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

TEST REPORT #42

System Soft-optimization Tests of Refrigerant R-32 in a 3-ton Split System Air-Conditioner

Hao Li (Stephen)
Robert By

Goodman Manufacturing
1440 Greengrass Dr.
Houston, TX 77008

April 23, 2015

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

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

Low-GWP AREP SOFT-OPTIMIZED SYSTEM TEST

1. Introduction:

A R410A 3 ton (3T) split system air conditioner (SSX140361 / ARPT36D14) was selected for the soft-optimization test of R32 in Goodman Manufacturing (1440 Greengrass Dr., Houston, TX 77008) from 9/24/2014 – 9/30/2014.

2. Details of Test Setup:

a. Description of Baseline System

The R410A system selected for the soft-optimization test is SSX140361 (outdoor, OD) and ARPT36D14 (indoor, ID). The compressor was replaced by a new dropped-in scroll compressor for baseline test for the reason of research purpose and R32 compressor availability. Original production POE oil and production 4T TXV were still used in this baseline system with optimization of charge and valve opening.

b. Description of Modifications to System

- Compressor was changed to ZP31K6 for all the tests including baseline;
- Charge was adjusted to get TXV bulb superheat 3 ^{o}F and liquid service valve subcooling 8 ^{o}F;
- 3T TXV was used for R32 system due to low refrigerant flow rate;

c. Description of Tests Conducted

Fig. 1 is the schematic of the test setup with data measurement location marked in the diagram. Table 1 lists the measuring points in the heat pump system.
Three tests were performed with this configuration.

1) R410A baseline test with ZP31K6 compressor, 4T TXV, and Emerson production POE oil;
2) R32 test with the existing ZP31K6 compressor, 3T TXV, and existing Emerson production POE oil;
3) R32 test with another ZP31K6 compressor charged with Emerson prototype R32 POE oil, 3T TXV;

Steady state cooling mode tests were conducted at standard rating conditions (Test A and Test B) as defined in Table 3 of ANSI/AHRI Standard 210/240-2008 (with Addenda 1 and 2). Additional cooling mode tests were conducted at higher outdoor air entering temperatures of 115 °F and 125 °F. Additional tests were conducted (Test C and Test D) to determine Seasonal Energy Efficiency Ratio (SEER).

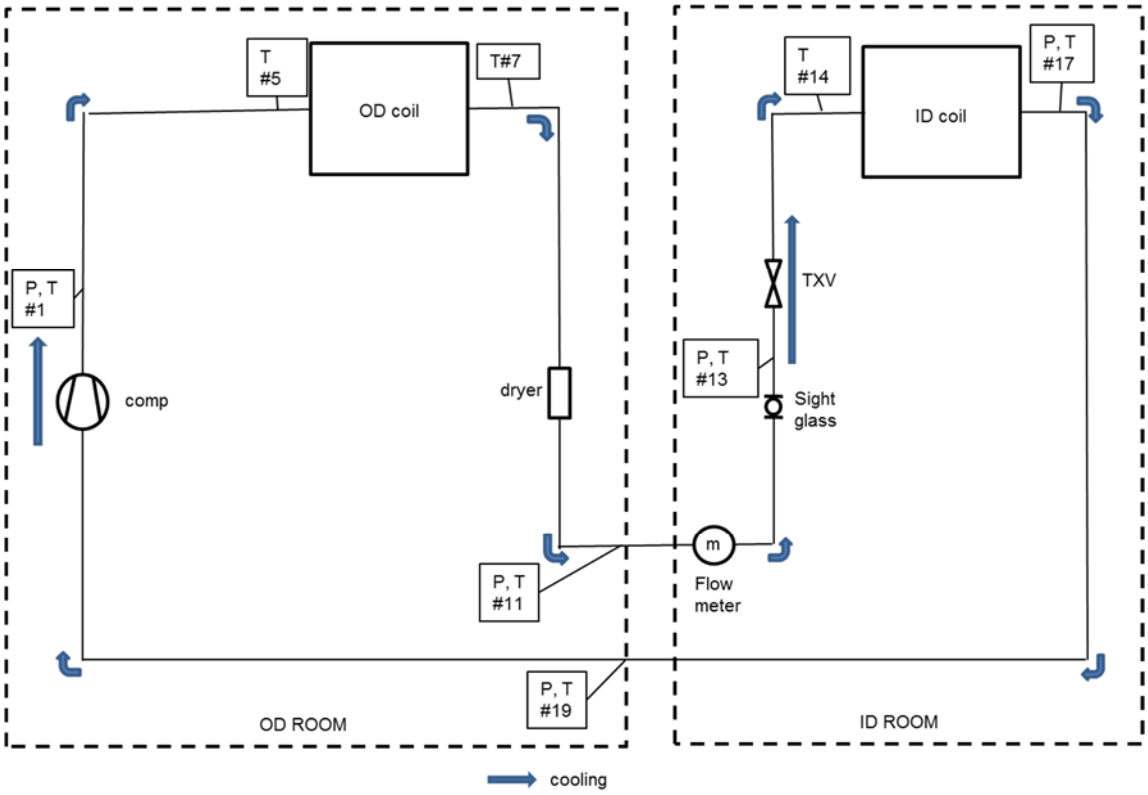


Figure 1 Schematic of soft-optimization test setup

Table 1 Data measurement locations

data locations in refrigeration system	P	T
Comp discharge (#1)	x1	x1
OD coil common in (#5)		x1
OD coil out (#7)		x1
OD Liquid @ SV (#11)	x1	x1
Before ID TXV (#13)	x1	x1
ID coil in (#14)		x1
ID coil common out @ TXV bulb (#17)	x1	x1
OD vapor @ SV (#19)	x1	x1
Comp suction (#24)	x1	x1
Total	x6	x9

