Opteon™ XL41

Refrigerant (R-454B)

Properties, Uses, Storage, and Handling

Chemours™

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Introduction

Background

Opteon™ XL41 (R-454B) is a low global warming potential (GWP) hydrofluoro-olefin (HFO) based refrigerant to replace R-410A in new equipment designs. Opteon™ XL41 is suitable for positive displacement, direct expansion air conditioning, heat pumps and chillers in the residential, light commercial, and commercial market segments.

Opteon™ XL41 is classified as having low toxicity and lower flammability (ISO/ASHRAE class A2L). **Please check your local regulations and standards to verify the allowable filling charge, new equipment design and safe handling requirements for the intended application.**

Table 1. Opteon™ Compositions (wt%)

	R-32	R-1234yf	R-125
Opteon™ XL41 (R-454B)	68.9	31.1	-
Freon™ 410A (R-410A)	50	-	50

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

Benefits

- 78% reduction in GWP relative to R-410A
- Improved capacity and efficiency compared to R-410A
- Excellent performance in normal and high ambient conditions
- Physical properties very close match to R-410A – easily convertible from R-410A designs
- Very low temperature glide – can be topped off after leaks
- Enables higher charge sizes compared to other flammable refrigerants
- Miscible with polyolester (POE) lubricants

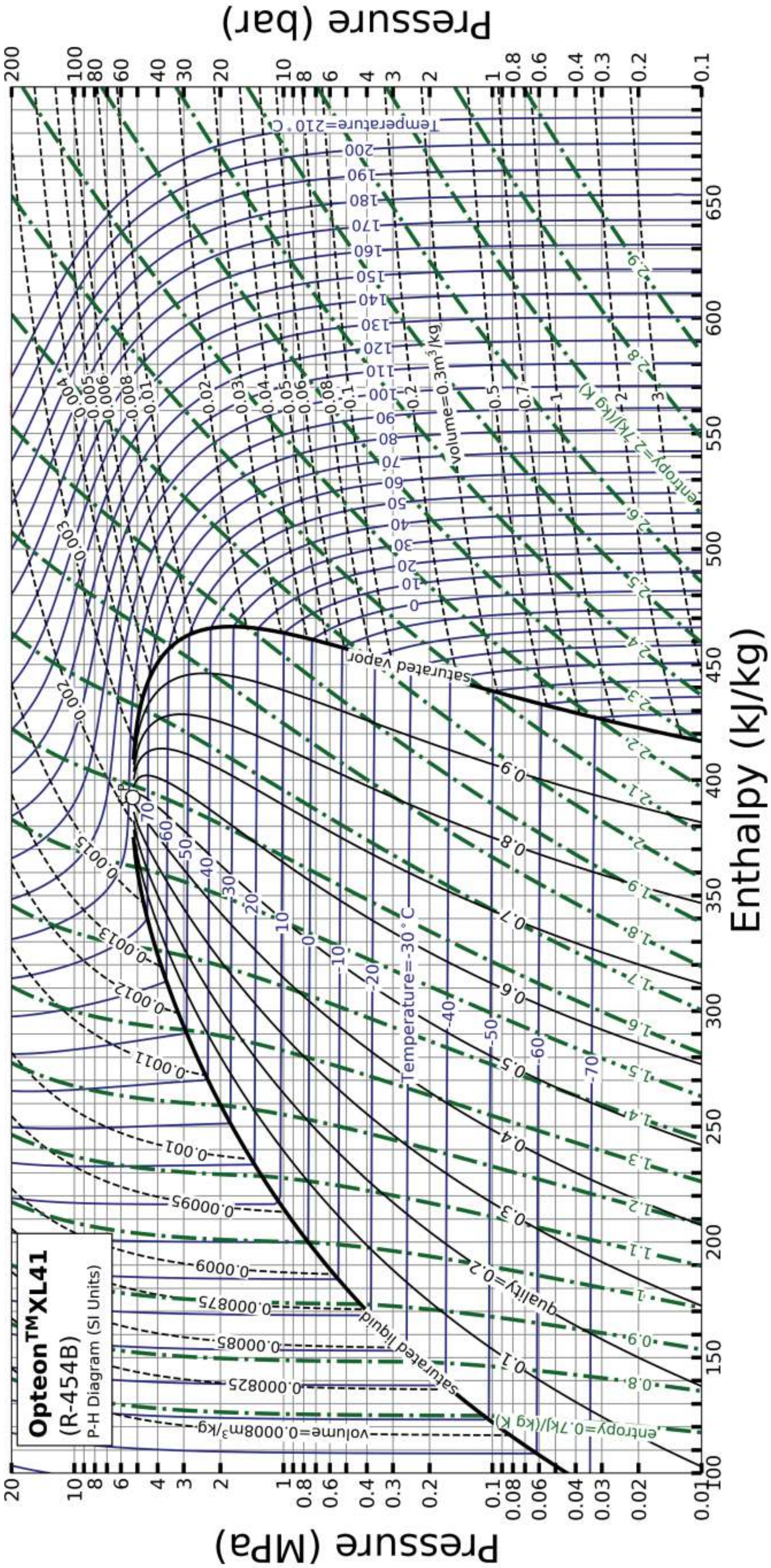
Physical Properties

Table 3. Opteon™ XL41 General Property Information

Physical Property[1]	Unit	Opteon™ XL41 (R-454B)	Freon™ 410A (R-410A)
Molecular Weight, avg.	g/mol	62.6	72.6
Boiling Point (1 atm)	°C °F	-50.5 -58.9	-51.4 -60.6
Critical Temperature	°C °F	78.10 172.6	71.34 160.4
Critical Pressure	kPa abs psia	5266.9 763.91	4901.1 710.84
Critical Density	kg/m^3 lbm/ft^3	443.0 27.66	459.08 28.659
Liquid Density at 25°C (77°F)	kg/m^3 lbm/ft^3	984.6 61.47	1058.6 66.088
Density, Saturated Vapor at 25°C (77°F)	kg/m^3 lbm/ft^3	50.7 3.17	65.97 4.119
Specific Heat, Liquid at 25°C (77°F)	kJ/kgK BTU/lbm°R	1.80 0.43	1.71 0.408
