin at the top and work your way down to the basement, asking some of the same questions and adding others. Collection and exhibit areas should be inspected once a month. Open drawers; look in dark corners. Document structural changes or failures and make repairs as needed.

This information will:

1. Form the basis of a maintenance program.
2. Alert you to problems, potential or actual, in a timely way.
3. Provide a management tool for getting the work done.
4. Be the base line for the preservation of your building and your collections (even if you do not have a historic building).
5. Provide a document that you can use for further preservation planning.
6. Help set priorities for repairs.

Checklist for building inspections
Exterior

- Roof and gutters: Clean gutters in the spring and the fall. Look at the condition of the roof, the shingles, etc.
- Examine the exterior walls or siding of the building, looking for damage, rotten wood, holes and breaks. If the building is brick or stone make sure that the mortar is in good shape. Are there cracks? Holes?
- Windows and sills: Look at condition of the paint. Is bare wood showing?
- Doors: Is the material and finish sound? Are there gaps around the door?
- Foundation: Are there cracks?
- Grounds: Is the landscaping maintained? Does the landscaping contribute to pest problems? Is it graded to move water away from the foundation?

Interior

- Attic and Basement: Is there evidence of water or dampness?
- Mechanical Systems (HVAC, alarms, water, etc.): Is everything functioning within design parameters?
- Pipes: Leaking?

Goals for building maintenance
Exterior

- Close all structural gaps: weather strip doors, install door sweeps and thresholds to provide tight barriers, caulk joints around doors and windows.
- Place fine mesh screen covers on floor drains and ceiling exhausts.
- Install double door entries at all exits.
- Keep the exterior perimeter of the building free of vegetation to avoid harboring pests.

Interior

- Obtain well-sealed storage cabinets for the entire collection to protect against dust and pests.
- Weather strip and install door sweeps around interior doors to provide an isolation seal for storage rooms.
- Screen and filter incoming and return air vents.
- Seal exhibit cases with inert weather-stripping and provide screened ventilation.
- Seal all raw wood on exhibit cases; fill cracks and crevices.

Pest Control

An unclean storage area can attract pests or mask an infestation. Extensive physical damage can occur rapidly from pests and microorganisms. Most organic material will be merrily consumed by rodents, dermestid and other beetles, fungi and mold. Each of these pests leaves distinctive evidence and irreversible damage. Molds and fungi weaken and stain objects. They also serve as the necessary precursor for some beetle infestations. Beetles and rodents physically remove large portions of material. Rodent, bird and fly excrement are acidic and can stain and damage material. Larger mammals, such as cats and porcupines, may consume, tear or alter organic material. Inorganic material also can get knocked off shelves or corroded by excrement.

Good housekeeping is an excellent way to prevent and stop infestations. Storage areas should be as clean as your house before guests arrive. Remember, dust can act as food for pests. Vacuum regularly under cabinets and shelves, along corners and edges, as well as in the center of aisles. Take a flashlight and examine the walls, ceiling and floor. Are there cracks or holes where pests can enter? Seal them with silicone caulking, metal plates or cement plugs. Open drains allow pests access to storage areas. Screen the top of drains with fine mesh and slather an inch-wide ring of petroleum jelly or Tanglefoot (available from a garden supply store or www.collectioncare.org) around the inside. Replenish on a regular basis. (Sealing drains is tempting, but can compound problems if water pours into storage areas.)

Combating infestations requires correct pest identification. This may be done with traps (large and small), site inspections and analysis of damaged material. An integrated pest management (IPM) program will let you know which small, unwanted visitors have entered. Adherence to an IPM will prevent any infestation from becoming major.

Integrated Pest Management (IPM) is an ecosystem approach to the control of pests. IPM combines systematic care with a variety of treatments options. The goal is to prevent and solve problems efficiently and ecologically without compromising safety. IPM limits pesticide use to avoid damage to collections and staff.

In brief, an IPM program combines the following:

- Regular monitoring of galleries, offices and storage using sticky traps (available from garden suppliers, hardware stores, exterminators, www.collectioncare.org, or county extension agents). The most common type is made of yellow plastic covered with adhesive.
- Collecting and labeling of all pests, dead or alive, found within museum buildings. A janitor is often the best person to locate the source of an infestation. Janitorial staff should collect pests found during cleaning.
- Identifying pests found on sticky traps and picked up within the museum using an entomologist. Large universities or your county extension agent often provide this service for a small fee. (Bio-Integral Resource Center in Berkely, CA provides identification services to members. It is well worth joining them. http://www.keyed.com/birc/index.html.)
- Isolating, examining and treating all incoming organic material before it enters the building. If pest activity is noticed or suspected, the object(s) should be isolated in sealed polyethylene bags to prevent infestation. Organic material includes artifacts, gift shop inventory and exhibit construction supplies made from any plant or animal sources. Active infestations can be stopped by freezing or oxygen deprivation. Call a conservator for details if you discover an active infestation. Ideally, incoming organic materials should be cycled through a freezer or an oxygen deprivation tent before entering the building.
- Removing all pest residues from incoming material. (see appendix on cleaning)
- Regularly inspecting buildings and seal cracks and crevices, including doorjambs and window sills.
- Regularly inspecting collections, especially furs, feathers, wood, wool, silk and

quill work. Make inspections part of inventory procedures.

