PRESERVATION OF OBJECTS IN MUSEUM EXHIBITS

by

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A Preprint from the Session
on Conservation and Security in Museum Exhibits
Mountain-Plains Museums Conference
Annual Meeting
Abilene, Kansas
October 8-11, 1974

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CARING FOR COLLECTIONS ON EXHIBIT*

Regardless of their nature, museums depend upon physical objects to tell their stories. Some of these objects, such as the Liberty Bell, have transcendent national importance. Others are simple everyday objects which reflect aspects of the story being told or record and verify research on certain subjects. All these objects, whatever their importance, are alike in requiring constant care to preserve them. Metals corrode; paints, dyes, and inks fade; cloth, hides, and wood are subject to insect and rodent attack; and many other hazards threaten the survival of museum objects. None will last forever, but with proper attention, you can enable the objects in your museum to endure for centuries to come. It is the obligation of every museum to make sure the objects entrusted to it do survive.

Much has been said and written about preparing, repairing, and preserving museum objects and how to handle and store collections. Nevertheless, there are many museums which devote a great deal of attention to proper preparation, conservation, and storage but which never are concerned with the protection of objects on exhibit. It may be true that, in many museums, exhibit cases provide more protection that store rooms but that should not be an excuse for ignoring the care of objects once they have been placed inside an exhibit case.

This paper will attempt to identify the hazards that objects on exhibit may face and note the several ways in which these hazards may be reduced or eliminated.

Basic Steps

There are four things a museum curator must do without fail in order to preserve and protect the collections entrusted.to him.

1. See that each object entering the collection is properly prepared for preservation.

2. Place the object in a safe environment.

3. Inspect it periodically.

4. Provide it repeated preservative treatment as necessary.

This paper will not be concerned with how to prepare newly acquired objects. We will assume that the objects we shall discuss have been prepared and are on exhibit.

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* Adapted from Chapter 4, Part I, MUSEUM HANDBOOK. U.S. National Park Service.

Execution of the second basic step--placing the object in a secure environment--implies protecting it as fully as practicable from the numerous agents of deterioration and destruction which may be found in any museum. To protect your collection intelligently and efficiently, you must know the enemy. By knowing what factors endanger museum objects and how these factors operate, and by being able to recognize their presence or the conditions that favor them, they can be combatted successfully. The destructive agents listed below and discussed on the following pages almost certainly will be encountered in many museums at one time or another.

Agents of Deterioration

Humidity (either too high or too low)
Temperature
Light
Dust
Chemical Air Pollution
Mold
Insects
Rodents
Fire
Humans

Humidity

Water vapor in the air, and the liquid water which may condense from it, form a potential hazard to museum specimens. Humidity affects objects in several ways. Too low a relative humidity extracts water from some materials, with resultant damage. Paper, parchment, and leather become brittle. Glue and paste dry out and lose adhesive power. Even well-seasoned wood in equilibrium with its normal environment will lose water and may warp. When relative humidity is too high, many materials absorb water. The water enters into degenerative chemical reactions, as in the corrosion of metals. It also permits the growth of mold which digests components of the object and leaves disfiguring stains. It softens adhesives. Rapid changes in relative humidity cause hygroscopic materials to swell and contract. Wood warps and checks. Oil paintings crack and flake. If the object contains soluable salts, these dissolve, migrate, and recrystallize which may cause either chemical or physical damage.

Temperature

Low temperatures (at least above freezing) seldom cause damage to museum objects. However, temperatures above 70° F permit molds to grow, and may speed up the life cycle of harmful insects. Fluctuating temperatures can be doubly destructive. Matter tends to expand and contract as temperature rises and falls. When an object, such as an oil painting on canvas, is composed of two or more substances that respond to temperature changes at different rates, dangerous strains can develop. A secondary effect of temperature variation is often even more serious. When the temperature drops, relative humidity rises, and vice versa. In order to hold the relative humidity within safe limits, it is much easier if temperatures are held stable as well. Generally, the best temperature range is between 60° and 75°F.

Light

The radiant energy of light absorbed by molecules of objects may cause chemical changes that seriously damage the object. Organic materials are most vulnerable, but even such seemingly inert substances as some ceramics and glasses are affected. One familiar result is the fading of colors. Less apparent is the weakening of fibers. Silk, for example, may lose half its strength from less than a month of exposure to sunlight. Both wave-length and amount of light influence the processes of degeneration. The shorter wavelengths, especially in the ultraviolet range, produce the greatest photochemical activity, but the visible spectrum also causes deterioration which increases with the amount of light and the duration of exposure. Infrared radiation, especially in small enclosures, can cause heat buildup and consequent drying out of materials.

Dust

Dust is composed largely of minute mineral particles; these particles act as an abrasive. Some dust may be fly ash or other chemical compounds from smokestacks and exhausts; if water condenses around these particles on objects, they may become active chemical agents attacking the surface directly. Dust disfigures objects by soiling their surfaces; its removal involves washing, wiping, or shaking, all of which accelerate wear and tear and increase the risk of physical damage through handling. Nearly all types of objects suffer to some extent if allowed to gather dust.

Chemical Air Pollution

Industrial fumes, motor vehicle exhausts, and domestic heating byproducts contaminate tha air with numerous chemical compounds. These include, or combine to produce, sulphuric acid, nitric acid, and other strongly corrosive or oxidizing agents. Some of the pollutants attract water and so facilitate harmful chemical reactions. Air near oceans contains chloride salts and other compounds which are often highly corrosive. These salts in solution may penetrate porous objects and migrate inward and outward, crystallize, and redissolve with changes in humidity. In the crystal state, salts occupy considerably more volume than they do in solution, developing severe pressures within the object. Thus, air pollution exposes many kinds of museum objects to chemical and physical damage. Metals, stone, and many organic materials suffer attack, fabrics and leather especially.

Mold

If the collection provides organic material to support growth and the humidity exceeds 65% with a temperature of 70°F or above, molds and mildew can be expected; particularly affected will be leather and paper. Mold spores are so fine, light, and numerous (and always present in the air except in "clean room" environments) that outbreaks of growth can occur practically everywhere. It has been estimated that molds have destroyed more museum objects than any other agent of destruction. Since the mycelium of the mold actually dissolves and absorbs components of the objects, it causes more than superficial damage.

Insects

Almost certainly your collection will be infested sooner or later by some of the destructive species of insects. The damage that can occur may be rapid and irrevocable. Therefore, insect infestation is one of the real emergency situations encountered in museum work. Insects attack, in some degree, all objects composed of organic materials. They eat the sizing on paper, the glue in bindings, and the paper itself. They devour cloth, hair, feathers, They bore tunnels in wood. The insects wreaking havoc with your collection may be larvae or adults, small or large, conspicuous or hidden. The most common destructive insects are dermestids, powder-post beetles, clothes moths, silverfish, and cockroaches.

Rodents

Mice, rats, squirrels, and other small rodents that sometimes infest buildings may attack museum objects. Because they can destroy numerous objects in a single night, their incursions call for emergency measures. These animals may eat some kinds of organic materials and use others for nest-making. Prehistoric fiber sandals, for example, provide fine nesting materials. So do valuable textile specimens and paper, including specimen labels.

Fire

Few objects in museums would survive a major fire, at least without severe damage from burning, heat, smoke, or water. Metals cabinets and shelving commonly used for collections storage transmit heat readily and afford little protection in a fire. While wooden cabinets and shelving do offer some insulation, they can be consumed in a fire along with their contents. The likelihood of suffering significant losses as a result of fire is one reason why your museum catalog records must be kept in a fireproof vault or safe at all times that they are not in actual use. If your records survive a fire, you will at least know what has been lost and its value.

