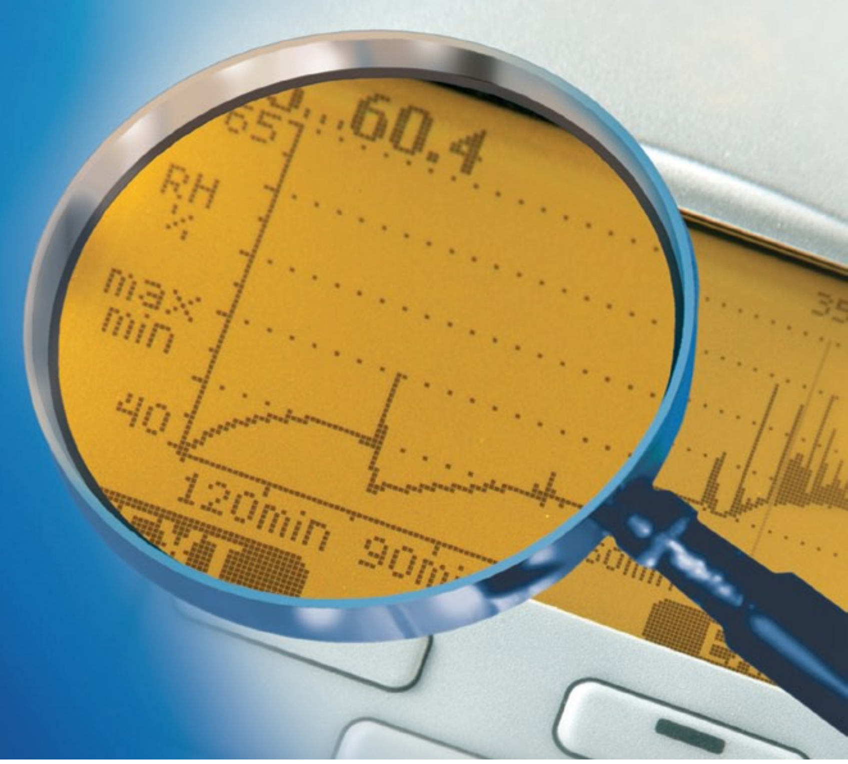
# Warmed Probe Technology




A wet humidity sensor cannot measure relative humidity. Once liquid water is present on the sensor, the humidity instrument is effectively "offline" until the sensor dries out. This can be a problem in a high humidity environment as the vapor pressure gradient is insufficient for effective evaporation of liquid water from the sensor surface. A sensor might stay wet for minutes or hours, even though the surrounding environment is no longer saturated. This would create a prolonged measurement outage.

Measurement of high relative humidity (> 90%RH) is challenging because the measurement environment is always very close to saturation. Objects in the measurement environment, including the humidity probe and sensor, are likely to be at a temperature that is close to the saturation temperature.

As an example, consider an environmental chamber that is at 23 °C and 90 % RH. The corresponding dewpoint temperature is 22.2 °C. This means that water vapor will condense on any object that is at a temperature equal to or less than 22.2 °C.

*The HMT337 with the warmed probe, and the HM70 handheld indicator for spot-checking.*

In ideal conditions the sensor and the body of the humidity probe will be in equilibrium at 23 °C, but then there is only a slender margin (0.8 °C) before condensation occurs. A number of things can happen to create a problem when the margin is so small:

- The chamber's conditions may have been adjusted to change rapidly from one with a lower temperature to one with a higher temperature and relative humidity. The humidity probe has thermal mass and therefore its temperature lags that of the chamber temperature, causing condensation to form on the probe and sensor before it warms up to match the chamber temperature.
- The system that controls chamber humidity may overshoot the intended settings, causing saturation and condensation on the probe and sensor. This only has to happen once to create a problem.
- The probe could be installed in such a way as to sink heat from the chamber to the outside environment. Effectively the probe becomes cooler than the chamber interior, creating the possibility of condensation if the probe cools sufficiently to meet the chamber's dew point temperature.

Variations of this problem occur in other high humidity applications. Outdoor environmental measurements are corrupted by fog, mist, rain, or heavy dew. High humidity process measurements can be corrupted if the process pressure spikes, raising the dew point of the process gas to the point of condensation on the sensor. Therefore, the challenge of high humidity environments is to provide valid measurements and maximum "uptime" even though the measurement environment is close to saturation, or with excursions into saturation.

