A Pulse-Echo Instrument for Liquid-Phase Speed of Sound and Measurements on Propane

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We describe a new instrument for the measurement of liquid-phase speed of sound. It is based on the dual-path, pulse-echo technique and operates over a temperature range of –45 ˚C to 150 ˚C, with pressures to 90 MPa. A quartz crystal with a resonant frequency of 8 MHz sits in a sample volume 24 mm in diameter by 42 mm long; the path lengths are 12 mm and 30 mm. Several novel design features permit the entire transducer assembly (crystal, sample volume, and reflectors) to fit in a pressure vessel with internal dimensions of 29 mm diameter by 165 mm deep; the total volume of sample required is approximately 25 mL. The (transducer + pressure vessel) assembly is placed in a liquid bath for temperature control. The input pulse is a modulated sine wave consisting of 10 to 20 cycles and is generated by an arbitrary function generator. The speed of sound is calculated from the time difference between the short-path and long-path echo signals, as recorded by a digital storage oscilloscope. We make use of the signal-processing capabilities of the oscilloscope to automatically record only the actual echo signals, discarding the "dead time" between the echoes. The echo data, together with temperature and pressure data, are stored for off-line analysis of the speed of sound. The path lengths were calibrated with measurements on water, and measurements on propane serve to verify the performance of the instrument.