GREYSTONE
ACCURACY BY DESIGN

Technical Tidbit
Measuring RH
TT-040

Relative Humidity (RH) is the ratio of the actual vapor pressure of water in the gas mixture to the vapor pressure of water in saturated air at the same temperature.

Dew Point is the temperature of condensation or the temperature at which the partial pressure of the water vapor contained in the gas mixture equals the saturation vapor pressure.

Almost all air contains some moisture, the air is said to be saturated when it contains all the vapor it can hold. The actual amount of water vapor that air can hold is governed by the temperature of the mixture. At low temperatures very little moisture is required to cause saturation, while much more moisture is required to cause saturation at higher temperatures. Thus a sudden drop in temperature will cause a mixture to have a much higher RH.

At saturation, a condition exists where the wet bulb temperature, the dry bulb temperature and the dew point temperature are equal. This only occurs at the mixture saturation point.

-Methods of measuring RH

Wet/Dry Bulb Method (Psychrometers)

These units are quite common because they are very easy and inexpensive to build. These devices utilize two thermometers, one which measures the "dry bulb" or ambient air temperature and the second which measure "wet bulb" or the temperature depression caused by the heat loss due to evaporation. The amount of temperature depression caused by evaporation determines the moisture content of the aspirated air sample and RH can be calculated using both the wet and dry bulb temperatures.

The accuracy of this method depends on thermometer accuracy, cleanliness of the wet bulb wick, use of distilled water, sufficient and constant air flow rate, proper thermal coupling of the wick to the thermometer, correct and immediate reading of temperatures, correct use of tables, data corrected to actual barometric pressure, etc.

Most errors resulting from the above factors tend to restrict the lowering of the wet bulb temperature and usually this method will indicate a higher RH than actual. Also, errors tend to become larger at low RH because moisture is evaporated from the wick at such a high rate that inadequate wetting of the wick occurs which again results in a positive error.

According to the American Society for Testing and Materials (ASTM) in document E337-84 titled "Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)" the following is found under section 4.3.2 on Sling Psychrometers:
"Read the thermometers with the necessary precision, obtaining the dry-bulb temperature with an overall uncertainty of ±0.6 C or better, and the temperature depression with an overall uncertainty of ±0.3 C or better for an uncertainty in the relative humidity of ± 5 %RH."

Also in section 10.3.1 on reading the Psychrometer:
"Under ordinary conditions, an approximate 0.15 C error in wet-bulb depression results in a 1 % error in relative humidity." For example, at a measured condition of 50% RH at 70 F, a thermometer error of only 1 F could result in the actual condition being 44 to 56% RH.

Electronic RH Sensors

These electronic sensors typically exhibit a change in impedance (capacitance and resistance) with changes in humidity. An electronic circuit must be utilized to read the sensor output and convert the impedance signal to a scaled RH output. The circuit must also be able to compensate the sensor for changes in temperature.

The accuracy of the electronic RH sensors depends on several factors; proper circuit design, initial calibration, electronic temperature compensation, long term drift of the sensing element, stability of the sensing element in actual environments, hysteresis effects, etc.

Errors occurring in electronic sensors usually require a re-calibration of the entire unit and can either be done in a proper calibration chamber or, to some extent, in the field.

Since electronic sensors are not primary methods of measuring relative humidity, they must be calibrated using a primary source such as a chilled mirror sensor and the accuracy of the device must also include any errors associated with the reference as a "degree of uncertainty".

Dew Point Hygrometers

The dew point hygrometer, or chilled mirror, is generally considered the best method of measuring dew point or RH. The hygrometer actually creates a dew point condition by lowering the temperature of a mirror surface until water condenses on it and then measures the temperature at which this occurs; the dew point temperature. If the sampled air temperature is also measured then RH can be electronically calculated.

Accuracy of chilled mirror type sensors are usually specified as a plus or minus temperature variation for both the dew point and the dry bulb temperatures. Calculation must be done to determine worse case RH accuracy.

Sources of error include mirror contamination, accuracy of the temperature measurements, electronic conversion errors, correct and constant air sampling, proper filtering, ensuring no artificial pressure gradients exists, etc.

The errors associated with this type of sensor are usually positive and are typically larger at higher RH levels.

For example, at a measured condition of 70% RH at 20 C, the actual condition may be 67.45 to 72.66% RH if the dry bulb temperature has an error of 0.6 C even if the dew point is measured correctly. This error will become larger with an error in reading the dew point temperature.