SOLSTICE® LIQUID BLOWING AGENT

Technical Information

Solstice

Solstice® Liquid Blowing Agent Technical Data

Solstice® Liquid Blowing Agent (HFO-1233zd(E), trans-1-chloro-3,3,3- trifluoropropene) is a liquid halogenated olefin, which has been developed as a blowing agent for polymer foams. It is also referred to as a hydrofluoro-olefin (HFO) foam blowing agent. Solstice® LBA is primarily intended for use as an ultra-low global warming potential (GWP), non-flammable replacement blowing agent for applications where hydrocarbons, HFCs, HCFCs, and other liquid blowing agents are currently used. Solstice® LBA is a non-flammable liquid having a room temperature boiling point. The physical properties, environmental properties, transportation requirements and exposure guidelines of Solstice® LBA are summarized in Tables 1 and 2 below.

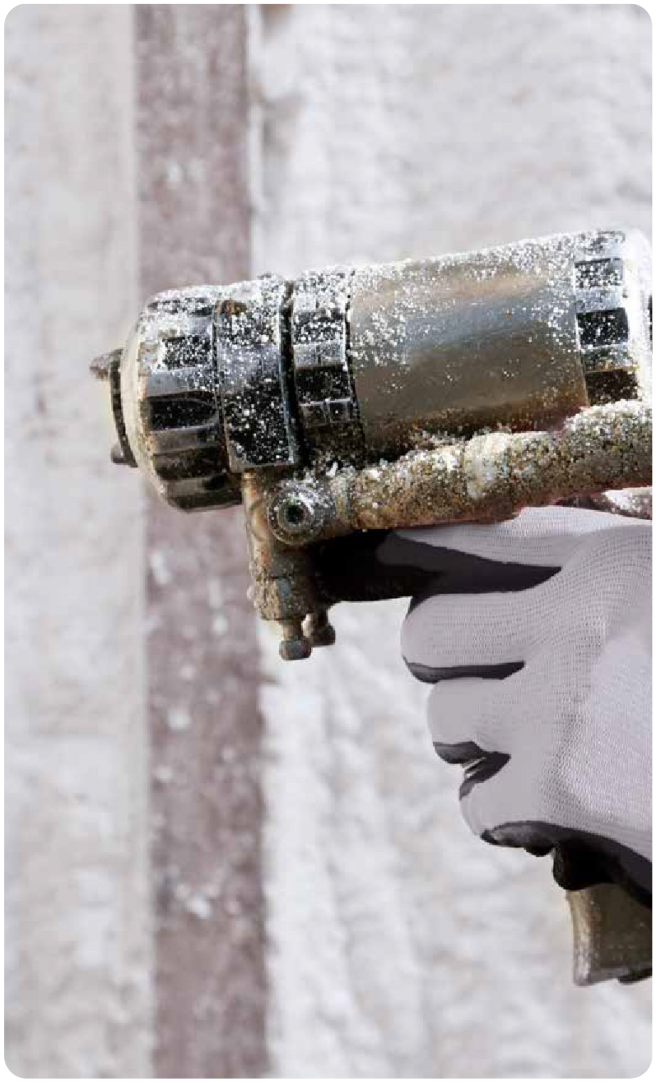


Table 1: Physical and Environmental Properties of Solstice® LBA

Chemical Name	Trans- 1-chloro-3,3,3-trifluoropropene
Molecular Formula	(E)CF3-CH=CClH
CAS Number	102687-65-0
Molecular Weight [g/mol]	130
Atmospheric Life[1]	26 Days
GWP[2]	1
ODP[3]	~ 0
Boiling Point	19 °C / 66 °F
Latent Heat of Vaporization at boiling point	194 kJ/kg / 83.4 BTU/lb
Freezing Point	-107 °C / -161 °F
Vapor Pressure at 68 °F [20°C]	106.3 kPa / 15.4 psia
Liquid Density at 68 °F [20°C]	1.296 g/ml / 10.83 lb/gal
Vapor Thermal Conductivity @ 20 °C	10.2 mW/mK / 0.0708 BTU in/ ft2 hr °F
Surface Tension at 68 °F [20°C]	13.3dyne/ cm
Liquid Viscosity at 68 °F [20°C]	0.489 cP
Solubility of water in Solstice® LBA @ 25 °C	460 ppm
KB [kauri- butanol] value	25
Flash Point[4]	None
Vapor Flame Limits[5]	None

