

HFO-1234ze

Honeywell



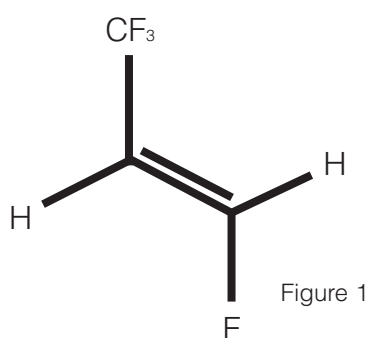
**New Low Global Warming Potential
Aerosol Propellant**

HFO-1234ze Aerosol Propellant

With the advent of global-warming-based regulations in many regions, the HFCs (hydrofluorocarbons) have come under pressure as potential contributors to global warming. In Europe, the F-Gas regulations will phase out the use of HFC-134a in automotive air conditioning systems for all new models beginning in 2011. Other parts of F-Gas have already eliminated HFC-134a from products such as one-component polyurethane foams (“foam-in-a-can”) and novelty aerosols. It is uncertain whether additional aerosol product categories will be regulated in the future.

In response to current and possible future restrictions on the use of HFCs, Honeywell is developing a platform of ultra-low GWP (global warming potential) products for a variety of applications. The main objective of our low GWP development programs is to identify compounds that have many of the useful features of the HFCs but with negligible impact on global warming. One of those products, called HFO-1234ze, has a GWP of only 6 and is an excellent candidate to replace HFC-134a in aerosol formulations based on its physical, chemical and toxicological and environmental properties.

Honeywell's HFO-1234ze is an unsaturated fluorocarbon. The full chemical name is trans-1,3,3,3-tetrafluoroprop-1-ene. The chemical structure is shown below in Figure 1.



Uses

HFO-1234ze is currently being used in aerosol and other products in Europe and Japan. The primary applications today are in one-component foams, novelty aerosols, such as party strings and air horns, and an insect spray. It is also being used in dusters and defluxing products for electronics. Other

potential uses are in Tire Inflators, Topical Anesthetics, Degreasers, other Technical Aerosols and Personal/Consumer Care products, such as hair sprays, antiperspirants, deodorants, and shaving creams.

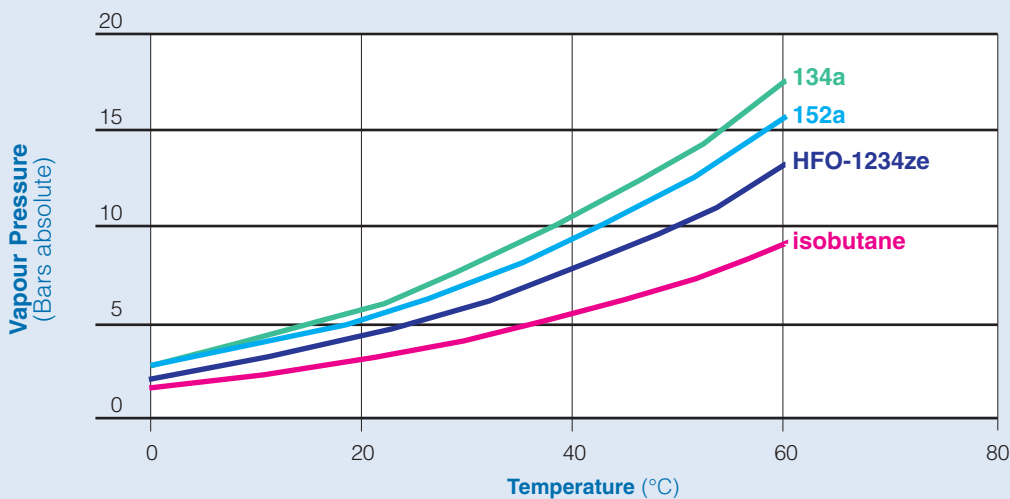
Physical Properties

Some of the properties of HFO-1234ze are shown in Table 1, along with those of other commonly used propellants. Figure 2 shows vapour pressure versus temperature for HFO-1234ze and other commonly-used propellants. Figures 3 and 4 are vapour pressure curves of HFO-1234ze/HFC-134a and

