



Opteon™ XL
Refrigerants

Safety of Opteon™ XL Refrigerants

Chemours Answers Your Questions About the Safe
Handling and Use of Opteon™ XL Refrigerants



Chemours™



Introduction

This technical bulletin answers common safety questions that customers and service technicians may have regarding the use and handling of Opteon™ XL Refrigerants.

Opteon™ XL refrigerants, are composed of hydrofluoro-olefins (HFOs) or blends of hydrofluoro-olefins (HFOs) and hydrofluorocarbon (HFC) compounds. Hydrofluoro-olefins (HFOs) are unsaturated fluorocarbon refrigerants due to the double bond. It is this double bond that gives the HFO type compounds their unique properties. In general, HFO's have low global warming potential (GWP), good system stability, energy efficiency, short atmospheric lifetime and low flammability. Therefore, HFOs are ideal candidates for use in blend refrigerants with HFCs. The Opteon™ XL refrigerants were developed as effective, low-GWP alternatives to existing hydrofluorocarbon refrigerants.

Opteon™ XL10 (R-1234yf): Opteon™ XL10 is composed of pure HFO-1234yf which is a non-ozone depleting, low GWP refrigerant. It was developed to meet the EU Mobile Air Conditioning (MAC) Directive for phase-out of high GWP refrigerants for automotive air conditioning. The use of HFO-1234yf is growing exponentially and by the end of 2017, an estimated 40 million vehicles are expected to be utilizing it in their air conditioning systems. Opteon™ XL10 is also a very good solution for stationary equipment using R-134a, as shown by pilot projects and early field trials.

Opteon™ XL20 (R-454C) and Opteon™ XL40 (R-454A):

These low-GWP replacements can be used as a substitute for R-404A and R-22 technology. Opteon™ XL40 offers a GWP of 238 as well as superior performance with respect to cooling capacity and efficiency. This enables a reduction in CO₂-equivalents of 94% compared to R-404A.

Opteon™ XL20 is a closer match to R-22 based technology, but it is also a valid solution for R-404A equipment. With a GWP of 146, it falls under the important maximum value of 150 in the F-Gas regulation and Ecodesign requirements.

Opteon™ XL41 (R-454B) and Opteon™ XL55 (R-452B):

Both Opteon™ XL41 and Opteon™ XL55 are excellent replacements for R-410A in new equipment. Opteon™ XL41 provides the lowest GWP available (467) of leading R-410A-type solutions with a reduction of 78% GWP compared to R-410A. In addition to GWP reduction, it is a very close match to R-410A and in some cases even provides superior performance with respect to capacity and efficiency.

Opteon™ XL55 offers improved performance compared to R-410A, while also maintaining design compatibility. It also has the lowest flammability compared to industry tested R-410A alternatives.

Table 1: Opteon™ XL Refrigerants

ISO 817 / ANSI / ASHRAE 34 Refrigerant Designation	Chemours Tradename	Composition (weight %)	GWP*	ODP	Application Area	Replaces
R-1234yf	Opteon™ XL10	R-1234yf (100)	<1 (4)	0	Stationary Refrigeration/AC	R-134a
R-452B	Opteon™ XL55	R-32/125/1234yf (67/7/26)	676 (698)	0	AC and Heat-pumps	R-410A
R-454A	Opteon™ XL40	R-32/1234yf (35/65)	238 (239)	0	Medium and Low Temperature Refrigeration	R-404A, R-507A, R-407A, R-407F
R-454B	Opteon™ XL41	R-32/1234yf (68.9/31.1)	467 (466)	0	AC and Heat-pumps	R-410A
R-454C	Opteon™ XL20	R-32/1234yf (21.5/78.5)	146 (148)	0	Hermetic Medium and Low Temperature Refrigeration	R-22, R-407C, R-404A

* GWP is per IPCC Assessment Report 5, AR5, and () is per IPCC Assessment Report 4, AR4.

