Opteon™ YF

Automotive Refrigerant

Properties, Uses,
Storage, and Handling

Chemours™

LOW GWP ©

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Introduction

Background

Under increasing pressure to address global warming concerns, a directive was issued in the European Union to begin the phaseout of high global warming potential (GWP) refrigerants in automotive air conditioning starting January 1, 2011. R-134a is the predominant refrigerant used globally in automotive air conditioning. R-134a has a 100 year GWP value of 1430 according to the Intergovernmental Panel on Climate Change 4th Assessment Report (AR4). Under the EU Mobile Air Conditioning (MAC) Directive, replacement refrigerants must have a GWP of less than 150. Therefore, R-134a will have to be phased out for use in the European Union for automobile air conditioning use.

Opteon™ YF Refrigerant Description

Opteon™ YF is a non-ozone depleting, low GWP refrigerant that was developed to meet the EU MAC Directive. With a GWP of 4, Opteon™ YF readily meets the EU MAC Directive.

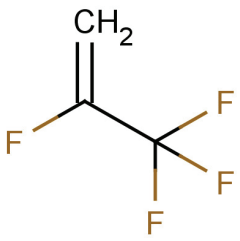
Opteon™ YF or HFO-1234yf is a hydrofluoro-olefin (HFO) or a hydrofluorinated compound with a double bond. The double bond gives HFO-1234yf some unique environmental properties. It is chemically stable in closed systems, such as mobile air conditioning systems. However, when Opteon™ YF is accidentally released into the atmosphere, it has a short atmospheric lifetime of 11-12 days (compared to 13 years for R-134a). The short atmospheric lifetime results in very low global warming potential. The low GWP and equivalent cooling capacity and energy efficiency to R-134a enables HFO-1234yf to provide better environmental benefits.

HFO-1234yf is a single component refrigerant; so, it does not have a temperature glide in heat exchangers. Opteon™ YF does not contain chlorine or bromine; so, it has an ozone depletion potential (ODP) of zero. While HFO-1234yf is similar to R-134a, it is mildly flammable and classified by ASHRAE Standard 34 as a class 2L refrigerant (ASTM E-681-04). The properties of HFO-1234yf have been well investigated and published in various journals. HFO-1234yf has a lower flammability limit (LFL) of 6.2 vol% in air and upper flammability limit (UFL) of 12.3 vol% in air at 23 °C (73 °F). Results indicate HFO-1234yf has mild flammability versus other refrigerant candidates when comparing lower flammability limit and the difference between LFL and UFL. HFO-1234yf has high minimum ignition energy, 5,000-10,000 mJ, indicating it is very difficult to ignite with a spark ignition source. It also has a low burning velocity of 1.5 cm/sec, indicating very slow flame propagation in the unlikely event an ignition were to occur. Basic chemical information for Opteon™ YF is given in **Table 1**, and its chemical structure is given in **Figure 1**.

Table 1: Opteon™ YF Chemical Information

Chemical Name	2,3,3,3- tetrafluoropropene
Molecular Formula	$CF_3CF=CH_2$
CAS Registry Number	754-12-1
Molecular Weight	114.04
Lower Flammability Limit, Vol. % in air (23 °C [73 °F], ASTM E681-09)	6.2
Upper Flammability Limit, Vol. % in air (23 °C [73 °F], ASTM E681-09)	12.3
Minimum Ignition Energy, mJ at 20 °C (68 °F) and 1 atm (Chemours in-house method. Tests conducted in 12 liter flask to minimize wall quenching effects)	5,000-10,000
Autoignition Temperature, °C (°F) (EC Physico/Chemical Test A15, Measured by Chilworth Technology, UK)	405 (761)
Heat of Combustion, MJ/kg per ASHRAE Standard 34 (Stoichiometric composition 7.73% in air)	10.7
Fundamental Burning Velocity, cm/s (per ISO 817, Measured by AIST, Japan)	1.5

Figure 1: Opteon™ YF Chemical Structure



Uses

Opteon™ YF performs similarly to R-134a from a cooling capacity and energy efficiency standpoint over a wide range of operating conditions. It is designed for use in direct expansion type systems for new OEM mobile air-conditioning system applications. Opteon™ YF exhibits similar operating temperatures and pressures compared to R-134a, and has the potential to replace R-134a in all applications where mild flammability is accepted.

Opteon™ YF has been listed by the U.S. Environmental Protection Agency (EPA) under the Significant New Alternatives Policy (SNAP) program as an acceptable substitute for ozone-depleting substances in motor vehicle air-conditioning applications, subject to use conditions.

Information on HFO-1234yf use conditions can be found in the U.S. Federal Register, 76 FR 17488. Opteon™ YF is subject to the Significant New Use Rule (SNUR) in the United States. Therefore, in the United States, this product should be used only in applications listed in the Opteon™ YF Safety Data Sheet (MSDS or eSDS) regulatory section.

Performance Comparison

Opteon™ YF thermodynamic properties are very similar to R-134a. Boiling point, critical point, and liquid and vapor density are comparable to R-134a, as shown in **Table 2** and **Figure 2**.

Table 2: HFO-1234yf vs. R-134a Property Comparison

Properties	HFO-1234yf	R-134a
Boiling Point, T_b	-29.5 °C (85.1 °F)	-26.1°C (79 °F)
Critical Point, T_c	94.7 °C (202.5 °F)	101 °C (214 °F)
P_{vap}, MPa (25 °C [77 °F])	0.683	0.665
P_{vap}, MPa (80 °C [176 °F])	2.62	2.63
Liquid Density, kg/m³ (25 °C [77 °F])	1092	1207
Vapor Density, kg/m³ (25 °C [77 °F])	37.9	32.4
ASHRAE Safety Class	A2L	A1

Information generated using REFPROP version 9, release date November 2010. Ref. State: Enthalpy = 200 kJ/kg, entropy = 1 kJ/kg-K for the saturated liquid at 0°C (32 F) (IIR)

