PERFORMANCE TESTING OF DR-55 AS A REPLACEMENT FOR R-410A REFRIGERANT

Laboratory test at the Western Cooling Efficiency Center-UC Davis

DR-55 refrigerant testing on a Trane heat pump in WCEC's environment chamber

EFFICIENCY SAVINGS

5% greater efficiency at AHRI conditions than R-410A

DISCHARGE PRESSURE PERFORMANCE

7% lower discharge pressure than R-410A

REFRIGERANT CHARGE PERFORMANCE

9% less refrigerant charge than R-410A

PROBLEM

The modernization and economic growth in countries like China and India have led to an even larger marketplace for vapor compression cooling—and a larger overall carbon footprint and global warming potential (GWP). Because of the inevitable increase in vapor compression cooling throughout the world, solutions to reduce the global warming potential of each of these units can have a significant impact on our environment.

SOLUTION

One part of that solution is to reduce the global warming potential of the refrigerants used in these systems. Accidental release of refrigerant to the atmosphere is inevitable with these systems so it is imperative to identify a working fluid that has low GWP while also achieving acceptable performance and low safety risk to occupants. The predominant refrigerant used in air conditioning equipment today is R-410A. While R-410A provided a good alternative to R-22, recent advances in refrigerant blends are showing further reductions in global warming potential, while also demonstrating comparable performance.

TESTING PROCEDURES

The UC Davis Western Cooling Efficiency Center performed controlled laboratory testing of a Heat Pump before and after replacement with a new refrigerant blend (DR-55) identified by Ingersoll Rand from within Chemours' refrigerant portfolio that reduces the GWP to levels similar to R-32 but with lower flammability. The manufacturer claims that the tested refrigerant, DR-55, has a 70% reduction in GWP compared to R-410A. This new refrigerant was developed to be a design-compatible replacement for R-410A meaning no major component changes are required. The testing was performed on a 14kW (4-ton) Trane WSC048E3 Heat Pump in Davis, CA, to determine its true efficacy as a replacement for R-410A.

The environmental test chamber at UC Davis was built following ASHRAE 37 guidelines and meets the AHRI testing standard. The chamber consists of an outdoor environmental chamber and indoor environmental chamber both with humidity and temperature control. The UC Davis test facility can test equipment up to 17.5kW (5-Tons) and is designed primarily for cooling operations.

The only modification made to the heat pump at the time of the retrofit with DR-55 was replacement of the existing TXVs with adjustable TXVs to account for change in operating pressures and refrigerant mass flow rate. The TXV and refrigerant charge adjustments were made in order to approximate the superheat and subcooling measured during the baseline tests with R-410A.

The WCEC tested the heat pump in cooling mode under a wide range of outdoor air conditions as well as one heating condition. Table 1 shows the range of test conditions measured for this study.

Test	Ambient Temperatures °C DB* (°F DB)	Indoor Load Temperatures °C DB/WB** (°F DB/WB)
C1	51.7 (125)	26.7/19.4 (80/67)
C2	46.1 (115)	
C3	40.6 (105)	
C4	35.0 (95) [1]	
C5	27.4 (85)	
C6	27.8 (82) [2]	
C7	23.9 (75)	
C8	18.3 (65)	

Table 1: Range of test conditions.

**DB: Dry-Bulb temperature*
*** WB: Wet-Bulb temperature*

[1] AHRI Standard 210/240 "A" rating condition
[2] AHRI Standard 210/240 "B" rating condition