Humans

Careless handling, malicious destruction, and theft constitute the principal human hazards to a museum collection. Broken, bent, scratched, dented, soiled, or corroded objects may result from careless handling. When objects are dropped, piled together, or leaned against something improperly, damage may occur. Even nominally clean fingers leave a print of oil and moist salts that can corrode metal. The dangers of handling are greatest when objects are being transported within and without the museum, such as between storage and exhibition or being shipped to a borrowing museum. In the September 1964 issue of Museum News is a convenient list of good rules for handling objects compiled by Frieda Kay Fall. While written mainly for use by art museums, this list can be adpted for use by any museum.

Inspection, your third basic step for collection protection, is a vital responsibility. It is part of your job to examine every object in your collection at regular intervals. The frequency of this inspection will vary according to the nature of the collection and the adequacy of storage and exhibit conditions. If the collection is carefully stored in a secure room with good control of light, humidity, and temperature and if equally good conditions pertain in exhibit rooms and cases, ordinarily your inspection can be timed as follows:

Annually:
- Geological specimens
- Ceramics
- Glass
- Well-treated and preserved metal

Semi-annually: Specimens subject to insect attacks
Specimens subject to mold

Quarterly: Biological specimens preserved in liquid

If storage and exhibit conditions are less than ideal, objects will have to be examined more often. Generally, since environmental conditions in exhibit rooms are not as good as those in store rooms, objects on exhibit will need more frequent examination. In addition to daily inspections of exhibits through the glass, open the cases every three to six months for a closer examination of objects susceptible to damage from light, mold, insects, corrosion, or dryness. The act of inspection consists of searching for evidence that one or more of the agents of deterioration have been at work. It is essential that you know what may attack objects and what these agents or their effects look like.

We have already discussed what kinds of damage the common agents of deterioration can do. Now let us discuss how to recognize the effects of these agents.

Humidity

When inspecting your collection, watch for signs of humidity that is too low as well as too high. Mold is due to excessive humidity and appears as fuzzy, usually white, patches growing on any organic material, or as discolored, usually brown, spots on paper (foxing). Active corrosion forms encrustations on metals when the humidity is too high. Paintings sag a little on their stretchers or become to taut depending on whether the humidity is too high or too low; oil paintings may crack and the paint flake off when the humidity changes frequently. Similarly, changes in humidity cause flakes to fall off of salt-impregnated metal as crystallization exerts pressures. These, it should be noted, are signs of advanced deterioration. It is better to measure the relative humidity and keep it within safe limits. You should aim at maintaining the relative humidity between 45% and 65% with 55% as the ideal (for most types of materials). In semi-arid regions where hygroscopic materials have already achieved equilibrium at a lower percentage, the relative humidity can be kept lower.

Temperature

In caring for your collection, monitor the temperature along with the relative humidity. Temperatures above 70^{o} for more than a few hours or temperatures that wildly fluctuate are danger signals. When conditions are too warm, look for mold, especially in dark and poorly ventilated places. If the temperature varies much beyond the recommended range of 60^{o}-75^{o}F range, check artifacts made of more than one material to see if the bond between them is loosening (check furniture and inlaid wood carefully). Such objects may include paintings, objects made of two or more kinds of metal, or wood and metal combinations, such as firearms.

Light

In checking your collection, make sure that organic materials not on exhibit are stored in darkness to minimize fading. Watch susceptible objects on exhibit for any signs of fading or of threads breaking. More important, use filters to screen out the ultra-violet wave lengths of light (sunlight and fluorescent light) and limit the total amount of illumination to 15 foot-candles or less in exhibits containing vulnerable objects such as documents, textiles, and water colors. The illumination levels permitted should be no greater than are required for easy viewing.

Dust

Again, prevention is better than treatment. Keep objects in dust-tight storage containers or exhibit cases whenever possible. Provide dust covers of unbleached muslin (or old bed sheets) or of polyethylene for objects stored on shelves or otherwise exposed in storage. If plastic covers are used, be sure to allow enough ventilation to prevent condensation from occuring within the plastic cover. Check for accumulated dust, perhaps with some form of "white glove" inspection. Clean objects by approved methods before they get too dirty. If exhibit cases are not dust-tight, install seals between doors and frames or apply tape to cracks (when aesthetically permissable). If cases are ventilated in order to prevent heat build-up and dust is entering through the ventilation holes, place filters over the holes and clean or replace them often.

Chemical Air Pollution

Watch for rust or flaking in iron specimens, corrosive encrustations on copper and its alloys, heavy tarnishing of silver. Observe stone for signs of flaking, pitting, or crumbling. Look for evidence of rotting in textiles or of leather becoming brittle. Since there are no convenient ways of determining the amount and kinds of chemical air pollutants which may be entering your museum, be vigilant to detect their effects on your collection. In urban areas, and elsewhere if conditions are bad, steps should be taken to clean and filter the air before it enters the museum and extra prevautions may have to be taken in preparing and conserving objects before they are placed in storage or on exhibit.

Mold

As described under "Humidity" above, look for velvety patches or small areas of discoloration. Avoid placing organic materials in warm, damp environments. If mold is found, treat the object immediately and correct the cause of the problem

Insects

To recognize infestations by the common insect pests, look for the following signs:

Dermestids: The carpet beetle and related species that attack a wide variety of museum objects are destructive in their larval stage. The adults are small, about 1/8" wide and 3/16" long, and inconspicuous. The larvae are elongate-oval or tapering and 1/4" to 1/2" long, characterized by prominent reddish, brown, or black bristles at the small end. The first evidence of an infestation may be a cast larval skin, visible on the bottom of a specimen tray or on the floor of an exhibit case. A fine, dark powder may collect at this point, indicating the larva is eating on something directly above. In entomology collections, this dust gathers at the foot of the mounting pin while the larva devours the body of the specimen. Infestation may be detected through visible damage to an object such as holes in woolen textiles, loose hair or pile, and wings and legs falling off mounted insect specimens.

Powder-post Beetles: Several species of wood boring beetles may attack the wooden parts of museum specimens as well as elements of historic structures. The larvae do the damage but you do not see them and rarely see the adults. Evidence of infestation are the small, round or oval holes some species leave at the surface of the wood and the fine, light powder that may accumulate below such openings or that can be shaken or tapped out of them.

Clothes Moths: You will probably recognize on sight the adult moth with its narrow, buff-colored wings spreading about 1/2". The larvae do the actual feeding on hair, fur, wool, feathers, or other animal fibers. The larvae are white grubs, about 1/2" long, with dark heads. They spin a light-colored web or case covering their bodies and you may observe the cases before seeing the insect itself. Moth holes and other damage caused by their feeding may be all too evident unless you detect the infestation early.

Silverfish: These wingless insects, which may be up to 1/2" long, have a tapering shape and three prominent caudal "bristles". Their bodies are covered with gray scales. At all stages in their development, they may be destructive to paper objects, bookbindings, rayon textiles, and starch in cloth. Most often their presence is detected by seeing a silverfish when a light is turned on, a book opened, or an object lifted. By closer inspection, you can tell where sizing or paste has been eaten from the surface of paper. In extreme cases, the insects may have removed the entire surface including any printing or lettering on it. This can be disastrous with specimen labels as well as specimens.

Cockroaches: All five species that infest buildings are relatively broad, oval, flat, brownish insects. They vary in size according to age and species, from barely visible to 2" long. They eat many things, but are especially destructive to book bindings, any paper having paste or mucilage on it, mounted insects, and some textiles. Roaches tend to feed at night and are most often seen when a light is turned on. Look for them in dark crevices and other hiding places during your inspection. Also watch for their characteristic egg cases. Evidence of their feeding on paper specimens may resemble the work of silverfish.

