

An Automated Densimeter for Rapid Screening of Industrial Fluids

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We describe an apparatus for the automated measurement of liquid densities over the temperature range 253 to 473 K and pressures to 35 MPa. The heart of the apparatus is a commercial vibrating tube densimeter. In order to achieve a consistent uncertainty of 0.0005 to 0.001 g/cm³ in our measurements, several physical and procedural improvements have been implemented, beyond those of the commercial instrument operated in a stand-alone mode. The densimeter is housed in a specially designed two-stage thermostat, for tight temperature control. The inner stage consists of the densimeter; a standard PRT (SPRT) reads its temperature. The outer stage (shield) minimizes heat exchange between the densimeter and ambient. The uncertainty in the temperature is 0.03 K, with a short-term stability of 0.005 K. The thermostat also incorporates a pre-heat loop, to bring the sample to temperature equilibrium more quickly. Pressures are measured with an oscillating quartz crystal pressure transducer with an uncertainty of 5 kPa. The densimeter is calibrated with measurements of vacuum, water, and a third well-known reference fluid over the temperature and pressure range of the apparatus. The calibrations of the SPRT and the pressure transducer are checked regularly against NIST traceable standards, to maintain the measurement uncertainty.

The apparatus has been designed, and software has been written, so that the operation and data acquisition are fully automated. Data are taken along isotherms over a temperature/pressure matrix programmed by the operator prior to the start of measurements. Two electronically actuated pneumatic valves and a programmable syringe pump are used to move from one pressure to the next and/or flush fresh sample through the system. Operation of the densimeter in this manner allows for measurements to be made 24 hours a day. Liquid density data will be presented, as well as the measurement and calibration protocol.