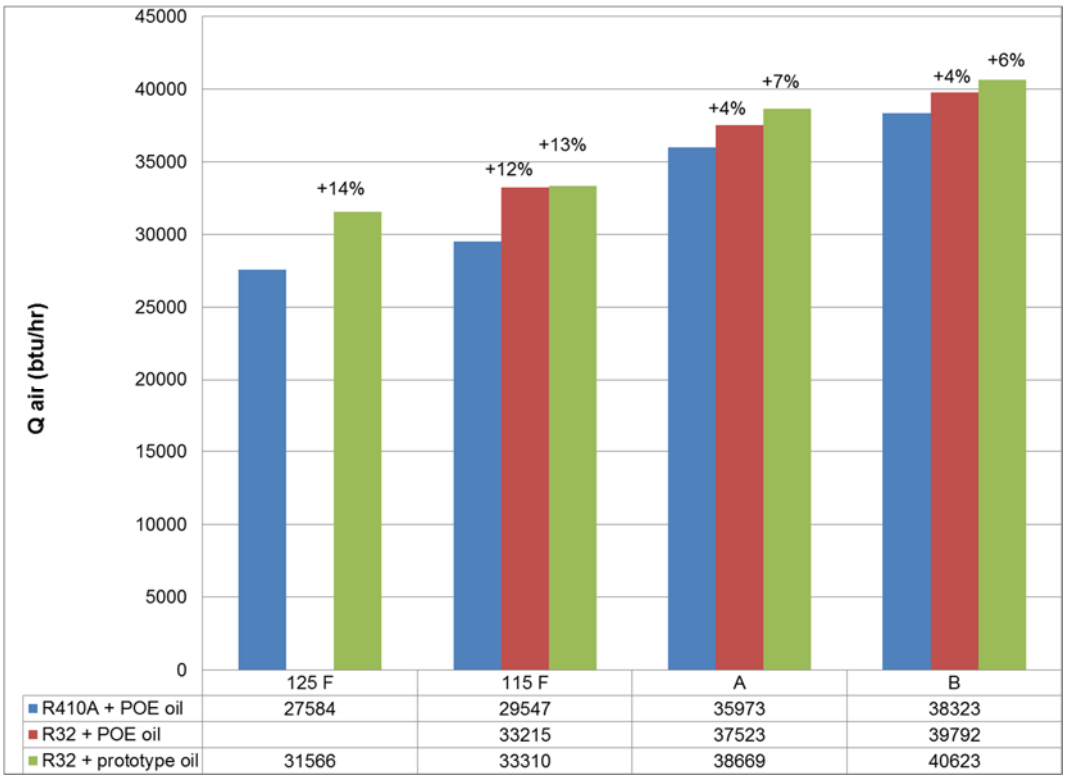
3. Results

a. Data Form

Please see data forms of steady state test A/B/115/125 in the following pages.

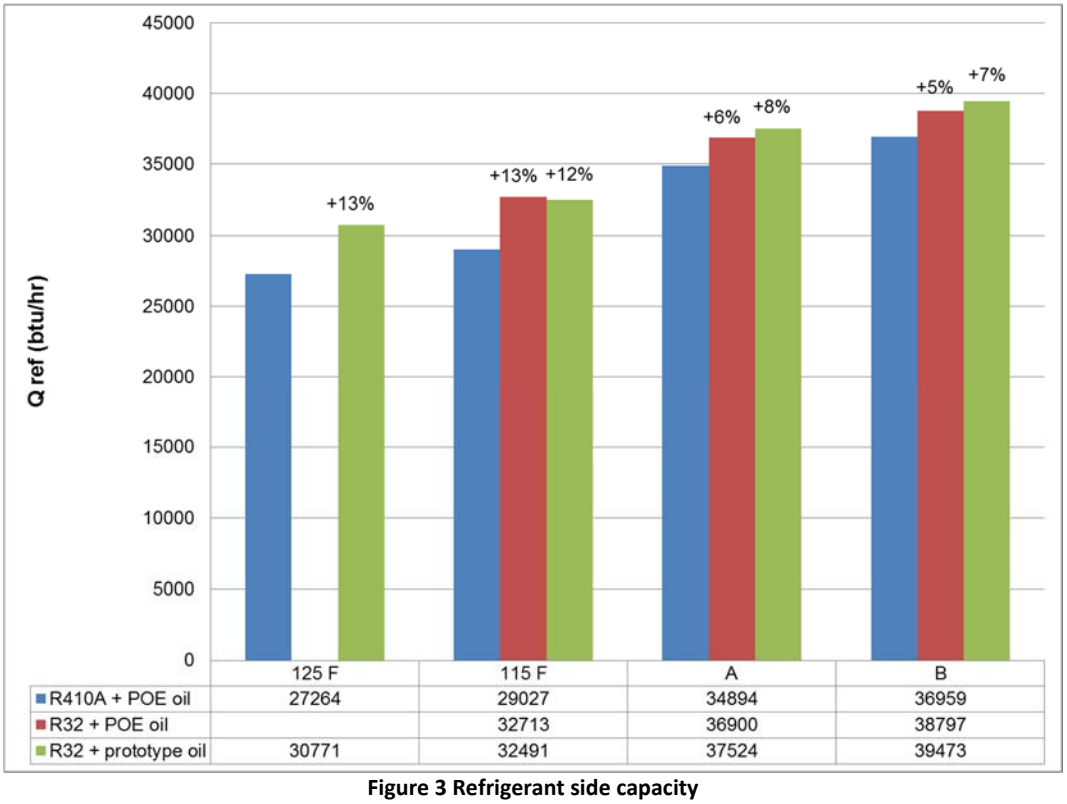
b. Other

- R32 is compatible to the existing R410A system, including extreme conditions;
- A/B/C/D/115/125 was tested for SEER evaluation;
- Compressor tripping occurred at high ambient condition (125 ^{o}F) of R32 refrigerant. High pressure switch was bypassed to continue the test. We were able to continue and finished the test of R32 with prototype oil. However, R32 with production POE oil still could not be performed due to high discharge temperature;
- Heat balance has a crucial impact on the comparison of efficiency since the efficiency gain is marginal and heat balance in the test is not exactly the same (ranging from 0.65% to 3.56%), therefore refrigerant side capacity and efficiency are also listed for further analysis;
- R32 has higher capacity by 4 ~ 8% and efficiency by +0.1 ~ +0.4 at rating conditions (Fig. 2-5);
- At high ambient conditions, R32 shows higher capacity (up to +14%) and efficiency (up to +0.8) (Fig. 2-5);
- R32 has higher discharge pressure (+10 psi) and discharge temperature (+25 ^{o}F) than R410A at rating conditions (Fig. 6-7);
- At high ambient conditions, R32 discharge pressure and temperature is even higher, +20 psi and +50 ^{o}F, respectively (Fig. 6-7);
- Cd of R32 is about the same as R410A;
- Charge of R32 is 13% lower than R410A;
- R32 flow rate is 30% lower than R410A (Fig. 8), therefore, pressure drop of OD and ID unit is 2 ~ 4 psi lower;
- R32 shows higher compressor isentropic efficiency, $\eta_s = (h_{out,s} - h_{in}) / (h_{out} - h_{in})$, than R410A (Fig. 9);
- R32 shows comparable volumetric efficiency, $\eta_v = m_{ref} / (\rho \, V \, RPM)$, than R410A (Fig. 10);
- Although there is compressor-to-compressor variation, the prototype R32 oil from Copeland is preliminarily tested good for R32 performance;



