High-Pressure Vibrating-Tube Densimeters – Performance Limit and Uncertainty at Low Densities

Dennis Panke[1, C], Robin Wegge[1, S] and Markus Richter[2]

[1]*Green Energy Lab, Technical University of Applied Science Georg Agricola, Bochum, Germany*
[2]*Applied Thermodynamics, Chemnitz University of Technology, Chemnitz, Germany*
dennis.panke@thga.de

Vibrating-tube densimeters (VTD) have become essential tools for precise fluid density measurements across broad pressure and temperature ranges in the petrochemical, pharmaceutical, and materials science industries, facilitating quality control and product development. Additionally, if the instruments are improved in a meaningful way and the experiments are carried out with due care, vibrating-tube densimeters are also a valuable addition to thermophysical property research, enabling fast measurements with uncertainties that easily exceed the requirements of industry partners. However, low measurement uncertainties and good repeatability depend directly on a comprehensive calibration, as well as on the density of the investigated fluid. Due to the utilized measuring principle, vibrating-tube densimeters are especially well suited to measure fluids with high densities. Nonetheless, these types of apparatuses are frequently used to perform gas-phase measurements.

This study aims to identify the lower limit in the resonant period that can be reliably resolved by means of a vibrating-tube densimeter and to provide a robust uncertainty analysis for the corresponding density range. Towards this end, we performed a state-of-the-art calibration of the device and measured the density of selected gases. The measurements were carried out over the entire operating range of the apparatus, with a particular focus on the range of gas densities. The substances investigated were carefully selected so that different substance properties (*e.g.*, different molecular structures) can be investigated in similar density ranges. We will present comparisons to experimental data sets obtained from literature to results calculated with the corresponding reference equations of state, and a comprehensive uncertainty analysis prepared according to the Guide to the Expression of Uncertainty in Measurement (GUM). Our preliminary insights reveal areas for future improvements in both technology and methodology, which we will discuss in detail.