Refrigerant Classification Scheme

ISO 817 and ANSI/ASHRAE 34 standards provide safety classifications for refrigerants. Toxicity classifications are divided into two groupings with lower toxicity refrigerants given an A designation and those with higher toxicity given a B designation. Flammability classifications per these standards are divided into four categories with class 1 being practically non-flammable under most use conditions. R-410A and R-22 both qualify as class 1 or practically non-flammable. Class 2L is considered mildly flammable due to the low burning velocity and lower heat of combustion. Class 2 and class 3 denote the flammable and extremely flammable refrigerants. HFC-152a is a class 2 flammable refrigerant, while the hydrocarbons (propane, butane) generally populate the extremely flammable class 3.

ISO 817 Refrigerant Classification Scheme			
Propane	A3	B3	Highly Flammable
R-152a	A2	B2	Flammable
Opteon™ XL Products	A2L	B2L	Mildly Flammable
R-410A R-22	A1	B1	Non-Flammable
	Lower Toxicity	Higher Toxicity	

Figure 1: ISO 817 Refrigerant Classification Scheme

Opteon™ XL refrigerants all have the ISO 817 flammability classification A2L which means they are of low toxicity and mildly flammable. Mildly flammable refrigerants have the lowest flammable characteristics per the standards and must have a burning velocity below 10 cm/s. The 2L classification is now incorporated into various standards. Both ISO 5149 and EN 378 also recognize the classification and detail the necessary safety precautions needed for the safe use of the 2L class refrigerants.

Equipment Designed for A2L Refrigerants

Users must read and understand the Safety Data Sheets (SDS) before handling or using Opteon™ XL Refrigerants. Users should also follow all pertinent safety information provided by 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, locations listed on the last page of this technical bulletin or from any Chemours refrigerants distributor.

Due to the mild flammability, 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.

Table 2: Physical Properties of Opteon™ XL Refrigerants

ISO 817 Refrigerant Designation ANSI/ASHRAE 34	Composition (weight %)	Safety Class	ATEL/ ODL (kg/m ³)	LFL @ WCFF (kg/m ³)	Vapor Density @ 25°C, and 101.3 kPa (kg/m ³)	Molar Mass @WCFF	Normal Boiling Point (°C)
R-1234yf	R-1234yf (100)	A2L	0.47	0.289	4.66	114	-26
R-452B	R-32/125/1234yf (67/7/26)	A2L	0.467	0.298	2.63	98.48	-51.0 / -50.2
R-454A	R-32/1234yf (35/65)	A2L	0.461	0.289	3.34	113.9	-48.4 / -41.6
R-454B	R-32/1234yf (68.9/31.1)	A2L	0.435	0.354	2.59	111.8	-50.9 / -50.0
R-454C	R-32/1234yf (21.5/78.5)	A2L	0.371	0.289	3.78	114	-45.9 / -37.7

Are Retrofits Allowed for A2L Refrigerants?

Opteon™ XL refrigerants have been developed for new equipment design only. All intended application must comply with the relevant National laws and regulation when being operated with a 2L flammable gas. Additional safety measurements and modifications to the equipment may be necessary in order to guarantee a safe operating mode.

What are Typical Filling Charges for A2L Refrigerants?

Filling charges are usually covered by the respective codes and standards for refrigeration equipment, such as the general safety and use standard ISO 5149 “Refrigeration systems and heat pumps”. There are also more specific standards covering selected appliances, such as the IEC 60335-2 series.

- IEC 60335-2-24 for “refrigerating appliances, ice-cream appliance sand ice makers”
- IEC 60335-2-40 for “electrical heat pumps, air-conditioners and dehumidifiers”
- IEC 60335-2-89 for “commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor”

ISO and IEC standards are international safety-in-use type standards. European Norms or EN standards are typically based on an international standard.

Table 3: Relationship between International and European Union standards

Standard Type		International	Europe
Refrigerant Classification		ISO 817	Follows ISO 817
Safety in Use	General	ISO 5149	EN 378
	Equipment Specific	IEC 60335-2-24	EN 60335-2-24
		IEC 60335-2-40 IEC 60335-2-89	EN 60335-2-40 EN 60335-2-89

Check your local regulations and the correct standards such as those listed above to verify the allowable filling charge, new equipment design and safe handling requirements for the intended application.