RESULTS

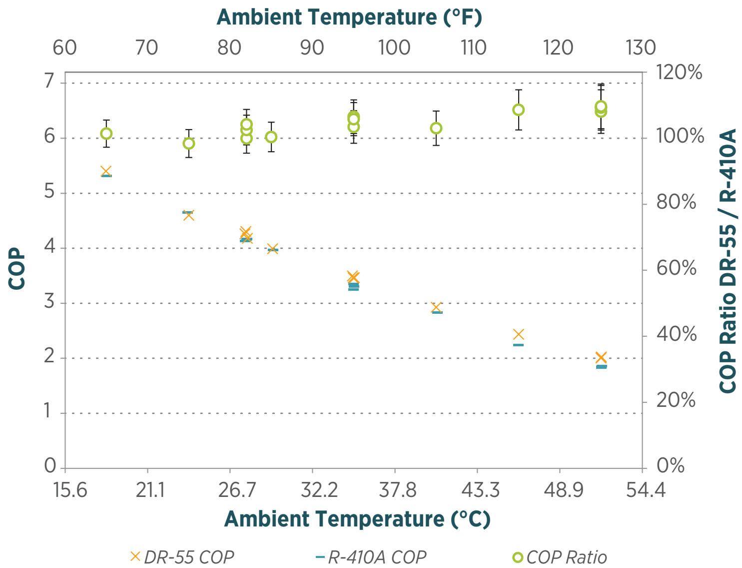

Figure 1: Coefficient of Performance for DR-55 vs. R-410A

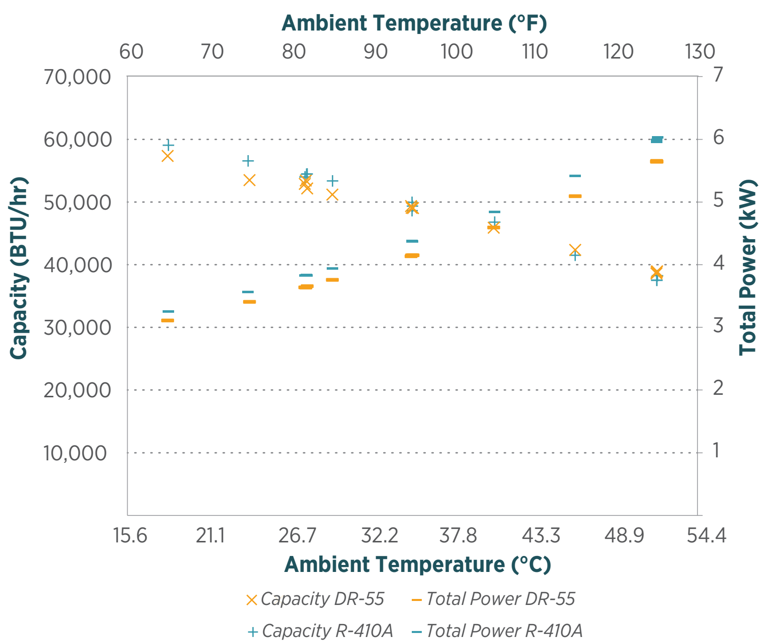

Figure 2: Capacity and total power usage of DR-55 vs. R-410A

The coefficient of performance (COP) is plotted showing comparable performance between DR-55 and R-410A at lower temperatures, and a small improvement in performance for DR-55 at higher temperatures (Figure 1). The average COP improvement of DR-55 over the range of outdoor air conditions tested was 4%. Actual savings at a particular location would depend on the number of hours that the unit is expected to run at each air temperature.

The capacity and total power draw are plotted together showing slightly lower capacity for DR-55 at low outdoor air temperatures compared to R-410A (Figure 2); however, the capacity using DR-55 is flatter across the range of outdoor air conditions tested and shows slightly higher capacity than R-410A at hotter outdoor air temperatures.

The total power draw is lower for the unit running with DR-55 refrigerant across all outdoor air conditions tested likely due to the lower compressor discharge pressure. On average the power draw for the air conditioner with DR-55 refrigerant was about 5% lower than with R-410A. While the compressor running with DR-55 had lower suction and discharge pressures, the corresponding temperatures were higher. The discharge temperature ranged from 6-7°C (11-13°F) higher than R-410A over the ambient temperature range of 24-52°C (75-125°F).

CONCLUSION

Lab testing of a new refrigerant designed to be a design-compatible replacement for R410A equipment with lower global warming potential was performed at the UC Davis Western Cooling Efficiency Center laboratory in Davis, CA. The air conditioning equipment was tested at eight outdoor air conditions from 18°C-52°C (65°F-125°F) using R-410A to obtain a baseline and the tests were repeated after retrofit with the new DR-55 refrigerant.

The only modification to the unit at the time of the retrofit involved changing out the existing TXV with an adjustable TXV to allow for appropriate tuning of superheat. It is expected that an R-410A piece of equipment with an existing adjustable TXV would not require this modification. The test unit required only 8.2 pounds of refrigerant to obtain the target subcooling while the manufacturer recommends charging with 9.0 pounds of R-410A.

The results show that the equipment operating with DR-55 refrigerant achieved similar capacity to the equipment operating with R-410A but used less total power in each test performed. The combination of providing comparable cooling capacity using less power is what results in the better efficiency observed for the unit operating with DR-55. DR-55 showed a 5% improvement in the equipment coefficient of performance at the AHRI rated condition (95°F) and 4% improvement in coefficient of performance on average across all tested conditions.

Given the relatively low global warming potential and refrigerant charge requirement, DR-55 refrigerant should be considered as a possible replacement for R-410A. Lab testing performed for this project has shown excellent performance over a wide range of outdoor air conditions. Although it is being acknowledged around the world that some flammability will need to be accepted in order to achieve use of refrigerants with lower GWP, lower flammability of refrigerants like DR-55 offer potential for safer implementation.

ABOUT WCEC

The Western Cooling Efficiency Center was established along side the UC Davis Energy Efficiency Center in 2007 through a grant from the California Clean Energy Fund and in partnership with California Energy Commission Public Interest Energy Research Program. The Center partners with industry stakeholders to advance cooling-technology innovation by applying technologies and programs that reduce energy, water consumption and peak electricity demand associated with cooling in the Western United States.

PREPARED BY

Curtis Harrington
Associate Engineer

Paul Fortunato
Outreach Coordinator

Western Cooling Efficiency Center
University of California, Davis
215 Sage Street #100
Davis, CA 95616

wcec.ucdavis.edu