Opteon™ XP

Refrigerants

Properties, Uses, Storage, and Handling

Opteon™ XP10 (R-513A)

Opteon™ XP40 (R-449A)

Opteon™ XP44 (R-452A)

Chemours™

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Introduction

Background

The Opteon™ XP series, including Opteon™ XP10, XP40, and XP44 refrigerants, was introduced by Chemours as more environmentally sustainable refrigerants for refrigeration and air conditioning applications. They are nonflammable, non-ozone depleting, low global warming potential (GWP) hydrofluoroolefin (HFO)-based refrigerants that replace the current ozone-depleting chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC)-based refrigerant options, as well as higher GWP hydrofluorocarbon (HFC) refrigerant options.

Description

Opteon™ XP10 (R-513A) is a replacement for R-134a in positive displacement, direct expansion, medium-temperature commercial and industrial refrigeration and air conditioning applications, including centrifugal chillers. Opteon™ XP10 is an azeotropic refrigerant offering excellent capacity and efficiency match for R-134a in new systems, as well as for retrofit of existing systems.

Opteon™ XP40 (R-449A) is a replacement for R-404A/R-507, R-22, or R-407 series refrigerants that offers the optimal balance of properties. It can be used in positive displacement, direct expansion, and low- and medium-temperature commercial and industrial refrigeration applications. Opteon™ XP40 is suitable for use in new installations, as well as for retrofit of existing systems.

Opteon™ XP44 (R-452A) is a replacement for R-404A/R-507 in positive displacement, direct expansion, low- and medium-temperature commercial, industrial, and transport refrigeration applications. Opteon™ XP44 is suitable for use in new equipment, as well as for retrofit of existing systems, while matching compressor discharge temperatures of R-404A.

Table 1. Opteon™ Compositions (wt%)

	R-32	R-125	R-1234yf	R-134a	Blend Molecular Weight
Opteon™ XP10 (R-513A)	0.0	0.0	56.0	44.0	108.4 g/mol
Opteon™ XP40 (R-449A)	24.3	24.7	25.3	25.7	87.2 g/mol
Opteon™ XP44 (R-452A)	11.0	59.0	30.0	0.0	103.5 g/mol

Table 2. Refrigerant Information

Refrigerant	Chemical Name	Formula	CAS No.	Molecular Weight
HFC-32	Difluoromethane	CH_2F_2	75-10-5	52.0 g/mol
HFC-125	Pentafluoroethane	CF_3CHF_2	354-33-6	120.0 g/mol
HFO-1234yf	2,3,3,3-Tetrafluoropropene	CF_3CFCH_2	754-12-1	114.0 g/mol
HFC-134a	1,1,1,2-Tetrafluoroethane	CF_3CH_2F	811-97-2	102.0 g/mol

Uses

The refrigerants that make up the Opteon™ XP series are all safe and nonflammable (ASHRAE A1 Safety classification). They have been approved for use as refrigerants by major equipment and component manufacturers and extensively field tested, as well as are compatible with existing equipment designs and lubricants. These existing equipment designs include systems running R-134a, R-22, R-404A/R-507, and R-407 series refrigerants. Like other refrigerant blends, Opteon™ XP10, XP40, and XP44 can be topped off after leaks.

Opteon™ XP10 (R-513A)

- Applications
  - Medium-temperature circuit of hybrid cascade systems
  - Medium-temperature commercial and industrial DX refrigeration
  - Water chillers, AC, heat pumps
- Benefits
  - Low GWP: 56% compared to R-134a
  - Excellent capacity and energy efficiency match
  - Close performance match, retrofit and new systems
  - Azeotrope with zero glide

Opteon™ XP40 (R-449A)

- Applications
  - Low- and medium-temperature commercial and industrial DX refrigeration
  - Supermarkets: centralized racks, distributed systems, walk-in coolers/freezers
  - Food service and cold storage
  - Self-contained systems
- Benefits
  - Low GWP: 65% reduction compared to R-404A/R-507
  - Alternative to R-407 series low-/medium-temperature (equivalent capacity)
  - 8-12% lower energy consumption

Opteon™ XP44 (R-452A)

- Applications
  - Low- and medium-temperature commercial and industrial DX refrigeration
  - Low- and medium-temperature transport DX refrigeration
- Benefits
  - Low GWP: 45% reduction compared to R-404A/R-507
  - Matches discharge temperature
  - Matches mass flow rate (no TXV adjustments)

Physical Properties

Physical properties of Opteon™ XP10, XP40, and XP44 are given in **Table 3**. Additional physical property data for Opteon™ XP10, XP40, and XP44 may be found at www.opteon.com.

