DuPont Fluoroproducts

HFC-236fa clean agent

Properties, Uses, Storage, and Handling

DuPont Product Names:
FE-36™ Fire Extinguishant
Suva® 236fa Refrigerant

HFC-236fa
Properties, Uses, Storage, and Handling

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Introduction

Chlorofluorocarbons (CFC), bromofluorocarbons, and bromochlorofluorocarbons (Halons),which were developed in the 1930s, have unique properties. They are low in toxicity, nonflammable, noncorrosive, and compatible with other materials. In addition, they have thermodynamic and physical properties that make them ideal for a variety of uses. CFCs have been used as refrigerants; as blowing agents in the manufacture of insulation, packaging, and cushioning foams; as cleaning agents for metal and electronic components; and in many other applications. Two high-value uses of Halon compounds are as fire extinguishants and explosion suppressants. Halons are used in handheld portable extinguishers, flooding systems, and local application systems.

However, the stability of these compounds, coupled with their bromine and/or chlorine content, has linked them to the depletion of the earth's protective ozone layer. As a result, these compounds are being phased out of production. DuPont has developed environmentally acceptable alternative compounds, such as HFC-236fa.

HFC-236fa

HFC-236fa does not contain chlorine or bromine; therefore, it has an ozone-depletion potential (ODP) of zero. Uses are as a fire extinguishant and explosion suppression agent. It also can be used as a pure refrigerant for low-pressure chillers. HFC-236fa is nonflammable, has low toxicity, and is nonozone depleting.

It may be identified by any of the following names:

- Hydrofluorocarbon 236fa
- HFC-236fa
- FE-36™ fire extinguishant
- Suva® 236fa

Table 1 gives the chemical name and formula for HFC-236fa.

Table 1
Product Information

Product Name:	HFC-236fa
Chemical Name:	1,1,1,3,3,3 hexafluoropropane
Formula:	$CF_3CH_2CF_3$
CAS No.:	690-39-1
Molecular Wt.:	152.04

Uses

Refrigeration

Suva® 236fa is a single-component refrigerant. It has been specified by the U.S. Navy as a replacement for R-114 in centrifugal chillers. Suva® 236fa is currently the only zero ODP, commercially available replacement for R-114.

Fire Extinguishant

When used as a fire extinguishing agent, HFC-236fa is called FE-36™. It is listed as an acceptable Halon replacement in the EPA SNAP Program for Halon 1211 in portable fire extinguishers and local application systems. FE-36™ is noncorrosive, electrically nonconductive, free of residue, and has an ODP of zero. It is ideally suited for protecting high-value equipment such as in computer rooms, telecommunication facilities, and aircraft.

FE-36™ also has application as a total flooding agent and explosion suppression agent in normally occupied spaces.

The heptane cup burner extinguishing concentration for FE-36™ in air is 5.9% (volume).

Physical Properties

Physical properties of HFC-236fa are shown in **Table 2**.

Saturated vapor pressure and density are given in **Table 3**.

Saturated vapor pressure is shown in **Figure 1**.

