



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

## **TEST REPORT #52**

### **System Drop-in Tests of Refrigerant Blends ARM-71a, DR-5A (R-454B), HPR2A, L-41-1 (R-446A), L-41-2 (R- 447A) in a R-410A Split System Heat Pump**

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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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## 1. Introduction

This test report summarizes the results of performance testing of a production Carrier 14 SEER R-410A, 3.0 ton split system heat pump tested with five proposed R-410A replacement refrigerants. The purpose of this investigation was to evaluate performance of Low GWP options to replace R-410A. Using R-410A to establish baseline performance, the following refrigerants were tested as a “drop-in” into the R-410A system:

ARM-71a  
 DR-5A (R-454B)  
 HPR2A  
 L-41-1 (R-446A)  
 L-41-2 (R-447A)

The testing was conducted in the Carrier Residential Commercial Systems facility in Indianapolis, Indiana during April and May 2015.

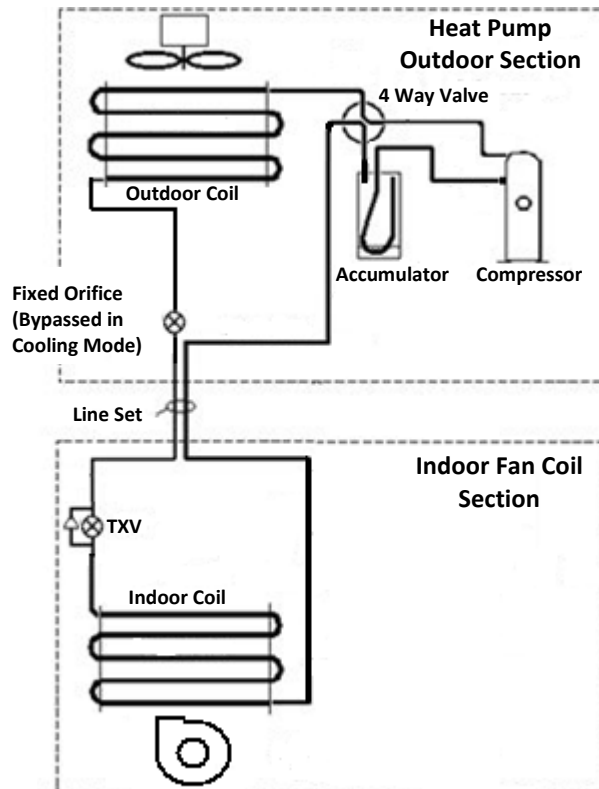
## 2. Test Description

### a. System

The outdoor unit tested was a production 14 SEER R-410A, 3.0 ton single capacity split system heat pump, model 25HCD436. The compressor was changed to a calorimeter tested sample provided by LGE. The indoor unit tested was a production fan coil, model FX4DN037L.

The system diagram is shown below:

**System Diagram**





**b. System Modifications**

The compressor was changed to the same model calorimeter tested sample. To address expansion control differences, an adjustable TXV was utilized in cooling. A fixed orifice was used as the expansion control in heating.

**c. Test Description**

The system was tested to determine SEER and HSPF as well as the cooling and heating capacity in accordance with AHRI210/240. The psychrometric capacity was determined following ASHRAE standard 37-2009. The indoor unit was placed on a “code tester” section composed of the following major components: entering damper box, entering psychrometer sampler, leaving psychrometer sampler, leaving damper, and nozzle box. The entering and leaving psychrometers consisted of a dry bulb RTD and a dew point hygrometer and were used for the steady state capacity measurements. Entering and leaving thermocouple grids were utilized for the transient capacity measurements. The psychrometric test facility is recognized as a satellite test facility. The facility undergoes annual audits to ensure compliance with ISO 17025. The psychrometric test facility is also subjected to annual calibration traceable to NIST standards. A list of measuring points, instrumentation used and their accuracy is summarized in the table below:

<b>Measurement point</b>	<b>Instrumentation</b>	<b>Accuracy (+/-)</b>	<b>Units</b>
Air Dry Bulb Temperature	Resistance Temperature Detectors (RTDs)	0.1	F
Air Dew Point Temperature	Optical Chilled Mirror Hygrometers	0.27	F
Air Dynamic Differential Pressure	High Accuracy Manometer	0.05	% Read
Air Static Differential Pressure	Low Range Differential Pressure Transmitter	0.0075	InWg, 0.15%FS (5" FS)
Refrigerant Temperature	T Type Thermocouples	0.26	F
Refrigerant Pressure	High Range Pressure Sensor	0.1	% Read
Barometric Pressure	Digital Pressure Gauge	0.0065	InHg, 0.02%FS (32.486 FS)
Power	Precision Power Analyzer	0.1	% Read

The uncertainty propagation for the psychrometric capacity at the DOE A condition (with 95% confidence) is an estimated 3.8%. The uncertainty of power measurement is estimated 0.1%.

The proposed replacement refrigerants were evaluated on a “drop-in” basis. The system was tested with R-410A and then tested with each of the proposed replacements without modification to the system. The system refrigerant charge quantity for all refrigerants was not “soft-optimized,” but rather the system charge level was determined by matching the following baseline refrigerant state point



conditions. In cooling, the state points used for control were superheat leaving the evaporator and subcooling leaving the condenser at the DOE B condition. These points were maintained to within a  $\pm 2^\circ\text{F}$  tolerance. Specifically, an adjustable TXV was used to adjust superheat leaving the evaporator and charge level was used to adjust subcooling leaving the condenser. The charge level determined by these criteria for each refrigerant was held constant for the complete cooling and heating series. In heating, the state point used for control was subcooling leaving the condenser (indoor coil) at the DOE H1 test condition. For options L-41-1 and L-41-2, which have high evaporating glide at DOE B cooling condition, the system charge was not determined by matching baseline state point of superheat leaving the evaporator. Rather, for these two options, the superheat leaving the evaporator was determined for maximum cooling capacity.

The fixed orifice size used for heating operation was not changed for any refrigerants.

### **3. Test Results**

The following tables contain the results of the “drop-in” testing performed for the steady state tests.

The DOE cyclic testing was also performed for all refrigerants. The raw data is not included, but the resulting SEER and HSPF are listed in the table for each refrigerant tested.



Manufacturer: Carrier \_\_\_\_\_

<b>Basic Information</b>	
Alternative Refrigerant (If not proprietary, composition as Charged, % wt)	Arkema ARM-71a
Lubricant Type and ISO Viscosity	POE oil, ISO VG32
Baseline Refrigerant and Lubricant	R410A and POE Oil
Make and Model of System	Carrier 25HCD436 and FX4DN037L
Nominal Capacity and Type of System	3.0 ton capacity split system

<b>Other System Changes</b>
To address expansion control differences, an adjustable TXV was used in cooling. A fixed orifice was used as the expansion control in heating.
The compressor was changed to same model calorimeter tested sample.

System Data	Base.	Alt.	Ratio
Degradation Coefficient (Cooling)– Cd	0.09	0.08	0.889
Seasonal Energy Efficiency Ratio - SEER	14.24	14.25	1.001
Degradation Coefficient (Heating) – Cd *	0.365	0.273	0.649
Heating Seasonal Performance Factor - HSPF	8.358	8.453	1.011

\* Note: If Cd is larger than 0.25, then use 0.25 for HSPF calculation.

