A New Wide-Range Reference Equation of State for Natural Gases and Other Mixtures

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A new reference equation of state for the thermodynamic properties of natural gases, similar gases, and other mixtures will be presented. The new equation is an extended version of the previously developed GERG-2004 wide-range reference equation of state for natural gases. The extended equation covers 21 specific natural gas components. The equation is valid in the gas and the liquid phase, for the vapor-liquid equilibrium, and in the supercritical region. The wide range of validity enables the use of the equation in both standard and advanced technical applications for natural gases, similar gases, and other mixtures, e.g., pipeline transport, natural gas storage, improved processes with liquefied natural gas (LNG), processing of raw natural gas, and acid-gas injection.
As a multi-fluid approximation explicit in the reduced Helmholtz free energy, with its independent variables density, temperature, and molar composition, the new mixture model is based on accurate fundamental equations for the considered pure components, and equations developed for binary mixtures. This allows for an accurate description of the properties of a variety of multi-component mixtures in a wide range of compositions. The basis for the development of the new equation of state is experimental data of thermal and caloric properties for binary mixtures. Data for natural gases and other multi-component mixtures are used for comparisons.

The normal range of validity covers temperatures from 90 K to 450 K and pressures up to 35 MPa. The uncertainty of the equation in gas phase density and speed of sound of natural gases and similar mixtures is less than 0.1% over the temperature range from 250 K to 450 K at pressures up to 35 MPa. Accurate data of isobaric enthalpy differences of binary and multi-component mixtures are reproduced to within their experimental uncertainty, which is less than (0.2 – 0.5) %. In the liquid phase of many binary and multi-component mixtures, the uncertainty of the equation in density amounts to approximately less than (0.1 – 0.5) %, which is in agreement with the experimental uncertainty. The vapor-liquid equilibrium of binary and multi-component mixtures, including the dew points of natural gases, is accurately described as well.