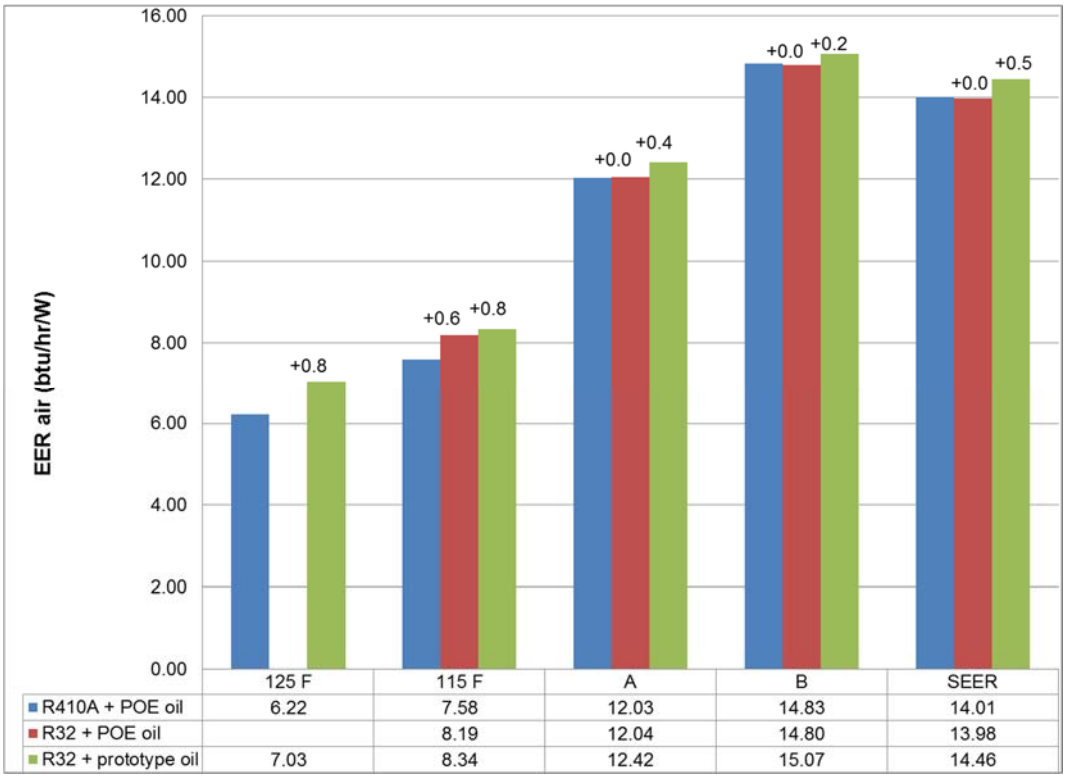
	125 F	115 F	A	B
R410A + POE oil	27584	29547	35973	38323
R32 + POE oil		33215	37523	39792
R32 + prototype oil	31566	33310	38669	40623

Figure 2 Air side capacity



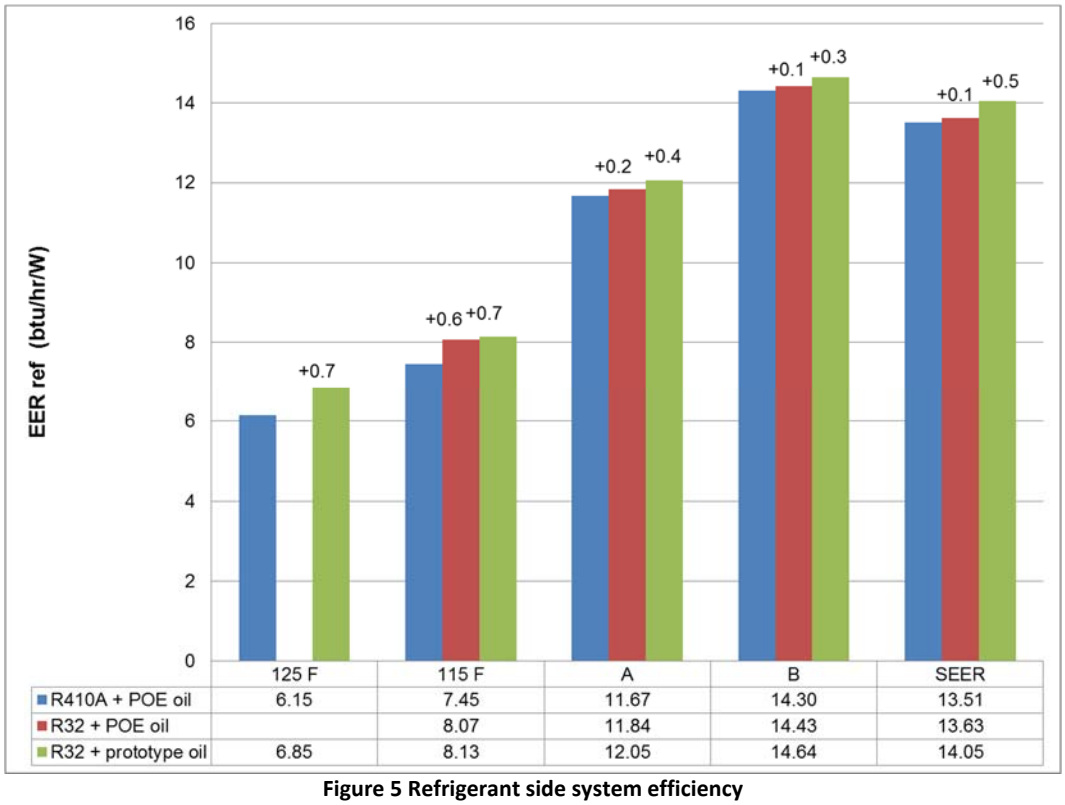
	125 F	115 F	A	B
R410A + POE oil	27264	29027	34894	36959
R32 + POE oil		32713	36900	38797
R32 + prototype oil	30771	32491	37524	39473