**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Cooling A							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.31	kg	8	7.3	lb	0.91	
Refrigerant Mass Flow Rate		3.83	2.85	kg/min	8.43	6.29	lb/min	0.75	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35.00	35.00	C	95	95	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity		10,187	9,337	W	34,759	31,860	Btu/hr	0.92	
Sensible Capacity		8,086	7,781	W	27,591	26,549	Btu/hr	0.96	
Total System Power Input		2,869	2,656	W	2,869	2,656	W	0.93	
Compressor Power Input		2,446	2,230	W	2,446	2,230	W	0.91	
Energy Efficiency Ratio (EER)		12.12	12.00	Btuh/W	12.12	12.00	Btuh/W	0.99	
Coeff. Of Performance (COP)		3.55	3.52					0.99	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	34.94	34.94	m <sup>3</sup> /min	1234	1234	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.63/19.42	26.66/19.44	C	79.94/66.96	79.98/67	F	
Outlet Temperature	15.14/14.46	15.63/14.93	C	59.25/58.03	60.14/58.88	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	85.46	89.62	m <sup>3</sup> /min	3018	3165	ft <sup>3</sup> /min	1.05
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	42.33	41.41	C	108.19	106.54	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	18.19	1080.44	19.53	979.07	64.74	156.71	67.15	142.00
Compressor Discharge	74.79	2776.33	80.41	2522.24	166.62	402.68	176.74	365.82
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	39.89	2733.93	39.08	2490.53	103.80	396.53	102.34	361.22
Expansion Device Inlet	38.43	2681.80	37.68	2456.54	101.17	388.97	99.83	356.29
Subcooling, at expansion device	5.76		6.09		10.37		10.97	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.66	1104.57	13.04	997.89	56.58	160.21	55.47	144.73
Evaporator Superheat	3.04		1.24		5.48		2.23	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.31	kg	8	7.3	lb	0.91
Refrigerant Mass Flow Rate			3.83	2.91	kg/min	8.44	6.42	lb/min	0.76
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	27.78	27.78	C	82	82	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			10,931	10,089	W	37,298	34,426	Btu/hr	0.92
Sensible Capacity			8,302	8,121	W	28,327	27,711	Btu/hr	0.98
Total System Power Input			2,499	2,323	W	2,499	2,323	W	0.93
Compressor Power Input			2,078	1,897	W	2,078	1,897	W	0.91
Energy Efficiency Ratio (EER)			14.93	14.82	Btuh/W	14.93	14.82	Btuh/W	0.99
Coeff. Of Performance (COP)			4.37	4.34					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	34.97	34.94	m <sup>3</sup> /min	1235	1234	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.69/19.43	26.67/19.44	C	80.04/66.97	80/67	F	
Outlet Temperature	14.9/14.09	15.18/14.55	C	58.82/57.36	59.33/58.19	F	
Condenser							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	88.74	90.84	m <sup>3</sup> /min	3134	3208	ft <sup>3</sup> /min	1.02
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	35.10	34.34	C	95.19	93.81	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	16.13	1059.14	17.39	970.42	61.04	153.62	63.30	140.75
Compressor Discharge	63.54	2349.27	67.98	2138.80	146.38	340.74	154.37	310.21
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	33.17	2299.18	32.46	2100.10	91.71	333.47	90.43	304.60
Expansion Device Inlet	32.17	2247.99	31.54	2066.95	89.90	326.05	88.78	299.79
Subcooling, at expansion device	4.72		5.06		8.50		9.11	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.04	1085.41	12.82	990.76	55.47	157.43	55.08	143.70
Evaporator Superheat	3.02		1.26		5.44		2.27	





**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Heating H1							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.31	kg	8	7.3	lb	0.91	
Refrigerant Mass Flow Rate		2.83	2.28	kg/min	6.22	5.01	lb/min	0.81	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	8.33	8.33	C	47	47	F	
		wb	6.11	6.11	C	43	43	F	
Total Capacity		9,616	9,086	W	32,812	31,003	Btu/hr	0.94	
Sensible Capacity		9,616	9,086	W	32,812	31,003	Btu/hr	0.94	
Total System Power Input		2,628	2,420	W	2,628	2,420	W	0.92	
Compressor Power Input		2,201	1,994	W	2,201	1,994	W	0.91	
Energy Efficiency Ratio (EER)		n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a	
Coeff. Of Performance (COP)		3.66	3.75					1.03	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	4.65	4.92	C	40.37	40.861	F	
Condenser							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	36.76	36.76	m <sup>3</sup> /min	1298	1298	ft <sup>3</sup> /min	1.00
Inlet Temperature	21.11	21.11	C	70	69.99	F	
Outlet Temperature	35.06	34.28	C	95.1	93.7	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	3.17	792.05	1.61	749.83	37.70	114.88	34.90	108.75
Compressor Discharge	66.87	2397.28	64.24	2141.18	152.37	347.70	147.63	310.55
Condenser Inlet	60.92	2391.35	57.16	2134.63	141.66	346.84	134.89	309.60
Condenser Outlet	31.52	2362.25	33.27	2108.57	88.73	342.62	91.89	305.82
Expansion Device Inlet	30.04	n/a	31.34	n/a	86.07	n/a	88.41	n/a
Subcooling, at expansion device	7.39		4.15		13.31		7.46	
Evaporator Inlet	n/a	938.67	n/a	869.22	n/a	136.14	n/a	126.07
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Heating H3						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.31	kg	8	7.3	lb	0.91
Refrigerant Mass Flow Rate *			n/a	n/a	kg/min	n/a	n/a	lb/min	n/a
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	-8.33	-8.33	C	17	17	F	
		wb	-9.44	-9.44	C	15	15	F	
Total Capacity			5,894	5,517	W	20,112	18,824	Btu/hr	0.94
Sensible Capacity			5,894	5,517	W	20,112	18,824	Btu/hr	0.94
Total System Power Input			2,373	2,190	W	2,373	2,190	W	0.92
Compressor Power Input			1,933	1,753	W	1,933	1,753	W	0.91
Energy Efficiency Ratio (EER)			n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a
Coeff. Of Performance (COP)			2.48	2.52					1.01

\* Note: Refrigerant flow measurement is erratic for some heating tests.

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	-10.05	-9.90	C	13.904	14.186	F	
Condenser							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	36.64	36.67	m <sup>3</sup> /min	1294	1295	ft <sup>3</sup> /min	1.00
Inlet Temperature	21.12	21.11	C	70.01	70	F	
Outlet Temperature	29.55	29.04	C	85.19	84.27	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	-13.76	502.55	-12.61	479.36	7.24	72.89	9.31	69.53
Compressor Discharge	59.01	1971.60	63.53	1815.90	138.22	285.96	146.36	263.38
Condenser Inlet	48.92	1970.43	50.43	1813.83	120.05	285.79	122.78	263.08
Condenser Outlet	30.44	1952.64	29.57	1791.21	86.79	283.21	85.22	259.80
Expansion Device Inlet	29.27	n/a	28.64	n/a	84.68	n/a	83.55	n/a
Subcooling, at expansion device	0.85		1.32		1.52		2.38	
Evaporator Inlet	n/a	610.67	n/a	562.52	n/a	88.57	n/a	81.59
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.29	kg	8	7.25	lb	0.91
Refrigerant Mass Flow Rate			3.48	2.62	kg/min	7.67	5.76	lb/min	0.75
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	15.56	15.56	C	60	60	F	
	Outdoor	db	51.67	51.67	C	125	125	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			7,432	7,222	W	25,360	24,644	Btu/hr	0.97
Sensible Capacity			7,453	7,265	W	25,431	24,790	Btu/hr	0.97
Total System Power Input			3,964	3,607	W	3,964	3,607	W	0.91
Compressor Power Input			3,559	3,201	W	3,559	3,201	W	0.90
Energy Efficiency Ratio (EER)			6.40	6.83	Btuh/W	6.40	6.83	Btuh/W	1.07
Coeff. Of Performance (COP)			1.87	2.00					1.07