For complete thermodynamic properties, see DuPont bulletin T-236fa

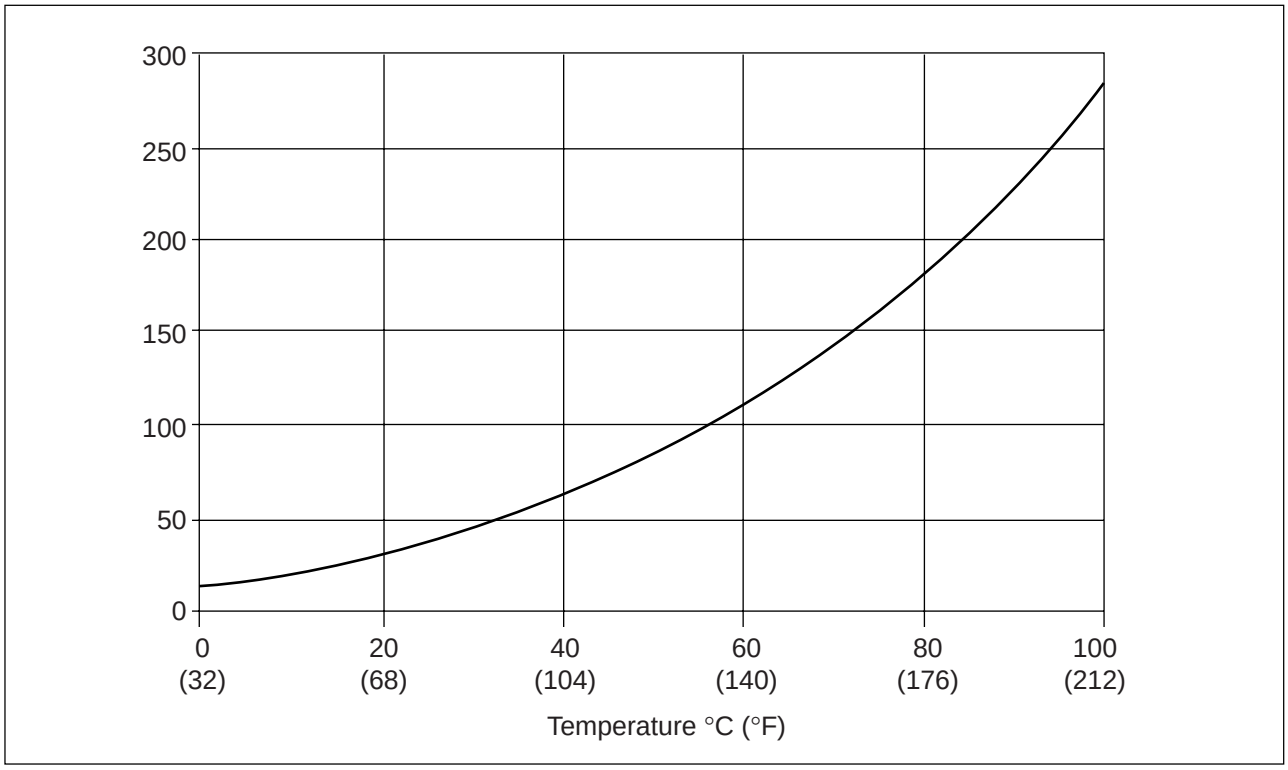
Table 2
Physical Properties of HFC-236fa

Property	Value
Molecular Weight	152.04
Boiling Point (1 atm), °C (°F)	–1.4 (29.4)
Freezing Point, °C (°F)	–103 (–153)
Critical Temperature, °C (°F)	124.9 (256.9)
Critical Pressure, kPa (psia)	3200 (464)
Critical Density, kg/m³ (lb/ft³)	555.3 (35.29)
Liquid Density @ 25°C (77°F), kg/m³ (lb/ft³)	1360 (84.89)
Vapor Density @ 25°C (77°F) and 1 atm, kg/m³ (lb/ft³)	6.430 (0.4014)
Specific Heat, Liquid @ 25°C (77°F), kJ/kg °C (Btu/lb °F)	1.1085 (0.3022)
Specific Heat, Vapor @ 25°C (77°F) and 1 atm, kJ/kg °C (Btu/lb °F)	0.8444 (0.2007)
Vapor Pressure, Saturated @ 25°C (77°F), kPa (psia)	272.4 (39.5)
Heat of Vaporization @ Boiling Point, kJ/kg (Btu/lb)	160.4 (68.97)
Thermal Conductivity, Liquid @ 25°C (77°F), W/m·°C (Btu/hr·ft·°F)	0.0745 (0.1289)
Thermal Conductivity, Vapor @ 25°C (77°F), W/m·°C (Btu/hr·ft·°F)	0.0042 (0.0073)
Viscosity, Liquid @ 25°C (77°F), Pa·s (lb-hr/ft²)	3.060E-04 (1.775E-09)
Relative dielectric strength @1 atm @760 mmHg, 25°C (N_2=1)	1.0166
Solubility of Water in HFC-236fa @ 20°C (68°F), ppm	740
Solubility of HFC-236fa in Water @ 20°C (68°F), ppm	2,100
Ozone-Depletion Potential (CFC-11 = 1)	0.0
Halocarbon Global Warming Potential (CFC-11 = 1)	4.2
Global Warming Potential (GWP) (100 yr ITH. for CO_2, GWP = 1)	6,300
TSCA Inventory Status	Reported, Included
SNAP Status	Listed
Inhalation Exposure Limit	AEL=1000 ppm (v/v) (8- and 12-hr TWA)

