Opteon™ 1100

Foam Blowing Agent

Properties, Uses,
Storage, and Handling

Chemours™

LOW GWP

Table of Contents

Introduction 4
- Background 4
- Uses 4

Properties 4
- Chemical Properties 4
- Physical Properties 5
- Chemical/Thermal Stability and Compatibility 7
- Chemical Stability 7
- Thermal Decomposition 7
- Compatibility with Metals 7
- Compatibility with Elastomers 7
- Compatibility with Plastics 7

Safe Use 8
- Inhalation Toxicity 8
- Skin and Eye Contact 8
- Spills or Leaks 9
- Enclosed and Confined Spaces 9
- Air Monitors and Leak Detection 9

Storage and Handling 9
- Shipping 9
- Storage 10
- Bulk Storage Systems 10
- Converting Bulk Storage Systems to Opteon™ 1100 10
- Handling 10
- Recycle and Disposal 11
  - Leaks and Spills 11
  - Disposal 11

Introduction

Background

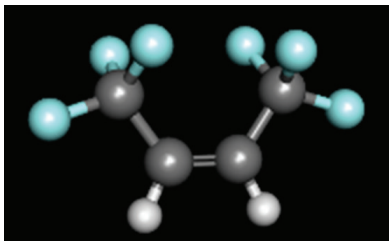
With the establishment and continued evolution of the Montreal Protocol, foam blowing agents (FBAs) used for closed-cell polymeric foam products have changed dramatically over the last two decades. Beginning in 1989, both thermoset and thermoplastic foam industries worldwide moved away from chlorofluorocarbons (CFCs) in favor of hydrochlorofluorocarbons (HCFCs), such as HCFC-141b and 142b. These alternatives were chosen as they provided a greatly decreased ozone depletion potential (ODP). Today, countries have either eliminated the use of, or are in the process of phasing out, HCFCs in foam applications, in order to meet the amended Montreal Protocol's regulated goal of zero ODP foam blowing agents.

This has led to the widespread use of third-generation zero ODP hydrofluorocarbon (HFC) foam blowing agents, such as HFC-245fa, HFC-365mfc, and HFC-134a. However, maturing environmental awareness has put such HFCs under speculation and, per the amended Montreal Protocol, will not be suitable for use as early as 2017 (based on application and country), due to their moderate global warming potential (GWP). As a result, many countries and polymeric foam manufacturers find themselves in need of a zero ODP and low GWP foam expansion agent.

Uses

Opteon™ 1100 is a zero ODP, low GWP foam blowing agent. With a GWP of 2, Opteon™ 1100 readily meets regulations established by the Montreal Protocol.

Opteon™ 1100 is used as a physical foam blowing agent for thermoset polymer foams, including polyurethane, polyisocyanurate, and phenolic resins, as well as thermoplastic foams, such as polystyrene or polyolefins. Opteon™ 1100 is a nonflammable and low toxicity molecule that provides excellent formulation stability, as well as low vapor thermal conductivity. Due to its boiling point of 33 °C (91 °F), it can easily be handled as a liquid in B-side formulations for thermosets and is also well suited as a gas in thermoplastic extrusion applications.



Opteon™ 1100 (formerly DuPont™ Formacel® 1100) has been listed by the U.S. Environmental Protection Agency (EPA) under the Significant New Alternatives Policy (SNAP) program as an acceptable substitute for ozone-depleting substances in multiple polyurethane, polyisocyanurate, and phenolic foam applications, subject to use conditions. Information on HFO-1336mzz-Z use conditions can be found in the U.S. Federal Register, 79 FR 62863 and 80 FR 42053. Opteon™ 1100 is subject to the Significant New Use Rule (SNUR) in United States, 40 CFR 721.10830. Export notification requirements from the United States are referenced in the Opteon™ 1100 Safety Data Sheet (SDS) regulatory section.

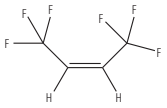
This technical bulletin is intended for general informational purposes only. As we are always discovering new and unique applications for Opteon™ 1100, one should consult Chemours technical staff to best serve your application's needs. Safety data sheets for Opteon™ 1100 should always be consulted prior to use for additional information.

