DuPont™ Suva®
refrigerants

ART-2

DuPont™ Suva® 123 in Chillers

Introduction

DuPont produces HCFC-123 (DuPont™ Suva® 123) refrigerant as a replacement for CFC-11 in chillers and is providing this new refrigerant to chiller manufacturers for use in new and existing chillers. DuPont has converted its own CFC-11 chillers to HCFC-123.

General Considerations

Property comparisons of HCFC-123 with CFC-11 are contained in **Table 1**. The boiling point of the new refrigerant is close to that of CFC-11. This means that HCFC-123 will develop system operating pressures similar to CFC-11.

The environmental advantages of HCFC-123 over CFC-11 are clearly shown by the ozone-depletion potential (ODP) and global warming potential (GWP) values of the two compounds. Neither compound is flammable. The 50 ppm acceptable exposure limit (AEL) of HCFC-123 means that indoor installations using this refrigerant should be monitored to confirm a safe working environment. However, extensive experience over the past six years has shown that, with proper care, emission levels in chiller machinery rooms can easily be maintained well below the AEL.

Table 1
Property Comparisons

	CFC-11	HCFC-123
Boiling Point, °C (°F)	24 (74.9)	27.85 (82.0)
Flammability	None	None
Ozone Depletion Potential	1.0	0.02
Global Warming Potential (100 yr. ITH)	4600	120
Exposure Limit, ppm (v/v)	1,000 TLV*	50 AEL**I

*A threshold limit value (TLV), established for industrial chemicals by the American Conference of Governmental Hygienists, is the time-weighted average concentration of an airborne chemical to which workers may be exposed during an 8-hour workday, 40 hours per week for a working lifetime without adverse effect.

** An acceptable exposure limit (AEL) is the recommended time-weighted average concentration of an airborne chemical to which nearly all workers may be exposed during an 8-hour workday, 40 hours per week for a working lifetime without adverse effect, as determined by DuPont for compounds that do not have a TLV.

Performance Comparisons

HCFC-123 was selected as a replacement for CFC-11 because the two compounds will produce roughly the same operating pressures and temperatures in a chiller. However, the chiller will produce less cooling capacity and an equivalent or lower efficiency with HCFC-123 than it did with CFC-11. The difference in capacity and efficiency will depend on system component selection and operating conditions. **Table 2** gives expected performance ranges.

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Table 2
Retrofit Performance Comparison
HCFC-123 versus CFC-11

Capacity	–5 to –20%
Coefficient of Performance	0 to –5%
Evaporator Pressure	–2 to –3 psi –0.1 to –0.3 bar
Condenser Pressure	–2 to –3 psi –0.1 to –0.3 bar
Discharge Temperature	–1 to –3°C –2 to –6°F

Elastomers/Plastics Compatibility

Ironically, the same hydrogen atom that makes HCFC-123 desirable from an environmental standpoint makes it a stronger solvent toward some plastics and elastomers than CFC-11. **Table 3** compares the relative effects of CFC-11 and HCFC-123 on plastics. Several plastics used with CFC-11 are also compatible with HCFC-123. As HCFC-123 use becomes more common, other materials will be tested and approved.

Swelling and weight change of several elastomers after exposure to CFC-11 and HCFC-123 are shown in **Table 4**. As in the case of plastics, HCFC-123 may affect some elastomers more than CFC-11 does. Low swelling and extraction are not sufficient to qualify an elastomer. Elastomers that show limited effects must still be tested for changes in mechanical properties, such as hardness, tensile strength, and compression set. Some of the elastomers listed here, such as polysulfide, show limited swelling and weight change, but significant differences in properties after exposure to HCFC-123. Reformulation of elastomers, or changes in system clearance tolerances, may prove useful toward incorporating these elastomers into systems for HCFC-123.

Lubricant/Refrigerant Relationships

In refrigeration and air conditioning systems, some lubricant escapes from the compressor discharge area and circulates through the system with the refrigerant.

Table 3
Plastics Compatibility of CFC-11 versus HCFC-123
(Screening Test Conditions: Plastic specimens exposed to liquid in sealed glass tubes at temperatures and exposure times given below.)

Plastic		Compatibility Ratings			
		4 hr at 24°C (75°F)		100 hr at 54°C (130°F)	
Chemical Type	**Trade Name**	**CFC-11**	**HCFC-123**	**CFC-11**	**HCFC-123**
ABS	Kralastic	0	4	0	4
Acetal	Delrin®	0	0	0	1
Acrylic	Lucite	0	4	0	4
Fluorocarbon PTFE	Teflon®	0	0	0	1
Polyamide 6/6 nylon	Zytel®	0	0	0	0
Polycarbonate	Lexan	0	4	0	4
Polyethylene-HD	Alathon	0	0	1	1
Polypropylene	Alathon	0	0	2	2
Polystyrene	Styron	0	4	4	4
Polyvinyl Chloride		0	0	1	1

Ratings:
0 = Suitable for use
1 = Probably suitable for use
2 = Probably not suitable for use
3 = Not suitable
4 = Plastic disintegrated or dissolved in liquid

Ratings Based On: Specimen dimensional, weight, and surface changes.