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: ARM-71a \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	35.14	35.14	m <sup>3</sup> /min	1241	1241	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.66/15.9	26.67/16.05	C	79.99/60.62	80/60.89	F	
Outlet Temperature	15.95/11.84	16.27/12.13	C	60.71/53.31	61.28/53.84	F	
Condenser							
Heat Exchange Fluid	R410A	ARM-71a					
Flow Rate (gas)	86.90	83.56	m <sup>3</sup> /min	3069	2951	ft <sup>3</sup> /min	0.96
Inlet Temperature	51.67	51.67	C	125	125	F	
Outlet Temperature	57.90	57.77	C	136.21	135.99	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	26.46	1061.73	24.03	970.33	79.63	153.99	75.26	140.73
Compressor Discharge	105.97	3975.43	113.87	3574.38	222.74	576.59	236.97	518.42
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	54.15	3952.11	55.08	3554.65	129.48	573.21	131.15	515.56
Expansion Device Inlet	52.52	3897.45	52.52	3520.05	126.53	565.28	126.53	510.54
Subcooling, at expansion device	8.14		7.23		14.65		13.01	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	11.89	1078.62	13.50	985.42	53.41	156.44	56.30	142.92
Evaporator Superheat	2.09		2.12		3.76		3.82	



Manufacturer: Carrier

<b>Basic Information</b>	
Alternative Refrigerant (If not proprietary, composition as Charged, % wt)	Chemours (DuPont) DR-5A (R-454B)
Lubricant Type and ISO Viscosity	POE oil, ISO VG32
Baseline Refrigerant and Lubricant	R410A and POE Oil
Make and Model of System	Carrier 25HCD436 and FX4DN037L
Nominal Capacity and Type of System	3.0 ton capacity split system

<b>Other System Changes</b>
To address expansion control differences, an adjustable TXV was used in cooling. A fixed orifice was used as the expansion control in heating.
The compressor was changed to same model calorimeter tested sample.

System Data	Base.	Alt.	Ratio
Degradation Coefficient (Cooling)– Cd	0.09	0.05	0.556
Seasonal Energy Efficiency Ratio - SEER	14.24	14.45	1.015
Degradation Coefficient (Heating) – Cd *	0.365	0.373	1.022
Heating Seasonal Performance Factor - HSPF	8.358	8.419	1.007

\* Note: If Cd is larger than 0.25, then use 0.25 for HSPF calculation.

**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP

Alternate Refrigerant: DR-5A (R-454B)

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Cooling A							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.18	kg	8	7	lb	0.88	
Refrigerant Mass Flow Rate		3.83	2.92	kg/min	8.43	6.44	lb/min	0.76	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35.00	35.00	C	95	95	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity		10,187	9,600	W	34,759	32,756	Btu/hr	0.94	
Sensible Capacity		8,086	7,933	W	27,591	27,068	Btu/hr	0.98	
Total System Power Input		2,869	2,728	W	2,869	2,728	W	0.95	
Compressor Power Input		2,446	2,302	W	2,446	2,302	W	0.94	
Energy Efficiency Ratio (EER)		12.12	12.01	Btuh/W	12.12	12.01	Btuh/W	0.99	
Coeff. Of Performance (COP)		3.55	3.52					0.99	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	34.94	34.86	m <sup>3</sup> /min	1234	1231	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.63/19.42	26.67/19.44	C	79.94/66.96	80.01/67	F	
Outlet Temperature	15.14/14.46	15.49/14.8	C	59.25/58.03	59.89/58.64	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	85.46	90.95	m <sup>3</sup> /min	3018	3212	ft <sup>3</sup> /min	1.06
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	42.33	41.50	C	108.19	106.70	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	18.19	1080.44	19.12	1000.16	64.74	156.71	66.42	145.06
Compressor Discharge	74.79	2776.33	80.99	2607.45	166.62	402.68	177.79	378.18
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	39.89	2733.93	38.35	2576.58	103.80	396.53	101.03	373.70
Expansion Device Inlet	38.43	2681.80	37.26	2541.47	101.17	388.97	99.06	368.61
Subcooling, at expansion device	5.76		6.65		10.37		11.97	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.66	1104.57	13.54	1019.67	56.58	160.21	56.38	147.89
Evaporator Superheat	3.04		2.82		5.48		5.08	





**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.18	kg	8	7	lb	0.88
Refrigerant Mass Flow Rate			3.83	2.99	kg/min	8.44	6.58	lb/min	0.78
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	27.78	27.78	C	82	82	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			10,931	10,352	W	37,298	35,323	Btu/hr	0.95
Sensible Capacity			8,302	8,199	W	28,327	27,977	Btu/hr	0.99
Total System Power Input			2,499	2,379	W	2,499	2,379	W	0.95
Compressor Power Input			2,078	1,952	W	2,078	1,952	W	0.94
Energy Efficiency Ratio (EER)			14.93	14.85	Btuh/W	14.93	14.85	Btuh/W	0.99
Coeff. Of Performance (COP)			4.37	4.35					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	34.97	34.94	m <sup>3</sup> /min	1235	1234	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.69/19.43	26.67/19.44	C	80.04/66.97	80/67	F	
Outlet Temperature	14.9/14.09	15.07/14.41	C	58.82/57.36	59.12/57.94	F	
Condenser							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	88.74	92.23	m <sup>3</sup> /min	3134	3257	ft <sup>3</sup> /min	1.04
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	35.10	34.41	C	95.19	93.95	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	16.13	1059.14	17.36	995.14	61.04	153.62	63.25	144.33
Compressor Discharge	63.54	2349.27	68.51	2207.99	146.38	340.74	155.32	320.24
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	33.17	2299.18	31.60	2170.29	91.71	333.47	88.88	314.78
Expansion Device Inlet	32.17	2247.99	30.83	2135.25	89.90	326.05	87.50	309.69
Subcooling, at expansion device	4.72		5.83		8.50		10.50	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.04	1085.41	13.36	1015.62	55.47	157.43	56.04	147.30
Evaporator Superheat	3.02		2.77		5.44		4.98	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Heating H1							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.18	kg	8	7	lb	0.88	
Refrigerant Mass Flow Rate		2.83	2.33	kg/min	6.22	5.13	lb/min	0.82	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	8.33	8.33	C	47	47	F	
		wb	6.11	6.11	C	43	43	F	
Total Capacity		9,616	9,209	W	32,812	31,424	Btu/hr	0.96	
Sensible Capacity		9,616	9,209	W	32,812	31,424	Btu/hr	0.96	
Total System Power Input		2,628	2,461	W	2,628	2,461	W	0.94	
Compressor Power Input		2,201	2,035	W	2,201	2,035	W	0.92	
Energy Efficiency Ratio (EER)		n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a	
Coeff. Of Performance (COP)		3.66	3.74					1.02	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	4.65	4.81	C	40.37	40.665	F	
Condenser							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	36.76	36.56	m <sup>3</sup> /min	1298	1291	ft <sup>3</sup> /min	0.99
Inlet Temperature	21.11	21.11	C	70	70	F	
Outlet Temperature	35.06	34.42	C	95.1	93.95	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	3.17	792.05	0.89	761.70	37.70	114.88	33.60	110.48
Compressor Discharge	66.87	2397.28	63.22	2195.46	152.37	347.70	145.80	318.43
Condenser Inlet	60.92	2391.35	56.43	2188.77	141.66	346.84	133.57	317.46
Condenser Outlet	31.52	2362.25	32.97	2161.81	88.73	342.62	91.34	313.55
Expansion Device Inlet	30.04	n/a	31.41	n/a	86.07	n/a	88.54	n/a
Subcooling, at expansion device	7.39		4.20		13.31		7.57	
Evaporator Inlet	n/a	938.67	n/a	883.77	n/a	136.14	n/a	128.18
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Heating H3						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.18	kg	8	7	lb	0.88
Refrigerant Mass Flow Rate *			n/a	n/a	kg/min	n/a	n/a	lb/min	n/a
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	-8.33	-8.33	C	17	17	F	
		wb	-9.44	-9.44	C	15	15	F	
Total Capacity			5,894	5,601	W	20,112	19,110	Btu/hr	0.95
Sensible Capacity			5,894	5,601	W	20,112	19,110	Btu/hr	0.95
Total System Power Input			2,373	2,242	W	2,373	2,242	W	0.94
Compressor Power Input			1,933	1,793	W	1,933	1,793	W	0.93
Energy Efficiency Ratio (EER)			n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a
Coeff. Of Performance (COP)			2.48	2.50					1.01

\* Note: Refrigerant flow measurement is erratic for some heating tests.