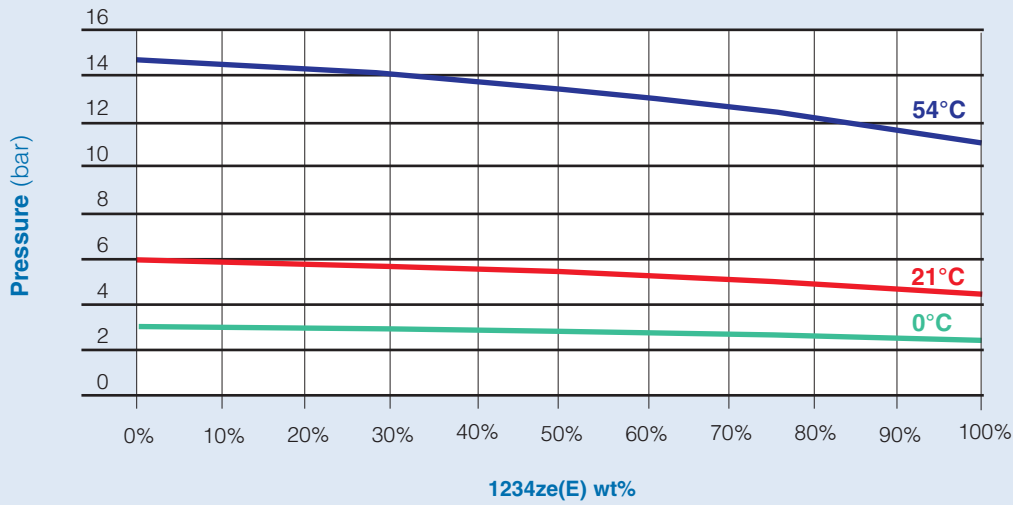
HFO-1234ze/ HFC-152a blends. In most ways, HFO-1234ze behaves like HFC-134a, so it can be handled and used very much like HFC-134a. The key differences are that HFO-1234ze has an extremely low GWP and its vapour pressure is lower than that of HFC-134a.

Property	HFO-1234ze	HFC-134a	HFC-152a	DME	Propane	Isobutane
Molecular Weight	114	102	66	46	44	58
Boiling Point (C°)	-19	-26	-25	-25	-42	-12
Vapour Pressure (bars gauge) at 21°C	3.2	4.9	4.3	4.3	7.5	2.1
Vapour Pressure at 54°C	9.7	13.7	12.1	12	17.7	6.7
LFL/UFL (Vol.% in Air) Measured at 21°C	NONE	NONE	3.9 – 16.9	3.4 – 18.0	2.2 – 9.5	1.8 – 8.4
Liquid Density (g/cc) 21°C	1.17	1.22	0.91	0.67	0.51	0.55
Flammable	No	No	Yes	Yes	Yes	Yes

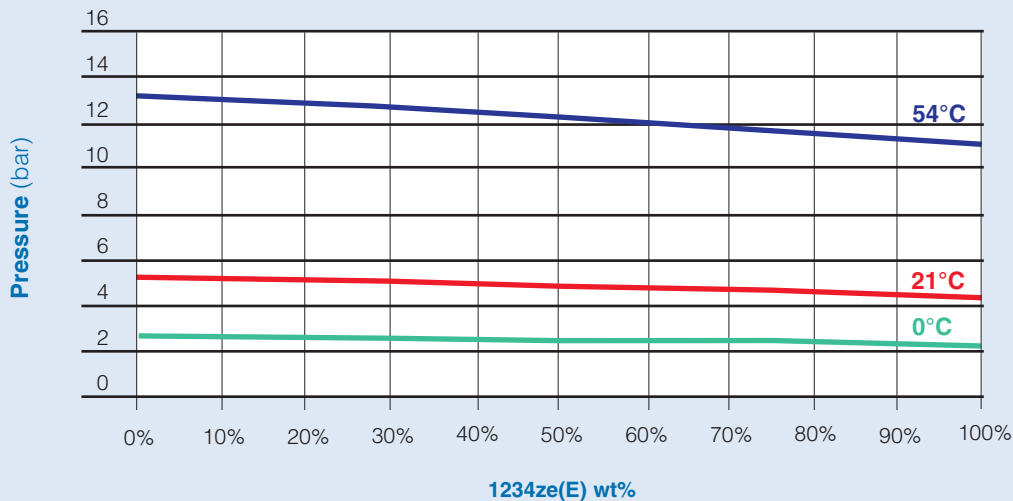
Vapour Pressure versus Temperature



Vapour Pressure of 1234ze(E) + 134a



Vapour Pressure of 1234ze(E) + 152a



Flammability

As shown in Table 1, HFO-1234ze does not exhibit vapor flame limits under standard test conditions. It is therefore classified as nonflammable according to *EC Testing Method A11: Flammability of Gases*, as well as by the U.S. Department of Transportation (DOT) standard (tested according to ASTM E681). HFO-1234ze is nonflammable in the ASTM flame projection test. When tested against HFC-134a and HFC-152a,

its performance was identical to that of HFC-134a, whereas some degree of flame projection was observed with the HFC-152a samples. HFO-1234ze has also been tested and found to be nonflammable in the ignition distance test and the enclosed space ignition test (closed drum test). The heat of combustion of HFO-1234ze is 10.2 kJ per gram.

