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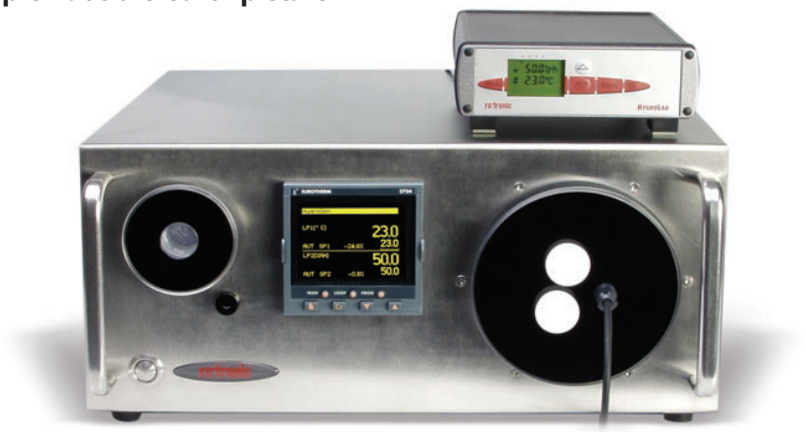
BY **DAVID P. LOVE**

Examining Uncertainty

Analysis of temperature and humidity variables and values provides a clearer picture



From saturated salt solutions to humidity generators, there are many different ways to generate a humidity value for calibration. In order to define a method for your humidity calibrations and to properly evaluate the number of commercial solutions available on the market today, there are several key areas requiring close examination.

LAB ANALYSIS (CONT'D)

This article will broadly review the issues presented when using a commercial humidity generator. These are available from a variety of manufacturers. The principles used to generate the precise humidity environment vary; two pressure generators, two temperature generators, and split flow are the most common. Within each group the instruments may appear similar. There are, however, vast differences in the accuracy and quality of the instruments available in each category. The critical question is how to tell the difference between a good and a poor instrument. Are the lower cost generators really as good as the more expensive generators? This brief review will provide a framework for facilitating the decision process required to decide which humidity generator is right for your requirements.

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Mainstream Maladies

Let's look initially at the problems associated with the humidity generator itself. In order to properly calibrate a humidity sensor, the reference generator must provide a very stable and uniform humidity and temperature environment. This is critical for two very basic reasons. First, small temperature gradients throughout the chamber can result in significant errors in the measured relative humidity values. A temperature gradient inside the calibration chamber of as little as ±0.1°C can cause errors of more than ±0.5 percent relative humidity (RH) at higher humidity levels. While temperature differences within the chamber will lead to problems with the humidity level, the design of the instrument can also lead to gradients in the actual humidity in the chamber. Therefore, it is also critical to examine the homogeneity of the humidity values in the chamber. Poor airflow design, the previously mentioned temperature effects, and inefficient chamber design can lead to uneven humidity values.

The second reason a uniform and stable chamber is critical is the response time of the instrument under test to real changes in humidity and temperature. These instruments move rather slowly in response to environmental changes (primarily due to their physical mass). Therefore, if the environment never truly stabilizes, then the instrument will never come to equilibrium with the environment. In this situation, an accurate calibration is close to impossible.

If the stability and uniformity of both humidity and temperature inside the chamber are critical to proper calibration then it also makes sense to review the contribution of the instruments that measure these parameters to the overall uncertainty of the calibration.

When you are serious about the quality of the calibrations you are performing you will want to use reference instruments separate from the humidity generator control instruments to provide the reference values. This is due to that fact that laboratory grade temperature and RH reference instruments will provide better levels of uncertainty than the control instruments used on most if not all humidity generators.

On the temperature side, a high quality reference PRT co-located with the instruments under test will help minimize any errors. The manufacturer of the temperature reference should provide you with all of the data needed to calculate the uncertainty of your calibrations. To maintain consistency of your calibrations over time, it is critical that the reference thermometer is always at the exact same location. If the reference thermometer is not in the same location the changes in the temperature reading may be small; however the focus is to minimize all uncertainties, no matter how small.