Specific Heat, Vapor at 25°C (77°F) (1 atm)	kJ/kgK BTU/lbm°R	0.865 0.207	0.823 0.197
Vapor Pressure, Saturated Liquid at 25°C (77°F)	kPa abs psia	1570.8 227.83	1657.4 240.39
Heat of Vaporization at Boiling Point	kJ/kg BTU/lbm	316.28 136.07	272.96 117.43
Thermal Conductivity at 25°C (77°F)			
Liquid	W/mK BTU/hrft°F	0.105 0.0610	0.0892 0.0516
Vapor (1 atm)	W/mK BTU/hrft°F	0.0151 0.00872	0.0157 0.00909
Viscosity at 25°C (77°F)			
Liquid	Pa-s cP	0.000115 0.115	0.000118 0.0118
Vapor (1 atm)	Pa-s cP	0.0000127 0.0127	0.0000133 0.0133
ASHRAE Standard 34 Safety Classification	-	A2L	A1
Flammability Properties			
LFL @ WCF	Vol %	11.5	-
LFL @ WCF	ppm v/v	115,000	-
LFL @ WCF	$lb/1000\ ft^3$	18.5	-
LFL @ WCF	g/m^3	296.8	-
Autoignition Temperature	°C	496	-
Hot Surface Ignition Temperature	°C	> 800	-
[2]Burning Velocity (Su) @ WCF: 23°C, Dry Air	cm/s	5.2	-
[2]Burning Velocity @ WCFF: 23°C, Dry Air	cm/s	< 4.0	-
[3]Burning Velocity (Su) @ Nominal: 23°C, 50% RH	cm/s	5.7	-
[2]Heat of Combustion @ WCF	MJ/kg	9.9	-
[2]Heat of Combustion @ WCFF	MJ/kg	9.9	-
Ozone Depletion Potential (ODP)	CFC-11=1.0	0	0
AR5 (AR4) Global Warming Potential (GWP)	CO_2=1.0	467 (466)	1924 (2088)
TSCA Inventory Status	Listed	Yes	Yes

WCF - Worst case of formulation for flammability, WCFF - Worst case of fractionation for flammability, [1]Based on NIST Standard Database 23, Version 10.0 (Lemmon, E.W.; Huber, M.L.; McLinden, M.O.; REFPROP Reference Fluid Thermodynamic and Transport Properties – National Institute of Standards and Technology, 2018)., [2]Values per ISO817, [3]Preliminary, pending final publication

Physical Properties

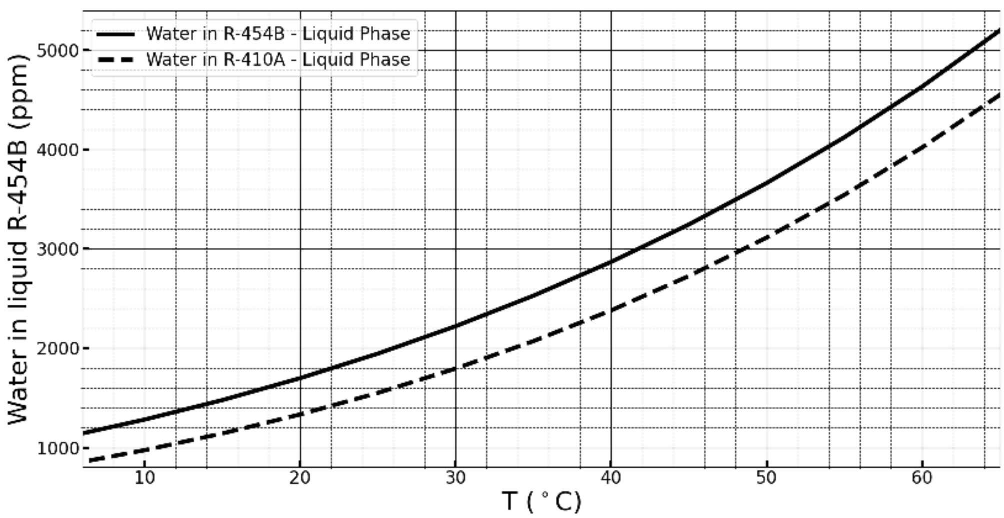


Physical Properties

Water Solubility

The maximum amount of moisture allowed in a system before issues present themselves is a function of the solubility between the refrigerant and water. The solubility of water in refrigerant is temperature dependent. From the saturated solubility plot below, R-454B exhibits slightly higher solubility over R-410A for the range of temperatures presented.