Figure 2: HFO-1234yf Vapor Pressure Compared to R-134a

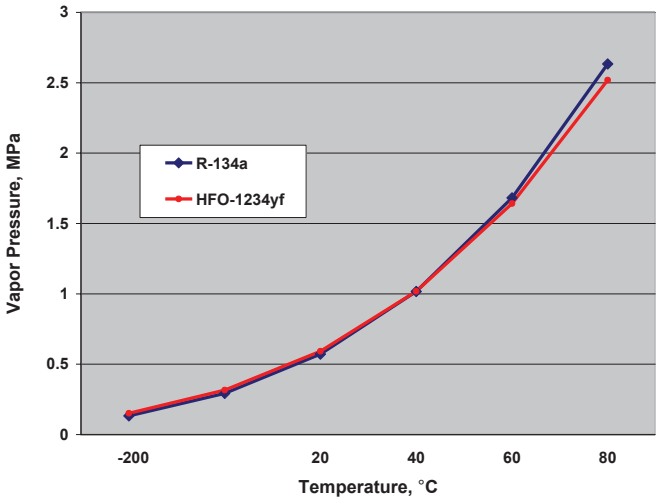


Figure 3: Infrared Spectra of HFO-1234yf – Transmittance

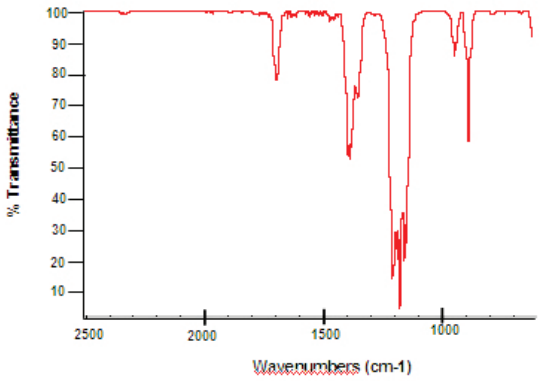
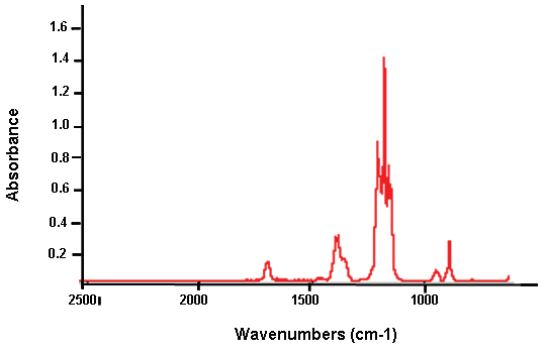


Figure 4: Infrared Spectra of HFO-1234yf – Absorbance



Physical Properties

General physical properties for Opteon™ YF are shown in **Table 3**. Additional thermodynamic and physical property data may be found in other Chemours publications.

Table 3: Opteon™ YF General Property Information

Physical Property	Unit	Opteon™ YF (HFO-1234yf)
Molecular Weight	g/mol	114.04
Vapor Pressure at 25 °C (77° F)	kPa abs psia	683 99.0
Boiling Point (1 atm)	°C °F	-29.5 -21.0
Critical Temperature	°C °F	94.7 202.5
Critical Pressure	kPa abs psia	3382 490.6
Critical Density	kg/m^3 lb/ft^3	476 29.7
Density (Liquid) at 25 °C (77 °F)	kg/m^3 lb/ft^3	1092 68.2
Density (Satd. Vapor) at 25°C (77 °F)	kg/m^3 lb/ft^3	37.9 2.37
Heat Capacity (Liquid) at 25 °C (77 °F)	kJ/kg·K Btu/lb·F	1.3921 0.21786
Heat Capacity (Vapor) at 25 °C (77 °F) (1 atm)	kJ/kg·K Btu/lb·F	0.9055 0.2165
Heat of Vaporization at Normal Boiling Point	kJ/kg Btu/lb	145.37
Thermal Conductivity at 25 °C (77 °F) Liquid Vapor (1 atm)	 W/m·K Btu/hr·ft·F W/m·K Btu/hr·ft·F	 0.063585 0.036763 0.013648 0.0078784
Viscosity at 25 °C (77 °F) Liquid Vapor (1 atm)	 mPa·s mPa·s	 0.15545 0.012372
Flammability Rating	ASHRAE Std. 34, ISO 817	A2L
Flammability Limit in Air (1 atm, 23 °C [73 °F]) LFL UFL	 vol % vol %	 6.2% 12.3%
Ozone Depletion Potential	CFC-11 = 1.0	0
Global Warming Potential (AR4)	CO_2 = 1	4
TSCA Inventory Status	Included	Yes
WEEL Exposure Limit**	ppm (8 and 12 hr TWA)	500

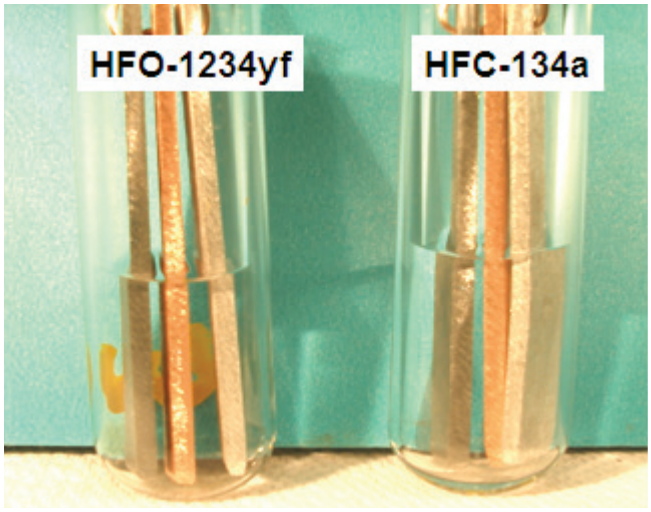
Chemical/Thermal Stability

Stability with Metals

Stability tests for refrigerants with metals are typically performed neat and in the presence of refrigeration lubricants. Traditionally, the stability test is run in sealed glass tubes at temperatures much higher than those encountered in refrigeration and air conditioning systems, and is therefore referred to as an accelerated aging test.

HFO-1234yf has been evaluated for thermal stability versus R-134a per ANSI/ASHRAE Standard 1997-99. Both the neat refrigerant and a mixture of lubricant and refrigerant (50/50 volume ratio) were tested. Typically, refrigerant or refrigerant/lubricant stability tests are conducted at 175 °C (347 °F) for 2 weeks. In one study, neat refrigerants were individually placed in sealed glass tubes containing metal coupons (Al, Cu, and carbon steel) and held at 200 °C (392 °F), a more severe condition, for two weeks **(Figures 5a** and **5b)**.

Figure 5a: HFO-1234yf and R-134a Thermal Stability Testing at 200 °C (392 °F) for 2 weeks



Results indicate neat HFO-1234yf and R-134a are thermally stable, even at extremely high temperatures (200 °C [392 °F]). There was no dulling of the steel coupon, no coating or visible corrosion to any of the metals tested; in addition, there was no fluoride ion or acid generation. No deposits or flocs formed during the testing.

As mentioned before, refrigerant/lubricant stability tests are normally conducted at 175 °C (347 °F) for 2 weeks. However, HFO-1234yf had very good thermal stability, and tests were conducted up to 200 °C (392 °F).

