



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

## **TEST REPORT #58**

### **Compressor Calorimeter Test of Refrigerant DR-5A in a R-410A Scroll Compressor**

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



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## List of Tested Refrigerants' Compositions (Mass%)

DR-5A (R454B)	R-32/R-1234yf (68.9% / 31.1%)
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## **Introduction**

This Report covers the performance testing of DR-5A performed by Emerson Climate Technologies, Inc. (Emerson) for the AHRI Low-GWP AREP 2 Study. The testing was done in Emerson's A2L Research calorimeter lab test facility located in Sidney, Ohio. The refrigerant was tested with a R-410A Copeland Scroll Compressor ZP31K5E-PFV for Air Conditioning applications. This report is based on a drop-in test. No optimization, oil, or hardware changes were made to account for the alternative refrigerant. All compressor tests are performed at a refrigerant's dew point temperature for suction and discharge pressure conditions, per AHRI Standard 540 requirements. This does not have an impact on comparing compressor performance between two or more refrigerants that do not exhibit temperature glide. However, when refrigerants exhibit temperature glide, it is important to note that actual systems operate closer to the mid-point condition. When comparing compressor performance of one refrigerant to another refrigerant without glide, or comparing two refrigerants with significantly different glides, comparison at pressures corresponding to the mid-point of the temperature glide rather than the dew point will yield results that are more representative of actual operation in a system. The typical temperature glide of DR-5A is 2° to 3° F, as opposed to near-zero for R-410A.

## **Details and Test Setup**

### **Description of Test Refrigerant-Lubricant and Charge**

- Refrigerant / Refrigerant Blend Tested:
  - Initial Refrigerant Charge: 4 lbs (1.8 kg)
- Lubricant:
  - Oil: 32-3MAF POE Oil
  - Viscosity Grade: 32 cSt.
  - Any modifications to base lubricant? No

### **Description of Compressor**

- Copeland R-410A Scroll Compressor
- No Compressor Modifications
- Emerson Climate Technologies, Inc. Copeland Brand
- Model No. ZP31K5E-PFV, Serial No.10C28D08L
- Motor Nameplate Rating: 208/230 V
- Displacement: 1.8 in<sup>3</sup>/rev
- Air Flow Required (Y/N?): Yes
- Quantity: 1,360 ft<sup>3</sup>/min (38.5 m<sup>3</sup>/min)
- Velocity and Temperature of Air: 95 °F Ambient

- Orientation of Air Flow IN Relation to the Compressor: Perpendicular to the vertical axis of the compressor
- Compressor Test Points (See Test Points in Table 1)

**Table 1 Compressor Calorimeter Test Points**

Ambient Air Temperature		Suction Pressure		Saturated Suction Temperature (Dew Point)		Refrigerant Vapor Temperature Entering Compressor		Discharge Pressure		Saturated Discharge Temperature (Dew Point)		Discharge Temperature		Volts – Phase – Frequency	Speed
°F	°C	psia	Bar	°F	°C	°F	°C	psia	Bar	°F	°C	°F	°C		RPM
95	35.0	46.8	3.23	-10	-23.33	-10	-23.33	229.60	15.83	80	26.67	215	101.67	230-1-60	3551
95	35.0	70.4	4.85	10	12.22	10	12.22	229.60	15.83	80	26.67	174	78.89	230-1-60	3549
95	35.0	102.2	7.05	30	-1.11	30	-1.11	229.60	15.83	80	26.67	148	64.44	230-1-60	3554
95	35.0	156.2	10.77	55	12.78	55	12.78	229.60	15.83	80	26.67	132	55.56	230-1-60	3559
95	35.0	57.6	3.97	0	-17.78	0	-17.78	265.30	18.29	90	32.22	116	46.67	230-1-60	3542
95	35.0	70.4	4.85	10	-12.22	10	-12.22	265.30	18.29	90	32.22	190	87.78	230-1-60	3544
95	35.0	12.8	0.88	40	4.44	40	4.44	265.30	18.29	90	32.22	155	68.33	230-1-60	3544
95	35.0	71.9	4.96	11.1	-11.61	11.1	-11.61	271.00	18.68	91.5	33.06	194	90.00	230-1-60	3544
95	35.0	46.8	3.23	-10	-23.33	-10	-23.33	305.20	21.04	100	37.78	279	137.22	230-1-60	3532
95	35.0	85.2	5.87	20	-6.67	20	-6.67	305.20	21.04	100	37.78	193	89.44	230-1-60	3540
95	35.0	144	9.93	50	10	50	10	305.20	21.04	100	37.78	159	70.56	230-1-60	3542
95	35.0	147.1	10.14	51.3	10.72	51.3	10.72	311.10	21.45	101.4	38.56	160	71.11	230-1-60	3537
95	35.0	57.6	3.97	0	-17.78	0	-17.78	349.40	24.09	110	43.33	279	137.22	230-1-60	3515
95	35.0	102.2	7.05	30	-1.11	30	-1.11	349.40	24.09	110	43.33	195	90.56	230-1-60	3527
95	35.0	104.4	7.20	31.2	-0.44	31.2	-0.44	356.00	24.55	111.4	44.11	197	91.67	230-1-60	3525
95	35.0	144	9.93	50	10	50	10	373.40	25.75	115	46.11	181	82.78	230-1-60	3520
95	35.0	147.1	10.14	51.3	10.72	51.3	10.72	380.30	26.22	116.4	46.89	183	83.89	230-1-60	3520
95	35.0	121.8	8.40	40	4.44	40	4.44	398.60	27.48	120	48.89	202	94.44	230-1-60	3511
95	35.0	156.2	10.77	55	12.78	55	12.78	398.60	27.48	120	48.89	186	85.56	230-1-60	3519
95	35.0	85.2	5.87	20	-6.67	20	-6.67	453.10	31.24	130	54.44	243	117.22	230-1-60	3494
95	35.0	132.5	9.14	45	7.22	45	7.22	453.10	31.24	130	54.44	213	100.56	230-1-60	3496
95	35.0	132.5	9.14	45	7.22	45	7.22	453.10	31.24	130	54.44	214	101.11	230-1-60	3497
95	35.0	135.2	9.32	46.2	7.89	46.2	7.89	460.00	31.72	131.2	55.11	212	100.00	230-1-60	3499
95	35.0	102.2	7.05	30	-1.11	30	-1.11	513.40	35.40	140	60.00	280	137.78	230-1-60	3467