- Cleaning exhibits, offices and storage areas regularly.
- Never allowing food or drink into storage areas.
- Removing trash daily.
- Removing vegetation close to the building.
- Placing mouse and rat traps at regular intervals in offsite storage.
- Cleaning cracks and crevices throughout the museum at least weekly.
- Never placing collections directly on the floor (they are more accessible to pests and susceptible to water damage).
- Placing screens on doors and windows to limit access even in non-collections areas. A double set of entry doors or an "air door" (a stream of vertical air just inside the entrance door) will limit pest access when humans enter the building.

Integrated Pest Management

One goal of IPM is to limit the use of pesticides. IPM combines systematic procedures with a variety of treatment options to prevent and solve pest problems in the most efficient and ecologically sound manner without harming collections, staff or visitors.

Pesticides, of course, can cause health problems for humans. But they also can damage museum collections. Overuse or improper use is illegal. Most pesticides that are sold over the counter are not approved for use in public facilities. The label on the container is the law. If it says, “For home use only,” then use in the museum is illegal.

IPM is based on understanding the life cycle of the pest – be it insect, rodent, bat or mold – to control or limit pest activity in the building and collections. All living things require food, water, air and shelter. By blocking access to one of these requirements, the infestation can often be eliminated or more easily controlled.

There are five steps to an IPM program:

1. Monitoring: tells you what species are present, why they are there and where they are entering.
2. Blocking: prevention by eliminating ways that pests can enter the building.
3. Treating: once an infestation is discovered, treat using the least toxic approach to eliminate the problem.
4. Documentation: Keep track of treatments and infestations using forms that become part of a regular review and assessment of success.
5. Evaluation and Revision: modify procedures to meet changing needs. IPM is not a static process.

1. MONITORING

Knowing which pests threaten your collections is vital. Once you have identified pests you can develop a strategy to eliminate them. Monitoring gives you a fairly complete picture of pest activity in your building, including the identity of the pest, the extent of activity and the potential source of infestation. Monitoring does not solve the problem, but it does provide critical information that leads to a solution.

Any and all evidence of pest activity is thoroughly documented. Monitoring for pests using traps provides an indication of how many pests you have and what kind they are – in other words, just how serious is the infestation. In addition, keep a log of the location and date of any live or dead pests found within the museum (See appendices for a sample log). With regular monitoring, an infestation should not be a surprise.

Monitoring procedures

1. Make a complete inspection of the area you wish to monitor. Look for places pests can enter and exit, as well as places they like to live. Some places to look include exterior doors and windows, drains, recycling or trash disposal areas, break rooms, food preparation areas, dark and inaccessible corners and chronically damp areas.

Conduct inspections monthly and rotate through the collection so that everything is examined at least twice annually. Document any pest activity and treat as soon as possible. Use plain sticky traps with no bait to monitor collections. Document the treatment of specific objects in conservation records and note it on catalog cards. Label objects that have pesticide residue using an acid-free tag. Don't forget to inspect adjacent areas, even if they are not under your control, such as warehouse space and other tenants in your building.

2. Create or obtain a map for the areas you plan to monitor. Building plans work well. See if you can obtain a set. Mark the areas you want to monitor, label your traps (see below) and their location on the map.

3. Lay traps in the areas you identified in your building inspection. Record each location on the map and number it. Remember to make changes when traps are moved. Inform cleaning and other staff of what the traps look like, so they don't inadvertently discard them. Involve everyone in IPM. Janitorial staff can regularly monitor cracks and crevices. Train them to look for spider webs and small piles of powdery material that resemble sawdust. The latter is frass, an artful term for insect leavings (an artful term for dung).

4. Set a regular and realistic schedule for monitoring. Monthly examination is adequate, unless there is a severe active infestation requiring weekly checks. Replace plain sticky traps monthly or as they are contaminated by insects or dirt. Replace other traps every six months or as indicated in their instructions. Place insect sticky traps in zippered plastic bags to send out for identification.

