



1100/1150 Blends

Foam Blowing Agents

Properties, Uses, Storage, and Handling



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Introduction

Background

With the establishment and the continued evolution of the Montreal Protocol, the 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 regulation and, per the Kigali Agreement, are being phased out (based on application and country) due to their moderate Global Warming Potentials (GWPs). As a result, many countries and polymeric foam manufacturers find themselves in need of a zero ODP and low GWP foam expansion agent.

Opteon™ 1100 and 1150 Blend Uses

Opteon™ 1100 and 1150 are zero ODP, low GWP foam expansion agents. With GWPs of 2 and 7 respectively, (1) Opteon™ 1100 and 1150 both readily meet regulation established by the Montreal Protocol individually and blended.

Opteon™ 1100 and 1150 are used as physical foam blowing agents for thermoset polymer foams including polyurethane, polyisocyanurate, and phenolic resins, as well as thermoplastic foams such as polystyrene or polyolefins. Opteon™ FBAs are non-flammable and low toxicity molecules, which provide excellent formulation stability as well as low vapor thermal conductivities.

Blends of Opteon™ 1100 and 1150 have shown many advantages as primary or co-blowing agents in polyurethane foam resins, or froth foams. In Spray Polyurethane Foam (SPF) applications, blends of Opteon™ 1100 and 1150 have shown improvements in cold temperature application behavior as well as insulation performance.(2) For appliance and cold chain applications, blends demonstrated significantly improved low temperature insulation performance versus incumbent HFC BAs.(3) In panel applications, blends of Opteon™ 1100 and 1150 in combination with pentanes have shown advantages in lower k-factors and improving aged insulation behavior.(4) Consult your local Chemours™ Technical Service representative with question about the appropriate blends for your application.

Regulatory

The United States Environmental Protection Agency (EPA) has listed Opteon™ 1100 and Opteon™ 1150 as acceptable substitutes in foam blowing agents for the end uses listed below under the Significant New Alternatives Policy (SNAP) program.

- Rigid Polyurethane Spray Foam (High Pressure Two-Component)
- Integral Skin Polyurethane
- Laminated Boardstock
- Rigid Polyurethane Appliance
- Rigid Polyurethane Commercial Refrigeration
- Rigid Polyurethane Sandwich Panels
- Rigid Polyurethane Slabstock and other

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.

Opteon™ 1150 is subject to a Significant New Use Rule (SNUR) under the U.S. EPA Toxic Substance Control Act (TSCA) – 40 CFR § 721.10907. Export notification requirements according to TSCA §12(b) are referenced in the Opteon™ 1150 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 blends of Opteon™ 1100 and 1150, one should consult the Chemours™ technical staff to best serve your application's needs. Safety Data Sheets (SDS) for blends of Opteon™ 1100 and 1150 should always be consulted prior to use for additional information.

Properties

Chemical Properties

Opteon™ 1100 and 1150 are hydrofluorinated compounds containing a double bond, otherwise known as a hydrofluoro-olefins (HFOs). These molecules do not contain chlorine or bromine; therefore, they have zero ODP. The double bond of these molecules allows Opteon™ 1100 and 1150 to maintain thermal stability in closed systems such as polymeric foams, but when accidentally released to the atmosphere, they have a very short atmospheric lifetime. This short atmospheric lifetime leads to Opteon™ 1100 and 1150 having 100-year ITH Global Warming Potentials of 2 and 7 respectively (AR5). Chemical information for Opteon™ 1100 is shown in Table 1. Chemical information for Opteon™ 1150 is shown in Table 2.

Table 1: Opteon™ 1100 Chemical Information

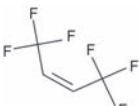
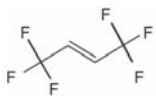
Chemical Name	Cis-1,1,1,4,4,4-Hexafluoro-2-butene
Synonyms	Opteon™ 1100 HFO-1336mzz-Z FEA-1100* Formacel® 1100*
Molecular Formula	$\text{CF}_3\text{CHCHCF}_3$
CAS Registry Number	692-49-9
Molecular Weight	164.05
Chemical Structure	

Table 2: Opteon™ 1150 Chemical Information

Chemical Name	Trans-1,1,1,4,4,4-Hexafluoro-2-butene
Synonyms	Opteon™ 1150 HFO-1336mzz-E
Molecular Formula	$\text{CF}_3\text{CHCHCF}_3$
CAS Registry Number	66711-86-2
Molecular Weight	164.05
Chemical Structure	

Physical Properties

Physical properties of Opteon™ 1100 and 1150 are shown in **Table 3**.