The bilbiography in the Appendix refers to several U.S. Department of Agriculture publications which describe these damaging insects in greater detail, discuss their life cycles and habits, and recommend ways to get rid of them. Fumigation of some sort usually is required if the infestation is wide spread. Additional preventive measures include keeping paradichrolobenzine crystals with all organic objects (such as in jar lids in storage cases and in hidden containers in exhibit cases, provided they are air tight), the use of insect-tight storage cabinets, and rigorously good housekeeping.

Rodents

Watch closely for droppings, for signs of gnawing on vulnerable objects, and for the rodents themselves. Most commercially available storage cabinets and most exhibit cases are rodent proof, especially metal ones. Use traps or poisons with safeguards to eliminate infestations in the building. In severe instances, fumigation might be necessary.

Fire

When inspecting collections, make sure that flammable materials do not accumulate near your collection, either on exhibit or in store rooms. Do not let paints, solvents, packing materials, lumber, and cleaning supplies be stored in the same room with the collection. If small quantities of flammables are on hand for frequent use, place them in special containers approved for fire protection. Stress good housekeeping in the museum. Eliminate extension cords and any other make-shift electric wiring. Work out with your safety officer or with the fire department the number, kinds, and proper locations of fire extinguishers and who should be trained to use them. Decide what objects in your collection, if any, are so rare and valuable that they should be evacuated from the building in the event of fire. Mark their location(s) clearly and work out an evacuation plan with your safety officer and your local fire department. Study and apply recommended practices for fire protection in museums, as issued by the National Fire Protection Association (see bibliography).

Humans

It is not as easy to inspect for the human agents of deterioration as it is to inspect for the environmental and animal ones. Of course, if someone on the staff drops an object and it breaks, it is immediately apparent that he or she was careless. Guard against possible accidents by applying rigorously the standard practices for handling museum objects. Try to minimize vandalism by keeping those objects you wish to protect away from the reach of visitors. You should restrict access to your collection in every way possible, consistent with exhibition and interpretive uses, to minimize theft. Make your collection accessible on your terms. Conduct a security survey to determine if your building is sufficiently protected. If not, correct such problems as weak locks, poor night lighting, locks accessible through windows which can be broken out, unprotected skylights and other roof openings, and inadequate safes in sales areas. Installation of alarms may be necessary. Implement and enforce proper operating procedures which may includeprocedures for closing the museum each night to be sure no hidden thief remains inside, daily inspections to assure prompt report of any loss or tampering, closer control of keys, training of attendants to detect and react properly to signs of trouble, and making provisions to prevent an insider from removing collections records to cover his theft of objects. Control access to study collections by locked doors, with the curator having the key. See the security bibliography for works containing additional information.

The fourth protection step becomes essential because several kinds of objects require periodic treatment to assure their continued protection. As soon as the effects wear off, they must be processed again. The following list is not exhaustive but includes the commoner situations needing repeated treatment.

Annually: Apply appropriate leather dressing to leather artifacts (except rawhide, suede, and buff leather); similar treatment for bookbindings of full or part leather.

Semi-Annually:	Specimens preserved in liquid: add enough preservation liquid to keep jar filled. Herbaria: fumigate with ethylene dichloride and carbon tetrachloride.
Quarterly:	Herbaria: refill containers of paradichlorobenzine crystals in each cabinet or case. Insect collections: refill container of paradichlorobenzine crystals in each drawer, cabinet, or case. Study skins: refill container of paradichlorobenzine crystals in each drawer, cabinet, or case. Textiles (especially wool) and articles made of hair, feathers, hide, or wood: refill container of paradichlorobenzine crystals in each storage container and hidden containers in each exhibit case.
Monthly:	Books and documents on exhibit: turn pages even if exhibited under ultra-violet filter. (It is better to use high quality photo reproductions for exhibition anyway.)
As Needed:	Iron artifacts and silver: wipe clean after each handling and renew protective covering as needed.

Adjust the frequency of repeated treatments to fit observed conditions in the museum. Objects on exhibit as furnishings in historic structures will probably require treatment renewal more frequently.

Information on achieving the proper temperature, humidity, and light levels within a museum can be found in the Appendix entitled The Museum Environment: Measurement and Control. Additional, more detailed information can be found in the references listed in the Bibliography.

THE MUSEUM ENVIRONMENT: MEASUREMENT AND CONTROL

By keeping museum specimens in a suitable environment, you prolong their existence and minimize the preservative treatment they need. Materials differ in their optimum humidity and temperature requirements. The working comfort of the people who use the specimens must be considered also. Taking these variables into account, it has been determined that the best attainable conditions for most museum collections are the following:

Relative Humidity.	45% to 65%
Temperature.	60° to 75° F
Light.	15 foot candles or less; free of ultraviolet
Air.	Freed of as much dust and chemical pollution as is practicable

Most museums should try to maintain this climate in the exhibit and study collection rooms the year round. Special circumstances admit a few exceptions, however. In the semi-arid sections of the Southwest, specimens have adjusted their water content in balance with a lower range of moisture in the air. Museums in such dry areas should hold the relative humidity as near 30% as feasible. Some museums necessarily close during the winter, often becoming buried in snow. The continuous cold protects objects from insects and mildew and the snow denies access to some other destructive agents, but humidity conditions may become detrimental, especially during thaws. A careful inspection with this in mind, made when the museum is reactivated, may indicate future protective measures. Fortunate museums that are far from industrial plants, traffic congestion and sources of blowing dust, need not worry about purifying the air.

The first step in climate control is to measure the temperature and relative humidity of the air surrounding the objects in the collections, and the amount of light that reaches them. The instruments used to determine the relative humidity will also indicate the temperature. At least two kinds are needed. As the basic instrument, use a battery operated aspirated psychrometer. This compact piece of equipment has a small electric fan driven by flashlight batteries. The fan draws a uniform stream of air over the wet bulb and dry bulb thermometers. As long as the wick is clean, distilled water used in the reservoir, and adequate battery power maintained, the psychrometer will provide accurate readings. Employ it to take periodic measurements of relative humidity and temperature in the rooms as a whole, and in confined spaces where poor air circulation may create different conditions. Use it also, to calibrate the second instrument.

The psychrometer does not permit you to measure effectively the relative humidity inside exhibit cases and specimen storage cabinets where most objects are kept. For these situations a hygrothermograph that will measure relative humidity and temperature continuously for as long as a week, and record them by inked lines on a chart is needed. Set the hygrothermograph inside and close the case. It will operate long enough to record the atmospheric conditions as they settle down to normal after the opening and closing. The recording instrument depends on a hair or synthetic fiber element that expands and contracts as it absorbs or releases moisture. The element, however, tends to accommodate to prevailing conditions so must be calibrated every few weeks by comparing the reading with that of the psychrometer and making any adjustments required.

If the collections contain important or valuable objects susceptible to damage by too much or too little moisture, measure conditions continually. Do so, especially if the local climate imposes severe humidity conditions. Museums that face less critical climatic situations should make occasional checks at different seasons to be sure that humidity percentages really are not dangerous.

To determine the amount of light striking the specimens, use a light meter. Ordinary photographers' light meters do not give readings in foot candles, so use a meter which registers directly the foot candles of light (such as the GE Type 213). Hold the meter close to the specimen without shading it. If no daylight enters the rooms housing specimens, one set of readings should suffice until new lighting fixtures are introduced. When natural light reaches the objects, a series of measurements are needed to reveal the range produced by daily and seasonal cycles, and by changing weather. Be sure that the light fixtures and all transmitting or reflecting surfaces are clean, and that any fluorescent tubes are relatively fresh when taking readings.

As yet, no convenient device for measuring and analyzing air pollution in museums is available. So watch for situations in the neighborhood that might produce dangerous concentrations, and observe closely for surface deposits and other signs of air contamination.

