Systematic Investigation of the Force Transmission Error in a Tandem-Sinker Densimeter Based on a Magnetic-Suspension Balance

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A tandem-sinker densimeter, which incorporates a magnetic-suspension coupling and two sinkers, is commonly used as a sorption analyzer with simultaneous density measurement. Here, we present a systematic investigation of the force transmission error (FTE) of this type of densimeter. The basic assumption of the analysis is that the FTE can be separated into an apparatus contribution and a fluid-specific contribution. Measurements in an evacuated measuring cell using various sinkers (of different mass, volume, and material) demonstrated that the apparatus contribution to the FTE increased with increasing suspended load on the magnetic-suspension coupling based on a quadratic relation. The fluid-specific contribution is proportional to the density and the specific magnetic susceptibility of the sample fluid, and the proportionality factor is an apparatus-specific constant. Measurements on synthetic air with the same sinkers revealed a complicated but reasonable relation between the apparatus-specific constant and the suspended load on the coupling. Both, the apparatus contribution to the FTE and the apparatus-specific constant were independent of the temperature within the investigated range from (293.15 to 333.15) K. An empirical solution, which aimed at correcting the FTE, was developed to calculate accurately the fluid density based on one sinker and the adsorbed mass on another 'sinker', which could also be a porous material (*e.g.*, zeolite, activated carbon, metal organic framework, etc.). The empirical solution was successfully verified by comparing the results of density measurements of pure methane, nitrogen, argon, and carbon dioxide with values calculated from the respective reference equations of state. A comprehensive uncertainty analysis showed that the expanded uncertainties (k = 2) in measurement were: 20 mK for temperature, 1.0 kPa for pressure, 0.02 kg/m^3 or $0.0002{\cdot}\rho$ whichever was higher for density, and 0.08 mg for adsorbed mass.