Bubble Point Vapor Pressure vs. Temperature is shown in **Figure 1**.

Dew Point Vapor Pressure vs. Temperature is shown in **Figure 2**.

Liquid Density vs. Temperature is shown in **Figure 3**.

Table 3: Blends of Opteon™ 1100 and 1150 General Physical Properties

Physical Property	Unit	1100:1150	1100:1150	1100:1150	1100:1150
Blend of Opteon™ 1100: Opteon™ 1150	Ratio	50:50	60:40	70:30	80:20
Vapor Pressure at 25 °C (77 °F)	kPa	143.6	131.0	117.6	103.4
	psia	20.82	19.00	17.05	15.00
Boiling Point (1 atm)	°C	15.55	18.02	20.95	24.45
	°F	59.99	64.43	69.72	76.01
Critical Temperature	°C	150.6	155.1	159.4	163.7
	°F	303.0	311.1	319.0	326.6
Critical Pressure	kPa abs	2940.4	2959.1	2966.2	2960.6
	psia	426.5	429.2	430.2	429.4
Critical Density	kg/m ³	510.1	506.8	503.0	499.17
	lb/ft ³	31.85	31.64	31.40	31.16
Liquid Density at 25 °C (77 °F)	kg/m ³	1321.4	1329.8	1338.4	1347.1
	lb/ft ³	82.49	83.01	83.55	84.10
Vapor Density at 25 °C (77 °F)	kg/m ³	10.18	9.24	8.25	7.22
	lb/ft ³	0.64	0.58	0.52	0.45
Specific Heat, Liquid at 20 °C (68 °F)	kJ/kg-K	1.203	1.206	1.209	1.213
	Btu/lb-°F	0.9308	0.9331	0.9357	0.9384
Specific Heat, Vapor at 20 °C (68 °F)	kJ/kg-K	0.8859	0.8833	0.8800	0.8761
	Btu/lb-°F	0.6856	0.6836	0.6810	0.6780
Heat of Vaporization at Normal Boiling Point	kJ/kg	159.3	160.9	162.1	163.0
	Btu/lb	68.48	69.15	69.70	70.10
Thermal Conductivity, Liquid at 25 °C (77 °F)	W/m-K	0.0771	0.0763	0.0755	0.0745
	Btu/hr-ft-°F	0.1443	0.1413	0.1413	0.1395
Thermal Conductivity, Vapor at 25 °C (77 °F)	W/m-K	0.01155	0.01153	0.01151	0.01149
	Btu/hr-ft-°F	0.02163	0.02159	0.02155	0.02150
Viscosity, Liquid at 25 °C (77 °F)	mPa-s	0.2855	0.2984	0.3127	0.3282
Viscosity, Vapor at 25 °C (77 °F)	mPa-s	0.0107	0.0106	0.0105	0.0104
Flammability Rating	ASTM E-681	Non-flammable	Non-flammable	Non-flammable	Non-flammable
Solubility of H ₂ O in Blends of HFO-1336mzz-Z & HFO-1336mzz-E at 25 °C (77 °F)	ppm	478.7	497.4	516.0	534.2
Solubility of Blends of HFO-1336mzz-Z & HFO-1336mzz-E in H ₂ O at 25 °C (77 °F)	ppm	839.5	838.1	832.5	821.7
Ozone Depletion Potential (ODP)	CFC-11 = 1	0	0	0	0
Global Warming Potential (GWP) 100 yr ITH (AR5)	CO ₂ = 1	4.5	4	3.5	3
TSCA Inventory Status		Included	Included	Included	Included
WEEL Exposure Limit	ppm v/v (8-hr TWA)	450	460	470	480

