

Recommended Environmental Conditions



Preventive conservation is the practice of managing the risks posed to artifacts by display, movement, storage, and environmental conditions. Creating and maintaining a suitable environment is the most effective form of mass treatment because it benefits all the items in a collection at the same time. Proper environmental conditions will ensure the long-term survival of a collection.

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Temperature and Relative Humidity

The storage and exhibition environment best suited for the long-term survival of art materials is one in which the relative humidity is as stable as possible and the temperature is as low as practically possible. For Nebraska collections, relative humidity levels in the range of 50% to 30% are thought to be best for general collections; however, it is actually the **stability of the relative humidity** that is paramount rather than the actual value. This is

certainly true in an arid environment like that in western Nebraska where 50% Relative Humidity (RH) may be difficult to maintain particularly in the cold winter months. Fifty percent relative humidity is not essential; it is the stability that is most important. Therefore, if the relative humidity is more stable at 45%, then all efforts should be focused on maintaining that relative humidity. Temperatures that fall in a range below 72° F and above freezing

are acceptable provided that relative humidity is controlled.

Each degree the temperature is lowered, under stable relative humidity conditions, will slow the rate of deterioration of collection materials. We recommend conditions that will provide a stable **relative humidity in a range falling below 50% and above 30% and a temperature in a range falling below 72° F and above freez-**

ing. Above 50% RH mold and mildew can form and below 30% RH serious dehydration of organic materials can occur. Above 72° F some materials begin to soften and flow and below 32° F any materials containing water will begin to freeze and expand. Lower room temperatures with stable relative humidity will prolong the life of the collections, but may interfere with human comfort.

Lighting and Illumination

“Damage from visible and ultraviolet radiation is cumulative; it is not reversed or repaired by periods of reduced exposure. Objects cannot be ‘rested.’”

Exposure to visible and ultraviolet radiation can be a significant factor in the survival of objects. All wavelengths of radiation provide energy for deterioration reactions that degrade materials; the more powerful the radiation the faster the deterioration. Damage from visible and ultraviolet radiation is cumulative; it is not reversed or repaired by periods of reduced exposure. Objects cannot be “rested.”

It is important to limit the **levels** (foot-candles or lux), **types** (visible or ultraviolet) and **length** of exposure (minutes to days of illumination) to visible and ultraviolet radiation in order to protect collection objects.

It has been shown that the healthy human eye requires only 2 foot-candles of illumination to discern color. This indicates that we actually



require less light to accurately see objects than we might believe. There are many alternative methods that can be used to produce the effect of increased illumination without actually increasing

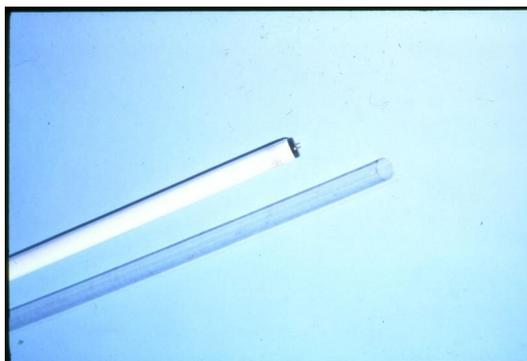
the foot-candles. For example, when entryways are kept more dimly lit than the adjacent areas, the display areas are perceived as being more brightly lit. When objects are illuminated on darker walls or backgrounds they are perceived as being more dramatically lighted, without the need for additional illumination. The levels of illumination in surrounding spaces have an important impact on those areas where objects are exhibited. Using occupant activated light sources can help reduce exposure when there are no visitors.

The generally accepted levels of visible illumination for historic and artistic collections ranges from 2-5 foot-candles for sensitive materials (like watercolors and silk textiles) to 30-50 foot-candles for materials that are not as light sensitive (paintings, furniture). Very few materials should be exposed to levels of illumination above 50-60 foot candles (ceramics, metals).

Illumination in the storage areas should always be occupant activated. Where incandescent light fixtures are used in storage areas they should be of the lowest wattage possible and should be well ventilated to carry away the excessive heat that incandescent light sources generate. All lighting in storage that produces ultraviolet light (daylight, fluorescent tubes, incandescent bulbs, etc.) should be filtered for ultraviolet emissions. The emission spectrum is available from the manufacturer for each lamp manufactured. The spectrum indi-

cates the amount of light emitted in each wavelength range for the bulb (lamp) in question. Illumination from windows should be blocked out in all storage areas.

