Feasibility Study for a new Densimeter for the Accurate Measurement of Densities of Liquefied Natural Gas

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Natural gas is an important energy source of the future. To ensure a secure energy supply in Europe the trade with Liquefied Natural Gas (LNG) will increase significantly. The accurate determination of LNG densities is gaining importance not only for custody transfer calculations with regard to loading and unloading of LNG carriers and tanks but also for process simulations, e.g., for modelling of economically and ecologically optimised liquefaction and evaporation processes. Today the calculation models used for natural gas only offer uncertainties of 0.3 to 0.5 % in the liquid phase. To reduce these relatively large uncertainties new accurate sets of experimental p-ρ-T-data are essential.

In the presented project, we carried out a feasibility study for the accurate measurement of LNG densities. The first task was to review the relevant literature. It became obvious that only a small number of data for the densities in the liquid phase of LNG or similar mixtures is available. This small number results from the technical difficulties related to the measurement of the densities of multi-component mixtures in the liquid phase (e.g. decomposition of the mixture). Most of the measurements have been carried out at the National Bureau of Standards (NBS), USA, in the late 1970s and early 1980s (the NBS became the well known NIST, the National Institute of Standards and Technology, later on). Only saturated liquid densities have been measured. The uncertainty in density was estimated to be about 0.3 %.

In our study we report a new measuring procedure and a detailed conceptual design for a special LNG-densimeter. This densimeter will allow us to measure LNG densities in the homogeneous liquid region, along the saturated liquid line (incl. vapour pressures) and in the homogeneous gas phase. The apparatus will be designed for measurements in a temperature range from 90 K to 290 K at pressures up to 12 MPa. The achievable experimental uncertainty is estimated to be 0.02 %. The particular problems related to measuring densities of LNG can be solved by using the single-sinker principle with a magnetic suspension coupling in connection with a new kind of reference cell. The single-sinker densimeter technique developed at Ruhr-University Bochum has proven to be very successful for liquids and gases at high pressure. This type of instrument applies the Archimedes (buoyancy) principle to provide an absolute determination of the density, i.e., a measurement that is independent of calibration fluids. The state of the art of this general type of instrument is described by Wagner and Kleinrahm[1].

The talk will show the results of the literature study we have undertaken and it will give a detailed overview about the specifications for the new LNG-densimeter. Difficulties regarding the measurement of LNG densities will be explained and also the way we solved these. Furthermore we will present a description of our new measuring procedure and the prospective design for the LNG-densimeter.

[1] *Wagner, W., Kleinrahm, R.* Densimeters for very accurate measurements of fluids over a large range of temperature and up to high pressures. Metrologia 41 (2004), issue 2, S24-S39.