*Calculated properties of two non-azeotropic, dissimilar boiling liquids using Refprop

*Non-flammability based on the assumption that two non-flammable components blended remain non-flammable

Figure 1: Opteon™ 1100 and 1150 Blends Bubble Point Vapor Pressure vs. Temperature (SI Units)

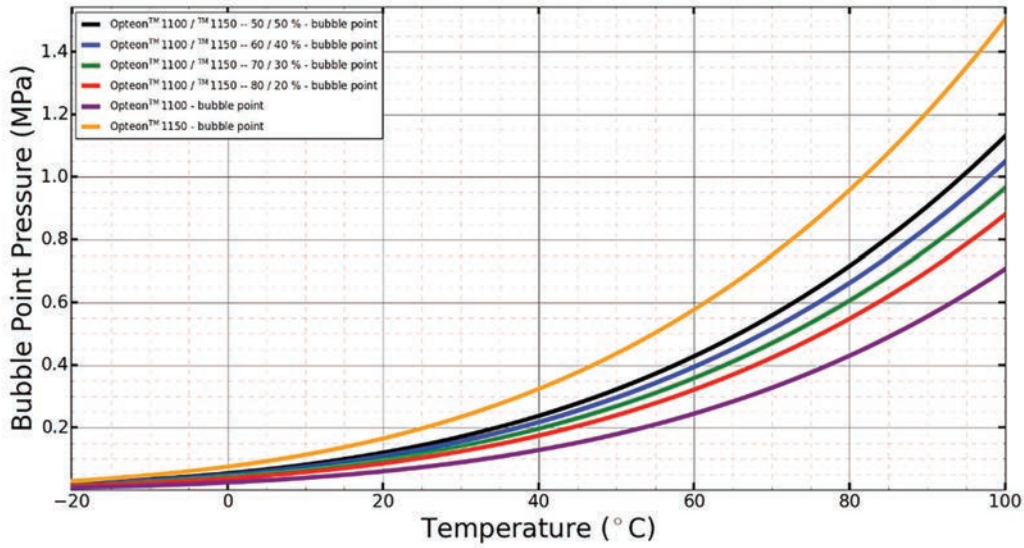


Figure 2: Opteon™ 1100 and 1150 Blends Dew Point Vapor Pressure vs. Temperature (SI Units)

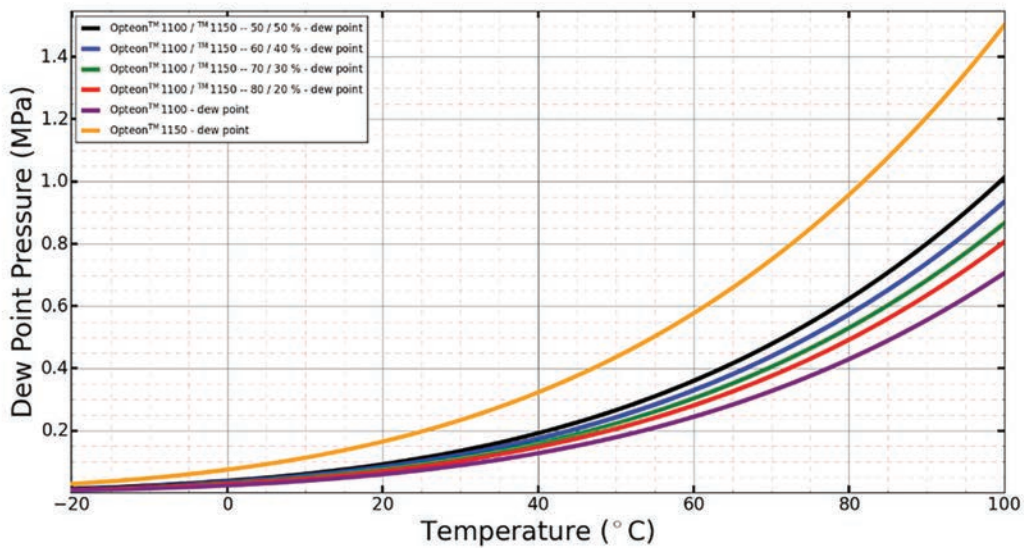


Figure 3: Opteon™ 1100 and 1150 Blends Liquid Density vs. Temperature (SI Units)