Table 2: Transportation requirements and exposure guidelines for Solstice® LBA

Transportation Requirements	
UN Number	UN 3163
Proper Shipping Name	LIQUEFIED GAS, N.O.S. (Trans-1-Chloro-3,3,3-trifluoropropene)
Hazard Class	2.2
Exposure Guidelines	
OEL	800 ppm

REFERENCES

1. Reference: Phys. Chem. Chem. Phys., 2012, 14, 1735–1748, Atmospheric chemistry of t-CF3CHQCHCl: products and mechanisms of the gas-phase reactions with chlorine atoms and hydroxyl radicals; M. P. Sulbaek Andersen, O. J. Nielsen, M. D. Hurley and T. J. Wallington.
2. Reference (Private Correspondence with Donald Wuebbles).
3. No impact on ozone layer depletion and is commonly referred to as zero, Reference: Preliminary report: Analyses of tCFP's potential impact on atmospheric ozone; Dong Wang, Seth Olsen, and Donald Wuebbles Department of Atmospheric Sciences University of Illinois, Urbana, IL.
4. Flashpoint by ASTM D 3828-97; ASTM D 1310-86.
5. Flame limit measured at ambient temperature and pressure using ASTM E 681-85 with electrically heated match ignition, spark ignition and fused wire ignition; ambient air.

Toxicity

Overall results from a series of genetic studies indicate that Solstice® LBA is non-mutagenic and non-teratogenic. Based on extensive toxicity testing, the Workplace Environmental Exposure Level (WEEL) committee of the American Industrial Hygiene Association (AIHA) has established a TWA (8 hour time weighted average) exposure level of 800 ppm. Anyone who uses or handles Solstice® LBA should carefully review the SDS and product label prior to use.

Environmental

Solstice® LBA is a halogenated olefin with a GWP 1. As with all materials, care should be taken to avoid releases into the environment. Follow all applicable regulatory guidelines when treating or disposing of wastes generated from the use of this product.

Applications

Solstice® LBA offers a cost-effective means of achieving high performance insulation with the advantage of a low environmental impact. Solstice® LBA has been evaluated in a variety of foam systems and applications including but not limited to rigid foam applications such as refrigerators, freezers, spray foam, panels and insulation for LNG shipping, and flexible foam applications such as integral skin, molded and slabstock foam. Thermal insulating foams formulated with Solstice® LBA generally have excellent thermal insulation properties and equivalent or better dimensional and compressive strength properties compared to foamed plastic insulation manufactured today as using HFC blowing agents such as HFC-245fa or HFC-365mfc.

Miscibility

As reflected in Table 3, Solstice® LBA exhibits acceptable miscibility in a wide range of polyols and in polymeric MDI. The miscibility determination procedure: a mixture containing 40 wt.% Solstice® LBA and 60 wt. % polyol or polymeric MDI is prepared in a calibrated miscibility tube. The mixture is thoroughly mixed at an elevated temperature. The tube is then placed in a constant temperature bath for 24 hours. The height of the polyol and Solstice® LBA is measured and the maximum blowing agent concentration where a single phase solution is observed.

