ANALYSIS OF THE FLOW RATE AND ITS UNCERTAINTIES FOR THE BELLOWS FLOWMETER

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Abstract

The Bellows Flowmeter is a primary standard used in leaks and high vacuum calibrations at the National Institute of Standards and Technology. It is a constant pressure, variable volume flowmeter, which incorporates bellows to provide the volume variability. The determination of the flow rate depends upon the measurements of pressure, volume, temperature, and time, and hence the uncertainties associated with these measurements all contribute to the overall uncertainty in the flow rate. Moreover, for flow rate of 10^{-11} mol/s or less, the effects of out-gassing in the flowmeter must be taken into account for an accurate determination of the flow rate. We have found that of all the component uncertainties, that due to the instability in calibration of the capacitance diaphragm gauges (CDGs) for pressure measurements is the most dominant. Replacing CDGs with more stable gauges, such as MEMS type resonant silicon gauges, would reduce the overall uncertainty in flow rate. Correctional schemes for the out-gassing effects on the flow rate are discussed and formulated. The procedures to estimate the uncertainties of the flow rate for the range of 10^{-12} mol/s to 10^{-6} mol/s are presented.