The control of relative humidity in the museum may involve three approaches, singly or perhaps in combination: condition the air and circulate it through the museum; simply add water vapor to the air at one time and extract it at another to counteract seasonal and day-to-day weather changes; or buffer the humidity fluctuations that normally occur. The choice should depend on such factors as the importance and susceptibility of the objects being protected, as well as on cost. Air-conditioning, if it is designed and operated in the interest of the specimens, provides the fullest and most effective control. A good system should be able to hold both temperature and relative humidity continuously within the safe limits defined above. A problem occurs in freezing weather, however, because water vapor condenses on the cold surface of windows and exterior walls even when the overall relative humidity of the inside air is far below the desirable minimum. Condensation occurs, for example, when the air-conditioning system is delivering air at relative humidities of 30% - 35%. The resulting liquid water damages or disfigures woodwork and structural members. Thus, in a climate with cold winters, an air-conditioned museum must be particularly well insulated and have double glazed windows in order to allow proper humidity levels. Another difficulty arises if the equipment is turned off at night to save money. This practice not only permits the relative humidity to climb too high overnight but causes wide, rapid fluctuations each morning as the system resumes operation.

If air-conditioning is impractical, use humidifying and dehumidifying appliances in the museum rooms to raise and lower the relative humidity before it exceeds safe percentages. In temperate climates, this usually means operating the dehumidifier in summer when humid weather prevails outside, and turning on the humidifier in winter to overcome the drying effect of central heating. In both situations, control the equipment with humidistats that will turn them on and off in response to significant changes in the relative humidity of the room air. You will also need to keep a hygrothermograph in operation, or a dial hygrometer under observation as a check on the actual conditions the appliances create. If a dial hygrometer, which is cheaper, is used, be sure to calibrate it regularly in the same manners as the hygrothermograph. Portable dehumidifiers designed for household use serve the purpose adequately if fitted with humidistats. Some extract water by refrigeration. Others use silica gel and reactivate it automatically. In selecting a humidifier, choose one that supplies water vapor by evaporation. Avoid for museum use the kinds which create aerosol dispersions of water in the air because they may spread chemical impurities contained in the water.

Small room dehumidifiers can be used to dry the air in individual exhibit cases displaying valuable objects. This has worked well in the highly humid and salt-laden atmosphere of some Atlantic coastal forts, for example, where exposed metal specimens would visibly corrode overnight. In such critical circumstances, a spare machine should always be at hand in case of mechanical failure. Silica gel will serve the same purpose if a sufficient quantity is exposed to the air inside the case and reactivated as often as necessary. Silica gel is reactivated by heating it at about 400° F. for several hours. By including a small amount of the gel treated with a humidity sensitive blue dye it is easy to tell by the color (which turns pink) when it needs baking. Both the dehumidifying appliance and the silica gel method require specially designed exhibit cases to contain but conceal the drying agent.

When objects which require controlled humidity are kept in tight exhibit or study collection cases, buffering may suffice. Buffering depends on the fact that a hygroscopic substance readily exchanges water vapor with the air around it until its moisture content is in balance with the relative humidity of the air. In this state the substance gives off or takes in moisture whenever the relative humidity falls or rises. It thus tends to hold the relative humidity close to the point of equilibrium. Therefore, if you can condition such hygroscopic material to air at 55% relative humidity and enclose enough of it in the case with the specimens, it will keep the case air near the optimum percentage. For precise control you would need special laboratory equipment to condition the buffer, since it must be held under just the right atmosphere environment for several days. To calculate accurately the amount of buffer needed would require special data on the hygroscopic characteristics of the material. In less critical situations, take advantage of the buffering effect without such precision. Silica gel is an excellent buffer. Wood, cellulose fiber boards, newsprint, and cotton or linen cloth, have similar hygroscopic properties at a lower level of efficiency. These materials placed in a case tend to reduce the magnitude of relative humidity changes. Use them particularly to supplement other control methods and to protect specimens in shipment. Since wood, fiber board, and newsprint may contain acids, the cloth offers a safer substitute for silica gel. To give some idea of effective quantities, one successful installation reported in Technical Supplement No. 11 to Museum News used about 4 pounds of conditioned silica gel to every 3 cubic feet of air in the case. Care was taken to expose the gel as fully as possible to the case air.

Temperature control in an air-conditioned museum should give few problems. Be sure, of course, that the system operates continously to maintain the stable environment needed for the specimens. If the museum is not air-conditioned, there may be more difficulty with temperature in summer than in winter. Most central heating systems should permit, in the cold months, room temperatures above 60° and well below 75° overnight and on weekends, as well as during working hours. In summer you may have to depend on the judicious manipulation of shades and ventilation to hold to a minimum periods when the temperature in the museum exceeds 75°. Shutting out as much as possible of day-time heat, and letting in cooler night air, help the situation some. In many museums, exhibit lighting is outside the cases. Check, however, to be sure that sufficient air and glass separate the light sources from the specimens to prevent heating of the objects.

Control of light in a museum should protect the specimens from ultraviolet radiation and from too much exposure to the visible spectrum. Although the ultraviolet factor could be eliminated by depending entirely on incandescent lamps for illumination, most museums choose to cope with it for practical and esthetic reasons. Msueums usually want a token amount of daylight, not to light the exhibits but to keep in touch with the outdoors. The light contains much ultraviolet, but adds to visitor comfort and pleasure. Museums also prefer fluorescent lamps because they generate less heat and cost less to operate. On the other hand, they emit ultraviolet wave lengths. As a first step in control, minimize the amount of ultraviolet coming from these two sources. Let no direct sunlight reach a specimen. Use curtains, Venetian blinds, baffles, overhangs, plantings, or other means, to moderate the amount of daylight entering the rooms containing specimens, without cutting off a view or at least a sense of the outdoors. When a fluorescent tube burns out in the museum, always replace it with a standard warm white lamp. White fluorescent tubes come in at least seven color variations: white, soft white, warm white, deluxe warm white, cool white, deluxe cool white, and daylight. Tests have indicated that the standard warm white lamps normally release substantially less ultraviolet than the others. That is why nearly all museum exhibits should originally have this type of light.

A second step should be taken when an exhibit contains an important specimen liable to photochemical damage. It should be shielded from all ultraviolet radiation. The best method presently available filters out all wave lengths of radiant energy below visible light by a chemical formulation in clear plastic, for example Plexiglas UF-3. To filter out the ultraviolet components of all light reaching the object, cover it with a sheet or box made of this highly transparent, almost colorless material. If there are several specimens in the case to protect, and daylight is not involved, slip sleeves of the plastic filter over the fluorescent tubes. Sheets of the material could be used to cover windows or case tops, but it would be relatively expensive and hard to keep clean without scratching.

To protect specimens from an excess of visible light, control the amount striking them. Limit the level of illumination and also its durations. Measures for reducing the quantity of daylight in your museum are noted above. If the light meter still shows more than 15 foot candles reaching vulnerable objects, seek professional assistance. Exhibits are lighted for convenient and effective viewing. An exhibit specialist should collaborate on the necessary changes in number, voltage, or distance, of the light sources, to retain the proper display effect. Paper and ink may suffer particularly from exposure to light. Therefore, cover any valuable document on exhibit with a clear yellow filter such as Plexiglas 2208. This cuts out the light waves at the lower end of the visible band without affecting legibility. The light, however, can still energize photochemical deterioration, so turn the pages of a book at least once a month. A single page document should not ordinarily remain on exhibit. Show it on special occasions and substitute a photocopy (identified as such) for everyday viewing. It is also good practice to install a dense filter or opaque cover over especially susceptible objects and let visitors lift it to examine the specimens. As another way to minimize the time of exposure, provide a means for visitors to switch on the case lights while using the exhibit, but have the lights switch off automatically after a certain time.