Figure 5b: HFO-1234yf and R-134a with PAG Thermal Stability Testing at 200 °C (392 °F) for 2 weeks

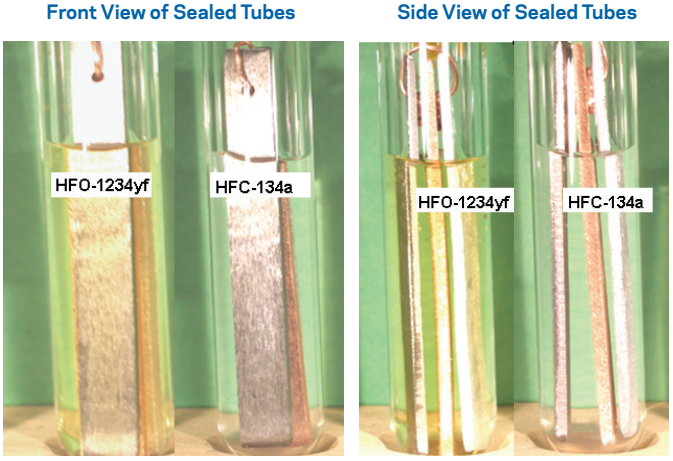
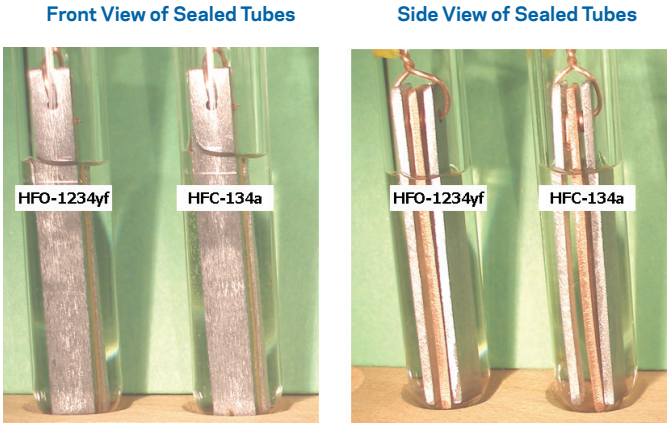


Figure 6: HFO-1234yf and R-134a with POE Lubricant, Thermal Stability Testing at 175 °C (347 °F) for 2 weeks



Results obtained from these sealed tube stability tests for Opteon™ YF indicate acceptable chemical stability in the presence of common metals used in refrigeration and air conditioning systems.

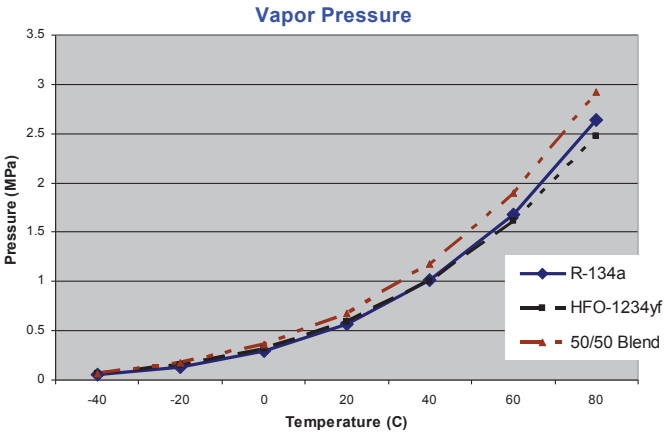
Thermal Decomposition

Like R-134a, Opteon™ YF will decompose when exposed to high temperature or flame sources. Decomposition may produce toxic and/or irritating compounds, such as hydrogen fluoride. The decomposition products released will irritate the nose and throat. Therefore, it is important to prevent exposure to decomposition products by following Chemours Material Safety Data Sheet (MSDS) recommendations for handling.

Compatibility Concerns If R-134a and Opteon™ YF Are Mixed

Opteon™ YF and R-134a are chemically compatible with each other. This means they do NOT react with each other and form other compounds. However, when these two refrigerants are mixed by accident or deliberately, they will form mixtures that are extremely difficult to separate. Mixtures of HFO-1234yf and R-134a refrigerant cannot be separated via on-site recycle machines or in typical facilities of an off-site reclaimer. The resulting blend will have a small glide and may still be flammable, depending upon degree of cross-contamination.

Accidental blends containing large amounts of R-134a within HFO-1234yf will be virtually impossible to service due to altering of P-T relationship. These mixtures will need to be disposed of by a certified waste handler through incineration.



Materials Compatibility

HFO-1234yf was evaluated for compatibility with a wide array of plastics and elastomers used in automotive air conditioning systems to ensure compatibility with materials used in standard, as well as electric and hybrid, systems. Materials selected were those used in seals, gaskets, hoses, motor fabrication, and insulation. Sealed tubes were prepared containing either HFO-1234yf or R-134a and plastic/ elastomeric material, and held at 100 °C (212 °F) for two weeks. Testing was done using more severe conditions (100 °C [212 °F]) than typical material testing (60 °C [140 °F]).

Elastomers were inspected for weight change, linear swell, and hardness change immediately after removing from the sealed tube and after 24 hours. Plastics were then inspected for weight change immediately after removing from the sealed tube and again 24 hours later. Materials exposed to HFO-1234yf were then compared to those materials exposed to R-134a. Results show that HFO-1234yf is slightly less aggressive to materials than R-134a.

Compatibility with Elastomers

Compatibility results are listed in **Tables 4** and **5** for Opteon™ YF in the presence of elastomers. It should be recognized that these data reflect compatibility in sealed tube tests, and that refrigerant compatibility in real systems can be influenced by the actual operating conditions, the nature of the polymers used, compounding formulations of the polymers, and the curing or vulcanization processes used to create the polymer. Polymers should always be tested under actual operating conditions before reaching final conclusions about their suitability.

Additional studies were also done with Opteon™ YF in the presence of selected elastomers and a 46 SUS PAG. Information is available in **Table 6**. Opteon™ YF has similar material compatibility with the selected elastomers in the presence of the PAG tested.

Table 4: Compatibility with Elastomers

Percent weight change, linear swell, and hardness change after 2 weeks at 100 °C (212 °F) in R-134a vs. HFO-1234yf immediately after removing from sealed tubes

	R-134a				HFO-1234yf			
Material	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating
Buna S (SBR)	2.7	0.4	-11.3	1	2.1	0.4	-9.7	1
Butyl Rubber	4.1	0.8	0.3	0	5.0	1.5	-2.3	0
EPDM (Nordel)	3.6	0.5	0.3	0	3.5	0.7	-1.7	0
Hypalon®	3.2	0.8	-3.3	0	2.7	0.9	-2.3	0
HNBR	15.2	4.5	-7.3	1	5.2	1.5	-8.7	0
NBR	14.1	3.5	3.0	1	5.8	1.2	7.3	0
Neoprene O-ring	-0 .4	-2.2	1.0	1	3.0	-2.6	1.0	0
Neoprene WRT	2.6	1.3	0.7	0	2.4	0.4	0.3	0
Polyurethane	13.5	-	-	2	1.0	-	-	2
Silicone	10.6	2.3	0.3	1	2.0	0.0	1.7	0
Viton™	47.4	15.1	-24.0	2	20.0	7.2	-20.3	2