Table 3: Miscibility of Solstice® LBA in Various Polyols			
Polyol Name	**Maximum Wt% for Single Phase Solution**	**Polyol Name**	**Maximum Wt% for Single Phase Solution**
Polyether		**Polyether**	
Carpol® GSP-280[1]	>40	Phantol® SV-298[10]	35
Jeffol® A630[2]	>40	Phantol® JP-733[10]	29
Multranol® 3901[3]	>40	Phantol® 6300[10]	44
Pluracol® 824[4]	>40	Phantol® 6301[10]	35
Voranol® 270[5]	>40	Phantol® 6305[10]	>50
Voranol® RH360[5]	>40	Stepanol® 2352[6]	>40
Voranol® 350X[5]	>40	Terate® 2031[7]	~11
Voranol® 470X[5]	>40	Terate® 2540[7]	40
Voranol® 490[5]	>40	Terate® 4020[7]	~20
Voranol® 800[5]	>40	Terol® 198[8]	40
		Terol® 250[8]	40
Polyester		Terol® 256[8]	25
Maximol® RDK-133[9]	25	Terol® 305[8]	26
Maximol® RDK-121[9]	25	Terol® 352[8]	23
Maximol® RDK-142[9]	25	Terol® 925[8]	21
Phantol® PL-272[10]	24	Terol® 1254[8]	39
Phantol® PL-306[10]	16	Terol® 1304[8]	47
Phantol® PL-405[10]	19	Terol® 1465[8]	25
Phantol® SV-208[10]	37	Terol® 1481[8]	30

Table 4: Miscibility of Solstice® LBA in polymeric MDI	
MDI Name	**Maximum Wt% for Single Phase Solution**
Luprinate M20s[11]	>10

REFERENCES

1. Trademark of Carpenter Co.
2. Trademark of Huntsman
3. Trademark of Bayer Corporation
4. Trademark of BASF
5. Trademark of The Dow Chemical Company
6. Trademark of Stepan
7. Trademark of Invista
8. Trademark of Oxid L.P. / Data provided by manufacturer
9. Trademark of Kawasaki Kasei Chemicals LTD. / Data provided by manufacturer
10. Trademark of Hitachi Kasei Polymer Co. Ltd. / Data provided by manufacturer
11. Trademark of BASF

Thermal and Hydrolytic Stability

Laboratory tests indicate that Solstice® LBA has a high degree of thermal and hydrolytic stability. In sealed tube studies the neat material was judged to be thermally stable after two (2) weeks of exposure at 150° C. Additional sealed tube studies were conducted to evaluate both the thermal and hydrolytic stability of Solstice® LBA with metals and water. After two (2) weeks of exposure at 150° C in the presence of metals (3003 aluminum, copper, and /or 316 stainless steel), in the presence of water (at 300 ppm), and in the presence of metals and water, no chemical breakdown of the blowing agent was detected. Solstice® LBA was judged to be thermally and hydrolytically stable.

Compatibility with Metals, Plastics and Elastomers

Solstice® LBA is non-reactive and non-corrosive toward commonly used metals in polyurethane processing equipment. This includes carbon steel, stainless steel, copper, iron, and aluminum with and without excess water present. The tests were conducted by refluxing the neat blowing agent for two (2) weeks in the presence of the metal and water. At the conclusion of the test, no chemical break down of the blowing agent was detected. There is a concern with the use of aluminum in contact with any halogenated material, which includes Solstice® LBA, due to the reactive nature of aluminum, particularly if aluminum fines are present and if the oxide layer on the surface of the aluminum is removed.

Solstice has evaluated plastics and elastomers for use with Solstice® LBA. The unstressed plastics and elastomers were fully submerged in Solstice® LBA for two (2) weeks at room temperature. Tables 5 and 6 report the findings of this study. Elastomers that may find application in both static conditions (for example, gasketing between flanges) versus dynamic conditions (for example, seals on rotating shafts) may have varying degrees of suitability in use. It is important to note that compatibility with neat Solstice® LBA does not predict compatibility with a polyurethane premix containing Solstice® LBA.