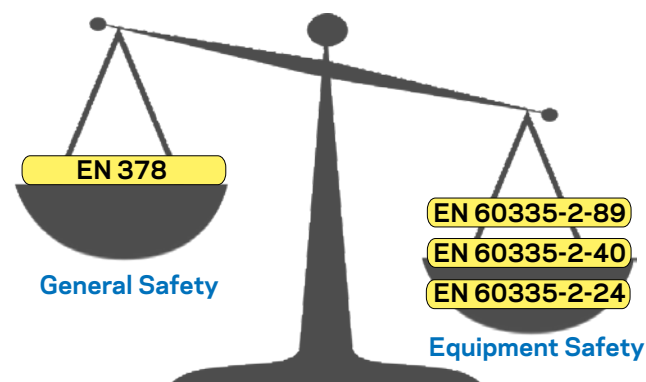


Figure 2: It should be noted that where an equipment standard provides guidance for charge limitations, the equipment standard over-rides charge limitations in the general safety standard.

Maximum Refrigerant Charge with No Room Volume Restrictions per EN 378

In the standards ISO 5149 and EN 378 the charge size of refrigerants is given as a function of the classification, the LFL and the room size of where the intended system is installed. However, there are some minimum charges that have no room volume restrictions and can be used in every application without constraints from the location. The flammability classes 2 or 3 are restricted below or equal to 4 x LFL without the need to consider room size. Flammability class 2L refrigerants can have up to 6 x LFL without any restrictions. Also, taking into account the higher LFL values of the 2L class refrigerants, the maximum charge allowed without restrictions is remarkably higher for 2L class refrigerants. For example, an A3 class refrigerant such as R-290 has a maximum charge of 150 g without any

Table 4: Comparison of Maximum Charge with No Room Volume Restrictions for EN 378

Refrigerant	ISO 817 Designation	Safety Class	LFL @ WCFF (kg/ m³)	Maximum Refrigerant Charge, No Room Vol Restriction (m1) (kg)
Opteon™ XL10	Opteon™ YF	A2L	0.289	1.73
R-452B	Opteon™ XL55	A2L	0.298	1.79
R-454A	Opteon™ XL40	A2L	0.289	1.73
R-454B	Opteon™ XL41	A2L	0.354	2.12
R-454C	Opteon™ XL20	A2L	0.289	1.73
R-152a	R-152a	A2L	0.130	0.52
R-290	Propane	A3	0.038	0.15

constraints due to room size whereas Opteon™ XL20 offers similar properties but charge sizes of 1.73 kg are allowed without any room volume restriction.

Maximum Refrigerant Charge with Room Volume Restrictions per EN 378

Planning for higher charge sizes, the room size needs to be considered and Figure 3 compares the allowed charge size for the different classes 2L, 2 and 3 with increasing room volume for a refrigeration application in public space under EN 378.

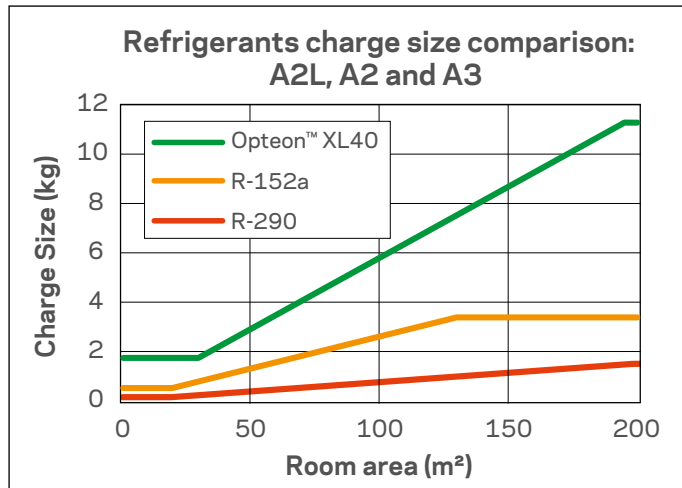


Figure 3: Allowed refrigerant charge size under EN 378 for flammable refrigerants (general occupancy, refrigerant-containing parts in the occupied space)

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.
- Follow standards for refrigerants as required and specified by the most current version of ISO 5149 or EN 378.

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, per local codes and regulations.
2. Make certain the area is well ventilated. Use auxiliary ventilation, rated for A2L refrigerants, 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 an A2L flammable rated refrigerant leakage detection and oxygen monitoring equipment in the work areas.

