Report

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Calibration of Relative Humidity Sensors using a Dew Point Generator

Milo Brooks, February 2010

A relative humidity sensor can be calibrated using a dew point generator to continuously supply an air stream of known constant humidity and a temperature chamber to control the dew point and ambient temperature.

Relative humidity is the ratio of the current amount of water vapour in the air to the maximum amount of water vapour the air can contain at that temperature (Saucier, 2003). *Partial vapour pressure* is the pressure of the water vapour in a given parcel of air. *Saturation vapour pressure* is the maximum possible pressure of water vapour in that same parcel of air before condensation occurs (Saucier, 2003). Relative humidity can be determined from the partial vapour pressure and saturation vapour pressure of the air using the formula:

$$\text{Relative humidity} = \frac{\text{Partial Vapour Pressure}}{\text{Saturation Vapour Pressure}} \times 100\%$$

The *dew point* is the temperature at which the moisture in the air, when cooled, will begin to condense (Institute of Measurement and Control, 1996). The partial vapour pressure can be determined from the dew point and the saturation vapour pressure can be determined from the ambient temperature using the Goff-Gratch formulation (Wikipedia, 2009). A relative humidity sensor can then be calibrated by reading the sensor for two fixed dew points.

Laboratory calibration procedure

The laboratory calibration procedure at CEH Wallingford uses a dew point generator, dew point sensor, temperature chamber, thermometer and voltmeter to generate two fixed dew points. During the calibration procedure, the relative humidity should always be less than 80 % to avoid saturating the instruments (McNeil, pers. comm. 2010).

The calibration equipment consists of a dew point generator (LI-COR LI610, Figure 1), a dew point sensor (Michigan Instruments Series 3000, Figure 2), a Temperature Chamber (Townson and Mercer, Figure 3), an precision thermometer (ASL F200, Figure 4), and a voltmeter (Fluke 27, Figure 5). The voltmeter is connected to the relative humidity sensor to be calibrated. The relative humidity sensor, the dew point sensor and the thermometer are inserted into a sealed glass tube T-Junction in the temperature chamber as shown in figure 6. The dew point generator feeds air via a plastic tube into the T-junction. A diagram of the equipment connections is shown in figure 7.

Figure 1: LI-COR LI610 dew point generator

Figure 2: Michigan Instruments Series 3000 dew point sensor

Figure 3: ASL F200 precision thermometer

Figure 4: Fluke 27 voltmeter

Figure 5: Sealed glass T-junction

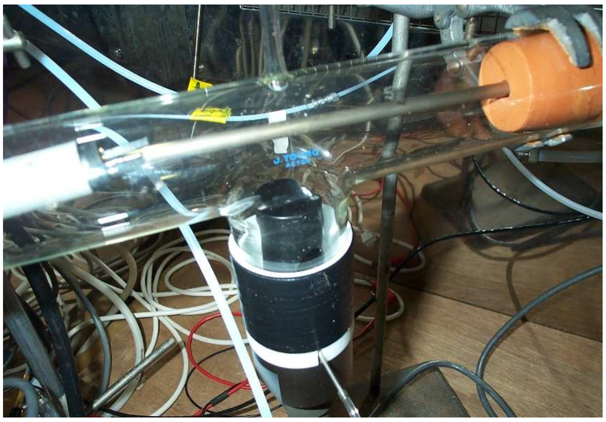
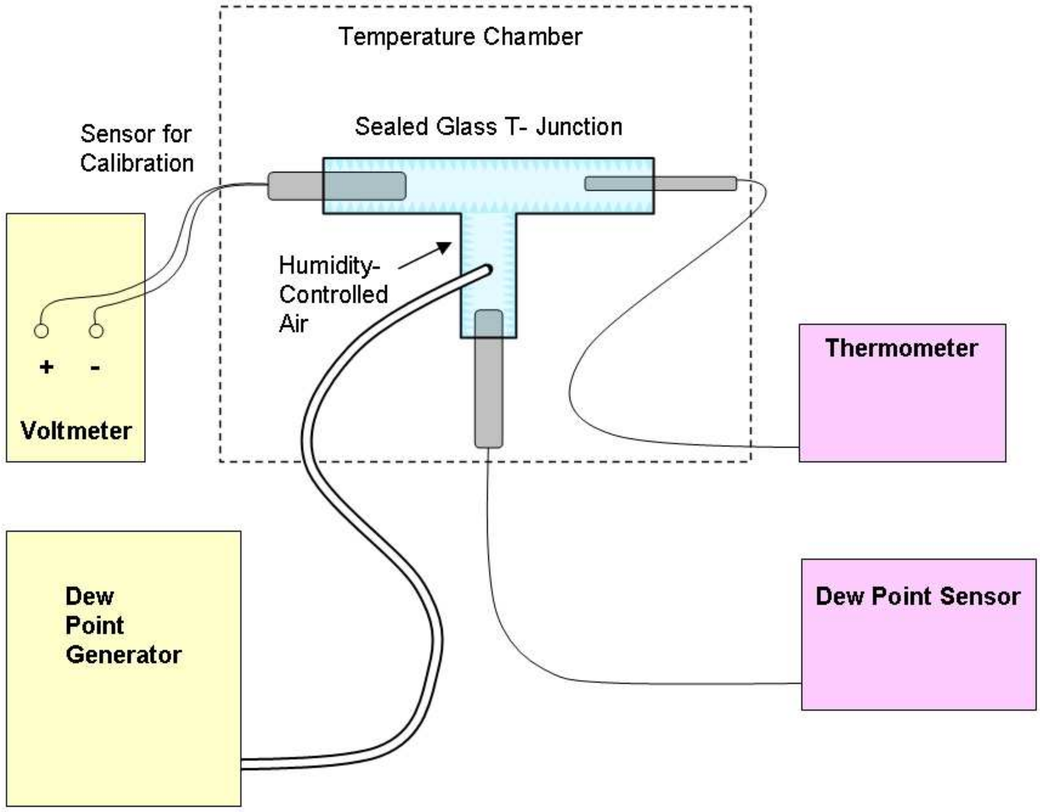


