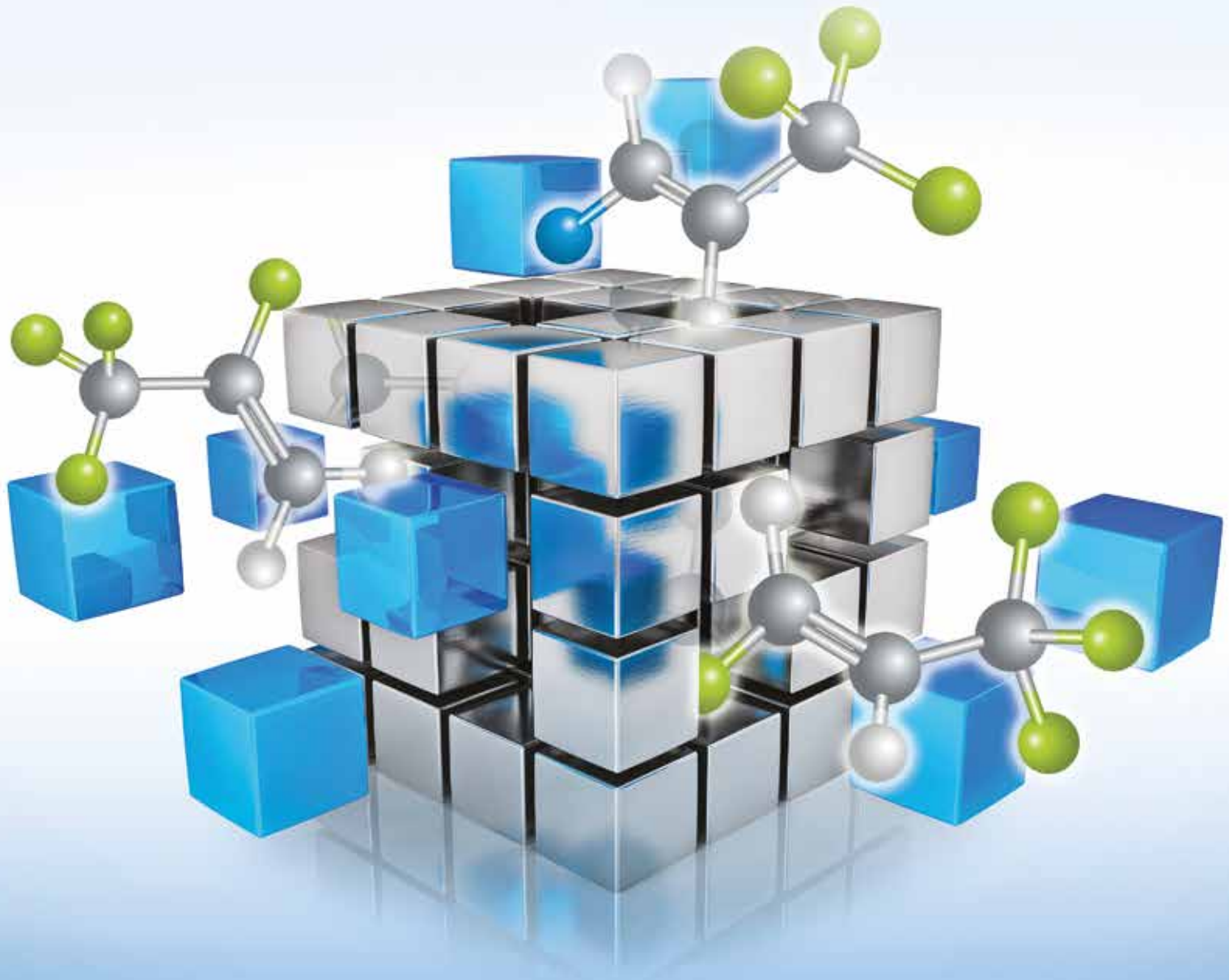
Honeywell | Aerosol Technology



Solstice® Propellant

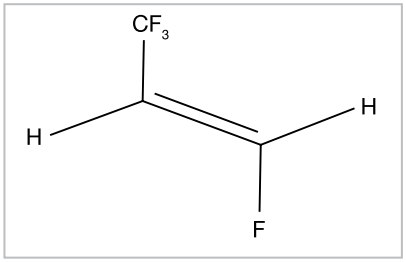
Technical Bulletin

Introduction

This document provides technical information for choosing and using Solstice® Propellant (HFO-1234ze(E)). Section 1 describes the key physical properties of Solstice Propellant while Section 2 covers chemical stability and materials compatibility.

