NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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Using A Psychrometer To Measure Relative Humidity

Monitoring and controlling relative humidity and temperature in areas where museum collections are stored and exhibited are essential to preventive conservation. Measuring temperature to determine relative humidity (RH) can be accomplished with a psychrometer, a relatively simple and reliable instrument when properly used. The psychrometer is used to make spot readings, to take readings in areas where there are no hygrothermographs or other monitoring devices, and to calibrate hygrothermographs and hygrometers. (See *Conserve O Gram* 3/2.)

There are two types of psychrometers: the sling psychrometer and the aspirating psychrometer. The sling psychrometer is a hand-operated device, while the aspirating psychrometer is usually battery powered, although wind-up models exist. These instruments are accurate to ±2% RH when properly maintained and operated by trained and practiced users.

The Sling Psychrometer

The advantages of this instrument are its simple design, low cost, and portability. The sling psychrometer is constructed of two thermometers secured to a frame. The frame either pivots on a handle or is attached to a handle by means of a chain. A cotton wick, which is wetted prior to use, covers the bulb of one of the thermometers. This thermometer is referred to as the *wet bulb*, while the other thermometer is termed the *dry bulb*. The dry bulb measures room temperature. The thermometers may be graduated in degrees Celsius or degrees Fahrenheit. By using a psychrometric chart or slide rule to compare the dry bulb (room temperature) reading to the wet bulb reading, the relative humidity is determined. Sling psychrometers are available in various sizes ranging from pocket-size models to larger units approximately a foot in length. The longer the thermometer, the smaller the increments, and the more accurate the reading.

The sling psychrometer, though simple and reliable, can be incorrectly used; however, with proper instruction and practice, the user can become adept at measuring relative humidity.

Using the Sling Psychrometer

- Prior to use, read both thermometers. When they are dry, they should register the same temperature. Otherwise, results may be inaccurate.

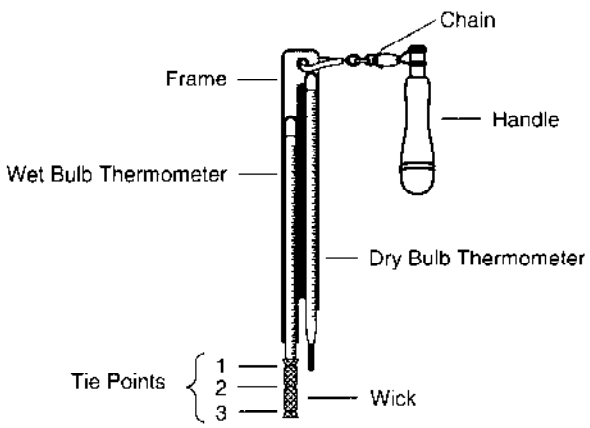
- Thoroughly saturate the wick on the wet bulb using distilled or deionized water only. Tap water may contain salts and other contaminants that could prevent uniform evaporation, thus interfering with an accurate reading.

- Some wick materials may contain sizing that interferes with proper wetting. It is advisable to wash a new wick in distilled water to remove the sizing before installing.

- Tie the wick securely with string or white sewing thread to the bulb while wet to allow it to conform to the bulb while drying. First, tie the wick onto the stem near the bottom of the thermometer; second, tie the wick at the top of the bulb; third, stretch the wick over the bulb and tie it firmly below the bulb.

- Avoid touching the wick with bare fingers. Oils and dirt that accumulate on the wick from handling or improper storage will result in erroneous readings. Change the wick when it becomes dirty.

- When using the psychrometer to calibrate another instrument, e.g., a hygrothermograph, take readings as close to the instrument as possible. Patches of sunlight and conditions away from the instrument may be different from nearby conditions.



- Ensure that there is sufficient space to swing the psychrometer safely.

- Droplets of water may fly off the wick as it is whirled. Use caution that the droplets do not land on surrounding museum objects.

- Because body heat and body moisture may affect the reading, hold the instrument at arm's length when swinging it.

- Whirl the instrument rapidly for at least one minute, but no more than three. The dry bulb thermometer simply reads the temperature of the surrounding air. However, as the wet bulb passes through the air, water evaporates from the wick causing the wet bulb thermometer to read a lower temperature than the dry bulb. This happens because evaporation has a cooling effect on the wet bulb thermometer. The temperature of the wet bulb thermometer will decrease as the instrument is swung until the moisture content of the wet wick reaches equilibrium with that of the surrounding air.