Air pollution presents another problem in climate control. If the museum is air-conditioned, reasonable control can be achieved with care and testing. The right kind of dry filter can remove 90% or more of the solid particles. Avoid electrostatic filters for museum use because they tend to add ozone to the air. Ozone is a strong oxidizing agent. The water spray that washes and humidifies the air in the system takes out some of the remaining solids and some of the gases. By making the water alkaline it will remove more of the dangerous sulphur dioxide. Activated charcoal in the system also eliminates some gaseous pollutants. Some museums without air-conditioning have reduced air pollution in study collection storerooms by installing good quality dry filters in the doors and any other air intake points.

APPENDIX A

THE EFFECTS OF UNFAVORABLE HUMIDITY ON DIFFERENT MATERIALS *

Material	Humidity Tolerance High	Low	Dimensional Response	Susceptibility to Mold
Paper	65% RH (critical)	40-45% RH	Rapid. Loose leaves tolerate moderate dimensional change.	Extreme. For safety 60% RH may be adopted as upper limit.
Stretched paper	65% RH (critical)	45% RH (critical)	Paper screens, drawings, pastels stretched on frames, will tear from shrinkage in dry atmospheres.	Extreme.
Fabric (natural fibers)	65% RH (critical)	45% RH	Inverted. Because of twisted fibers, fabrics shrink when fibers swell, relax when they shrink.	Marked.
Parchment, Vellum	A steady state near 55% RH		Extremely rapid. Dryness causes loss of flexibility.	Moderate because of inherent alkalinity
Leather	65% RH	45% RH	Variable according to tanning process.	Variable. Marked for many fine leathers.
Bone, Ivory	65% RH	45% RH	Very slow, except in thin sheets. Avoid hot lamps in cases for emphasis lighting.	Negligible except at very high RH.
Wood	65% RH	45% RH (critical)	Slow varying with massiveness and moisture barrier coatings. Affected by weekly cycles and especially by seasonal cycles.	Negligible except at very high RH.

*Taken from "A Specification for Museum Airconditioning" by Richard D. Buck; Technical Supplement No. 5 from Museum News, December 1964.

Material	Humidity Tolerance High	Low	Dimensional Response	Susceptibility to Mold
Painted wood	65% RH	45% RH (critical)	Dryness which causes shrinkage of wood is especially damaging to a class of objects in which wood is the structural support for other materials. A painted wood panel is typical. Wood sculpture, furniture, models, musical instruments, and decorative objects may also be coated with a gesso plaster, then painted or gilded. These rigid coatings are more or less unaffected by humidity but if the supporting wood shrinks, the coatings are compressed causing them to buckle or "blister" and flake off.	
Metal, Stone, Ceramic, Plaster	Not normally responsive		Some polished metals, notably steel, corrode at humidities above 45% RH. Bronze, stone, ceramic, and plaster long buried may have been infused with or corroded by salts which behave hygroscopically. These should be examined and treated if possible. Cases of "bronze disease" can be kept benign in a dry atmosphere.	

APPENDIX B

Suggested Guidelines for Air Conditioning Historic Structures by the Park Service *

There is no unanimous view on when or how to provide atmospheric controls in historic structures. Some people advocate no controls, arguing that over the years of its existence, an historic structure will have adjusted itself to its environment and no controls are needed for its continued preservation. Others argue that providing controls not only makes visiting an historic site more pleasant for the public but also that it reduces air pollutants whic would otherwise damage interior paint and furnishings, especially in urban areas where pollutants are concentrated.

The problem faced by the administrator of an historic structure is essentially to balance the proven benefits of atmospheric controls against the expense factor, interpretive problems (i.e., explaining away an air vent in a room where none would have existed historically), and, most important, the danger of violating the structural integrity of an architectural monument. We must conclude that the particular local conditions must be the determining factor in striking this balance.

Because of the widely varying atmospheric conditions throughout the vast area over which the Park Service operates, it is manifestly impossible for the Service to adopt a simple, unvarying policy in regard to the use of atmospheric controls in the historic properties in its care. Its policy should, therefore, be a flexible one, determined in each case by local conditions.

The following guidelines are suggested as an aid to determining what atmospheric control measures are needed in each case:

(1) Take careful stock of the building's contents. Decide just how important they are in relation to the interpretation of the structure. If furnishings play a central role, and especially if they include irreplaceable originals, measures for their preservation are accordingly of great importance.

(2) Make a study of the local atmospheric conditions. With the aid of the local weather bureau, air pollution control authority, or other interested agencies, get an objective view of the climatic

* Selected from A SURVEY OF ATMOSPHERIC CONTROLS IN MUSEUMS AND HISTORIC BUILDINGS by David Wallace, Museum Curator, Independence National Historical Park, Philadelphia, Pennsylvania. 1960. Unpublished manuscript.

conditions, such as variations in relative humidity and temperature, and of air contamination levels, which may adversely affect the contents of your building. If the climate is equable and dirt or chemical contamination levels low, elaborate atmospheric controls will not be necessary. If, on the other hand, the outside humidity fluctuates wildly from day to day or remains above 60% or below 40% for long periods, and if dirt or other air contaminants are present in appreciable quantities, air conditioning should be seriously considered.

(3) Determine your own air conditioning requirements. Not every situation calls for the full range of atmospheric controls. Filtration of air, for example, is likely to be less of a necessity in the country or in small towns than in cities. Likewise, air cooling may be unnecessary in non-urban situations where windows may be opened safely to promote air circulation. The use of permanent or portable equipment (such as humidifiers and dehumidifiers) will depend on local conditions also. In general, it is probably safe to say that the more rural the situation the less complex the problem and the solution.

(4) Obtain an air conditioning plan and cost estimates. Based on your specific needs, have plans drawn up by a qualified air conditioning engineer. It is helpful to have more than one alternative plan to choose from. One may show the most efficient method of air conditioning the building; another the method which least affects the original structure; and a third which can be a compromise. Every effort should, of course, be made to avoid tampering with the original structure and to make visible elements of the system as unobtrusive as possible. Cost estimates should include cost of installation, operation, and maintenance. Remember, in the long run you may find a system that costs slightly more to install than its competitors may be considerably cheaper to operate; all things being equal, the most efficiently operated system is going to cost less, something to consider in these days of high energy costs.

(5) The decision. Once you have made a plan and have cost estimates, you can decide whether or not it is feasible to obtain the measure of protection you deem necessary for the contents of the building. The cost factor or the threat to the integrity of the building may, in the end, tip the balance in favor of leaving the contents to fend for themselves. The value or historical importance of the furnishings will, however, in some instances, outweigh these factors and provide sufficient justification for a considerable capital expenditure. Each case must be decided on its own merits.

APPENDIX C

GUIDELINES FOR PROTECTION OF HISTORICAL OBJECTS IN MUSEUM EXHIBITS

The following guidelines were prepared by the Park Service's Division of Museum Services for use by the Divisions of Exhibit Design and Exhibit Production so that factors harmful to artifacts exhibited in Service museums would be designed out before the exhibits are installed. These guidelines also apply to the non-Service exhibit designers and contractors who occasionally do work for the Service.

1. Original Object or Reproduction?

   Since the National Park Service has a double obligation to use and preserve historic objects, uses which destroy historic objects are not acceptable. When originals are used they must be protected from various threats to their preservation. If interpretation requires exposure of objects to damage, the use of reproductions is indicated.

2. Modification of Original Object.

   Irreversible modification of original objects (trimming, drilling holes, etc.) to make them fit an exhibit plan is not permissible as a general rule. Specific exceptions must be approved by the owner and by the Chief Curator, Division of Museums.

3. Light Intensity.

   The intensity of light falling on the object must be the minimum necessary to illuminate the object. Other damaging, non-visible. wave lengths should be eliminated by using ultra-violet filters between the light source and the object.

