Standards for the Calibration of Density Meters

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Most density meters, including vibrating-U-tube instruments, must be calibrated over the temperature, pressure, and density range of interest with fluids of known density. We review the requirements for a good calibration fluid. These include: stability with time, temperature, and the absorption of air and atmospheric water, stability of composition, compatibility with the instrument, suitable viscosity, and safety considerations. A calibration fluid can be either a "pure" material characterized for density over some temperature and pressure range, or a particular batch of material that has been measured and certified. We review the fluids for which adequate data of low uncertainty have been published and that are available in suitably high purity, such that published data are applicable for calibration purposes. The traceability of a density standard to the fundamental SI units of mass and length is most direct with a batch-certified standard. We review the available standards in this category, and we present as an example NIST Standard Reference Material® (SRM) 211d, which is toluene certified for liquid density over the temperature range –50 ˚C to 150 ˚C and pressure range 0.1 MPa to 30 MPa. The measurements underlying this SRM were made with a two-sinker hydrostatic-balance densimeter. The main set of measurements comprised 975 p-ρ-T data points. The effect of dissolved air was determined by additional measurements. A thorough analysis of the uncertainties is presented; this includes effects resulting from the experimental density determination, possible degradation of the sample due to time and exposure to high temperatures, dissolved air, uncertainties in the empirical density model, and the sample-to-sample variations in the SRM vials. The combined standard uncertainty in the density ranges from 0.030 kg/m^3 at near-ambient conditions to 0.049 kg/m3 at 150 ˚C and 30 MPa. Also considered was the effect of uncertainties in the user's temperature and pressure measurements.