Figure 3 Refrigerant side capacity



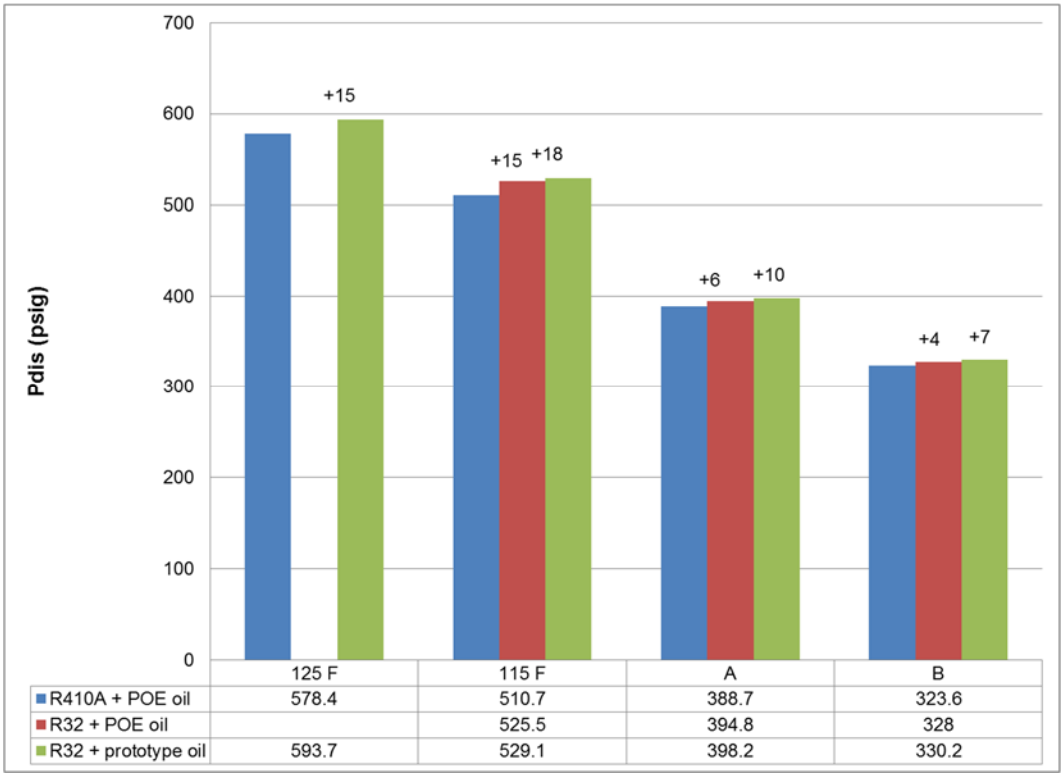
	125 F	115 F	A	B	SEER
R410A + POE oil	6.22	7.58	12.03	14.83	14.01
R32 + POE oil		8.19	12.04	14.80	13.98
R32 + prototype oil	7.03	8.34	12.42	15.07	14.46

Figure 4 Air side system efficiency



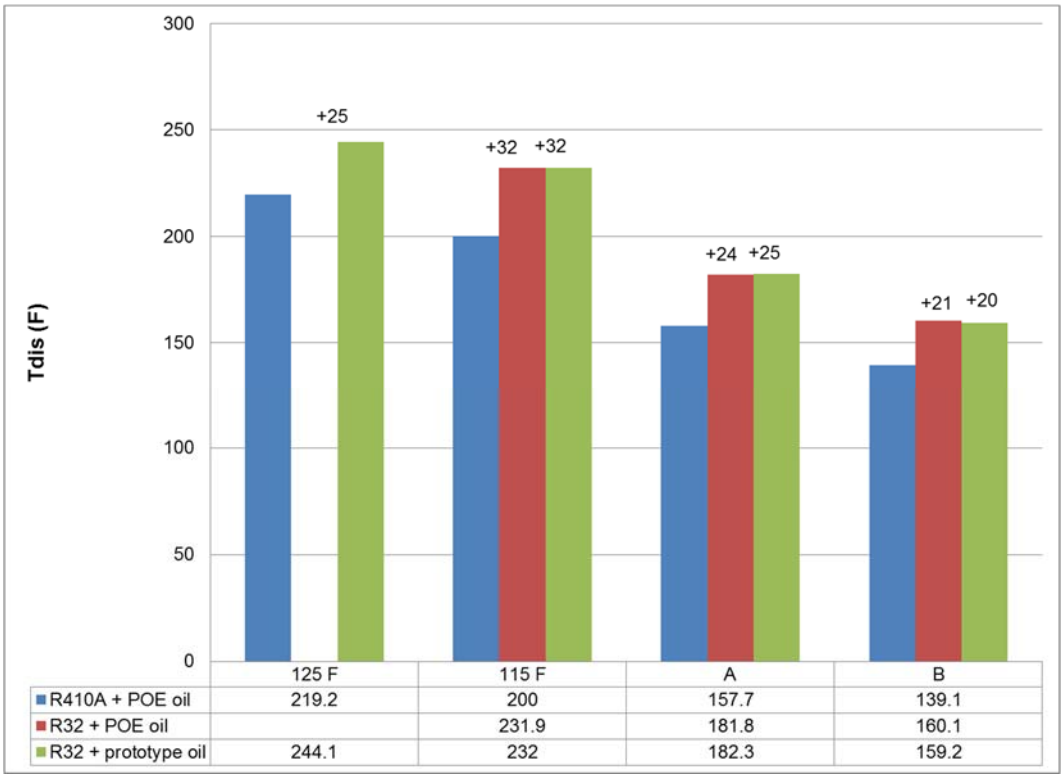
	125 F	115 F	A	B	SEER
R410A + POE oil	6.15	7.45	11.67	14.30	13.51
R32 + POE oil		8.07	11.84	14.43	13.63
R32 + prototype oil	6.85	8.13	12.05	14.64	14.05

