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

TEST REPORT #44

System Drop-in Tests of Refrigerant R-32 in Single Packaged Vertical Heat Pump (SPVH)

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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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Friedrich Test Report

1. Introduction:

This document reports performance testing conducted on a 1 Ton SPVH, Single Packaged Vertical Heat Pump, designed for operation with R410A, but tested with both R410A and R32 (difluoromethane). This testing occurred during July-August 2014 in the Friedrich Design and Development Center in San Antonio, TX.
The purpose for this work was to investigate the suitability of lower Global Warming Potential (GWP) refrigerants as candidate replacements for the HFC refrigerant: R410A.

These two refrigerants have GWP's (IPCC AR4, 100 year ITH) of:
R410A - 2088
R32 - 675

2. Details of Test Setup:

a. Description of System

This 1 Ton Single Packaged Vertical Heat Pump, SPVH, is designated as model VHA12R34RTM-A. This R410A heat pump uses a rotary compressor, a dual shaft PSC totally enclosed fan motor, an evaporator blower wheel, a 6 pedal condenser fan blade, one indoor and one outdoor copper tube/aluminum fin heat exchanger, one cooling and one heating capillary metering device, one cooling capillary tube check valve and one heating capillary tube check valve. This production model was built and charged with 37.0 oz. of R410A in January 2014.

The AHRI 390-03 Directory ratings for this SPVH system are:

AHRI # 6563866

Product: Single Package Vertical System - HP

Model Number: VHA12R****M

Cooling Capacity (BTU/HR): 12,000

EER Rating (BTU/watt) Cooling: 9.80

Heating Capacity (BTU/HR): 11,500

Coefficient of Performance (COP): 3.00

This system tested 103% of "A" cooling capacity and 101% of "A" cooling EER.

b. Description of Modifications to System

This baseline R410A refrigeration system had its production charge evacuated and recharged with nameplate charge of 37.0 oz. of R410A. Prior to R410A re-charging pressure gauges were added to the low side and high side process lines to measure suction and discharge line pressure readings for both the baseline and the "drop-in" testing performance. Thermocouples were added to the outside piping of the refrigeration system to measure the evaporator, condenser, suction and discharge line temperatures. Likewise, after the R410A tests the same SPVH was evacuated and charged with R32. Testing was performed in the same test room for both refrigerant charged series of tests.

c. Description of Tests Conducted

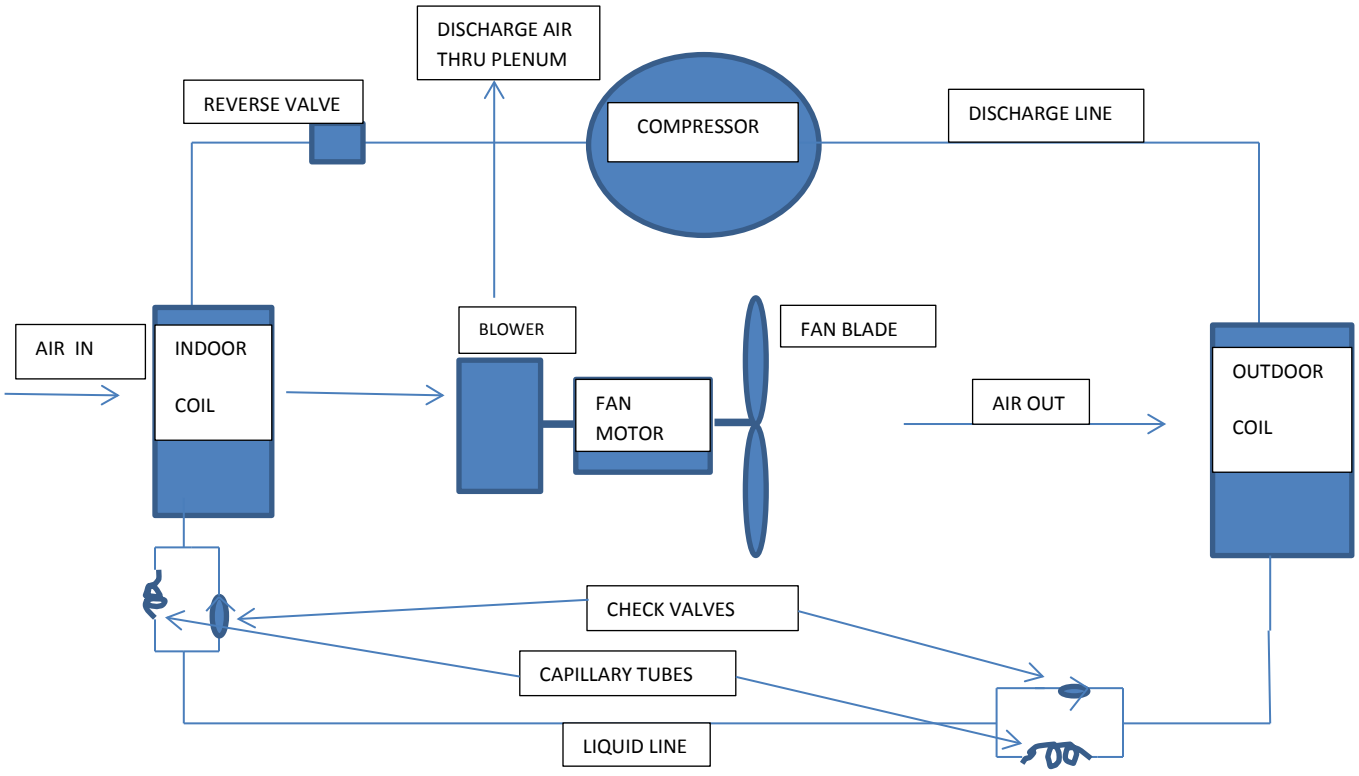
The heat pump was performance evaluated using a code tester positioned in the indoor conditioning space of a calorimeter room. For the cooling portion of the test the unit's discharge air plenum is attached to the code tester using an insulated duct. Using the tunnel indoor air-enthalpy method an insulated duct transfers the indoor air CFM through the code tester for measuring the cooling capacity as well as the air temperatures dry bulb and wet bulb entering the indoor conditioning space. A pressure equalizing device is positioned between the indoor and outdoor rooms to adjust to zero static pressure between the indoor and outdoor calorimeter room.