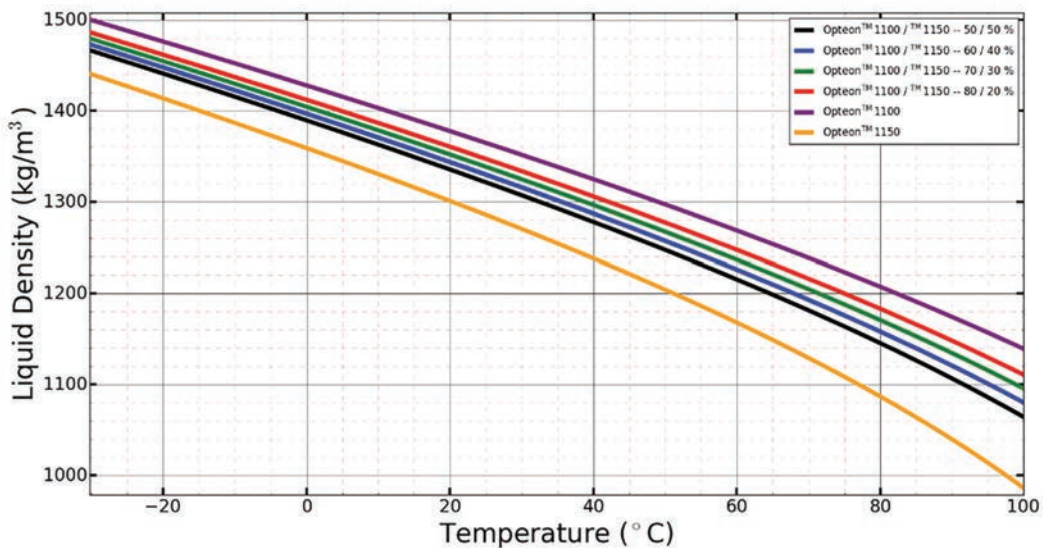
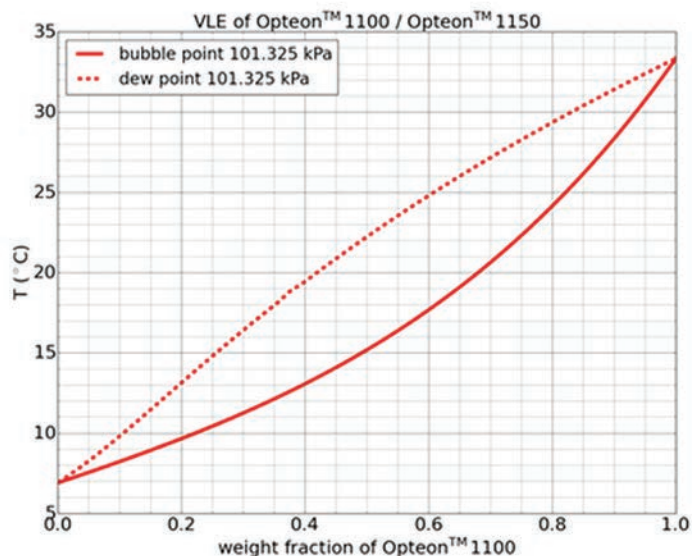


Figure 4: Opteon™ 1100 and 1150 Blends VLE vs. Temperature (SI Units)



Chemical/Thermal Stability and Compatibility

Due to the wide range of applications in which Opteon™ 1100 and 1150 blends can 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 and 1150 blends 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. Opteon™ 1100 and 1150 blends are azeotrope like, but compositional drift can occur. Contact your Chemours™ Technical Service representative to ensure proper handling.

Chemical Stability

Opteon™ 1100 and 1150 blends are expected to be stable when used in combination with many typical polyurethane foam components including polyols, surfactants, catalysts, and flame retardants indicating no compatibility problems for at least 6 months at 50°C. Consult your Chemours™ technical representative for details.