Rating

0 – <10% wt gain and <10% linear swell and <10 hardness change

1 – >10% wt gain or > 10% linear swell or > 10 hardness change

2 – >10% wt gain and >10% linear swell and >10 hardness change

Table 5: Compatibility with Elastomers

Percent weight change, linear swell, and hardness change after 2 weeks at 100 °C (212 °F) in R-134a vs. HFO-1234yf 24 hours after removing from sealed tubes

	R-134a				HFO-1234yf			
Material	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating
Buna S (SBR)	1.1	0.2	-7.7	0	0.8	0.2	-14.3	1
Butyl Rubber	3.2	0.4	1.7	0	4.1	0.9	-4.7	0
EPDM (Nordel)	0.7	-0.1	0.7	0	0.6	-0.1	4.3	0
Hypalon®	2.6	0.5	-1.7	0	2.4	0.6	4.3	0
HNBR	9.9	2.5	-5.7	1	4.4	1.2	-7.7	0
NBR	8.0	2.0	1.7	0	4.6	1.0	5.0	0
Neoprene O-ring	-0.5	-1.6	7.7	0	2.3	1.1	1.7	0
Neoprene WRT	1.3	0.6	-0.7	0	1.3	0.3	3.7	0
Polyurethane	1.5	-	-	2	0.1	-	-	2
Silicone	-0.1	0.2	1.0	0	-0.4	-0.5	2.3	0
Viton™	8.0	2.7	-13.7	1	8.0	3.0	-16.7	1

Rating

0 – <10% wt gain and <10% linear swell and <10 hardness change

1 – >10% wt gain or > 10% linear swell or > 10 hardness change

2 – >10% wt gain and >10% linear swell and >10 hardness change

Table 6: Compatibility with Elastomers and 46 SUS PAG

Percent weight change, linear swell, and hardness change after 2 weeks at 100 °C (212 °F) in R-134a vs. HFO-1234yf 24 hours after removing from sealed tubes

	R-134a				HFO-1234yf			
Material	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating	Weight Change,%	Linear Swell, %	Hardness Change, delta	Rating
Butyl Rubber	-1.56	-1.12	-3.50	0	-1.94	-1.55	0.50	0
EPDM	-0.40	-1.06	-2.00	0	-1.16	-0.51	0.00	0
HNBR	8.62	2.08	-5.50	0	5.54	1.63	-7.00	0
NBR	2.96	0.02	-3.50	0	-0.69	-1.20	4.00	0
Neoprene WRT	-1.26	-0.58	2.00	0	-0.33	0.00	1.00	0
Silicone	1.44	-1.37	-2.50	0	-2.48	-0.51	-14.50	1

Rating

0 – <10% wt gain and <10% linear swell and <10 hardness change

1 – >10% wt gain or > 10% linear swell or > 10 hardness change

2 – >10% wt gain and >10% linear swell and >10 hardness change

Compatibility with Plastics

Compatibility results are listed in **Tables 7** and **8** for Opteon™ YF in the presence of plastics. It should be recognized that these data reflect compatibility in sealed tube tests, and that refrigerant compatibility in real systems can be influenced by the actual operating conditions, the nature of the plastics used, and the actual product formulations. Plastics should always be tested under actual operating conditions before reaching final conclusions about their suitability.

Additional studies were also done with Opteon™ YF in the presence of selected plastics and a 46 SUS PAG. Information is available in **Table 9**. Opteon™ YF has similar material compatibility with the selected plastics in the presence of the PAG tested.

Table 7: Compatibility with Plastics

Percent weight change after 2 weeks at 100 °C (212 °F) in HFO-1234yf vs. R-134a immediately after removing from sealed tubes

	R-134a			HFO-1234yf		
Material	Weight Change,%	Physical Change	Rating	Weight Change,%	Physical Change	Rating
Acetal (Delrin™)	2.7	0	0	0.7	0	0
Epoxy	0.1	0	0	-0.1	0	0
Motor Insulation	0.0	0	0	-2.9	0	0
Motor Insulation (Wire)	0.2	0	0	-0.1	0	0
Nylon Resin (Zytel™ 330)	0.3	0	0	-0.2	0	0
Phenolic	-0.8	0	0	-0.8	0	0
Polycarbonate	4.2	0	0	0.9	0	0
Polyester PBT (Crastin™ SK605)	12.5	0	1	1.1	0	0
Polyester PET (Bexloy™ 550)	9.3	0	0	5.3	0	0
Polyester Resin (Hytrel™ 5526)	7.6	0	0	4.2	0	0
Polyethylene (Alathon™)	1.3	0	0	1.7	0	0
Polyimide (Vespel™)	3.7	0	0	3.4	0	0
Teflon™ FEP	3.1	0	0	3.8	0	0
Teflon™ PTFE	2.7	0	0	3.0	0	0
Tefzel™ ETFE	6.0	0	0	4.9	0	0

Rating

0 – weight percent change <10 and no physical change

1 – weight percent change >10 or physical change 1 or greater

2 – weight percent change >10 or physical change 1 or greater

Physical Change

0 – no change

1 – surface change

2 – destroyed or dissolved

Table 8: Compatibility with Plastics

Percent weight change after 2 weeks at 100 °C (212 °F) in HFO-1234yf vs. R-134a 24 hours after removing from sealed tubes

	R-134a			HFO-1234yf		
Material	Weight Change,%	Physical Change	Rating	Weight Change,%	Physical Change	Rating
Acetal (Delrin™)	2.1	0	0	0.6	0	0
Epoxy	-0.3	0	0	-0.1	0	0
Motor Insulation	-1.6	0	0	-2.9	0	0
Motor Insulation (Wire)	-0.1	0	0	-0.2	0	0
Nylon Resin (Zytel™ 330)	-0.5	0	0	-0.4	0	0
Phenolic	-1.0	0	0	-0.8	0	0
Polycarbonate	3.9	0	0	0.8	0	0
Polyester PBT (Crastin™ SK605)	12.3	0	1	1.1	0	0
Polyester PET (Bexloy™ 550)	5.8	0	0	3.8	0	0
Polyester Resin (Hytrel™ 5526)	2.2	0	0	2.3	0	0
Polyethylene (Alathon™)	1.1	0	0	1.3	0	0
Polyimide (Vespel™)	3.2	0	0	3.2	0	0
Teflon™ FEP	2.7	0	0	3.2	0	0
Teflon™ PTFE	2.3	0	0	2.4	0	0
Tefzel™ ETFE	4.8	0	0	4.2	0	0

Rating
0 – weight percent change <10 and no physical change
1 – weight percent change >10 or physical change 1 or greater
2 – weight percent change >10 or physical change 1 or greater

Physical Change
0 – no change
1 – surface change
2 – destroyed or dissolved

Table 9: Compatibility with Plastics and 46 SUS PAG

Percent weight change after 2 weeks at 100 °C (212 °F) in HFO-1234yf vs. R-134a 24 hours after removing from sealed tubes