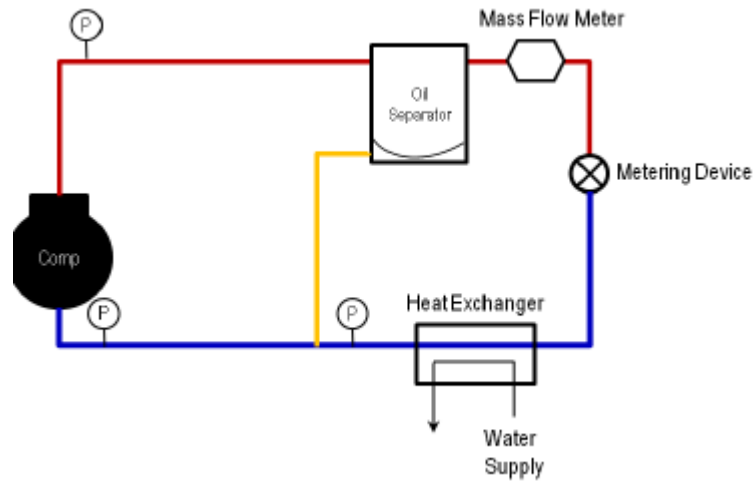
95	35.0	156. 2	10.7 7	55	12.78	55	12.78	513.4 0	35.4 0	140	60.0 0	225	107.22	230-1-60	3481
95	35.0	156. 2	10.7 7	55	12.78	55	12.78	546.0 0	37.6 5	145	62.7 8	230	110.00	230-1-60	3469
95	35.0	159. 3	10.9 8	56.2	13.44	56.2	13.44	553.4 0	38.1 6	146. 1	63.3 9	232	111.11	230-1-60	3464
95	35.0	121. 8	8.40	40	4.44	40	4.44	580.3 0	40.0 1	150	65.5 6	282	138.89	230-1-60	3450
95	35.0	156. 2	10.7 7	55	12.78	55	12.78	580.3 0	40.0 1	150	65.5 6	247	119.44	230-1-60	3455

<sup>1</sup> Discharge temperature measured 6 in. (152.4 mm) downstream of compressor discharge port

<sup>2</sup> Suction Superheat of 20 °F

## Description and Size of Test Loop

- Test Loop Components: See Figure 1
  - Testing was completed on a gas cycle stand which does not require evaporator or condenser. Therefore, there is no measured glide data for this test.
- Instrumentation / Accuracy: See Table 2



**Figure 1 Simplified System Diagram of Test Setup**

**Table 2 Test Loop Component Accuracy**

<b>Device</b>	<b>Instrumentation Accuracy</b>	<b>Full Scale/Span</b>
<b>3051S1TA3A2E11A2AT1</b>		
Suction Pressure Transducer	± .025% span	300 psia
Discharge Pressure Transducer	± .025% span	800 psia
EVI Pressure Transducer	± .025% span	400 psia
<b>G4AD3</b>		
Suction Pressure Signal Conditioning Module	± 0.08% full scale	300 psia
Discharge Pressure Signal Conditioning Module	± 0.08% full scale	800 psia
EVI Pressure Signal Conditioning Module	± 0.08% full scale	400 psia
<b>3144PD1A1NA</b>		
Suction Temperature Transducer	± 0.45 °F ± 0.02% of span	200 °F
Discharge Temperature Transducer	± 0.45 °F ± 0.02% of span	400 °F
Compressor Ambient Temperature Transducer	± 0.45 °F ± 0.02% of span	200 °F
<b>G4AD3</b>		
Suction Temperature Signal Conditioning Module	± 0.08% full scale	200 °F
Discharge Temperature Signal Conditioning Module	± 0.08% full scale	400 °F
Compressor Ambient Temperature Signal Conditioning Module	± 0.08% full scale	200 °F
<b>G4AD18</b>		
EVI Temperature Signal Conditioning Module	± 1.62 °F (± 0.9 °C)	435 °F
<b>DSP-1Y25A125</b>		
Watts	± 0.1% reading ± 0.01% full scale	155.885kW
Volts	± 0.1% full scale	720 V
Amps	± 0.1% full scale	125 A
<b>CMF025 W/MVD Transmitter</b>		
Compressor Mass Flow	± 0.35% of rate	
<b>CMF010 W/MVD Transmitter</b>		
Oil Circulation Mass Flow	± 0.1% rate	



## Results

Table 3 shows the test results from drop-in compressor testing with DR-5A. The R-410A baseline data is from published nominal rating data (Capacity and EER within  $\pm 5\%$  of test data). Capacity calculations for DR-5A are done via measured mass flow multiplied by enthalpy change using the refrigerant properties supplied by the chemical manufacturer. All compressor performance is based on dew temperature / pressure and was tested per AHRI Standard 540-2004.