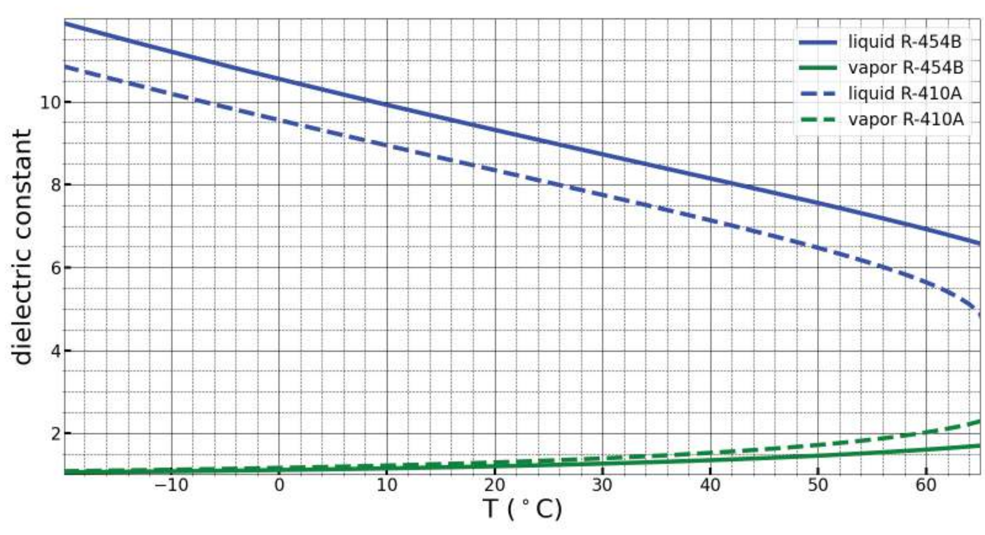
Figure 1. Opteon™ XL41 Solubility



Dielectric Properties

In hermetically sealed refrigeration and air conditioning systems, the refrigerant aids in cooling the electric motor that drives the compressor as the refrigerant is in direct contact with electric motor components. As a result, the electrical properties of a refrigerant are important to understand. The dielectric constant of a refrigerant is a measure the ability of the refrigerant to shield an electric charge in an electric field. Electrical properties of the refrigerant in a refrigeration system, however, can differ as they can be significantly impacted by the amount and type of lubricants, contaminants, moisture, and etcetera. The dielectric constant as a function of temperature for R-410A and R-454B can be seen below.

Figure 2. Dielectric constant versus Temperature for R-410A and R-454B



Performance Comparison

The performance comparisons detailed below for both air conditioning and heat pump applications are theoretical thermodynamic model calculations at specific conditions. Actual results will be system dependent.

Table 3. Performance Comparisons

		AC		HP	
		R-454B	*R-410A*	*R-454B*	*R-410A*
Relative Capacity	-	0.97	1.0	0.98	1.0
Relative COP	-	1.02	1.00	1.03	1.00
Evaporator Glide[1]	Δ°F	2.0	0.20	1.7	0.10
Relative Mass Flow	-	0.82	1.0	0.80	1.0
T Discharge	°F	180	169	232	216
P Discharge	psia	355	381	465	498
P Suction	psia	135	145	107	116

[1]Evaporator glide is the temperature difference between evaporator inlet and the saturated vapor temperature at the evaporator pressure (evaporator dew point).

AC Conditions: 7.2°C[45°F] average evaporator, 43.3°C [110°F] average condenser, 2.8K [5R] subcooling, 8.3K [15R] superheat, 70% isentropic efficiency

HP Conditions: 0°C [32°F] average evaporator, 55°C [131°F] average condenser, 3K [5.4R] subcooling, 10K [18R] superheat, 70% isentropic efficiency

Chemical/Thermal Stability

Stability with Metals

Thermal stability was evaluated using ASHRAE Standard 97 with lubricant. Tubes were loaded with carbon steel, copper, and aluminum coupons, then filled with refrigerant and lubricant. Additional tests to assess the impact of refrigerant with air contamination (2000 ppm) and oil with moisture contamination (500 ppm) were performed. Tubes were sealed and aged at 175°C (347°F) for 14 days. Fluoride ion concentrations were measured as an indication of fluid decomposition. Both POE and PVE oils were tested.

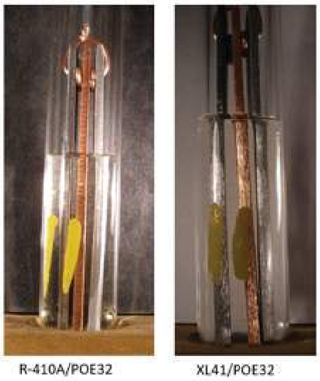
The results show thermal stability similar to R-410A.

Table 4. Thermal Stability

Refrigerant	Air (mmHg)	Water (ppm)	Metal Coupons	F- (ppm)	Total Acid Number (TAN) (mg KOH/g)
R-410A/POE	None	None	Yes	6.46	0.49
R-410A/POE	7.6	None	Yes	11.7	0.17
R-410A/POE	None	500	Yes	2.02	0.66
R-410A/POE	7.6	500	Yes	3.07	0.5
R-454B/POE	None	None	Yes	3.46	0.22
R-454B/POE	7.6	None	Yes	6.06	0.17
R-454B/POE	None	500	Yes	8.06	2.28
R-454B/POE	7.6	500	Yes	7.41	1.82
R-410A/PVE	None	None	Yes	<MDL	0.3
R-410A/PVE	None	500	Yes	<MDL	<MDL
R-454B/PVE	None	None	Yes	<MDL	<MDL
R-454B/PVE	None	500	Yes	<MDL	<MDL
Baseline oil as-is				<MDL	0.23

No visible changes were noted after 14 days at 175°C (347°F). Opteon™ XL41 is comparable to R-410A in use with both POE32 and PVE68.

Figure 3. Thermal Stability Test Setup



Thermal Decomposition

Like R-410A, Opteon™ XL41 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 Safety Data Sheet (SDS) recommendations for handing.

Compatibility Concerns with Mixing Refrigerants

While Opteon™ XL41 and R-410A are chemically compatible with each other, these two refrigerants should never be deliberately mixed in a system. Mixing refrigerants violates EPA section 608 and the resulting performance will be unpredictable as the exact blend composition will be unknown.

Materials Compatibility

Because Opteon™ refrigerants will be used in many different applications, it is important to assess materials of construction for compatibility when designing new equipment, retrofitting existing equipment, or preparing storage and handling facilities.

Opteon™ XL41 was evaluated for compatibility with a wide array of plastics and elastomers commonly used in refrigeration and air conditioning applications. Sealed glass tubes were prepared containing XL41, POE lubricant 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). Evaluations were also done with R-410A for comparison. Additional XL41 glass tubes were prepared containing PVE lubricant. After exposure, elastomers and plastics were removed and measured for weight change, linear swell and changes in hardness both immediately after removing from the sealed tube and also 24 hours after exposure.

