Making the Move: R-22 to R-410A

Most individuals in the HVACR trade agree that R-410A will be the likely replacement for R-22 in A/C applications. Here's some insight as to why.

BY SATISH VISHNUBHATLA, STEPHEN MADIGAN AND MAX ROBINSON

It has been well-documented (and known) that new refrigeration and air-conditioning equipment using R-22 refrigerant cannot be manufactured after Jan. 1, 2010. For a number of reasons, some requiring a bit of explanation, R-410A is thought by many to be the most efficient replacement for R-22 in A/C systems.

R-410A is an azeotropic mixture; it exhibits a temperature glide. The R-410A glide, though, is negligible (<0.3°F) compared to the glides exhibited by other R-22 replacements proposed in years past. This article will discuss the differences between R-22 and R-410A, and also review the important differences in equipment and procedures that service technicians should know. Let's examine the reasons and the practical implications.

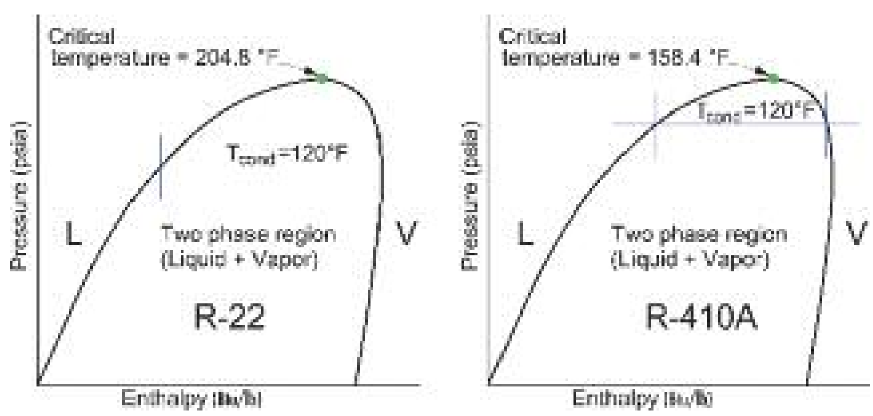

Figure 1 **This illustration highlights pressure-enthalpy schematics, showing how at higher ambient temperatures, R-410A has less room to work with in the two-phase region than does R-22. This is a key consideration in replacement, especially in areas where the system's design ambient condition is often high.**

The basics

R-410A is not a new refrigerant; its use in A/C systems has grown steadily in the past decade. R-410A is a 50:50 mixture of R-32 and R-125, neither of which contains chlorine. This means that the ozone-depletion potential (ODP) of R-410A is 0 for the blend (compared to an ODP of 0.055 for R-22). On the other hand, according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) "2006 Handbook—Refrigeration," R-410A has a global warming potential (GWP) of 2,000, higher than that of R-22 (GWP=1,700). The difference is offset, though, when considering the total carbon footprint of each refrigerant. The total carbon footprint, also called the total equivalent warming impact (TEWI), includes the refrigerant's direct warming potential together with the indirect effect of the equipment's energy consumption. In terms of TEWI, R-410A performs better than R-22 because of its superior thermodynamic properties.

Because of the extensive changes to evaporators, controls, condensers and other system components needed to accommodate the characteristics of R-410A, an R-410A compressor should not be used to replace an R-22 compressor. The much higher operating pressures of R-410A (50%–70% higher than R-22) necessitate the use of equipment and components that can handle those pressures; the

Table 1: Thermal properties of R-22 and R-410A compared

	R-22	R-410A
Liquid Specific heat (Btu/lb°F)@ 82°F	0.3	0.42
Vapor Specific heat (Btu/lb°F)@ 82°F	0.21	0.36
Vapor Density (lb/ft^3) @ 50°F	1.8	2.61

Data collected from ASHRAE 2005 Handbook—Fundamentals; and "A comparison of an R-22 and R-410A air conditioner operating at high ambient temperatures", Payne, W.V and Domanski, P.A, NIST-Building Environment Division; Thermal Machinery Group.

Table 2: Efficiency comparison of R-22 and R-410A compressors in isolation (not in a system)

Refrigerant	Compressor model	Compressor cooling capacity Btu/h	COP Btu/W
R22	HRM032U-1	35,213	14.76
R410A	HRH032U-1	36,000	14.09

Operating conditions: ARI 540 ACB suction: evaporating temperature 45°F; evaporator out superheat 20°F; compressor suction superheat 20°F; subcooling at condenser out 15°F; and condensing temperature 115°F.

failure to do so can do can have catastrophic consequences to the system's equipment, and possibly endanger those working around the system and its components.

[*Editor's Note: For more information on key component and system considerations involved with changing from R-22 to R-410A, review the feature article "Refrigerant Changes Make R-410A Systems More Appealing Than Ever," on page 18 in the March 2008* RSES Journal.]

Comparing operating pressures

Using typical data from an R-410A system, high-pressure cut-out is 610 psig, with high-pressure cut-in at about 500 psig. Because R-410A pressures are so much higher than R-22 pressures, any service tools, gauges, gauge manifold sets, hoses, recovery cylinders, recovery machines or valves used must be rated for these pressures.