**Table 3 DR-5A Test Results**

Evap Temp. (Dew Point)		Evaporator Glide <sup>1</sup>	Condensing Temperature (Dew Point)		Condenser Glide <sup>1</sup>	Discharge Temperature		Applicable Superheating		Applicable Subcooling		Cooling Compressor Capacity		Refrigerant Mass Flow Rate		Current	Input Power	Cooling EER	Cooling COP	Cooling COP (DR-5A)/(R410A)
°F	°C		°F	°C		°F	°C	°F	°C	°F	°C	Btu/hr	W	lbm/hr	kg/hr	A	W	btu/W-hr		
-10	-23.3		80	26.7		215	101.5	20.0	11.11	15.0	8.3	11,196	3,278	122.4	55.5	7.01	1577	7.10	2.08	0.92
10	-12.2		80	26.7		174	79.0	20.0	11.11	15.0	8.3	18,830	5,514	184.8	83.8	6.95	1566	12.03	3.52	0.93
30	-1.1		80	26.7		148	64.2	20.0	11.11	15.0	8.3	29,494	8,636	283.6	128.7	6.80	1527	19.31	5.66	0.93
55	12.8		80	26.7		132	55.4	20.0	11.11	15.0	8.3	47,066	13,781	443.3	201.1	6.50	1451	32.44	9.50	0.93
0	-17.8		90	32.2		116	46.6	20.0	11.11	15.0	8.3	13,727	4,019	142.0	64.4	7.88	1779	7.72	2.26	0.97
10	-12.2		90	32.2		190	87.6	20.0	11.11	15.0	8.3	17,820	5,218	182.2	82.7	7.83	1765	10.10	2.96	0.97
40	4.4		90	32.2		155	68.2	20.0	11.11	15.0	8.3	34,015	9,960	337.4	153.1	7.60	1711	19.88	5.82	0.95
11.1	-11.6		91.5	33.1		194	90.1	20.0	11.11	15.0	8.3	17,789	5,209	182.9	82.9	7.97	1799	9.89	2.90	0.95
-10	-23.3		100	37.8		279	137.2	20.0	11.11	15.0	8.3	9,237	2,705	101.2	45.9	9.19	2078	4.45	1.30	0.97
20	-6.7		100	37.8		193	89.6	20.0	11.11	15.0	8.3	21,283	6,232	224.9	102.0	8.80	1989	10.70	3.13	0.99
50	10.0		100	37.8		159	70.6	20.0	11.11	15.0	8.3	39,048	11,434	400.8	181.8	8.50	1925	20.28	5.94	0.96
51.3	10.7		101.4	38.6		160	71.3	20.0	11.11	15.0	8.3	39,680	11,619	409.3	185.7	8.61	1950	20.34	5.96	0.97
0	-17.8		110	43.3		279	137.2	20.0	11.11	15.0	8.3	11,092	3,248	125.9	57.1	10.36	2348	4.72	1.38	0.99
30	-1.1		110	43.3		195	90.6	20.0	11.11	15.0	8.3	24,927	7,299	273.0	123.8	9.93	2249	11.08	3.25	0.99
31.2	-0.4		111.4	44.1		197	91.7	20.0	11.11	15.0	8.3	25,289	7,405	278.5	126.3	10.08	2287	11.06	3.24	0.99
50	10.0		115	46.1		181	82.9	20.0	11.11	15.0	8.3	35,891	10,509	395.0	179.2	10.38	2354	15.25	4.46	0.97
51.3	10.7		116.4	46.9		183	84.0	20.0	11.11	15.0	8.3	36,432	10,668	403.3	182.9	10.54	2392	15.23	4.46	0.98
40	4.4		120	48.9		202	94.3	20.0	11.11	15.0	8.3	28,524	8,352	325.1	147.4	11.25	2552	11.18	3.27	0.98
55	12.8		120	48.9		186	85.5	20.0	11.11	15.0	8.3	38,214	11,190	429.4	194.8	11.05	2502	15.27	4.47	0.98
20	-6.7		130	54.4		243	117.3	20.0	11.11	15.0	8.3	17,250	5,051	212.6	96.4	13.13	2979	5.79	1.70	1.11
45	7.2		130	54.4		213	100.6	20.0	11.11	15.0	8.3	29,362	8,597	351.5	159.5	12.83	2911	10.09	2.95	0.99
45	7.2		130	54.4		214	101.2	20.0	11.11	15.0	8.3	29,342	8,592	351.3	159.3	12.81	2907	10.09	2.96	1.00
46.2	7.9		131.2	55.1		212	99.8	20.0	11.11	15.0	8.3	29,926	8,763	360.3	163.4	12.96	2942	10.17	2.98	1.00
30	-1.1		140	60.0		280	137.8	20.0	11.11	15.0	8.3	18,731	5,485	242.3	109.9	15.05	3413	5.49	1.61	1.04
55	12.8		140	60.0		225	107.3	20.0	11.11	15.0	8.3	32,918	9,639	414.2	187.9	14.51	3293	10.00	2.93	1.00
55	12.8		145	62.8		230	109.9	20.0	11.11	15.0	8.3	31,701	9,282	412.0	186.9	15.58	3533	8.97	2.63	1.01
56.2	13.4		146.1	63.4		232	110.9	20.0	11.11	15.0	8.3	31,829	9,320	416.2	188.8	15.80	3580	8.89	2.60	1.01
40	4.4		150	65.6		282	138.8	20.0	11.11	15.0	8.3	21,274	6,229	291.0	132.0	17.13	3878	5.49	1.61	1.04
55	12.8		150	65.6		247	119.4	20.0	11.11	15.0	8.3	29,907	8,757	402.2	182.5	16.68	3780	7.91	2.32	1.02

<sup>1</sup>Testing completed on gas cycle stand

## Performance Curves and Coefficients

The following plots show baseline R-410A and LGWP alternative DR-5A capacity, input power and COP using the 10-Coefficient polynomial equation for each refrigerant (See Figure 2 for DR-5A Coefficients). These coefficients should only be applied within the acceptable compressor operating envelope to avoid excessive extrapolation error in the results.

### R-410A Coefficients

CAPACITY:									
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9
2.7649E+04	4.6479E+02	-1.8341E+02	5.4160E+00	-6.0828E-01	9.4401E-01	6.8451E-03	-1.9080E-02	-2.1820E-03	-4.9607E-03

POWER:									
P0	P1	P2	P3	P4	P5	P6	P7	P8	P9
-5.6136E+02	-1.5626E+01	4.6925E+01	-2.1795E-01	4.3506E-01	-4.4240E-01	2.2457E-04	2.3734E-03	-3.3234E-03	2.4999E-03

### DR-5A Coefficients

CAPACITY:									
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9
3.7010E+04	5.1253E+02	-5.5008E+02	4.6311E+00	-1.9862E+00	4.7403E+00	1.1774E-02	-2.1021E-02	5.7709E-03	-1.6798E-02

POWER:									
P0	P1	P2	P3	P4	P5	P6	P7	P8	P9
2.1509E+02	-4.4243E+00	2.3012E+01	-8.0518E-02	1.3921E-01	-1.9086E-01	-8.1719E-04	1.3971E-03	-1.2663E-03	1.4293E-03

Figure 2 R-410A & DR-5A 10-Coefficient Polynomial Equations for Cooling Capacity and Power (20F Superheat, 15F Subcool)

