DATE: August 2009
REFERENCE DOCUMENT NO. RD-0005-E

GUIDELINES FOR UTILIZATION OF

R407C

DATE: August 2009

REFERENCE DOCUMENT NO. RD-0005-E

GUIDELINES FOR UTILIZATION OF R407C

After many years of testing and investigation, R407C is recognized as a suitable alternative refrigerant for R22 in medium and high temperature applications such as residential and light commercial air conditioning.

R407C is a ternary blend of hydro fluorocarbon or HFC compounds, comprising 23% of R32, 25% of R125 and 52% of R134a. It has no chlorine content, no ozone depletion potential, and only a modest direct global warming potential. ODP = 0, GWP = 1610.

R407C is NOT a "drop-in" replacement for R22. In addition to slight capacity losses, there are differences between R407C and R22 that must be considered when handling, processing, applying or retrofitting refrigerants. These guidelines are offered to assist in understanding the differences.

Any Tecumseh compressor with the letter "C" in the Model Number (Example: AWG5528**C**XD) is approved for use with R407C.

REFRIGERANT PROPERTIES

A) Pressure/temperature table of R407C vs. R22 is shown in Figure 1.

B) Figure 2 (page 2) shows the comparison of some properties of R407C and R22.

The data is taken at the standard refrigerant conditions of 5°F (-15°C) evaporating or 86°F (+30°C) condensing.

Figure 1

Temperature		Pressure			
		PSIG		kPa	
°F	°C	R22	R407C	R22	R407C
-40	-40.0	0.6	4.6	4.1	31.7
-30	-34.0	4.9	1.6	33.8	11.0
-20	-28.0	10.2	6.5	70.3	44.8
-10	-23.0	16.5	12.3	113.6	84.8
0	-18.0	24.0	19.4	165.5	133.8
10	-12.2	32.8	27.8	226.2	191.7
20	-9.0	43.1	37.8	297.2	260.6
30	-1.0	55.0	49.4	379.2	340.6
40	4.4	68.6	63.0	473.0	434.4
50	10.0	84.1	78.7	579.9	542.6
60	15.6	101.6	96.7	700.5	666.7
70	21.1	121.4	117.1	837.1	807.4
80	26.7	143.6	140.4	990.1	968.1
90	32.2	168.4	166.5	1,161.1	1,148.0
100	37.8	195.9	195.9	1,350.7	1,350.7
110	43.3	226.4	228.7	1,561.0	1,576.9
120	48.9	260.0	265.3	1,792.7	1,829.2
130	54.4	296.9	305.8	2,047.1	2,108.5
140	60.0	337.4	350.5	2,326.4	2,416.7
150	65.6	381.7	399.8	2,631.8	2,756.6

REFRIGERANT PROPERTIES (Cont'd)

Figure 2

Performance of R407C vs R22

Temperature				R407C Capacity (Btuh)	R22 Capacity (Btuh)	Capacity Ratio	Percent Change	R407C EER Btu/W-hr	R22 EER Btu/W-hr	EER Ratio	Percent Change
Evaporator		Condensor									
°F	°C	°F	°C								
5	-15.0	90	32.2	13,282	12,594	1.055	5.46%	8.62	8.34	1.034	3.36%
30	-1.1	90	32.2	29,580	28,182	1.050	4.96%	14.90	14.53	1.025	2.55%
5	-15.0	95	35.0	12,936	11,666	1.109	10.89%	8.71	7.45	1.169	16.91%
15	-9.4	100	37.8	16,455	16,130	1.020	2.01%	9.46	9.01	1.050	4.99%
30	-1.1	100	37.8	26,745	25,668	1.042	4.20%	12.96	12.40	1.045	4.52%
45	7.2	100	37.8	39,515	37,138	1.064	6.40%	17.15	16.79	1.021	2.14%
55	12.8	100	37.8	49,669	45,981	1.080	8.02%	20.81	20.24	1.028	2.82%
5	-15.0	110	43.3	10,670	10,678	0.999	-0.07%	6.56	6.44	1.019	1.86%
30	-1.1	110	43.3	23,282	23,291	1.000	-0.04%	11.00	10.90	1.009	0.92%
55	12.8	110	43.3	45,630	42,928	1.063	6.29%	17.69	17.37	1.018	1.84%
5	-15.0	130	54.4	7,701	8,287	0.929	-7.07%	4.89	4.85	1.008	0.82%
30	-1.1	130	54.4	18,543	18,565	0.999	-0.12%	8.14	8.14	1.000	0.00%
45	7.2	130	54.4	28,091	28,136	0.998	-0.16%	10.64	10.55	1.009	0.85%
55	12.8	130	54.4	36,945	36,018	1.026	2.57%	12.66	12.53	1.010	1.04%
55	12.8	140	60.0	32,740	32,669	1.002	0.22%	10.78	10.74	1.004	0.37%

C) The solubility of water in R407C is comparable to that of water in R22. It is necessary to keep the system dry. See Section II, B.