	R-134a			HFO-1234yf		
Material	Weight Change,%	Physical Change	Rating	Weight Change,%	Physical Change	Rating
Epoxy	0.25	2	1	0.26	2	1
Nylon (Zytel™ 330)	-1.41	2	1	-1.54	2	1
Polyester PET (Bexloy™ 550)	2.81	1	1	2.01	1	1
Polyester	5.58	1	1	4.40	1	1
Polyimide (Vespel™)	0.67	1	1	0.15	1	1

Rating
0 – weight percent change <10 and no physical change
1 – weight percent change >10 or physical change 1 or greater
2 – weight percent change >10 or physical change 1 or greater

Physical Change
0 – no change
1 – surface change
2 – destroyed or dissolved

Compatibility with Desiccants

In refrigeration systems, keeping the refrigerant and lubricant free of moisture is very important. Dryers filled with moisture-absorbing desiccant are typically used to prevent moisture accumulation. The required desiccant amount/type depends on 1) refrigerant solubility and reactivity with water, 2) rate of water permeation into a system, and 3) the desired level of system dryness. R-134a systems currently use UOP XH-7™ or UOP XH-9™ type desiccants with about 40-60 grams of charge.

Opteon™ YF has generally been found to be compatible with current R-134a UOP XH-7™ and UOP XH-9™ driers used in automotive systems for R-134a. In general, Opteon™ YF has moisture pick-up similar (a little lower) to R-134a. HFO-1234yf was found to be generally less reactive with desiccant than R-134a.

Lubricants

Lubricant return to the compressor is required to provide proper lubrication. One factor that affects oil return is the liquid-phase lubricant/refrigerant miscibility, particularly at evaporator temperatures. Miscibility is the ability of two liquids to mix and form a single liquid phase—similar to water and alcohol. Ideally, the lubricant/refrigerant pair have sufficient miscibility or mutual solubility to allow the lubricant to flow with the liquid refrigerant and return to the compressor. Even if the lubricant/refrigerant pair are not miscible (two liquid phases form) in the evaporator, they may still have some degree of solubility. Solubility of refrigerant in lubricant lowers lubricant viscosity, which helps it flow through the evaporator and return to the compressor. This is why many refrigeration systems can operate properly, even though the lubricant and refrigerant are immiscible (yet partially soluble) at evaporation temperatures. Other factors, such as refrigerant vapor velocity and system geometry, play key roles in lubricant return. Overall, it is important to note that lubricant/refrigerant miscibility is helpful, but not necessarily essential, for proper system operation.

Lubricant selection is based on many factors, including compressor wear characteristics, material compatibility, and lubricant/refrigerant miscibility (this can affect oil return to the compressor). Opteon™ YF, similar to R-134a, is compatible with PAG and POE lubricants. It should be noted that HFO-1234yf, while having similar material compatibility to R-134a with commercially available PAGs, did not have the same level of miscibility. Therefore, PAGs used with HFO-1234yf should be those PAGs that are designed for use with HFO-1234yf.

Table 10: Miscibility of Opteon™ YF in Various Lubricants

Lubricant Type	POE		PAG 1		PAG 2	
Wt% Refrigerant	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
10%	-65 °C (-85 °F)	80 °C (176 °F)	-65 °C (-85 °F)	80 °C (176 °F)	-65 °C (-85 °F)	80 °C (176 °F)
25%	-65 °C (-85 °F)	80 °C (176 °F)	-65 °C (-85 °F)	80 °C (176 °F)	-65 °C (-85 °F)	80 °C (176 °F)
50%	-65 °C (-85 °F)	80 °C (176 °F)	-65 °C (-85 °F)	80 °C (176 °F)	Immiscible	Immiscible
75%	-50 °C (-58 °F)	65 °C (149 °F)	-45 °C (-49 °F)	25 °C (77 °F)	Immiscible	Immiscible
90%	-65 °C (-85 °F)	75 °C (167 °F)	-50 °C (-58 °F)	35 °C (95 °F)	Immiscible	Immiscible

Safety

Decomposition

What causes decomposition?

Refrigerants will decompose when exposed to high temperatures from flames or electric resistance heaters. Decomposition may produce toxic and irritating compounds, such as hydrogen fluoride, fluorinated compounds, and/or carbon oxides.

How can I tell if a refrigerant has thermally decomposed?

The strong odors released from the thermally decomposed refrigerant will provide early warning and likely result in an attempt to evacuate the area. The irritating fumes released from thermal decomposition will likely irritate the nose, throat, eyes, and skin. Follow all Chemours recommendations listed in the extended Safety Data Sheet or Material Safety Data Sheet for refrigerant handling to prevent refrigerant thermal decomposition and other hazards.

Are thermal decomposition products hazardous?

Yes. The acidic vapors produced are dangerous, and the area should be evacuated immediately and ventilated to prevent exposure to personnel. Anyone exposed to the thermal decomposition products should be taken to fresh air and medical treatment sought immediately. The exposure area should not be re-entered until it is deemed safe by the appropriate authorities.

Inhalation Toxicity

Is Opteon™ YF toxic?

This refrigerant has an excellent safety profile and can be safely used when handled in accordance with Chemours recommendations and exposures are maintained at or below appropriate occupational exposure limits (OELs).

What are OELs?

Occupational exposure limits are airborne chemical concentrations that are expected to be safe for nearly all healthy workers who may be exposed over a working lifetime. Occupational exposure limits are set by several organizations or manufacturers. Some examples of OELs are the Workplace Environment Exposure Limit (WEEL), the Threshold Limit Value (TLV), and the Allowable Exposure Limit (AEL). The American Industrial Hygiene Association WEEL committee has adopted a WEEL of 500 ppm 8-hr time weighted average for HFO-1234yf, which is consistent with the low toxicity profile for Opteon™ YF.

What are common symptoms of overexposure?

Inhalation abuse and misuse may be associated with temporary central nervous system depression with narcosis (sleepiness), lethargy, weakness, dizziness, a feeling of intoxication, incoordination, unconsciousness, and may be fatal.

What is cardiac sensitization?

Cardiac sensitization is a situation where the body has a heightened sensitivity to adrenaline. Under such circumstances, the heart rhythm may be affected with a potentially fatal outcome. Cardiac sensitization potential has been observed with many hydrocarbons and fluorocarbons. For example, R-134a has a cardiac sensitization threshold of 75,000 ppm in highly susceptible laboratory model systems. However, in these same laboratory model systems, HFO-1234yf did not produce cardiac sensitization at the highest concentration tested (120,000 ppm).

Can inhaling Opteon™ YF vapors cause suffocation?