Environmental Properties

In work done at the University of Copenhagen, the atmospheric lifetime of HFO-1234ze was determined to be approximately two weeks. The GWP, which is largely a function of atmospheric lifetime, was determined to be 6 versus CO₂ on a 100-year integrated time horizon. In a companion study, also at the University of Copenhagen, it was determined that the atmospheric degradation products of HFO-1234ze have negligible impact on the environment.

Compounds with short atmospheric lifetimes often contribute to the generation of tropospheric, or ground-level, ozone

which is one of the components of photochemical smog. That is not the case with HFO-1234ze. The MIR (maximum incremental reactivity) value for HFO-1234ze has been measured and found to be 0.09 g O₃/g VOC, which is approximately one-third of the value for ethane. The calculated POCP (photochemical ozone creation potential) of HFO-1234ze is only 6.4. This is roughly half the value for ethane. The very low MIR and POCP values indicate that HFO-1234ze does not contribute in any significant way to tropospheric ozone generation. HFO-1234ze is expected to be classified as a non-VOC in the United States.

Table 2 shows the environmental properties of HFO-1234ze compared to those of some commonly used propellants.

Property	HFO-1234ze	HFC-134a	HFC-152a	DME	Propane	Isobutane
GWP (versus CO ₂ , 100 year ITH)	6	1320	122	<15	<15	<15
Photochemical Reactivity (MIR g O ₃ /g VOC)	0.09	0.0007	0.0175	0.93	0.57	1.23

Toxicity

An extensive series of toxicity tests were carried out on HFO-1234ze with excellent results. The toxicity testing program included: acute exposure, repeat exposure, mutagenicity and developmental toxicity studies. The results of those tests

support the conclusion that HFO-1234ze exhibits a very low order of toxicity. A Workplace Environmental Exposure Level (WEEL) of 800 PPM (8-hour time weighted average) has been assigned to HFO-1234ze

Propellant Properties

Miscibility

Honeywell's HFO-1234ze is miscible with other propellants such as 134a, 152a, DME and the hydrocarbons (butane, isobutane and propane). It is also miscible with many commonly-used solvents such as the lower alcohols, ketones,

chlorinated solvents and hydrocarbons. It should thus be possible to formulate a wide range of aerosol products with HFO-1234ze.

Compatibility

Honeywell's HFO-1234ze propellant is compatible with copper, steel, aluminum and tinplate aerosol cans. HFO-1234ze is generally compatible with plastics, with the exception of acrylics, and with many elastomers including butyl rubber,

natural rubber, silicone and EPDM. It is always recommended that testing be done to confirm compatibility with specific materials of construction.

Stability and dielectric strength

HFO-1234ze has been shown to be thermally and hydrolytically stable. In one experiment, samples of HFO-1234ze, in the presence of water and metals, were stored at 200°C for two weeks. There was no observed effect on the metals and analysis showed no indication of breakdown of the HFO-1234ze. Also, samples stored in steel cylinders for several years have been analyzed and found to be in specification. It

is always advisable to confirm the stability of any aerosol formulation containing a new propellant.

The dielectric strength of HFO-1234ze vapor has been measured. At ambient temperature and 1 atmosphere pressure, the dielectric strength is 11.7 kV for a 0.25 cm gap. Under the same conditions, the dielectric strength of HFC-134a is 6.6 kV.

Storage and handling

Honeywell HFO-1234ze should be handled in a manner consistent with materials categorized as "liquefied gases under pressure". As illustrated by the vapour pressure data, Honeywell HFO-1234ze is a moderate pressure gas and containers (bulk storage tanks or packages) should be rated for the pressure of Honeywell's HFO-1234ze.

Honeywell HFO-1234ze, in approved packages (containers), should be stored in a cool, well-ventilated area. HFO-1234ze packages (containers) should neither be punctured or dropped, nor exposed to open flames, excessive heat or direct

sunlight. The package (container) valves should be tightly closed after use and when the container is empty.

Based on industry experience, HFO-1234ze should not be mixed with oxygen at elevated pressures. Applications necessitating pressurization – exceeding the vapour pressure of HFO-1234ze – should use dry nitrogen.

The Honeywell material safety data sheet (MSDS) contains the most current and comprehensive information on the health, safety and environmental aspects of HFO-1234ze.

Regulatory

HFO-1234ze is registered under REACH (Regulation 1907/2006) for tonnages of more than 1000 tonnes/annum. It is also registered in the U.S.A., Japan and China.

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