Modeling Thermodynamic Properties of Isopentane and Mixtures Used as Working Fluids for Heat Pumps and Organic Rankine Cycles

Hiroyuki Miyamoto [C, S]
Department of Mechanical Systems Engineering, Toyama Prefectural University, Imizu, Toyama, Japan
miyamoto@pu-toyama.ac.jp

Ryo Akasaka
Department of Mechanical Engineering, Kyushu Sangyo University, Fukuoka, Japan

Eric W. Lemmon
Applied Chemicals and Materials Division, NIST, CO, U.S.A.

For higher thermal efficiency and lower environmental impact, mixtures of natural substances could be used as alternative working fluids for geothermal heat pumps and organic Rankine cycles. To obtain accurate thermodynamic properties for mixtures, reliable equations for the pure fluids are first required. However, compared to the reference models for water and CO2, the reliability of the data for isopentane is insufficient. This is because most of the input data used for fitting were older literature data published before the 1990's, when the new international temperature scale (ITS-90), a guide to the expression of uncertainty in measurements (GUM), and a new international formulation for water (IAPWS-90 model) were not available. Especially the IAPWS-90 model is very important since water has been mainly used for the calibration of the inner volume for volumetry including the bellows method since a long time ago. It is thought that the accuracy of the measurements has improved by the improvement of the equation for water. We therefore set out to measure the most reliable data of various thermodynamic properties for isopentane. For the measurements, two apparatuses were used for various temperature and pressure regions. For example, the expanded uncertainties (k=2) in temperature, pressure, and density measurements of one apparatus have been estimated to be less than 3 mK, 1.5 kPa – 0.2 % ($p > 150$ MPa), and 0.10 %, respectively. We also give details on a new Helmholtz-type equation of state based on the present data as input data in our presentation.