In a similar manner, for the heating capacity testing, the unit's reversing valve is energized to allow the indoor coil to become the heated side of the refrigeration system. For both the cooling and the heating capacity tests stabilization time of a minimum of 2-3 hours is required to maintain the steady state conditions of the unit under test as well as ensuring the test room, and annular spaces adjacent to the test room, are uniformly temperature stabilized. This calorimeter facility is then operated as a psychrometric room with measurement equipment calibrated annually to NIST standards (see calibration records on last page). For this refrigerant comparison I followed the DOE test procedure for SPVU's and SPVH's per AHRI Standard 390 and ANSI/ASHRAE Standard 58.

The testing performed used production components to first operate the test unit at 265v 60 Hz for the baseline "A" test using the R410A production charge quantity of 37.0 oz. at both cooling and heating room conditions. The compressor used was a production R410A rotary compressor with POE oil charged from the supplier. In addition to the compressor the unit under test utilized a 4 row-5/16" OD copper tube-aluminum fin indoor coil and a 4 row- ¼"OD copper tube-aluminum fin outdoor coil and a dual shaft, ¼ HP, 6 pole, permanent split capacitor fan motor.

Following the baseline "A" testing this same 1 ton SPVH was evacuated on a vacuum pump and recharged with a lighter charge of R32, recognizing R410A consists of 50% R32. This approach was used realizing using a light charge to balance the system is more accurate than over-charging and weighing refrigerant charge removed. For the "B" drop-in testing the R32 charge amount was set for the cooling capacity test at 28.6 oz. The goal was to set the charge to obtain as close to a 5-10 degree superheat found in the baseline test. The final heating capacity testing for the "B" R32 test was held at the 28.6 oz. charge amount.