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	-10.05	-9.86	C	13.904	14.252	F	
Condenser							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	36.64	35.14	m <sup>3</sup> /min	1294	1241	ft <sup>3</sup> /min	0.96
Inlet Temperature	21.12	21.11	C	70.01	70	F	
Outlet Temperature	29.55	29.41	C	85.19	84.93	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	-13.76	502.55	-12.87	487.85	7.24	72.89	8.84	70.76
Compressor Discharge	59.01	1971.60	63.82	1852.86	138.22	285.96	146.88	268.74
Condenser Inlet	48.92	1970.43	50.94	1851.14	120.05	285.79	123.69	268.49
Condenser Outlet	30.44	1952.64	30.12	1830.32	86.79	283.21	86.21	265.47
Expansion Device Inlet	29.27	n/a	29.15	n/a	84.68	n/a	84.46	n/a
Subcooling, at expansion device	0.85		0.40		1.52		0.72	
Evaporator Inlet	n/a	610.67	n/a	572.14	n/a	88.57	n/a	82.98
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.18	kg	8	7	lb	0.88
Refrigerant Mass Flow Rate			3.48	2.67	kg/min	7.67	5.89	lb/min	0.77
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	15.56	15.56	C	60	60	F	
	Outdoor	db	51.67	51.67	C	125	125	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			7,432	7,373	W	25,360	25,157	Btu/hr	0.99
Sensible Capacity			7,453	7,412	W	25,431	25,292	Btu/hr	0.99
Total System Power Input			3,964	3,702	W	3,964	3,702	W	0.93
Compressor Power Input			3,559	3,298	W	3,559	3,298	W	0.93
Energy Efficiency Ratio (EER)			6.40	6.80	Btuh/W	6.40	6.80	Btuh/W	1.06
Coeff. Of Performance (COP)			1.87	1.99					1.06

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: DR-5A (R-454B) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	35.14	35.00	m <sup>3</sup> /min	1241	1236	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.66/15.9	26.67/15.92	C	79.99/60.62	80/60.66	F	
Outlet Temperature	15.95/11.84	16.07/11.89	C	60.71/53.31	60.92/53.41	F	
Condenser							
Heat Exchange Fluid	R410A	DR-5A					
Flow Rate (gas)	86.90	83.96	m <sup>3</sup> /min	3069	2965	ft <sup>3</sup> /min	0.97
Inlet Temperature	51.67	51.67	C	125	125	F	
Outlet Temperature	57.90	57.90	C	136.21	136.22	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	26.46	1061.73	24.33	994.69	79.63	153.99	75.80	144.27
Compressor Discharge	105.97	3975.43	114.98	3676.45	222.74	576.59	238.97	533.23
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	54.15	3952.11	54.62	3659.16	129.48	573.21	130.32	530.72
Expansion Device Inlet	52.52	3897.45	52.16	3620.74	126.53	565.28	125.88	525.15
Subcooling, at expansion device	8.14		7.46		14.65		13.42	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	11.89	1078.62	14.61	1009.72	53.41	156.44	58.29	146.45
Evaporator Superheat	2.09		4.21		3.76		7.58	





Manufacturer: Carrier

<b>Basic Information</b>	
Alternative Refrigerant (If not proprietary, composition as Charged, % wt)	Mexichem HPR2A
Lubricant Type and ISO Viscosity	POE oil, ISO VG32
Baseline Refrigerant and Lubricant	R410A and POE Oil
Make and Model of System	Carrier 25HCD436 and FX4DN037L
Nominal Capacity and Type of System	3.0 ton capacity split system

<b>Other System Changes</b>
To address expansion control differences, an adjustable TXV was used in cooling. A fixed orifice was used as the expansion control in heating.
The compressor was changed to same model calorimeter tested sample.

System Data	Base.	Alt.	Ratio
Degradation Coefficient (Cooling)– Cd	0.09	0.09	1.000
Seasonal Energy Efficiency Ratio - SEER	14.24	13.84	0.972
Degradation Coefficient (Heating) – Cd *	0.365	0.382	1.047
Heating Seasonal Performance Factor - HSPF	8.358	8.398	1.005

\* Note: If Cd is larger than 0.25, then use 0.25 for HSPF calculation.

**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP

Alternate Refrigerant: HPR2A

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Cooling A							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.29	kg	8	7.25	lb	0.91	
Refrigerant Mass Flow Rate		3.83	2.50	kg/min	8.43	5.51	lb/min	0.65	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35.00	35.00	C	95	95	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity		10,187	9,066	W	34,759	30,934	Btu/hr	0.89	
Sensible Capacity		8,086	7,654	W	27,591	26,118	Btu/hr	0.95	
Total System Power Input		2,869	2,647	W	2,869	2,647	W	0.92	
Compressor Power Input		2,446	2,224	W	2,446	2,224	W	0.91	
Energy Efficiency Ratio (EER)		12.12	11.69	Btuh/W	12.12	11.69	Btuh/W	0.96	
Coeff. Of Performance (COP)		3.55	3.42					0.96	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	34.94	34.97	m <sup>3</sup> /min	1234	1235	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.63/19.42	26.66/19.44	C	79.94/66.96	79.99/67	F	
Outlet Temperature	15.14/14.46	15.77/15.07	C	59.25/58.03	60.39/59.13	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	85.46	90.36	m <sup>3</sup> /min	3018	3191	ft <sup>3</sup> /min	1.06
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	42.33	41.21	C	108.19	106.19	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	18.19	1080.44	19.71	926.75	64.74	156.71	67.48	134.41
Compressor Discharge	74.79	2776.33	86.06	2485.09	166.62	402.68	186.90	360.43
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	39.89	2733.93	38.07	2460.54	103.80	396.53	100.53	356.87
Expansion Device Inlet	38.43	2681.80	36.96	2432.55	101.17	388.97	98.53	352.81
Subcooling, at expansion device	5.76		6.63		10.37		11.94	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.66	1104.57	12.36	942.12	56.58	160.21	54.24	136.64
Evaporator Superheat	3.04		0.06		5.48		0.11	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.29	kg	8	7.25	lb	0.91
Refrigerant Mass Flow Rate			3.83	2.55	kg/min	8.44	5.62	lb/min	0.67
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	27.78	27.78	C	82	82	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			10,931	9,782	W	37,298	33,378	Btu/hr	0.89
Sensible Capacity			8,302	7,952	W	28,327	27,135	Btu/hr	0.96
Total System Power Input			2,499	2,307	W	2,499	2,307	W	0.92
Compressor Power Input			2,078	1,883	W	2,078	1,883	W	0.91
Energy Efficiency Ratio (EER)			14.93	14.47	Btuh/W	14.93	14.47	Btuh/W	0.97
Coeff. Of Performance (COP)			4.37	4.24					0.97

