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ENVIRONMENTAL MONITORING EQUIPMENT OVERVIEW

This document provides basic information on common environmental monitoring methods and equipment for temperature, relative humidity, light, atmospheric particulate pollution and atmospheric gaseous pollution.

IMPORTANT FACTORS

1. Before addressing the logistical questions of how or what to monitor, it is important to know:
   - Why are you monitoring?
   - How will the data be used?
   - Who will do the monitoring?
   - Who will interpret the data?
2. The monitoring equipment should be chosen to capture the information needed.
3. The equipment for permanent or long term monitoring of environmental conditions is different than the equipment for instantaneous monitoring.
4. The equipment will need to be calibrated or replaced periodically!
5. 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 moistened 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 psychometric 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 bimetallic 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 recording 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 than 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), AND 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 museum artifacts 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% and better.

- **Ultraviolet light meters** measure ultraviolet radiation in μW/lumen. Readings should not exceed 75 μW/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/m^2.

- **Infrared radiation** is monitored as heat and can be measured by IR thermometers, 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 8 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 sensitive as number two and so on through to number 8. The swatches are graded on a scale from 1 (fugitive) to 8 (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 Institute **Light Damage Slide Rule** is a tool that enables one 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 in 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 ides 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.

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