Any substance can cause suffocation if the chemical concentration is high enough to displace the oxygen needed to maintain a healthy breathing atmosphere. If a large release of refrigerant occurs, vapors can concentrate near the floor or in low areas, displace available oxygen, and potentially cause suffocation. In the event of a large spill or leak, always wear proper respiratory and other personal protective equipment per Chemours eSDS or MSDS guidelines. Canister-type respiratory masks do not provide adequate protection when entering an enclosed space with high levels of refrigerant vapors. These should be used for escape purposes only. Use self-contained breathing apparatus or an air-line respirator when entering confined areas, such as tanks or basement areas, where vapors may have accumulated. Test all work areas for available oxygen using appropriate monitoring equipment before entering. Place a second employee outside the work area when you enter, and use a lifeline to that employee.

How can I work safely on systems in enclosed areas?

1. Make sure all relief and purge vent piping is routed outdoors and away from all air intakes to the building.

2. Make certain the area is well-ventilated. Use auxiliary ventilation such as blowers or fans, if necessary, to disperse refrigerant vapors.

3. Test the work area for available oxygen before entering enclosed areas. Do not use a leak monitor to test for oxygen. A refrigerant leak detector will not tell you if adequate oxygen is present to sustain life.

4. Install refrigerant leak detection and oxygen monitoring equipment in the work areas. For a discussion of leak detection equipment, see Chemours technical bulletin ARTD-27A. Also, refer to ASHRAE Standard 15, "Safety Code for Mechanical Ventilation," for ventilation and air monitoring requirements for equipment rooms.

What should I do if a large refrigerant leak or spill occurs?

Do not attempt to enter the area to repair equipment until the vapors are dispersed OR until you are equipped with proper breathing apparatus. Evacuate everyone until the area has been ventilated. Use blowers or fans to circulate air at the floor level and in any basement or low areas.

- Appropriate respiratory protection equipment should be readily available in case of a large release.

- Personnel should be trained how to use this equipment.
- Consult the eSDS or MSDS for additional safety and use information.

Is the deliberate inhalation of Opteon™ YF dangerous?

Intentional misuse or deliberate inhalation of any hydrocarbon or fluorocarbon refrigerant is potentially dangerous, as they may disrupt heart rhythm and cause death without warning. This practice is extremely dangerous.

Can I smell Opteon™ YF?

Most refrigerants have such a faint odor that they can be difficult to detect, even at dangerous levels. Do not use smell as a test for safe levels of refrigerants in a work area. Frequent leak checks and air monitoring are the only adequate ways to determine that areas are safe for entry and work.

Skin and Eye Contact

Is skin or eye contact with Opteon™ YF hazardous?

At room temperature, refrigerant vapors have little effect on skin or eyes.

Always wear protective clothing, including long-sleeve clothing and gloves, when there is a risk of exposure to liquid refrigerants. Protection should include goggles and face shield to protect the eyes. If liquid refrigerant enters your eyes, flush them with plenty of water and then seek medical attention immediately.

Is frostbite a possible hazard?

In liquid form, this refrigerant can freeze skin or eyes on contact, causing frostbite. If you are splashed with liquid, immediately remove all clothing that contains refrigerant to prevent additional freezing. Soak the exposed area in lukewarm water, not cold or hot. Do not use dressings or ointments. Then seek medical attention immediately.

Flammability

As mentioned previously, Opteon™ YF has been assigned a safety classification of A2L, mildly flammable, based on flammability tests conducted according to ASHRAE Standard 34 and ISO 817 guidelines. This refrigerant can be used safely following industry and Chemours recommended guidelines. Before working with this refrigerant, read all safety data information and Chemours handling guidelines.

Refrigerants should not be exposed to open flames or electrical heating elements. High temperatures and flames can cause refrigerants to decompose, releasing toxic and irritating fumes. In addition, a torch flame can become dramatically larger or change color if used in high concentrations of many refrigerants, including R-134a, as well as many other refrigerants. This flame enhancement can cause surprise or even injury. Always recover refrigerants, evacuate equipment, and ventilate work areas properly before using any open flames.

Based on the above information, the following operating practices are recommended.

- Do Not Mix with Air for Leak Testing
  - Equipment should never be leak tested with a pressurized mixture of Opteon™ YF and air. Pressurized mixtures of dry nitrogen and Opteon™ YF can be used for leak testing.
- Bulk Delivery and Storage
  - Opteon™ YF is flammable and needs to be considered in the design and maintenance of bulk delivery and storage facilities. Before designing any systems, read all Chemours safety information, and follow all local/regional regulations that may apply to bulk delivery and storage facilities, including all site safety requirements.
  - Tanks should normally be evacuated prior to initial filling and should never be filled while under positive air pressure.
  - Tank pressure should never be allowed to exceed the maximum allowable working pressure when filling with Opteon™ YF. Relief devices on either the tanks or the supply system should be present and in good operating condition.
  - Tank pressures should be monitored routinely.
  - Air lines should never be connected to storage tanks.
- Filling and Charging Operations
  - Before evacuating cylinders or refrigeration equipment, any remaining refrigerant should be removed by a recovery system.
  - Vacuum pump discharge lines should be free of restrictions that could increase discharge pressures and result in the formation of combustible mixtures.

  - Cylinders or refrigeration equipment should be evacuated at the start of filling and should never be filled while under positive air pressure.
  - Filled cylinders should periodically be analyzed for air (non-absorbable gas [NAG]).

- Refrigerant Recovery Systems. Efficient recovery of refrigerant from equipment or containers requires evacuation at the end of the recovery cycle. Be sure to use equipment that meets the flammability requirements of HFO-1234yf. Suction lines to a recovery compressor should be periodically checked for leaks to prevent compressing air into the recovery cylinder during evacuation. In addition, the recovery cylinder pressure should be monitored and evacuation stopped in the event of a rapid pressure rise indicating the presence of air. The recovery cylinder contents should then be analyzed for NAG, and the recovery system leak checked if air is present. Do not continue to evacuate a refrigeration system that has a major leak.

Air Monitors and Leak Detection

Service personnel have used leak detection equipment for years when servicing equipment. Leak detectors exist not only for pinpointing specific leaks, but also for monitoring an entire room on a continual basis for the absence of oxygen or presence of refrigerant. There are several reasons for leak pinpointing or area monitoring, including conservation of refrigerants, protection of valuable equipment, reduction of fugitive emissions, and protection of employees.

Prior to the purchase of a detector or monitor, make sure you consider your requirements or criteria for the monitor, such as sensitivity, detection limits, selectivity, product flammability, and/or flammability limits in air. Air monitors and leak detectors should be labeled as appropriate for use with HFO-1234yf. UV dyes should meet SAE J 2297, and electronic leak detectors should meet SAE J2913 and/or VDA requirements.

Types of Detectors

Using selectivity as a criteria, leak detectors can be placed into one of three categories: nonselective, halogen-selective, or compound-specific. In general, as the specificity of the monitor increases, so does the complexity and cost. Other methods used to find leaks are to add fluorescent additives to the system or coat the suspect area with a soapy water solution, and look for soap bubbles.

Nonselective Detectors

Nonselective detectors are those that will detect any type of emission or vapor present, regardless of its chemical composition. These detectors are typically quite simple to use, very durable, inexpensive, and usually portable. However, their inability to be calibrated, long-term drift, lack of selectivity, and lack of sensitivity limit their use for area monitoring.