- Whirl the psychrometer until the wick achieves equilibrium with the surrounding air, otherwise the resulting wet bulb temperature will be too high and the relative humidity determination incorrect.

- Use caution that the psychrometer is not whirled too long. This will cause the wick to dry out and the wet bulb temperature to rise from its minimal reading, thus resulting in an erroneous relative humidity reading.

- As soon as the swinging is stopped, read the thermometers. Always read the wet bulb temperature first, since it will begin to rise once the instrument is stopped.

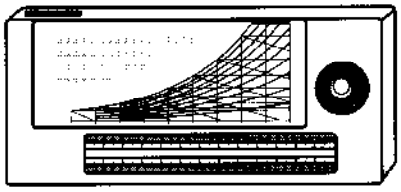
- The readings from the wet bulb and the dry bulb are then used to determine the relative humidity from a psychrometric chart or slide rule that is provided with the instrument. Readings taken from charts are generally more accurate than those from a slide rule because the slide rule introduces another interpretive factor. Some charts require that the wet bulb temperature first be subtracted from the dry bulb temperature. Other charts allow for direct comparison of the wet bulb and dry bulb temperatures. See NPS *Museum Handbook*, Part I (Rev 9/90), Chapter 4, for guidance on using the psychrometric chart. ***NOTE:*** Inaccurate RH measurements will result if calculations are not adjusted for changes in atmospheric pressure due to high altitude.[1]

- A minimum of three successive readings are advised to ensure accuracy. Inconsistent readings may indicate procedural error.

The Aspirating Psychrometer

The aspirating psychrometer is a mechanized unit, compact and easily transportable, that functions much like the sling psychrometer. The typical battery powered model will be discussed here. A fan inside the unit circulates a steady stream of air over the wet bulb. Advantages of the mechanized device are accuracy, less chance for procedural error, and usefulness in confined areas where there might not be space to whirl a sling psychrometer. Some models are equipped

with a lamp for illuminating the thermometers in dark areas. Body heat and moisture are less likely to affect the aspirating psychrometer.



Using the Aspirating Psychrometer

- The aspirating psychrometer is prepared for use in much the same way as the sling psychrometer. Thoroughly saturate the wick on the wet bulb with distilled or deionized water, in this case using a dropper. A small dropper bottle is often provided with the instrument.

- Refer to the sling psychrometer guidelines for how to handle, wash, and replace the wick.

- Take the reading as close to the instrument to be calibrated as possible. After the psychrometer is turned on, check the reading of the wet bulb after 30 seconds and then every 10-15 seconds as it descends. After 1½-2 minutes the wet bulb temperature should appear constant. Equilibrium has been achieved.

- Immediately turn off the psychrometer and take the readings from both thermometers, wet bulb first. Use caution that the psychrometer is not allowed to run too long, as this will cause the wick to dry out and the wet bulb temperature to rise from its minimal reading, resulting in an erroneous relative humidity reading.

- Determine the relative humidity by reading the chart or slide rule provided with the psychrometer.

- Although the aspirating psychrometer is recognized as the more accurate of the two types, a second reading is advisable, especially if the user is inexperienced with the instrument.

- Check the batteries in the unit periodically and replace them as needed. Weak batteries can affect fan speed and thus the accuracy of the reading. The batteries should be removed from the unit when it is not going to be used for a long period.

Further discussion on the relationship between temperature and relative humidity, and information on National Park Service standards and procedures for monitoring and controlling relative humidity, are available in the NPS *Museum Handbook*, Part I (Rev 9/90), Chapter 4; see the applicable appendix for a discussion of the effects of temperature and relative humidity on specific types of objects and materials found in museum collections. Guidelines for meeting NPS standards for temperature and relative humidity are found in Special Directive 80-1 (revised), "Guidance for Meeting NPS Preservation and Protection Standards for Museum Collections."

Note

1. Psychrometers and psychrometric charts are intended for use within a certain range of atmospheric pressure. High altitude, above 900 m (approx. 3,000 ft), will directly affect the accuracy of the RH reading unless a pressure correction formula is applied or a psychrometric chart or slide rule for the appropriate pressure is used. For further information see Ann Hitchcock and Gordon C. Jacoby, "Measurement of Relative Humidity in Museums at High Altitude," *Studies in Conservation* 25 (1980): pp. 78-86. (Copies are available to NPS sites from Curatorial Services Division, Harpers Ferry office.)

Reference

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