EXECUTIVE SUMMARY

FINAL REPORT ARTI-21CR/610-10030-01
EVALUATION OF THE PERFORMANCE POTENTIAL OF CO_2 AS A REFRIGERANT IN AIR-TO-AIR AIR CONDITIONERSAND HEAT PUMPS: SYSTEM MODELING AND ANALYSIS

(ABSTRACT)

This study presents the development, validation and application of a new model for simulating the performance of unitary air-to-air CO_2 air conditioners and heat pumps. Validation of the model has been accomplished using recent experimental data for a gas cooler and evaporator, each tested as stand-alone components, as well as CO_2 system data. Heat exchanger capacities were predicted within the bounds of experimental error. The compressor power consumption and system COP were predicted within 5% of the experimental values. The air-side pressure drop was predicted within 30% of the experimental values and the refrigerant-side pressure drop was overpredicted by a factor of 1.0 to 2.5. Using alternate friction factor correlations, checking density calculation and removing minor loss coefficients failed to isolate the source of the CO_2 pressure drop prediction error.

Case studies simulating a carbon dioxide heat pump system in both cooling and heating modes were conducted. Two different carbon dioxide prototype compressors were used to build the simulated carbon dioxide heat pump system. The case studies included improvements of the CO_2 system by internal heat exchange, work producing expansion machine, using a high-efficiency compressor, and using more effective heat exchangers. The simulated EER of 6.5 of the baseline CO_2 system is about 60% of the value of a mid-efficiency R-410A air-conditioner, while the maximum simulated EER of 12.0 of a greatly enhanced CO_2 system is about 116% of

the value of a mid-efficiency R-410A air-conditioner. The simulated HPF of 7.5 of the baseline CO_2 system is about 60% of the value of a mid-efficiency R-410A heat pump while the maximum simulated HPF of 13.6 of a greatly enhanced CO_2 system is about 107% of the value of a mid-efficiency R-410A heat pump. Based on the simulation conducted in this study, it seems that a greatly enhanced CO_2 system has the potential to be used in unitary air conditioners and heat pumps without losing energy efficiency compared to a conventional R-410A system.