Table 3. Opteon™ XP10, XP40, and XP44 Property Information

Physical Property	Unit	Opteon™ XP10 (R-513A)	Opteon™ XP40 (R-449A)	Opteon™ XP44 (R-452A)
Molecular Weight, avg.	g/mol	108.4	87.2	103.5
Boiling Point (1 atm)	°C °F	-28.0 -18.4	-44.0 -47.3	-45.8 -50.4
Critical Temperature	°C °F	97.5 207.5	85.0 185.1	76.6 169.9
Critical Pressure	kPa abs psia	3,668.4 532.1	4,484.9 650.5	3,983.7 577.8
Critical Density	kg/m^3 lb/ft^3	490.2 30.6	466.0 29.1	497.7 31.1
Liquid Density at 25 °C (77 °F)	kg/m^3 lb/ft^3	1,140.6 71.2	1,105.3 69.0	1,130.5 70.6
Density, Saturated Vapor at 25 °C (77 °F)	kg/m^3 lb/ft^3	35.4 2.2074	49.7 3.1018	66.4 4.1475
Specific Heat, Liquid at 25 °C (77 °F)	kJ/kg·K Btu/lb·°F	1.4060 0.3360	1.5323 0.3662	1.4591 0.3487
Specific Heat, Vapor at 25 °C (77 °F) (1 atm)	kJ/kg·K Btu/lb·°F	0.8820 0.2107	0.8513 0.2035	0.8351 0.1996
Vapor Pressure, Saturated Liquid at 25 °C (77 °F)	kPa abs psia	675.6 97.98	1,192.7 172.99	1,256.6 182.26
Heat of Vaporization at Boiling Point	kJ/kg Btu/lb	196.2 83.83	252.1 108.46	198.1 85.22
Thermal Conductivity at 25 °C (77 °F)				
Liquid	W/m·K Btu/hr·ft·°F	0.070725 0.040892	0.081012 0.046839	0.067318 0.038922
Vapor (1 atm)	W/m·K Btu/hr·ft·°F	0.013667 0.007902	0.014644 0.007865	0.013787 0.007971
Viscosity at 25 °C (77 °F)				
Liquid	Pa·s cP	1.71E-04 1.71E-01	1.43E-04 1.43E-01	1.38E-04 1.38E-01
Vapor (1 atm)	Pa·s cP	1.15E-05 1.15E-02	1.27E-05 1.23E-02	1.26E-05 1.26E-02
Flammability Limit in Air (1 atm)	vol%	None	None	None
Temperature Glide		0 °C (0 °F)	~4 °C (~7 °F)	~3 °C (~5.4 °F)
Ozone Depletion Potential (ODP)	CFC-11=1.0	0	0	0
AR5 Global Warming Potential (GWP)	CO_2=1.0	573	1,282	1,945
ASHRAE Safety Classification		A1	A1	A1
TSCA Inventory Status		Listed	Listed	Listed
Inhalation Exposure Limit (8- and 12-hr TWA) (AEL*)	ppm	650	840	790

*Acceptable exposure limit (AEL) is an airborne exposure limit established by Chemours that specifies time-weighted average (TVA) concentrations to which nearly all workers may be repeatedly exposed without adverse effects.

Note: kPa is absolute pressure.

Chemical/Thermal Stability

Thermal Decomposition

Opteon™ XP10, XP40, and XP44 will all decompose when exposed to high temperatures or flame sources. Decomposition may produce toxic and 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 recommendations for handling.

Stability with Metals and Refrigeration Lubricants

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.

Opteon™ XP10, XP40, and XP44 have been evaluated for thermal stability per ANSI/ASHRAE Standard 97. Both the neat refrigerant and a mixture of polyolester (POE) 32 oil 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. Neat refrigerants and refrigerant/lubricant mixtures were individually placed in sealed glass tubes containing metal coupons (Al, Cu, and carbon steel) and held at these conditions for two weeks. These conditions included tests with and without contaminants, such as air and water.

Results indicate both neat Opteon™ refrigerants and Opteon™ and lubricant mixtures are thermally stable. There was no dulling of the steel coupon, nor coating or visible corrosion to any of the metals tested; in addition, there was no fluoride ion or acid generation. Also, no deposits or flocs formed during the testing.

