

Radio-Frequency Resonator as a Primary Hygrometer

NIST organized a workshop at the 2004 Fuel Cell Seminar on humidity measurement needs for fuel cell applications at the request of its many industrial customers. The overall performance of fuel cell systems is critically dependent on the proper humidification of the feed gases. The workshop attendees (including representatives from sensor manufacturers, automobile manufacturers, researchers in government and academia, and fuel-cell manufacturers) identified key needs for standards and sensor development.

P.H. Huang, D.C. Ripple, M.R. Moldover, and
G.E. Scace (Div. 836)

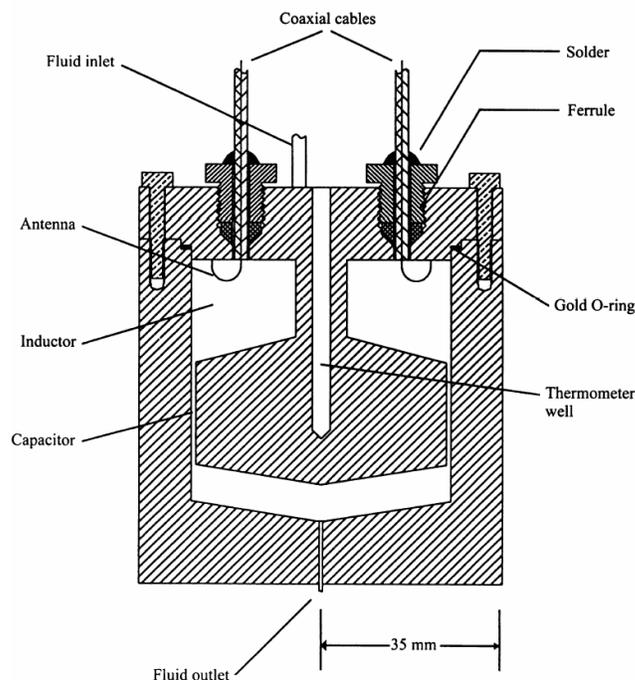
Fuel cell membranes are operated at temperatures as high as 150 °C, pressures up to 1.5 MPa and nearly 100 % relative humidity. These temperatures and pressures are well in excess of the capabilities of existing humidity standards at NIST and other national laboratories. To meet the need for a humidity standard in this range, we have developed a radio-frequency (RF), cavity resonator operating at frequencies near 370 MHz that serves as a primary hygrometer. The resonance frequency of the cavity is a sensitive measure of the dielectric constant of the gas inside the resonator that can be theoretically related to the moisture content of the gas. Similar resonators have been used previously at NIST to determine the dielectric constant of liquid water at state-of-the-art uncertainties. This work was funded as part of a larger Advanced Technology Program project on measurements of fuel cell membranes.

The newly commissioned NIST Hybrid Humidity Generator produces gas streams of known humidity *via* well established thermodynamic techniques, at dew-point temperatures as high as 85 °C. Comparison of the mole fraction generated by the Hybrid Humidity Generator with values measured by the RF resonator gave agreement to within 0.0026 mole fraction, which is fully satisfactory for fuel cell applications. The excellent agreement of the resonator-hygrometer with the generator over a broad range of water vapor concentrations demonstrates that the hygrometer can serve as a reliable reference standard.

Impact: By 2007, we anticipate the RF hygrometer will be a NIST primary standard hygrometer for calibrations at dew points up to 200 °C.

Future Plans: NIST is presently studying the reproducibility of the hygrometer. In 2006, we will fabricate a steam generator whose output will then be measured by both the primary hygrometer and test instruments to be calibrated.

NIST developed a novel radio-frequency, cavity resonator that can serve as a primary standard hygrometer and is suitable for calibrations of dew points up to 200 °C, well in the range of operating fuel cell membranes.



Cross-section of the RF-resonator hygrometer

References and Workshops:

P. H. Huang, D. Ripple, M. R. Moldover, and G. E. Scace, "Re-entrant Radio-Frequency Resonator Hygrometer for Fuel Cell Research and Development," *Proceedings of the 2005 Fuel Cell Seminar, PEMFC #143*, Palm Springs CA (Nov. 14-18, 2005).

P. H. Huang (moderator and organizer) "Measuring Humidity in the Fuel Cell Environment Workshop," 2004 Fuel Cell Seminar (Nov. 3, 2004).

P. H. Huang (moderator and organizer) "Humidity Measurement and Control for Fuel Cell Applications Workshop," 2005 Fuel Cell Seminar (Nov. 15, 2005).