Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Low-GWP Alternative Refrigerants Evaluation Program (Low-GWP AREP)

TEST REPORT #40

Compressor Calorimeter Test of Refrigerant DR-5 in a R-410A Rotary Type Compressor

Zhang Lei
Zhu Yanting

Shanghai Hitachi Electrical Appliances CO., LTD
888 Ningqiao Rd. Pudong Jinqiao
Shanghai, China

May 1, 2014

This report has been made available to the public as part of the author company's participation in the AHRI's Low-GWP AREP.

AHRI
Air-Conditioning, Heating, and Refrigeration Institute
2111 Wilson Boulevard, Suite 500
Arlington VA 22201
(703) 524-8800
www.ahrinet.org

List of Tested Refrigerant's Composition (Mass%)

DR-5	R-32/R-1234yf (72.5/27.5)

1. Introduction

In this report, we compare the performance of DuPont DR-5 with the baseline R-410A in a hermetic rotary type compressor. Tests under standard conditions were conducted in Shanghai Hitachi's explosion-proof laboratory.

2. Test Setup

The compressor being used in the calorimeter test is a hermetic rotary type compressor manufactured by Shanghai Hitachi. The original compressor model is specially designed for refrigerant R-410A with a nominal displacement of 28.0 cc. The compressor is driven by a constant-speed electric motor which holds a nameplate size of 2.5 hp. Single phase source with 220V and 50Hz is used to supply power. The lubricant is the same as the R-410A compressor. And its kinematic-viscosity is about 68 mm/s^2（40℃）. It should be noted that both low GWP refrigerant DR-5 and baseline R-410A were tested in the **same** compressor.

Since the testing compressor is positive displacement type, all calorimeter tests were done in accordance with ASHARE Standard 23-2010. Our testing equipments are designed on the basis of secondary refrigerant calorimeter method, the test loop of which can be described as figure 1 below, and confirming test method is the liquid refrigerant flow meter method. Differences of refrigerant flow rate obtained from primary test method and confirming method are within ±3% as stated.

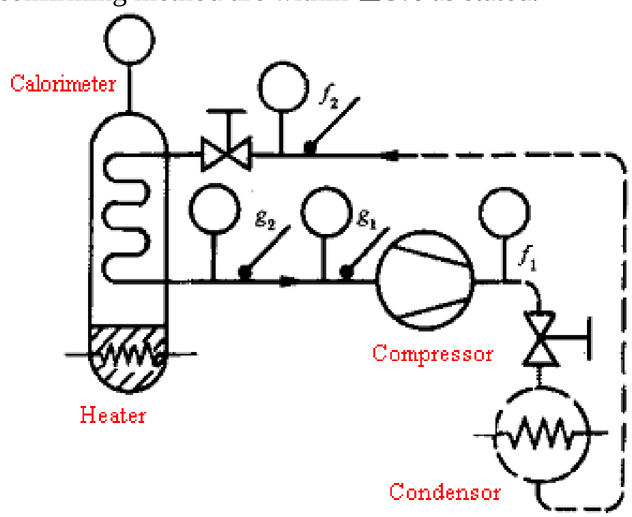

Figure1. Test Loop Schematic using Secondary Refrigerant Calorimeter Method

f1---Discharge Pressure Sensor; f2----Temperature Sensor;

g1--- Temperature Sensor; g2--- Temperature Sensor;

Instruments equipped in testing bench are selected to meet the error limits specified in ASHARE Standard 23-2010. Measurement accuracy requirement of some parameters are listed in table 1.

Table1. Measurement Accuracy

Items	Stated measurement accuracy	Sensor accuracy
Temperature	±0.3K	±0.1℃(suc) , ±0.2℃(dis)
Pressure	±1.0%	±0.01Mpa(dis), ±0.005Mpa(suc)
Liquid Flow Rate	±1.0%	±0.2%
Power input	±1.0%	±0.2%

Shaft rotational speed	±1.0%	±1.0%
Time	±0.5%	±0.1%
Weight	±0.2%	±0.2%

3. Test Conditions

In Low-GWP AREP participants' handbook, 8 different standard rating conditions for compressors used in air-conditioners and heat pumps are provided. Learning about the basic performance difference between R-410A and DR-5 is our main purpose， we needn't make the 10- coefficient models this time. And considering the limited resource of our test， we determine to conduct tests under following conditions as listed in table2 this time. The ambient temperature around the compressor during the tests is 35℃.