Compatibility results are listed in Tables 5 and 6 for XL41 and R-410A evaluations with elastomers and POE oil. Tables 8 and 9 have XL41 and R-410A evaluations with plastics and POE oil. Results demonstrate there are many elastomers and plastics suitable for use with these refrigerants and the performance of XL41 and R-410A are very similar. Compatibility results of XL41 with PVE lubricant and various elastomers and plastics are listed in Tables 7 and 10. Results of XL41 and PVE lubricant were similar to the POE counterparts, indicating adequate compatibility with many elastomers and plastics. 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 specific polymers, and the curing or vulcanization processes used. 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.

Compatibility with Elastomers

Table 5. XL41 Elastomers Compatibility w/POE – 0 and 24 hours after removing from sealed tubes

XL41 + POE 32 Elastomers after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene C1276 -70	0	5	2	1
Neoprene C0873-70	1	10	4	-6
Epichlorohydrin	1	13	5	-8
Butyl Rubber	1	12	4	-3
EPDM	0	8	3	-10
Fluorosilicone	1	11	5	-10
HNBR	1	28	9	-8
NBR	1	20	8	-9
Fluorocarbon FKM V0747-75	1	22	11	-7
Viton™ A	1	22	10	-10
Viton™ GF	1	14	6	-9
XL41 + POE 32 Elastomers after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Neoprene C1276 -70	0	2	1	3
Neoprene C0873-70	0	8	3	-6
Epichlorohydrin	0	9	3	-6
Butyl Rubber	0	9	3	-4
EPDM	0	5	2	-7
Fluorosilicone	0	4	2	-9
HNBR	1	17	6	-7
NBR	1	11	5	-8
Fluorocarbon FKM V0747-75	1	13	7	-7
Viton™ A	1	13	6	-12
Viton™ GF	0	7	3	-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 6. R-410A Elastomers Compatibility w/POE – 0 and 24 hours after removing from sealed tubes

R-410A + POE 32 Elastomers after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene C1276 -70	0	4	2	-4
Neoprene C0873-70	0	9	3	-7
Epichlorohydrin	1	10	3	-11
Butyl Rubber	0	9	4	-5
EPDM	1	7	2	-10
Fluorosilicone	1	9	3	-13
HNBR	1	27	8	-9
NBR	1	19	7	-11
Fluorocarbon FKM V0747-75	1	20	9	-15
Viton™ A	1	20	8	-10
Viton™ GF	1	14	5	-7
R-410A + POE 32 Elastomers after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Neoprene C1276 -70	0	2	1	-2
Neoprene C0873-70	0	7	3	-6
Epichlorohydrin	1	7	3	-11
Butyl Rubber	0	8	3	-3
EPDM	0	5	2	-7
Fluorosilicone	1	4	2	-10
HNBR	1	19	6	-8
NBR	1	12	5	-10
Fluorocarbon FKM V0747-75	1	14	7	-12
Viton™ A	1	13	6	-8
Viton™ GF	0	8	3	-6

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. XL41 Elastomers Compatibility w/ PVE – 0 and 24 hours after removing from sealed tubes

XL41 + PVE 32 Elastomers after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Neoprene C1276 -70	0	2	1	-3
Neoprene C0873-70	0	6	3	-8
Epichlorohydrin	1	7	3	-12
Butyl Rubber	1	12	4	-17
EPDM	1	10	3	-13
Fluorosilicone	1	8	4	-14
HNBR	1	15	5	-7
NBR	1	11	4	-11
Fluorocarbon FKM V0747-75	1	13	7	-14
Viton™ A	1	13	6	-14
Viton™ GF	1	11	5	-13
XL41 + PVE 32 Elastomers after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Neoprene C1276 -70	0	-1	0	1
Neoprene C0873-70	0	4	2	-5
Epichlorohydrin	0	4	2	-9
Butyl Rubber	1	9	3	-13
EPDM	1	6	2	-11
Fluorosilicone	0	3	1	-6
HNBR	0	8	2	-5
NBR	0	5	1	-6
Fluorocarbon FKM V0747-75	1	7	4	-10
Viton™ A	1	7	3	-11
Viton™ GF	1	6	3	-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

Compatibility with Plastics

Table 8. XL41 Plastics Compatibility w/POE – 0 and 24 hours after removing from sealed tubes

XL41 + POE 32 Plastics after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Polyester	1	14	4	-3
Nylon resin	0	0	0	1
Polyamide-imide	0	0	0	0
Polyphenylene sulfide	0	1	0	-1
PEEK	0	1	0	1
Nylon	0	0	1	0
PTFE	0	1	1	-1
XL41 + POE 32 Plastics after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Polyester	0	9	3	-1
Nylon resin	0	0	0	-1
Polyamide-imide	0	0	0	0
Polyphenylene sulfide	0	0	0	0
PEEK	0	1	0	1
Nylon	0	0	0	-3
PTFE	0	1	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 9. R-410A Plastics Compatibility w/POE – 0 and 24 hours after removing from sealed tubes

R-410A + POE 32 Plastics after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Polyester	1	14	2	0
Nylon resin	0	0	3	0
Polyamide-imide	0	1	0	1
Polyphenylene sulfide	0	0	0	-2
PEEK	0	1	0	0
Nylon	0	1	0	0
PTFE	0	2	1	0
R-410A + POE 32 Plastics after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Polyester	0	9	2	0
Nylon resin	0	0	2	1
Polyamide-imide	0	0	0	0
Polyphenylene sulfide	0	0	0	-1
PEEK	0	1	0	0
Nylon	0	1	0	0
PTFE	0	1	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 10. XL41 Plastics Compatibility w/ PVE – 0 and 24 hours after removing from sealed tubes