Results obtained from these sealed tube stability tests for Opteon™ refrigerants indicate that they perform similarly to existing HFC refrigerants, which have been proven to be of acceptable chemical stability in the presence of common metals used in refrigeration and air conditioning systems.

Materials Compatibility

Because Opteon™ refrigerants will be used in many different applications, it is important to assess materials of construction for compatibility with these new refrigerants when designing new equipment, retrofitting existing equipment, or preparing storage and handling facilities. Opteon™ XP10, XP40, and XP44 were evaluated for compatibility with a wide array of elastomers and plastics used in refrigeration and air conditioning applications to investigate compatibility with materials commonly used in these systems. Sealed glass tubes were prepared containing either Opteon™ XP10, XP40, or XP44 with POE 32 and elastomeric/plastic 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]). After exposure, plastics and elastomers were removed and measured for weight change, linear swell, and hardness change immediately after removing from sealed tube and also 24 hours after exposure.

Compatibility with Elastomers and Plastics

Compatibility results are listed in **Tables 4-15** for Opteon™ XP10, XP40, and XP44 in the presence of elastomers and plastics. Results demonstrate there are many elastomers and plastics suitable for use with these refrigerants. It should be recognized that this data reflects 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. Specific grades, additives, etc., can also vary and potentially affect results for different polymers and other materials. Components should always be tested under actual operating conditions before reaching final conclusions about their suitability.

For further information on Opteon™ XP10, XP40, and XP44, including retrofit guidelines, please visit www.opteon.com or contact your local Opteon™ representative.

Table 4: Opteon™ XP10 and POE 32 Elastomers Compatibility – Immediately After Removing from Sealed Tubes

Elastomer	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene	0	2	1	1
Epichlorohydrin	0	7	3	-2
Butyl Rubber	1	21	6	-9
EPDM	1	16	5	-11
Fluorosilicone	1	28	10	-16
HNBR	1	22	6	-6
NBR	1	14	5	-9
Fluorocarbon FKM	2	36	17	-16
Viton™ A	1	35	16	-9
Viton™ GF	2	26	11	-11

Rating

0 <10% weight gain, and <10% linear swell and <10 hardness change

1 >10% weight gain, or >10% linear swell or >10 hardness change

2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 5: Opteon™ XP10 and POE 32 Elastomers Compatibility – 24 Hours After Removing from Sealed Tubes

Elastomer	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Neoprene	0	0	0	1
Epichlorohydrin	0	6	2	-4
Butyl Rubber	1	19	6	-7
EPDM	1	11	4	-10
Fluorosilicone	1	8	4	-12
HNBR	1	16	5	-6
NBR	1	9	3	-7
Fluorocarbon FKM	1	19	10	-15
Viton™ A	2	19	11	-12
Viton™ GF	1	12	5	-11

Rating

0 <10% weight gain, and <10% linear swell and <10 hardness change

1 >10% weight gain, or >10% linear swell or >10 hardness change

2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 6: Opteon™ XP40 and POE 32 Elastomers Compatibility – Immediately After Removing from Sealed Tubes

Elastomer	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene WRT	0	7	3	-5
HNBR	1	26	11	-8
NBR	1	16	6	-8
EPDM	0	3	4	-1
Silicone	1	24	9	-12
Butyl Rubber	0	8	3	-8
Buna S (SBR)	1	9	7	-32
Viton™	2	26	16	-12
Hypalon®	0	8	7	-8
Neoprene W	1	13	9	-11
Epichlorohydrin	1	13	5	-14

Rating

0 <10% weight gain, and <10% linear swell and <10 hardness change

1 >10% weight gain, or >10% linear swell or >10 hardness change

2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 7: Opteon™ XP40 and POE 32 Elastomers Compatibility – 24 Hours After Removing from Sealed Tubes

Elastomer	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Neoprene WRT	0	5	1	-6
HNBR	1	17	7	-6
NBR	0	10	4	-6
EPDM	0	0	1	0
Silicone	0	9	0	-4
Butyl Rubber	0	5	2	-2
Buna S (SBR)	1	7	0	-19
Viton™	1	13	4	-5
Hypalon®	0	6	4	-4
Neoprene W	0	10	1	-2
Epichlorohydrin	0	10	3	-5