In the exhibit spaces, there are a variety of lighting fixtures available to be used. Many produce both visible and ultraviolet radiation, as well as heat, and should



be filtered for UV emissions, vented for heat dissipation, and used at the lowest visible light levels possible. All natural light in exhibit spaces should be blocked or at the minimum filtered for heat, visible radiation, and ultraviolet radiation, particularly in the bright Nebraska sunshine. (This can help reduce cooling costs, as well, by reducing the heat load on the building.) If light level problems are found, the use of other passive methods or the reduction of light exposure, where possible, is recommended, as well as the use of moderated light transitions and contrasts to reduce the appearance of dark and light areas.

Sodium vapor lights, like those used in parking lots, are not suitable for museum use. Although these lights emit little ultraviolet radiation, they generate

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very high levels of visible illumination in the yellow and red regions of the spectrum.

Ultraviolet radiation is more harmful than visible radiation and is not required for human vision. It should be excluded from the museum environment. The ultraviolet light levels recommended for museums should not exceed 75 microwatts per lumen.

Museums should also consider changing out incandescent and fluorescent lighting for LED lighting. LED lights do not emit UV radiation or heat. Although initially expensive, the switch to LED lighting would greatly reduce

the amount of electricity required for lighting, which might be a factor in a historic building. There would also be an associated reduction in cooling costs associated with the removal of hot incandescent light bulbs. Finally, the very long lifespan associated with LED lighting will reduce the number of bulb changes needed on a yearly basis.

Museums need a full spectrum light meter so that the galleries and other object locations can be monitored regularly for light levels. Museums can borrow an Ultraviolet light meter to regularly check UV light levels in collection spaces.

Environmental Monitoring Equipment

The following sections provide basic information on common environmental monitoring methods and equipment for temperature, relative

humidity, light, atmospheric particulate pollution and atmospheric gaseous pollution.

Important Factors

Before addressing the logistical questions of how or what to monitor, it is important to know:

1. Why are you monitoring?
2. How will the data be used?
3. Who will do the monitoring?
4. Who will interpret the data?
5. The monitoring equipment should be chosen to capture the informa-

tion needed.

6. The equipment for permanent or long term monitoring of environmental conditions is different than the equipment for instantaneous monitoring.
7. The equipment will need to be calibrated or replaced periodically!
8. The interpretation of the data is as important as the collection of it.

Monitoring Temperature (T) and Relative Humidity (RH)

There are two general methods for monitoring temperature and relative humidity:

1) Measuring and indicating devices:

these devices can be mechanical, chemical, or electronic and do not record conditions over time. They record instantaneous data at the time of measurement. To collect data one must read the instrument and record the data manually. Some of the most common non-recording devices are listed below.



- A **psychrometer** is the most reliable instrument for determining relative humidity, if used properly. It is used to measure daily readings, to make spot readings, and most importantly for calibrating other devices. The psychrometer consists of two thermometers; one that measures the ambient temperature and another that has a moistened sock over the bulb and measures the “wet bulb” temperature. The wet bulb temperature will be lower than the dry bulb temperature because the mois-

tened bulb is cooled by evaporation of water from the sock as air flows across the surface. The degree of evaporative cooling is a consequence of the RH, and therefore considered a primary reference for the RH. The RH is calculated by comparing the dry and wet bulb temperatures using a psychrometric chart or a special slide rule. Manual psychrometers, called sling psychrometers, are swung by hand. Battery psychrometers are powered by a battery and a small fan and are more accurate than the sling psychrometer.

- **Humidity indicator cards** are impregnated paper strips that change color with RH and are small, inexpensive, and easy to read. The strips are impregnated with chemical salts that change color as the RH changes. The humidity color scale changes from deep blue (dry) through lavender to pink (humid) and back as the humidity fluctuates. The individual squares on the cards normally represent a 10% RH range and the area between blue and pink represents the total RH range. They provide an overview of the RH conditions, but are not very accurate. Although they are handy, inexpensive, and may last for several years, the information quality deteriorates as the paper and dyes deteriorate and are damaged with high RH ranges. Ultraviolet radiation or high levels of visible light may also



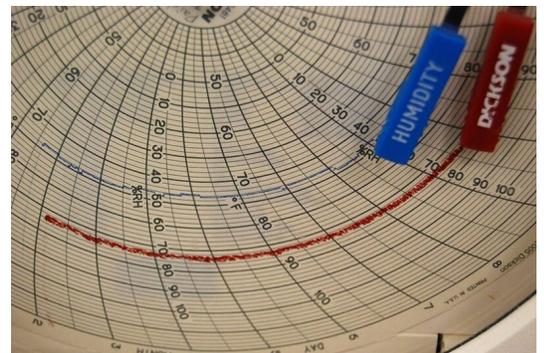
damage the cards and fade the dyes.

