21CR Project 605-50010

Investigation of AC&R Systems Operated Near and Above the Refrigerant Critical Temperature - NIST

Updated 10 March 2003

Objectives:

The main goal of this project was to investigate and compare the performance of an R410A air conditioner to that of an R22 air conditioner, with specific interest in performance at high ambient temperatures at which the condenser of the R410A system may be operating above the refrigerant's critical point.

Summary:

Part 1 of this project consisted of conducting comprehensive measurements of thermophysical for refrigerant R125 and refrigerant blends R410A and R507A and developing new equation of state formulations and mixture models for predicting thermophysical properties of HFC refrigerant blends.

For R125, isochoric (constant volume) heat capacity was measured over a temperature range of 305 to 397 K (32 to 124 C) at pressures up to 20 MPa.

For R410A, isochoric heat capacity was measured along 8 isochores with a temperature range of 303 to 397 K (30 to 124 C) at pressures up to 18 MPa. Pressure-density-temperature was also measured along 14 isochores over a temperature range of 200 to 400 K (-73 to 127 C) at pressures up to 35 MPa and thermal conductivity along 6 isotherms over a temperature range of 301 to 404 K (28 to 131 C) with pressures to 38 MPa.

For R507A, viscosity was measured along 5 isotherms over a temperature range of 301 to 421 K (28 to 148 C) at pressures up to 83 MPa and thermal conductivity along 6 isotherms over a temperature range of 301 to 404 K (28 to 131 C) with pressures to 38 MPa.

Mixture models were developed to calculate the thermodynamic properties of HFC refrigerant mixtures containing R32, R125, R134a and/or R125. The form of the model is the same for all the blends considered, but blend-specific mixing functions are required for the blends R32/125 (R410 blends) and R32/134a (a constituent binary of R407 blends). The systems R125/134a, R125/143a, R134a/143a, and R134a/152a share a common, generalized mixing function.

The new equation of state for R125 is believed to be the most accurate and comprehensive formulation of the properties for that fluid. Likewise, the mixture model developed in this work is the latest state-of-the-art for thermodynamic properties of HFC refrigerant blends. These models were incorporated into version 7 of NIST REFPROP database.
Part 2 of this project conducted performance measurements of split-system, 3-ton R22 and R410A residential air conditioners in the 80 to 135 F (27.8 to 57.2 C) outdoor temperature range and development of a system performance model. The performance data was used in preparing a beta version of EVAP-COND, a windows-based simulation package for predicting performance of finned-tube evaporators and condensers. The modeling portion of this project also included the formulation of a model for an air-conditioner equipped with a thermal expansion valve (TXV).

Capacity and energy efficiency ratio (EER) were measured and compared. The R22 system's performance was measured over the outdoor ambient temperature range of 80 to 135 F (27.8 to 57.2 C). The same test range was planned for the R410A system. However, the compressor's safety system cut off the compressor at the 135.0 F (57.2 C) test temperature. The highest measurement on this system was at 130.0 F (54.4 C). Subsequently, a custom-manufactured R410A compressor with a disabled safety system and a more powerful motor was installed and performance was measured at outdoor temperatures up to 155.0 F (68.3 C).

Both systems had similar capacity and EER performance at 82.0 F (27.8 C). The capacity and EER degradation of both systems were nearly linearly dependent with rising ambient outdoor ambient test temperatures. The performance degradation of R410A at higher temperatures was greater than R22. However, the R22 and R410A systems both operated normally during all tests. Visual observations of the R410A system provided no indication of vibrations or TXV hunting at high ambient outdoor test conditions with the compressor operating in the transcritical regime.

Research subcontractor:

National Institute of Standards and Technology, Gaithersburg, MD (Principal Investigators: Mark O. McLinden, Ph.D. & Piotr A. Domanski, Ph.D.)

Status:

Project completed. The final report can be downloaded at no cost from the ARTI website.

Responsible 21CR Subcommittee: Working Fluids