Table 3
Vapor Pressure and Density of HFC-236fa

Temperature		Saturated Vapor Pressure		Density: Liquid at Saturation		Density: Vapor at 1 atm	
°C	°F	kPa	psia	kg/m³	lb/ft³	kg/m³	lb/ft³
0	32	107.55	15.6	1440.3	89.91	7.1100	0.4439
5	41	131.68	19.1	1424.7	88.94	6.9608	0.4345
10	50	159.95	23.2	1408.9	87.95	6.8188	0.4257
15	59	192.35	27.9	1392.8	86.95	6.6832	0.4172
20	68	229.58	33.3	1376.5	85.93	6.5537	0.4091
25	77	272.32	39.5	1359.8	84.89	6.4297	0.4014
30	86	321.27	46.6	1342.8	83.83	6.3109	0.3940
35	95	375.74	54.5	1325.5	82.75	6.1964	0.3868
40	104	437.75	63.5	1307.6	81.63	6.0875	0.3800
45	113	506.73	73.5	1289.3	80.49	5.9822	0.3735
50	122	583.95	84.7	1270.4	79.31	5.8809	0.3671
55	131	670.12	97.2	1250.7	78.08	5.7833	0.3610
60	140	764.58	110.9	1230.3	76.81	5.6892	0.3552
65	149	869.37	126.1	1209.0	75.48	5.5983	0.3495
70	158	984.50	142.8	1186.6	74.08	5.5106	0.3440

Figure 1. Saturated Vapor Pressure of HFC-236fa



Materials Compatibility

Because HFC-236fa could be used in many applications, it is important to review the materials of construction for compatibility when designing new equipment, retrofitting existing equipment, or preparing storage and handling facilities.

Stability with Metals

Stability tests were conducted in heavy-walled glass tubes in accordance with ASHRAE 97. The tests were conducted with copper, aluminum, and iron strips immersed 50% in liquid HFC-236fa and were aged for 14 days at 175°C (347°F). Visual ratings were obtained on both the liquid and the metals after the exposure.

There were no changes in the color of the liquid or in 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]). As shown in **Table 4**, this test indicates that eight out of the nine common elastomers exhibit negligible swelling, weight gain, or hardness change after exposure.

Compatibility with Plastics

Compatibility tests with plastics were performed to determine whether HFC-236fa would damage plastics if in direct path of a discharge from a fire suppression system. In this test plastic surfaces were sprayed with HFC-236fa liquid. Other pieces of plastics were placed in an atmosphere of 20% (volume) HFC-236fa for 168 hours (7 days) at atmospheric pressure and 23°C (74°F). As shown in **Table 5**, this test indicates that all of the common plastics that were tested exhibited negligible weight gain or surface change after exposure.

Compatibility tests performed by the National Institute of Standards and Technology (NIST) at elevated temperatures (150°C [302°F]) has identified compatible combinations of metals, elastomers, and plastics. Test results are available in NIST publications.

Table 4
Elastomer Compatibility

Elastomer	Linear Swell (percent)	Weight Gain (percent)	Hardness Change (units)
Butyl	0	1	0
Nordel® EPDM	1	2	–2
Neoprene CR	–1	1	3
NBR	1	3	–4
Hypalon® CSM	–1	1	–1
Viton® A	15	51	–13
Epichlorohydrin homopolymer	–1	1	0
FA polysulfide	–1	1	–1
Hytrel® TPE	2	7	1
Teflon® PTFE	—	2	—

Table 5
Plastic Compatibility

Plastic	Weight Gain (percent)	Surface Condition
High-density polyethylene (HDPE)	<1	No Change
Polystyrene (PS)	<1	No Change
Polypropylene (PP)	<1	No Change
Acrylonitrile-butadiene-styrene (ABS)	<1	No Change
Polycarbonate (PC)	<1	No Change
Polymethyl methacrylate (PMMA)	<1	No Change

Desiccants

Driers filled with desiccant are typically used in refrigeration systems and bulk storage facilities. A common molecular sieve desiccant used with CFC-114, UOP's 4A-XH-5, is not compatible with HFC-236fa. However, manufacturers have developed other molecular sieve desiccants that perform well with HFC-236fa. UOP XH-7 and XH-9 or Grace MS 592 or MS 594 desiccants may be used in loose filled driers. Compacted bead dryers, in which the desiccant is compacted by mechanical pressure, may use UOP XH-6 in addition to the desiccants listed above.

In molded core driers, the molecular sieve is dispersed within a solid core. Several manufacturers offer molded core driers that are compatible with HFC-236fa. Consult the drier manufacturer for recommendations.

Refrigeration Lubricants

Most compressors require a lubricant to protect internal moving parts. The compressor manufacturer usually recommends the type of lubricant and viscosity that should be used to ensure proper operation and equipment durability. Recommendations are based on several criteria, such as, lubricity, compatibility with materials of construction, thermal stability, and refrigerant/oil miscibility. To ensure efficient operation and long equipment life, it is important to follow the manufacturer's recommendations. Current lubricants used with CFC-114 are fully miscible over the range of expected operating conditions, easing the problem of getting the lubricant to flow back to the compressor. Refrigeration systems using CFC-114 take advantage of this full miscibility when considering lubricant return. Refrigerants such as Suva® 236fa, with little or no chlorine, may exhibit less solubility with many existing mineral oil or alkylbenzene lubricants.