4. Heat.

   Exhibits must be designed to eliminate serious heat build-up which will adversely affect most museum specimens. Heat inside cases must be no more than 5 to 10 degrees warmer than the exhibit room. The use of hot spot lights on heat sensitive organic objects should be avoided because of the stresses set up by the alternative heating and cooling where the lights are on and off.

5. Insects and Mold, etc.

Objects on exhibit should be shielded from dirt, dust, insect infestation, and to some extent, deteriorating atmospheric gases. Cases should provide for convenient access by curators to introduce pesticides or fumigants into the case environment. Objects that cannot safely be dusted (such as basketry, textiles, papers) should be exhibited only under cover.

6. Touching, Theft, and Vandalism.

Objects on exhibit should not be accessible to the touch of the visitor unless it has been determined by the owner that the object is expendable. Under normal circumstances this would eliminate from touchability all but the most common or substantial artifacts (cannon balls and tubes, for instance). Where touching is desired [for interpretive purposes], reproductions should be used as a general rule. Cases must be designed to prevent at least casual, spur-of-the-moment theft or vandalism, without making curatorial entry impracticable. In the instance of very valuable objects, alarm systems should be considered.

7. Humidity.

Safe relative humidity for most organic objects falls within the range of 40-60% and must be stable. Humidity control of the exhibit room is the best way of achieving this goal. When this cannot be achieved and the objects exhibited react critically, humidity controlling devices may have to be put in the exhibit.

APPENDIX D

INSTRUMENTS FOR MEASURING AND/OR RECORDING TEMPERATURE AND RELATIVE HUMIDITY

Psychrometer, Sling (Portable):

Abrax Instrument Co.
179-15 P Jamaica Avenue
Jamaica, New York 11432

Model designation unknown.

Bacharach Instruments Company
625 Alpha Drive
Pittsburgh, Pennsylvania 15238
412-782-3500

Model SAC. Pocket size with self-contained water reservoir; slide rule included. Matched 20° to 120° F range thermometers. Also available from Fisher Scientific as Catalog Number 11-664.

Commercial Products
Environmental Tectonics Corporation
P. O. Box 367
Lancaster, Pennsylvania 17604
717-394-2631

Model 22005. Range of -20° to 120° F. Accuracy is claimed to be ± 0.5° F.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Catalog Number 3980K1. 30° to 110° F range.

Catalog Number 3995K19. 20° to 120° F range. Accuracy is claimed to be ± 1 scale division.

Master Sling Psychrometer (Catalog Number 3995K12 for 20° to 120° F range and Catalog Number 3995N13 for -5° to 50° C range). Accuracy is claimed to be ± 1 scale division.

Macarco Humidity Indicator (Catalog Number 3971K11). RH range of 20 to 100% at temperatures of -30° to 120° F. Accuracy is claimed to be ± 2%. Self-contained slide rule.

Taylor Instruments
Consumer Products Division
Glen Bridge Road
Arden, North Carolina 28704
704-684-8111

No model designation known. 20° to 120° F scale. Computation tables included. Also available from Fisher Scientific as Catalog Number 11-666.

Psychrometer, Aspirating (Portable):

The Bendix Corporation
Environmental Science Division
Department 81
1400 Taylor Avenue
Baltimore, Maryland 21204
301-825-5200

Friez Battery Operated Psychron Model 566 (Model 566-2 has Fahrenheit scales and Model 566-3 has Centigrade scales). Includes carrying case, water bottle, slide rule, and instruction manual. Minimum readable values of 0.2° F and 0.1° C. Response time of 1 1/2 to 2 minutes.

Commercial Products
Environmental Tectonics Corporation
P. O. Box 367
Lancaster, Pennsylvania 17604
717-394-2631

"Psychro-Dyne" battery operated aspirating psychrometer. Model 22010 has Fahrenheit scale; Model 22012 has Centigrade scale. Includes carrying case, instruction manual, water bottle, and slide rule. Accuracy is claimed to be $\pm$ 0.3 on the Fahrenheit scale and $\pm$ 0.2° on the Centigrade scale.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Motor operated psychrometer (Catalog Number 3969K1 for battery operated model and 3965K3 for AC operated). Temperature range of 25° to 125° F. Accuracy is claimed to be $1/2^{\circ}$ F at center of range and 1° F at the extremes.

Yellow Springs Instruments
Box 279
Yellow Springs, Ohio 45387
513-767-7242

Model 90 Electronic Psychrometer. Has removable probe for measurements inside confined space, such as cases. Reads wet- and dry-bulb depressions directly on 4-range meter; use slide rule to calculate RH from meter readings. Centigrade scale only. Accuracy is claimed to be ± 2% RH when ambient temperature is below 32° C and RH is above 50% or when above 35° C and better than ± 3.5% when the ambient temperature is below 35° C and the RH is below 50%. Also available from Fisher Scientific a Catalog Number 11-662-40. The manufacturer advises that this model will be discontinued soon.

Psychrometer, Electronic (Portable):

Bacharach Instruments Company
625 Alpha Drive
Pittsburgh, Pennsylvania 15238
412-782-3500

Direct-Reading Hygrometer. Shows relative humidity directly from 15% to 95% with an accuracy of ± 1.5% claimed. Temperature range of -35° to 130° F. Small enough to go inside a case. Also available from Fisher Scientific as Catalog Number 11-657.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Portable Hygrometer (Catalog Number 3967K11). Direct reading in range of 30% to 95% RH with accuracy claimed of ± 5%. Sensor connects to metering case by a ten foot cable. Sensor can be placed inside a confined space.

Hygrothermograph, Recording (Semi-Portable):

Bacharach Instruments Company
625 Alpha Drive
Pittsburgh, Pennsylvania 15238
412-782-3500

Serdex Hygrothermograph. Records humidity changes of ± 1% with accuracy claimed of ± 3%. Records for 7 days on paper drum. Also available from Fisher Scientific as Catalog Number 11-658-20.

RH and Temperature Recorder. Not as accurate as a hygrothermograph. Records from -35° to 130° F on 7-day circular chart. Also available from Fisher Scientific as Catalog Number 11-658-25 and from McMaster-Carr Supply Co. as Catalog Number 4032K2.

Belfort Instrument Company
1600 South Clinton Street
Baltimore
Maryland 21224
301-342-2626

Model 5-594 Hygrothermograph. Clock movement. Records temperature and humidity on rotating, 7-day paper drum.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Hygrothermograph (Catalog Number 3977K15 for 7-day model). Range of 10° to 120° F and 0 to 100% RH. Accuracy is claimed to be ± 1% between 20 and 80% RH and as ± 3% RH at the extremes; temperature accuracy is claimed to be ± 1° F. Clock movement.

Hygrometer (Wall-Mounted):

Abbeon Cal Inc.
123-06 Gray Avenue
Santa Barbara, California 93101
805-963-7000

Model AB-167 Certified Hygrometer. Brass case, 6" in diameter, black dial face with white numbers and letters. Registers 0 to 100% RH and -10^{o} to 190^{o} F.

Airguide Instrument Co.
2210 Wahansia Avenue
Chicago, Illinois 60647
312-486-3000

Model 605 Humidity Indicator. 4 5/8" diameter metal case; white dial, red pointer. Measures 0 to 100% RH.

Belfort Instrument Company
1600 South Clinton Street
Baltimore
Maryland 21224
301-342-2626

Model 5-587 Wall-Mounted Humidity Indicator.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Certified Hygrometer (Catalog Number 3887K12). RH range of 0 to 100% usable in temperatures of $32^{o}$to 320^{o} F. Accuracy is claimed to be $\pm$ 2% RH. (Probably made by Abbeon Cal Inc.)