Figure 1. Diagram of SPVH Heat Pump



3. Results

Test Data Form for Test: "A" and "B" Cooling Test

Type of System: SPVH **Alternate Refrigerant: R32**

Air Side Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
INDOOR COIL							
Heat Exchange Fluid	R410A	R32 *					
Flow Rate (air side)	10.96	10.90	m^3/min	387	385	CFM	1.00
Inlet Temperature	26.67/19.44	26.67/19.44	C	80.0/67.0	80.0/67.0	F	
Outlet Temperature	15.39/14.11	15.00/13.94	C	59.7/57.4	59.0/57.1	F	
OUTDOOR COIL							
Heat Exchange Fluid	R410A	R32					
Flow Rate (air side) †	Not measured						
Inlet Temperature	35.05/24.31	35.00/23.01	C	95.09/75.77	95.01/73.41	F	
Outlet Temperature	Not measured	Not measured	C	Not measured	Not measured	F	
Net Air Side Cooling Capacity	3631	3745	W	12,390	12,780	BTU/HR	

*3kg cylinder from Daikin Chemicals † outdoor equilibrium maintained between baseline and alternate for slinger ring steady state operation

Refrigerant Side Data Temperature and Pressures	Baseline		Alternate	SI Units	Baseline		Alternate	IP Units
	T (C)	P [kPa]	T (C)	P [kPa]	T (F)	P [psia]	T (F)	P [psia]
Compressor Suction	21.6	1087.3	15.0	1149.3	71	157.7	59	166.7
Compressor Discharge	78.3	2990.2	80.5	3024.7	173	433.7	177	438.7
Outdoor Coil Midpoint	48.3		47.7		119		118	
Outdoor Coil Liquid Line	35.5		42.7		96		109	
Subcooling	12.8		5		23		9	
Indoor Coil Inlet	18.3		11.7		65		53	
Indoor Coil Outlet	18.9		12.2		66		54	
Indoor Coil Superheat	3.3		3.3		6		6	
Net Refrigerant Side Cooling Capacity					12,390	12,780	BTU/HR	

Test Data Form for Test: "A" and "B" Cooling Test

Type of System: SPVH **Alternate Refrigerant: R32**

Comparison Data	**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP Units**	**Ratio**
Mode (Heating/Cooling)	**Cooling**						
Compressor Type	rotary	rotary					
Compressor Displacement	11.4	11.4	CC/REV	0.69	0.69	CI/REV	1.00
Nominal Fan Motor Size	1/4	1/4	hp				
Compr. Motor Speed	3500	3500	rpm				1.00
Expansion Device Type	Capillary	Capillary					
Lubricant Charge	0.414	0.414	liters	14	14	fl. oz.	1.00
Lubricant Type	POE RB68EP	POE RB68EP		POE RB68EP	POE RB68EP		
Refrigerant Charge	1.048	0.807	kg	2.31	1.78	lb.	0.77
Refrigerant Mass Flow Rate							
Composition, at compr. inlet if applicable		n/a	n/a				
Indoor Dry Bulb/Wet Bulb	26.67	26.67	C	80.0	80.0	F	
	19.44	19.44	C	67.0	67.0	F	
Outdoor Dry Bulb/Wet Bulb	35.00	34.94	C	95.0	94.9	F	
	24.27	23.88	C	75.7	75.0	F	
Total Capacity	3631	3746	W	12390	12780	Btu/hr.	1.03
Sensible Capacity	2561	2794	W	8738.59	9532.35	Btu/hr.	1.09
Total System Power Input *	1254	1290	W	1254	1290	W	1.03
Compressor Power Input			W			W	
Energy Efficiency Ratio	9.88	9.9	W/W	9.88	9.9	Btu/Wh	1.002
Coeff. Of Performance (COP)	2.89	2.90					1.002

*includes compressor and fan motor

Test Data Form for Test: "A" and "B" Heating Test

Type of System: SPVH **Alternate Refrigerant: R32**

Air Side Data	**Base.**	**Alt.**	**SI Units**	**Base.**	**Alt.**	**IP Units**	**Ratio**
INDOOR COIL							
Heat Exchange Fluid	R410A	R32					
Flow Rate (air side)	11.49	11.41	m^3/min	406	403	CFM	1.00
Inlet Temperature	21.11/12.16	21.11/11.23	C	70.0/53.89	70.0/52.21	F	
Outlet Temperature	36.83	34.8	C	98.3	94.6	F	
OUTDOOR COIL							
Heat Exchange Fluid	R410A	R32					
Flow Rate (air side) †	Not measured						
Inlet Temperature	8.34/6.1	8.34/6.12	C	47.01/42.98	47.01/43.01	F	
Outlet Temperature	Not measured	Not measured	C	Not measured	Not measured	F	
Net Air Side Heating Capacity	3195	3196	W	10,900	10,910	BTU/HR	

† outdoor equilibrium maintained between baseline and alternate for slinger ring steady state operation