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	34.97	34.91	m <sup>3</sup> /min	1235	1233	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.69/19.43	26.67/19.44	C	80.04/66.97	80/66.99	F	
Outlet Temperature	14.9/14.09	15.37/14.69	C	58.82/57.36	59.67/58.45	F	
Condenser							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	88.74	92.31	m <sup>3</sup> /min	3134	3260	ft <sup>3</sup> /min	1.04
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	35.10	34.07	C	95.19	93.33	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	16.13	1059.14	18.01	925.20	61.04	153.62	64.42	134.19
Compressor Discharge	63.54	2349.27	72.74	2097.50	146.38	340.74	162.93	304.22
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	33.17	2299.18	31.26	2067.30	91.71	333.47	88.26	299.84
Expansion Device Inlet	32.17	2247.99	30.52	2039.72	89.90	326.05	86.94	295.84
Subcooling, at expansion device	4.72		5.80		8.50		10.45	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.04	1085.41	12.68	941.26	55.47	157.43	54.82	136.52
Evaporator Superheat	3.02		0.41		5.44		0.74	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Heating H1							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.29	kg	8	7.25	lb	0.91	
Refrigerant Mass Flow Rate		2.83	3.21	kg/min	6.22	7.08	lb/min	1.14	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	8.33	8.33	C	47	47	F	
		wb	6.11	6.11	C	43	43	F	
Total Capacity		9,616	8,967	W	32,812	30,597	Btu/hr	0.93	
Sensible Capacity		9,616	8,967	W	32,812	30,597	Btu/hr	0.93	
Total System Power Input		2,628	2,362	W	2,628	2,362	W	0.90	
Compressor Power Input		2,201	1,937	W	2,201	1,937	W	0.88	
Energy Efficiency Ratio (EER)		n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a	
Coeff. Of Performance (COP)		3.66	3.80					1.04	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	4.65	4.99	C	40.37	40.988	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	36.76	37.12	m <sup>3</sup> /min	1298	1311	ft <sup>3</sup> /min	1.01
Inlet Temperature	21.11	21.11	C	70	69.99	F	
Outlet Temperature	35.06	33.97	C	95.1	93.15	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	3.17	792.05	2.22	737.90	37.70	114.88	36.00	107.02
Compressor Discharge	66.87	2397.28	65.13	2082.57	152.37	347.70	149.23	302.05
Condenser Inlet	60.92	2391.35	57.19	2076.02	141.66	346.84	134.94	301.10
Condenser Outlet	31.52	2362.25	34.87	2050.86	88.73	342.62	94.76	297.45
Expansion Device Inlet	30.04	n/a	33.62	n/a	86.07	n/a	92.52	n/a
Subcooling, at expansion device	7.39		1.68		13.31		3.02	
Evaporator Inlet	n/a	938.67	n/a	850.37	n/a	136.14	n/a	123.34
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: Arkema ARM-71a \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Heating H3						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.29	kg	8	7.25	lb	0.91
Refrigerant Mass Flow Rate *			n/a	n/a	kg/min	n/a	n/a	lb/min	n/a
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	-8.33	-8.33	C	17	17	F	
		wb	-9.44	-9.44	C	15	15	F	
Total Capacity			5,894	5,371	W	20,112	18,327	Btu/hr	0.91
Sensible Capacity			5,894	5,371	W	20,112	18,327	Btu/hr	0.91
Total System Power Input			2,373	2,181	W	2,373	2,181	W	0.92
Compressor Power Input			1,933	1,740	W	1,933	1,740	W	0.90
Energy Efficiency Ratio (EER)			n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a
Coeff. Of Performance (COP)			2.48	2.46					0.99

\* Note: Refrigerant flow measurement is erratic for some heating tests.

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	-10.05	-10.27	C	13.904	13.507	F	
Condenser							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	36.64	36.13	m <sup>3</sup> /min	1294	1276	ft <sup>3</sup> /min	0.99
Inlet Temperature	21.12	21.11	C	70.01	69.99	F	
Outlet Temperature	29.55	28.88	C	85.19	83.99	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	-13.76	502.55	-12.07	467.42	7.24	72.89	10.28	67.79
Compressor Discharge	59.01	1971.60	68.74	1786.31	138.22	285.96	155.74	259.08
Condenser Inlet	48.92	1970.43	53.29	1785.41	120.05	285.79	127.93	258.95
Condenser Outlet	30.44	1952.64	28.80	1764.86	86.79	283.21	83.84	255.97
Expansion Device Inlet	29.27	n/a	27.94	n/a	84.68	n/a	82.29	n/a
Subcooling, at expansion device	0.85		1.79		1.52		3.23	
Evaporator Inlet	n/a	610.67	n/a	543.30	n/a	88.57	n/a	78.80
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	





**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.29	kg	8	7.25	lb	0.91
Refrigerant Mass Flow Rate			3.48	2.62	kg/min	7.67	5.78	lb/min	0.75
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	15.56	15.56	C	60	60	F	
	Outdoor	db	51.67	51.67	C	125	125	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			7,432	7,109	W	25,360	24,258	Btu/hr	0.96
Sensible Capacity			7,453	7,200	W	25,431	24,567	Btu/hr	0.97
Total System Power Input			3,964	3,688	W	3,964	3,688	W	0.93
Compressor Power Input			3,559	3,319	W	3,559	3,319	W	0.93
Energy Efficiency Ratio (EER)			6.40	6.58	Btuh/W	6.40	6.58	Btuh/W	1.03
Coeff. Of Performance (COP)			1.87	1.93					1.03

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: HPR2A \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	35.14	35.62	m <sup>3</sup> /min	1241	1258	ft <sup>3</sup> /min	1.01
Inlet Temperature	26.66/15.9	26.67/15.63	C	79.99/60.62	80/60.13	F	
Outlet Temperature	15.95/11.84	16.53/11.77	C	60.71/53.31	61.76/53.19	F	
Condenser							
Heat Exchange Fluid	R410A	HPR2A					
Flow Rate (gas)	86.90	78.04	m <sup>3</sup> /min	3069	2756	ft <sup>3</sup> /min	0.90
Inlet Temperature	51.67	51.67	C	125	125	F	
Outlet Temperature	57.90	58.20	C	136.21	136.76	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	26.46	1061.73	14.44	1003.72	79.63	153.99	57.99	145.58
Compressor Discharge	105.97	3975.43	107.58	3563.52	222.74	576.59	225.64	516.85
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	54.15	3952.11	56.37	3540.35	129.48	573.21	133.47	513.49
Expansion Device Inlet	52.52	3897.45	54.04	3510.08	126.53	565.28	129.28	509.10
Subcooling, at expansion device	8.14		5.74		14.65		10.34	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	11.89	1078.62	13.41	1021.24	53.41	156.44	56.13	148.12
Evaporator Superheat	2.09		-1.55		3.76		-2.79	



Manufacturer: Carrier \_\_\_\_\_

<b>Basic Information</b>	
Alternative Refrigerant (If not proprietary, composition as Charged, % wt)	Honeywell L-41-1 (R-446A)
Lubricant Type and ISO Viscosity	POE oil, ISO VG32
Baseline Refrigerant and Lubricant	R410A and POE Oil
Make and Model of System	Carrier 25HCD436 and FX4DN037L
Nominal Capacity and Type of System	3.0 ton capacity split system

<b>Other System Changes</b>
To address expansion control differences, an adjustable TXV was used in cooling. A fixed orifice was used as the expansion control in heating.
The compressor was changed to same model calorimeter tested sample.

System Data	Base.	Alt.	Ratio
Degradation Coefficient (Cooling)– Cd	0.09	0.09	1.000
Seasonal Energy Efficiency Ratio - SEER	14.24	14.04	0.986
Degradation Coefficient (Heating) – Cd *	0.365	0.273	0.748
Heating Seasonal Performance Factor - HSPF	8.358	8.453	1.011

\* Note: If Cd is larger than 0.25, then use 0.25 for HSPF calculation.