Choice Conundrum

The right instrument to use for the reference humidity value can be a more confusing choice, for there are several

Table 1. Uncertainty of RH Percentage Inside the Hygrogen (at 20 °C)

Humidity	Reference Temperature Uncertainty ó % RH	Chilled Mirror Uncertainty ó % RH	Dew Point to RH Conversion Algorithm ó % RH	HydroGen ó % RH	Expanded Uncertainty 95% Confidence (k=2) % RH
80%	0.190	0.367	0.001	0.073	0.84
50%	0.107	0.244	0.001	0.125	0.59
35%	0.071	0.177	0.002	0.036	0.39
10%	0.027	0.088	0.014	0.048	0.21
5%	0.017	0.048	0.007	0.044	0.14

Instruments included in the chilled mirror uncertainty analysis include the following:

- Temperature indicator Chub-E4, mod. 1529-R (Hart Scientific)
- Platinum Resistance Thermometer (PRT), mod. 5614 (Burns Engineering)
- Dew point indicator, mod. M1 (General Eastern)
- Chilled mirror sensor mod. 1311DR-SR (General Eastern)

The development of this data follows ANSI/NCSL Z540-2-1997 (R2002) standard regarding the expression of uncertainty in measurement. Please refer to this standard for a more detailed discussion on uncertainty analysis if needed.

different types of methods used as a humidity control instrument: Chilled mirrors, pressure and temperature measurements as well as capacitive humidity sensors. Which instrument is used to control humidity is less important than which instrument is used as the reference humidity instrument. It is generally accepted that a reference chilled mirror will provide an excellent level of uncertainty in a humidity calibration.

As with the temperature reading, the manufacturer of the chilled mirror should be able to provide you with all the data necessary to calculate the uncertainty of the reference instrument. If the accuracy of your calibrations is a bit looser, say ±2.0 percent or higher, the use of a high quality RH instrument based on a capacitive sensor can be used. But, it is critical to note here that the sensors should be specialized for calibrations at one point only. This is due to the negative effect sensor hysteresis has on the accuracy of the capacitive sensor.

Chamber stability, chamber uniformity, and reference instruments uncertainty have all been discussed regarding their impact on your instrument choice. But what can be done with all this information? It must be pulled together in a total study of the uncertainty of the calibration system. A summary example of this is shown in Table 1. Each column of data has a specific uncertainty analysis which generated the values shown in the table. This data was then summarized into one standard using common statistical methods.

In order to properly evaluate a calibration instrument for use in your calibration lab it is very important to review the data provided by the instrument manufacturer. This information must include specifications addressing the stability and uniformity of the calibration chamber. The specifications must also address both temperature and humidity variables. This data should include analysis at the actual temperatures and humidity values you plan to use. Due to mechanical design, controller performance, temperature control, and the humidification system, performance of the various generators on the market today can vary widely over the stated operating range of the unit.

Look at all the facts, compare the key uncertainty data, address your individual calibration needs, and then decide which instrument is right for your calibration laboratory. ■

David Love is vice president of marketing and sales of Rotronic USA (Huntington, N.Y.). Reach him at 631-427-3898.

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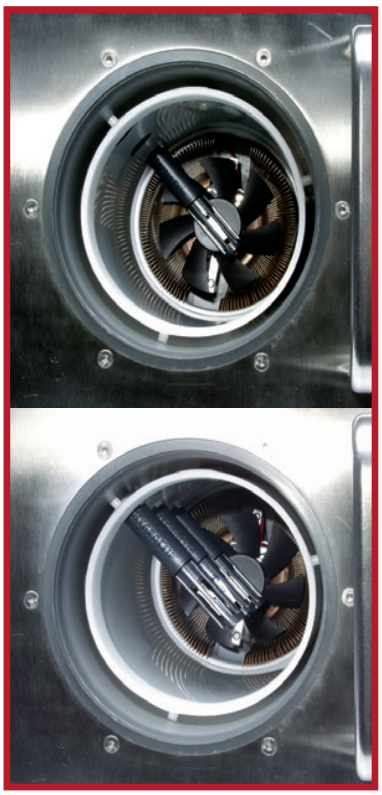

Inside the HygroGen chamber with control probe (top). The chamber with two additional probes for additional mapping and monitoring (bottom).

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