Halogen-Selective Detectors

Halogen-selective detectors use a specialized sensor that allows the monitor to detect compounds containing fluorine, chlorine, bromine, and iodine, without interference from other species. The major advantage of such a detector is a reduction in the number of "nuisance alarms"—false alarms caused by the presence of some compound in the area other than the target compound.

These detectors are typically easy to use, feature higher sensitivity than the nonselective detectors (detection limits are typically <5 ppm when used as an area monitor and <0.05 oz/yr when used as a leak pin-pointer), and are very durable. In addition, due to the partial specificity of the detector, these instruments can be calibrated easily.

Compound-Specific Detectors

The most complex detectors, which are also the most expensive, are compound-specific detectors. These units are typically capable of detecting the presence of a single species, without interference from other compounds.

Fluorescent Additives (UV Dyes)

Fluorescent additives have been used in refrigeration systems for several years. These additives, invisible under ordinary lighting, but visible under ultraviolet (UV) light, are used to pinpoint leaks in systems. The additives are typically placed into the refrigeration lubricant when the system is serviced. Leaks are detected by using a UV light to search for additive that has escaped from the system. The color of the additive when subjected to UV light is normally a bright green or yellow and is easily seen.

As a leak pin-pointer, fluorescent additives work very well, because large areas can be rapidly checked by a single individual. And, the use of high quality battery-powered UV lights has made this task even simpler. Leak rates of less than 0.25 oz/yr can be found with the additives. The only drawback to the use of additives is that some areas may be visually unobservable, due to cramped spaces.

One cautionary note concerning the use of fluorescent additives: the compatibility of the specific additive with the lubricant and refrigerant should be tested prior to use. For detailed information about which lubricants and refrigerants have been tested with which additives, contact the fluorescent additive manufacturers.

Shipping, Storage, and Handling

Shipping Information (Cylinders, Half-Ton, Ton, and ISO Containers)

For information on shipping containers in your specific region, contact your local Chemours refrigerant distributor or technical service representative. As mentioned previously, Opteon™ YF is subject to a Significant New Use Rule (SNUR) and in the United States should be used only in applications listed in the Opteon™ YF Safety Data Sheet (MSDS or eSDS) regulatory section.

ADR

Class	2
Classification Code	2F
HI Number	23
UN Number	3161
Labeling Number	2.1
Proper Shipping Name	Liquefied gas, flammable, n.o.s. (2,3,3,3,-Tetrafluoropropene)
Tunnel Restriction Code	B/D

IATA

Class	2.1
UN Number	3161
Proper Shipping Name	Liquefied gas, flammable, n.o.s. (2,3,3,3,-Tetrafluoropropene)

DOT

UN Number	3161
Proper Shipping Name	Liquefied gas, flammable, n.o.s. (2,3,3,3,-Tetrafluoropropene)
Class	2.1
Labeling Number	2.1

Cylinders Storage and Handling

Depending upon the region, Chemours offers a wide variety of returnable cylinders from 45 kg (6 L) to 100 kg (108 L). In some regions, and depending upon local regulations, Chemours is also able to offer disposable cylinders. Details on available cylinders can be obtained from your local Chemours representative.

- Keep cylinders at temperature not exceeding 52 °C (126 °F).
- Do not roll large cylinders. Use a hand cart or dolly to move.
- Do not store cylinders with or near incendiary items.
- Do not pierce or burn the cylinder, except when following Dispose-A-Can™ (DAC™) cylinder disposal procedures.
- Never refill disposable cylinders with anything. The shipment of refilled disposable cylinders is prohibited by EU and U.S. regulations.
- Never refill returnable cylinders without Chemours consent.
- If cylinders must be stored outside, store under a roof to protect from weather extremes.
- If a large number of cylinders must be stored in an unoccupied space, potentially exceeding the lower flammability limit (LFL) per room volume in the event of catastrophic leak, be sure to check with local regulations, country codes, and fire officals for additional guidance.

Aftermarket Cylinder Use and Storage

HFO-1234yf is a mildly flammable refrigerant gas as classified by ASHRAE standard 34 and ISO 817. Therefore, while local codes may differ from region to region, it is always best practice to limit the amount of flammable product in the aftermarket air conditioning service shop.

Opteon™ YF aftermarket cylinder size will be 4.5 kg or 10 lb. Typical air conditioning service shop bays are at least 28 m^2 or 300 ft^2, roughly a little larger than the size of a large car. Therefore, even in the event of a leak from one cylinder in a garage bay, the LFL will not be exceeded.

Bulk Storage Systems

Chemours can supply storage systems to its Opteon™ YF customers. The type of systems can vary from region to region and from customer site to customer site. Some systems are prefabricated, tested, and ready to install on-site. The units are designed to optimize economy, efficiency, and safety in the storage and dispensing of these refrigerants. The delivered systems include all components, such as storage tanks, pumps, piping, valves, motors, and gauges, as an integrated unit. All systems are equipped with the Chemours Fluorochemical Emission Elimination Delivery (FEED) or alternative system to prevent emissions during deliveries and with dual pumps to

provide an installed spare. The units are skid-mounted, and require only placement on a concrete pad and connection to electrical and process systems.

Your Chemours Marketing Representative can arrange for guidance on site selection, purchase, installation, startup, and maintenance.

Bulk Storage Preparation

Bulk Storage Tank

Bulk storage tanks will need to meet required regulatory codes and standards. Conversion from an existing HFC-134a bulk storage tank to HFO-1234yf can require significant planning to meet the requirements needed for flammable material storage. Depending on the history of the bulk storage container shell, there will be a need to ensure there is no degradation of the interior shell surfaces (no pitting, gouges, etc.). The same issue will apply to the exterior of the bulk storage container. New or refurbished bulk tanks will need to be checked for possible manufacturing residue particle debris, including cleaning agents or solutions, that could negatively impact product quality.

Piping and Lines

Pipe lines that convey HFO-1234yf will have to be compliant for flammable gas. In general, carbon steel or stainless steel lines that are used for HFC-134a can be re-used for HFO-1234yf, but need to be checked for additional flammable gas requirements. Changing the lines from HFC-134a to HFO-1234yf will also require that new O-rings and seals are used. The general rule is that once the line is broken, the seals/O-rings lose integrity and can be a potential leak point. Therefore, complete replacement of seals, gaskets and O-rings is common.

There has been a tendency to overlook the small points in refrigerant line installations. One common point that can have major impact on future refrigerant quality is line cleanliness. While lines are new, there could be residual particles from the welding process and other manufacturing processes that can negatively impact product quality. Therefore, it is imperative that proper cleaning procedures are used.

