DUPONT®

Suva®
refrigerants

ART-14

Properties and Performance of Suva® 407C and Suva® 410A in Air Conditioners and Heat Pumps

Introduction

Chlorodifluoromethane (R-22 or HCFC-22) has been commercially available for use in various refrigeration, industrial cooling, air-conditioning, and heat pump applications for over five decades. The low ozone depletion potential of HCFC-22, compared with CFC-11 and CFC-12, and its excellent refrigerant properties have helped facilitate the transition away from CFCs. However, as national and international policy makers continue to strengthen regulations towards the protection of the ozone layer, HCFC-22 and other hydrochloro-fluorocarbons (HCFCs) will be phased out. By identifying potential alternatives for HCFC-22 today, DuPont provides equipment manufacturers and users with time to fully test HCFC-22 alternatives before they are needed.

DuPont has developed Suva® 407C as the equivalent pressure replacement for HCFC-22 in positive displacement, direct expansion air conditioners and heat pumps, and has developed Suva® 410A, a near-azeotrope, as a replacement for use in new equipment designed for the higher operating pressures of Suva® 410A.

Environmental and Safety Properties of Suva® 407C and Suva® 410A

Suva® 407C is a ternary mixture of hydrofluorocarbons (HFCs) HFC-32, HFC-125, and HFC-134a in the ratio of 23/25/52 wt%. Suva® 410A is a binary mixture of HFC-32 and HFC-125 in the ratio of 50/50 wt%. Environmental and safety properties of Suva® 407C and Suva® 410A are listed in **Table 1**.

Table 1
Environmental and Safety Properties of Suva® 407C and Suva® 410A versus HCFC-22

	Suva® 407C	Suva® 410A	HCFC-22
Ozone Depletion Potential (CFC-11=1.0)	0.00	0.00	0.055
Global Warming Potential (CO2=1.0[100 yr ITH*])	1600	1725	1600
Flammable	No	No	No

*Integrated Time Horizon

The components of Suva® 407C and Suva® 410A have undergone extensive toxicity testing by the Program for Alternative Fluorocarbon Toxicity Testing (PAFT). Results from this testing indicate that the components of Suva® 407C and Suva® 410A have very low toxicity. The calculated DuPont Acceptable Exposure Limit (AEL) of both products, based upon the AEL for each component, is 1,000 ppm, 8- and 12-hour time weighted average (TWA). This AEL is the same as the Threshold Limit Value (TLV) established for HCFC-22.

Suva® 407C and Suva® 410A liquid and vapor compositions are nonflammable and will remain nonflammable during shipping, storage, handling, and use in equipment.

Table 2
Performance of Suva® 407C Relative to HCFC-22 in Unmodified Air Conditioners and Heat Pumps

Range of Performance: Cooling Mode[a]		Range of Performance: Heating Mode[b]	
Relative Capacity, %	–2 to +3	Relative Capacity, %	–7 to +6
Relative Energy Efficiency Ratio (EER), %	–7 to –3	Relative Energy Efficiency Ratio (EER), %	–6 to –3
Change in Discharge Temperature, °C (°F)	–8.3 to –4.4 (–15 to –8)	Change in Discharge Temperature, °C (°F)	–10 to 0 (–18 to 0)
Change in Discharge Pressure		Change in Discharge Pressure	
bar	+1.03 to +2.76	bar	+0.62 to +2.34
kPa	+103 to +276	kPa	+62 to +234
psi	+15 to +40	psi	+9 to +34

[a] Values compared with HCFC-22 in unmodified split system heat pumps and an unmodified window air conditioner using the DOE cooling test conditions A and B.

[b] Values compared with HCFC-22 in unmodified split system heat pumps and an unmodified window air conditioner using the DOE heating test conditions E and H.