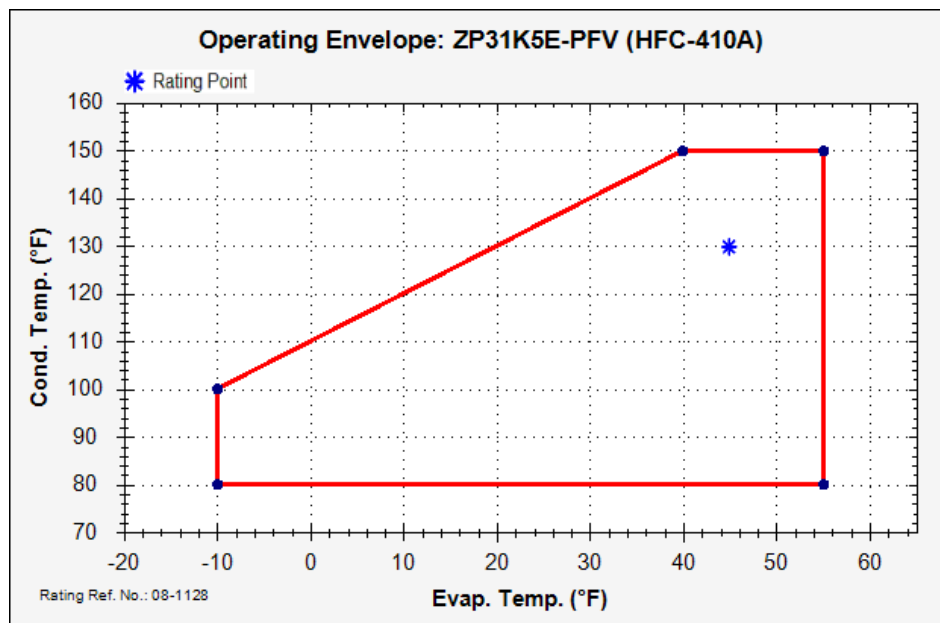
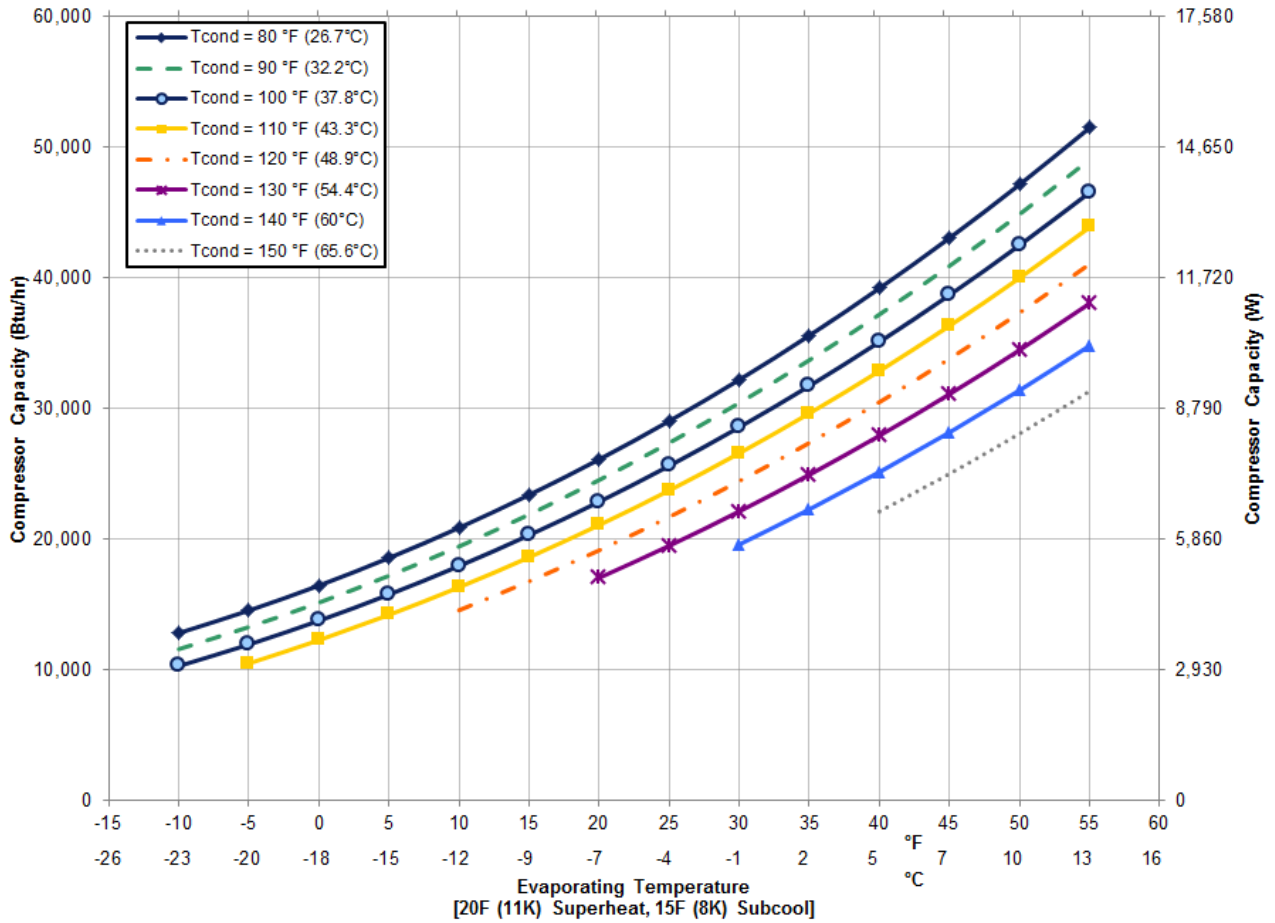
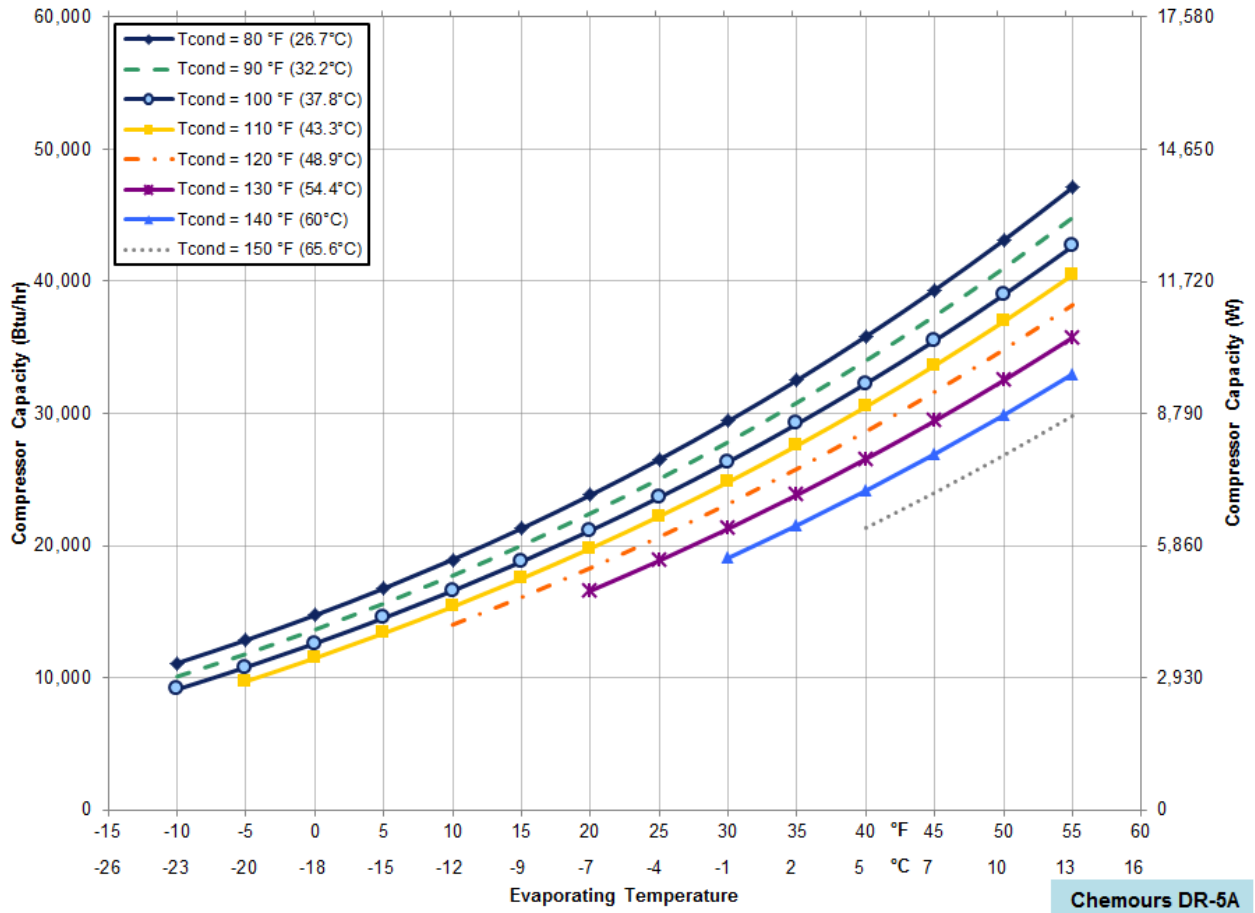