Properties

Chemical Properties

Opteon™ 1100, or HFO-1336mzz-Z, is a hydrofluorinated compound containing a double bond, otherwise known as a hydrofluoro-olefin (HFO). The molecule does not contain chlorine or bromine; therefore, it has zero ODP. The double bond of the molecule allows HFO-1336mzz-Z to maintain its thermal stability in closed systems, such as polymeric foams; but, when accidentally released to the atmosphere, it has a very short atmospheric lifetime. This short atmospheric lifetime leads to HFO-1336mzz-Z having a 100 year ITH GWP of 2 (AR5). Chemical information for Opteon™ 1100 is shown in **Table 1**.

Table 1. Opteon™ 1100 Chemical Information

Chemical Name	Cis-1,1,1,4,4,4-Hexafluoro-2-butene
Synonyms	Opteon™ 1100 HFO-1336mzz-Z FEA-1100 Formacel® 1100
Molecular Formula	$CF_3CHCHCF_3$
CAS Registry Number	692-49-9
Molecular Weight	164.05
Chemical Structure	

Physical Properties

Table 2. Opteon™ 1100 General Property Information

Physical Property	Unit	Opteon™ 1100
Vapor Pressure at 25 °C (77° F)	kPa psia	60.40 8.76
Boiling Point (1 atm)	°C °F	33.4 92.1
Critical Temperature	°C °F	171.3 340.3
Critical Pressure	kPa abs psia	2899.9 420.6
Critical Density	kg/m^3 lb/ft^3	504.01 31.46
Liquid Density at 20 °C (68 °F)	kg/m^3 lb/ft^3	1377.98 86.02
Vapor Density at 20 °C (68 °F)	kg/m^3 lb/ft^3	4.21 0.26
Specific Heat, Liquid at 20 °C (68 °F)	kJ/kg·K Btu/lb·°F	1.23 0.30
Specific Heat, Vapor at 20 °C (68 °F)	kJ/kg·K Btu/lb·°F	0.82 0.20
Heat of Vaporization at Normal Boiling Point	kJ/kg Btu/lb	165.0 70.98
Thermal Conductivity, Liquid at 20 °C (68 °F)	W/m·K Btu/hr·ft·°F	0.0908 0.0527
Thermal Conductivity, Vapor at 20 °C (68 °F)	W/m·K Btu/hr·ft·°F	0.0104 0.0060
Viscosity, Liquid at 20 °C (68 °F)	mPa·s	0.312
Viscosity, Vapor at 20 °C (68 °F)	mPa·s	0.011
Flammability Rating	ASTM E-681	None
Solubility of H20 in HFO-1336mzz-Z at 25 °C (77 °F)	% by weight	0.0566
Solubility of HFO-1336mzz-Z in H20 at 25 °C (77 °F)	% by weight	0.0767
Ozone Depletion Potential (ODP)	CFC-11 = 1	0
Global Warming Potential (GWP) 100 yr ITH (AR5)	$CO_2 = 1$	2
TSCA Inventory Status	Included	Yes
WEEL Exposure Limit	ppm v/v (8-hr TWA)	500

Figure 1. Opteon™ 1100 Saturated Vapor Pressure vs. Temperature (SI Units)