Figure 5 Refrigerant side system efficiency



	125 F	115 F	A	B
R410A + POE oil	578.4	510.7	388.7	323.6
R32 + POE oil		525.5	394.8	328
R32 + prototype oil	593.7	529.1	398.2	330.2

Figure 6 Compressor discharge pressure



	125 F	115 F	A	B
R410A + POE oil	219.2	200	157.7	139.1
R32 + POE oil		231.9	181.8	160.1
R32 + prototype oil	244.1	232	182.3	159.2

Figure 7 Compressor discharge temperature

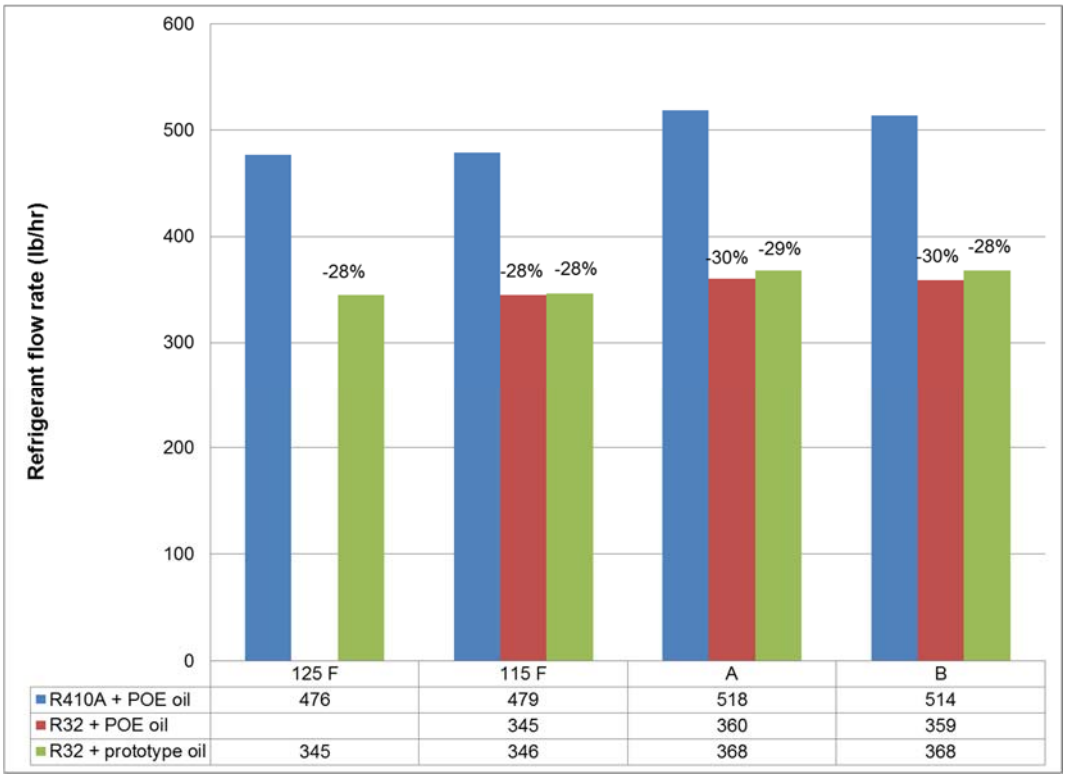


Figure 8 Refrigerant mass flow rate

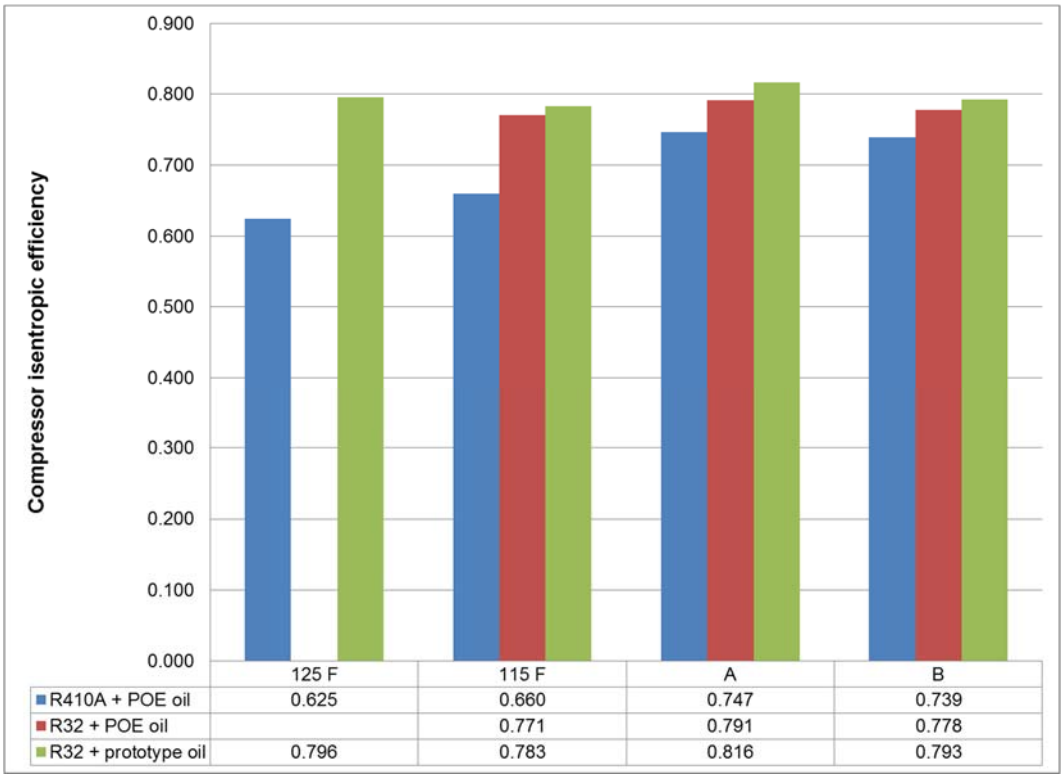
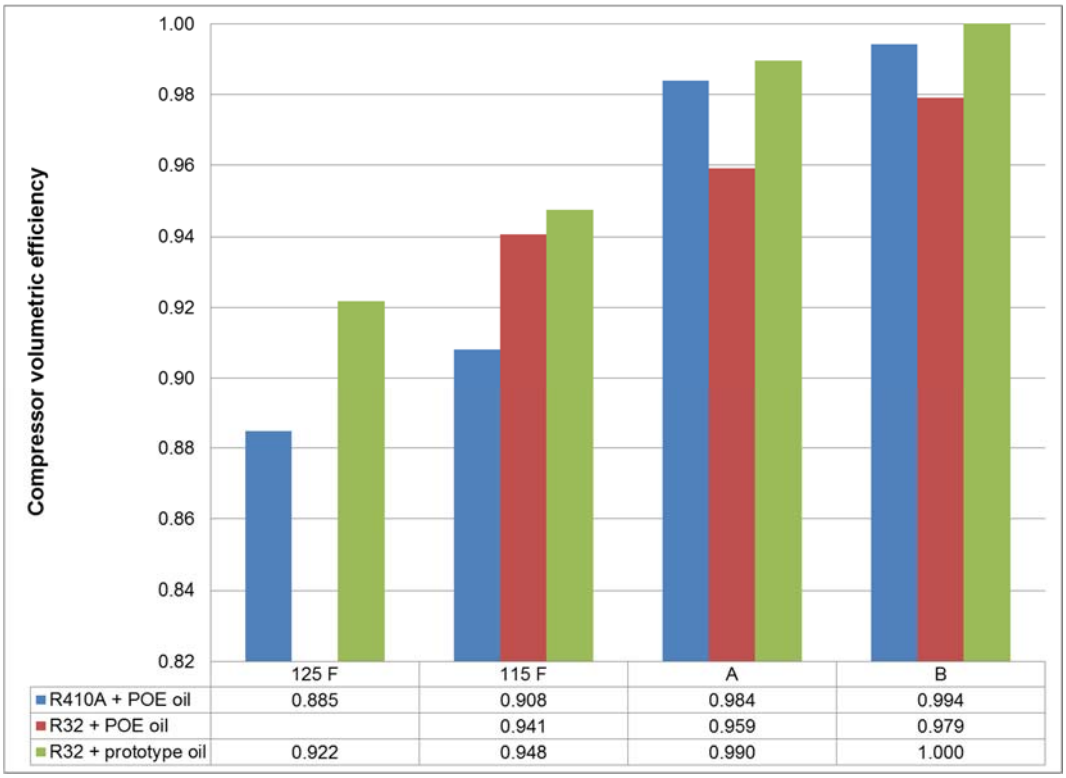