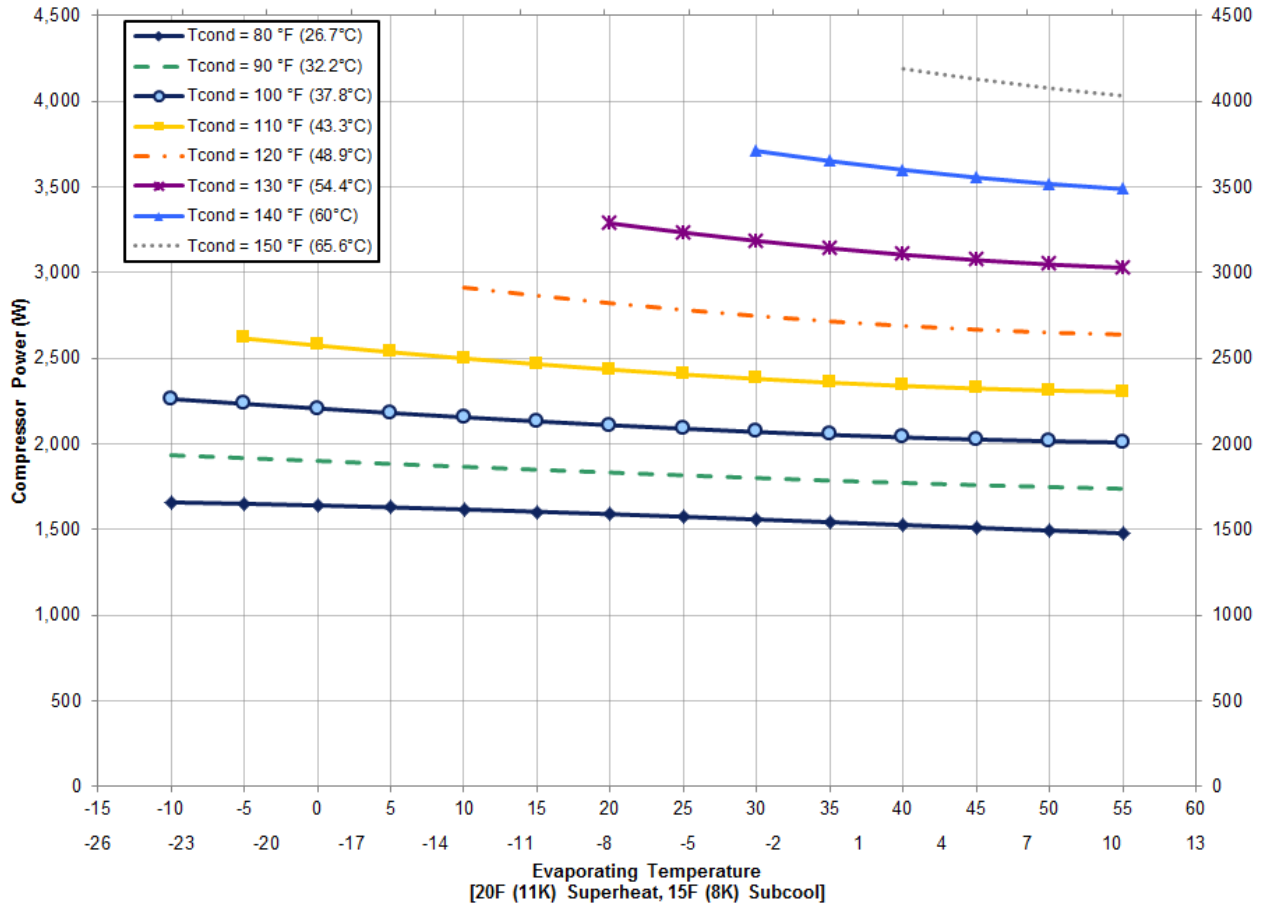
Figure 3 ZP31K5E-PFV R-410A Operating Map (20F Superheat)