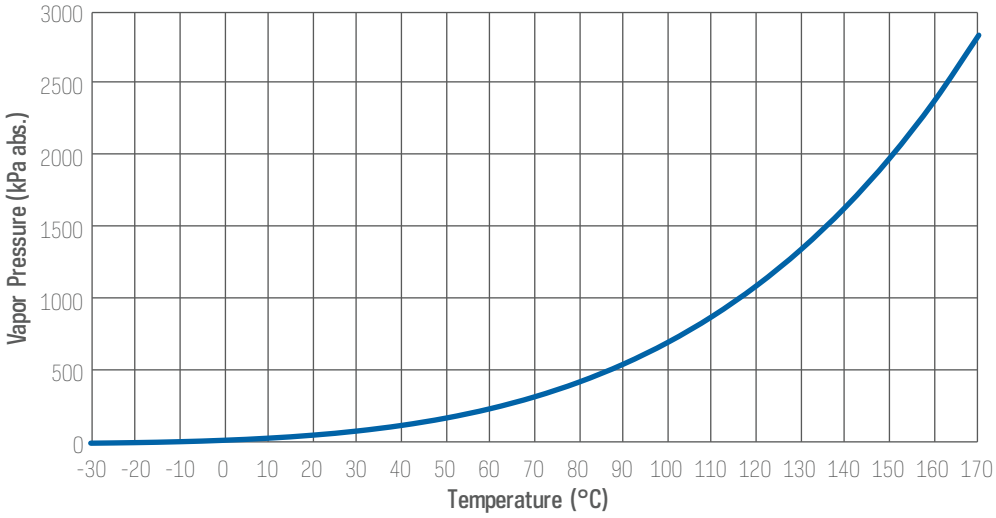


Figure 2. Opteon™ 1100 Liquid Density vs. Temperature (SI Units)

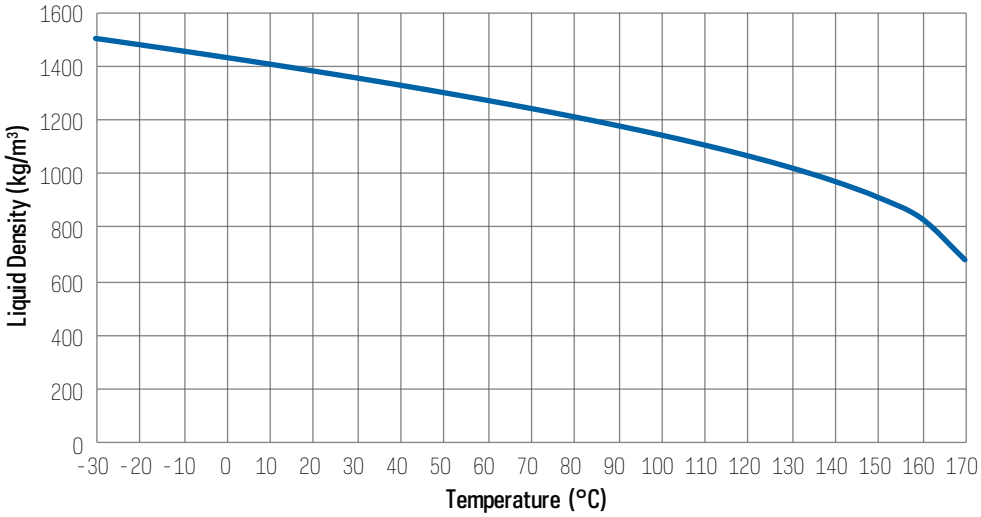
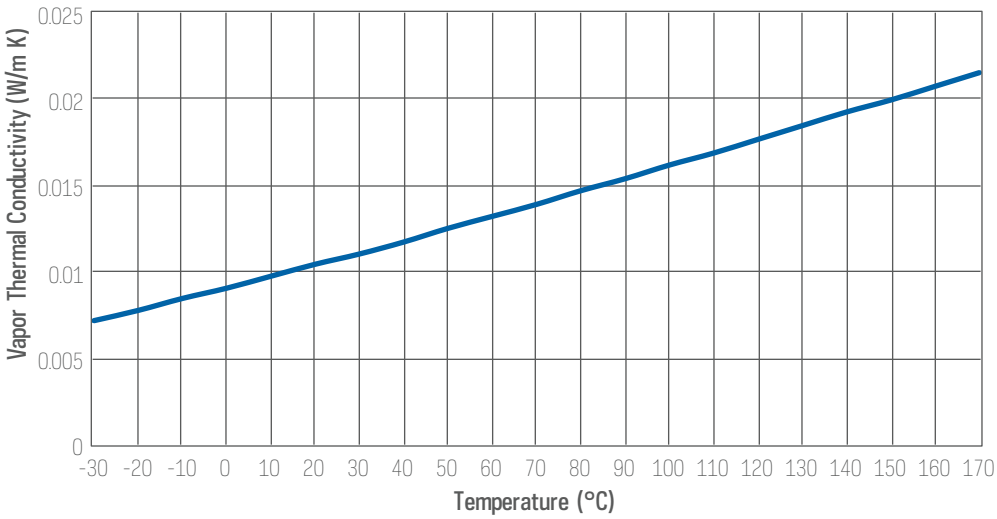


