Helmholtz Type Equations of State - Some Practice Applications

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In the practice of experimental thermodynamics, for either scientific or commercial contract projects, the correlation of results is generally the first theoretical step after the measurements. Unfortunately, for experimentalists, the correlation is sometimes a troublesome task or necessary evil. On the other hand, for the theorists, the experimental results, especially for contract measurements, are often not accurate enough for their sophisticated models. Often exotic or impure substances or undefined mixtures are subject of these investigations. Nevertheless, in contract projects, the customers generally prefer the correlation provided with the reports. For properties like high-pressure densities, heat capacities, or vapor pressures, simple correlations are still common. A more integrated way of correlation is the usage of more complex equations of state to correlate simultaneously density data, vapor pressures, and caloric data. Such correlations enable not only the inter- or extrapolation of the experimental data, but moreover the reliable calculation of additional derived properties.

In cooperation with NIST, high-pressure liquid and supercritical densities, vapor pressures, and critical data were measured and short fundamental equations of state were developed and published for pure compounds [1,2]. The new Helmholtz type short fundamental equations of state (HEOS) are now presented as a solution for practice applications. Measured high-pressure liquid densities and atmospheric heat capacities were used to set up an HEOS, e.g., for hydraulic oil. Such an HEOS is applicable for a defined task, e.g., for the calculation of adiabatic compressibilities and maybe limited to the liquid phase.

For technical applications in the development of comprehensive HEOS for pure compounds or limited HEOS for pseudo pure compounds or mixtures, the software DynaSol ThermoProp can be employed. This software is integrated into Excel and allows alternatively correlations of density data with simple equations or integrated correlations of volumetric and caloric data using HEOS. For the user/customer side, a compact calculation edition of the software can be provided with the experimental data and correlation. This is crucial for the successful usage and further acceptance of the more complex Helmholtz type equations of state.

[1] E.C. Ihmels, E.W. Lemmon, J. Gmehling, *Fluid Phase Equilib.* **207,** 111-130 (2003).
[2] E.W. Lemmon and E.C. Ihmels, *Fluid Phase Equilib.* **228-229**, 173-187 (2005).