D) Extensive investigation and testing has been conducted to determine that R407C is compatible with all materials used in Tecumseh Products' compressors and condensing units.

SYNTHETIC LUBRICANTS: POLYOL ESTERS (POEs) and POLYVINYL ETHERS (PVEs)

A) Miscibility

1. Miscibility is the ability of the lubricant and the refrigerant to mix. This miscibility is a very important factor in providing proper heat transfer and in returning lubricant to the compressor in a refrigeration system over its range of operating temperatures.
2. R407C and Mineral oils (MO) are <u>not miscible</u>
3. Polyol Ester (POE) as well as Polyvinyl Ether (PVE) oils and R407C <u>are miscible</u>.
4. R407C and Synthetic Alkylate (SA) oils are partially miscible.

B) Moisture

1. Polyol ester and polyvinyl ether oils are **<u>100 times</u>** more hygroscopic (ability to absorb moisture) than MO or SA oils. This moisture is difficult to remove even with heat and vacuum.
2. **Utmost care must be taken to prevent moisture from getting into the refrigeration system**. Do not leave the compressor or system open to the atmosphere for longer than 10 minutes maximum. The preferred method of assembly would be to remove system component plugs and caps just prior to brazing. The maximum system moisture content after completing system processing should be 80 PPM. After running the system with the appropriate drier installed, the system moisture level should be 10 PPM or less. These levels are based on measuring moisture in liquid refrigerant samples taken from the system.
3. **<u>Always</u>** use an appropriate drier in the system when using R407C. (See section on DRIERS.)

C) Compatibility

1. Extensive investigation and testing have been conducted by Tecumseh Products Company to determine that the polyol ester and polyvinyl ether lubricants **approved by Tecumseh** are compatible with all materials used in Tecumseh hermetic compressors. Contact your Tecumseh sales representative for the latest list of approved oils. (Policy Bulletin No. 105)
2. While polyol ester and polyvinyl ether oils are compatible with mineral oils, they should not be indiscriminately mixed with mineral oils in R407C refrigerant systems. This practice could result in the inability of the oil to return to the compressor and/or reduce heat transfer performance in the evaporator. However, small amounts up to 5% of mineral oil are acceptable in field retrofit situations (1% or less is preferred).

SYSTEM DESIGN

A) Compressor Selection

Tecumseh is continuing to test and approve R407C compressors with the compatibility of oil, refrigerant, and materials in mind. These compressors will have the letter "C" as the refrigerant designator, e.g. RGA5512CXA. These compressors are designed to closely match the capacity of their corresponding R22 compressors at their individual rating point. In many cases, the same displacement is used. It will be necessary to test each compressor selection in the applications to determine its suitability, since system operating conditions vary greatly from one application to another.

B) Capillary Tube Selection

In general, the refrigerating effect of R407C is less than that of R22, thus increasing the required mass flow for a given capacity. However, capillary tubes selected for R22 applications should be adequate for a preliminary selection. As with any capillary tube selection, system testing is necessary to determine the proper final selection.

C) Expansion Valve Selection

Expansion valve manufacturers have designed product specifically for use with R407C. Consult them for their recommendations.

D) Driers

Tecumseh requires that an appropriate drier be used on every R407C system. See section on DRIERS.

E) Return Gas/Discharge Temperatures

The theoretical discharge temperature for R407C is **slightly** lower than that of R22 at similar conditions. Therefore, existing compressor guidelines regarding return gas and discharge temperatures for R22 should apply to R407C compressors as well. In general, keeping the return gas cool without flooding liquid refrigerant back to the compressor is beneficial in limiting compressor discharge and motor temperatures to acceptable levels.

F) Refrigerant Quantity

The refrigerant quantity will depend on the system components. Based on limited application data, the quantity of R407C needed will be about the same as R22.

DRIERS

A) Synthetic lubricants used with R407C are prone to hydrolyze with moisture resulting in the formation of acids. Tecumseh requires that an appropriate drier be used in every R407C application.

B) The types of driers which should be used are the molecular sieve types that are compatible with R22. The XH-6 **(bonded core)**, XH-7 and XH-9 types are recommended. The XH-6 (loose fill) type is not recommended due to its somewhat higher attrition rate.

C) For specific drier selection, contact your drier supplier.

SYSTEM PROCESSING

A) Compatibility

1. Polyol ester and polyvinyl ether oils are good solvents and have a tendency to wash system processing materials such as drawing components, rust inhibitors, and cleaning compounds from system surfaces. Care must be taken to remove such processing materials from all the system components.
2. Residual chlorinated materials **should** be considered system contamination and eliminated from all internal surfaces of the refrigeration system.