Figure 9 Compressor isentropic efficiency



	125 F	115 F	A	B
R410A + POE oil	0.885	0.908	0.984	0.994
R32 + POE oil		0.941	0.959	0.979
R32 + prototype oil	0.922	0.948	0.990	1.000

Figure 10 Compressor volumetric efficiency

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: A / POE oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	POE
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.47	kg	6.31	5.44	lb	0.86
Refrigerant Mass Flow Rate			3.91	2.72	kg/min	8.63	6	lb/min	0.70
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35	35	C	95	95	F	
		wb	19.78	19.72	C	67.6	67.5	F	
Total Capacity			10543	10997	W	35973	37523	Btu/hr	1.04
Sensible Capacity			7856	8008	W	26805	27323	Btu/hr	1.02
Total System Power Input			2990	3116	W	2990	3116	W	1.04
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			3.53	3.53	W/W	12.03	12.04	Btuh/W	1.0
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.109	0.99
Seasonal Energy Efficiency Ratio - SEER	14.01	13.98	1.00
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.23	31.09	m ^3/min	1103	1098	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	26.67	26.67	C	80.0	80.0	F	
Outlet Temperature	14.44	14.11	C	58.0	57.4	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	35.0	35.0	C	95.0	95.0	F	
Outlet Temperature			C			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	14.48	1098.4	14.9	1116.3	58.07	159.31	58.82	161.9
Compressor Discharge	69.84	2781.3	83.2	2823.4	157.72	403.4	181.8	409.5
Condenser Inlet	68.47		81.22		155.24		178.19	
Condenser Outlet	39.94	2699.5	39.98	2767.6	103.89	391.53	103.96	401.4
Expansion Device Inlet	39.12	2645.0	38.94	2747.6	102.42	383.63	102.10	398.5
Subcooling, at expan. device	4.48		5.33		8.07		9.60	
Evaporator Inlet	13.2		12.26		55.76		54.06	
Evaporator Outlet	12.51	1109.0	12.1	1121.1	54.52	160.85	53.88	162.6
Evaporator Superheat	1.75		1.71		3.15		3.08	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: B / POE oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	POE
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.47	kg	6.31	5.44	lb	0.86
Refrigerant Mass Flow Rate			3.88	2.71	kg/min	8.56	5.98	lb/min	0.70
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	26.67	26.67	C	80.0	80.0	F	
		wb	19.44	19.44	C	67.0	67.0	F	
	Outdoor	db	27.78	27.78	C	82.0	82.0	F	
		wb	15.06	15.28	C	59.1	59.5	F	
Total Capacity			11231	11662	W	38323	39792	Btu/hr	1.04
Sensible Capacity			8135	8285	W	27758	28269	Btu/hr	1.02
Total System Power Input			2583	2689	W	2583	2689	W	1.04
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			4.35	4.34	W/W	14.84	14.80	Btuh/W	1.00
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.109	0.99
Seasonal Energy Efficiency Ratio - SEER	14.01	13.98	1.00
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.3	31.1	m ^3/min	1105	1100	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	26.67	26.67	C	80.0	80.0	F	
Outlet Temperature	14.06	13.78	C	57.3	56.8	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	27.78	27.78	C	82.0	82.0	F	
Outlet Temperature			C			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	13.89	1078.4	14.67	1092.8	57.0	156.41	58.40	158.5
Compressor Discharge	59.55	2333.0	71.19	2363.0	139.19	338.37	160.15	342.72
Condenser Inlet	58.24		69.33		136.83		156.8	
Condenser Outlet	33.37	2237.3	33.17	2298.4	92.06	324.5	91.71	333.35
Expansion Device Inlet	33.17	2185.9	32.86	2279.2	91.71	317.04	91.14	330.57
Subcooling, at expan. device	2.59		3.75		4.67		6.75	
Evaporator Inlet	12.39		11.48		54.30		52.67	
Evaporator Outlet	12.33	1091.1	12.29	1099.0	54.19	158.25	54.13	159.4
Evaporator Superheat	2.13		2.54		3.83		4.57	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: 115 °F / POE oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	POE
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.47	kg	6.31	5.44	lb	0.86
Refrigerant Mass Flow Rate			3.62	2.61	kg/min	7.97	5.75	lb/min	0.72
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	28.89	28.89	C	84.0	84.0	F	
		wb	18.89	18.89	C	66.0	66.0	F	
	Outdoor	db	46.11	46.11	C	115.0	115.0	F	
		wb	25.67	25.61	C	78.2	78.1	F	
Total Capacity			8659	9734	W	29547	33215	Btu/hr	1.12
Sensible Capacity			8292	8882	W	28292	30310	Btu/hr	1.07
Total System Power Input			3894	4052	W	3894	4052	W	1.04
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			2.22	2.40	W/W	7.59	8.20	Btuh/W	1.08
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.109	0.99
Seasonal Energy Efficiency Ratio - SEER	14.01	13.98	1.00
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.28	31.43	m ^3/min	1104.5	1110	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	28.89	28.89	C	84.0	84.0	F	
Outlet Temperature	15.83	15.83	C	60.5	59.0	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	46.11	46.11	C	115.0	115.0	F	
Outlet Temperature			C			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	17.6	1119.0	18.22	1115.1	63.68	162.29	64.79	161.73
Compressor Discharge	93.37	3622.5	161.73	3724.6	200.06	525.4	231.98	540.21
Condenser Inlet	91.57		108.47		196.83		227.24	
Condenser Outlet	49.79	3566.0	49.98	3683.7	121.62	517.2	121.96	534.27
Expansion Device Inlet	47.94	3518.6	48.16	3663.3	118.29	510.33	118.69	531.32
Subcooling, at expan. device	8.08		8.62		14.55		15.52	
Evaporator Inlet	13.78		12.43		56.8		54.38	
Evaporator Outlet	14.15	1128.5	13.73	1122.8	57.47	163.68	56.71	162.85