Related literature is also available on the Solstice Propellant website. Feel free to reach us via our Contact Us page or by calling 1-800-631-8138.

Figure 1. Chemical Structure



Section 1:

Key Physical Properties of Solstice Propellant

Solstice Propellant is a new, nonflammable aerosol propellant that has an ultra-low global warming potential (GWP) of less than 1, and very low photochemical reactivity. Its full chemical name is trans-1,3,3,3-tetrafluoroprop-1-ene and its INCI name is tetrafluoropropene. See Figure 1 for the chemical structure.

Propellant Properties

Key physical properties of Solstice Propellant are shown in Table 1. Tables 2-3 and Figures 2-3 show vapor pressures and liquid densities as a function of temperature.

Table 1. Key Physical Properties of Solstice Propellant

Synonyms	HFO-1234ze (E), 1234ze(E), trans-1234ze	
Formula	$CF_3CH=CHF$	
Molecular Weight	114.0	
Properties	**Units**	**Values**
Vapor Pressure	70°F psig 21.1°C bar g	49.5 3.4
	100°F psig 37.8°C bar g	89.9 6.2
	130°F psig 54.4°C bar g	147 10.1
Boiling Point	1 ATM, °F 1 ATM, °C	-2.2 -19.0
Auto-Ignition Temperature	°F °C	694 368
Specific Gravity of Gas	60°F (15.5°C)	3.958
Density of Liquid	Lbs./Gal. @ 60°F Grams/cc @21.1°C	9.96 1.17
Volume of Vapor	Per Gal. of Liquid @ 60°F, ft^3 Per liter of Liquid @ 16.6°C, m^3	33.02 0.25
Expansion Ratio	1 ATM and 60°F (15.6°C) (Liquid to Gas)	247
Flash Point	°F, °C	Non-Flammable
Specific Heat of Gas, Cp	60°F, BTU/lb. 15.6°C, cal/g	0.224
Specific Heat of Liquid, Cp	60°F, BTU/lb. 15.6°C, cal/g	0.323 0.323
Heat of Vaporization	BTU/lb. @ BP KJ/g @ BP	84 195
Theoretical (Net) Heat of Comb. of Liquid, 70°F (21.1°C)	BTU/lb. KJ/g	4,359 10.1
Viscosity of Liquid, Centipoises	100°F (37.8°C)	0.171
Coefficient of Liquid Expansion	60°F (15.6°C)	0.0017
Solubility in Water, % by Weight	70°F (21.1°C)	0.037
Solubility of Water, % by Weight	70°F (21.1°C)	0.022
Surface Tension, dynes/cm	70°F (21.1°C)	8.95
Other	Kauri-Butanol Value	12.5

