How to Measure Relative Humidity in Fuel Cells

The Vaisala HUMICAP® Humidity and Temperature Transmitter HMT337 with a warmed probe is pressure tight to 10 bar and rated to 180°C.

RH = 60 to 100%

P = 4 to 6 bar

T = 60 to 100°C

Measuring the water vapor content of hydrogen in these difficult conditions is now possible using unique, patented humidity sensor technology. The "warmed probe technique" pioneered by Vaisala has been successfully adapted and deployed in dozens of fuel cell applications.

The Measurement Challenge

The high temperature, high humidity fuel cell environment poses a number of challenges for humidity measurement. The formation of condensation on in-situ mounted sensors is a critical issue, as it effectively disables the humidity measurement. One solution to this problem is a heated, extractive sample system and measurement device. Excellent results can be achieved with this approach, but the cost and complexity of this solution are often unwelcome. Warmed probe technology provides a simpler alternative.

Background on Warmed Probe Technology

Vaisala's polymer based humidity sensors are commonly used to measure humidity over a wide range of conditions. Condensing conditions compromise accurate and responsive humidity measurements. These conditions are detected by a polymer sensor, but the wet sensor may not respond to subsequent drier conditions in a timely fashion, as it is necessary for water on the sensor to completely evaporate before accurate measurement can resume.

Vaisala developed and patented the warmed probe technique to specifically address this problem. In this method, the polymer humidity sensor is warmed a few degrees above ambient temperature to prevent condensation. The temperature of the humidity sensor is measured by a platinum resistance temperature detector, which is bonded to it. With measured temperature and relative humidity values, it is possible to calculate the partial pressure of water vapor and other humidity parameters using well-known formulas.

The warmed probe technique also improves speed of response when the temperature around the sensor is changing. With a conventional relative humidity measurement, the sensor must come to thermal equilibrium with the environment before a reliable measurement can be obtained. This is a dominant factor in response time. The warmed probe technique does not require thermal equilibrium with the environment; speed of response depends primarily on the diffusion rate of water vapor molecules to the sensor's polymer dielectric material.

The warmed probe technique has been applied to environmental measurements with proven success. More recently, the technique has been used to address industrial applications with similar challenges. Warmed probe technology has been fully integrated with proven industrial probe designs to provide off-the-shelf humidity measurement solutions for water management in fuel cells.

Applying the Warmed Probe to Water Management in Fuel Cells

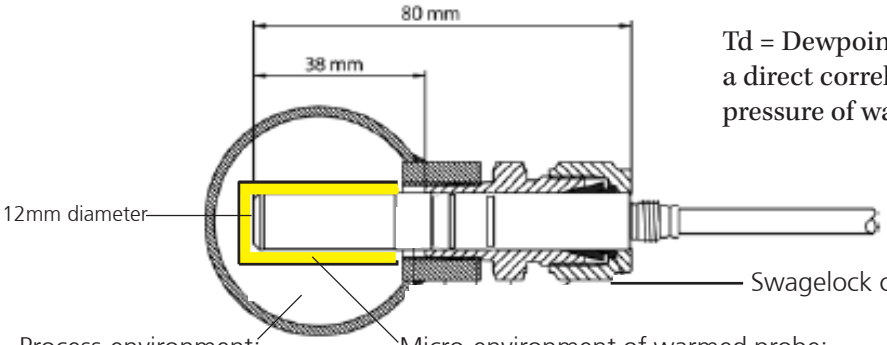
The Vaisala HUMICAP® polymer sensor technology has been developed for more than 30 years and is well characterized for a variety of process variables.

- Pressure:
  The sensor technology correctly measures water vapor concentration at pressures other than ambient. Off-the-shelf sensor head configurations are pressure tight to 10 bar.
- Temperature:
  HUMICAP®sensors can be directly installed into processes at temperatures up to 180 °C.
- Hydrogen:
  The HUMICAP®polymer sensor chemistry is 100% compatible with hydrogen.
- Relative Humidity:
  Patented warmed probe technology automatically maintains the sensor temperature above the process temperature, preventing condensation from forming on the sensor and accelerating response time.

Installation of the warmed probe requires some planning. Large temperature gradients between the installed probe and the surrounding environment should be avoided, and the probe should be mounted to allow the drainage of condensation that may form on metallic parts during a process excursion into condensing conditions. Vaisala application engineers are available to provide guidance for the installation and use of warmed probe instruments.

Warmed Probe:

Warmed probe technology heats the probe when RH increases to 80%. Power increases until the RH value is between 70...80% RH, and is then kept constant.



Td = Dewpoint temperature, a direct correlate to partial pressure of water vapor.

Process-environment:
90% RH
95 °C
Td = 92.2 °C

Micro-environment of warmed probe:
70% RH
102 °C
Td = 92.2 °C

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