A New Fundamental Equation of State for cis-1,1,1,4,4,4-Hexafluoro-2-butene (R-1336mzz(Z))

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A new fundamental equation of state is presented for cis-1,1,1,4,4,4-hexafluoro-2-butene (R-1336mzz(Z)). Due to its high normal boiling-point and critical temperature, this fluid is considered as a possible alternative for 1,1,1,3,3pentafluoropropane (R-245fa). The first equation of state for this fluid consisted of polynomial and exponential terms, and was published by the authors in 2016. The uncertainties of this older equation are higher than typical of those for other refrigerants, especially for sound speeds and heat capacities at high pressures. This is because the equation was fitted to limited and partly inaccurate experimental data for the vapor pressures and densities at moderate pressures, and because estimated ideal-gas isobaric heat capacities formed the basis of the ideal-gas part of the equation of state. In this work, we performed very precise and wide-ranging measurements for the density and sound speed and developed a new equation of state by fitting to these measurements. The ideal-gas part is formulated from experimentally determined vapor phase speed of sound measurements, which can be used to derive isobaric heat capacities. The functional form of the residual part uses Gaussian bell-shaped terms coupled with conventional terms, according to recent trends in the development of accurate fundamental equations of state. A state-of-the-art nonlinear fitting technique, combined with numerous thermodynamic constraints, optimized all coefficients and exponents of the terms so that the equation represents the measurements within their experimental uncertainties. The new equation is valid for temperatures from 250 K to 500 K and pressures up to 47 MPa. Typical uncertainties in calculated properties in this range are 0.02 % in liquid densities, 0.1 % in vapor densities, 0.05 % in liquid- and vapor-phase sound speeds, and 0.1 % in vapor pressures. The equation shows reasonable extrapolation behavior at extremely low and high temperatures, and at high pressures.