Figure 3. Opteon™ 1100 Vapor Thermal Conductivity vs. Temperature (SI Units)



Chemical/Thermal Stability and Compatibility

Due to the wide range of applications in which Opteon™ 1100 could be used, it is important to always review the system's chemicals as well as the materials of construction for compatibility before using Opteon™ 1100 in a new application. The following are general test results. To determine the compatibility of the specific system and materials being considered for use, additional tests should be considered at the conditions of the system.

Chemical Stability

Opteon™ 1100 has been tested in combination with a number of typical polyurethane foam components, including polyols, surfactants, catalysts, and flame retardants, indicating no compatibility problems for at least 6 months at 50 °C (122 °F). In addition, Opteon™ 1100 has been tested in combination with a range of amine catalysts at elevated temperatures, indicating no compatibility problems.

Thermal Decomposition

Although Opteon™ 1100 contains a carbon-carbon double bond, the molecule shows remarkable stability at temperatures up to 250 °C (482 °F) for at least 2 weeks in the presence of air, moisture, and metals (ASHRAE Standard 97 Sealed Tube Method).

Opteon™ 1100 will decompose when exposed to temperatures in excess of several hundred degrees Celsius (such as prolonged exposure to 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 the Chemours Safety Data Sheet's recommendations for handling.

Compatibility with Metals

Compatibility tests were conducted in heavy walled glass tubes in accordance with ASHRAE 97. The tests were conducted with metal coupons (copper, brass, carbon steel, stainless steel, and aluminum) immersed in 100% liquid Opteon™ 1100 and aged for 14 days at 100 °C (212 °F). Changes in weight and appearance of the metal coupons were recorded. The liquid solutions were also evaluated for appearance and decomposition products, such as fluoride. There were no changes in the color of the liquid or the condition of the metals at the conclusion of this test.

Compatibility with Elastomers

Compatibility tests with elastomers were performed similar to the metals stability test, except the aging was done at room temperature (23 °C [74 °F]). This test indicates that Opteon™ 1100 is compatible with most of the common elastomers that exhibit negligible swelling, weight gain, or hardness change after exposure. This is shown in **Table 3**.

Compatibility with Plastics

Plastics compatibility tests were similarly performed by exposing plastic materials to Opteon™ 1100 at room temperature for two weeks. Weight, volume, and hardness before and after the exposure were measured. Observations of changes are summarized in **Table 4**, which indicates that Opteon™ 1100 is compatible with commonly employed plastics.

As always, verifying compatibility using actually fabricated parts under end-user conditions is advised, as the performance of plastics is affected by polymer variations, compounding agents, fillers, and molding processes.

Table 3. Elastomer Compatibility – 2 Weeks Exposure to Opteon™ 1100 at Room Temperature

Material	Brand	% Weight Change	% Volume Change	% Hardness Change
Natural Rubber	Natural Rubber	4.4	1.9	0.0
Polychloroprene	Neoprene® W	0.8	0.1	0.0
Acrylonitrile Butadiene	BUNA N	15.3	2.6	-13.6
Chlorosulfonated Polyethylene	Hypalon 40®	0.2	0.8	-1.3
Fluoroelastomer	Kalrez®	7.9	-3.4	-2.9
Fluoroelastomer	Viton™	98.0	127.5	-33.8
Polysulfide	THIOKOL FA®	0.3	6.7	-6.1
Isobutylene Isoprene	Butyl Rubber	0.3	13.1	-13.3
Hydrocarbon (Ethylene-Propylene Terpolymer	Nordel®	1.4	5.5	-7.1

