Measuring Gas Collected in Large Volumes Using Microwave and Acoustic Resonances

Michael R. Moldover[1], Jodie G. Pope[1], Keith A. Gillis[1], James B. Mehl[2], Eric Harman[3]

[1]National Institute of Standard and Technology, 100 Bureau Dr, Gaithersburg, USA
[2]36 Zunuqua Trail, PO Box 307 Orcas, WA 98280-0307, USA
[3]Colorado Engineering Experiment Station Incorporated (CEESI) 54043 WCR 37, Nunn, CO 80648, USA

We tested two large, metal-walled, pressure vessels (0.3 m^3 and 1.8 m^3) for use as collection volumes during the calibration of gas flow meters. In exploratory measurements, the standard uncertainty of the mass of gas collected in the 0.3 m^3 volume was 0.16 %; we expect to achieve smaller uncertainties using the 1.8 m^3 quasi-spherical volume. We determined the shape and size of the collection volume from measurements of the frequencies f_m of microwave resonances within the volume. We deduced the average temperature T of the collected gas from measurements of the frequencies f_a of acoustic resonances within the volume. We combined the measured pressure p with f_m and f_a to deduce the mass of the collected gas, using $w(p,T)$, the known dependence of the gas's speed of sound on the temperature and the pressure. We have used theory and test measurements to demonstrate that the acoustic resonance frequencies are only weakly sensitive to temperature gradients that persist in large, un-thermostatted pressure vessels; therefore, we expect these techniques can be scaled up to much larger volumes.