**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Cooling A							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.86	kg	8	8.5	lb	1.06	
Refrigerant Mass Flow Rate		3.83	2.78	kg/min	8.43	6.13	lb/min	0.73	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35.00	35.00	C	95	95	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity		10,187	9,118	W	34,759	31,113	Btu/hr	0.90	
Sensible Capacity		8,086	7,725	W	27,591	26,359	Btu/hr	0.96	
Total System Power Input		2,869	2,610	W	2,869	2,610	W	0.91	
Compressor Power Input		2,446	2,186	W	2,446	2,186	W	0.89	
Energy Efficiency Ratio (EER)		12.12	11.92	Btuh/W	12.12	11.92	Btuh/W	0.98	
Coeff. Of Performance (COP)		3.55	3.49					0.98	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	34.94	34.97	m <sup>3</sup> /min	1234	1235	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.63/19.42	26.71/19.46	C	79.94/66.96	80.08/67.03	F	
Outlet Temperature	15.14/14.46	15.73/15.06	C	59.25/58.03	60.31/59.11	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	85.46	93.96	m <sup>3</sup> /min	3018	3318	ft <sup>3</sup> /min	1.10
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	42.33	40.98	C	108.19	105.76	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	18.19	1080.44	12.86	948.16	64.74	156.71	55.15	137.52
Compressor Discharge	74.79	2776.33	71.82	2420.79	166.62	402.68	161.28	351.11
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	39.89	2733.93	40.18	2387.67	103.80	396.53	104.32	346.31
Expansion Device Inlet	38.43	2681.80	38.94	2356.40	101.17	388.97	102.10	341.77
Subcooling, at expansion device	5.76		4.44		10.37		7.99	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.66	1104.57	12.69	967.25	56.58	160.21	54.85	140.29
Evaporator Superheat	3.04		-1.74		5.48		-3.13	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.86	kg	8	8.5	lb	1.06
Refrigerant Mass Flow Rate			3.83	2.79	kg/min	8.44	6.14	lb/min	0.73
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	27.78	27.78	C	82	82	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			10,931	9,913	W	37,298	33,825	Btu/hr	0.91
Sensible Capacity			8,302	7,998	W	28,327	27,292	Btu/hr	0.96
Total System Power Input			2,499	2,300	W	2,499	2,300	W	0.92
Compressor Power Input			2,078	1,873	W	2,078	1,873	W	0.90
Energy Efficiency Ratio (EER)			14.93	14.71	Btuh/W	14.93	14.71	Btuh/W	0.99
Coeff. Of Performance (COP)			4.37	4.31					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	34.97	34.94	m <sup>3</sup> /min	1235	1234	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.69/19.43	26.67/19.47	C	80.04/66.97	80.01/67.05	F	
Outlet Temperature	14.9/14.09	15.33/14.67	C	58.82/57.36	59.6/58.41	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	88.74	96.45	m <sup>3</sup> /min	3134	3406	ft <sup>3</sup> /min	1.09
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	35.10	33.88	C	95.19	92.98	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	16.13	1059.14	12.42	929.19	61.04	153.62	54.36	134.77
Compressor Discharge	63.54	2349.27	61.35	2058.48	146.38	340.74	142.43	298.56
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	33.17	2299.18	32.52	2020.80	91.71	333.47	90.54	293.10
Expansion Device Inlet	32.17	2247.99	31.91	1991.53	89.90	326.05	89.44	288.85
Subcooling, at expansion device	4.72		4.49		8.50		8.08	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.04	1085.41	12.27	948.98	55.47	157.43	54.09	137.64
Evaporator Superheat	3.02		-1.53		5.44		-2.75	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Heating H1							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.86	kg	8	8.5	lb	1.06	
Refrigerant Mass Flow Rate		2.83	2.11	kg/min	6.22	4.65	lb/min	0.75	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	8.33	8.33	C	47	47	F	
		wb	6.11	6.11	C	43	43	F	
Total Capacity		9,616	8,828	W	32,812	30,123	Btu/hr	0.92	
Sensible Capacity		9,616	8,828	W	32,812	30,123	Btu/hr	0.92	
Total System Power Input		2,628	2,376	W	2,628	2,376	W	0.90	
Compressor Power Input		2,201	1,947	W	2,201	1,947	W	0.88	
Energy Efficiency Ratio (EER)		n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a	
Coeff. Of Performance (COP)		3.66	3.72					1.02	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	4.65	4.71	C	40.37	40.481	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	36.76	36.84	m <sup>3</sup> /min	1298	1301	ft <sup>3</sup> /min	1.00
Inlet Temperature	21.11	21.11	C	70	69.99	F	
Outlet Temperature	35.06	33.96	C	95.1	93.12	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	3.17	792.05	3.11	725.57	37.70	114.88	37.60	105.24
Compressor Discharge	66.87	2397.28	63.34	2044.25	152.37	347.70	146.01	296.50
Condenser Inlet	60.92	2391.35	55.59	2039.29	141.66	346.84	132.07	295.78
Condenser Outlet	31.52	2362.25	34.40	2017.84	88.73	342.62	93.92	292.67
Expansion Device Inlet	30.04	n/a	32.56	n/a	86.07	n/a	90.62	n/a
Subcooling, at expansion device	7.39		2.53		13.31		4.56	
Evaporator Inlet	n/a	938.67	n/a	836.63	n/a	136.14	n/a	121.34
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	





## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Heating H3						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.86	kg	8	8.5	lb	1.06
Refrigerant Mass Flow Rate *			n/a	n/a	kg/min	n/a	n/a	lb/min	n/a
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	-8.33	-8.33	C	17	17	F	
		wb	-9.44	-9.44	C	15	15	F	
Total Capacity			5,894	5,339	W	20,112	18,219	Btu/hr	0.91
Sensible Capacity			5,894	5,339	W	20,112	18,219	Btu/hr	0.91
Total System Power Input			2,373	2,131	W	2,373	2,131	W	0.90
Compressor Power Input			1,933	1,688	W	1,933	1,688	W	0.87
Energy Efficiency Ratio (EER)			n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a
Coeff. Of Performance (COP)			2.48	2.51					1.01

\* Note: Refrigerant flow measurement is erratic for some heating tests.