Table 5: Full immersion study of compatibility with plastics

Polymer	Δ Weight %	Δ Volume %
HDPE	+1.7	+1.2
Polyproplyene	+5.0	+3.7
PET	+0.1	0.0
Nylon 66	-0.1	-0.1
Polycarbonate	+3.5	+3.0
PVC (Type1)	+0.1	+0.0
PVDF	+0.1	-0.3
PTFE	+2.1	+3.9
Polyetherimide	+0.0	-0.5

Table 6: Full immersion study of compatibility with elastomers			
Elastomer	**Δ % Hardness**	**Δ Weight %**	**Δ Volume %**
SBR/CR/NBR	+26	-19	-29
BUNA N	+38	-15	-21
Butyl rubber	+8.9	+1.2	-2.4
Viton B	-6.2	+5.6	+8.6
EPDM	+41	-28	-27
Epichlorohydrin	-0.7	+0.3	-0.5
Silicone	-1.4	-4.1	-5.9
Neoprene	+4.4	+1.0	+0.3
Kalrez 6375	-10	+7	+11
Thermoplastic PU	-2.2	+8.6	+6.9

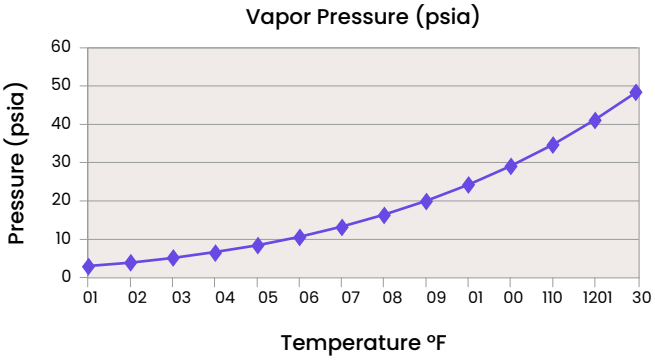
Storage and Handling

Solstice® LBA should be stored in a cool, well-ventilated area. The materials should only be stored in an approved cylinder or container. Please consult Solstice's Technical Service Department prior to storage of the material in any vessel other than the original shipping package to ensure that the new container meets all necessary requirements. The container and its fittings should be protected from physical damage. It should neither be punctured or dropped, nor exposed to open flames, excessive heat or direct sunlight. The container's valves should be tightly closed after use and when the container is empty.

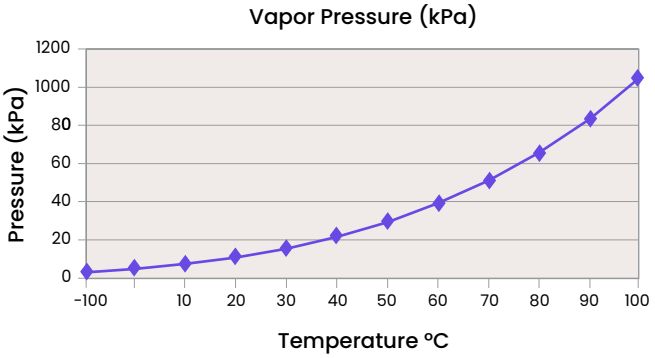
Solstice® LBA should not be mixed with either air or oxygen at elevated pressures. If pressurization is required in the application or process, the use of dry nitrogen is recommended.

For additional information on the use of cylinders, please consult a Solstice's Technical Service Representative.

Temperature vs Pressure

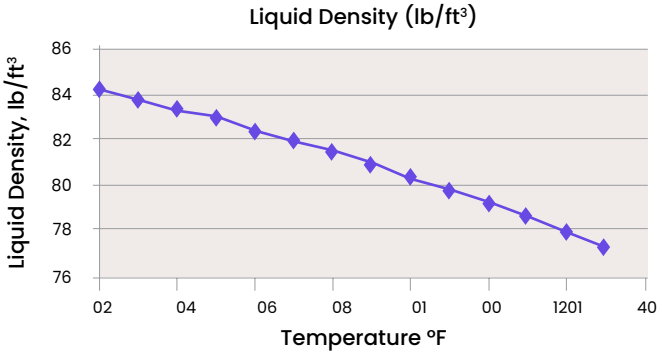


Temperature [°F]	Vapor Pressure [psia]	Temperature [°F]	Vapor Pressure [psia]
0	3.0	70	16.3
10	3.9	80	20.0
20	5.1	90	24.2
30	6.6	100	29.0
40	8.4	110	34.7
50	10.6	120	41.1
60	13.2	130	48.4