Refrigerant Side Data Temperature and Pressures - Heating	**Baseline**		**Alternate**	**SI Units**	**Baseline**		**Alternate**	**IP Units**
	T (C)	**P [kPa]**	**T (C)**	**P [kPa]**	**T (F)**	**P [psia]**	**T (F)**	**P [psia]**
Compressor Suction	2.77	797.7	3.55	830.1	37	115.7	38.4	120.4
Compressor Discharge	78.3	2480.0	80.5	2415.9	142	359.7	158	350.4

Test Data Form for Test: "A" and "B" Heating Test (continued)

Type of System: SPVH **Alternate Refrigerant: R32**

Refrigerant Side Data Temperature and Pressures - Heating	**Baseline**		**Alternate**	**SI Units**	**Baseline**		**Alternate**	**IP Units**
	T (C)	**P [kPa]**	**T (C)**	**P [kPa]**	**T (F)**	**P [psia]**	**T (F)**	**P [psia]**
Outdoor Coil Midpoint	0.0		0.55		32		33	
Outdoor Coil Liquid Line	28.3		35		83		95	
Expansion Device Inlet	Not measured							
Subcooling								
Indoor Coil Inlet	57.2		63.8		135		147	
Indoor Coil Outlet	27.7		33.7		81.9		92.7	
Indoor Coil Superheat								
Net Refrigerant Side Heating Capacity					10,900	10,910	BTU/HR	

Test Data Form for Test: "A" and "B" Heating Test

Type of System: SPVH **Alternate Refrigerant: R32**

Comparison Data	Base.	Alt.	SI Units	Base.	Alt.	IP Units	Ratio
Mode (Heating/Cooling)	**Heating**						
Compressor Type	rotary	rotary					
Compressor Displacement	11.4	11.4	CC/REV	0.69	0.69	CI/REV	1.00
Nominal Fan Motor Size	1/4	1/4	hp				
Compressor Motor Speed	3500	3500	rpm				1.00
Expansion Device Type	Capillary	Capillary					
Lubricant Charge	0.414	0.414	liters	14	14	fl. oz.	1.00
Lubricant Type	POE RB68EP	POE RB68EP		POE RB68EP	POE RB68EP		
Refrigerant Charge	1.048	0.807	kg	2.31	1.78	Lb.	0.77
Refrigerant Mass Flow Rate							
Composition, at compr. inlet if applicable		n/a	n/a				
Indoor Dry Bulb	21.1	21.1	C	70.0	70.0	F	
Wet Bulb	12.11	11.23	C	53.8	52.21	F	
Outdoor Dry Bulb	8.33	8.41	C	47.01	47.15	F	
Wet Bulb	6.1	6.18	C	42.98	43.14	F	
Total Capacity	3195	3196	W	10,900	10,910	Btu/hr	1.00
Sensible Capacity							
Total System Power Input *	1122	1124	W	1122	1124	W	1.00
Coeff. Of Performance (COP)	2.85	2.84					1.002

