Easy and Reliable Calibration with the HMK15 Humidity Calibrator

Jan Grönblad, M.Sc. (Eng.)
Product Manager
Sensor Systems Division
Vaisala Helsinki
Finland

No humidity instrument stays accurate on its own. From time to time, the performance of these instruments must be checked against a reference. When calibration is done in-house, the use of saturated salt solutions as a reference is a proven and affordable method. With Vaisala's HMK15 humidity calibrator humidity calibration is easy and reliable.

FINAS AKKREDITOINTI SUOMI FINLAND

K08 (EN45001)
(ISO/IEC Guide 25)

Vaisala's Measurement Standards Laboratory at the Vaisala headquarters in Helsinki, Finland, is a FINAS accredited calibration facility. For more information, please visit ***www.european-accreditation.org***

The use of saturated salt solutions is an accepted and reliable method for calibrating humidity instruments. Many leading laboratories use this method, which has been generally known since the early 1900s. The operating principle is based on the properties of salt and water solutions, which generate a known relative humidity in the air above them.

Based on these reference values, the reading of the humidity instrument can then be adjusted and calibrated. Saturated salt solutions provide a reliable measurement standard as the humidity levels generated by these solutions and their behavior at different temperatures are well documented and have been verified by many researchers. The Greenspan table (Table 1) is one of the most well-known references.

Several different salts are suitable for reference measurements, providing a number of options for the user. With high quality instruments, however, no more than two reference points are needed to adjust the measurement over the entire relative humidity range.

Shortened thermal and humidity stabilization time

During the development of the HMK15, Vaisala's latest humidity calibrator based on saturated salt solutions, the main goals were to improve the ease of use and reliability of the system. The shortened thermal and humidity stabilization time of the HMK15, which is one of the main improvements in the new design, speeds up calibration and improves the reliability of the results. By combining an aluminum chamber and proper mechanical design, the salt chamber is optimized for fast temperature stabilization. The inner space of the chamber is shaped to promote fast humidity stabilization and the generation of a homogenous atmosphere above the salt solution.

Ready-dosed salt packages come with calibration certificates

Other new additions include salt packages with calibration certificates from an accredited laboratory. Examples of the salt solutions suitable for the HMK15 calibrator include lithium chloride LiCl (11% RH), magnesium chloride $MgCl_2$ (33% RH), sodium chloride NaCl (75% RH) and potassium sulphate K_2SO_4 (97% RH). All these salts are delivered from the factory in dry format to avoid any problems that may occur with ready-made salt solutions. Dry salts also offer a much longer storage life than ready-mixed salt solutions.

The ready-dosed salt pack-

With Vaisala's HMK15 humidity calibrator, humidity calibration is easy and reliable.

ages are delivered with calibration certificates granted on the basis of a batch check. In this process, a sampling of packages is taken from the batch and the salts are prepared according to the user instructions. These salt solutions are then checked at Vaisala Helsinki's accredited Measurement Standards Laboratory. The calibration certificate verifies that the equilibrium humidities generated by these salt solutions correspond to Greenspan's calibration table within the specified accuracy (Table 2). To achieve this accuracy, the HMK15 instruction manual includes a guide on how to prepare and store salt solutions. Various standards (ASTM E104-85, DIN 50008, JIS Z8806) also include recommendations and instructions on how to prepare salt solutions.

Traceability to a National Standard

For some applications, traceability to a National Standard is needed. In these cases a humidity transmitter like the Vaisala HMP233 can be used as the reference in parallel with the actual humidity instrument in the salt chamber.

When verifying traceability, the salts are used only to generate different humidity levels, and the reference value is read from the output/display of the reference instrument. The HMP233 reference transmitter must then

Temp./°C	LiCl / %RH	$MgCl_2$ / %RH	NaCl / %RH	K_2SO_4 / %RH
0	*	33.7 ±0.3	75.5 ±0.3	98.8 ±1.1
5	*	33.6 ±0.3	75.7 ±0.3	98.5 ±0.9
10	*	33.5 ±0.2	75.7 ±0.2	98.2 ±0.8
15	*	33.3 ±0.2	75.6 ±0.2	97.9 ±0.6
20	11.3 ±0.3	33.1 ±0.2	75.5 ±0.1	97.6 ±0.5
25	11.3 ±0.3	32.8 ±0.2	75.3 ±0.1	97.3 ±0.5
30	11.3 ±0.2	32.4 ±0.1	75.1 ±0.1	97.0 ±0.4
35	11.3 ±0.2	32.1 ±0.1	74.9 ±0.1	96.7 ±0.4
40	11.2 ±0.2	31.6 ±0.1	74.7 ±0.1	96.4 ±0.4
45	11.2 ±0.2	31.1 ±0.1	74.5 ±0.2	96.1 ±0.4
50	11.1 ±0.2	30.5 ±0.1	74.4 ±0.2	95.8 ±0.5

