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SI Traceable Non-Laboratory Humidity Measurements – How to Minimize Measurement Uncertainty

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Summary:
SI traceability forms a baseline for high quality measurements. In case of humidity measurements, the traceability is usually established through temperature and dew point temperature calibrations. However, when the measurements are taken out from laboratories, new uncertainty sources are introduced. Naturally, environments, both process and ambient, are not as stable as in a laboratory, stabilization times are minimized, and it is not always possible to carry the best instrument for the specific measurement to the field. In this work, these topics are discussed and potential solutions introduced.

Keywords: SI traceability, measurement uncertainty, humidity, capacitive humidity sensor

Introduction

In industry, humidity measurements are typically carried out to optimize processes, to improve energy efficiency and to improve end-product quality. Thus, they cover wide range of applications from extremely dry applications to extremely humid, from cold to hot, up to high pressure and from clean to dirty environments. Therefore, laboratory calibrations may not be presentative and other uncertainty sources should be taken into account. For example, outdoor humidity measurements are always carried out in chancing temperature: slope is usually slower when night turns into day but more rapid when bright day turns into thunder. This problem of non-static environments has already been recognized by humidity metrology community [1].

Primary measurand of a capacitive humidity sensor is typically relative humidity [e.g. 2]. Also, temperature is normally measured to enable humidity conversions from one unit to another. However, if the probe around the humidity sensor is large, it may have a heat flux ruining temperature representativity and thus ruining humidity measurement. Also, heavier probes have longer stabilization times especially in terms of temperature.

In practice the additional uncertainty sources of a field humidity measurement instrument can put in the following categories:

- Short-term uncertainty sources
- Long-term uncertainty sources
- High humidity or condensate

Short-term uncertainty sources include e.g. long stabilization times i.e. temperature changes during humidity measurement (see Fig. 1) or long thermal stabilization of massive probes [3]. This is often a problem in field when the measurement needs to be completed as quickly as possible without long enough stabilization time.

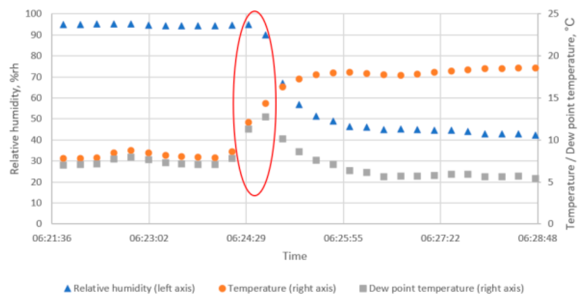

Fig. 1. An example measurement with Vaisala's HMP9 humidity probe. The probe reacts to increasing temperature, although humidity sensor has not yet reacted. Thus, the calculated dew point temperature increases for few data points although in this test the dew point temperature should be almost constant.

Long-term uncertainty sources include e.g. bad representativity of the humidity probe. This could be caused by significant temperature gradient over the probe. Hence, the measured temperature and thus relative humidity do not represent the targeted environment. More severe problem would be if the probe measures process humidity at higher dew point temperature than the ambient temperature. In those cases, condensation may take place at the sensor causing sensor failure or significant drift. Similarly, drift can be caused by exposing the sensor on harmful chemicals.

Third category includes exposure of a humidity sensor to high humidity or even condensate. Some capacitive humidity sensors never recover after high humidity exposure and liquid water on a sensor is even worse. In these cases, it is hard or even impossible to know when and how much the probe has drifted without calibration.

Short-term uncertainties

Stability related uncertainties are usually caused by non-ideal instrumentation. Naturally, service personnel cannot bring all kind of instruments on site and therefore measurements are completed with the instruments on hand. This is especially a problem when high accuracy is a requirement. In general, smaller thermal mass probes are faster and thus reaches stability faster. If a larger probe is not thermally stabilized it can easily add from 2 %rh to 5 %rh error to the indicated value [3]. Also filtering of data might be useful, although that would increase response time, which is typically unwanted in field measurements.

If a probe is thermally controlled, the probe overreacts significantly less. In Fig. 2 Vaisala's HMP7 was tested in a heat chamber without humidity control when temperature is increased from 20 °C to 30 °C. The result clearly indicates that the dew-point temperature drop in the beginning is significantly less when the probe is thermally controlled.

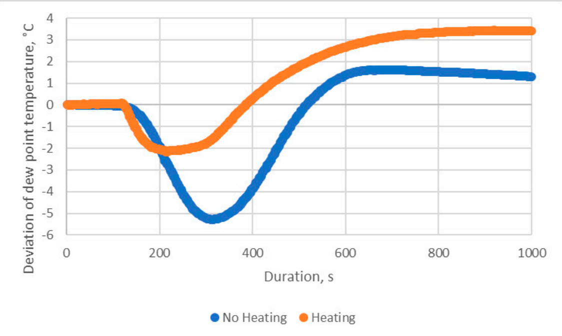

Fig. 2. Vaisala's HMP7 dew-point temperature response to temperature change from 20 °C to 30 °C. During the test dew-point temperature was not controlled resulting difference to the ends of measurements.

However, one thing that must be considered on field is that the probes used have to be robust enough. Otherwise, there might be some sort of mechanical failure which can rise as a small and not obvious drift.

Long-term uncertainties

In a third-party humidity laboratory Vaisala's HMP9 was tested in a non-standard way. Before each measurement point purge function was performed and the hysteresis was almost completely removed (see Table 1). Vaisala designed the purge function initially to prevent humidity sensor drifting due to chemicals.

Table 1: Drift and repeatability of Vaisala's HMP9 with active purge usage resulting 0.0 %rh error in repeatability and 0.1 %rh error in hysteresis.

Relative humidity, %rh	10	50	90	50	10	50
Error, %rh		0.0		0.1		0.0

Back in the old days climatic chambers used psychrometric wicks and temperature sensors for humidity measurements. The problem with the capacitive humidity sensors was poor tolerance of high humidity exposure. This is still the problem with many sensor types and manufacturers, but significant development steps have been taken by manufacturers.

Recovery from condensate

Especially humidity sensors that measures outdoor weather are exposed to wide range and significant variations of humidity and temperature conditions. One way to tackle this issue is to build a shield or cover on the probe. However, there is still chance that condensation occurs. In addition of this external protection, some manufacturers have introduced protective warming systems. This way the maximum relative humidity the sensors are exposed is reduced and the sensors measures rather dew point temperature than relative humidity.

Conclusions

As pointed out in [3], transient conditions may increase measurement inaccuracy significantly. Thus, it is important to understand requirements for the specific measurement and to specify the need to the instrument supplier.

Vaisala's solution is to offer handheld instruments with wide range of probe types and features for different environments and applications to enable quick, repeatable, and reliable measurements.

References

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