Rating

0 <10% weight gain, and <10% linear swell and <10 hardness change

1 >10% weight gain, or >10% linear swell or >10 hardness change

2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 8: Opteon™ XP44 and POE 32 Elastomers Compatibility – Immediately After Removing from Sealed Tubes

Elastomer	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene WRT	0	9	-1	-9
Neoprene W	1	15	2	-17
HNBR	1	22	2	-8
NBR	1	13	4	-8
EPDM	0	9	2	-9
Silicone	1	32	7	-17
Butyl Rubber	1	21	0	-16
Buna S (SBR)	1	10	0	-31
Viton™	2	22	13	-25
CSPE	0	7	2	-7
Neoprene W	1	15	2	-17
Epichlorohydrin	1	6	0	-9

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 9: Opteon™ XP44 and POE 32 Elastomers Compatibility – 24 Hours After Removing from Sealed Tubes

Elastomer	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Neoprene WRT	0	6	0	-4
Neoprene W	1	11	1	-4
HNBR	1	13	3	-6
NBR	0	8	3	-6
EPDM	0	4	1	-8
Silicone	1	15	4	-16
Butyl Rubber	1	17	-1	-12
Buna S (SBR)	1	8	0	-28
Viton™	1	11	9	-21
CSPE	0	6	2	-3
Neoprene W	1	11	1	-4
Epichlorohydrin	0	5	0	-5

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 10: Opteon™ XP10 and POE 32 Plastics Compatibility – Immediately After Removing from Sealed Tubes

Plastic	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Polyester	1	12	3	-2
Nylon Resin	0	-1	3	1
Polyamide-imide	0	-1	0	1
Polyphenylene Sulfide	0	0	0	2
PEEK	0	0	0	1
Nylon	0	-1	0	0
PTFE	0	2	2	1

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 11: Opteon™ XP10 and POE 32 Plastics Compatibility – 24 Hours After Removing from Sealed Tubes

Plastic	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Polyester	0	9	2	-2
Nylon Resin	0	-1	3	0
Polyamide-imide	0	-1	0	1
Polyphenylene Sulfide	0	0	0	1
PEEK	0	0	0	0
Nylon	0	-1	0	0
PTFE	0	2	1	-1

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 12: Opteon™ XP40 and POE 32 Plastics Compatibility – Immediately After Removing from Sealed Tubes

Plastic	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Polyester Resin	0	9	2	0
Nylon Resin	0	0	-1	2
Epoxy	0	1	2	2
Polyester PBT	0	2	0	1
Polycarbonate	0	4	0	-1
Polyimide	0	3	0	5
Polyethylene	0	2	1	5
Teflon™ PTFE	0	2	0	1
Teflon™ FEP	0	3	2	0
Tefzel™ ETFE	0	3	1	0
Phenolic	0	1	0	0
Acetal	0	3	0	1
PVC	0	4	-1	0
Polypropylene	0	5	1	2

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 13: Opteon™ XP40 and POE 32 Plastics Compatibility – 24 Hours After Removing from Sealed Tubes

Plastic	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Polyester Resin	0	4	0	0
Nylon Resin	0	0	-1	2
Epoxy	0	1	-1	2
Polyester PBT	0	2	0	0
Polycarbonate	0	4	0	-1
Polyimide	0	3	0	4
Polyethylene	0	2	1	4
Teflon™ PTFE	0	1	-1	0
Teflon™ FEP	0	2	1	0
Tefzel™ ETFE	0	3	0	0
Phenolic	0	0	0	0
Acetal	0	2	0	1
PVC	0	3	-1	0
Polypropylene	0	4	1	2

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 14: Opteon™ XP44 and POE 32 Plastics Compatibility – Immediately After Removing from Sealed Tubes

Plastic	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Nylon	0	0	-9	0
Epoxy	0	1	0	-1
Polyester PET	0	3	0	0
Polyester	0	1	0	0
Polycarbonate	0	2	1	0
Polyimide	0	2	0	0
Polyethylene	0	3	2	0
Teflon™ PTFE	0	2	0	0
Teflon™ FEP	0	2	-1	-1
Tefzel™ ETFE	0	3	2	0
Phenolic	0	0	0	-1
Acetal	0	2	0	0
PVC	0	1	0	-1
Polypropylene	0	7	2	0
PEEK	0	0	0	0