The search for lubricants for use with Suva® 236fa started with commercially available products. Solubility and compatibility of various lubricants with HFC-236fa is available in NIST publications. Current naphthenic, paraffinic, and alkylbenzene lubricants have very poor solubility with Suva® 236fa. PAGs with very low viscosity show good solubility but, as viscosity increases, they become less

soluble. Polyol ester (POE) lubricants, of which there are many types, generally show good solubility with Suva® 236fa. When compared with PAGs, ester lubricants are more compatible with hermetic motor components and are less sensitive to mineral oil and CFC-114 remaining in the refrigeration system.

Although Suva® 236fa and CFC-114 are chemically compatible with each other, such is not the case with CFC-114 and PAG lubricants. In particular, the chlorine contained in CFC-114 or other chlorinated compounds can react with the PAG and cause lubricant degradation. CFC-11, which is often used as a cleaning or flushing agent, is also incompatible with PAGs. At contamination levels of 1% CFC-11 or 2 to 10% residual mineral oil (saturated with CFC-114), the stability of the system is affected enough to cause possible degradation. Lubricant degradation can result in poor lubrication and premature failure. In addition, sludge will be formed that can plug orifice tubes and other small openings.

Safety

Users of HFC-236fa should read and understand the DuPont Material Safety Data Sheet (MSDS). Copies of the HFC-236fa MSDS can be obtained from DuPont Customer Service or International Offices (see last page of this document for locations and telephone numbers) or from any DuPont authorized distributor.

Inhalation Toxicity

HFC-236fa poses no acute or chronic hazard when it is handled in accordance with DuPont recommendations and when the exposure is maintained below the recommended exposure limits. The DuPont acceptable exposure limit (AEL) is 1,000 ppm (8- or 12-hour time weighted average).

However, inhaling high concentrations of HFC-236fa 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.

Cardiac Sensitization

If vapors are inhaled at a concentration of 150,000 ppm, which is well above the AEL, 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.

The threshold cardiac sensitization, lowest observed actual exposure level (LOAEL), for HFC-236fa was 150,000 ppm (15%) and the no observed actual exposure level (NOAEL) was 100,000 ppm (10%).

Skin and Eye Contact

At room temperature, HFC-236fa vapors have little or no effect on the skin or eyes. However, in the liquid form, HFC-236fa can freeze the skin or eyes on contact, causing frostbite. If contact with the liquid does occur, soak the exposed area in lukewarm water, not cold or hot. In all cases, seek medical attention as soon as possible.

Always wear protective clothing when there is a risk of exposure to liquid HFC-236fa. Always wear eye protection and a face shield when splashing of HFC-236fa may occur.

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 or unless the area has been monitored to indicate that the concentration of HFC-236fa vapors in the area is below the AEL.

Always use self-contained breathing apparatus or a supplied air mask when entering tanks or other areas where vapors might exist. Use the buddy system and a lifeline. Refer to the HFC-236fa MSDS for more information.

HFC-236fa vapors have virtually no odor. Therefore, frequent leak checks or the installation of area monitors are necessary in enclosed areas were leaks can occur.

To ensure safety when working with halocarbons in confined areas:

- Route relief and purge vent piping (if used) outdoors, away from air intakes.
- Make certain the area is well ventilated, using auxiliary ventilation, if necessary, to move vapors.
- Make sure the area is clear of vapors prior to beginning work.
- Use monitoring equipment to detect leaks.

Storage and Handling

Shipping Containers in the U.S.

HFC-236fa is a liquefied compressed gas. According to the U.S. Department of Transportation (DOT), a gas is a material that has a vapor pressure of >43.5 psi at 50°C (122°F) or completely vapor at 20°C (68°F). A liquefied gas is defined as a gas which, in a packaging under the charged pressure, is partially liquid at 20°C (68°F). The appropriate DOT designation is as follows:

Proper shipping name:	Liquefied Gas, N.O.S. (Hexafluoropropane)
Hazards class:	2.2
UN No.:	3163
DOT/IMO Labels:	LIQUEFIED GAS, N.O.S.

Containers

Two types of containers are used for shipping HFC-236fa. A description of the containers is provided in **Table 6**.

The 123-lb water capacity cylinder is designed for fire extinguishant and blowing agent applications. This cylinder can contain up to 145 lb of HFC-236fa and is equipped with a “Pressure Flow” liquid/vapor valve. The valve body allows liquid to be removed through the CGA-660 connector without inverting the cylinder. The handwheel for liquid removal is on the top of the valve. The liquid valve port is attached to a dip tube, which extends to the bottom of the cylinder. Vapor is removed through the 1/4 AN fitting on the side of the valve. The small handwheel on the side of the valve is used for vapor removal.