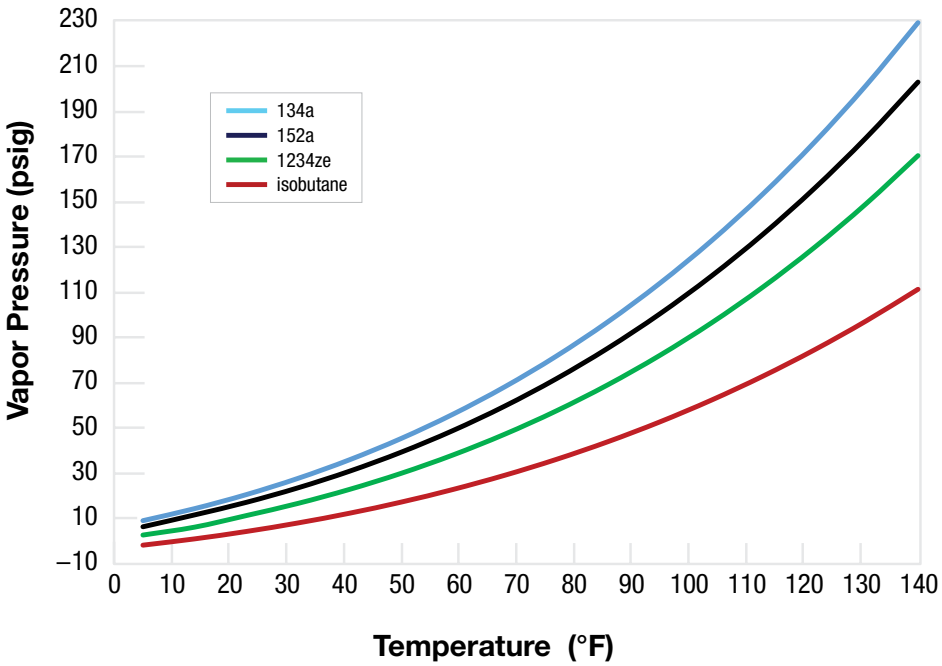
Table 2. Vapor Pressure and Liquid Density, English Units

°F	psig	Lbs./ft³	°F	psig	Lbs./ft³	°F	psig	Lbs./ft³
0	0.8	80.6	45	25.9	76.1	90	74.8	71.1
5	2.7	80.1	50	30.0	75.6	95	82.1	70.5
10	4.8	79.6	55	34.4	75.0	100	90.3	69.9
15	7.1	79.1	60	39.1	74.5	105	98.3	69.3
20	9.7	78.6	65	44.1	74.0	110	107.3	68.6
25	12.4	78.1	70	49.5	73.4	115	116.3	68.0
30	15.4	77.6	75	55.2	72.8	120	126.3	67.3
35	18.7	77.1	80	61.3	72.3	125	136.3	66.6
40	22.2	76.6	85	67.8	71.7	130	147.3	65.9

Table 3. Vapor Pressure and Liquid Density, SI Units

°C	bar g	kg/m³	°C	bar g	kg/m³	°C	bar g	kg/m³
-15	0.20	1280	9	1.98	1210	33	5.31	1140
-12	0.36	1270	12	2.30	1200	36	5.86	1130
-9	0.53	1270	15	2.64	1200	39	6.46	1120
-6	0.73	1260	18	3.01	1190	42	7.09	1100
-3	0.94	1250	21	3.41	1180	45	7.76	1090
0	1.17	1240	24	3.84	1170	48	8.47	1080
3	1.42	1230	27	4.29	1160	51	9.23	1070
6	1.69	1220	30	4.78	1150	54	10.03	1060

Figure 2: Vapor Pressure vs. Temperature, ºF



Miscibility

Solstice® Propellant is miscible with the other liquefied gas propellants: HFC-134a, HFC-152a, DME, butane, isobutane and propane. It is also miscible with commonly used solvents such as the lower alcohols, ketones, chlorinated solvents and hydrocarbons.

In some situations, it may be beneficial to blend Solstice Propellant with other propellants to optimize a formulation. For example, blends of Solstice Propellant with hydrocarbons or HFC-152a might be useful in personal care formulations while blends with HFC-134a might be used in certain technical aerosols. Vapor pressure data for blends of Solstice Propellant with other propellants are shown in Tables 4-5.