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

Table 15: Opteon™ XP44 and POE 32 Plastics Compatibility – 24 Hours After Removing from Sealed Tubes

Plastic	24 hr Rating	24 hr % Weight Change	24 hr % Linear Swell	24 hr Hardness Change, Delta
Nylon	0	0	-9	-3
Epoxy	0	0	0	1
Polyester PET	0	2	-1	0
Polyester	0	1	0	-1
Polycarbonate	0	2	0	-1
Polyimide	0	2	0	1
Polyethylene	0	3	2	1
Teflon™ PTFE	0	2	0	1
Teflon™ FEP	0	2	-1	0
Tefzel™ ETFE	0	3	2	0
Phenolic	0	0	0	0
Acetal	0	1	0	1
PVC	0	1	-1	0
Polypropylene	0	6	2	1
PEEK	0	0	0	0

Rating
0 <10% weight gain, and <10% linear swell and <10 hardness change
1 >10% weight gain, or >10% linear swell or >10 hardness change
2 >10% weight gain, and >10% linear swell and >10 hardness change

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. Opteon™ refrigerants have generally been found to be compatible with current driers used in HFC systems. Individual drier manufacturers should be contacted for specific recommendations.

Lubricants

Lubricants developed for HFC systems, such as R-134a, R-404A/R-507, and R-407 series refrigerants, have shown similar characteristics with Opteon™ refrigerants. 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). See **Table 16** for miscibility data.

Table 16: Miscibility of Opteon™ Refrigerants in POE 32

Refrigerant	Opteon™ XP10		Opteon™ XP40		Opteon™ XP44	
Wt% Refrigerant/Oil	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
95/5%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	75 °C (167 °F)
90/10%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)
85/15%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)
80/20%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)
70/30%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)
40/60%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)
30/70%	-50 °C (-58 °F)	75 °C (167 °F)	-50 °C (-58 °F)	70 °C (158 °F)	-50 °C (-58 °F)	60 °C (140 °F)

Safety

Users must have and understand the applicable Opteon™ refrigerant Safety Data Sheets (SDS).

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 SDS 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 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

Are Opteon™ refrigerants toxic?

The refrigerants described in this bulletin, Opteon™ XP10, XP40, and XP44, have an ASHRAE Class A rating, indicating low toxicity. They 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 Opteon™ XP10, XP40, and XP44, which is consistent with the low toxicity profile for these refrigerants.

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, and unconsciousness, as well as 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, Opteon™ XP10, XP40, and XP44 did not produce cardiac sensitization at the highest concentration tested (120,000 ppm).

Can inhaling refrigerants 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 SDS 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. Opteon™ refrigerants have virtually no odor and, therefore, can be extremely difficult to detect in enclosed areas. Frequent leak checks and the installation of permanent leak detectors may be necessary for enclosed areas or machinery rooms. Refer to ASHRAE Standards 15 and 34 for machinery room requirements.

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 "Leak Detector Guidance for Freon™ Refrigerants". 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 SDS for additional safety and use information.

Skin and Eye Contact

Is skin or eye contact with Opteon™ refrigerants 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 a face shield to protect the eyes. If liquid refrigerant enters 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.

Combustibility

Opteon™ XP10, XP40, and XP44 refrigerants are not flammable in air at temperatures up to 100 °C (212 °F) at atmospheric pressure. However, mixtures of these refrigerant blends with high concentrations of air at elevated pressure and/or temperature can become combustible in the presence of an ignition source. Opteon™ XP10, XP40, and XP44 can also become combustible in an oxygen-enriched environment (oxygen concentrations greater than that in air). Whether a mixture containing Opteon™ XP10, XP40, XP44 and air or Opteon™ XP10, XP40, and XP44 in an oxygen-enriched atmosphere becomes combustible depends on the interrelationship of:

- The temperature
- The pressure
- The proportion of oxygen in the mixture

In general, Opteon™ XP10, XP40, and XP44 should not be allowed to exist with air above atmospheric pressure or at high temperatures or in an oxygen-enriched environment. Refrigerants should not be exposed to open flames or electrical heating elements. High temperatures and flames can cause the 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 alternative 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™ and air. Pressurized mixtures of dry nitrogen and Opteon™ can be used for leak testing.
- Bulk Delivery and Storage
  - Tanks should normally be evacuated prior to initial filling and 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™ products. 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 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. 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. There are several reasons for leak pinpointing or area monitoring, including:

- Conservation of refrigerants
- Protection of employees
- Detection of fugitive or small emissions
- Protection of valuable equipment

Leak detectors can be placed into two broad categories: leak pin pointers and area monitors. Before purchasing a pin pointer or monitor, several criteria should be considered, including sensitivity, detection limits, and selectivity.