Table2. Standard Rating Conditions

Test Point	Suction Dew Point Temperature	Discharge Dew Point Temperature	Expand Valve Inlet Temperature	Return Gas Temperature
	℃	℃	℃	℃
A	7.2	54.4	46.1	18
B	7.2	46.1	37.8	18
C	7.2	37.8	29.5	18
D	-1.1	43.3	35	10

4. Result and Discussion

Detailed compressor testing data under standard conditions are listed in table 3, appendix A. Some major parameters are illustrated in the form of bar graphs as the four figures below, so as to directly compare the different compressor performance when using alternative refrigerant DR-5 and the baseline R-410A.

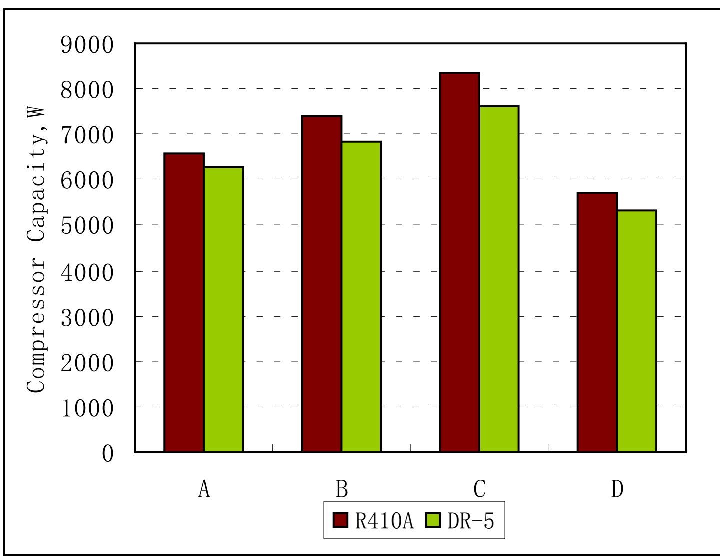

Figure 2. Compressor Capacity of DR-5 and R-410A

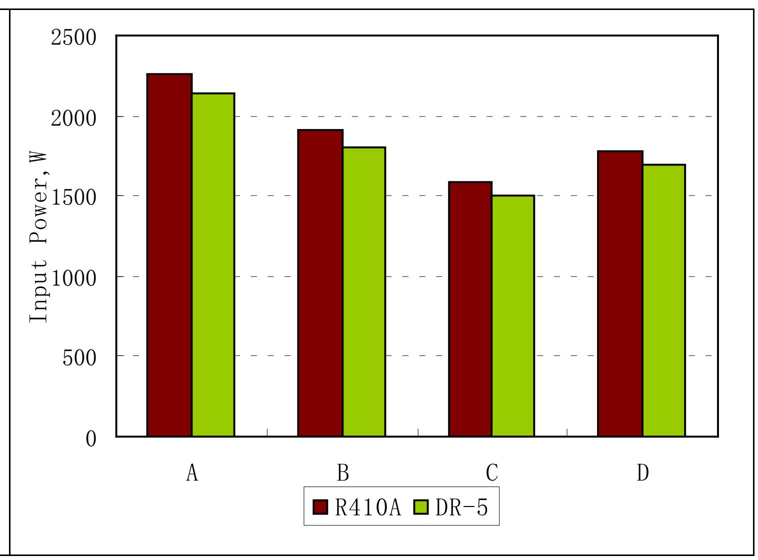

Figure 3. Input Power Input of DR-5 and R-410A

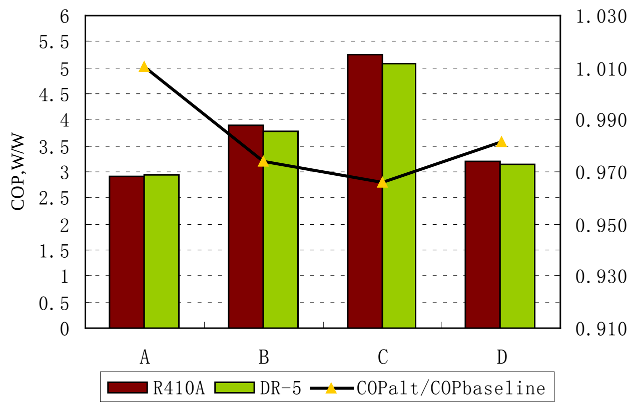

Figure 4. COP of DR-5 and R-410A

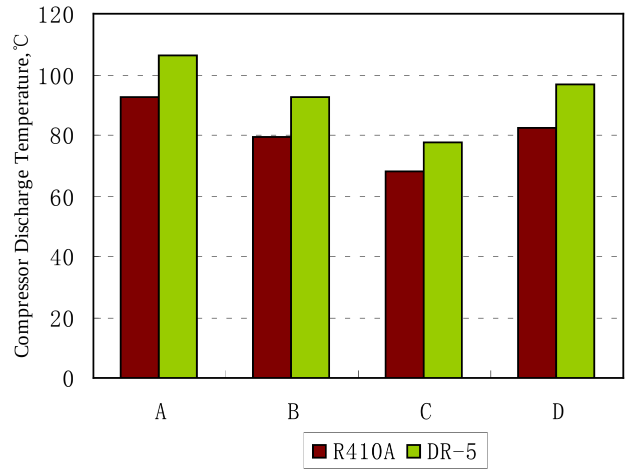

Figure 5. Discharge Temperature of DR-5 and R-410A

Based on Figure 2 and Figure 3, we may conclude that DuPont DR-5 has a relatively lower capacity than R-410A with the biggest shortfall by about 9% at test condition C. Accordingly, compressor using DR-5 calls for a lower input power as well.

