SERVICE AND APPLICATION NOTES

June 24, 2013

Retrofitting From HCFC-22 to HFC-407C

AFFECTED SYSTEMS

All HCFC-22 Systems

ISSUE

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.

Refrigerant	ASHRAE 34 Class	Glide (°F)	Oil	GWP (AR4 Value)	ODP	Refrigerant Blend	HFC Component (Weight %)
R22	A1	0	Mineral	1700	0.05	22	100
R407C (AC9000, KLEA-66)	A1	9	POE	1700	0	32/125/134a	23/25/52

RETROFITTING PROCEDURE

When changing from mineral-based oils to polyolester oils, the maximum permissible residual mineral oil left in the system is 5%. The residual mineral oil can be measured with a refractometer.

- In general, **refrigerant charging equipment valves, and hoses**, which are compatible with R22 should be compatible with R407C.
- Before starting the conversion, the system should be thoroughly leak-tested with the HCFC still in the system.
- All leaks should be repaired before the new refrigerant is added. It is also advisable to check the system operating conditions, particularly the suction superheat at the compressor inlet and the manufacturer's published sub-cooling value for R22.
- Run the compressor for at least half an hour under steady conditions to allow as much oil as possible to return to the compressor.
- Cycle all power **OFF** to the system and recover all the R22 from the system. Use a refrigerant recovery machine to recover the refrigerant from the system. Measure the amount of refrigerant removed from the system (lbs {kg}).
- Remove the compressor from the system.
- Remove the oil from the compressor through the compressor suction stub. Measure the amount of oil (ounces {liters}) removed from the compressor. The mineral oil must be removed from the compressor crankcase. It should be within 4 to 6 ounces of the compressor's factory oil charge. The lubricant charge is indicated on the nameplate of the compressors.
- It is also advisable to carry out an acid test on the lubricant removed from hermetic compressor.
- Systems that have **suction line accumulators** must also have the oil drained from them. It is advisable that the suction line, liquid line, and evaporator coil be blown clean using regulated dry nitrogen. Add a similar amount of polyolester lubricant to the compressor compared with the amount of oil taken out of the system.
- The capacity of the existing R22 **thermal expansion valve (TEV)** will be approximately the same when using R407C. Use a dew point pressure table when measuring and/or adjusting TEV superheat after retrofitting with R407C.

- Filter driers must be changed at the time of conversion with filtration levels conforming to DIN8949 or with an equilibrium point of dryness (EPD) of 50 PPM or lower. Filter driers are important when using HFC refrigerants as these reduce the moisture level within the refrigerant to be between 50 and 120 PPM. The XH-6 (bonded core), XH-7 and XH-9 types are recommended.
- Polyolester oils are very hygroscopic. They will very quickly absorb moisture from the air once the container is opened. Once the lubricant is added to the compressor it should be quickly sealed. Furthermore, they are generally more abrasive than mineral oils and may pick up additional foreign material in the system and cause damage to the compressor. For this reason, use of a **suction filter** is recommended.
- Polyolester lubricants approved by the compressor manufacturers for use in Lennox equipment are **Mobil EAL Arctic 22 CC or EMKARATE RL 32-3MAF**. Mineral oil lubricants, such as 3GS, cannot be used with HFC refrigerants.
- Polyolester 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 evacuation, it should not be a problem with the R407C system evacuation. Consult your vacuum pump manufacturer to learn if your existing equipment may need to be converted for use on R407C polyolester or polyvinyl ether systems.
- 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. 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. **CAUTION: Never start the compressor while it is under a deep vacuum.**
- Use leak detection equipment which is designed for R407C or approved for R407C use by its manufacturer. Many leak detector manufacturers have R407C detectors on the market. Consult these manufacturers for their recommendations on their equipment.

CAUTION

Always use a mixture of nitrogen with R407C to pressure test for leaks. Never use air as it contains oxygen

WARNING

Fire, Explosion and Personal Safety Hazard. Failure to follow this warning could result in damage, personal injury or death.