Where to Place Traps

Most pests travel along walls. They rarely cross open spaces. Place insect monitors in dark corners, near outside entrances, near windows, near water sources or drains, on the floor or in areas where insect movement might occur. Place sticky traps parallel to walls. Hanging sticky traps will help identify flying insects. Place pheromone traps a good distance from doors or other openings. You do not want to attract insects into the museum while monitoring. Choose the placement according to the life cycle of the species – different insects have different habits. By placing traps in unobtrusive places, you increase the odds that they will be there when you check. Move trap locations if no pests are caught. With experimentation, optimum locations will be identified.

Insect traps

Sticky traps provide a quantitative and qualitative measure of the extent of an insect infestation. Trap styles vary and include flypaper, tent- or box-like traps and pheromone lures. They capture anything that walks across or flies into them. Pheromone lures provide a sexual attractant for particular types of insects, usually common food pests, and are often combined with sticky traps. Most traps incorporate an attractant such as food, food smell, pheromones, yellow colorant, light or ultraviolet (blue) light and a method of holding the insect, typically corrugated cardboard or sticky substances. The insect determines the type of trap. If you don’t know what you’ve got, choose a plain sticky trap, also known as a blunder trap, to collect samples.

Rodent Traps

Forget finding a better mousetrap. The classic snap trap is the most humane and economical way to catch rodents. Snap traps can be found at hardware stores, groceries or ordered through pest control companies. Windup multi-use mousetraps (called “quick catch”) can be used in high traffic areas where snap traps might accidentally fire.

Rodent poison typically causes mice and rats to bleed to death slowly, giving them a chance to crawl into walls or under storage cabinets. They can become food for dermestid or moth larva – and the smell of rotting mice in the walls is nauseating. Glue boards can be dragged away and the mouse will die of dehydration in about 24 hours. Live traps are not humane; unless they are checked daily, mice die. Mice also tend to be killed by other mice when released outdoors. Some museums drown live-trapped mice.

Rodents like to skitter along walls. Place traps perpendicular to the wall so that mice cross the trigger areas. If one trap doesn't work, place two together. When placing snap traps, be certain the public cannot reach them. You do not want to catch inquisitive toddlers! Mice are smart and eventually learn to avoid traps.

Bait snap traps with food. The Science Museum of Minnesota uses a combination of peanut butter with a small nut (mice seem to like almonds) jammed into the trigger. This gives the mice something to chew on. Mice can be adept at licking peanut butter off traps without triggering them.

Empty snap traps and quick catches into the garbage and reset them. Reuse rodent traps. The more they smell like other rodents the more effective they become.

Health Note: Because of Hanta Virus and other diseases, wear rubber gloves, toxic respirators (available at hardware stores) and protective clothing when handling rodents.

Data collection and documentation
Individual insects collected by staff should be labeled with the date, time and location of collection, and the name of the person who collected them. Empty film canisters work well for collection of insects. Specimens should be given to a specific staff member, usually the curator or conservator. An entomologist must examine all insects and insect residue such as frass or eggs. It is helpful to have a pest control professional help you identify insects and mice if you can afford it.

Document the presence of webs or insect bodies and then discard the remains. Spiders can help you locate where insects enter the building.

Keep a chart of the locations, numbers, dates and results of identification. Summarize your data periodically so that you can detect trends. Seasonal summaries, especially in cold weather climates where pest activity generally drops in the winter, are useful.

Summary
IPM monitoring data is invaluable in identifying potential threats to your collection. It can show where pests are entering your building and where pests are living within it. It also shows which pests are seasonal visitors from outside and which pests have taken up permanent residence. With this knowledge, you will have more success in controlling unwanted pests.

2. BLOCKING/ PREVENTION

Once you have determined which pests are present and why, you can go through the building and block their access. The more you know about the pest the easier it is. Mice can enter a building through a hole about one quarter inch in diameter. Insects require much less. Rats can chew through almost anything and go through a half-inch hole.

There are many strategies to exclude mammal, bird and insect pests from your museum. Weather-strip doors and windows, seal gaps and cracks, and avoid vegetation around the foundations of the building. Eliminate food sources, habitat, access points and water sources to reduce populations. For example, if a drain isn't being used, block it or ensure the trap is always filled. That eliminates most critters coming in through the drain.

Special situations:

Some pest species, such as bats, hold special status. Some bats are endangered; all are considered beneficial when outside the building. They should not be killed. There are also health issues. Some bats carry diseases such as rabies. Their droppings provide a suitable environment for the fungal growth that causes the lung disease histoplasmosis in humans, dogs and cats. This can be fatal. Pigeon droppings cause the same problems. Contact professionals to deal with bat and bird problems.

