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Project No. G100032212 March 31, 2010

REPORT NO. 100032212COL-001

PERFORMANCE TESTING OF HCR-188C REFRIGERANT VERSUS R-134a REFRIGERANT TO APPLICABLE PORTIONS OF ARI 540 AND CUSTOM TEST PROTOCOL

RENDERED TO

A. S. TRUST & HOLDINGS INC.
KANEOHE, HI

GENERAL: This Report gives the results of the tests and evaluation of HCR-188C, a hydrocarbon refrigerant blend, designed for replacing R-134a in refrigeration and air-conditioning systems. The HCR-188C refrigerant was tested through side-by-side comparison with R-134a in identical refrigeration systems and by applicable requirements of the *Standard for Positive Displacement Refrigerant Compressors and Compressor Units, ARI 540, dated 01/01/1999.* This investigation was authorized by signed quotation number 500207680, dated February 2, 2010. The investigation was started on February 18, 2010 and completed on March 31, 2010. The applicant provided the sample HCR-188C for testing. Joe Sexton of Haier provided identical refrigeration compressors for testing. Testing was conducted at the Columbus, OH Intertek facility.

Positive Displacement Refrigerant Compressors and Compressor Units, ARI 540, dated 01/01/1999

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PRODUCT DESCRIPTION

PRODUCT

The product is a proprietary hydrocarbon refrigerant blend, designated HCR-188C, designed to be suitable as a replacement for R-134a in refrigeration and air-conditioning systems.

PRODUCT DESCRIPTION

The product is flammable. The product is not an ozone depleting substance. The product has low GWP (Global Warming Potential). The product operates at approximately one quarter of the charge amount as compared to R-134a.

ELECTRICAL RATINGS

None

OTHER RATINGS

Saturation pressure approximately 110 psig at 75℉

TEST PROCEDURE

Two identical refrigeration systems were constructed and one was charged with 372.5 grams of R-134a and the other was charged with 131.0 grams of HCR-188C. The systems were operated simultaneously from the same power supply from February 18, 2010 thru March 31, 2010. Flow measurements of each system's capillary tube were recorded at the beginning and end of the test. Daily measurements of the operating pressures, temperatures and power consumption were recorded. Oil samples from each compressor were analyzed at the conclusion of the test for moisture, acid, viscosity and wear metals.

RESULTS #1

Capillary Tube Clogging Characteristics			
	Flow Reading (lpm at 10" Hg positive pressure)		
	February 12, 2010	March 31, 2010	
	@ 0 Hours	@ 1000 Hours	Flow Loss Percent
R-134a Cap Tube	4.65	4.58	0.015%
HCR-188C Cap Tube	4.68	4.65	0.006%

Both capillary tubes exhibited minimal flow loss. Neither loss translated into any detrimental effect on the performance of the respective system compressor.

RESULTS #2

Project # G100032212 Client A.S. TRUST Refrigerant R-134a

Compressor EMBRACO EGX70HLC Duration 1000 HOURS (42 DAYS) Lubricant ESTER / ISO 7