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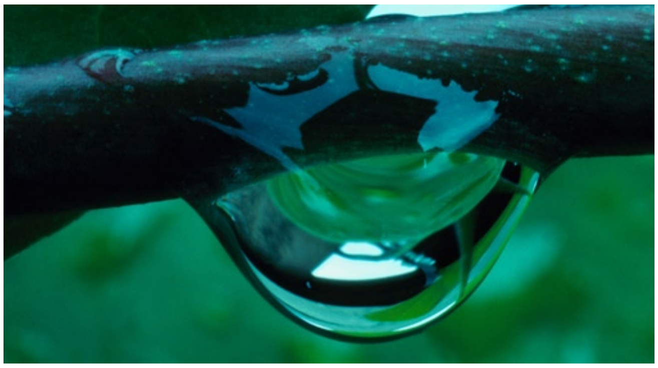
Vaisala has designed a warmed probe measurement technology that successfully addresses many of the high humidity measurement challenges. This technology is available in the Vaisala HUMICAP® Humidity and Temperature Transmitter HMT337. The warmed probe relies on a composite sensor. This is a humidity sensor with a temperature sensor bonded to it. With a composite sensor, it is possible to know the relative humidity and the precise temperature of the relative humidity sensor at any given time. In the warmed probe, a separate electrical resistance heater is installed within the probe. This heater is controlled by the measured relative humidity. The control algorithm is designed to keep the probe several degrees above ambient temperature. This assures that water will not condense on the composite sensor even when the measurement environment is at the dewpoint temperature, or 100 %RH. Note that the probe warming feature increases the temperature of the entire probe, including the filter. This prevents the formation of a "microclimate" within the filter.

Because relative humidity is temperature dependent, probe heating corrupts the humidity measurement.
However, knowing the relative humidity and temperature, it is possible to accurately calculate dewpoint temperature. As a default, all of Vaisala's warmed probe transmitters output dewpoint temperature. If a user needs to know relative humidity, it is possible to specify a warmed probe instrument with a separate air temperature probe. The probe measures actual air temperature, and relative humidity is calculated from dewpoint and air temperature.

A second heating function known as extra heat (XHEAT) is also available on the HMT330 Series Transmitters that use the composite Vaisala HUMICAP® sensor. Extra heat rapidly heats the composite sensor to 100 °C for about 30 seconds (these are factory default values that can be changed by the user if necessary). Unlike probe warming, extra heat is achieved by directly exciting the temperature sensor that is bonded to the humidity sensor. This approach is much faster, but it also takes the measurement "offline" until the sensor is heated and then cooled back down to operating temperature (this typically takes 60 seconds or less). During this time, the last valid measurement is held in the output and display of the transmitter. During the XHEAT period, the last valid measurement is held, put out and displayed by the transmitter. XHEAT can be configured by the user to activate automatically at a specified humidity level. Maximum protection from condensation can be achieved by using extra heat in conjunction with a warmed probe, but as mentioned above, XHEAT is available in non-warmed-probes too. XHEAT can be thought of as a "final defense" against rapidly increasing humidity levels that might wet the sensor and cause the measurement to go "offline."



A third heating function called chemical purge is also available on all HMT330 series transmitters with composite sensors. Chemical purge heats the humidity sensor to 160 °C for a short period of time to drive contaminants out of the polymer. Like XHEAT, it directly excites the temperature sensor that is bonded to the humidity sensor. Chemical purge can be set by the user to run on startup and/or on a regular time interval. It can also be initiated manually at any time.

Warmed probe technology was developed by Vaisala to address difficult outdoor humidity measurements for meteorological applications. In this application, the warmed probe technology eliminates downtime due to condensation and decreases response time of the sensor. This is well documented in a paper authored by Timo Ranta-aho and Lars Stormbom ("Real Time Humidity Measurement Using the Warmed Sensor Head Method"; 4th Int. Symp. on Humidity and Moisture ISHM 2002, Taipei, pp. 583-588).

Warmed probe technology has also been applied to industrial applications. Inlet air humidity measurement on gas turbines, particularly when water injection is used, is an example of a very demanding application that can be satisfied with warmed probe technology.

Vaisala is also very successful in the fuel cell industry measuring the dewpoint in hydrogen that is used as a fuel in proton exchange membrane type fuel cells. In this application the carrier gas is hydrogen, temperatures and dewpoint are near 100 °C, and pressure is sometimes higher than atmospheric.

In conclusion, condensation can pose problems for a variety of different processes. Humidity measurement is compromised when condensation forms on the humidity sensor. Warmed probe technology can improve humidity measurement performance in saturated environments. In order to avoid condensation problems, heating or drying is the solution. Be it the drying of the environment to lower the dewpoint temperature, or the heating of the humidity sensor for near uninterrupted humidity or dew point measurement.

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