Keynote Lecture 7

Finding a non-flammable, low-GWP replacement for R-134a

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Dr. McLinden holds a Ph.D. in chemical engineering from the University of Wisconsin and joined the National Institute of Standards and Technology in 1984. His research in the NIST Applied Chemicals and Materials Division focuses on highly accurate measurements of fluid properties over wide ranges of temperature and pressure and the design and fabrication of instruments for such measurements. He is the author or coauthor of more than 140 peer-reviewed publications; these have included research on “new” refrigerants; in the 1990s these were replacements for the ozone-depleting CFC and HCFC refrigerants, and more recently, his attention has turned to fluids having low global warming potential (GWP). Dr. McLinden is a fellow of ASHRAE and has received several awards related to his refrigerants research, including the J&E Hall Gold Medal of the Institute of Refrigeration.

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ABSTRACT

We describe a comprehensive, multiyear project to identify and verify a refrigerant blend to replace R-134a in an air-conditioning application. The particular application of the project sponsor requires a non-flammable refrigerant, ruling out R-1234yf. With no viable single-component fluid, we searched refrigerant blends comprising the new HFOs mixed with HFCs that might suppress flammability. To estimate flammability we developed a new estimation method based on molecular structure and thermodynamics. A screening study applied a simplified cycle model to calculate the performance of over 100 000 candidate blends, from which a list of 23 "best" blends were selected.

But would these blends actually perform as promised (i.e., simulated)? A second phase thus carried out an experimental verification of (1) thermodynamic and transport properties; (2) heat transfer performance (two factors which are important inputs to simulation models); (3) flammability characteristics in a test more severe than the one typically used to classify refrigerants; and (4) performance in a lab-scale modular heat-pump system, which served to tune and verify a detailed simulation model. The final phase will test three blends in a full-scale environmental control unit.

Our project is illustrative of the many factors that must be considered to arrive at viable replacement refrigerants. Our project has taken more of a research-focused approach (on properties, flammability, and heat transfer) than might a similar project in industry, and the talk focuses on this, rather than specific results.