Performance Characteristics of Suva® 407C in Existing HCFC-22 Designs

At typical air-conditioner and heat pump conditions, Suva® 407C performs comparably to HCFC-22 in existing positive displacement, direct expansion equipment. **Table 2** summarizes the actual performance of Suva® 407C versus HCFC-22 (cooling and heating modes) in different units designed for HCFC-22. The units were not modified or optimized for performance with Suva® 407C. Department of Energy (DOE) standard test conditions for cooling (test conditions A and B) and heating (test conditions E and H) were used for this comparison.

These results show that Suva® 407C is an alternative for HCFC-22 that can be used not only in new equipment but also to service existing HCFC-22 equipment. Due to the increase in discharge pressure, it will be necessary to contact the original equipment manufacturer to determine if discharge pressure controls will need to be adjusted to compensate for the higher discharge pressure of Suva® 407C.

Even better performance will be achieved when modifications to heat pump and air-conditioning equipment are made to optimize it for use with Suva® 407C.

Performance Characteristics of Suva® 410A versus HCFC-22

Table 3 shows the results of comparison testing between Suva® 410A and HCFC-22 in a system designed for optimum performance with HCFC-22. With the two modifications of a compressor change and an adjustable expansion valve, efficiencies of Suva® 410A were about the same as those of HCFC-22. This suggests that a system designed specifically for Suva® 410A may give better efficiencies than the results indicated in **Table 3**.

Suva® 410A is being positioned by manufacturers as a replacement for HCFC-22 in residential air conditioners and heat pumps because of opportunities for improved efficiency versus HCFC-22 and Suva® 407C. Because of the higher operating pressures of Suva® 410A, its application will be in new equipment designed specifically for this new refrigerant.

Table 3
Performance of Suva® 410A Relative to HCFC-22 in Unmodified Air Conditioners and Heat Pumps

Range of Performance: Cooling Mode[a]		Range of Performance: Heating Mode[b]	
Relative Energy Efficiency Ratio (EER), %	–2 to +2	Relative Energy Efficiency Ratio (EER), %	+1 to +4[c]
Change in Discharge Temperature, °C (°F)	–5 to –6 (–9 to –11)	Change in Discharge Temperature, °C (°F)	–8 (–14[c])
Change in Discharge Pressure		Change in Discharge Pressure	
bar	+9.032 to +10.34	bar	+7.308 to +9.032
kPa	+9032 to +1034	kPa	+730.8 to +903.2
psi	+131 to +150	psi	+106 to +131[c]

[a] Values compared with HCFC-22 in split system heat pump with capacity-matched compressor using the DOE cooling test conditions A and B.

[b] Values compared with HCFC-22 in split system heat pump with capacity-matched compressor using the DOE heating test conditions E and H.

[c] Values based on 48/52 blend versus 50/50 blend currently in production.

Influence of Leak/Recharge on Performance

Suva® 407C

Recharging after a leak of Suva® 407C results in minimal impact on system performance, even under worst-case, multiple-leak/recharge scenarios.

If there is a Suva® 407C leak from an operating unit in a two-phase region where mixing occurs (heat exchangers or after expansion device), both vapor and liquid will leak from the unit. The composition of the refrigerant left in the system will remain essentially unchanged from the original composition. After recharging Suva® 407C to the system to get back to the original charge size, the performance of the unit will be the same as its original performance with Suva® 407C.

However, if the unit is not operating and there is a vapor leak from a static two-phase region, the composition of the refrigerant that remains in the unit will change. The refrigerant remaining in the unit will be more concentrated in the high boiling component (HFC-134a) and less concentrated in the lower boiling components (HFC-32 and HFC-125). The effect of this composition shift on the performance of Suva® 407C is summarized in **Table 4**. These data summarize the observed performance of Suva® 407C for multiple recharges of the system after 50 wt% of the refrigerant charge is lost through a vapor leak above a two-phase region.