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.

1. Appropriate respiratory protection equipment should be readily available in case of a large release.
2. Personnel should be trained how to use this equipment.
3. Consult the most recent version of ISO 5149 or EN 378 for additional information.

Servicing Equipment Containing A2L Refrigerants

Service Equipment?

Many of the same service items can be used for servicing A2L refrigerants versus R-22 and R-410A. However, some service equipment, due to the electrical components and motors, should be specifically designed for use with mildly flammable A2L refrigerants (e.g. R-1234yf, R-32, etc.), which also needs to be compliant with local regulation. All service should be conducted in a safe manner and with respect to the guidelines given by the relevant codes and standards in your country/region. This new A2L service items should be available as there is an increasing number of service equipment companies providing these tools.

Table 5: Comparison of Service Equipment for Opteon™ XL products compared to R-404A and R-410A

Service Item	R-404A	R-410A	Opteon™ XL
Guage manifold	Routine	Routine	Routine
Charging hose	Routine	Routine	Routine
Torque wrench	Routine	Routine	Routine
Flare tool	Routine	Routine	Routine
Pipe cutter	Routine	Routine	Routine
Pipe bender	Routine	Routine	Routine
Hex wrench	Routine	Routine	Routine
Ventilation Fan, if low ventilation	Routine	Routine	Routine
Scales	Routine	Routine	Routine
Vacuum pump	Routine	Routine	Switch located away from work zone
Dry Powder/CO ₂ Fire Extinguisher	Not necessary	Not necessary	Chemical compatible
Gas Detector	Routine	Routine	2L certified
Electronic leak detector	Routine	Routine	2L certified
Refrigerant recovery cylinder	Routine	Routine	Flammable (GHS label, left hand thread)
Recovery machines	Routine	Routine	2L certified

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

- Review the Refrigerant Safety Data Sheet and the service instructions 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.

GENERAL REFRIGERANT HANDLING INFORMATION

FLAMMABILITY INFORMATION

In general, all refrigerants, including the Opteon™ XL refrigerants should not be mixed with any flammable gases or liquids for any reason because these mixtures can have unpredictable flammability properties and could be unsafe.

Mixtures of Opteon™ XL refrigerants with high concentrations of air at elevated pressure and/or temperature will change the flammability in the presence of an ignition source. The flammability is also elevated in an oxygen-enriched environment (oxygen concentrations greater than that in air). The exact flammability

characteristics of a mixture containing these refrigerant products and air, or these refrigerant products in an oxygen-enriched atmosphere, depends on the inter-relationship of 1) the temperature, 2) the pressure, and 3) the proportion of oxygen in the mixture. In general, these products should not be allowed to exist with air above atmospheric pressure or at high temperatures; or in an oxygen-enriched environment.

These products should NOT be mixed with air under pressure for leak testing or other purposes.

Care should be taken to ensure that the Opteon™ XL refrigerants are compatible with any other chemicals that the refrigerant may come into contact with in a leakage scenario when being used in process cooling applications.

In general 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 flame (such as a cutting torch) can become dramatically larger or change color if used in high concentrations of many 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.

Service cylinders for use A2L

Service Item	R-404A	R-410A	Opteon™ XL
Cylinder Type	Returnable	Returnable	Returnable
Cylinder Pressure Rating			Min 42 bar
Valve Threading	Right hand	Right hand	Left hand
Valve type			Typical DIN 477-1
GHS Markings			 

Pressure and Cylinder Safety

Can pressurized refrigerants ever cause a hazard?

Yes. Some of the potential hazards may include:

- In an overfilled container, vessel, or pipeline where temperature increases may become “liquid full” and immediately cause a dangerous increase in hydrostatic pressure, which can cause high -pressure leaks or even rupture of the vessel.
- A correctly filled returnable cylinder that is heated above the recommended maximum temperature of 52°C (125°F) could result in dangerously high pressures, possibly in excess of the cylinder design pressures.
- A returnable refrigerant cylinder connected to the discharge side of refrigeration or air-conditioning equipment may be exposed to pressures that can exceed the capacity of the cylinder relief devices, causing the cylinder to rupture or shatter.