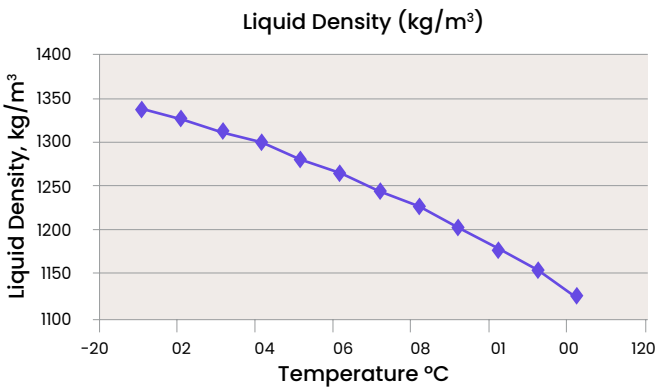


Temperature [°C]	Vapor Pressure [kPa]	Temperature [°C]	Vapor Pressure [kPa]
-10	30.1	50	293.3
0	47.9	60	390.9
10	73.1	70	511.3
20	108.0	80	657.7
30	154.6	90	833.6
40	215.5	100	1042.4

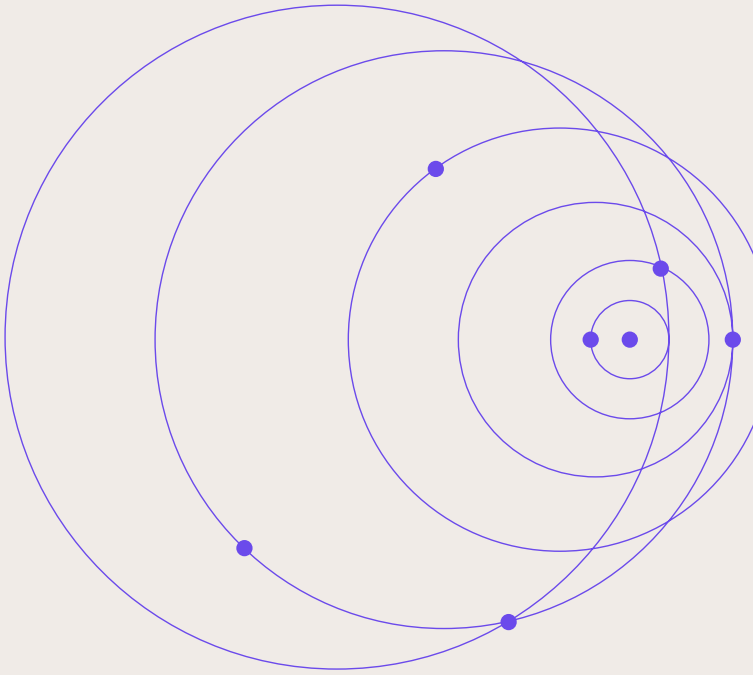
Temperature vs Density



Temperature [°F]	Liquid Density [lb/ft³]	Temperature [°F]	Liquid Density [lb/ft³]
0	84.2	70	80.9
10	83.8	80	80.4
20	83.4	90	79.8
30	82.9	100	79.2
40	82.5	110	78.6
50	82.0	120	78.0
60	81.5	130	77.3



Temperature [°C]	Liquid Density [kg/m³]	Temperature [°C]	Liquid Density [kg/m³]
-10	1339.6	50	1246.7
0	1326.7	60	1226.7
10	1312.9	70	1204.9
20	1298.1	80	1181.2
30	1282.2	90	1155.1
40	1265.1	100	1126.3



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