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Kralastic is a USS Chemicals registered trademark.
Lexan is a General Electric registered trademark.
Lucite is an ICI Americas registered trademark.
Styron is a Dow Chemical registered trademark.

Table 4
Elastomer Compatibility of CFC-11 versus HCFC-123
(Test Conditions: Exposure to liquid in sealed tubes for 7 days at 54°C (130°F), then ambient air drying for 21 days.)

Elastomer		Length Change at End of Exposure, %		Weight Change After Drying, %	
Chemical Type	**Trade Name**	**CFC-11**	**HCFC-123**	**CFC-11**	**HCFC-123**
Butyl Rubber		16	11	–4	–2
Chlorosulfonated Polyethylene (CSM)	Hypalon®	2	12	–2	–5
Fluoroelastomer	Viton® A	2	23	0	5
Hydrocarbon Rubber (EPDM)	Nordel®	12	13	–9	–6
Natural Rubber		31	39	–4	–4
Neoprene		2	10	–8	–9
Nitrile Rubber					
Buna N (NBR)		1	50	0	–4
Buna S (SBR)		13	26	–8	–9
Polysulfide	Thiokol FA	0	7	–1	–2
Silicone		33	28	–2	–2
Urethane	Adiprene C	7	56	–3	–5

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Current lubricants used with CFC-11 are fully miscible over the range of expected operating conditions, easing the problem of getting the lubricant to flow back to the compressor. Refrigeration systems using CFC-11 take advantage of this full miscibility when considering lubricant return.

Existing refrigeration lubricants are being used with HCFC-123 in current field tests with no apparent problems.

Several families of lubricants that have acceptable miscibility with HCFC-123 have been identified. Although most applications for HCFC-123 will not involve high discharge temperatures, or temperatures below 0°C (32°F), the candidate lubricants were tested over a broad temperature range. Alkylbenzene, paraffinic, and naphthenic lubricants all meet the miscibility target.

Metals/Lubricant/Refrigerant Compatibility

DuPont conducted a severe test on CFC-11 versus HCFC-123 with metals and a naphthenic lubricant at elevated temperatures. The results (**Table 5**) show that HCFC-123 is more stable. After three days at 171°C (304°F), decomposition products of HCFC-123 were at least an order of magnitude less than decomposition products of CFC-11. Samples exposed to HCFC-123 showed comparable, or less, visual effects than CFC-11 samples.

Retrofitting Existing CFC-11 Chillers

Background

The decision to retrofit CFC equipment with alternative refrigerants must be made based on the cost to retrofit versus the expected life of the equipment and the anticipated efficiency of the system after the retrofit.

In general alternative refrigerants cannot be simply "dropped into" a system designed to use CFCs. As discussed earlier, alternative refrigerants are similar to, but not identical to the CFCs they are targeted to replace. The differences in properties must be considered carefully because systems designed for CFCs may perform inefficiently or completely fail if improperly retrofitted with an alternative refrigerant.

Tables 3 and **4** show that some plastics and elastomers in a CFC-11 chiller may have to be replaced if that chiller is to be successfully converted to HCFC-123.

Retrofit requirements can range from a minimum effort, such as replacing the lubricant, to significant equipment changes, such as replacing gears, impellers, or materials of construction located throughout the system.

Table 5
Stability of HCFC-123 with Steel, Copper, Aluminum, and Heavy Naphthenic Oil
(Test Conditions: Sealed tubes containing 3.0 mL refrigerant + 0.52 mL lubricant;
metal specimens: 6.0 cm [2-3/8″] × 6.4 mm [1/4″] × 1.6 mm [1/16″];
exposure: 2.95 days at 151°C [304°F])

Metals: Steel 1010, Copper, Aluminum 1100

Oil: Witco Freezene, heavy white naphthenic mineral oil, 255 SUS (approx. 55 cSt at 38°C [100°F])

		HCFC-123	
Refrigerant	**R-11**	**Sample 1**	**Sample 2**
Visual Ratings			
Liquid	3	0+	2
Steel	1	1+	2
Copper	3	2	2
Aluminum	1	0	0
Decomposition Analyses			
Chloride, wt%	1.7	0.08	0.13
Fluoride, wt%	0.42	0.003	0.004

Visual Ratings: 0 to 5

Rating	**Metal**	**Liquid**
0	Bright, shiny	Clear, colorless
3	Darkening	Clear, brown
5	Severe deposits	Black, coke present

(Ratings of 3 and higher considered unacceptable.)

The main point to remember is that a service technician cannot simply put an alternative refrigerant into a CFC system. The property data must be compared and the materials of construction reviewed. Then, changes recommended by the original equipment manufacturer (OEM) must be made to ensure that the system will perform correctly and efficiently.

The DuPont Retrofit Program

In 1989, DuPont began an extensive equipment retrofit program working with major chiller manufacturers to convert all of its large CFC chillers to use alternative refrigerants.