Figure 3: Vapor Pressure vs. Temperature, °C

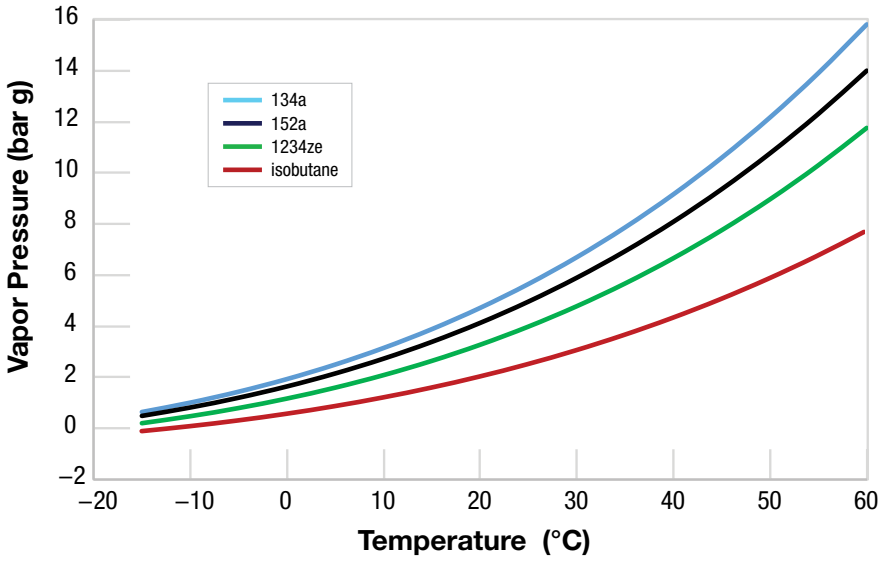


Table 4. Blend Vapor Pressure (psig), English Units

	70°F				130°F			
Weight % 1234ze (E)	20	40	60	80	20	40	60	80
1234ze/134a	68	65	61	56	192	184	174	162
1234ze/152a	61	60	58	55	174	171	167	160
1234ze/DME	58	54	50	47	163	154	146	140
1234ze/butane	30	40	47	49	93	116	134	148
1234ze/isobutane	41	50	55	58	119	138	153	161
1234ze/propane	113	114	111	102	266	270	266	245

Table 5. Blend Vapor Pressure (bar g), SI Units

	21°C				54°C			
Weight % 1234ze (E)	20	40	60	80	20	40	60	80
1234ze/134a	4.7	4.5	4.2	3.9	13.3	12.7	12.0	11.2
1234ze/152a	4.3	4.2	4.0	3.8	12.0	11.8	11.5	11.0
1234ze/DME	4.0	3.8	3.5	3.3	11.2	10.7	10.1	9.7
1234ze/butane	2.0	2.8	3.2	3.6	6.4	8.0	9.3	10.2
1234ze/isobutane	2.9	3.5	3.8	4.0	8.2	9.6	10.6	11.2
1234ze/propane	7.8	7.9	7.7	7.0	18.4	18.6	18.4	16.9

Section 2:

Chemical Stability and Materials Compatibility

Testing demonstrates that Solstice® Propellant has good chemical stability and materials compatibility. However, as with any material, it is recommended that customers confirm compatibility in their operations.

Thermal/Hydrolytic Stability

Honeywell has studied the thermal stability of pure Solstice Propellant at up to 230 °F (110°C) in the presence of common materials of construction, including steel (carbon and stainless), copper and aluminum and found that there was no measurable impact on Solstice Propellant purity. Further, Honeywell and third-party testing of Solstice Propellant – combined with various common refrigeration lubricants and coupons of the above metals in the presence of up to 500 ppm moisture and 2,000 ppm air in sealed glass tubes at 347°F (175°C) for 14 days – has shown Solstice Propellant to be stable.

Effect of pH

Samples of Solstice Propellant and solutions of various pH levels were stored for 10 days at 104°F (40°C). Increasing fluoride levels indicate breakdown. Solstice Propellant becomes more reactive above a threshold level of pH greater than 10, as shown in Table 6 and Figure 4.