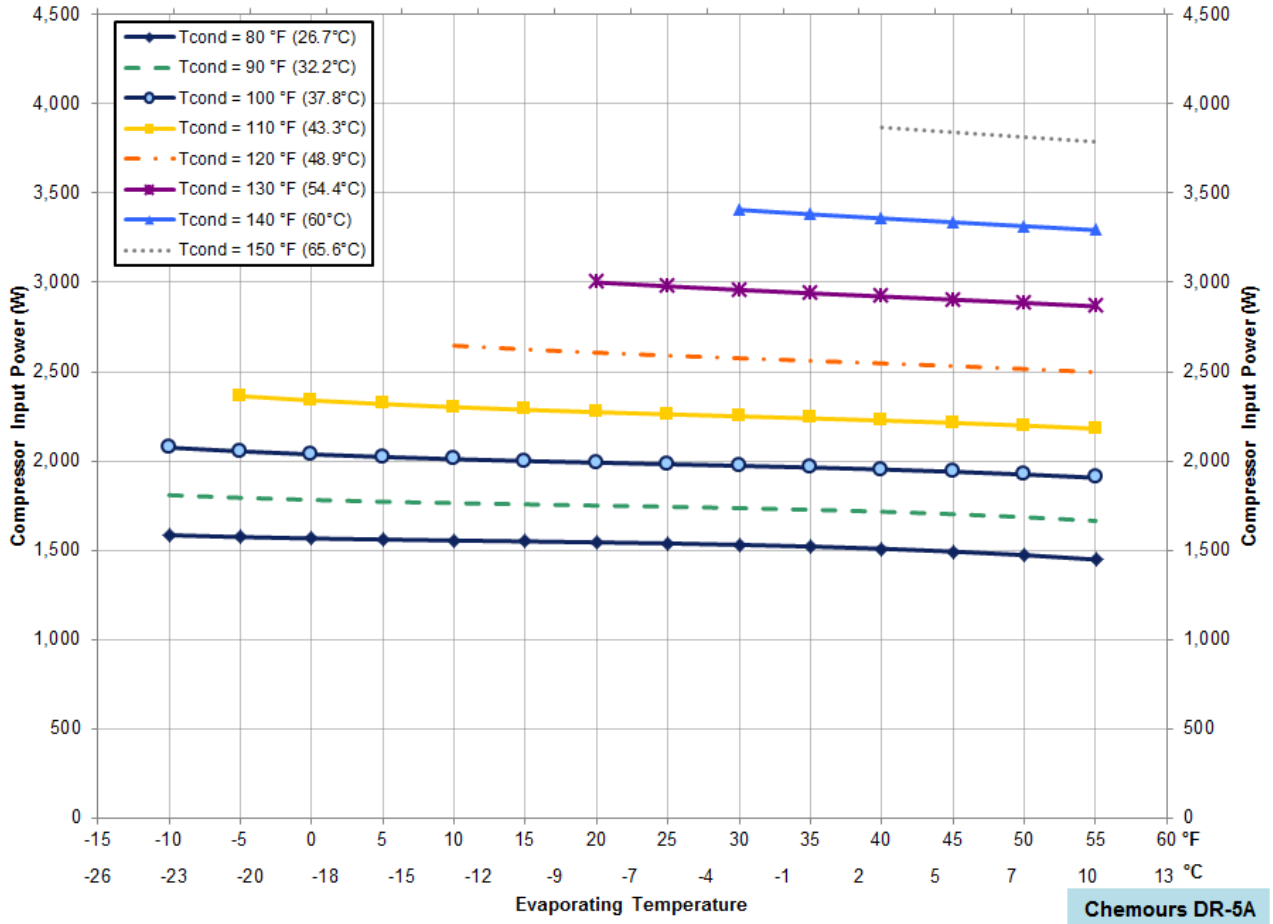
**Figure 4 R-410A Cooling Capacity vs. Evaporating Temperature (Dew Point)**



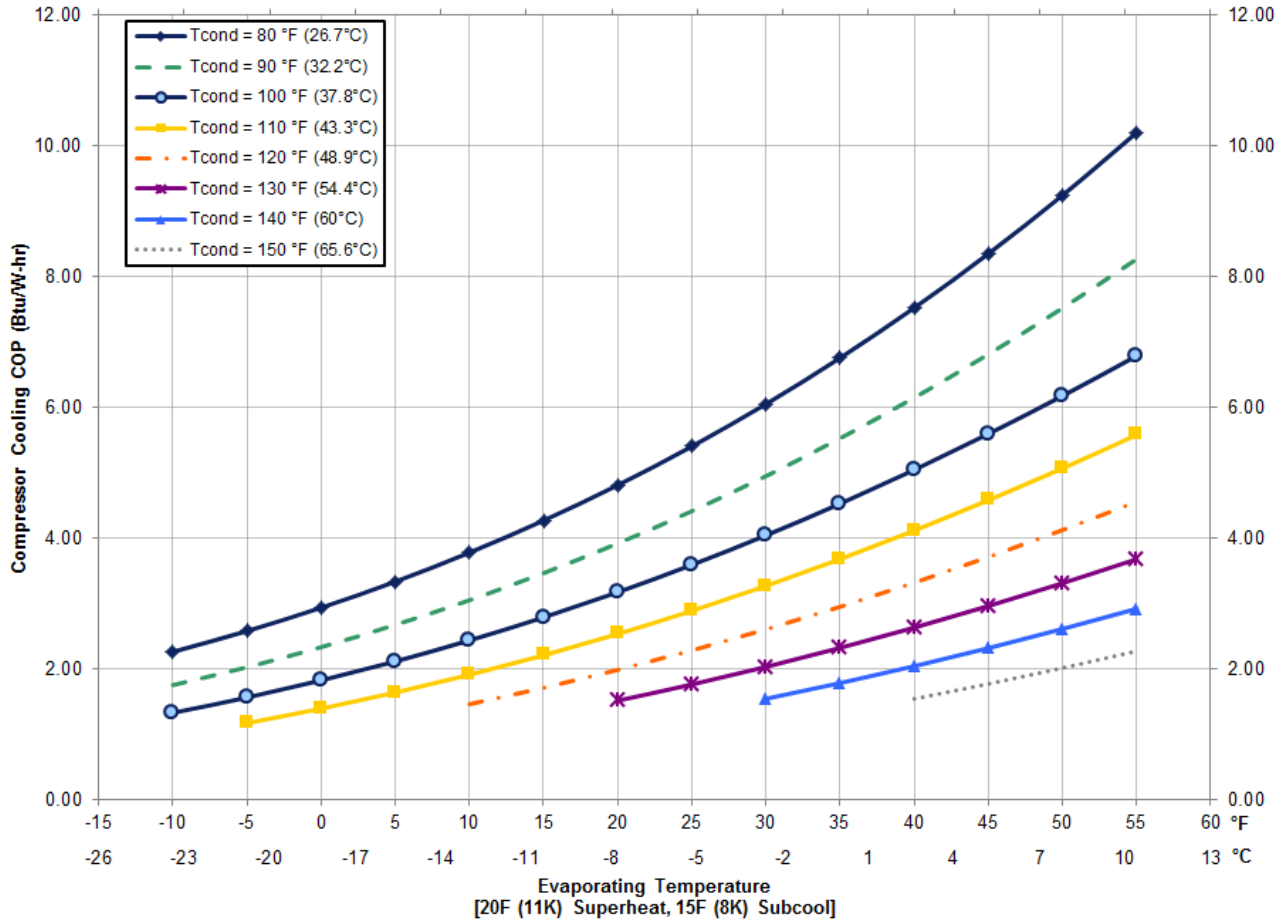
**Figure 5 DR-5A Cooling Capacity vs. Evaporating Temperature (Dew Point, 20°F Superheat, 15°F Subcool)**