Bulk Tank and Line Preparation

Do's

- Do ensure that the bulk tank and lines are clean before starting the commissioning process. If these are not clean or suspected of being fouled with welding flux, oil, or debris, clean the contaminated surfaces with mild detergent or even clean warm water.
- Do ensure that the bulk tank and lines are dry. Purge the bulk tank and lines with dry nitrogen (99.99% purity), which has a maximum moisture specification of 10 ppm.
- Do ensure that the bulk tank and lines are evacuated to at least 28.5 in Hg vacuum prior to filling with refrigerant. This step should take only 1–2 days, but can take longer depending on volume to be evacuated.

Don'ts

- Don't use strong cleaning agents to clean the bulk tank, lines, or filling equipment. While Opteon™ YF has good material compatibility and stability, it is not compatible with strong oxidizers—such as those found in peroxide-type cleaning agents.
- Don't let extraneous chemicals, such as thread locking agents or sealants, get into the system and possibly lead to contamination and incompatibilities. There are at least several hundred different thread locking agents, and while one from a particular family may be compatible with Opteon™ YF, that does not ensure that all products are compatible.
- Don't let excess air or moisture get into the system. As with all refrigerants, excessive amounts of air and moisture can lead to improper vehicle filling and poor A/C system performance.

Converting Bulk Storage Tanks from R-134a to Opteon™ YF

Before switching from R-134a to Opteon™ YF refrigerant, the existing storage equipment must be checked to verify that it is adequate and can be converted for use with HFO-1234yf. Storage tanks built to the specifications of the Pressure Equipment Directive (PED) 97/23/EC of the EU or the American Society of Mechanical Engineers (ASME) Pressure Vessel Code are required to have a metal nameplate indicating each tank's maximum allowable working pressure (MAWP). The rating must be 186 psig (1375 kPa abs) or higher for Opteon™ YF service. The set pressure and capacity of the relief devices on the top of the tanks must also be verified and changed, if necessary.

Due to the flammability of Opteon™ YF, it is recommended that an on-site visit be conducted by appropriate personnel to verify potential for tank conversion and necessary steps for this process. Your Chemours Marketing Representative can arrange for guidance on site selection, purchase, installation, startup, and maintenance.

Material Compatibility Concerns

Most metal components suitable for use with R-134a are also compatible with Opteon™ YF, including standard types of carbon steel, aluminum, and copper. Some elastomeric or non-metallic components suitable for R-134a may not be adequate. However, manufacturing of materials varies regionally across manufacturers. Therefore, all elastomeric or nonmetallic components throughout the system must be identified and their compatibility with Opteon™ YF verified. See Material Compatibility section for starting point guidelines. For complete reliability, any component that cannot be properly identified should be replaced.

In a fluorocarbon storage system, elastomers are most commonly found in:

- Packing and seats of manual valves
- Pressure-relief device seats
- Flange and manway gaskets
- Mechanical pump seals
- Wet-end pump gaskets and O-rings
- Filter O-rings
- Sight-flow indicator gaskets
- Back-pressure regulator diaphragms and O-rings

Handling Precautions for Opteon™ YF Shipping Containers

The following rules for handling these refrigerants containers are strongly recommended:

- Use personal protective equipment, such as safety glasses with side shields, gloves, and safety shoes, when handling containers. Eye protection should comply with EN 166 or ANSI Z87.1. Additionally, wear a face shield when the possibility exists for face contact due to splashing, spraying, or airborne contact with this material. Protective gloves should comply with EN 374 or U.S. OSHA guidelines.
- The choice of an appropriate glove does not depend only on its material, but also on other quality features, and is different from one producer to the other. Please review the instructions regarding permeability and breakthrough time that are provided by the glove supplier. Also take into consideration the specific local conditions under which the product is used, such as the danger of cuts, abrasion, and potential contact time.
- Avoid skin contact with liquid refrigerant, as it may cause frostbite.
- Never heat a container to a temperature higher than 52 °C (125 °F).
- Never apply direct flame or live steam to a container or valve.
- Never use a lifting magnet or sling (rope or chain) when handling containers. A crane may be used when a safe cradle or platform is used to hold the container.
- Never use container for rollers, supports, or any purpose other than to store refrigerants.
- Never tamper with the safety devices in the valves or containers.
- Never attempt to repair or alter containers or valves.
- Never force connections that do not fit. Make sure the threads on the regulators or other auxiliary equipment are the same as those on the container valve outlet.
- Keep valves tightly closed, and valve caps and hoods in place, when containers are not in use.
- Protect containers from any object that will result in cuts or other abrasion in the surface of the metal.
- Use a vapor recovery system to collect refrigerant vapors from lines after unloading a container.

Recovery, Reclamation, Recycle, and Disposal

Recovery

Recovery refers to the removal of Opteon™ YF from equipment and collection in an appropriate external container. As defined by the U.S. Air Conditioning, Heating, and Refrigeration Institute (AHRI), a recovery does not involve processing or analytical testing. These refrigerants may be recovered from refrigeration equipment using permanent on-site equipment or from mobile air-conditioning systems using portable recovery recycle recharge (R/R/R) machines. The portable R/R/R machines

contain a small compressor and an air-cooled condenser, and may be used for vapor or liquid recovery. At the end of the recovery cycle, the system is evacuated to remove vapors.

Standards for recovery equipment are readily available. Please check the appropriate regional regulations. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it can be used to recover HFO-1234yf refrigerant.

NOTE: Due to mild flammability of Opteon™ YF compared to R-134a, equipment should be designed to handle HFO-1234yf. It is not adequate to use existing R-134a R/R/R or recovery-only equipment with HFO-1234yf. Equipment used should meet all regulatory and industry standards. While there may be other standards, some known appropriate R/R/R standards or recovery-only standards are SAE J2843, SAE J2851, and/or the VDA standards.

Reclamation

Reclamation refers to the reprocessing of used Opteon™ YF to new product specifications. Quality of reclaimed product is verified by chemical analysis. In the United States, HFO-1234yf refrigerant is included in the Chemours refrigerant reclamation program. Contact Chemours or one of its refrigerant distributors for further information.

Reclamation offers advantages over on-site refrigerant recycling procedures, because these systems cannot guarantee complete removal of contaminants. Putting refrigerants that do not meet new product specifications back into expensive equipment may cause damage to the automotive system and/or contaminate virgin refrigerant.

Recycle

Refrigerant recycle refers to the reduction of used refrigerant contaminants using devices that reduce oil, water, acidity, and particulates. Recycle is usually a field or shop procedure with no analytical testing of refrigerant. Before using one of these devices with Opteon™ YF, consult the manufacturer to confirm compatibility.

Disposal

Disposal refers to the destruction of used Opteon™ YF. Disposal may be necessary when the refrigerant has become badly contaminated with other products and no longer meets the acceptance specifications of Chemours or other reclaimers. Licensed waste disposal firms are available for this purpose. Be sure to check the qualifications of any firm before sending them used Opteon™ YF.

For more information on the Opteon™ family of refrigerants, or other refrigerants products, visit opteon.com or call (800) 235-7882.

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