XL41 + PVE 32 Plastics after 0 hrs	0 hr Rating	0 hr % Weight Change	0 hr % Linear Swell	0 hr Hardness Change, Delta
Polyester	1	11	3	2
Nylon resin	1	1	-11	1
Polyamide-imide	0	1	0	0
Polyphenylene sulfide	0	1	0	-1
PEEK	0	1	0	-2
Nylon	0	1	0	3
PTFE	0	2	1	1
XL41 + PVE 32 Plastics after 24 hrs	**24 hr Rating**	**24 hr % Weight Change**	**24 hr % Linear Swell**	**24 hr Hardness Change, Delta**
Polyester	0	6	2	2
Nylon resin	1	1	-11	1
Polyamide-imide	0	0	0	-1
Polyphenylene sulfide	0	1	0	0
PEEK	0	1	0	-1
Nylon	0	1	0	3
PTFE	0	1	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

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. Opteon™ XL41 has generally been found to be compatible with current R-410A driers. Consult with the dryer manufacturer to confirm compatibility.

Lubricants

Miscibility

A range of refrigerant and oil mixture compositions were prepared in sealed glass tubes. The miscibility of Opteon™ XL41 was tested with POE32 and PVE68 lubricants. The tubes were heated to 75°C (167°F) and then cooled to -50°C (-58°F) and observed in 5K (9°F) increments. Testing was also done with R-410A for comparison.

Figure 4. Miscibility with POE32

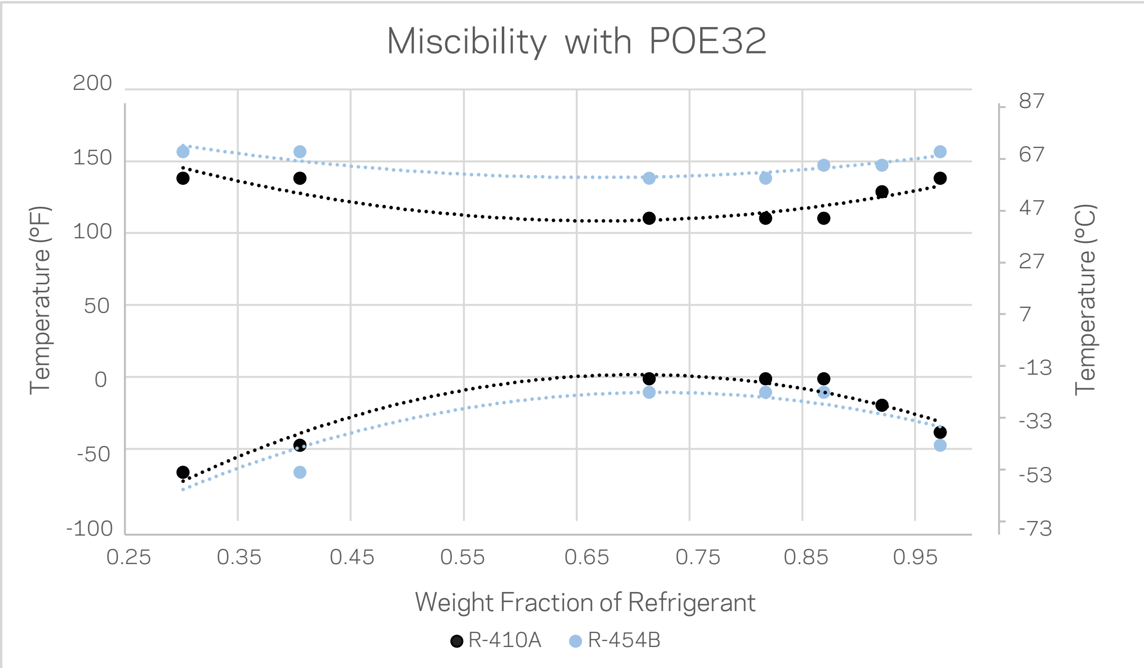
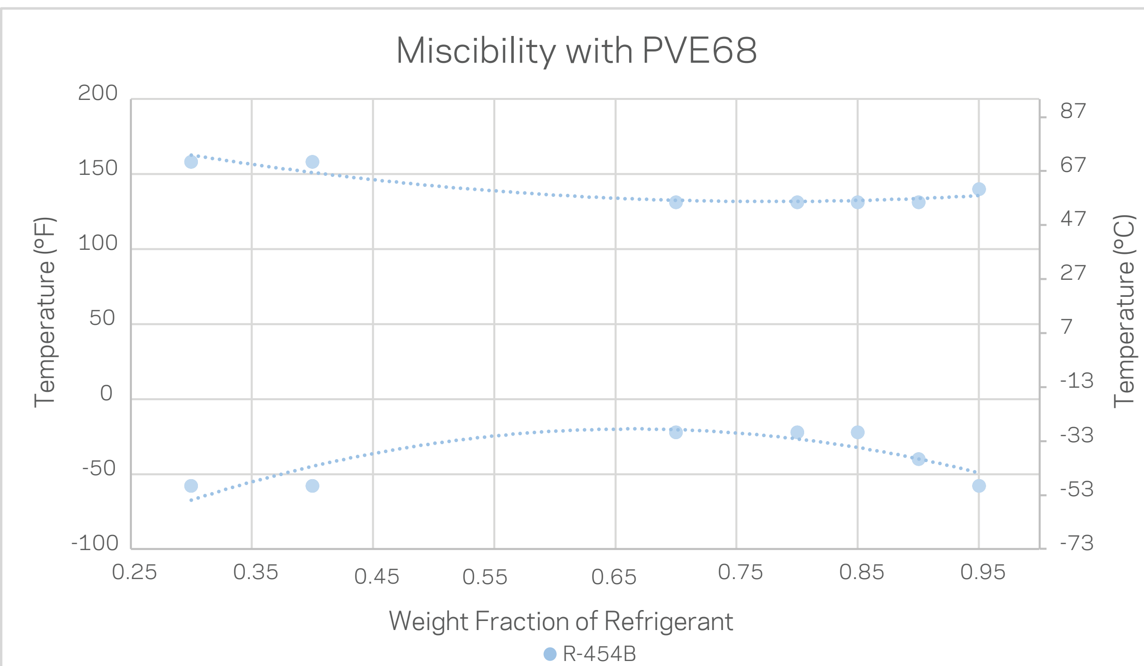


Figure 5. Miscibility with PVE68



Daniel Plots

Daniel plots for the baseline R-410A with POE as well as R-454B with POE and PVE were generated.