Figure 6: Townson and Mercer temperature chamber.

Figure 7: Equipment connection diagram



The dew point generator is first set to a dew point lower than the ambient temperature. For a temperature chamber setting of 20°C, a dew point of 15°C is used. The precise dew point of the air in the T-Junction is read by the dew point sensor. The dew point is used to determine the partial vapour pressure and the ambient temperature is used to determine the saturation vapour pressure using the Goff-Gratch formulation. The relative humidity is then calculated from the partial vapour pressure and the saturation vapour pressure. The process is repeated for a dew point of 10°C and the two points are interpolated to express the relative humidity as a function of the sensor voltage.

$$y = mx + b$$

where x = voltage reading of sensor, y = relative humidity, and

$$m = \frac{y_1 - y_2}{x_1 - x_2} \qquad b = \frac{y_2 x_1 - y_1 x_2}{x_1 - x_2}$$

where

x_i = voltage reading of multimeter for the i^{th} dew point setting

y_i = calculated relative humidity for the i^{th} dew point setting

For example, when calibrating a relative humidity sensor, the following readings were taken:

Table 1: Temperature chamber, dew point and sensor voltage readings.

Temperature chamber (℃)	Dew Point (℃)	Sensor voltage (V)
20.8	14.3	0.727
20.8	9.98	0.541

The saturation vapour pressure, partial vapour pressure and relative humidity were calculated as shown in Table 2.

Table 2: Calculated saturation vapour pressure, partial vapour pressure and relative humidity.

Saturation Vapour Pressure (mb)	Partial Vapour Pressure (mb)	Relative Humidity (%)
24.6	16.397	66.7
24.6	11.98	48.7

The multiplier *m* and offset *b* were computed as follows:

$$m = \frac{66.7 - 48.7}{0.727 - 0.541} = 96.8 \qquad b = \frac{(48.7 \times 0.727) - (66.7 \times 0.541)}{(0.727 - 0.541)} = -3.7$$

The relative humidity as a function of the sensor voltage was therefore

$$y = 96.8x - 3.7$$

where x = voltage reading of the sensor (V), and y = relative humidity (%)

Conclusion

A relative humidity sensor can be calibrated by generating known dew points with a dew point generator. The corresponding relative humidities of the dew points can be determined and interpolated to express relative humidity as a function of the sensor voltage.

References

Institute of Measurement and Control, 1996. *A Guide to the Measurement of Humidity*. London: HMSO.

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Wikipedia, 2009. *Goff-Gratch Equation* [Online] http://en.wikipedia.org/wiki/Goff-Gratch_equation [Accessed 4 February 2010].