Table 4. Plastic Compatibility – 2 Weeks Exposure to Opteon™ 1100 at Room Temperature

Material	Brand	% Weight Change	% Volume Change	% Hardness Change
ABS	Cycolac® EX58	-0.1	-0.6	0.0
High Impact Polystyrene		0.3	-0.4	-2.9
Poly(ethylene terephthalate)	Rynite®	0.0	0.7	-1.2
Polystyrene	Styron®	-0.4	0.9	0.0
Polyvinyl Chloride	Bakelite®	0.0	0.0	0.0
Chlorinated Polyvinyl Chloride		0.0	-0.3	0.0
Fluorocarbon (PTFE)	Teflon™	1.1	0.3	-17.2
Fluorocarbon (ETFE)	Tefzel™	0.7	0.0	12.9
Ionomer	Surlyn®	0.3	0.0	1.9
Acetal	Delrin®	0.1	-1.2	-1.3
Polycarbonate	Tuffak®	0.0	-0.6	0.0
Polyetheretherketone (PEEK)	Victrex®	0.0	0.2	0.0
Polyarylate	Arylon®	0.2	-0.2	-4.4
Polyester	Xydar®	0.0	-0.4	-1.5
Nylon 6/6	Zytel® 101	0.4	-0.5	3.1
Polyetherimide	Ultem®	-0.1	0.0	0.0
Polyaryl Sulfone	Radel®	-0.2	0.3	0.0
Poly(vinylidene fluoride)	Kynar®	0.1	-0.3	0.0
Polypropylene	Tenite®	0.3	-0.5	0.0
LCP	Zenite	-0.1	-0.9	0.0
High Density Polyethylene	Alathon®	0.0	0.3	3.3
Phenolic	Durez®	0.0	-0.1	1.2

Safe Use

Users of Opteon™ 1100 should read and understand the Chemours Safety Data Sheet (SDS). Copies of the Opteon™ 1100 SDS can be obtained from Chemours Customer Service or from any Chemours authorized distributor.

Inhalation Toxicity

Opteon™ 1100 poses no acute or chronic hazard when it is handled in accordance with Chemours recommendations and when the exposure is maintained below the WEEL of 500 ppm (8-hr TWA). Opteon™ 1100 should only be used with adequate ventilation; and, when inhalation is a possibility, NIOSH-approved respiratory protection should be employed.

Inhaling high concentrations of Opteon™ 1100 vapor may cause temporary nervous system depression with anesthetic effects, such as dizziness, headache, confusion, loss of coordination, and even loss of consciousness. Higher exposures to the vapors may cause temporary alteration of the heart's electrical activity with irregular pulse, palpitations, or inadequate circulation. Intentional misuse or deliberate inhalation may cause death without warning.

If a person is experiencing any of the initial symptoms, they should be moved to fresh air and kept calm. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek medical attention immediately.

If vapors are inhaled at a concentration of 25,000 ppm, which is well above the WEEL, the heart may become sensitized to adrenaline, leading to cardiac irregularities and, possibly, cardiac arrest. Similar effects are observed with many hydrocarbons and halocarbons at high concentrations. The likelihood of these cardiac problems increases if the person is under physical or emotional stress.

Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be considered only as a last resort in life-threatening emergencies.

Skin and Eye Contact

At room temperature, Opteon™ 1100 vapors have little or no effect on the skin or eyes.

Always wear protective clothing (e.g., eye protection and face shield) when there is a risk of exposure to liquid Opteon™ 1100. **If skin or eye contact occurs**, flush the exposed area in lukewarm water, not cold or hot, for at least 15 minutes. Seek medical attention as soon as possible.

Spills or Leaks

If a large release of vapors occurs, such as from a large leak or spill, the vapors may concentrate near the floor or in low elevation areas and displace the oxygen available for breathing, causing suffocation.