The 1,000-lb water capacity cylinder is designed for fire extinguishant and refrigerant applications. This is a palletized cylinder that can contain up to 1,200 lb of HFC-236fa. This cylinder is equipped with two liquid/vapor valves with a CGA-660 connector. The valve body allows liquid to be removed without inverting the cylinder. The handwheel for liquid removal is on the side of the valve. The liquid valve port is attached to a dip tube, which extends to the bottom of the cylinder. Vapor is removed through the same fitting by using the vapor handwheel on the top of the valve.

Transfer of HFC-236fa from the Container

The preferred method for transfer of liquid HFC-236fa from the cylinder is to use a suitable pump. There are several industrial pumps suitable for the transfer of HFC-236fa. Contact an industrial pump manufacturer for the recommended pump.

The receiving container should be evacuated to eliminate contamination by air and to facilitate transfer of HFC-236fa.

Table 6
Specifications of Shipping Containers for HFC-236fa

Water Capacity (lb)	Dimensions	DOT Specification	Net Weight HFC-236fa
123 lb	55”H × 10”OD	4BA300	145
1,000 lb	50”H × 30’OD	4BW260	1,200

If a pump is not available the chilled transfer line method will facilitate transfer of HFC-236fa to the receiving container. This method chills the transfer line as the material flows from the supply container to the receiver. A coil of copper refrigeration tubing is placed in the transfer line between the supply and the receiver. The coil is placed in a cold bath, such as water ice or carbon ice.

Leak Detection

Whenever a system is assembled or serviced, it should be checked for leaks. There are many commercially available leak detectors. These devices are readily available through a refrigeration contractor or service store.

A detailed discussion of leak detection, and a list of leak detection equipment manufacturers are available in DuPont Bulletin ARTD-27 (H-31753-2).

Handling Precautions for HFC-236fa Shipping Containers

The following rules for handling HFC-236fa containers are strongly recommended:

- Use personal protective equipment, such as side shield glasses, gloves, and safety shoes, when handling containers.
- Avoid skin contact with liquid HFC-236fa because it can cause frostbite.
- Never heat a container to a temperature higher than 52°C (125°F).
- Never refill returnable cylinders without DuPont consent. DOT regulations forbid transportation of returnable cylinders refilled without DuPont's authorization.
- Never use a magnet or sling (rope or chain) to lift containers. Use a safe cradle or platform basket that holds the container.
- Never use containers as rollers, supports, or for any other purpose than to contain HFC-236fa.
- Protect containers from any objects that will result in a cut or other abrasion in the surface of the metal.
- Never tamper with the safety devices in the valves or container.
- Never attempt to repair or alter containers or valves.
- Never force connections that do not fit. Make sure the threads on the regulator or other auxiliary equipment are the same as those on the valve outlets.
- Keep valves tightly closed, with valve caps and hoods in place when the container is not in use.
- Store containers under a roof to protect them from weather extremes.
- Use a vapor recovery system to collect HFC-236fa vapors from lines after unloading.

Recovery, Recycle, Reclamation, and Disposal

Responsible use of HFC-236fa requires that the product be recovered for reuse or disposal whenever possible. Recovery and reuse makes sense from an environmental and economic standpoint.

Recovery

Recovery refers to the removal of HFC-236fa from equipment and collection in an appropriate external container. Recovery does not involve processing or analytical testing. But if the system contains nitrogen or other gas to super-pressurize, it must be identified on the label. This is normally performed when a system must undergo maintenance and the HFC-236fa returned to the system after completion. There are a number of recovery devices on the market. These devices contain a compressor and an air-cooled condenser, and may be used for liquid or vapor recovery. At the end of the recovery the system is evacuated to remove vapors. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it contains the elastomeric seals and a compressor oil compatible with HFC-236fa.

Reclamation

Reclamation refers to the reprocessing of HFC-236fa recovered from a system to new product specifications. Quality of the reclaimed product is verified by chemical analysis. In the U.S., HFC-236fa is included in DuPont's reclamation program. Contact DuPont or one of its authorized distributors for further information.

Disposal

Disposal refers to the destruction of used HFC-236fa. Disposal may be necessary when HFC-236fa has become contaminated with other materials and no longer meets the acceptable specifications of DuPont or other reclaimer. DuPont does not presently accept severely contaminated HFC-236fa for disposal. Licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them used HFC-236fa.

For Further Information Regarding DuPont Fire Extinguishants, Contact:

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