* The use of an LiCl solution at temperatures below +18 °C is not recommended as its equilibrium humidity can change permanently.
[1] Greenspan, L.: Journal of Research of the National Bureau of Standards – A Physics and Chemistry Vol. 81A, No. 1 January–February 1977, pp. 89–95

Table 1. Greenspan's calibration table[1] for generated humidity levels for four commonly used salts over a temperature range of 0 to 50 °C. In each column, the numbers on the right indicate Greenspan's uncertainty for the reference humidity of the salt.

be calibrated by a national calibration laboratory (e.g. CETIAT, NIST, NPL, PTB) to obtain the necessary traceability to the national standard.

Thermometer as an accessory

A thermometer with a calibration certificate is included with the HMK15 calibrator. The purpose of the thermometer is to measure the temperature of the air above the salt solution. The temperature reading is used primarily to select the correct reference humidity value from Greenspan's table, which is printed on the calibrator.

In addition, the accuracy of the thermometer is sufficient for checking the temperature channel of the humidity instrument. The thermometer has been calibrated at six points and is traceable to the Finnish National Measurement Standards Laboratory* for temperature. For more accurate results, the corrections given in the calibration certificate or their interpolated values can be used.

On-site checks possible

In addition to laboratory use, the calibrator is suitable for on-site checks. During transportation, the chambers can be tightly closed with specially designed transit covers that provide a complete seal and prevent any leaks of the salt solution. The optional transit bag makes it easy to transport the calibrator. Thanks to the fast temperature stabilization of the calibrator, the waiting time for on-site calibration is comparatively short. ■

Table 2. The specified accuracy of an HMK15 calibrator delivered with a calibration certificate.

Lithium chloride LiCl	±1.0% RH + Greenspan's uncertainty *
Magnesium chloride $MgCl_2$	±1.0% RH + Greenspan's uncertainty *
Sodium chloride NaCl	±1.4% RH + Greenspan's uncertainty *
Potassium sulfate K_2SO_4	±1.5% RH + Greenspan's uncertainty *

* The uncertainty given in Greenspan's calibration table at the calibration temperature, e.g. the accuracy of LiCl salt at +20 °C is ±(1.0 + 0.3) % RH = ±1.3% RH

Typical sources of errors in humidity calibration

Temperature difference between the humidity probe and calibration chamber

As relative humidity is a very temperature dependent physical parameter, it is important to have both the calibrator and the humidity probe at the same temperature. A temperature difference of ± 1 °C at + 20 °C between the air in the chamber and the sensor causes an error of ±3% RH at 50% RH and ±6% RH at 97% RH. To avoid temperature differences, it is recommended to allow the humidity instrument and calibrator to stabilize for at least 30 minutes in the same ambient temperature.

The probe should be handled as little as possible to avoid the warming effect of the hands. To prevent the salt chamber and other parts of the calibrator from warming up and causing errors in the readings, they should not be held during calibration.

Insufficient stabilization time

The response time of thin film polymer sensors is very fast, usually less than 10 seconds for the sensor element itself. After the humidity probe is inserted in the calibrator, however, it takes some time before the air around the humidity sensor element reaches equilibrium with the generated humidity level. A temperature difference between the humidity probe and calibration chamber increases the stabilization time. The recommended stabilization time for reliable calibration is from 10 to 20 minutes.

Overly narrow range between the calibration points

Multiple calibration points ensure the accuracy of the calibration results over a wide humidity range. If the instrument reading must be adjusted (i.e. if the output reading is changed to correspond to the reference value), two points are sufficient for a high-quality humidity instrument that is used over a wide humidity range. The first point is used for zero point (offset) adjustment and the second point for span (gain) adjustment. A difference of 50% RH or more is recommended between these two points.

Dirty or wet equipment

To avoid contamination, the salts and equipment must be handled carefully and kept absolutely clean. Even a tiny drop of water on the probe near the sensors can distort the readings.

* The Finnish National Measurement Standards Laboritory is part of the Centre for Metrology and Accreditation.