Note: McMaster-Carr Supply Co. is a supplier only, not a manufacturer. The instruments cited as being available from McMaster-Carr are probably available from other suppliers and their manufacturers, the names of which McMaster-Carr would not divulge.

When ordering from Fisher Scientific, contact the home office to determine which regional sales office would service your order. The home office address is: 711 Forbes Avenue, Pittsburgh, Pennsylvania 15219. Tel: 412-562-8300.

APPENDIX E

SOURCES FOR INSTRUMENTS FOR MEASURING LIGHT

Measuring Ultraviolet Light:

International Light, Inc.
Dexter Industrial Green
Newburyport, Massachusetts 01950

UV-Visible Photometer IL200. Has two sensors, one to measure visible light levels, the other to measure radiation in the near ultraviolet range.

Littlemore Scientific Engineering Co.
Railway Lane
Littlemore
Oxford
England

Ultra Violet Light Monitor Type 678. Specially designed for use in museums.

Ultra-Violet Products Inc.
5114 Walnut Grove Avenue
San Gabriel, California 91778
213-285-3123

"Blak-Ray" Model J-221. Measures ultraviolet radiation in ranges of 0-1200 angstroms and 1000-1600 angstroms on a selective scale. The sensor cell attaches to the metering unit by a cable. Also available from Fisher Scientific as Catalog Number 11-984-53 and from McMaster-Carr Supply Co. as Catalog Number 1370Y1.

Measuring Visible Light:

General Electric (offices nationwide)

Type 213 Foot Candle Meter. Fairly accurate but has scale which is difficult to read. Inexpensive.

International Light, Inc.
Dexter Industrial Green
Newburyport, Massachusetts 01950

UV-Visible Photometer IL200. See description under UV meters.

Kling Photo Company
P. O. Box 1060
Woodside, New York 11377
219-932-4040

Gossen Pan-Lux Model C Electronic Luxmeter. Measures from 2 to 12,000 footcandles. Color-corrected. Sensor connects to metering unit by a four foot cable. Accuracy is claimed to be ± 5% in incandescent light and -0.1% to +2.0% in fluorescent light. Scale is easy to read throughout entire range.

Littlemore Scientific Engineering Co.
Railway Lane
Littlemore
Oxford
England

Makes a wide line of light meters.

McMaster-Carr Supply Co.
P. O. Box 4355
Chicago, Illinois 60680
312-281-1010

Economy Light Meter (Catalog Number 1696K14). Measures from 5 to 5000 footcandles in two ranges (5-500 and 50-5000). Color-corrected. Sensor self-contained in metering unit.

Various photographic light meters can be used in museums. Some read directly in footcandles; others must have the reading converted to footcandles by multiplying by some conversion factor. Among such meters are: Gossen Luna Pro, Weston Model 614 or Model 4, Honeywell Pentax, Sekonic Model L-28C, and Spectra. Photographic light meters are not truly suited for use in museums because they generally do not read accurately in the 0-50 footcandle range where museums need to take critically accurate readings. Moreover, in order to get accurate readings in any range, the metering scale must be large with small divisions (no more that 5 footcandle increments). Most of these meters do not meet these requirements.

APPENDIX F

LIGHT FILTERS: TYPES AND SOURCES

A. Types of Filters for Windows:

1. Polyester or Mylar Sheet Film Type.

These films are made to adhere to existing glass by a liquid adhesive or, sometimes, they are self-adhering. There are two types: ultraviolet absorbing (such as "sun-Stop") and pigmented (such as "Solar-X"). The former reduces ultraviolet light only; the latter reduces (by reflectance) a portion of all light, including ultraviolet.

Most of the brands of adhering films will not lie flat on old, rippled glass and none will adhere to plastic glazing. Moreover, at least 1/4" is required between the edge of the sheet of film and the mullion or frame around the glass in order to permit the application of a water-proofing lacquer to the edge of the film. This 1/4" border thus is not covered by the filtering medium. Both these factors can be considered a disadvantage to use of this film.

The 3M Company recently developed a new type of film containing both ultraviolet absorbants and reflective pigmentation. It is called "Scotchtint V-30".

2. Flow-On Film Type.

This type of filter is the best for use in historic structures from an aesthetic point of view because the liquid covers the entire surface of the glass; no border around the resulting film is needed. The resulting film can be removed with appropriate solvents if necessary. The film should last at least eight years with proper care. The most effective films of this type contain both ultraviolet absorbants and reflective pigmentation.

3. Plastic Panels.

The most effective filter for reducing ultraviolet radiation is "UF-3 Plexiglass" made by Rohm and Haas and available nationwide. It reduces up to 98% of the ultraviolet emission of both sunlight and fluorescent light. However, it has a slight yellow tint which makes it objectionable in some museum situations where accurately colored light is necessary. In these instances, UF Plexiglass could be used; it is clear but cuts out only about 90% of the ultraviolet.

All three of these types of filters can be used to reduce ultraviolet radiation from sunlight coming through doors and windows. In addition, the Plexiglass sheets can be placed between light sources and objects within an exhibit case. The film type filters can be so used but are not designed for this purpose and do not remove as much ultraviolet as the UF-3 plexiglass.

B. Filters for Use in Exhibit Cases:

Most practical are the several varieties of plastic tubes containing an ultraviolet absorbant. The tubes come in sizes to fit standard fluorescent bulbs and are simply slipped over the bulbs which are then mounted in the fixtures in the normal fashion. These tubes absorb varying amounts of fluorescent light depending upon how and by whom they are made. Some of these tubes are made of UF-3 Plexiglass and are to be prefered.

UF-3 Plexiglass sheets can be used in exhibit cases as explained above in A-3.

C. Self-Filtering Bulbs:

Incandescent bulbs emit very little ultraviolet radiation. However, fluorescent bulbs emit a great deal. One manufacturer has marketed a fluorescent bulb ("Fadex") which is claimed to emit almost no ultraviolet radiation because of the ultraviolet absorbants built into the bulb itself. Independent tests have yet to confirm this claim.

While incandescent bulbs emit little ultraviolet radiation, they do emit substantial infra-red radiation. There are bulbs on the market containing infra-red filters. These bulbs should be used where heat buildup would be a problem.

D. Reduction of Overall Light Levels:

No matter what form the filter--film, panel, or tube--the addition of reflective pigmentation to create a selective mirror will cut down on the total amount of light passing through the filter. While structural damage, tendering, and yellowing of organic materials--notably paper--is caused by ultraviolet radiation, the fading of dyes often is due to light in the visible spectrum, especially blue light. Therefore, to maximize the filtering effect, it is necessary to reduce total light levels as well as ultraviolet light levels. Heat-causing infra-red radiation also is reduced by use of reflective pigmented glazing or filters.

E. <u>Suppliers of Filters</u>:

1. Sheet Film Type.

Martin Processing Co.
Martinsville, Virginia 24112

W-2 Weatherable Mylar.

Plastic-View
Box 25
Van Nuys, California 91408
213-786-2801

"New Ice" and "Dusk" mylar shades reflect up to 89.5% of light. Similar films can be applied directly to window glass.

Solar Control Products Corp.
217 California Street
Newton, Massachusetts

"Solar-X" film is a polyester film to be applied directly to existing windows by a liquid adhesive. The film contains reflective pigmentation. It is similar to the 3M Scotchtint but can be self-installed.

Solar Screen Corp.
1023 Whitestone Blvd.
Whitestone, New York 11357
212-539-9344

Makes films and ready-made shades of ultraviolet absorbing plastics.

Thermoplastic Processes, Inc.
Valley Road
Stirling, New Jersey 07980
N.J. 201-647-1000 or 643-4600. N.Y. 212-267-6220.

Arm-A-Lite "Filter Ray" film.

