A new Single-Sinker Magnetic Suspension Densimeter for Cryogenic Liquid Mixtures and First Results for a Liquefied Natural Gas (LNG) Mixture

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A special densimeter has been developed for accurate measurements of the (p, ρ, T, x) behavior of liquid mixtures at cryogenic temperatures, e.g., liquefied natural gas (LNG). It covers the density range from (10 to 1000) kg × m^{-3}, thus enabling density measurements in the homogeneous liquid region, along the saturated liquid line, in the supercritical region and in the homogenous gas region. To realize measurements in the homogeneous liquid, a supercritical liquefaction procedure was established, and a special VLE-cell was implemented. The apparatus is designed for measurements in a temperature range from (90 to 290) K at pressures up to 12 MPa. The densimeter is based on the Archimedes (buoyancy) principle and is a single-sinker system incorporating a magnetic suspension coupling, which is used at cryogenic temperatures for the first time. This circumstance required the investigation of the force transmission error of the magnetic suspension coupling at low temperatures, and this will be discussed in further detail. Densities can be obtained directly without the need for calibration fluids. The relative combined expanded uncertainty (k = 2) for density measurements in the homogeneous liquid (including the contribution resulting from the uncertainty of the sample gas analysis) is estimated to be approximately 0.05 %. We will report first results for a selected synthetic LNG mixture obtained at temperatures T = (115, 120, and 125) K with pressures up to 6.5 MPa. The experimental results are compared to the GERG-2008 reference equation of state for natural gases, which performed very well. Moreover, we will discuss future improvement activities to reduce the overall measurement uncertainty of our instrument.