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A-GAS™

Refrigerant R123

- Non-flammable subsitute for R11
- Application: Chillers

A GAS®

Introduction

R123 refrigerant is a replacement for R11 in chillers and is providing this new refrigerant to chiller manufacturers for use in new and existing chillers. DuPont has converted its own R11 chillers to R123.

General Considerations

Property comparisons of R123 with R11 are contained in Table 1. The boiling point of the new refrigerant is close to that of R11. This means that R123 will develop system operating pressures similar to R11. The environmental advantages of R123 over R11 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 R123 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

	R11	R123
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**l

* A treshold 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 timeweighted 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

R123 was selected as a replacement for R11 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 R123 than it did with R11. The difference in capacity and efficiency will depend on system component selection and operating conditions. Table 2 gives expected performance ranges.

Table 2

Retrofit Performance Comparison
R123 versus R11

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 R123 desirable from an environmental standpoint makes it a stronger solvent toward some plastics and elastomers than R11. Table 3 compares the relative effects of R11 and R123 on plastics. Several plastics used with R11 are also compatible with R123. As R123 use becomes more common, other materials will be tested and approved. Swelling and weight change of several elastomers after exposure to R11 and R123 are shown in Table 4. As in the case of plastics, R123 may affect some elastomers more than R11 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 R123. Reformulation of elastomers, or changes in system clearance tolerances, may prove useful toward incorporating these elastomers into systems for R123.

Lubricant/Refrigerant Relationships

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

Current lubricants used with R11 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 R11 take advantage of this full miscibility when considering lubricant return.

Existing refrigeration lubricants are being used with R123 in current field tests with no apparent problems.

Several families of lubricants that have acceptable miscibility with R123 have been identified. Although most applications for R123 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.

Table 3

Plastics Compatibility of R11 versus R123

(Screening Test Conditions: Plastic specimens exposed to liquid in sealed glass tubes at temperatures and exposure times given below.)

Plastic		Compatibility Ratings			
		4 r at 24°C (75°F)		100 r at 54°C (130°F)	
Chemical Type	Trade Name	R11	R123	R11	R123
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.
Delrin®, Teflon®, and Zytel® are DuPont registered trademarks. Lexan is a General Electric registered trademark. Alathon is an Oxy Petrochemicals Inc. registered trademark. Lucite is an ICI Americas registered trademark. Kralastic is a USS Chemicals registered trademark. Styron is a Dow Chemical registered trademark.

Table 4

Elastomer Compatibility of R11 versus R123

(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	R11	R123	R11	R123
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

Hypalon®, Viton® A, and Nordel® are DuPont registered trademarks.
Thiokol FA is a Morton Thiokol registered trademark.
Adiprene C is a Uniroyal registered trademark

Metals/Lubricant/Refrigerant Compatibility

DuPont conducted a severe test on R11 versus R123 with metals and a naphthenic lubricant at elevated temperatures. The results (Table 5) show that R123 is more stable. After tree days at 171°C (304°F), decomposition products of R123 were at least an order of magnitude less than decomposition products of R11. Samples exposed to R123 showed comparable, or less, visual effects than R11 samples.

Table 5

Stability of R123 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 — Oil: Witco Freezene, heavy white naphthenic mineral oil, 255 SUS

Copper — (approx. 55 cSt at 38°C [100°F])

Aluminum 1100

		R123	
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.)

Retrofitting Existing R11 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 R11 chiller may have to be replaced that chiller is to be successfully converted to R123.

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 troughout the system.

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 R11 to R123. 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 R123 are primarily due to the design of the impeller and to the evaporator and condenser tube surfaces, which have been optimized for R11. Equipment manufacturers are working to modify these components to restore performance to ranges experienced with R11, which has been the industry’s most efficient refrigerant.

Emission Concentrations

Emissions monitoring has shown that properly maintained and operated R123 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 R123 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 R123 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 R11 in September 1984, the 1,670 kW (475-ton) York open-drive chiller was converted to R123 (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 R123. 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 R123 is equivalent to that with R11 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 R11.