Date	Time	Suction Pressure (psig)	Discharge Pressure (psig)	Ambient Temp (°F)	Comp. Discharge Temp (°F)	To Cap Tube Temp (°F)	From Cap Tube Temp (°F)	Comp. Suction Temp (°F)	Voltage	Amps
2·18·10	1200	STARTED SYSTEM - ADJUSTING CHARGE								
"	1530	29	141	74	101	106	41	38	118.5	1.5
2·19·10	0810	27	133	72	99	104	39	35	118.8	1.4
"	1810	28	139	74	101	105	40	37	119.8	1.4
2·20·10	1245	28	140	74	101	106	40	36	119.7	1.4
2·22·10	0810	28	140	74	101	106	40	36	118.9	1.4
2·23·10	0810	27	139	74	100	105	39	36	119.1	1.4
2·24·10	0810	27	136	73	99	104	38	35	119.3	1.4
2·25·10	0820	26	133	72	99	103	38	34	119.1	1.4
2·26·10	0810	26	133	73	100	104	38	35	119.1	1.4
2·27·10	1630	26	138	73	100	105	38	35	119.6	1.4
3·1·10	0800	28	145	75	103	108	39	36	119.7	1.4
3·2·10	0805	26	139	74	100	105	38	35	119.5	1.4
3·3·10	0800	26	139	73	101	105	38	35	119.7	1.4
3·4·10	0805	26	139	74	101	105	38	34	119.8	1.4
3·5·10	0940	26	140	74	101	106	38	35	118.7	1.4
3·6·10	1715	27	143	75	103	108	38	36	120.4	1.4
3·8·10	0815	26	139	73	100	105	37	34	118.8	1.4
3·9·10	0820	26	139	73	100	105	37	34	118.7	1.4
3·10·10	0815	27	146	74	102	108	38	35	119.0	1.4
3·11·10	0815	27	148	75	103	108	39	36	119.6	1.4
3·12·10	0815	27	146	75	103	108	38	35	120.5	1.5
3·13·10	2245	27	142	73	101	107	37	34	121.2	1.4
3·15·10	0815	25	139	71	100	104	35	32	119.8	1.4
3·16·10	0815	27	143	73	102	107	37	33	119.6	1.4
3·17·10	0820	26	141	73	101	106	37	33	120.0	1.4
3·18·10	0840	26	142	73	101	106	37	33	120.6	1.4
3·19·10	0840	25	138	72	99	104	35	32	120.1	1.4
3·21·10	1900	32	168	79	110	116	43	40	121.5	1.6
3·22·10	0840	27	146	74	102	108	38	34	120.2	1.4
3·23·10	0840	25	138	72	99	105	35	32	119.9	1.4
3·24·10	0845	26	140	73	101	106	37	32	119.9	1.4
3·25·10	0845	26	140	73	101	106	36	32	120.1	1.4
3·26·10	0900	27	147	74	103	108	38	33	119.1	1.4
3·28·10	1825	27	144	74	102	107	37	32	121.0	1.4
3·29·10	0845	27	142	74	101	107	36	32	120.2	1.4
3·30·10	0845	26	140	73	100	105	35	31	120.1	1.4
3·31·10	0845	26	139	73	100	105	36	32	120.7	1.4

RESULTS #2 Continued

Project # G100032212 Client A.S. TRUST Refrigerant HCR-188C

Compressor EMBRACO EGX70HLC Duration 1000 HOURS (42 DAYS) Lubricant ESTER / ISO 7

Date	Time	Suction Pressure (psig)	Discharge Pressure (psig)	Ambient Temp (°F)	Comp. Discharge Temp (°F)	To Cap Tube Temp (°F)	From Cap Tube Temp (°F)	Comp. Suction Temp (°F)	Voltage	Amps
2·18·10	1415	STARTED SYSTEM - ADJUSTING CHARGE								
"	1530	42	187	74	110	108	41	38	118.5	1.6
2·19·10	0810	39	180	72	107	106	39	36	118.8	1.5
"	1810	40	182	74	108	107	41	37	119.8	1.6
2·20·10	1245	42	188	74	111	111	43	41	119.7	1.6
2·22·10	0810	42	189	74	112	113	44	42	118.9	1.6
2·23·10	0810	41	183	74	110	110	42	40	119.1	1.6
2·24·10	0810	40	180	73	109	109	41	39	119.3	1.5
2·25·10	0820	39	179	72	109	109	41	39	119.1	1.5
2·26·10	0810	39	178	73	109	108	41	39	119.1	1.5
2·27·10	1630	39	178	73	109	108	41	39	119.6	1.5
3·1·10	0800	38	173	75	109	108	40	38	119.7	1.5
3·2·10	0805	37	170	74	108	107	40	37	119.5	1.5
3.3·10	0800	35	168	73	106	105	39	35	119.7	1.4
3·4·10	0805	37	170	74	108	107	40	37	119.8	1.5
3·5·10	0940	36	170	74	108	107	40	37	118.7	1.5
3·6·10	1715	37	170	75	109	109	41	38	120.4	1.4
3·8·10	0815	35	166	73	106	105	38	36	118.8	1.4
3·9·10	0820	35	166	73	106	105	39	36	118.7	1.4
3·10·10	0815	35	168	74	108	107	39	37	119.0	1.5
3·11·10	0815	36	169	75	109	107	40	37	119.6	1.4
3·12·10	0815	35	167	75	108	107	39	37	120.5	1.5
3·13·10	2245	34	162	73	107	106	39	36	121.2	1.4
3·15·10	0815	33	158	71	104	103	36	33	119.8	1.4
3·16·10	0815	34	161	73	106	105	37	35	119.6	1.4
3·17·10	0820	34	160	73	106	104	37	35	120.0	1.4
3·18·10	0840	34	161	73	106	104	37	35	120.6	1.4
3·19·10	0840	33	159	72	105	103	36	34	120.1	1.4
3·21·10	1900	39	177	79	115	113	44	42	121.5	1.5
3·22·10	0840	34	162	74	107	106	37	36	120.2	1.4
3·23·10	0840	32	157	72	104	102	35	33	119.9	1.4
3·24·10	0845	33	160	73	106	104	37	35	119.9	1.4
3·25·10	0845	33	159	73	106	104	37	35	120.1	1.4
3·26·10	0900	34	163	74	108	106	39	36	119.1	1.4
3·28·10	1825	34	162	74	107	106	38	36	121.0	1.4
3·29·10	0845	34	160	74	106	105	38	36	120.2	1.4
3·30·10	0845	33	159	73	105	104	36	35	120.1	1.4
3·31·10	0845	33	158	73	105	104	37	35	120.7	1.3