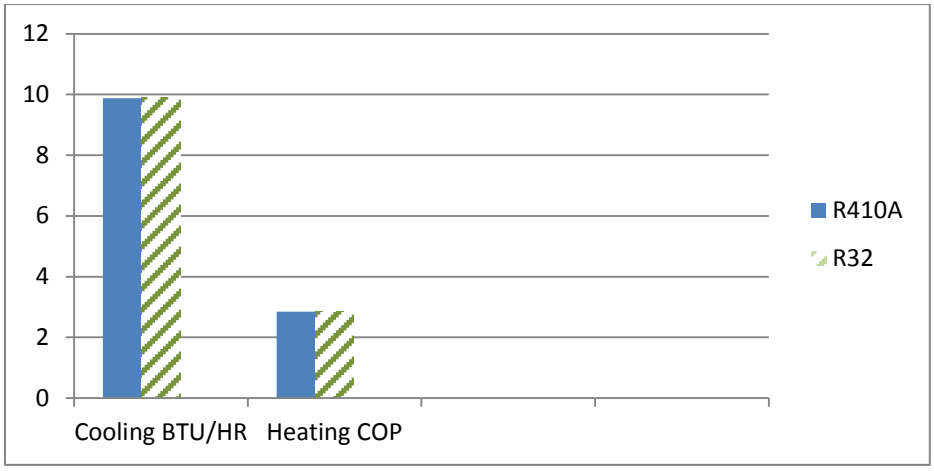
***** Includes compressor and fan motor

4. Conclusions

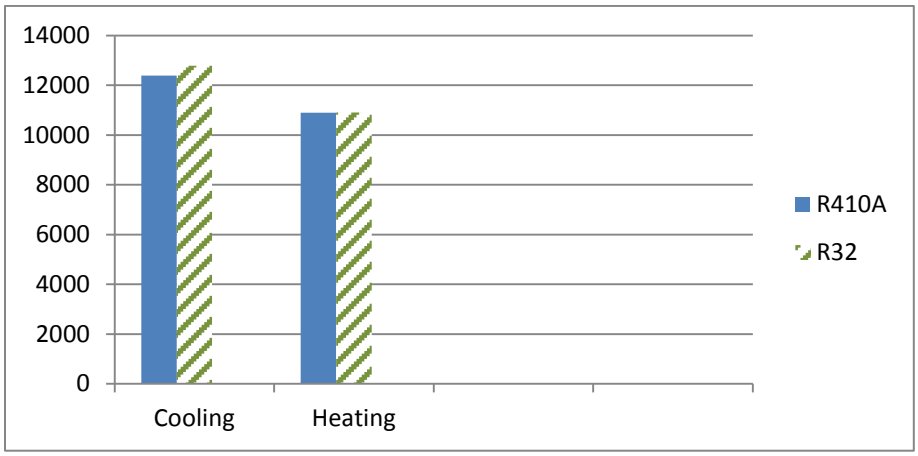
The alternate refrigerant was comparable to the R410A system without significant equipment modifications. The R32 capacity and efficiency would improve with further subcooling of the outdoor coil circuit through adjusting the metering device and optimizing the refrigerant charge.

The "drop-in" R32 charge amount was reduced by 22.7% compared to the baseline R410A production system.

EER COP Efficiency



BTU/HR Capacity



CALIBRATIONS, TEST INSTRUMENTS USED:

Test Inst ID	Make/Model/Serial Number/Asset No.
PE-160	PE-160, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 0204ACB93BC, Test Station- ID Power Meter- Blower (WT1) Cal1
PE-161	PE-161, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACBA116, Test Station- ID Power Meter- Air Heat (WT2)) Cal1
PE-162	PE-162, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB9A6A, Test Station- ID Power Meter- Devices (WT3)) Cal1
PE-163	PE-163, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB97F6, Test Station- ID Power Meter- Humidifier (WT4)) Cal1
PE-164	PE-164, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 2543901, Test Station- OD Power Meter- Blower (WT5) Cal1
PE-165	PE-165, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N T1N911587, Test Station- OD Power Meter- Air Heat (WT6) Cal1
PE-166	PE-166, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204AEAAC8F, Test Station- OD Power Meter- OD Devices (WT7) Cal1
PE-167	PE-167, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB97F8, Test Station- OD Power Meter- Humidifier (WT8) Cal1
PE-168	PE-168, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB9C23, Test Station- ID Power Meter- Crossover Blower (WT9)Cal1
PE-169	PE-169, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204AEA7A2D, Test Station- ID Power Meter- Variac 1 (WT10) Cal1
PE-170	PE-170, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB9C30, Test Station- ID Power Meter- Variac 2 (WT11) Cal1
PE-171	PE-171, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204ACB93B2, Test Station- ID Power Meter- Variac 3 (WT12) Cal1
PE-172	PE-172, USE-Power Meter, MANF-Yokogawa, MOD- PR-300, S/N 00204AEAADC9, Test Station- ID Power Meter- AFM Blower (WT13) Cal1
PE-130	PE-130, USE-Isom Cal 1 TCs, MANF-Q-Corp, MOD- Isom Cal 1 TCs, S/N na, Test Station- Cal1 Thermocouples
PE-131	PE-131, USE-Isom Cal 1 RTDs, MANF-Q-Corp, MOD- Isom Cal 1 RTDs, S/N na, Test Station- Cal1 RTDs
PE-132	PE-132, USE-Isom Cal 1 Press Transducers- Suc, Liq, Dischrg, MANF-Q-Corp, MOD- Isom Cal 1 Press Transducers- Suc, Liq, Dischrg, S/N na, Test Station- Cal1 Pressure
PE-104	PE-104, USE-Power Analyzer, MANF-Voltech, MOD- PM1000, S/N 100008201616, Test Station- Standby Power