Figure 6. R-410A and POE32 Daniel Plot

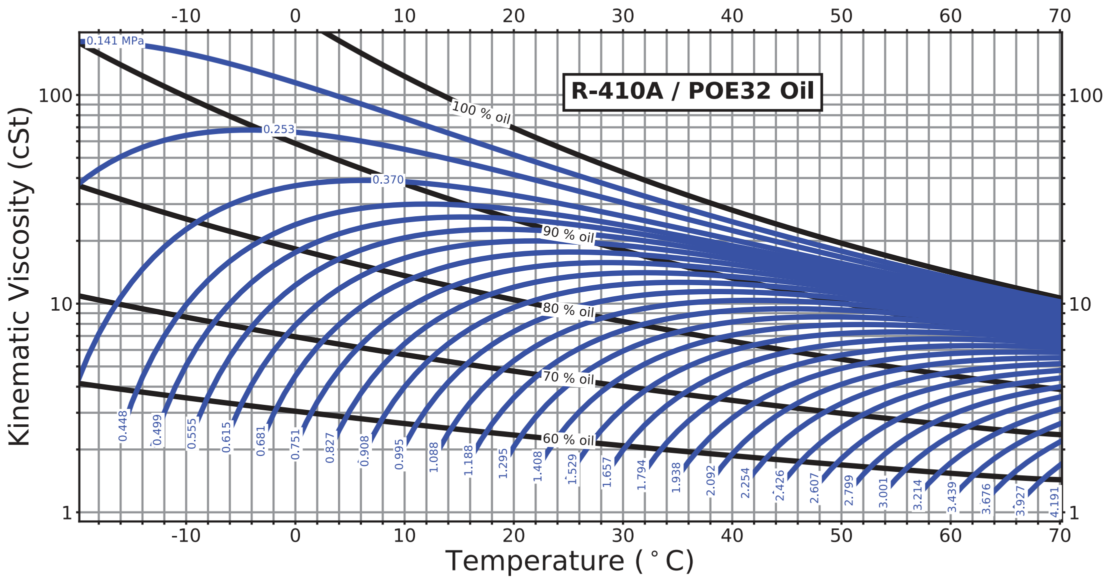


Figure 7. R-454B and POE32 Daniel Plot

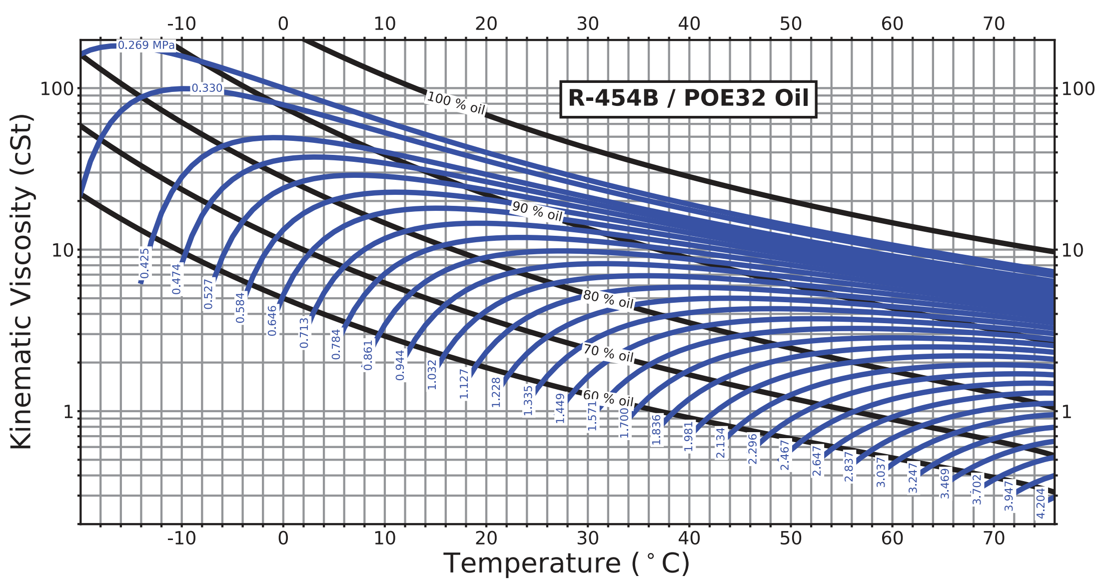
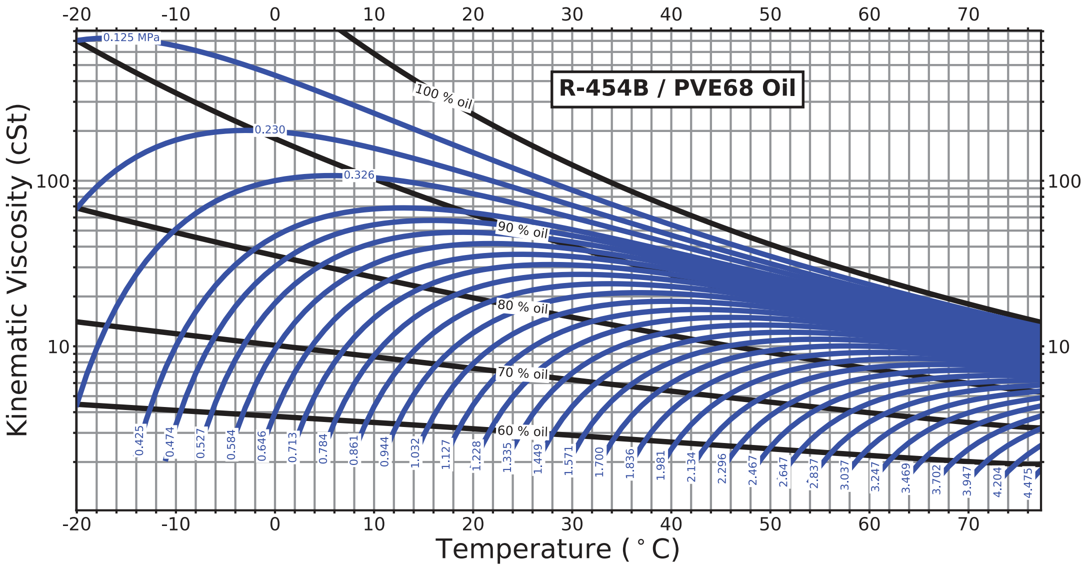