Evacuate everyone until the area has been well ventilated. Use blowers or fans to circulate the air at floor level. Do not re-enter the affected area without self-contained breathing apparatus (SCBA) or unless the area has been monitored to indicate that the concentration of Opteon™ 1100 vapors in the area is below the WEEL and oxygen levels have returned to normal.

Enclosed and Confined Spaces

To ensure safety when working with halocarbons in enclosed areas:

1. Route relief and purge vent piping outdoors, away from air intakes.
2. Make certain the area is well ventilated, using auxiliary ventilation if necessary, to move vapors.
3. Make sure the area is clear of vapors prior to beginning work. Be conscientious of low lying areas where vapors may gather.
4. Utilize constant air monitoring and/or spot check detection equipment to detect leaks.

Always use SCBA or a supplied air mask when entering tanks or other confined spaces where vapors might exist. Use the buddy system, a lifeline, and regular air monitoring. Refer to the Opteon™ 1100 SDS for more information.

Air Monitors and Leak Detection

Opteon™ 1100 vapors have virtually no odor. Therefore, frequent leak checks or the installation of area monitors are necessary in areas where leaks can occur. Whenever a system is assembled or serviced, it should be checked for leaks. This is not only for the protection of employees, but also to reduce fugitive emissions to the atmosphere, protect valuable equipment, and the conservation of material.

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 a fluorochemical. 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, and flammability.

There are many commercially available leak detectors. These devices are readily available through a refrigeration contractor or service store. For more information on recommended types and technologies of air monitors and leak detectors, please contact Chemours Customer Service or any authorized Chemours technical service representative.

Storage and Handling

Shipping

Opteon™ 1100 is a nonflammable liquid (ASTM E-681). It is not classified as dangerous in the meaning of transport regulations and, therefore, does not have a proper shipping name or hazard class. Details of our current Opteon™ 1100 packaging options are found in **Table 5**.

The drums used for Opteon™ 1100 are a tight head steel drum painted Grass Green, RAL 6010. Drums have 5.1-cm (2-in) and 1.9-cm (3/4-in) openings diametrically opposite on the top heads. Both openings have galvanized steel plugs with 4S closure systems and low density polyethylene seals. The 5.1-cm drum plug should be torqued to 20-30 Nm, while the 1.9-cm plug should be torqued to 15-20 Nm in order to prevent product vapor loss. The inside of the drum is coated with an RDL50 phenolic lining.

The pails used for Opteon™ 1100 are painted Royal Blue and have a single 5.1-cm (2-in) plug manufactured in accordance with DIN EN ISO 15750-3. The plug should be torqued to 20-30 Nm in order to prevent product vapor loss. The pail is also equipped with one 5-mm handle centered on the top of the drum, and the inside is also coated with a phenolic lining.

Upon full-scale commercialization of Opteon™ 1100, an ISO tank container option will also be available equipped with standard top manhole, an air/nitrogen inlet, bottom discharge, and top discharge.

Storage

Drums and pails of Opteon™ 1100 should be stored tightly closed and in an upright position. Drum plugs should be tightened at least to the container's recommended torque; up to 1.5 times the recommended torque in order to prevent product vapor loss. Containers should be in a clean, dry, and, if possible, temperature-regulated area. Containers should be kept away from direct sunlight. Prolonged exposure to temperatures above 46 °C (115 °F) could result in distortion of the drum. Never expose drums to temperatures at or above 52 °C (125 °F). If 52 °C (125 °F) or greater temperatures are possible, relocating to a temperature-controlled area or usage of refrigerated storage/transportation is recommended.

All drum bungs should be leak-tight (at a minimum, sealed with TFE tape). Storage of factory sealed drums does not require a continuously operating air monitor. A monitor is, however, required if liquid transfer or drumming operations are being performed at an indoor storage location. Storage areas should also be equipped with adequate ventilation. Quantities stored should be limited to that needed for reasonable process requirements. Empty drums should be stored outside. No storage of Opteon™ 1100 should be permitted in areas containing alkali or alkaline earth metals, such as powdered aluminum, zinc, or beryllium.