Good housekeeping

Cleanliness is not only next to godliness, it's vital. (Obviously, I think this is extremely important – this is my third mention of it!) An infestation can be controlled through good housekeeping. Fill all cracks and crevices with silicone caulk. Close all gaps around plumbing fixtures and pipe openings through walls and floors. Sealing prevents the entry of dust, dirt and moisture, thus denying pests a habitat. Clutter should be eliminated as much as possible because open areas are easier to keep clean. Cabinetry should permit easy access for cleaning beneath and behind.

Vacuum cleaners should be used as much as possible. All spaces including collection storage areas should be vacuumed once a week. Exhibit areas and anyplace food is consumed must be vacuumed daily. Vacuum bags should be changed at least weekly and disposed of properly outside the museum building. If an infestation has been found in the collection and treated (see options below), make sure that the area is clean before returning the object to the infested area.

Maintaining control

Avoid contamination of the collection. Nothing should be added until it is determined to be pest-free. Isolate acquisitions and prohibit non-collection items from collection areas. Bar all food and drink from collection areas. Prohibit plants and flowers in the museum building. Soil and foliage provide a breeding environment for pests. Some flower colors, such as white and yellow, are more attractive to insects. If plants and flowers are allowed in the museum for any event (please try to avoid this) make sure that they are from a clean nursery. Do not use wildflowers or homegrown flowers. Do not permit animals other than guide dogs in the museum building. Pets may harbor fleas, ticks or other pests. Restrict food and drink to specific areas. Apply special housekeeping attention to these areas to minimize crumbs and moisture upon which pests may feed.

Prohibit smoking in the museum building. Tobacco may contain the cigarette beetle (Lasioderma Serricorne), which can damage collections. There are two exceptions to the rule concerning tobacco and plant material: sage and sweet grass. If your museum holds a sacred object that falls under the rules for Native American Grave Protection and Repatriation Act, or NAGPRA, you may be required to keep tobacco, sage or sweet grass with the piece. If so, heat the tobacco or dried plant material to 150 degrees Fahrenheit for 30 minutes or freeze it one week at a temperature of at least minus 20 degrees Centigrade (about minus 8 Fahrenheit). This will kill any eggs or larva.

3. TREATING

To avoid introducing pests, isolate and examine all incoming organic material (new accessions) before exposing it to other collection spaces. If it appears to be infested then follow the steps below.

ISOLATE the infested material in sealed polyethylene film at least six mil thick. Clear polyethylene bags work well.

IDENTIFY the pest and its stage of development.

Determine the SOURCE of the pest.

TREAT the material. Choose an effective treatment that will cause the least amount of damage to the object, staff, visitors and the environment.

VACUUM CLEANING: Thoroughly, but gently, vacuum the infested object to remove pests, eggs and dust. Use a screen or a micropipette as explained in "Collections Cleaning," Museums Alaska Network, IV, #2, July 1990. (and later in the chapter **Preparing Materials for Storage**.) Immediately remove vacuum bag from the building and dispose of it properly.

FREEZER TREATMENT: Remove excess air from the polyethylene bag containing the infested material. Seal the bag. Place in a second bag and remove air. Follow the Freezer Procedures[12]. Place the bagged object in the freezer for at least a week at minus 20 degrees Celsius, or minus 10 degrees Fahrenheit. Remove to room temperature. Monitor for pest activity. Object may require repeat treatment.

HEAT TREATMENT: This treatment is best for unpainted wood, plant material and large collection artifacts. It can be used to treat structures, such as an infested log cabin.

CHEMICAL TREATMENTS: Choose the minimal effective dosages only after exhausting other treatment procedures. Apply species-specific and material-specific chemical treatments.

Health Note: Be sure you are in compliance with state and federal pesticide use regulations. File Material Safety Data Sheets (MSDS) on any products used in the museum building or on the collection. Note the chemical treatment on the catalogue card and on an acid-free tag that stays with the object at all times.

4. DOCUMENTATION

Good documentation is an important part of IPM. Keep records on trapping, pest pickups, treatments and their results. Keep summaries and checklists. Treatments on collection items should be noted in the conservation record and on the catalogue card as well as in the IPM file. A file on insect infestations, including specific artifacts treated, should be maintained at the museum.

5. EVALUATION

Evaluate each treatment to determine if it was effective. After treatment, material that had active infestation should be sealed in clean polyethylene bags for three months and then carefully inspected before returning it to storage or display. Thoroughly clean and monitor any area where an infestation occurred monthly for one year. Carefully inspect artifacts in the area and monitor monthly for one year. Review and modify the IPM program as necessary to prevent future infestations.

[12] You may have a chart on the freezer that needs to be filled out. I used stickers on the bags to determine how many times they were frozen. Thermal shock didn't seem to damage any of the collections I treated over 6 years of using a freezer. The sudden temperature extremes are part of the reason this technique kills insects so well.