Never use oxygen to pressurize or purge refrigeration lines. Oxygen, when exposed to a spark or open flame, can cause fire and/or an explosion, that could result in property damage, personal injury or death.

- Charge with the new refrigerant, which should be approximately 80% of the amount of refrigerant removed from the system. When charging with HFC refrigerants it is advisable to charge with liquid, being careful not to damage the compressor. It is suggested that a sight glass be connected between the charging hose and the compressor suction service valve. This will permit you to adjust the cylinder hand valve so that liquid can leave the cylinder while allowing vapor to enter the compressor.

  NOTE*: Because the properties of the R407C (zeotropic refrigerant blends) are different than traditional refrigerants it's useful to know how to read a two-column PT chart. Refer to information at the end of this note for more information on how to properly charge a R407C system.*
- Start the system and record the operating conditions. Compare operating conditions with the data taken before the change of oil. Note: On systems with long liquid lines, the sight glass should be installed near the expansion valve to avoid erroneous flash gas indication caused by pressure drop or ambient temperature.
- Re-check the oil, ensuring there is a maximum of 5% residual mineral oil in the system. If it has more than 5% then the oil and refrigerant have to be removed again, until there is less than 5% mineral oil.
- 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 keeping compressor discharge and motor temperatures to acceptable levels.

- After retrofitting an R22 system to R407C, tag the compressor with the refrigerant used (R-407C) and the lubricant used. The proper color code for R-407C is Burgundy PMS (Paint Matching System) 471.
- Clean up and properly dispose of the removed lubricant. Check local and state laws regarding the disposal of refrigerant lubricants. Recycle or reclaim the removed refrigerant.

NOTE: Lennox 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).

IMPORTANT !

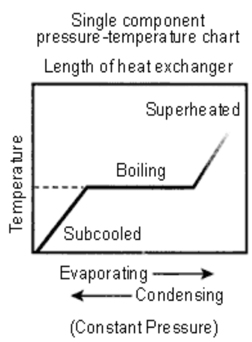
The information contained herein is based on technical data and tests which we believe to be reliable and is intended for use by persons having technical skill, at their own discretion and risk. Since conditions of use are beyond Lennox's control, we can assume no liability for results obtained or damages incurred through the application of the data presented.

PRESSURE-TEMPERATURE CHART

How to Use a Two-Column Pressure-Temperature Chart

Because the properties of the new zeotropic refrigerant blends are different than traditional refrigerants it's useful to know how to read a two-column PT chart.

The pressure-temperature (PT) chart is a valuable tool that service technicians use to check proper system operation. PT charts are most often used for three purposes: to set a coil pressure so that the refrigerant produces the desired temperature, to check the amount of superheat above the saturated vapor condition at the outlet of the evaporator and to check the amount of sub-cooling below the saturated liquid condition at the end of the condenser.



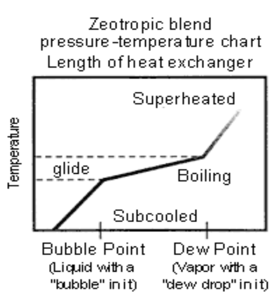
Pressure-temp. chart (psig)

T	R-12	R-22	R-502
-10	4.5	16.5	22.6
-5	6.7	20.1	26.7
0	9.2	24.0	31.1
5	11.8	28.2	35.9
10	14.6	32.8	41.0
15	17.7	37.7	46.5
20	21.0	43.0	52.4
25	24.6	48.8	58.8
30	28.5	54.9	65.6
35	32.6	61.5	72.8

Figure 1

Traditional PT charts list the saturated refrigerant pressure, in psig, with a column for temperature down the left side. Single-component refrigerants and boil and condense at one temperature for a given pressure. Therefore, only one column is needed to show the pressure-temperature relationship for any phase-change process in a system **(see Figure 1)**.

The properties of the new zeotropic blends are somewhat different than the traditional refrigerants. Zeotropic blends shift in composition during the boiling or condensing process **(see Figure 2)**. As the blend changes phase, more of one component will transfer to the other phase faster than the rest.