Figure 8. R-454B and PVE68 Daniel Plot



Safety

Decomposition

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 fumes released from thermal decomposition will likely irritate the nose, throat, eyes, and skin. Follow all Chemours recommendations listed in the 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 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

Are Opteon™ XL refrigerants toxic?

These refrigerants have 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). Consult the latest version of ASHRAE standard 34 as well as the R-454B SDS for updated exposure limits.

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. In experimental cardiac sensitization screening studies, test animals were exposed to various levels of refrigerant vapor followed by injection of high levels of epinephrine (adrenaline). Cardiac sensitization associated with Opteon™ XL refrigerant components is well above any concentrations expected in the workplace, and ranges from 20,000 to 150,000 ppm or higher in laboratory animals. By comparison, a cardiac sensitization response is observed with CFC-11 and CFC-12 under similar experimental conditions at approximately 5,000 and 50,000 ppm and higher, respectively. Because of possible disturbances of cardiac rhythm, catecholamine drugs such as epinephrine should be considered only as a last resort in life-threatening emergencies.

Can inhaling Opteon™ XL refrigerant 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.

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

How can I work safely on systems in enclosed areas?

1. Piping for pressure relief devices must be appropriately routed per ASHRAE standard 15. In many cases, the piping will be required to be 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. 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.

Can I smell Opteon™ XL Products?

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™ XL products 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™ XL41 has been assigned a safety classification of A2L 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. Always recover refrigerants, evacuate equipment, and ventilate work areas properly before using any open flames.

Equipment Designed for A2L Refrigerants

Users must read and understand the SDS before handling or using Opteon™ XL refrigerants. Users should also follow all pertinent safety information provided by the equipment manufacturer. Failure to follow the SDS and equipment manufacturer's instructions could result in injury or death. An SDS can be obtained for any Opteon™ refrigerant from the Chemours web site or from any Chemours refrigerants distributor.

Due to the flammability rating, Opteon™ XL refrigerants are intended for use in equipment specifically designed for these products and should always be used in accordance with the relevant national or international standards. Please consult the appropriate equipment manufacturer regarding which refrigerants can be used in the equipment.

Mechanical Equipment Room Requirements

- Install an A2L flammable rated air monitor capable of detecting the refrigerant(s) used in concentrations up to the OEL.
- Install suitable alarms that activate at or below the refrigerant's OEL, and that will alert persons outside of the equipment room that a leak condition exists.
- Route relief valve discharge headers and purge units outdoors, away from all air intakes to building or per local codes and regulations.
- Install local exhaust to ventilate the work area in the event that the air monitor alarm point is exceeded per local codes and regulations.
- Consult the latest revision of ASHRAE standard 15 for additional requirements

Servicing Equipment Containing A2L Refrigerants

Many of the same service items can be used for servicing A2L refrigerants versus R-410A. However, some service equipment, due to the electrical components and motors, should be specifically designed for use with A2L refrigerants. All service should be conducted in a safe manner and with respect to the guidelines given by the relevant codes and standards for your country/region.

Table 11. Comparison of service equipment for Opteon™ XL products compared to R-410A

Service Item	R-410A	Opteon™ XL
Gauge manifold	Routine	Routine
Charging hose	Routine	Routine
Torque wrench	Routine	Routine
Flare tool	Routine	Routine
Pipe cutter	Routine	Routine
Pipe bender	Routine	Routine
Hex wrench	Routine	Routine
Ventilation Fan, if low ventilation	Routine	Routine
Scales	Routine	Routine
Vacuum pump	Routine	Routine
Dry Powder/CO2 Fire Extinguisher	Not necessary	Chemical compatible
Gas Detector	Routine	2L approved
Electronic leak detector	Routine	2L approved
Refrigerant recovery cylinder	Routine	Updated labeling (check available guidelines)
Recovery machines	Routine	2L approved

How should I correctly braze or weld piping on A2L refrigeration or air-conditioning equipment?

- Review the refrigerant SDS and service instruction manuals provided by the equipment manufacturers.
- Review the relevant codes/regulations when servicing equipment.
- Be sure to set-up any safety barriers/sign as required before beginning servicing.
- Make certain there is adequate ventilation in the work area and that you have tested the air space for safe levels of refrigerant vapor and oxygen.
- Evacuate the Opteon™ XL refrigerant from the equipment you will be repairing.
- Recover the refrigerant into a properly rated and marked recovery cylinder.
- Do not vent refrigerant.
- Purge system with nitrogen if necessary, per code. If not, open the system and ensure no residual pressure is present.
- Drain all lubricant possible from the area to be welded to prevent fires.
- Leave system open during repair to prevent possible pressure buildup.
- Use auxiliary ventilation to disperse any fumes or decomposing refrigerant that may have remained in the piping or equipment during the repair process.
- If you notice an increase in the size or shape of the open flame, or the flame changes color, stop work immediately and re-ventilate the equipment. This flame enhancement effect should be a warning that too much refrigerant vapor is still present around the equipment.