Figure 4: Effect of pH on HFO-1234ze(E) Stability

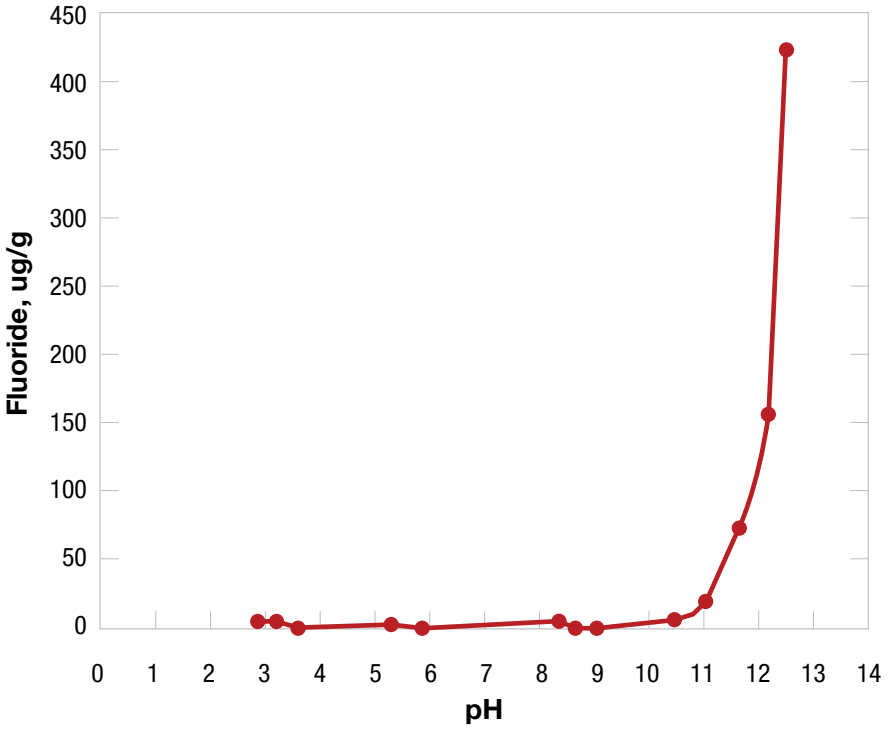


Table 6: Effect of pH

pH	Fluoride, ug/g
2.87	4.7
3.2	4.9
3.59	0.7
5.29	3.5
5.84	0.6
8.33	4.8
8.63	0.4
9.03	0.4
10.48	6.4
11.04	19.7
11.64	72.9
12.18	156.5
12.5	424.2

Material Compatibility

Metals

Honeywell has tested the compatibility of Solstice® Propellant with commonly used metals, including carbon steel, stainless steel, copper, brass and aluminum, and found that there was no measurable impact on Solstice Propellant purity. Further, Honeywell and third-party testing of Solstice Propellant – combined with various common refrigeration lubricants and coupons of the above metals in the presence of up to 500 ppm moisture and 2,000 ppm air in sealed glass tubes at 347°F (175°C) for 14 days — has shown Solstice Propellant to be stable. Although Solstice Propellant has been shown to be compatible with aluminum in thermal stability tests, exposure to finely divided aluminum or freshly abraded aluminum surfaces should be avoided.

Plastics and Elastomers

Solstice Propellant is compatible with most common materials. Preferred gasket materials for use with Solstice Propellant are PTFE and PTFE-encapsulated Viton®. Solstice Propellant has been found to be generally compatible with grades of buna and butyl rubbers and neoprene. However, because results may vary with different grades and manufacturers of a particular elastomer, it is recommended that you confirm compatibility. Tests have shown that Solstice Propellant is compatible with most plastics, except acrylics.

Table 7 show materials compatibility data resulting from tests performed by Honeywell in which samples were immersed for two weeks in liquid Solstice Propellant at room temperature. This data should be used only as a guide to the compatibility of materials with Solstice Propellant. Customers should consult the manufacturer or conduct further independent testing.