**Figure 6 R410A Input Power vs. Evaporating Temperature (Dew Point)**



**Figure 7 DR-5A Input Power vs. Evaporating Temperature (Dew Point, Superheat 20°F, Subcooling 15°F)**



**Figure 8 R-410A Cooling COP Vs. Evaporating Temperature (Dew Point)**



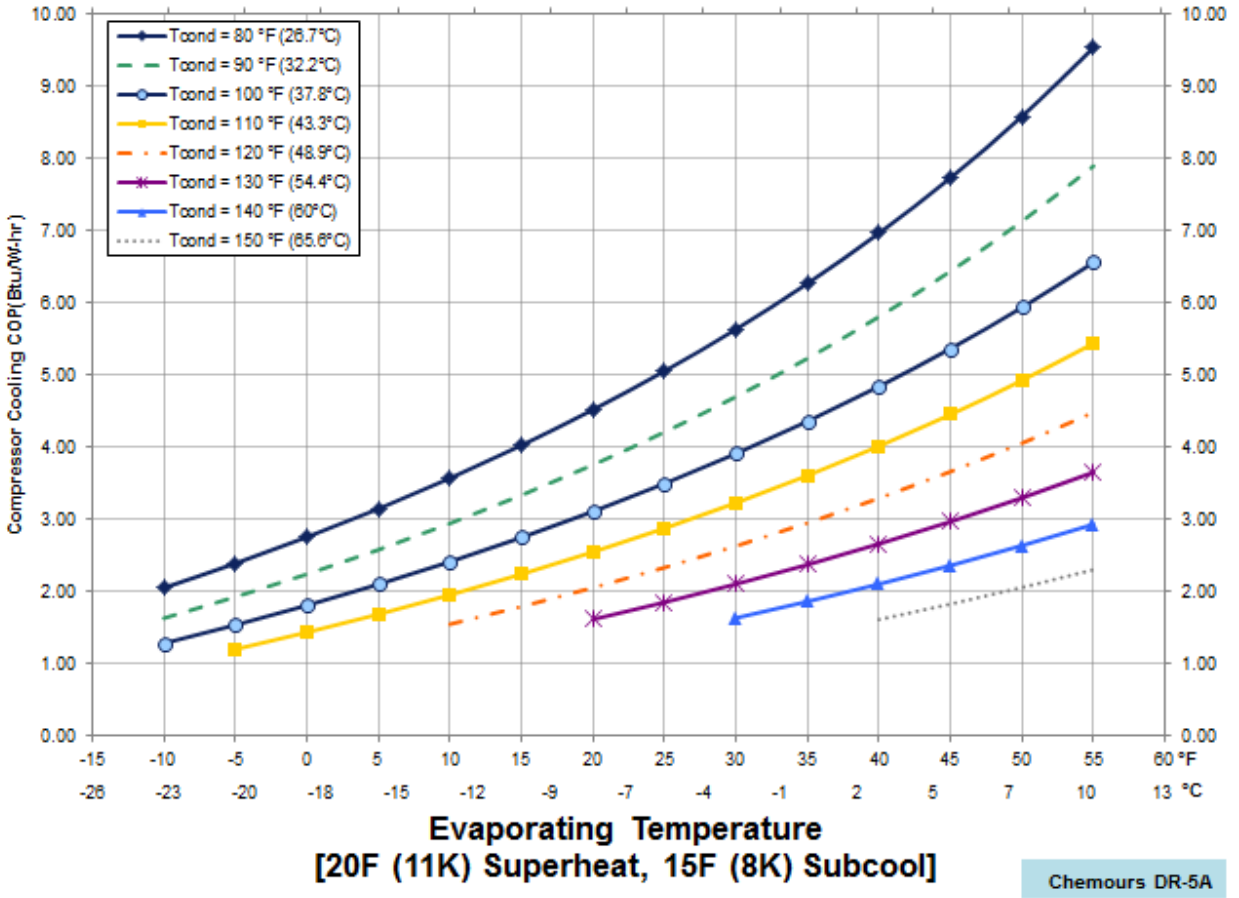


Figure 9 DR-5A Cooling COP Vs. Evaporating Temperature (Dew Point)

## Comparative Analysis

Figures 10 and 11 show the ratio of DR-5A to R-410A cooling COP and cooling capacity, respectively, versus evaporating temperature. At extreme operating conditions, testing uncertainties could lead to higher than normal variability in reported results.