Evaporator Superheat	2.81		3.25		5.06		5.85	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: A / prototype oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	Prototype oil
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.52	kg	6.31	5.56	lb	0.88
Refrigerant Mass Flow Rate			3.91	2.79	kg/min	8.63	6.14	lb/min	0.71
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	26.67	26.67	C	80	80	F	
		wb	19.44	19.44	C	67	67	F	
	Outdoor	db	35	35	C	95	95	F	
		wb	19.78	21.72	C	67.6	71.1	F	
Total Capacity			10543	11333	W	35973	38669	Btu/hr	1.07
Sensible Capacity			7856	8150	W	26805	27807	Btu/hr	1.04
Total System Power Input			2990	3113	W	2990	3113	W	1.04
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			3.53	3.64	W/W	12.03	12.42	Btuh/W	1.03
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.081	0.74
Seasonal Energy Efficiency Ratio - SEER	14.01	14.46	1.03
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.23	31.32	m ^3/min	1103	1106	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	26.67	26.67	C	80.0	80.0	F	
Outlet Temperature	14.44	14.06	C	58.0	57.3	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	35.0	35.0	C	95.0	95.0	F	
Outlet Temperature			C			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	14.48	1098.4	15.09	1108.7	58.07	159.31	59.16	160.81
Compressor Discharge	69.84	2781.3	83.52	2847.0	157.72	403.4	182.34	412.92
Condenser Inlet	68.47		80.66		155.24		177.19	
Condenser Outlet	39.94	2699.5	40.33	2788.6	103.89	391.53	104.59	404.45
Expansion Device Inlet	39.12	2645.0	39.52	2766.6	102.42	383.63	103.13	401.26
Subcooling, at expan. device	4.48		5.05		8.07		9.09	
Evaporator Inlet	13.2		12.05		55.76		53.69	
Evaporator Outlet	12.51	1109.0	11.94	1115.2	54.52	160.85	53.49	161.75
Evaporator Superheat	1.75		1.69		3.15		3.05	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: B / prototype oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	Prototype oil
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.52	kg	6.31	5.56	lb	0.88
Refrigerant Mass Flow Rate			3.88		kg/min	8.56	6.14	lb/min	0.72
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	26.67	26.67	C	80.0	80.0	F	
		wb	19.44	19.44	C	67.0	67.0	F	
	Outdoor	db	27.78	27.78	C	82.0	82.0	F	
		wb	15.06	14.72	C	59.1	58.5	F	
Total Capacity			11231	11906	W	38323	40623	Btu/hr	1.06
Sensible Capacity			8135	8395	W	27758	28644	Btu/hr	1.03
Total System Power Input			2583	2695	W	2583	2695	W	1.04
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			4.35	4.42	W/W	14.84	15.08	Btuh/W	1.02
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.081	0.74
Seasonal Energy Efficiency Ratio - SEER	14.01	14.46	1.03
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.3	31.4	m ^3/min	1105	1108	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	26.67	26.67	C	80.0	80.0	F	
Outlet Temperature	14.06	13.67	C	57.3	56.6	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	27.78	27.78	C	82.0	82.0	F	
Outlet Temperature			C			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	13.89	1078.4	14.27	1092	57.0	156.41	57.68	158.38
Compressor Discharge	59.55	2333.0	70.71	2378	139.19	338.37	159.28	344.9
Condenser Inlet	58.24		68.13		136.83		154.63	
Condenser Outlet	33.37	2237.3	34.12	2308.5	92.06	324.5	93.41	334.82
Expansion Device Inlet	33.17	2185.9	33.93	2286.9	91.71	317.04	93.07	331.69
Subcooling, at expan. device	2.59		2.81		4.67		5.05	
Evaporator Inlet	12.39		11.45		54.30		52.61	
Evaporator Outlet	12.33	1091.1	12.21	1099.4	54.19	158.25	53.98	159.45
Evaporator Superheat	2.13		2.45		3.83		4.41	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: 115 °F / prototype oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	Prototype oil
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.52	kg	6.31	5.56	lb	0.88
Refrigerant Mass Flow Rate			3.62	2.61	kg/min	7.97	5.76	lb/min	0.72
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	28.89	28.89	C	84.0	84.0	F	
		wb	18.89	18.89	C	66.0	66.0	F	
	Outdoor	db	46.11	46.17	C	115.0	115.1	F	
		wb	25.67	25	C	78.2	77.0	F	
Total Capacity			8659	9762	W	29547	33310	Btu/hr	1.13
Sensible Capacity			8292	8813	W	28292	30071	Btu/hr	1.06
Total System Power Input			3894	3993	W	3894	3993	W	1.03
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			2.22	2.44	W/W	7.59	8.34	Btuh/W	1.10
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.081	0.74
Seasonal Energy Efficiency Ratio - SEER	14.01	14.46	1.03
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.28	31.32	m ^3/min	1104.5	1106	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	28.89	28.89	C	84.0	84.0	F	
Outlet Temperature	15.83	15.06	C	60.5	59.1	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	46.11	46.17	C	115.0	115.1	F	
Outlet Temperature			C			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	17.6	1119.0	18.16	1110.3	63.68	162.29	64.69	161.04
Compressor Discharge	93.37	3622.5	111.16	3749.8	200.06	525.4	232.09	543.86
Condenser Inlet	91.57		107.54		196.83		225.58	
Condenser Outlet	49.79	3566.0	50.14	3708.8	121.62	517.2	122.26	537.91
Expansion Device Inlet	47.94	3518.6	48.52	3688.1	118.29	510.33	119.33	534.92
Subcooling, at expan. device	8.08		8.56		14.55		15.41	
Evaporator Inlet	13.78		12.27		56.8		54.09	
Evaporator Outlet	14.15	1128.5	12.94	1117.4	57.47	163.68	55.29	162.06
Evaporator Superheat	2.81		2.64		5.06		4.75	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Manufacturer: Goodman Manufacturing Manufacturer's Notation: 125 °F / prototype oil