Since the actual operating pressures for an R-410A system are high, some might expect the compression ratio to be high as well. In actuality, the compression ratio is about the same or slightly lower than that of an R-22 system. Since by definition, the compression ratio is the ratio of absolute discharge pressure to absolute suction pressure, it depends on the pressures relative to each other, not on the actual pressures. Also, under identical operating conditions, the discharge temperature on an R-410A system may actually be lower than that for an R-22 system.

Thermal properties

As mentioned earlier, higher R-410A system efficiencies result from the refrigerant's superior thermal properties. Some of the notable thermal and physical properties of R-410A are compared to those of R-22 in Table 1.

First, the liquid and vapor specific heats of R-410A are considerably higher than R-22. In the examples given in Table 1, with the two refrigerants being compared under the same high ambient temps, R-410A needs less of a temperature gradient than R-22 to transfer the same amount of heat. This makes heat transfer with R-410A very efficient. The vapor density of R-410A is higher because it operates at a higher pressure than R-22. This enables the unit to run at a lower volumetric flow rate, which makes it possible to use a smaller, and possibly quieter, compressor in a system. The higher vapor density of R-410A also permits the use of smaller suction- and discharge-line sizes with R-410A compared to those needed for R-22.

R-410A's higher heat-transfer rate also provides a great benefit in evaporator and condenser performance. This in turn gives system designers using R-410A the ability to reduce investment in evaporators and condensers while obtaining the same performance an R-22 system of a similar capacity supplies. For example, as Table 2 shows, when evaluated at identical evaporating and condensing temperatures, a compressor using R-410A falls short of meeting the coefficient-of-performance (COP) target set by the performance of a similar compressor using R-22. However, with an appropriately designed evaporator and condenser included as part of an R-410A system, this shortcoming is easily offset without an increase in the cost of heat exchangers.

Critical point temperature

Another interesting consideration for system designers and application engineers is the refrigerant's critical-point temperature. R-410A has a critical point of 158.4°F compared to 204.8°F for R-22. This could be an issue in air-cooled products in high-ambient-temperature locales such as the southwest United States, where the system's design ambient condition is often 95°F or higher. When a system is designed with a 25°F refrigerant temperature differential, R-410A is only 38°F from its critical point.

As shown in the pressure-enthalpy schematics in Figure 1 on page 27, at a higher ambient temperature, R-410A has less room in the two-phase region than R-22. Previous studies* on this subject show that while both refrigerants show a decrease in system capacity when increasing ambient temperature, R-410A is slightly more sensitive than R-22 up to an ambient temperature of around 113°F. Beyond this temperature, the cooling capacity of an R-410A system starts to fall more rapidly. The studies also found that at these temperatures, R-410A systems exhibit a relative drop in capacity that is about 10% greater than that of an R-22 system.

**The "previous studies" refer to two references. The first is "A comparison of an R-22 and R-410A air conditioner operating at high ambient temperatures," performed by Payne, W.V.; and Domanski, P.A. of the National Institute of Standards and Technology (NIST)-Building Environment Division: Thermal Machinery Group. The second reference applies to "R-410A—Application Experience," performed by Bivens, D.B.; Morley, J.R.; and Wells, W. of DuPont Fluoroproducts.*

Lubricants

The synthetic polyol ester (POE) and polyvinyl ether (PVE) oils used with R-410A are more hygroscopic than the mineral and alkyl benzene (AB) oils used with R-22. Therefore, when using R-410A, technicians need to close the system as soon as possible and change the filter-driers often.

When working to replace an R-22 residential split system with an R-410A system, the original interconnecting tubing can be used for R-410A service provided that it is thoroughly cleaned and purged of the oil left from R-22 operations. [*Editor's Note: Technicians should remember to dedicate a set of hoses, gauges, vacuum pump, recovery machine, and oil containers specifically for hydroflurocarbons (HFCs) when recovering refrigerant or changing over systems.*] A matching R-410A low-side (indoor coil in heat-pump vernacular, or the evaporator) must be installed with a corresponding R-410A high-side (condensing unit). In some cases, system providers have qualified indoor coils for both R-22 and R-410A. When dealing with an indoor coil approved for both R-22 and R-410A, the refrigerant expansion device must be changed when the refrigerant is changed. The evaporator manufacturer can provide details. In the case of larger, commercial-scale split systems, particularly when the condensing unit is above the evaporator, use of interconnecting tubing originally used for R-22 may present problems if the R-22 suction-line size is too large to insure adequate oil return under all operating conditions. As with residential split systems, both high-side and low-side must be designed for R-410A.◆

[*Editor's Note: Calculations and graphics seen in this article were made using Danfoss software available free of charge to readers. The authors used the RS+3 program, which can be downloaded at www.danfoss.com/north_america/hvacr-softwaretools. Other programs available from the same Web page allow easy sizing of expansion valves.*]

Satish Vishnubhatla is an Application Engineer; Stephen Madigan is Senior Application Engineer; and Max Robinson is Principal Writer and Editor, Technical Communications, at Danfoss North American headquarters in Baltimore, MD. Contact the authors at 410-931-8250, or send an e-mail to maxrobinson@danfoss.com.

Because R-410A operates at a much higher pressure than R-22, technicians should have specific recovery equipment, hoses, gauges and other related equipment dedicated for use with hydroflurocarbons.