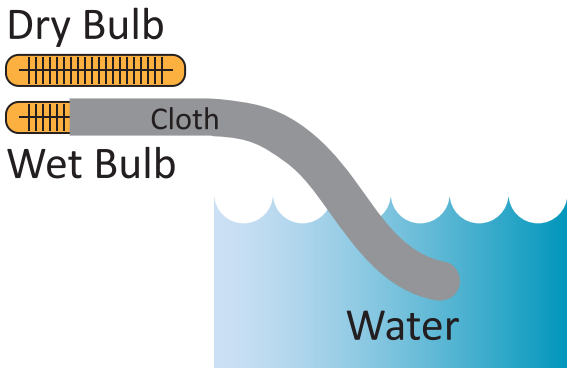
The Wet Bulb/Dry Bulb Technology (psychrometer)

Introduction

Wet- and dry-bulb temperature measurement is a commonly used and widely accepted technique for controlling relative humidity in environmental chambers. ASTM standard E 337-02 (2007) reviews in great detail the wet- and dry-bulb technique. According to this standard, the accuracy which can generally be expected in the case of a ventilated dry- and wet-bulb device is in the range of 2 to 5 %RH.

The accuracy generally achieved in the case of a ventilated dry- and wet-bulb device is acceptable in the case of environmental chambers where both temperature stability and uniformity are specified to within 1 degree C, because an uncertainty of 1 degree C at 95% confidence k=2 on temperature automatically results in an uncertainty of 5 to 6 %RH at 95% confidence k=2 at high humidity. However, some chambers that are specified to within 0.3-0.5 degree C permit and require better humidity control.



Pros and Cons of the Technique

While the wet- and dry-bulb measurement technique has a sound theoretical basis, the problem is that it's simple only in appearance, leading many users to forego the caution and precision necessary to achieve accurate results. We'll explore the most common overlooked requirements and other problems below.

Pros:

- Simple and fundamental measurement
- Low price
- Good stability if operated correctly and consistently
- Tolerates condensation without damage

Cons:

- High uncertainty
- Requires training and skill to use and maintain
- Results must be calculated
- Requires a large air sample
- Process adds water vapor to the sample
- Many variables cause increased uncertainty

Disregarding the Basic Requirements of the Technique

In practice, there is a tendency to disregard some of the following requirements of the wet- and dry-bulb technique:

- Psychrometer coefficient: This is used to establish the psychrometric chart that converts wet- and dry-bulb temperature readings into relative humidity. This coefficient has to be determined for each specific design of psychrometer and in particular for each design of the wet-bulb.
- Barometric pressure: Psychrometric charts are usually valid at the "standard" barometric pressure and require a correction at other pressures.
- Matching of the thermometers: The wet-and dry-bulb thermometers should not only be accurate, but they should also be matched so as to minimize the error on the temperature depression readings (or temperature difference).

Interferences During Measurements

In an environmental chamber, errors of measurement can result due to poor choice in the mounting location of the wet- and dry-bulb thermometers. This is the case when the thermometers are installed too closely to a source of moisture (water supply for the wet-bulb, steam injector, etc.). Errors may also occur when the thermometers are too close to the walls of the chamber.

Make sure the thermometers are mounted at a location where conditions are fairly representative of the average conditions inside the chamber.

Poor Handling and Maintenance

Proper handling and frequent maintenance are major requirements of the wet- and dry-bulb technique. Poor measurement is frequently a result of the following:

Dirty Wick

The wick should never be directly touched with fingers. A new wick should be flooded with distilled water so as to wash away any contamination. In an environmental chamber, the wick is continuously ventilated and tends to get dirty after some time. From a maintenance standpoint, this is probably the most concerning aspect of the dry- and wet-bulb technique.

Wick Not Properly Pulled

The wick should sufficiently cover the wet-bulb thermometer so as to minimize errors due to heat conduction along the stem of the thermometer. The wick must also be in close contact with the surface of the thermometer.

Wick Not Really Wet

A wick that is too old or that has been left to dry out may not supply enough water. A properly wetted wick should have a glazed appearance.

Never directly touch a wick. Flood a new wick with distilled water to wash away contamination. If the wick doesn't look glazed, it's too dry.

Typical Accuracy of the Technique

Most of the problems mentioned above have a direct influence on the accuracy of the wet- and dry-bulb technique. Specifically, most errors show up on the wet-bulb temperature and the temperature depression measurement.

Considering just the uncertainties on temperature measurement and psychrometric coefficient, ASTM Standard #E 337-02 (2007) indicates that the range of errors for ventilated wet- and dry-bulb devices goes from 2 to 5 %RH.

An error of 2 %RH corresponds to an error of 0.1C on temperature depression and 0.2C on dry-bulb temperature, while an error of 5 %RH corresponds to an error of 0.3C on temperature depression and 0.6C on dry-bulb temperature. The most important factor is the accuracy of temperature depression measurement.

Taking into account the many other potential sources of error, the effective accuracy of the wet- and dry-bulb devices installed in most environmental chambers is no better than 3 to 6 %RH. The error tends to be the largest at low humidity and low temperatures where readings are usually too high.

Operational Limitations of the Wet- and Dry-Bulb Technique

In addition to limitations regarding accuracy, the wet- and dry-bulb technique has other limitations which may be important in the case of environmental chambers:

- No measurement below the freezing point.
- Adds water to the environment (a problem with chambers operating at low humidity).
- Sluggish response and therefore, poor control characteristics. The wet-bulb temperature reacts slowly to changes in humidity because of the mass of the wet-bulb thermometer and wick. Slow reaction to changes in temperature is due to the time required by the water supply to adapt.
- Requires a water supply and, therefore, can support the growth of micro-organisms.
- Calibration can be difficult.