RESULTS #2 Continued

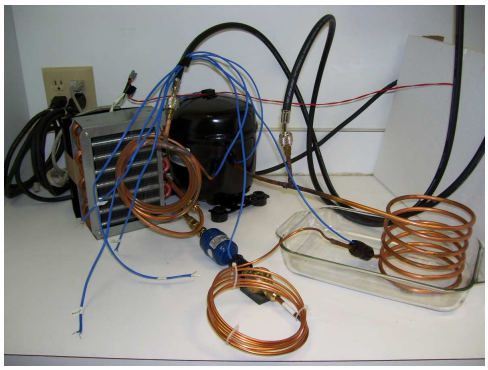
Initially, both systems were adjusted to achieve the same amount of cooling as measured at the compressor suction port. This was accomplished by a combination of the percent blockage across each system's condensing fan and also by varying the charge amount in each system, ultimately adding a HCR-188C charge that was approximately 35% of the R-134a charge. At this condition, the HCR-188C system operated at approximately 46 psig higher discharge pressure than the R-134a system and consumed approximately 0.15 Amps more power. Operating conditions were then maintained with no outside adjustments or changes. As both compressors broke in over the course of the test, they both exhibited increased cooling capacity and efficiency. At the end of the test, conditions had shifted such that the HCR-188C system operated at only 19 psig higher discharge pressure than the R-134a system and consumed approximately equal power, but the amount of cooling measured at the compressor suction port was warmer by approximately 3.75℉.

RESULTS #3

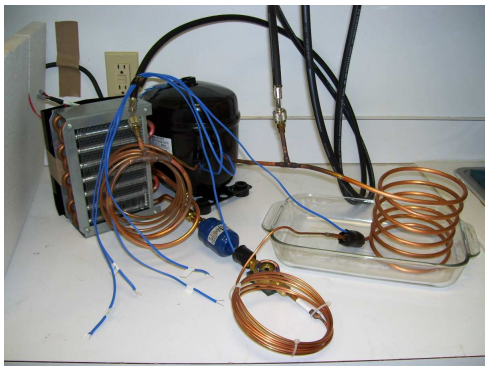
At the conclusion of the test, oil samples from each compressor were analyzed for moisture, acid, viscosity and wear metals. The lab reports for those analyses are included as an attachment to this report.