Types of Detectors

Using selectivity as a criterion, leak detectors can be placed into one of three categories: non-selective, 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.

A detailed discussion of leak detection is given in the technical bulletin, "Leak Detectior Guidance for Freon™ Refrigerants."

Non-Selective Detectors

Non-selective 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 rugged, inexpensive, and almost always portable. However, their inability to be calibrated, long-term drift, and lack of selectivity and sensitivity limit their use for area monitoring. Be sure to consult with the manufacturer before selecting or using a non-selective detector with Opteon™ refrigerants

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 non-selective detectors (detection limits are typically <5 ppm when used as an area monitor and <1.4 g/yr [<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 easily calibrated.

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 compound without interference from other compounds.

Fluorescent-Specific Detectors

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 or charged. Leaks are detected using a UV light to search for additive that has escaped from the system.

Recent innovations in dye technology have allowed fluorescent additives to be used with HFC and HFO refrigerant mixtures. However, before adding additives to a system, the compatibility of specific dye with the lubricant and refrigerant should be tested.

Shipping, Storage, and Handling (United States)

This section of the document details United States (U.S.) information only. For specific shipping, storage, and handling information in different regions, please contact your local Chemours representative.

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

Opteon™ XP10, XP40, and XP44 refrigerants are liquefied compressed gases. According to the U.S. Department of Transportation (DOT), a nonflammable compressed gas is defined as a nonflammable material having an absolute pressure greater than 40 psia at 21 °C (70 °F) and/or an absolute pressure greater than 104 psia at 54 °C (130 °F). See **Table 17** for the appropriate DOT designation.

The 30-lb, 123-lb, ½-ton, and 1-ton cylinders designed for refrigerant applications will be painted according to AHRI Guideline N-2016. Those assigned colors are sky blue, grayish blue, and metallic blue for Opteon™ XP10, XP40, and XP44, respectively.

A list of the different types of containers that can be used to ship Opteon™ XP10, XP40, and XP44 in the United States, along with their water capacities, dimensions, DOT specifications, and net weights are provided in **Table 18**. All pressure relief devices used on the containers must be in compliance with the corresponding Compressed Gas Association (CGA) standards for compressed gas cylinders, cargo, and portable tanks. All containers should be stored upright, at a temperature below 52 °C (125 °F), and out of direct sunlight.

Table 17: DOT Designations

DOT Proper Shipping Name	Opteon™ XP10	Refrigerant Gases, N.O.S. (2,3,3,3-Tetrafluoropropene, 1,1,1,2-Tetrafluoroethane)
	Opteon™ XP40	Refrigerant Gases, N.O.S. (1,1,1,2-Tetrafluoroethane, 2,3,3,3-Tetrafluoropropene, Pentafluoroethane, Difluoromethane)
	Opteon™ XP44	Refrigerant Gases, N.O.S. (Pentafluoroethane, 2,3,3,3-Tetrafluoropropene)
Hazard Class	All	Nonflammable Gas
DOT/IMO Hazard Class	All	2.2
UN/NA Number	All	1078
DOT Labels	All	Nonflammable Gas
DOT Placard	All	Nonflammable Gas