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	-10.05	-9.84	C	13.904	14.295	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	36.64	36.05	m <sup>3</sup> /min	1294	1273	ft <sup>3</sup> /min	0.98
Inlet Temperature	21.12	21.12	C	70.01	70.02	F	
Outlet Temperature	29.55	28.87	C	85.19	83.97	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	-13.76	502.55	-11.16	467.01	7.24	72.89	11.91	67.73
Compressor Discharge	59.01	1971.60	63.38	1768.31	138.22	285.96	146.09	256.47
Condenser Inlet	48.92	1970.43	49.68	1766.59	120.05	285.79	121.43	256.22
Condenser Outlet	30.44	1952.64	29.02	1746.18	86.79	283.21	84.24	253.26
Expansion Device Inlet	29.27	n/a	28.21	n/a	84.68	n/a	82.77	n/a
Subcooling, at expansion device	0.85		2.13		1.52		3.83	
Evaporator Inlet	n/a	610.67	n/a	545.79	n/a	88.57	n/a	79.16
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.18	kg	8	7	lb	0.88
Refrigerant Mass Flow Rate			3.48	2.44	kg/min	7.67	5.37	lb/min	0.70
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	15.56	15.56	C	60	60	F	
	Outdoor	db	51.67	51.67	C	125	125	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			7,432	7,211	W	25,360	24,605	Btu/hr	0.97
Sensible Capacity			7,453	7,242	W	25,431	24,712	Btu/hr	0.97
Total System Power Input			3,964	3,867	W	3,964	3,867	W	0.98
Compressor Power Input			3,559	3,462	W	3,559	3,462	W	0.97
Energy Efficiency Ratio (EER)			6.40	6.36	Btuh/W	6.40	6.36	Btuh/W	0.99
Coeff. Of Performance (COP)			1.87	1.86					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-1 (R-446A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	35.14	35.11	m <sup>3</sup> /min	1241	1240	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.66/15.9	26.67/15.79	C	79.99/60.62	80/60.43	F	
Outlet Temperature	15.95/11.84	16.33/11.84	C	60.71/53.31	61.39/53.32	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-1					
Flow Rate (gas)	86.90	82.83	m <sup>3</sup> /min	3069	2925	ft <sup>3</sup> /min	0.95
Inlet Temperature	51.67	51.67	C	125	125	F	
Outlet Temperature	57.90	57.95	C	136.21	136.31	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	26.46	1061.73	21.14	948.29	79.63	153.99	70.05	137.54
Compressor Discharge	105.97	3975.43	120.73	3815.18	222.74	576.59	249.31	553.35
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	54.15	3952.11	53.16	3801.21	129.48	573.21	127.69	551.32
Expansion Device Inlet	52.52	3897.45	50.60	3769.60	126.53	565.28	123.08	546.74
Subcooling, at expansion device	8.14		13.97		14.65		25.15	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	11.89	1078.62	13.12	960.91	53.41	156.44	55.61	139.37
Evaporator Superheat	2.09		-1.10		3.76		-1.97	



Manufacturer: Carrier \_\_\_\_\_

<b>Basic Information</b>	
Alternative Refrigerant (If not proprietary, composition as Charged, % wt)	Honeywell L-41-2 (R-447A)
Lubricant Type and ISO Viscosity	POE oil, ISO VG32
Baseline Refrigerant and Lubricant	R410A and POE Oil
Make and Model of System	Carrier 25HCD436 and FX4DN037L
Nominal Capacity and Type of System	3.0 ton capacity split system

<b>Other System Changes</b>
To address expansion control differences, an adjustable TXV was used in cooling. A fixed orifice was used as the expansion control in heating.
The compressor was changed to same model calorimeter tested sample.

System Data	Base.	Alt.	Ratio
Degradation Coefficient (Cooling)– Cd	0.09	0.06	0.667
Seasonal Energy Efficiency Ratio - SEER	14.24	14.33	1.006
Degradation Coefficient (Heating) – Cd *	0.365	0.283	0.775
Heating Seasonal Performance Factor - HSPF	8.358	8.54	1.022

\* Note: If Cd is larger than 0.25, then use 0.25 for HSPF calculation.

**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Cooling A							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.86	kg	8	8.5	lb	1.06	
Refrigerant Mass Flow Rate		3.83	2.83	kg/min	8.43	6.24	lb/min	0.74	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35.00	35.00	C	95	95	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity		10,187	9,444	W	34,759	32,225	Btu/hr	0.93	
Sensible Capacity		8,086	7,793	W	27,591	26,592	Btu/hr	0.96	
Total System Power Input		2,869	2,684	W	2,869	2,684	W	0.94	
Compressor Power Input		2,446	2,264	W	2,446	2,264	W	0.93	
Energy Efficiency Ratio (EER)		12.12	12.01	Btuh/W	12.12	12.01	Btuh/W	0.99	
Coeff. Of Performance (COP)		3.55	3.52					0.99	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “A” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	34.94	35.03	m <sup>3</sup> /min	1234	1237	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.63/19.42	26.67/19.44	C	79.94/66.96	80/66.99	F	
Outlet Temperature	15.14/14.46	15.53/14.87	C	59.25/58.03	59.96/58.77	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	85.46	91.97	m <sup>3</sup> /min	3018	3248	ft <sup>3</sup> /min	1.08
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	42.33	41.32	C	108.19	106.38	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	18.19	1080.44	12.47	963.65	64.74	156.71	54.44	139.77
Compressor Discharge	74.79	2776.33	74.02	2515.30	166.62	402.68	165.23	364.82
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	39.89	2733.93	38.55	2484.62	103.80	396.53	101.39	360.37
Expansion Device Inlet	38.43	2681.80	37.46	2452.70	101.17	388.97	99.42	355.74
Subcooling, at expansion device	5.76		7.39		10.37		13.31	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.66	1104.57	12.35	982.54	56.58	160.21	54.23	142.51
Evaporator Superheat	3.04		-2.23		5.48		-4.01	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.86	kg	8	8.5	lb	1.06
Refrigerant Mass Flow Rate			3.83	2.87	kg/min	8.44	6.32	lb/min	0.75
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	27.78	27.78	C	82	82	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			10,931	10,260	W	37,298	35,009	Btu/hr	0.94
Sensible Capacity			8,302	8,113	W	28,327	27,683	Btu/hr	0.98
Total System Power Input			2,499	2,367	W	2,499	2,367	W	0.95
Compressor Power Input			2,078	1,942	W	2,078	1,942	W	0.93
Energy Efficiency Ratio (EER)			14.93	14.79	Btuh/W	14.93	14.79	Btuh/W	0.99
Coeff. Of Performance (COP)			4.37	4.33					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “B” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
<b>Evaporator</b>							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	34.97	35.00	m <sup>3</sup> /min	1235	1236	ft <sup>3</sup> /min	1.00
Inlet Temperature	26.69/19.43	26.67/19.47	C	80.04/66.97	80.01/67.04	F	
Outlet Temperature	14.9/14.09	15.11/14.48	C	58.82/57.36	59.2/58.06	F	
<b>Condenser</b>							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	88.74	95.06	m <sup>3</sup> /min	3134	3357	ft <sup>3</sup> /min	1.07
Inlet Temperature	35.00	35.00	C	95	95	F	
Outlet Temperature	35.10	34.17	C	95.19	93.50	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	16.13	1059.14	12.05	955.06	61.04	153.62	53.69	138.52
Compressor Discharge	63.54	2349.27	62.53	2127.23	146.38	340.74	144.55	308.53
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	33.17	2299.18	31.84	2089.95	91.71	333.47	89.32	303.12
Expansion Device Inlet	32.17	2247.99	31.25	2059.25	89.90	326.05	88.25	298.67
Subcooling, at expansion device	4.72		6.30		8.50		11.34	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	13.04	1085.41	12.12	974.92	55.47	157.43	53.81	141.40
Evaporator Superheat	3.02		-2.20		5.44		-3.97	





**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Comparison Data		Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio	
Mode (Heating/Cooling)		Heating H1							
Compressor Type		Scroll	Scroll						
Compressor Displacement		0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1	
Nominal Motor Size		4	4	hp				1	
Motor Speed		3500	3500	rpm				1	
Expansion Device Type		TXV	TXV						
Lubricant Charge		0.600	0.600	L	20.3	20.3	fl. oz.	1	
Refrigerant Charge		3.63	3.86	kg	8	8.5	lb	1.06	
Refrigerant Mass Flow Rate		2.83	2.15	kg/min	6.22	4.73	lb/min	0.76	
Composition, at compressor inlet			100	% wt					
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	8.33	8.33	C	47	47	F	
		wb	6.11	6.11	C	43	43	F	
Total Capacity		9,616	8,971	W	32,812	30,612	Btu/hr	0.93	
Sensible Capacity		9,616	8,971	W	32,812	30,612	Btu/hr	0.93	
Total System Power Input		2,628	2,393	W	2,628	2,393	W	0.91	
Compressor Power Input		2,201	1,969	W	2,201	1,969	W	0.89	
Energy Efficiency Ratio (EER)		n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a	
Coeff. Of Performance (COP)		3.66	3.75					1.02	

