

# Measurements of Specific Heat Capacity at Constant Pressure and Assessment of Thermodynamic Properties in the Liquid Phase for Five Pure Hydrofluorocarbons

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Thermodynamic information on the specific heat capacity of liquid refrigerants is important not only for heat transfer calculations in heat exchangers but also for deriving accurate vapor pressures and heats of vaporization with the aid of thermodynamic relations. In addition, for the development of accurate thermodynamic equations of state for the liquid phase, the liquid specific heat is also necessary information because density changes little in the liquid phase.

Specific heat capacity at constant pressure for liquid hydrofluorocarbons (HFCs) has been consistently measured using a flow-calorimeter since 1989. We have already measured it for five pure HFCs, R134a, R152a, R32, R143a, R125, and the HFC mixture R507A (HFC-125 + HFC-143a with a composition of 50/50 mass percent). Most of the data have been measured at temperatures between 276 and 360 K and at pressures below 3.2 MPa. The experimental uncertainties are estimated to be between  $\pm 8.4$  and  $\pm 13$  mK in temperature,  $\pm 3$  to  $\pm 10$  kPa in pressure, and  $\pm 0.3$  to  $\pm 0.8$  % in specific heat capacity. Unfortunately these data do not always agree well with other measurements due to the experimental uncertainties including the impurity of sample liquid.

On the other hand, many high-quality measurements on the thermodynamic properties of HFCs have led to the development of wide-ranging and precise thermodynamic equations of state. In the present study, we assessed the reliability of our measurements by studying the thermodynamic consistency among our heat capacity data and the reliable experimental data such as speed of sound, heat capacity, and  $p$ - $\rho$ - $T$  measurements with existing fundamental equations of state including the IEA internationally recommended formulations.

A simple but precise equation of state for liquid HFCs is being developed at the moment. This equation will be also used for the discussion to confirm the thermodynamic consistency among the experimental data including the thermodynamic surface at low temperatures in the liquid phase.