As a first step in this effort, DuPont retrofitted several open-drive and hermetic chillers, developing a general understanding of what is required to convert each manufacturer's equipment from CFC-11 to HCFC-123. This program was expanded, and DuPont converted nearly all of its CFC chillers of 70 kW (20 ton) capacity or higher to alternative refrigerants by the end of 1994.

Performance Considerations During Retrofit

Four variables will determine actual capacity loss in converted equipment. In general, the higher the impeller speed and the larger the machine, the greater the loss. Conversely, if the compressor and expansion system are slightly oversized, losses in capacity can be minimized.

Losses in performance when converting to HCFC-123 are primarily due to the design of the impeller and to the evaporator and condenser tube surfaces, which have been optimized for CFC-11. Equipment manufacturers are working to modify these components to restore performance to ranges experienced with CFC-11, which has been the industry's most efficient refrigerant.

Emission Concentrations

Emissions monitoring has shown that properly maintained and operated HCFC-123 chillers have refrigerant emissions levels of 0 to 1 ppm in air. Installed infrared monitors tend to drift upward in reading over time and commonly show 1 to 2 ppm of HCFC-123 in air, but spot-checking of these chillers with recently calibrated monitors has consistently confirmed the lower concentrations. The "Field Experience" section refers to "indicated" emissions levels, which mean the levels observed by the installed monitor. These represent the highest emission level which might be present in the room. The actual concentration of HCFC-123 is probably significantly lower than this indicated value.

Field Experience

Case History #1

The first field conversion to an alternative refrigerant was at the DuPont Corporate Data Center in Newark, Delaware. Originally charged with CFC-11 in September 1984, the 1,670 kW (475-ton) York open-drive chiller was converted to HCFC-123 (635 kg [1,400 lb] charge) in September 1988, and has operated without incident ever since. In December 1988, after four months of operation, the chiller was shut down for an elastomer inspection. Several Buna N O-rings located in vapor lines were replaced at that time because they were missed during the original conversion. The Buna N had held up satisfactorily.

Refrigerant and lubricant samples taken during the O-ring changeover showed minimal effect from operation with HCFC-123. Subsequent inspections and sampling since then have yielded similar results. The chiller has required no other attention except routine maintenance.

Chiller mid-range performance efficiency with HCFC-123 is equivalent to that with CFC-11 because the compressor was originally 15 percent oversized and the unit typically operates at 60 to 70 percent of rated capacity. The machine is expected to obtain full rated capacity, but with a reduced efficiency compared to CFC-11.

Refrigerant samples showed minimal decomposition and 33 ppm moisture. Lubricant samples showed 92 ppm moisture and 0.003 acid number.

Because of the 100 ppm acceptable exposure limit set at that time for HCFC-123 (which has since been reduced to 50 ppm), an emissions monitor was installed at the chiller location. During charging and maintenance, a brief spike of approximately 8 ppm was occasionally indicated when making or breaking hose connections. However, the normal emission level indicated around the machine during routine maintenance and operation was 1 ppm. Maintenance included emptying the entire 635 kg (1,400 lb) charge into drums and recharging it into the machine.

The purge units that normally vent into the machinery room were piped outdoors along with the relief valve header to minimize potential personnel exposure to HCFC-123. Also, the room air exhaust fan system, which draws outdoor air into the room and exhausts it outside for temperature control, was connected to the monitor. It was set to actuate if the monitor indicated a 25 ppm concentration of HCFC-123 in the room. This safety feature has never actuated. The remaining two identical chillers at this site were converted to HCFC-123 in May/June of 1990. All three machines are operating without incident.

Case History #2

An open-drive chiller with a Carrier 17M compressor was converted to HCFC-123 in February 1988. The nominal 3,517 kW (1,000 ton) unit provides chilled water for process cooling and HVAC uses at the DuPont Spruance Plant in Richmond, Virginia. It was charged with 1,496 kg (3,300 lb) of HCFC-123. Material changes included minor gaskets.

The machine was tested in March 1989 and found to be 18 percent short of original capacity, due to compressor impeller design limitations.

The compressor was rebuilt in late 1989 with larger capacity wheels. Performance testing with the new compressor wheels showed a regain of original capacity, but an increase in energy consumption of approximately 15 percent. The normal emission level around the machine is indicated by the monitor as 1 ppm to 2 ppm during operation and maintenance, with occasional brief spikes as high as 20 ppm during maintenance.

Case History #3

The first DuPont conversion of a Trane hermetic chiller from CFC-11 to HCFC-123 was at the DuPont Chestnut Run facility in Wilmington, Delaware. The nominal 2,110-kW (600-ton) unit furnishes chilled water for comfort cooling to several office buildings. This is one of the first converted hermetic units operating outside an OEM installation.

The unit was charged with 680 kg (1,500 lb) of HCFC-123 in October 1990. All the gaskets were changed to a neoprene-based material and the hermetic motor was replaced. Performance data show the same capacity with a slightly higher energy consumption. The normal indicated emission level around the machine is 1 ppm to 2 ppm.

Information

For more information about retrofitting CFC equipment for use with HCFC-123, contact the OEM or DuPont at (800) 235-SUVA.

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