Basic Information	
Alternative Refrigerant (Composition as Charged, % wt, if not proprietary)	R32
Alternative Lubricant Type and ISO Viscosity	Prototype oil
Refrigerant and Lubricant of Baseline System	R410A & POE
Make and Model of Baseline System	SSX140361BC / ARPT36D14AC
Nominal Capacity and Type of Baseline System	3T AC unit

Comparison Data			**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP UNits**	**Ratio**
Mode (Heating/Cooling)			Cooling						
Compressor Type			Scroll	Scroll					
Compressor Displacement			0.096	0.096	M^3/min	3.40	3.40	Ft ^3min	1.0
Nominal Motor Size					hp				
Motor Speed			3500	3500	rpm				1.0
Expansion Device Type			4T TXV	3T TXV					
Lubricant Charge			0.71	0.71	kg	1.56	1.56	lb	1.0
Refrigerant Charge			2.86	2.52	kg	6.31	5.56	lb	0.88
Refrigerant Mass Flow Rate			3.60	2.61	kg/min	7.94	5.75	lb/min	0.72
Composition, at compr. Inlet if applicable					% wt				
Evaporator Face Area			0.28	0.28	m ^ 2	3.05	3.05	ft ^2	1.0
Condenser Face Area			1.61	1.61	m ^2	17.33	17.33	ft ^2	1.0
Ambient Temps.	Indoor	db	28.89	28.89	C	84.0	84.0	F	
		wb	18.89	18.89	C	66.0	66.0	F	
	Outdoor	db	51.67	51.67	C	125.0	125.0	F	
		wb	27.7	28.3	C	81.85	82.9	F	
Total Capacity			8084.4	9251.5	W	27584	31566	Btu/hr	1.14
Sensible Capacity			8020.5	8547.5	W	27366	29164	Btu/hr	1.07
Total System Power Input			4434	4490	W	4434	4490	W	1.01
Compressor Power Input					W			W	
Energy Efficiency Ratio (EER)			1.82	2.06	W/W	6.22	7.03	Btuh/W	1.13
Coeff. Of Performance (COP)									

Other System Changes (eg: llsl-hx, flow control, hx fins and circuiting, vapor/liquid injection, etc.)

System Data	**Base.**	**Alt.**	**Ratio**
Degradation Coefficient – Cd	0.11	0.081	0.74
Seasonal Energy Efficiency Ratio - SEER	14.01	14.46	1.03
Heating Seasonal Performance Factor - HSPF			

Low-GWP AREP SOFT – OPTIMIZED SYSTEM TEST DATA FORM

Type of System: air-sourcing split AC (e.g., SSHP, window RAC, chiller, etc.)

Alternate Refrigerant: R32 (and composition as charged, % weight, if not proprietary)

Air/Water Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Evaporator							
Heat Exchange Fluid							
Flow Rate (gas)	31.23	31.35	m ^3/min	1103	1107	ft^3/min	1.00
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	28.89	28.89	C	84.0	84.0	F	
Outlet Temperature	16.24	15.56	C	61.24	60.0	F	
Condenser							
Heat Exchange Fluid							
Flow Rate (gas)			m ^3/min			ft^3/min	
Flow Rate (liquid)			L/min			gal/min	
Inlet Temperature	51.67	51.67	C	125.0	125.0	F	
Outlet Temperature			C			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	19.04	1147.3	17.89	1131.4	66.27	166.4	64.21	164.09
Compressor Discharge	104.05	4193.7	118.1	4193.7	219.29	593.19	244.58	608.24
Condenser Inlet	102.08		117.88		215.75		244.18	
Condenser Outlet	54.84	4151.5	55.15	4151.5	130.72	585.11	131.27	602.12
Expansion Device Inlet	52.6	4130.2	53.21	4130.2	126.68	577.92	127.78	599.03
Subcooling, at expan. device	9.07		9.01		16.32		16.22	
Evaporator Inlet	14.67		12.92		58.40		55.26	
Evaporator Outlet	15.41	1139.5	12.73	1139.5	59.74	167.65	54.91	165.27
Evaporator Superheat	3.25		1.76		5.85		3.17	

Data Source(s) for Refrigerant Properties
NIST REFPROP V9.1

Additional Notes

Submitted by: Hao Li