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Comparing R-290 With R-22 in Heat Pumps

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The contribution of hydrofluorocarbons to global warming has led to the reinvestigation of hydrocarbons (HCs). Despite the flammability of HCs, some manufacturers of refrigerators and residential air conditioners (especially in the European Union and Japan) have begun to use HCs as refrigerants in small capacity equipment.[1,2] The increased use of HCs in refrigerators brings up the applicability of HCs in residential air-conditioning units and heat pumps. Among the HCs, R-290 has a similar vapor pressure to that of R-22. To contribute to a clearer understanding of the relative performance potential of R-290 as compared to R-22, the performance of both refrigerants was measured according to ASHRAE standards[3,4] in a residential, state-of-the-art, split-system air-conditioner heat pump using psychrometric chambers at the Center for Environmental Energy Engineering at the University of Maryland.

The test unit, with a nominal capacity of 9 kW (2.5 tons), uses a scroll-type compressor and a thermostatic expansion valve that was originally designed for R-22. In the R-290 comparison tests, a compressor of equal nominal efficiency to the R-22 compressor (with a displacement volume increased by 11%) was used to approach R-22's capacity. In addition to the compressor change, a metering valve was used to match the degree of a superheating at the evaporator outlet to simulate the thermostatic expansion valve appropriately designed for R-290. The purity of R-290 was 99.5%.

Cooling Test Results

R-290 showed 3% to 6% lower cooling capacity and 5% lower coefficient of performance (COP) than R-22. R-290 showed a better cyclic performance than R-22 by having 5% lower cycling efficiency loss factors as compared to R-22. The compressor inlet temperature of R-290 was as much as 13 K lower than that of R-22, which contributed a colder evaporator temperature. Additionally, the lower suction temperature and higher specific heat of R-290 resulted in a lower discharge temperature than that of R-22. Based on the steady-state and cyclic cooling test results, the SEERs were calculated for both refrigerants. As was similar to the steady state cooling performance results, the SEER of R-290 was lower than that of R-22.

Heating Test Results

The heating performance of R-22 and R-290 was evaluated at various ambient temperatures. Test results showed that R-290 had equal lower heating capacity and COP than R-22 when the ambient temperature was –8°C (17°F) or higher. The capacity improvement of R-290 at lower ambient temperature are consistent with the relative increase in vapor density and increasingly favorable transport properties of R-290 as compared to R-22 as ambient temperature decreases.

References

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4. ANSI/ASHRAE Standard 116-1995, *Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps.*

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