- **Thermometers** measure the temperature through measurement of expansion and contraction of a bi-metallic strip or a sealed tube containing an indicating liquid such as mercury. These are often used in combination with a hygrometer, e.g. the ARTEN Thermo-Hygrometer. These units need proper calibration to provide accurate data.
- **Mechanical hygrometers** measure the expansion and contraction of a hygroscopic element. They are often used in combination with a thermometer e.g. the ARTEN Thermo-Hygrometer. They vary widely in terms of accuracy and repeatability, and need regular calibration. They are useful for providing a general picture of the RH conditions.
- **Electronic thermo-hygrometers** store and recall minimum and maximum T and RH values. Although they are useful for measuring extreme conditions when no recording device is available, they cannot track changing values over time.

2) Recording devices: these can be either mechanical graphic based instruments or computer-based data loggers. Some of the most common re-

ording systems are described below.

- **Mechanical hygrothermographs** measure and record environmental conditions on paper charts with ink. Due to the graphic representation of the data, they provide instant feedback. For repeatable and accurate data the hygrothermographs must be calibrated regularly (every 3-6 months) and will need new charts each month or week. Analysis of the chart data is required when conditions are being charted over long periods of time. The most common charts run over 7 or 31 days, and may be rectangular or circular, depending on the type of equipment. These instruments used to be run by clock mechanisms which required regular winding for operation. Now they are battery operated or electric.
- **Data loggers are used in a wide range of monitoring options.** There are two types of data loggers. The first type is wired directly into a computer and delivers data directly to the data logger software. The



second type is portable and operates on batteries. It stores collected data for a specific period and time and then has to be physically taken to a computer where the recorded data is downloaded into the data logger software. The data recorded by data loggers is analyzed and manipulated by the software. Reports and trend logs can be prepared and printed.



Monitoring Visible (VIS), Infrared (IR), & Ultra-Violet (UV) Radiation



The radiation from an illumination source is divided into three categories: ultraviolet (wavelengths shorter than 400 nanometers), visible (from 400-760 nanometers), and infrared (wavelengths longer than 760 nanometers). In museum collections, photo-induced reactions initiated by light lead to deterioration. Damage to arti-

facts caused by illumination sources is both cumulative and irreversible. Some of the common light monitoring equipment is listed below.

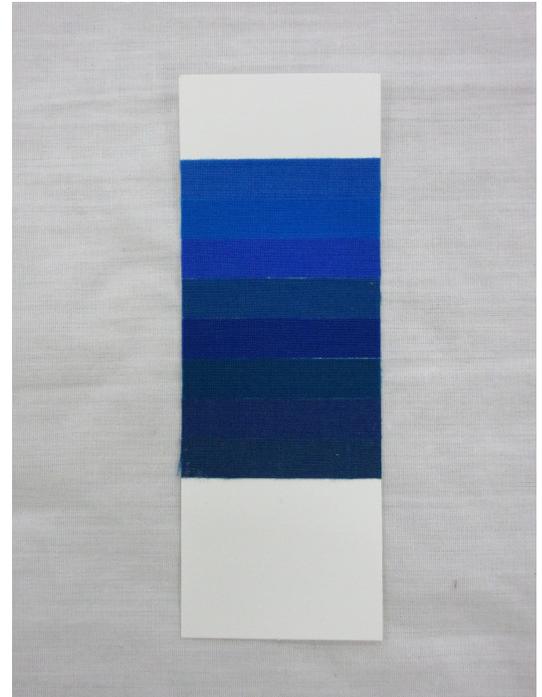
- **Visible light meters** generally measure visible radiation in foot-candles (fc) or lux (1fc = 10.76 lux). When choosing a light meter, it is important to use a meter that is sensitive enough to measure light levels as low as 25 - 50 lux with an accuracy degree of 10% or better.
- **Ultraviolet light meters** measure ultraviolet radiation in mW/lumen. Readings should not exceed 75 mW/lumen. Additionally, because the damage is done by the total amount of UV light falling on the object, it is useful to be able to measure this directly. The amount of UV light should be as little as possible and should not exceed 20 mW/m².
- **Infrared radiation** is monitored as heat and can be measured by IR ther-

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mometers, which read surface temperatures at a distance. Alternatively, temperature probes can be located on the surface of an object for short-term studies to determine if infrared radiation or heat in an environment is a problem.

When taking light readings with the light meter or the UV monitor, a standard set of procedures should be followed. The sensor on the instrument should be aimed so as to catch the light hitting the object directly, i.e. parallel to the object surface. Reading should not be taken in the shadows created by nearby items or the hand or body. Light readings should be taken at several points on the object. Before using light monitoring equipment, carefully read the manufacturer's instructions for operation and make sure you are choosing the right calibration mode.

