Calibration and verification of relative humidity (RH) sensors using V-Gen

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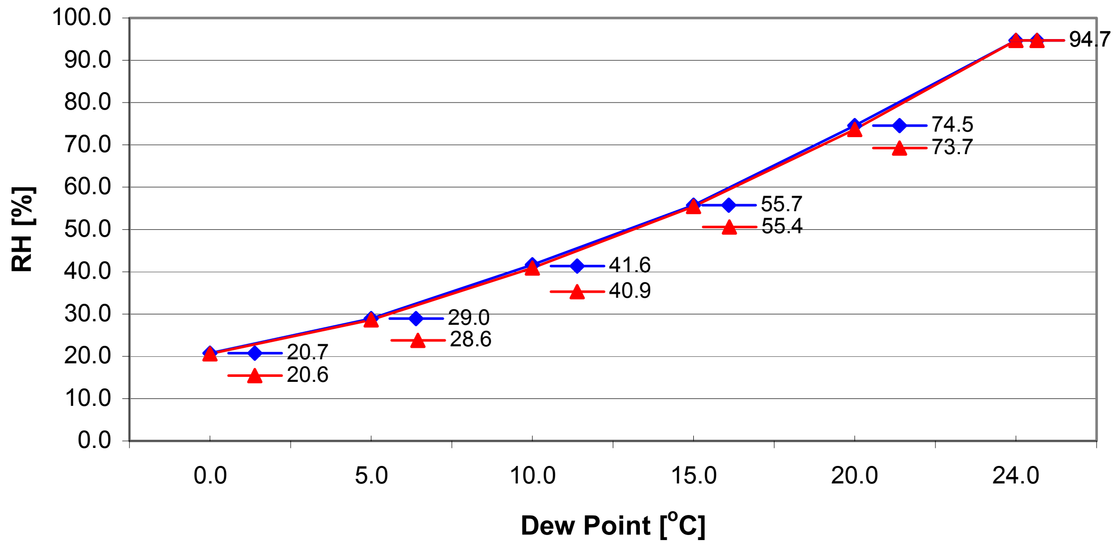
High quality RH probes, due to their improved technology, small size, and low cost, become more ubiquitous in relative humidity research and quality control. However, the provided few points of calibration data around room temperature, naturally raise a question: How the device will perform at different temperatures? Additional questions about RH probes hysteresis and changes with time are posed. The main practical problem in answering those questions is to generate humidity stream with high stability and accuracy in an economical way that will be available to majority of RH probes users.

To address many RH needs, a versatile Dew Point / RH Generator has been designed. The fundamental Two-Temperature principle is used in V-Gen as the main mode of vapor generation. The stream is 100% saturated with water vapor (Dew Point) when it leaves the condenser that is maintained at user selected temperature, T_{DP}. The stream is delivered to an experimental setup via heated transfer line. The transfer line is normally maintained at saturator temperature (a few degrees above the condenser temperature) to avoid condensation problems. Since the stream leaving the transfer line will most likely be at different temperature than the temperature of user calibration chamber, it is highly recommended to equilibrate the stream to the calibration chamber temperature, T_C, for calibration or verification purposes. Therefore, in a properly designed two-temperature setup, the accuracy of measurements depends mainly on the measurements of two temperatures, T_{DP} and T_C .

Having such setup prepared one can carry out variety of tests to answer the posed questions. To illustrate some of the possibilities we present three runs at different conditions using an RH probe from a leading manufacturer. The probe has been subjected a few times to liquid water at 60˚C in prior experiments and its last factory calibration was dated March 13, 2002. The probe was mounted inside of an aluminum block and the fixture with an equilibration coil was fully enclosed inside of a specially build chamber. The temperature of the chamber was measured using NIST traceable precision glass thermometers with 0.1˚C divisions. The set flow rate of air was measured using bubble flow meter and maintained constant at 116 cc/min throughout the experiments.