Table 7: Material Compatibility

Substrate	Avg. % Change in Hardness	Avg. % Change in Weight	Avg. % Change in Volume	Comments
ABS		0.21	-0.6	
Delrin® Acetal		0.18	-0.48	
Acrylic	Extremely distorted			Pitted after 1 week. Expands.
HDPE		0.82	-3.74	
Nylon 66		-0.26	0	
Polycarbonate*		1.1	0.77	Turbid fluid after 1 week. Residue.
ULTEM® Polyetherimide		-0.04	0	
Kynar® PVDF*		0.21	0	Fluid discoloration.
Teflon®		2.03	2.43	
Polypropylene*		0.83	0	Turbid fluid. Residue.
HIPS		0.26	-0.45	
PVC-Type 1		0.002	-0.44	
PET		-0.01	0	
SBR/CR/NBR	7.28	2	-4.31	
Viton® B Comm. Grade	-11.29	4.43	5.71	
Buna-Nitrile	8.91	-4.95	-7.18	
EPDM	-1.5	-2	-2.49	
Epichlorohydrin	-3.5	0.73	1.51	
Silicone*	-0.71	-1.57	-1.96	Slight fluid discoloration. Residue.
Natural Rubber (Gum)	2	-0.64	-0.75	
Texin® (Thermoplastic) Polyurethane 390	-4.35	5.14	4.41	
Butyl Rubber	-1.13	1.27	0.88	
Neoprene	7.32	-7.7	-11.47	
Kalrez® 6375	-10.36	5.22	33	

Suitable
Suitable under certain conditions
Unsuitable

* Although changes in weight, volume and hardness are minimal, fluid discoloration and/or residue suggest the material may not be suitable for some applications.

Aerosol Packaging Compatibility

Aerosol Cans

Solstice® Propellant has been tested for compatibility with various commonly used aerosol cans, and laboratory testing shows that it is compatible with common types. The tests were run at 40°C (104°F) to simulate an accelerated aging process. After aging for 12 months, each can was visually inspected for signs of corrosion or liner degradation, and the propellant was analyzed for evidence of chemical breakdown. See Table 8 for details. As shown, in long-term storage tests, no visual liner changes were observed in tinplated steel, PET-lined aluminum, PAM-lined aluminum or epoxy-lined aluminum cans filled with Solstice Propellant and stored at 104°F (40°C). The unchanging non-volatile residues confirm that Solstice Propellant did not extract plasticizers or other liner components.

Aerosol Valves

Valve compatibility studies were performed by Precision Valve and Summit Packaging. Good compatibility was seen with grades of buna and butyl rubbers and neoprene. In addition, an Aptar Pharma study of Solstice Propellant with their metered-dose inhaler valves concluded that the compatibility of Solstice Propellant was equivalent to that of HFC-134a and HFC-227ea.

Table 8: Aerosols Packaging Compatibility

Can Description	Storage Temperature	Exposure Time, Months	Observations
Tinplated Steel, Unlined	40°C (104°F)	12	• No visual liner changes • No propellant breakdown
Tinplated Steel, PET Liner	40°C (104°F)	19	• No visual liner changes • No increase in non-volatile residue • No propellant breakdown
Aluminum, PAM Liner	40°C (104°F)	12	• No visual liner changes • No increase in non-volatile residue • No propellant breakdown
Aluminum, Epoxy Liner	40°C (104°F)	12	• No visual liner changes • No increase in nonvolatile residue • No propellant breakdown

Bag-On-Valve (BOV)

The compatibility of Solstice Propellant with laminated BOV bags was tested by Summit Packaging Systems. BOV cans containing water as the surrogate product were pressurized with Solstice Propellant. Periodic testing included vapor pressure measurements and examination of the bags for signs of delamination. After 12 months at room temperature, 4-ply PE and 4-ply PP BOV bags showed the best results for long-term stability, with minimal vapor pressure loss and no delamination of the bag.

Stability and Compatibility Summary

Testing demonstrates that Solstice Propellant has good chemical stability. In addition, its compatibility with metals, plastics and elastomers, and with typical aerosol cans and valves, makes Solstice Propellant suitable for use in existing aerosol filling equipment and aerosol packaging.

Contact Honeywell to Learn More

To learn more about the benefits of Solstice Propellant, call Honeywell at 1-800-631-8138 or visit

honeywell-solstice-propellants.com

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