Thermal Decomposition

Although blends of Opteon™ 1100 and 1150 contains carbon-carbon double bonds, the molecules and blend show remarkable stability at temperatures up to 250°C for at least 2 weeks in the presence of air, moisture and metals (ASHRAE Standard 97 Sealed Tube Method).

Opteon™ 1100 and 1150 blends 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) in the presence of Opteon™ 1100 and 1150 and aged for 14 days at 175 °C. 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 metal stability tests, except the aging was done at room temperature (23 °C, 74 °F). This test indicates that Opteon™ 1100 and 1150 blends are compatible with most of the common elastomers which 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 and 1150 blends 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 and 1150 blends are compatible with commonly employed plastics.

As always, verifying compatibility using 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 4: Elastomer Compatibility – 2 Weeks Exposure to Opteon™ Blends at Room Temperature

Elastomer Material	Opteon™ 1100	50:50 Blend of Opteon™ 1100 and 1150	Opteon™ 1150
Neoprene C1276-70	Compatible	Compatible	Compatible
Epichlorohydrin YB 146-75	Compatible	Compatible	Compatible
Butyl B0612-70	Compatible	Borderline	Borderline
EPDM E0893-80	Compatible	Compatible	Compatible
Fluorosilicone	Incompatible	Incompatible	Incompatible
HNBR nitrile N1173-70	Incompatible	Incompatible	Borderline
NBR nitrile NA151-70	Borderline	Borderline	Compatible
Fluorocarbon FKM V0747-75	Incompatible	Incompatible	Incompatible
Neoprene C0873-70	Compatible	Compatible	Compatible
Viton A 401C	Incompatible	Incompatible	Incompatible
Viton GF 600S	Incompatible	Incompatible	Incompatible

Compatible materials have a Percent Linear Swell ≤ 10 and a Percent Hardness Change ≤ 10

Borderline materials have a Percent Linear Swell >10 OR a Percent Hardness change >10

Incompatible materials have a Percent Linear Swell ≥ 10 and a Percent Hardness Change ≥ 10

Table 5: Plastic Compatibility – 2 Weeks Exposure to Opteon™ Blends at Room Temperature

Plastic Material	Opteon™ 1100	50:50 Blend of Opteon™ 1100 and 1150	Opteon™ 1150
Polyester (thermoplastic) Bexloy V-978	Borderline	Borderline	Borderline
Nylon Resin -Zytel 330	Compatible	Compatible	Compatible
Torlon Polymer (polyamide-imide plastic)	Compatible	Compatible	Compatible
Ryton polymer (polyphenylene sulfide)	Compatible	Compatible	Compatible
PEEK (Ketaspire 820 NT)	Compatible	Compatible	Compatible
Nylon 6.6 polymer plastic (Zytel 101)	Compatible	Compatible	Compatible
PTFE	Compatible	Borderline	Borderline

Compatible materials have no weight gain and no physical change

Borderline materials have some weight gain and the physical surface is changed (dulled or crazed)

Incompatible materials have significant weight gain and the physical surface is significantly changed (destroyed or dissolved)

Safe Use

Users of blends of Opteon™ 1100 and 1150 should read and understand the Chemours™ Safety Data Sheet (SDS). Copies of the blend of Opteon™ 1100 and 1150 SDS can be obtained from Chemours™ Customer Service or International Offices (see last page of this document for locations and telephone numbers) or from any Chemours™ authorized distributor.

Inhalation Toxicity

When handled in accordance with Chemours™ recommendations and when exposure is maintained below the WEEL of 400 ppm (8-hr TWA) for pure Opteon™ 1150, no acute or chronic adverse health effects are expected from exposure to Opteon™ 1150. Opteon™ 1100 and 1150 blends should only be used with adequate ventilation and when inhalation is a possibility, NIOSH approved respiratory protection should be employed.

Inhaling high concentrations of blends of Opteon™ 1100 and 1150 vapor may cause temporary central nervous system effects such as convulsions, 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 concentrations above 20,000 ppm, which is well above the WEEL, severe convulsions may occur, and death may result. Additionally, 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 and 1150 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 or 1150. 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 and 1150 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 blend of Opteon™ 1100 and 1150 SDS for more information.

