Thermodynamic Properties of Liquid Toluene from Speed-of-Sound Measurements at Temperatures from 283.15 to 473.15 K and at Pressures up to 390 MPa

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Toluene (methylbenzene) is commonly used for a wide range of applications in industry and applied research, for example as a feedstock for manufacturing and as a solvent. Despite its prevalence, experimental data for the thermophysical properties of toluene are limited to the lower-pressure range, in particular for sound-speed data. In this work, we present a combined analysis of experimental sound-speed data for liquid toluene, measured independently at UWA and ICL using dual-path pulse-echo instruments operating over pressure ranges up to 65 MPa and 390 MPa respectively, and at temperatures between (283.15 and 473.15) K. Comparison is made with available literature data and the Helmholtz EOS of Lemmon and Span (2006), with general agreement to the data within the combined uncertainties but with deviations increasing to nearly 2% relative to the EOS at high temperatures and low pressures. We also present the development of a comprehensive software code that allows sound-speed data to be efficiently analysed for surface correlation, thermodynamic integration, and quantified uncertainty analysis of derived properties. The sound-speed data were combined with initial experimental values for density and isobaric heat capacity to derive both thermodynamic properties and several others over the full measurement range. The low uncertainty of these measured sound-speed data, and the resulting derived thermodynamic properties, could be used to improve the performance of the Helmholtz EOS. More generally, this measurement technique and efficient derived property analysis will be employed to rapidly characterise and tune models for a range of industrial fluids, including low-global-warming-potential refrigerant mixtures.