B) Evacuation

2. The evacuation levels for R407C systems should be the same as R22 systems (minimum of 200 microns at the system and pulled from both the low and high pressure sides of the system). If care is not taken to prevent moisture from entering the system components prior to assembly, evacuation could be expected to take longer to achieve acceptable limits of system moisture from entering the system components prior to assembly, evacuation could be expected to take longer to achieve acceptable limits of system moisture and non-condensable. Tecumseh recommends a maximum of 2% non-condensable and 80 PPM moisture. The completed system should have a moisture level of 10 PPM or less after running with an appropriate drier installed. These levels are based on measuring moisture in liquid refrigerant samples taken from the system.
3. Polyol ester and polyvinyl ether oils vaporize much less than mineral oils at the same level of heat and vacuum. Therefore, if oil vaporization was not a problem with the R22 system processing, it should not be a problem with the R407C system processing.
4. Consult your vacuum pump manufacturer to learn if your existing equipment may need to be converted for use on R407C polyol ester or polyvinyl ether systems.

C) Leak Testing

1. Use equipment which is designed for R407C detection or approved for R407C use by its manufacturer. Many leak detector manufacturers have R407C detectors on the market, and more are in development. Consult these manufacturers for their recommendations on their equipment.
2. **CAUTION:** Refrigerant suppliers warn **not** to use R407C mixed with air to pressure test for leaks.

D) Refrigerant Charging

1. In general, refrigerant charging equipment such as charging boards, valves, and hoses, which are compatible with R22 should be compatible with R407C.
2. Refrigerant charging equipment needs to be recalibrated for use with R407C. **Once designated for R407C use, it should be used specifically for that refrigerant only.** Converted R22 equipment should be clean of all residual R22.
3. Pulling a deep vacuum (50 microns) and repeated flushing with R407C should be sufficient. Consult your equipment and component manufacturer for specific recommendations for converting R22 equipment for use with R407C.
4. R407C is a zoetrope and should be charged in the liquid state into the liquid line.
5. **CAUTION: Never start the compressor while it is under a deep vacuum.**

RETROFITTING

The ideal situation regarding the use of R407C would be that it be limited to new equipment only. In this way, the system components would all be selected and tested by a system designer with all the necessary concerns regarding R407C and polyol ester and polyvinyl ether oils in mind. However, in the real world of today with millions of existing R22 in the systems in the field, and the supply of R22 rapidly declining as the CFC phase-out date approaches, this would not be possible.

We offer some **general** guidelines to those who elect to retrofit existing R22 units in the field (with compressor change-out) with R407C. Specific procedures can only be determined after an in depth evaluation of the existing equipment. Contact the equipment OEM for specific details.

A) Replacing an R22 compressor with a R407C ("C" denoted in the compressor model number) compressor: Use generally accepted system change-out procedures, taking special effort not to leave the system or the R407C compressor open to the atmosphere for more than a few minutes (10 minutes maximum).

1. Recover the R22 refrigerant in the system using proper recovery equipment. Take special effort to remove any residual mineral oil left in the system. The remaining amount of mineral oil should be 5% or less (1% or less is preferred).

2. Refit the system with the proper capillary tube, expansion valve, or other appropriate expansion device.
3. Install a drier suitable for R407C of suitable size for the system being retrofitted.
4. Install the proper Tecumseh R407C ("C") compressor. Be sure to use the correct electrical components, they could differ from those applied with a R22 compressor.
5. When pressure testing confirms that the system is free of leaks, evacuate the system thoroughly. Air, moisture and non-condensables must be removed to ensure long term reliability.
6. Break the system vacuum by charging R407C liquid refrigerant into the liquid line.
7. Change the system using industry acceptable charging methods with the proper amount of R407C. Generally the system will use the same amount of refrigerant as R22.
8. Check the system for proper operation.

After retrofitting an R22 system with R407C, always identify the system as being charged with that refrigerant and containing a polyol ester oil.. Indicate on the unit the amount of refrigerant used.

B) Tecumseh compressors which have refrigerant designation codes other than "C" are NOT approved for use with R407C.

C) Tecumseh R407C ("C") compressors can be used with R22, although the preferred refrigerant for these compressors is R407C.

The transition from R22 refrigerant to R407C refrigerant presents many challenges to our industry. Tecumseh Products Company is working diligently to meet these challenges. For information regarding the new Tecumseh R407C "C" compressors, contact you Tecumseh sales representative.

NOTE: Tecumseh recommends that a compressor change be considered when retrofitting an existing R22 system with refrigerant R407C. This is due to the potential difference in compressor performance and the compatibility of electrical components (of utmost importance is the overload protector).