PHOTOS

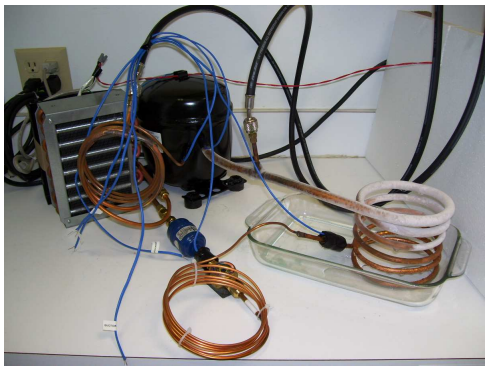
Test Start



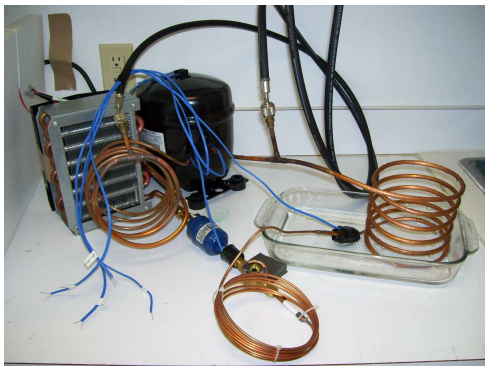
R-134a System Start



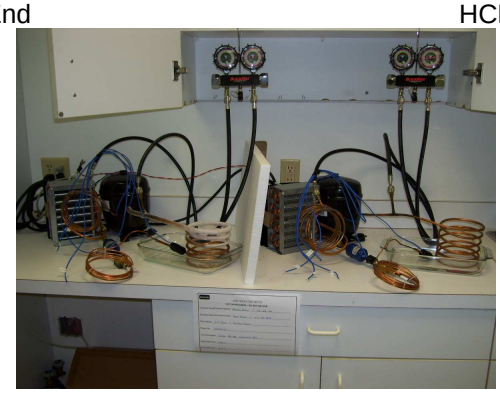
HCR-188C System Start



R-134a System End



HCR-188C System End



Test End

TEST EQUIPMENT

Climate Controlled Lab
2 Identical Complete Refrigeration System Test Fixtures Comprised Sequentially Of:

- Embraco Compressor, model EGX70HLC pre-charged with 280ml ESTER / ISO7 oil
- 3/16" OD Copper Tube, 70" long, coiled
- ¼" OD Copper Tube, 13" long, coiled
- ¼" Copper Tee, with access port to high side of manifold gauge
- ¼" OD Copper Tube, 13" long, coiled
- Finned Copper Tube Condenser Coil, ⅜" OD tubes, 3 rows, 4-½"W x 8"H x 2-½"D
  - Cooled by Ball 5-½" Ducted Fan, model XF1551ABHL, 0.32A, inlet grill 58% blocked
- ¼" Brass Swivel Union
- Emerson EK-032 Filter Drier
- ¼" Brass Swivel Union
- Parker Moisture Indicating Sight Glass
- 0.064" ID Capillary Tube, 96" long, coiled, with 2-½" long ¼" OD copper tube flared connections
- ¼" Brass Male Flare Coupler
- ¼" OD Copper Tube (Evaporator), 96" long, coiled
- ¼" Copper Tee, with access port to low side of manifold gauge
- ¼" OD Copper Tube, 7" long
- Compressor

Identical Brand New CPS Products Reference Only Manifold Set Pressure Gauges
Thermocouples Placed At:

- Room Ambient
- Compressor Discharge Port
- ¼" Brass Swivel Union Between Filter Drier and Sight Glass
- Outlet of 0.064" ID Capillary Tube
- Compressor Suction Port

Vacuum Pump
Virgin R-134a and Virgin HCR-188C

CALIBRATED EQUIPMENT

Item	Equipment Type	Equipment #	Cal. Due Date
1	Fluke 335 Volt/Amp Meter	E206	June 11, 2010
2	Omega Digital Thermometer	E132	Mar. 16, 2010
3	Omega Digital Thermometer	E237	Mar. 22, 2011
4	Top Loading Balance	CE1031	May 12, 2010
5	CECOMP 0 – 500 psi Digital Pressure Gauge	E184	June 9, 2010
6	Meriam 40" Mercury Manometer	CE1118	For Reference Only
7	Cole Parmer 0.5 – 5.0 lpm Acrylic Flow Meter	CE1121	For Reference Only
8	Reference Standard Cap Tube	LL1	For Reference Only

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