

A Reference Densimeter for Accurate Measurements of the Density of Natural Gas at Standard Conditions

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Large quantities of natural gas are transported through pipelines from suppliers to customers. For the billing of the quantity delivered, its energy must be determined very accurately. The energy of natural gas is the product of the volume and the superior calorific value at standard conditions ($T_s = 273.15 \text{ K}$, $p_s = 0.101325 \text{ MPa}$). The superior calorific value is calculated in recent times by means of the gas composition, measured with process gas chromatographs (PGCs). In order to determine the volume at standard conditions, the volume flow and the density of the natural gas is measured at flowing conditions in gas meter runs, and then converted to standard conditions by means of the density at standard conditions. Both the density at flowing conditions and the density at standard conditions are nowadays calculated from reliable equations of state for natural gas (AGA8-DC92 or GERG-2004 equation of state). For this calculation, the composition of the natural gas is also needed. Consequently, the accuracy of the composition of the natural gas, determined with PGCs, is very important for an accurate calculation of the delivered energy. For this reason, the PGCs used in large gas meter runs are calibrated at regular time intervals with certified binary gas mixtures and synthetic natural gases. To check the accuracy of the analyzed composition of these gas mixtures, the density at standard conditions is calculated and this value is compared with a highly accurate measured density of this particular gas. The deviation of the calculated value from the measured value should not be greater than a few 0.01 %. Against this background, a special reference densimeter was developed for very accurate measurements of the density of natural gases and gas mixtures at standard conditions. The densimeter covers a measuring range at very low densities from 0.7 kg/m^3 to 1.3 kg/m^3 ; its total measurement uncertainty in density is 0.02 % (level of confidence 95 %). The measurement principle used is the two-sinker method which is based on the Archimedes' buoyancy principle. It is a very accurate differential method which is described in detail by Wagner and Kleinrahm (Metrologia 41, 2004, S24-S39). The sinkers used are a hollow cylinder made of stainless steel ($V = 500 \text{ cm}^3$, $m = 200 \text{ g}$, gold-plated surface) and a solid ring also made of stainless steel ($V = 25 \text{ cm}^3$, $m = 200 \text{ g}$, gold-plated surface). The densimeter was developed for E.ON Ruhrgas AG, Germany, at the Chair of Thermodynamics of the Ruhr-University Bochum. The apparatus was developed several years ago and has been improved and updated during the last year. Our poster and our article will describe this special densimeter including the recent updates and will present some typical measurement results.