Table 5. Opteon™ 1100 Packaging Options

	Tight Head Pail	Tight Head Drum	ISO
Nominal Volume	20.6 L	216.5 L	15,000 L
Height	364 mm	884 mm	8.5 ft
Diameter or Length/Width	280 mm	585 mm	20 ft/8 ft
Weight	3 kg	23 kg	3,300 kg
Rating	UN1A1/X/500	UN1A1/X2.0/400	Maximum allowable working pressure: 4 bar (58 psi)

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. These units are designed to optimize economy, efficiency, and safety in the storage and dispensing of these fluorochemicals. These delivered systems include all components, such as storage tanks, pumps, piping, valves, motors, and gauges, as an integrated unit. All such systems are equipped with the Chemours Fluorochemical Emission Elimination Delivery (FEED) or alternative system to prevent emissions during deliveries and with dual pumps to provide an installed spare. When possible, units are skid-mounted and require only placement on a concrete pad and connection to electrical and process systems.

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

Converting Bulk Storage Systems to Opteon™ 1100

Before switching from previous foam expansion agents to Opteon™ 1100, the existing storage equipment must be checked to verify that it is adequate and can be converted for use with HFO-1336mzz-Z. Your Chemours marketing or technical service representative can arrange for guidance on storage system conversion.

Handling

- Opteon™ 1100 is shipped in drums that can weigh in excess of 600 lb (272 kg).
- A minimum of gloves, safety glasses with side shields, and safety shoes are recommended at all times when handling Opteon™ 1100. Always assess the job for the proper choice of glove. Splash goggles or face shield and chemical-resistant clothing/aprons to avoid skin contact are recommended when handling open drums.
- Drums should only be handled in areas with adequate ventilation. If exposure to Opteon™ 1100 vapors is possible, a NIOSH-approved respirator is recommended.
- Never apply direct flame or live steam to a container.
- 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.
- Use of proper drum handling equipment, such as hand carts, drum dollies, and forklifts, is recommended, per the equipment manufacturer's restrictions.
- Never use container for any purpose other than to store Opteon™ 1100.
- Never attempt to repair or alter containers.
- Never force connections that do not fit.
- Protect containers from any object that will result in cuts or other abrasion in the surface of the metal.
- Use a vapor recovery system when possible to collect vapors from lines after unloading a container.

- Pumps can be utilized for transfer of material. Selection will be based on individual setup and flow requirements and should be reviewed to minimize emissions, loss of product, safety, and efficiency.
- Methods of movement, such as nitrogen pressure pumping or blow casing, are not recommended, due to the inert gas' ability to solubilize in the product and potentially lead to pressurized containers.
- When working near other drums and equipment, be careful of pinch points.
- Opteon™ 1100 drums should always be stored and moved with the drum plugs tightly secured to at least the drum's recommended torque; up to 1.5 times the recommended torque to prevent spills and fugitive vapor emissions.

Recycle and Disposal

Responsible use of Opteon™ 1100 requires that the product be recovered for reuse or disposal. Chemours accepts return of unused Opteon™ 1100 or empty Opteon™ 1100 packages through its distributor networks in the United States and Europe. In addition, the U.S. Clean Air Act prohibits known venting of refrigerants during the maintenance, servicing, or disposal of refrigeration equipment.

Leaks and Spills

Major leaks or spills will not evaporate readily, due to the high boiling point of Opteon™ 1100, forcing recovery as a liquid. Self-contained breathing air (SCBA) is required until levels, as verified by the proper monitor, are reduced sufficiently to permit other or no respiratory protection. Spill control measures should be preplanned, and all washes should be disposed of in accordance with applicable government regulations. If splash potential exists, wear protective equipment fabricated from an impervious material, such as butyl rubber.

Disposal

Disposal refers to the destruction of used HFO-1336mzz-Z. Although Chemours does not presently accept severely contaminated foam blowing agents for disposal, licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them contaminated HFO-1336mzz-Z.

For more information on Opteon™ foam blowing agents, visit opteon.com or call (800) 235-7882.

C-11025 (9/16)