3M Company
Visual Products Division
P. O. Box 33235L
St. Paul, Minnesota 55133
612-733-0128

"Scotchtint" Solar Control Film is a polyester film intended for application to existing windows. The translucent film (W-50) is designed to reduce glare and is claimed to reduce total solar energy by 60% with a shading coefficient of 0.45 and an ultraviolet transmission of 9%. The aluminum vapor-coated film (V-30) is similar but provides increased heat rejection; its shading coefficient is 0.30, solar energy transmission is 0.16, and ultraviolet transmission is 5%. This film can be applied by trained servicemen only.

Westlake Plastic Co.
West Lenni Road
Lenni Mills, Pennsylvania 19052

"Ray Shield 403" ultraviolet absorbing tubes and sheets.

2. Flow-On Film Type.

Solar-Screen Company
1023 Whitestone Blvd.
Whitestone, New York 11357
212-539-9344

Information about film unavailable.

Transparent Glass Coatings Co., Inc.
1959 South La Cienega Blvd.
Los Angeles, California 90034
213-870-4777 or 553-5558 or 837-4468

"Sun-Stop". Must be applied by an experienced dealer. Can be applied to irregular glass, such as might be found in an historic structure. Not as effective as UF-3 Plexiglass in reducing ultraviolet radiation. When this film is pigmented, there is greater protection from fading because all light is reduced; the heavier the pigmentation, the greater the reduction but the glass will appear darker. The manufacturer claims 100% absorption of UV rays, 86% of heat-producing infra-red rays, and 95% of eye-irritating glare.

There are a number of Sun-Stop dealers in the Plains area. Write the manufacturer for the name of the dealer nearest you.

3. Plastic Panels.

American Cyanamid Co.
Wakefield
Massachusetts 01880

"OP-2 Acrylite". No further information available.

Rohm and Haas Co. (has dealers nationwide)
Plastics Department
Independence Mall West
Philadelphia, Pennsylvania 19105

"UF-3" Plexiglass in varying thickness and sizes; has light yellow tint. "UF" Plexiglass has no tint but reduces less ultraviolet.

4. Plastic Tubes.

Filter Sleeve Corporation (address unavailable)

Solar-Screen Company
1023 Whitestone Blvd.
Whitestone, New York 11357
212-539-9344

"Fade Controlled" fluorescent bulb jackets. Available in all standard sizes. Comes in amber to cut out the most ultraviolet and in transparent when color must not be affected (but cuts out less UV). Not as effective as UF-3 plexiglass.

TALAS-Technical Library Service
104 5th Avenue
New York, New York 10011

Sells filtering tubes and sheets but type and brand could not be determined.

Thermoplastic Processes, Inc.
Valley Road
Stirling, New Jersey 07980
N.J. 201-647-1000 or 643-4600. N.Y. 212-267-6220.

Arm-A-Lite "Filter Ray" shields. Supposed to cut ultraviolet radiation in the 0-3850 angstroms range. Available in lengths from 15" to 96" for most types of lamps. Not as effective as UF-3 Plexiglass.

Westlake Plastic Co.
West Lenni Road
Lenni Mills, Pennsylvania 19052

"Ray Shield 403" ultraviolet absorbing tubes and sheets.

5. Filtering Glass.

American Glass Company (address unknown)

"Lustragray" pigmented glass

Corning Glass Works
Corning
New York 14830

Makes photochromic glass which will darken or lighten in response to the intensity of illumination.

DuPont

Manufactures "Butacite" polyvinyl butyral sheeting containing an ultraviolet absorbant called "Tinuvin-P", a benzotriazole compound. The sheet normally is laminated between two sheets of plate glass for use in automobile and building windows. The architectural composition is known as Butacite-10UV (B-10UV). It is said to cut UV radiation by 91% when used in the 45 mil. thickness. Among the glass manufacturers offering B-10UV is:

Globe-Amerada Glass Co.
2001 Greenleaf Avenue
Elk Grove Village, Illinois 60007
312-439-5200

Pittsburgh Plate Glass Industries (dealerships nationwide)

"Solargray" pigmented glass cuts down on all light.

6. Low Ultraviolet and Infra-Red Emission Bulbs.

General Electric (dealerships nationwide)

Heat-filtered incandescent bulbs.

Sylvania (dealerships nationwide)

Heat-filtered incandescent bulbs.

Verd-A-Ray Corporation
615 Front Street
Toledo, Ohio 43605

"Fadex" fluorescent bulbs. Manufacturer claims the bulbs emit no ultraviolet radiation except in the range 3850 to 4000 angstroms. Tests by independent laboratories indicate that this may not be true and that the bulbs can emit significant levels of ultraviolet radiation. Not as effective as UF-3 Plexiglass.

Westinghouse Lamp Division
Westinghouse Corporation
Bloomfield, New Jersey 07003

Westinghouse 150 or 75 PAR (parabolic aluminized reflector) bulbs produce low infra-red radiation. They are incandescent bulbs.

7. Miscellaneous.

Filter-Ray Plastics, Inc.
56 Fort Point Street
East Norwalk, Connecticut 06855
203-853-4083

Makes light filtering plastics. Exact nature of products could not be determined.

NATIONAL PARK SERVICE
ACTIVITY STANDARDS
PART V - OPERATIONS MANAGEMENT
SECTION II - Environmental Interpretation
and Supporting Activities

page 4

Curatorial Activities

Curatorial activities will be satisfactory when:

1. Each park has an approved scope of collections statement clearly defining the needs and limits of its collection and guiding an active program of acquisition and disposal.

2. Each object is authoritatively identified and, where appropriate, authenticated.

3. Each specimen has been put into satisfactory condition for its preservation and intended use.

4. Each object is exhibited or stored under environmental conditions sufficiently controlled in regard to light, dust, temperature, relative humidity and infestation to minimize deterioration.

5. Each accession of objects is correctly and legibly entered in the permanent Accession Book of the park in which it is held.

6. Specimens have been individually numbered and catalogued in accordance with NPS museum records procedures.

7. A museum security system appropriate to the significance and value of the specimens has been planned and is implemented.

APPENDIX H

ADMINISTRATIVE POLICIES FOR HISTORICAL AREAS OF THE NATIONAL PARK SYSTEM
Part I: "Historic Preservation Policy"
Selected References

Administrative Policies: Historic Objects

p. 26: "All historic objects for which the Services is responsible should be properly documented and recorded in accordance with prescribed procedures, and receive the curatorial care needed for optimum preservation."

p. 27: "*Preservation.* All historic objects that come into the possession of the National Park Service shall be accessioned, catalogued, given appropriate preservation treatment, and provided a manner of storage that will insure their continued survival without deterioration. Such storage will include periodic inspection, cleaning, and preservation treatment, when necessary, and shall be performed in such conditions of atmospheric control as are most conducive to the survival of the objects."

Administrative Policies: Historic Structures

p. 29: "*Fire Detection and Suppression.* Where warranted by the significance or value of a historic structure or its contents, adequate fire warning and suppression systems should be installed. Where a manned fire station exists near the structure, a detection system providing a signal directly to the local fire authorities should be installed. Also, fire personnel should be advised of any peculiarities or dangers inherent in the structure and the features and contents whose value warrants the greatest care in the event of fire.

Where local fire equipment and personnel are not readily available, the detection system should trigger a suppression system. A fog or freon system is preferable. Water sprinkler systems should be used only in structures whose fabric and contents are not likely to be irreparably damaged by water. Foam systems should be used only when the structure can be swiftly vacated.

In planning and installing detection or suppression systems, the integrity of the structure and the requirements of its interpretation will be respected."

p. 29: "*Humidity and Temperature Control.* Where warranted by the significance and value of the structure or its contents, e.g., paintings, documents, fabrics, and furniture, an atmospheric control system may be installed to help their preservation by providing constant humidity and temperature."

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