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 R123 (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 R123. 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 R123 in the room. This safety feature has never actuated. The remaining two identical chillers at this site were converted to R123 in May/June of 1990. All tree machines are operating without incident.

Case History #2

An open-drive chiller with a Carrier 17M compressor was converted to R123 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 R 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 R11 to R123 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 R123 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 R123, contact the OEM or your local supplier.

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Refrigerant GUIDE

TRADITIONAL

R12
OIL: Mineral, Alkylbenzene
APPLICATION: Auto Air, Med Temp Refrig, High Temp Refrig
CFC

R500
R12/152a (74/26%)
OIL: Mineral, Alkylbenzene
APPLICATION: Med Temp Refrig
CFC

R22
A-GAS
OIL: Mineral, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig, Air Conditioning
HCFC

R502
R22/115 (50/50%)
OIL: Mineral, Alkylbenzene
APPLICATION: Low Temp Refrig, Med Temp Refrig
CFC

R13
OIL: Mineral, Alkylbenzene
APPLICATION: Ultra Low Temp Refrig
CFC

R503
R23/13 (40/60%)
OIL: Mineral, Alkylbenzene
APPLICATION: Ultra Low Temp Refrig
CFC

INTERIM REPLACEMENT

A-GAS R401A
(MP 39) R22/152a/124 (53/13/34%)
OIL: Alkylbenzene, Polyol Ester
APPLICATION: Med Temp Refrig
HCFC

A-GAS R401B
(MP 66) R22/152a/124 (61/11/28%)
OIL: Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig
HCFC

A-GAS R409A
(FX 56) R22/124/142b (60/25/15%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

A-GAS R413A
(ISCEON 49) R218/134a/600a (9/88/3%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

A-GAS R406A
(GHG 12) R22/142b/600a (55/41/4%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

A-GAS R417A
(ISCEON 59) R125/134a/600a (46/50/4%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig, Air Conditioning
HFC

A-GAS R402A
(HP80) R125/290/22 (60/2/38%)
OIL: Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

A-GAS R402B
(HP81) R125/290/22 (38/2/60%)
OIL: Alkylbenzene, Polyol Ester
APPLICATION: Ice Machine
HCFC

A-GAS R403B
(ISCEON 69L) R290/22/218 (5/56/39%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

A-GAS R408A
(FX10) R125/143a/22 (7/46/47%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HCFC

LONG TERM REPLACEMENT

A-GAS SP34E
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Auto Air, Med Temp Refrig, Air Conditioning
HFC

A-GAS R134a
OIL: Polyol Ester, Polyalkylene Glycol
APPLICATION: Auto Air, Med Temp Refrig, Air Conditioning
HFC

A-GAS R413A
(ISCEON 49) R218/134a/600a (9/88/3%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HFC

A-GAS R407C
(Suva 9000) 32/125/134a (23/25/52%)
OIL: Polyol Ester
APPLICATION: Air Conditioning
HFC

A-GAS R410A
(AZ20) R32/125 (50/50%)
OIL: Polyol Ester
APPLICATION: Air Conditioning
HFC

A-GAS R417A
(ISCEON 59) R125/134a/600a (46/50/4%)
OIL: Mineral*, Alkylbenzene, Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig, Air Conditioning
HFC

A-GAS R404A
(FX70/HP62) R125/143a/134a (44/52/4%)
OIL: Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HFC

A-GAS R507
(AZ50) R125/143a (50/50%)
OIL: Polyol Ester
APPLICATION: Low Temp Refrig, Med Temp Refrig
HFC

A-GAS R23
OIL: Polyol Ester
APPLICATION: Ultra Low Temp Refrig
HFC

A-GAS R508A
R23/116 (39/61%)
OIL: Polyol Ester
APPLICATION: Ultra Low Temp Refrig
HFC

* 50/50 Mix of Mineral/Alkylbenzene preferred.
** Material for hoses & connections: check compatibility
Please Note: Not all products are available in all outlets

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