- A useful passive tool for **monitoring light damage** is the **blue wool standard** card. (These standards have been adopted as ISO recommendation R 105 and British Standard BS1006: 1971.) Each blue wool standard card contains eight specially prepared dyed blue wool swatches. They are chosen so that standard dyed blue wool swatch number two is twice as sensitive to light fading as swatch number one and number three is twice as sensi-



tive as number two and so on through to number eight. The swatches are graded on a scale from one (fugitive) to eight (good light fastness). The swatches are glued onto card stock. Cards are placed in existing or potential exhibition or storage areas. They provide a relative idea of the amount of light damage occurring in a specific location over a specific period of time. The cards, along with a separate reference stored in the dark, are useful for long-term observations and comparative studies of fading. Users should be aware of the fact that once fading and color change appear on the standard card, the object has already received enough light exposure to be damaged as well.

- The Canadian Conservation Insti-

tute **Light Damage Slide Rule** is a tool that enables one to estimate the amount of damage potential from a specific light source, at a specific distance, for a specific period of time. By relating the intensity of light falling on an object from a specific type of lamp to the length of exposure time, the Slide Rule demonstrates the relative amount of damage that will result. It also indicates the differences in

the amount of damage if one or both of the damaging factors are reduced. The Slide Rule has two sides, one to calculate the light damage and the second to assist in selecting and using appropriate lamps for museum and other displays.

Air Quality Monitoring

No simple devices are available for measuring the presence of particulate and atmospheric pollution. The best method for **monitoring particulate pollution** is visual inspection. Observing locations where dust and debris can build up on surfaces of the collections, collection containers, display cases, storage cabinets, boxes, and dust covers will give you an idea of the amount and type of particulate pollution. The frequency of the need for cleaning, as well as, the size and type of soil (sooty, fibrous) might indicate the source of the pollution. Keeping samples of particulates can be useful for comparison.

Equipment for **monitoring** and distinguishing **gaseous pollutants** is very expensive. Readings are based on short-term collection and extraction of gas samples and do not provide information on long-term concentrations. For collection needs, it is important to

monitor the presence or absence of gaseous pollutants and to be able to detect changes in the air quality on a long-term basis. One way to detect the presence of aggressive gaseous pollutants involves exposing polished metal samples, known as corrosion coupons, to the air to be monitored. Changes in the appearance of the coupons indicate corrosion induced by atmospheric gasses. The speed at which the coupons corrode and the corrosion products formed can indicate the type of corrosive gas and the relative amount present. This method is known as passive sampling, and different methods for performing this type of testing have been developed. A good overview of atmospheric pollution monitoring is given in Grzywcz, Cecily M. "Air Quality Monitoring" in *Storage of Natural History Collections: A Preventive Conservation Approach*.



Consulting a Conservator

Consult a conservator if you have any questions concerning the environmental conditions of your collections. A conservator will be able to give you suggestions for temperature, relative humidity parameters and light levels specific to your needs. They can give recommendations for purchasing or renting monitoring equipment and can advise on proper storage materials and methods.

Additional Resources

American Institute for Conservation of Historic & Artistic Works. "Caring for Your Treasures." http://www.conservation-us.org/about-conservation/caring-for-your-treasures#.V_fIBsmvOnk

Canadian Conservation Institute. "Preventive Conservation and Risks." <http://canada.pch.gc.ca/eng/1447441965839>

National Parks Service. "Conserv-O-Grams." https://www.nps.gov/museum/publications/consveogram/cons_toc.html

National Parks Service. "NPS Museum Handbook, Part I: Museum Collections." <https://www.nps.gov/museum/publications/MHI/mushbkl.html>

North East Document Conservation Center. "Preservation Leaflets." <https://www.nedcc.org/free-resources/preservation-leaflets/overview>

Conservation Suppliers

Conservation Resources International

5532 Port Royal Road
Springfield, VA 22151
Toll free: (800) 634-6932
www.conservationresources.com
Archival housing/storage supplies, photographic supplies, general

Gaylord Archival

P. O. Box 4901
Syracuse, NY 13221-4901
Toll Free: (800) 448-6160
www.gaylord.com
General conservation supplies, housing supplies

Hollinger Metal Edge, Inc.

6340 Bandini Blvd
Commerce, CA 90040
Toll Free: (800)-862-2228
www.hollingermetaledge.com
Archival housing/storage supplies

Light Impressions

100 Carlson Road
Rochester, NY 14610
Toll Free: (800) 975-6429
www.lightimpressionsdirect.com
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P. O. Box 101
Holyoke, MA 01041
Toll Free: (800) 628-1912
www.universityproducts.com
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330 Morgan Ave
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