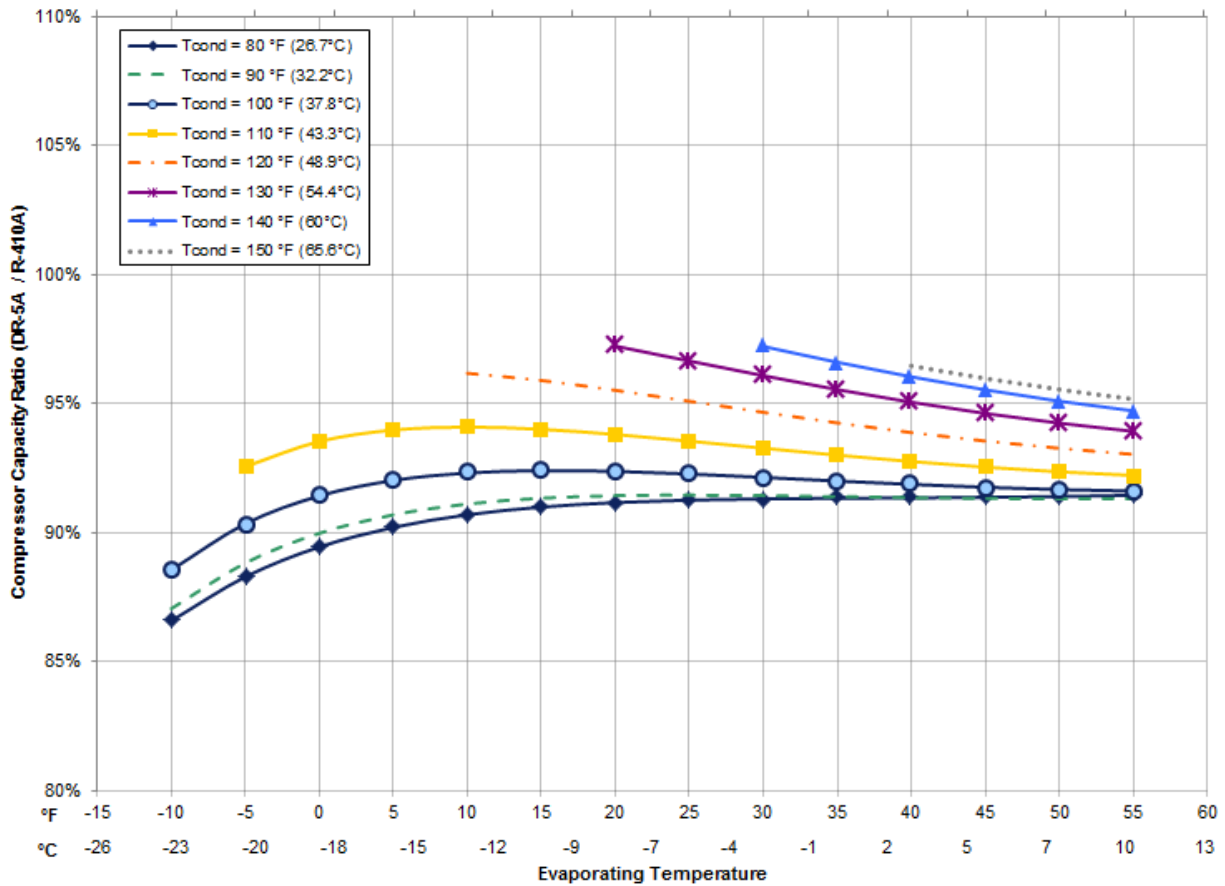
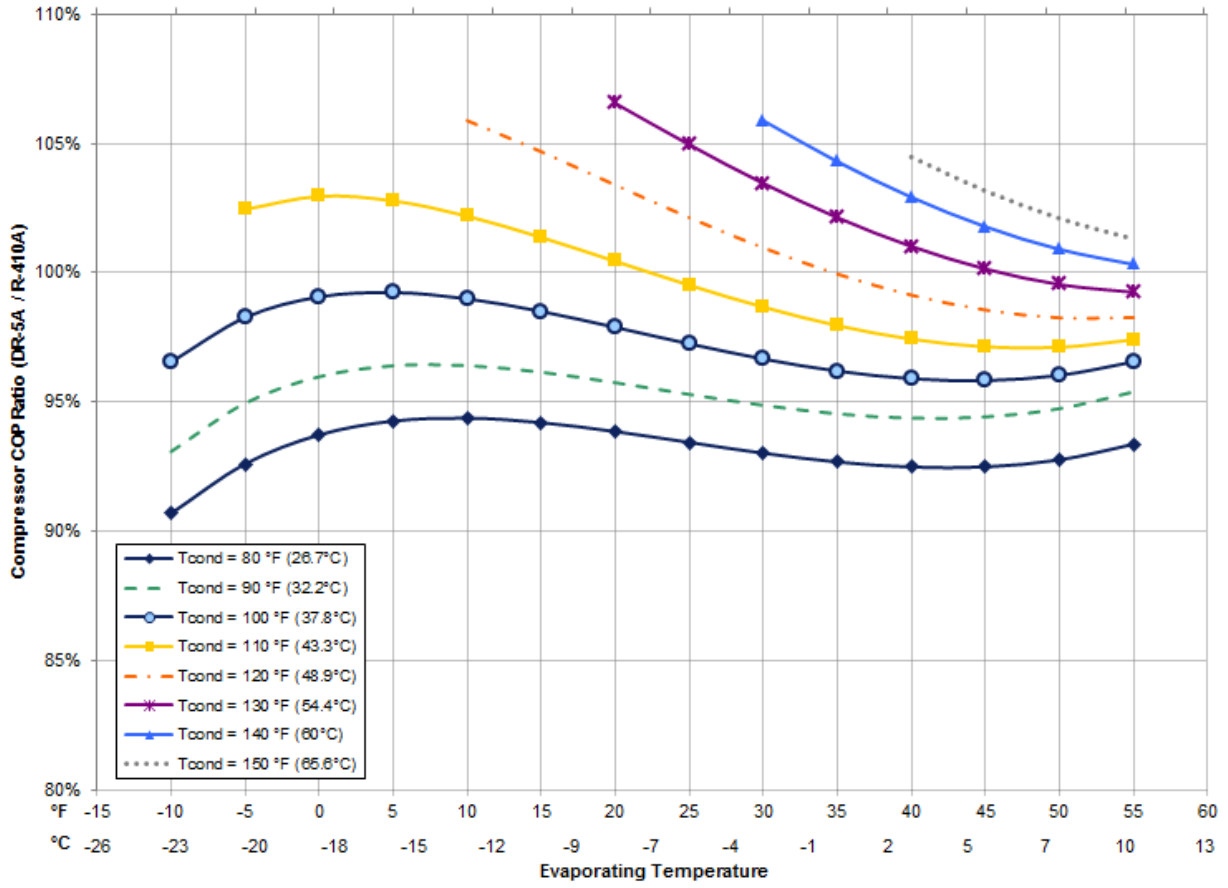


Figure 10 DR-5A / R-410A Cooling Capacity vs. Evaporating Temperature (Dew Point)



**Figure 11 DR-5A / R-410A Cooling COP vs. Evaporating Temperature (Dew Point)**

## **Summary**

The calorimeter testing of DR-5A was carried out at dew point conditions and compared to R-410A. The compressor cooling capacity vs R-410A is between 85-100% of the rated performance across the operating map of the tested compressor. (See Figure 3 for Operating Maps). The Compressor COP of DR-5A is between 90-110% across the compressor operating envelope.