Pressure-temperature chart (psig)

T	R-12	R-405A Liquid	R-405A Vapor
-10	4.5	8.7	1.7
-5	6.7	11.4	3.8
0	9.2	14.4	6.1
5	11.6	17.6	8.6
10	14.6	21.1	11.4
15	17.7	24.9	14.4
20	21.0	29.0	17.6
25	24.6	33.4	21.2
30	28.5	38.1	25.0
35	32.6	43.2	29.2

Figure 2

This property is called fractionation. The changing composition of the liquid causes the boiling point temperature to shift as well. The overall shift of temperature from one side of the heat exchanger to the other is called the temperature glide.

Zeotropic blends cannot be defined by a single pressure-temperature relationship. The temperature glide will cause different values for temperature at a given pressure, depending on how much refrigerant is liquid and how much is vapor. The most important values for checking superheat and sub-cool are the end points of the glide or the pressure-temperature relationship for saturated liquid and saturated vapor.

The saturated liquid condition is often referred to as the bubble point. Imagine a pot of liquid sitting on a stove; as it begins to boil it forms bubbles in the liquid. The saturated vapor condition is referred to as the dew point. Imagine a room full of vapor and dew drops forming on the furniture. PT charts for the zeotropic blends list two columns next to each temperature: one for the saturated liquid (bubble point) and the other for the saturated vapor (dew point).

Some of the zeotropic blends have very low glide (from I° F to 2.5° F). For these blends, the vapor and liquid pressures are only separated by 1 or 2 psi. Because the difference is quite small between the two values some manufacturers' PT charts will only list one column for these blends. Blends with higher glide (greater than 5° F) will generally have both columns listed.

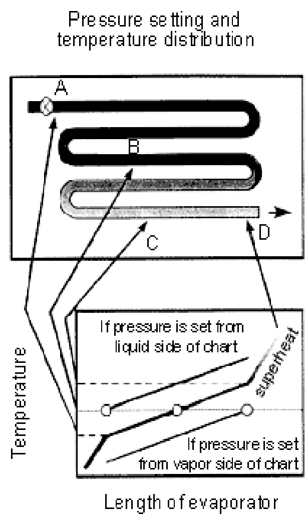
USING A TWO-COLUMN PT CHART

When checking a superheat or sub-cool temperature the procedure is the same as for a single-component refrigerant. Superheat is checked by measuring the temperature of the vapor line, measuring the pressure, then subtracting the saturated temperature from the measured temperature. In the case of a blend, you simply read the saturated temperature next to the pressure in the vapor (dew point) column of the chart.

When checking the sub-cool condition the technician will measure the temperature of the liquid line, the pressure at that point and subtract the measured temperature from the saturated temperature at the end of the condenser. With the blend you read the saturated temperature next to the pressure in the liquid (bubble point) column of the chart.

For a single-component or azeotropic refrigerant, the operating pressure for the low side of a system can be found by cross referencing the desired coil temperature on the PT chart. For high-glide blends, however, the desired coil temperature is the average (or midpoint) temperature of the coil.

Figure 3



The problem with two-column PT charts is that the conditions at the end-points of the temperature glide are listed, not the midpoint. In this case, you must add half of the temperature glide to the desired midpoint temperature, then, read the saturated vapor column to determine the operating pressure **(see Figure 3)**.

If the vapor column is read directly at the desired temperature, then the end of the evaporator will be the correct temperature, but the rest of the coil will be too cold. If the liquid column is used directly, then the beginning of the coil will be the correct temperature, but the rest of the coil will be too warm.

Two-column PT charts are every bit as useful as the traditional ones. The charging and service procedures are very similar for both single-component refrigerants and zeotropic blends, and the specialized liquid and vapor data correct for the effects of the blends' temperature glide.

Just remember to keep track of the phase of the blend at the point you are interested: saturated vapor uses the vapor (dew point) column and saturated liquid uses the liquid (bubble point) column.