Table 18: Specifications of Shipping Container for Opteon™ Refrigerants

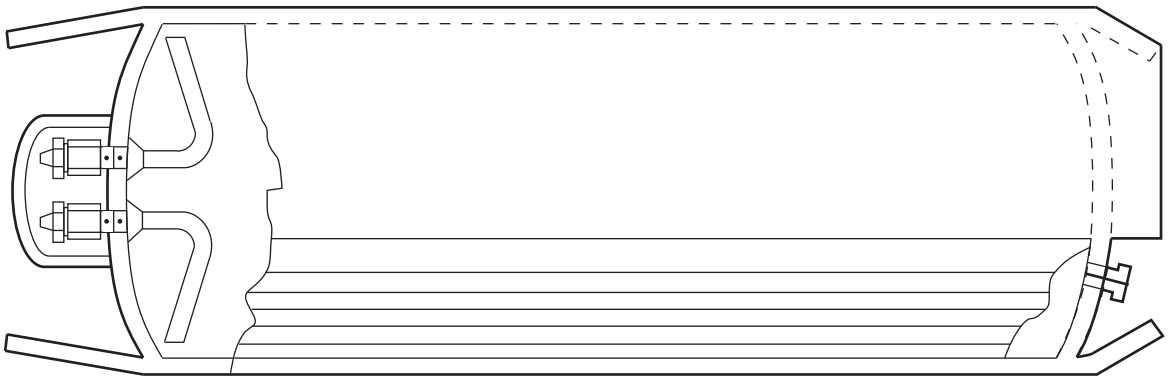
Container (Water Capacity)	Dimensions	DOT Specification	Net Weight
30 lb	18" H x 10" OD	DOT 39 (260/325)	31 lb
123 lb	55" H x 10" OD	4BW300/400	168 lb
1,000 lb	57" H x 31" OD	4BW260/400	1,350 lb
1,650 lb	82" L x 30" OD	110A500/800	3,182 lb

30-lb Opteon™ XP40 and XP44 cylinders in the United States are equipped with a CGA-165 vapor valve. Because Opteon™ refrigerants are blends, cylinders should be inverted when charging a system. When charging liquid to the suction side of the compressor, a throttling valve should be used to prevent a liquid slug from entering the compressor.

30-lb Opteon™ XP10 cylinders and all 123-lb, 1,000-lb, and 1,650-lb cylinders are equipped with a non-refillable liquid vapor CGA-660 valve. With this two-way valve, refrigerant can be removed from the cylinder as either vapor or liquid, without inverting the cylinder. The vapor valve hand wheel is located on the top of the valve assembly. The liquid hand wheel is on the side of the valve and attached to a dip tube extending to the bottom of the cylinder. Each is clearly identified as vapor or liquid.

The general construction of a one-ton returnable container is shown in **Figure 1**. Note that one end of the container is fitted with two valves. When the container is turned so that the valves are lined up vertically, the top valve will discharge liquid. The valves are protected by a dome cover.

Figure 1: One-Ton Returnable Container



One-ton containers are equipped with two fusible plugs in each end. The fusible metal in the plugs is designed to start melting at 69 °C (157 °F) and completely melt at 74 °C (165 °F). Containers should never be heated to temperatures higher than 52 °C (125 °F). One spring-loaded pressure relief valve is also located at each end of the container.