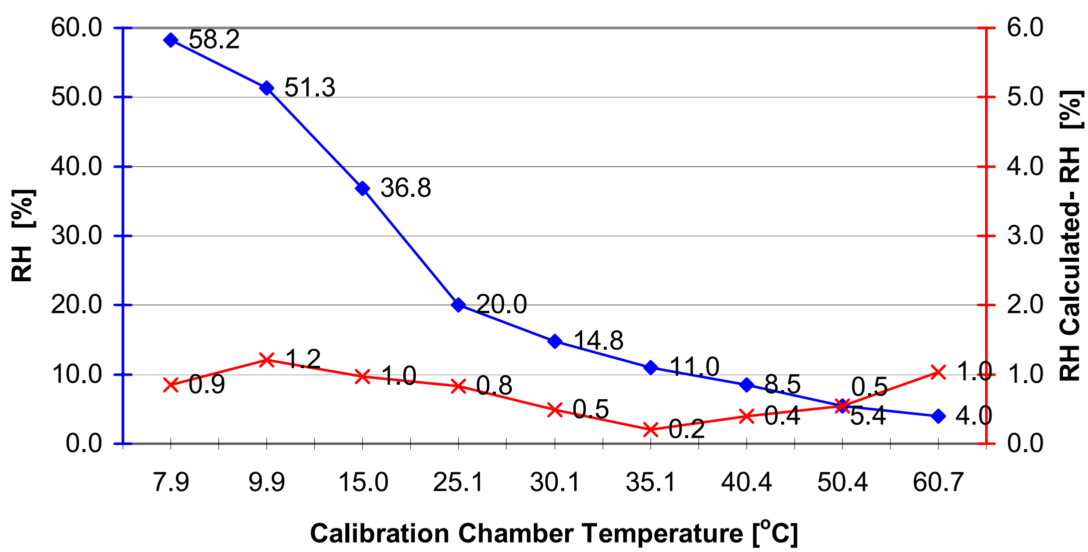
In the first test the calibration chamber temperature was maintained at 25 ˚C with ±0.2˚C variability throughout the experiment. The dew point temperatures were set to 0.0, 5.0, 10.0, 15.0, 20.0, 24.0, and back to 20.0, 15.0, 10.0, 5.0, and 0.0 ˚C. RH probe response was recorder 25-30 min after changing the dew point temperature. Fig. 1 shows response of the RH sensor to the dew point values in the increasing and decreasing direction. The small lagging effect can be noticed throughout the range with almost full recovery at the starting point.

Fig.1. RH probe hysteresis at 25 °C



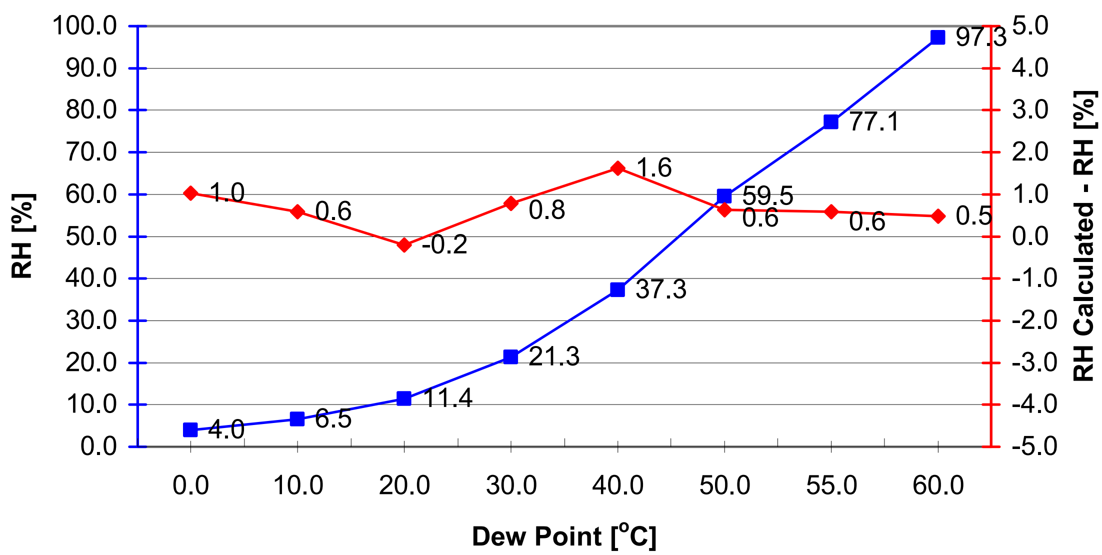
In the second type of experiment the dew point temperature can be set at a specific value (0.0 ˚C in this run) and the temperature of the calibration chamber can be varied from low to high temperatures. Fig. 2 shows response of the probe at different calibration chamber temperatures with sufficient time allowed for thermal equilibration at each step. The relative humidity values corresponding to dew point of 0 ˚C were calculated for the several chamber temperatures. The differences between the probe response and the calculated values are also presented on the figure.

Fig. 2. RH probe response vs. T at constant Dew Point = 0.0 °C



In the third type of experiment the calibration chamber was maintained at 61˚C with ±0.3˚C variability throughout the experiment. Fig. 3 shows response of the probe at different dew point settings. Again, the relative humidity values corresponding to different dew points were calculated at the measured chamber temperatures. The differences between the probe response and the calculated values are presented on the figure.

Fig. 3. RH probe response vs. Dew Point at 61 ^{o}C



The V-Gen instrument allows calibration or verification of RH probes at conditions that are application specific. An array of calibration points, that might not be readily available otherwise, can be incorporated in application software for corrections of RH probe values. Calibration or periodical verification can be carried out in situ, and without unnecessary downtime and cost.