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H1” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	4.65	5.02	C	40.37	41.043	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	36.76	36.76	m <sup>3</sup> /min	1298	1298	ft <sup>3</sup> /min	1.00
Inlet Temperature	21.11	21.11	C	70	70	F	
Outlet Temperature	35.06	34.10	C	95.1	93.38	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	3.17	792.05	2.39	738.28	37.70	114.88	36.30	107.08
Compressor Discharge	66.87	2397.28	64.01	2089.78	152.37	347.70	147.22	303.10
Condenser Inlet	60.92	2391.35	56.39	2083.92	141.66	346.84	133.50	302.25
Condenser Outlet	31.52	2362.25	35.07	2060.82	88.73	342.62	95.13	298.90
Expansion Device Inlet	30.04	n/a	33.11	n/a	86.07	n/a	91.60	n/a
Subcooling, at expansion device	7.39		2.51		13.31		4.51	
Evaporator Inlet	n/a	938.67	n/a	853.23	n/a	136.14	n/a	123.75
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



## Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Heating H3						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.86	kg	8	8.5	lb	1.06
Refrigerant Mass Flow Rate *			n/a	n/a	kg/min	n/a	n/a	lb/min	n/a
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	21.11	21.11	C	70	70	F	
		wb	n/a	n/a	C	n/a	n/a	F	
	Outdoor	db	-8.33	-8.33	C	17	17	F	
		wb	-9.44	-9.44	C	15	15	F	
Total Capacity			5,894	5,451	W	20,112	18,598	Btu/hr	0.92
Sensible Capacity			5,894	5,451	W	20,112	18,598	Btu/hr	0.92
Total System Power Input			2,373	2,181	W	2,373	2,181	W	0.92
Compressor Power Input			1,933	1,744	W	1,933	1,744	W	0.90
Energy Efficiency Ratio (EER)			n/a	n/a	Btuh/W	n/a	n/a	Btuh/W	n/a
Coeff. Of Performance (COP)			2.48	2.50					1.01

\* Note: Refrigerant flow measurement is erratic for some heating tests.

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: “H3” Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	n/a	n/a	m <sup>3</sup> /min	n/a	n/a	ft <sup>3</sup> /min	n/a
Inlet Temperature	8.33/6.11	8.33/6.11	C	47 /43	47 /43	F	
Outlet Temperature	-10.05	-9.90	C	13.904	14.185	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	36.64	36.61	m <sup>3</sup> /min	1294	1293	ft <sup>3</sup> /min	1.00
Inlet Temperature	21.12	21.10	C	70.01	69.98	F	
Outlet Temperature	29.55	28.88	C	85.19	83.99	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	-13.76	502.55	-11.73	472.07	7.24	72.89	10.89	68.47
Compressor Discharge	59.01	1971.60	65.46	1788.89	138.22	285.96	149.83	259.46
Condenser Inlet	48.92	1970.43	51.21	1787.31	120.05	285.79	124.18	259.23
Condenser Outlet	30.44	1952.64	29.19	1766.62	86.79	283.21	84.55	256.23
Expansion Device Inlet	29.27	n/a	28.30	n/a	84.68	n/a	82.94	n/a
Subcooling, at expansion device	0.85		2.22		1.52		3.99	
Evaporator Inlet	n/a	610.67	n/a	550.97	n/a	88.57	n/a	79.91
Evaporator Outlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Superheat	n/a		n/a		n/a		n/a	



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Comparison Data			Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)			Cooling B						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.102	0.102	m <sup>3</sup> /min	3.585	3.585	ft <sup>3</sup> /min	1
Nominal Motor Size			4	4	hp				1
Motor Speed			3500	3500	rpm				1
Expansion Device Type			TXV	TXV					
Lubricant Charge			0.600	0.600	L	20.3	20.3	fl. oz.	1
Refrigerant Charge			3.63	3.18	kg	8	7	lb	0.88
Refrigerant Mass Flow Rate			3.48	2.59	kg/min	7.67	5.72	lb/min	0.75
Composition, at compressor inlet				100	% wt				
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	15.56	15.56	C	60	60	F	
	Outdoor	db	51.67	51.67	C	125	125	F	
		wb	n/a	n/a	C	n/a	n/a	F	
Total Capacity			7,432	7,148	W	25,360	24,389	Btu/hr	0.96
Sensible Capacity			7,453	7,183	W	25,431	24,510	Btu/hr	0.96
Total System Power Input			3,964	3,868	W	3,964	3,868	W	0.98
Compressor Power Input			3,559	3,454	W	3,559	3,454	W	0.97
Energy Efficiency Ratio (EER)			6.40	6.31	Btuh/W	6.40	6.31	Btuh/W	0.99
Coeff. Of Performance (COP)			1.87	1.85					0.99

<b>Data Source(s) for Refrigerant Properties</b>
NIST REFPROP Version 9.1, modified



**Low-GWP AREP SYSTEM DROP-IN TEST DATA FORM: High Ambient Test**

Type of System: Split HP \_\_\_\_\_

Alternate Refrigerant: L-41-2 (R-447A) \_\_\_\_\_

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	35.14	34.09	m <sup>3</sup> /min	1241	1204	ft <sup>3</sup> /min	0.97
Inlet Temperature	26.66/15.9	26.67/15.73	C	79.99/60.62	80/60.32	F	
Outlet Temperature	15.95/11.84	16.13/11.7	C	60.71/53.31	61.03/53.06	F	
Condenser							
Heat Exchange Fluid	R410A	L-41-2					
Flow Rate (gas)	86.90	81.64	m <sup>3</sup> /min	3069	2883	ft <sup>3</sup> /min	0.94
Inlet Temperature	51.67	51.67	C	125	125	F	
Outlet Temperature	57.90	57.99	C	136.21	136.39	F	

Refrigerant Side Data Temperatures & Pressures	Baseline		Alternative		Baseline		Alternative	
	T (C)	P [kPa]	T (C)	P [kPa]	T [F]	P [psia]	T [F]	P [psia]
Compressor Suction	26.46	1061.73	14.24	945.46	79.63	153.99	57.63	137.13
Compressor Discharge	105.97	3975.43	114.22	3804.42	222.74	576.59	237.59	551.79
Condenser Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Condenser Outlet	54.15	3952.11	53.25	3786.34	129.48	573.21	127.85	549.17
Expansion Device Inlet	52.52	3897.45	50.76	3756.02	126.53	565.28	123.37	544.77
Subcooling, at expansion device	8.14		13.31		14.65		23.96	
Evaporator Inlet	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evaporator Outlet	11.89	1078.62	12.87	960.70	53.41	156.44	55.16	139.34
Evaporator Superheat	2.09		-0.97		3.76		-1.74	

#### 4. Conclusions

The proposed R-410A replacement refrigerants were able to be applied in the test system with minimal effort; however, none of the options is fully equivalent to R-410A on a drop-in basis. All options were lower in both cooling and heating capacity than that of baseline R-410A. The cooling capacity drop was between 5.7 ~ 11% and heating capacity drop was between 4.2 ~ 8.2%. However, all of the options were higher on heating efficiency (HSPF) and most options (except HPR2A and L-41-1) were higher on cooling efficiency (SEER). Low compressor power consumption was the major reason for the high efficiency. High ambient cooling tests (125°F outdoor dry air temperature) displayed similar capacity reduction comparing with R-410A baseline. The high ambient cooling capacity drop was between 0.8 ~ 4.3%. Additional study is required to evaluate the potential to minimize the performance differential through “soft optimization” such as charge and circuit optimization, or full technology optimization of compression, heat exchanger, airflow, and control technology for each refrigerant candidate.