Air Monitors and Leak Detection

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 approved for use with R-454B.

Equipment should never be leak tested with a pressurized mixture of Opteon™ XL41 and air. Pressurized mixtures of dry nitrogen and Opteon™ XL41, however, can be used for leak testing.

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 are not uncommon for use in refrigeration systems. 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. One drawback to the use of additives is that some areas may be visually unobservable, due to cramped spaces.

A 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. Components of Opteon™ XL41 are subject to a Significant New Use Rule (SNUR) and in the United States should be used only in applications listed in the Opteon™ XL41 SDS regulatory section. Consult the transport information section of the SDS for appropriate shipping information.

Cylinders Storage and Handling

Depending upon the region, Chemours offers a wide variety of returnable cylinders. Details on available cylinders can be obtained from your local Chemours representative.
General handling precautions for refrigerant containers include the following:

- Keep cylinders at temperature not exceeding 52 °C (125°F).
- Avoid skin contact with liquid refrigerant, as it may cause frostbite.
- 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 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.
- When containers are not in use, keep valves tightly closed with valve caps and hoods in place.
- 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.
- 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 cylinders.
- 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 officials for additional guidance.
- Remove liquid from the cylinder when charging any Opteon™ XL refrigerant blend. Once removed from the cylinder, it can be flashed to vapor for charging.
- Verify proper hookup of charging hoses. Do not charge to the discharge side of the compressor.
- Open valves slowly and transfer refrigerant
- Do not pressurize systems or vessels containing these refrigerants with air for leak testing or any other purpose.
- No not tamper with any relief devices on cylinders or refrigerant equipment.
- Do not drop, dent, or mechanically abuse containers.

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]).

Bulk Storage Systems

Opteon™ XL41 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.

Chemours can supply storage systems to its Opteon™ XL41 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 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 low emission connections to prevent emissions during deliveries.

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 R-410A bulk storage tank to R-454B can require significant planning to meet the requirements needed for flammable material storage. 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 400 psig (2859 kPa abs) or higher for Opteon™ XL41 service. The set pressure and capacity of the relief devices on the top of the tanks must also be verified and changed, if necessary.

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.

Due to the flammability of Opteon™ XL41, 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.

Piping and Lines

Pipelines that convey R-454B will have to be compliant for flammable gas. In general, carbon steel or stainless-steel lines that are used for R-410A can be re-used for R-454B, but need to be checked for additional flammable gas requirements. Changing the lines from R-410A to R-454B 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 during refrigerant line installations. One common point that can have major impact on future refrigerant quality is line cleanliness. Even though lines are new, there can still be residual particles and processing chemicals from the welding or other manufacturing processes that can negatively impact system performance, therefore, it is imperative that proper cleaning procedures are used.

Bulk Tank and Line Preparation Do's and Don'ts

Do's

- 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.
- 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 5000 microns vacuum prior to filling with refrigerant. This step should take only 1–2 days but can take longer depending on volume to be evacuated and the equipment utilized.
- Do monitor tank pressures routinely

Don'ts

- Don't use strong cleaning agents to clean the bulk tank, lines, or filling equipment. While Opteon™ XL41 has good material compatibility and stability, it is not compatible with strong oxidizers—such as those found in peroxide-type cleaning agents. Cleaning agents that bill themselves as natural or friendly may also contain strong oxidizing agents and must be avoided.
- 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™ XL41, that does not ensure that all products are compatible. These may have a negative interaction with Opteon™ XL41, generating a white material.
- Don't let excess air or moisture get into the system. As with all refrigerants, excessive amounts of air and moisture can lead to poor system performance. There have been some instances where system contamination has led to the appearance of a white material that can appear as a whitish residue or string. To avoid, do not overlook the small points in refrigerant transfer, storage, and handling installations. Common points that can have a major impact on refrigerant quality are storage tanks, transfer lines, and package cleanliness. Never fill systems while under positive air pressure.
- Don't allow tank pressure to exceed the maximum allowable working pressure when filling with Opteon™ XL41. Relief devices on either the tanks or the supply system should be present and in good operating condition.
- Don't connect air lines to storage tanks.

Material Compatibility Concerns

Most metal components suitable for use with R-410A are also compatible with Opteon™ XL41, including standard types of carbon steel, aluminum, and copper. Some elastomeric or non-metallic components suitable for R-410A 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™ XL41 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

Recovery, Reclamation, Recycle, and Disposal

Recovery

Recovery refers to the removal of Opteon™ XL41 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. Only Opteon™ XL41 approved recovery recycle recharge (R/R/R) machines should be utilized.

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 R-454B refrigerant. Due to the 2L flammability rating of Opteon™ XL41, equipment should be designed to handle R- 454B. It is not adequate to use existing R-410A R/R/R or recovery-only equipment with R-454B. Equipment used should meet all regulatory and industry standards.

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.

Reclamation

Reclamation refers to the reprocessing of used Opteon™ XL41 to new product specifications. Quality of reclaimed product is verified by chemical analysis. Contact Chemours or one of its refrigerant distributors for further information.

Reclamation offers advantages as on-site refrigerant recycling 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 system and/or contaminate virgin refrigerant.

Recycle

Refrigerant recycle refers to the removal 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™ XL41, consult the manufacturer to confirm compatibility.

Disposal

Disposal refers to the destruction of used Opteon™ XL41. Disposal may be necessary when the refrigerant has become badly contaminated 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™ XL41.

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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