An Apparatus for the Determination of Speeds of Sound of Fluids

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Speed of sound measurements are useful to describe acoustic phenomena, to calculate thermodynamic quantities [1] and to develop fundamental equations of state [2]. An apparatus for accurate measurement of the sound velocity in fluids, based on the pulse-echo technique, up to 30 MPa and a temperature range between 253.15 K and 353.15 K is described. This technique is based on measuring the flight time a sound signal needs for a known distance and it is the preferred method for speed of sound measurements in liquids. We have chosen a dual path length type sensor that consists of a transmitting–receiving piezoelectric transducer operating at 8 MHz, which has a diameter of 15 mm, and which is partially coated by gold electrodes. The acoustic sensor is placed in a pressure vessel where the pressure is measured by two pressure transducers. Temperature is controlled by a circulating liquid bath thermostat and measured by a Pt25. To determine the time difference between the two echoes we use the cancellation method [3]. Purified liquid water was used for calibration of the path lengths at ambient pressure and from 274.15 K to 353.15 K. The fundamental equation of state by Wagner and Pruss [4] represents the most accurate literature data within their experimental uncertainty and can be used for a convenient calibration. Nitrogen was chosen to examine the limits of the apparatus with regards to measurements in compressed gasses in the temperature range from 250 K to 350 K and at pressures up to 30 MPa. Measurements of speeds of sound for methanol and ethanol at temperatures from 253.15 K to 353.15 K and at pressures up to 30 MPa are presented and compared to available data from the literature. New sound speed data are provided for 2-butanol and 2-methyl-1-propanol in the temperature range between 253.15 K and 353.15 K and at pressures up to 30 MPa. To date, no accurate high pressure speed of sound data were available for theses fluids.

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