What are the proper procedures for safely handling A2L returnable cylinders?

- Verify that the refrigerant label matches any color code or labeling used on the equipment.
- 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.
- Protect cylinders from moisture and rusting during storage.
- Do not store cylinders near incompatible materials or near incendiaries, such as cartons or boxes
- Do not pressurize systems or vessels containing these refrigerants with air for leak testing or any other purpose.
- Do not place cylinders near flames or heat sources, or discard into fires.
- Do not tamper with any relief devices on cylinders or refrigerant equipment.
- Do not drop, dent, or mechanically abuse containers.

- Do not recharge refillable cylinders with used refrigerants. Use only proper recovery cylinders for this purpose. It is illegal to ship original cylinders with used refrigerants.
- Do not force connections.
- Do not use flame on cylinders to heat them. Never expose cylinders to temperatures above 52°C (125°F).

Transport Storage & Handling Section

While Opteon™ XL refrigerants exhibit low or mild flammability properties per ISO 817 and ANSI/ASHRAE 34, this classification system is not recognized by the Globally Harmonized System or GHS. Under GHS, there is no distinction between flammable gases. According to GHS, all flammable gases are noted currently as “extremely flammable” under section 2 of the SDS.

TOXICITY INFORMATION

Decomposition

What causes decomposition?

All refrigerants, including the Opteon™ XL products, will decompose when exposed to high temperatures from flames or electric resistance heaters. Decomposition may produce toxic and irritating compounds, such as hydrogen fluoride.

How can I tell if a refrigerant has decomposed?

The strong odors released from the decomposed refrigerant will irritate the nose and throat. The irritating fumes released from decomposition will provide early warning and will likely result in an attempt to evacuate the area. Follow all Chemours recommendations for refrigerant handling to prevent refrigerant decomposition and other hazards.

Are decomposition products hazardous?

Yes. The acidic vapors produced are dangerous and the area should be evacuated immediately and ventilated to prevent exposure to personnel. Any-one exposed to the 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.

Are Opteon™ XL Refrigerants toxic?

These refrigerants have an excellent safety profile and are all class A or lower toxicity per ISO 817 classification scheme similar to R-410A and R-22. These products can be safely used when they are handled in accordance with Chemours recommendations, and when exposures are maintained at or below the recommended occupational exposure limits (OEL).

What is cardiac sensitization?

As with many other halocarbons or hydrocarbons, such as R-22 and R-410A, inhalation of high concentrations of Opteon™ XL Series refrigerants in the presence of high blood levels of the body's adrenaline may result in serious heart irregularities and possible death, an effect known as cardiac sensitization.

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.

What are common symptoms of overexposure?

Inhaling high concentrations of refrigerant vapors may with time cause temporary central nervous system depression with narcosis (sleepiness), lethargy, and weakness. Other effects that may occur include dizziness, a feeling of well-being or intoxication, and a loss of coordination. Continued inhalation of refrigerant vapors at high concentrations may produce heartbeat irregularities (cardiac sensitization), unconsciousness and, with gross overexposure, even death. A person experiencing any of the initial symptoms should be moved to fresh air immediately and kept calm and quiet. If not breathing, give artificial respiration. If breathing is difficult, use oxygen. Call a physician immediately.

Can inhaling Opteon™ XL Refrigerant vapors cause suffocation?

If a large release of refrigerant occurs, vapors can concentrate near the floor or in low areas and displace available oxygen, causing suffocation. In the event of a large spill or leak, always wear proper respiratory and other personal protective equipment. 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.

Skin and Eye Contact

Is skin or eye contact with Opteon™ XL Refrigerants hazardous?

At room temperature, these 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, then seek medical attention immediately.

Is frostbite a possible hazard?

In liquid form, these refrigerants 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.

Is the deliberate inhalation of Opteon™ XL Refrigerant dangerous?

Intentional misuse or deliberate inhalation of these refrigerants may disrupt heart rhythm and cause death without warning. This practice is extremely dangerous.

Can I smell Opteon™ XL Refrigerants?

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.

For more information on the Opteon™ family of refrigerants or other refrigerants from Chemours, visit **opteon.com**

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