As shown in figure 4, when employed as the refrigerant in our testing compressor, at the given evaporator temperature of 7.2 ℃, R-410A has higher COP than DR-5 under test point B and C. DR-5 has slightly higher COP under test point A. Under test condition D in the heating mode, R-410A also has higher COP than DR-5. Considering R-410A as the baseline, the relative COP (COP_{alt} / $COP_{Baseline}$) varies from 0.96 to 1.01.

According to Figure 5, when no additional adjustment is made to the compressor or testing circuit, the compressor using DR-5 has a higher discharge temperature than R-410a with the increment by about 10~15 ℃.

Appendix A

Table3. Tabular Data

test conditions		A		B		C		D	
refrigerants		**R-410A**	**DR-5**	**R-410A**	**DR-5**	**R-410A**	**DR-5**	**R-410A**	**DR-5**
evaporating temperature	℃	7. 2		7. 2		7. 3	7. 2	−1. 1	
condensing temperature	℃	54. 4		46. 1		37. 8		43. 3	
discharge temperature	℃	92. 4	106	79. 2	92. 5	68	77. 6	82. 4	97
applicable superheating	℃	10. 9	10. 8	10. 9	10. 8	10. 7	10. 8	11. 1	11. 1
applicable subcooling	℃	8. 3	8. 3	8. 3	8. 3	8. 3	8. 3	8. 3	8. 3
compressor capacity	W	6561. 6	6259. 8	7397. 6	6815. 3	8337. 6	7608. 8	5718. 5	5330. 6
refrigerant mass flow rate	kg/h	148. 9	113. 4	153. 2	114. 8	159. 4	119	117	88. 1
amperes	A	10. 5	9. 9	8. 8	8. 3	7. 4	6. 9	8. 3	7. 8
input power	W	2264. 3	2135. 8	1907. 7	1803	1589. 3	1499. 9	1783. 6	1693. 5
COP	W/W	2. 90	2. 93	3. 88	3. 78	5. 25	5. 07	3. 21	3. 15
$COP_{alt}/COP_{baseline}$		1	1. 011	1	0. 974	1	0. 966	1	0. 981