Three important observations from the data generated in this leak/recharge study are:

- During a vapor leak, the HFC-32 (which is the flammable component in the mixture) remaining in the system decreases with concentration.
- The discharge temperature and pressure moved in a favorable direction during the vapor leak/recharge scenario.
- The capacity loss is limited to 5% as the performance of Suva® 407C levels out after four 50 wt% leak/recharge scenarios. The efficiency loss is limited to 2-3% under these leak/recharge conditions.

Table 4
Actual Unit Performance After 50 wt% Vapor Leaks and Recharges of Suva® 407C

			Compressor Discharge	
Recharge No.	Rel. COP[a],%	Rel. CAP[b],%	Temperature, °C (°F)	Pressure, bar, kPa (psig)
0	100	100	81.3 (178)	21.4, 2142 (296)
1	97.8	95.9	79.7 (176)	21.0, 2103 (290)
2	97.1	94.7	80.6 (177)	20.8, 2080 (287)
3	99.1	95.2	79.9 (176)	20.3, 2029 (280)
4	98.8	95.1	79.4 (174)	20.4, 2044 (282)

[a]Coefficient of Performance (measure of energy efficiency) relative to the Coefficient of Performance of the original charge of Suva® 407C.

[b]Refrigerant cooling capacity relative to the capacity of the original charge of Suva® 407C.

Suva® 410A

This refrigerant has even less tendency to separate during leakage than Suva® 407C. **Table 5** shows the effect of repeated loss of 50% of the refrigerant charge followed by addition of enough new Suva® 410A to restore the nominal amount of charge. After repeated leakage and recharge, the effect on system performance is negligible, with a slight increase in HFC-125 composition that causes the resulting blend to move further into the nonflammable region.

Charging a Unit with Suva® 407C or Suva® 410A

As with any other refrigerant blend, when charging equipment with Suva® 407C, remove liquid refrigerant from the cylinder and then charge this to the unit. Cylinders of Suva® 407C and Suva® 410A are equipped with liquid and vapor valves. The liquid valve is attached to a dip-tube that extends to the bottom of the cylinder, so liquid refrigerant can be removed from the cylinder as it is standing upright.

Table 5
Theoretical Unit Performance After 50 wt% Vapor Leaks and Recharges of Suva® 410A

			Compressor Discharge	
Recharge No.	Rel. COP[a],%	Rel. CAP[b],%	Temperature, °C (°F)	Pressure, bar, kPa (psig)
0	100	100	88 (191)	28.1, 2814 (393)
1	100	100	88 (190)	28.1, 2810 (393)
2	100	99	88 (190)	28.1, 2808 (393)
3	100	99	88 (190)	28.1, 2807 (392)
4	100	99	88 (190)	28.1, 2807 (392)

[a]Coefficient of Performance (measure of energy efficiency) relative to the Coefficient of Performance of the original charge of Suva® 410A.

[b]Refrigerant cooling capacity relative to the capacity of the original charge of Suva® 410A.

Lubricants

Evaluations of lubricants for use with Suva® 407C and Suva® 410A are currently being conducted. Because Suva® 407C and Suva® 410A are blends of HFC refrigerants, for most applications, a lubricant other than mineral oil will be required. Polyol ester lubricants are being studied for use with Suva® 407C and Suva® 410A, as well as other HFC refrigerants. You should discuss specific lubricant recommendations with your compressor manufacturer.

Availability

Suva® 407C and Suva® 410A are available to original equipment manufacturers and through DuPont authorized distributors.

Call (800) 235-SUVA for the name of the nearest DuPont authorized distributor.

Summary

Suva® 407C and Suva® 410A offer respectively equivalent-performance and higher-capacity alternatives to HCFC-22. Both new refrigerants are nonflammable, have the same low order of toxicity that HCFC-22 has, and yield similar energy efficiency and refrigeration capacity under typical air-conditioner and heat pump conditions. DuPont believes these will be the preferred refrigerants to replace HCFC-22 in new equipment and that Suva® 407C will be the preferred refrigerant in servicing of existing HCFC-22 systems.

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