Air Monitors and Leak Detection

Opteon™ 1100 and 1150 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

Blends of Opteon™ 1100 and 1150 with less than 20% Opteon™ 1150 are a nonflammable liquid and not DOT regulated. Blends of Opteon™ 1100 and 1150 over 20% Opteon™ 1150 are also not a DOT hazard but are an IATA hazard. The appropriate IATA designations are as follows:

Proper shipping name:

Environmentally Hazardous substance, liquid N.O.S.
(E)1,1,1,4,4,4-Hexafluoro-2-butene
Hazard class: 9
UN No.: 3082

Storage

Cylinders of Opteon™ 1100 and 1150 should be stored tightly closed and in an upright position. Cylinders should be in a clean, dry, and if possible, temperature regulated area. Cylinders should be kept away from direct sunlight. Cylinders should be stored at temperatures less than 46°C (115°F). Never expose cylinders to temperatures at or above 52°C (125°F). If 52°C or greater temperatures are possible, re-locating to a temperature-controlled area or usage of refrigerated storage/transportation is recommended.

Storage areas should also be equipped with adequate ventilation. Quantities stored should be limited to that needed for reasonable process requirements. No storage of blends Opteon™ 1100 and 1150 should be permitted in areas containing alkali or alkaline earth metals such as powdered aluminum, zinc, or beryllium.

Table 6: Blends Opteon™ 1100 and 1150 Packaging Options

Water Capacity	123 lb. (55kg)	1000 lb (453 kg)
Dimensions	55"H x 10" OD (140cm x 25.4cm)	50"H x 30" OD (127cm x 76cm)
Spec	4BA300	4BW260
Net Weight	145	1200

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 and 1150

Before switching from previous foam expansion agents to Opteon™ 1100 and 1150 blends, the existing storage equipment must be checked to verify that it is adequate and can be converted for these blends. Your Chemours™ Marketing or Technical Service Representative can arrange for guidance on storage system conversion.

Handling

- A minimum of gloves, safety glasses with side shields, and safety shoes are recommended at all times when handling blends of Opteon™ 1100 and 1150. 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.
- Opteon™ 1100 and 1150 should only be handled in areas with adequate ventilation. If exposure to blends of Opteon™ 1100 and 1150 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 cylinder handling equipment such as hand carts, dollies, and forklifts are recommended, per the equipment manufacturer's restrictions.
- Never use container for any purpose other than to store blends of Opteon™ 1100 and 1150.
- 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 set-up 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 chasing 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.
- Blends of Opteon™ 1100 and 1150 cylinders should always be stored while tightly secured.
- Composition of blends may drift if handled incorrectly. Reach out to Chemours™ Technical Service for specific questions.
- If you suspect a drift in compositional, a quantitative GC analysis may be performed to determine the extent.

Recycle and Disposal

Responsible use of blends Opteon™ 1100 and 1150 requires that the product be recovered for reuse or disposal. Chemours™ accepts return of unused blends Opteon™ 1100 and 1150 or empty blends of Opteon™ 1100 and 1150 packages through its distributor networks in the United States and Europe.

Leaks and Spills

Major leaks or spills may not evaporate readily due to the high boiling point of blends of Opteon™ 1100 and 1150, 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 of blend of Opteon™ 1100 and 1150. 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 blends of Opteon™ 1100 and 1150.

References

- 1.) Myhre, G., Shindell, D., Bréon, F.-M., Collins, W., Fuglestedt, J., Huang, J., Zhang, H. (2013). Anthropogenic and natural radiative forcing. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (Eds.), *Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. New York: Cambridge University Press.
- 2.) Sowder, J. et. al. (2019). Presentation: Opteon™ Foam Blowing Agents for Spray Foam and Cold Weather Applications. CPI proceedings 2019, Orlando, FL
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- 4.) Wysong, E. B. et. al. (2018). Presentation: Opteon™ Foam Blowing Agents for Refrigerator and Cold Chain Applications. UTECH proceedings 2018, Maastricht, NL

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

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