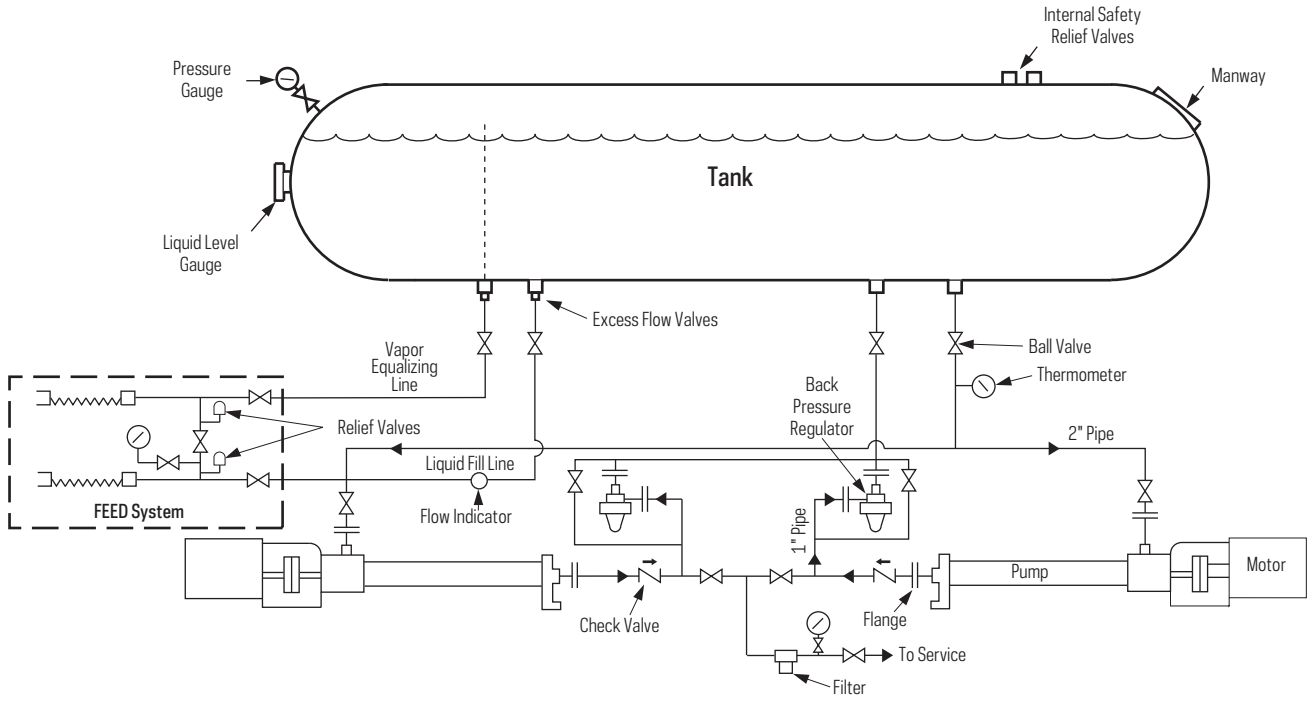
Bulk Storage Systems

Chemours can supply storage systems to its Opteon™ 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 systems 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.

A typical bulk storage system is shown in **Figure 2**. Your Chemours representative can arrange for guidance on site selection, purchase, installation, startup, and maintenance.

Figure 2: Typical Bulk Storage System



Converting Bulk Storage Tanks to Opteon™ Refrigerants

Before switching existing storage tanks to Opteon™ XP10, XP40, or XP44 refrigerants, the existing storage equipment must be checked to verify that it is adequate for conversion. 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. Consult with a Chemours representative for assistance with relief capacity and pressure rating of bulk storage systems.

Material Compatibility Concerns

Most metal components suitable for R-134a, R-22, R-404A/R-507, and R-407 series refrigerants are suitable for Opteon™ XP10, XP40, and XP44 refrigerants. These include standard grades of carbon steel, stainless steel, aluminum, and copper. Some elastomeric or nonmetallic components suitable for R-134a, R-22, R-404A/R-507, and R-407 series refrigerants may not be adequate with the new refrigerants. Therefore, all elastomeric or nonmetallic components throughout the system must be identified, and their compatibilities verified. 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-glass gaskets
- Back-pressure regulator diaphragms and O-rings

Handling Precautions for 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

Responsible use of refrigerants requires that the product be recovered for re-use or disposal whenever possible. Recovery and re-use of refrigerant makes sense from a legal, environmental, and economic standpoint. Contact your Chemours authorized distributor for information regarding relevant country-specific reclaim programs.

Recovery

Recovery refers to the removal of refrigerant from equipment and collection in an appropriate container. As defined by the Air Conditioning and Refrigeration Institute (ARI), recovery does not involve processing or analysis of the refrigerants. Opteon™ XP10, XP40, and XP44 refrigerants may be recovered from refrigeration equipment using permanent on-site equipment or many of the portable recovery/recycle/recharge (R/R/R) devices now available in the marketplace. The portable R/R/R devices 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 thoroughly to remove vapors. In the United States, the Environmental Protection Agency (EPA) sets standards for recovery equipment. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it contains proper materials of construction and lubricant for the refrigerants you intend to recover.

Due to the fact that Opteon™ XP40 and XP44 are not azeotropes, it is important that all refrigerant is removed from a system during recovery or recycle. It is always recommended that refrigerant transfers be made liquid phase, whenever possible, to minimize composition changes in the products.

Reclamation

Reclamation refers to the reprocessing of used refrigerant to new product specifications. Quality of the reclaimed product is verified by chemical analysis. Contact Chemours or one of its authorized distributors for further information regarding relevant country-specific reclaim programs.

Reclamation offers advantages over on-site refrigerant recycling procedures, because recycling systems cannot guarantee complete removal of all contaminants. Putting refrigerants that do not meet new product specifications into expensive equipment may cause damage to the 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. Opteon™ XP10, XP40, and XP44 refrigerants may be recycled using many of the devices now available. Before using one of these devices consult the manufacturer to confirm compatibility.

If you routinely recycle refrigerants through several cycles, we recommend that you have the composition of the refrigerant checked periodically. This will prevent loss of performance in the unlikely event that the composition has shifted.

Disposal

Disposal refers to the destruction of used refrigerant. 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 refrigerants.

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

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