

3M™ Novec™ 1230 Fire Protection Fluid

Introduction

3M™ Novec™ 1230 Fire Protection Fluid is a next-generation halon alternative offering outstanding performance, large margin of safety, and an excellent environmental profile.

- Zero ozone depletion potential
- A global warming potential of 1
- 5-day atmospheric lifetime
- A large margin of safety for occupied spaces

Novec 1230 Fire Protection Fluid is based on a proprietary chemical from 3M called a fluoroketone. The full chemical name for this compound is dodecafluoro-2-methylpentan-3-one. Its ASHRAE nomenclature – the way it is designated in the NFPA 2001 and ISO 14520 clean agent standards – is FK-5-1-12.

Novec 1230 fluid offers a unique combination of safety, low environmental impact and extinguishing performance, making it the first chemical halon replacement to offer a viable, long-term, sustainable technology for special hazards fire protection.

Physical Properties

Novec 1230 fluid is applied as a gas, but is liquid at room temperature. It is electrically non-conducting in both the liquid and gaseous state. The breakdown voltage of Novec 1230 fluid vapor under saturated conditions at 1 atm, 21°C over a 2.7 mm electrode gap is 15.6 kV, nearly 2.3 times that of dry nitrogen. The breakdown voltage of liquid Novec 1230 fluid under the same conditions is 48 kV.

The properties of Novec 1230 fluid are similar to many of the first generation halon alternatives with one primary exception – this compound is a liquid at ambient conditions. The boiling point of Novec 1230 fluid is 49.2°C, meaning this product has a much lower vapor pressure than other clean agents, which are gases at ambient conditions.

Novec 1230 fluid has a very low heat of vaporization, approximately 25 times less than that of water. This, along with a higher vapor pressure, causes Novec 1230 fluid to evaporate more than 50 times faster than water. This allows the agent to transition from a liquid to a gaseous state very rapidly when discharged through a nozzle. In a properly designed system, Novec 1230 fluid will rapidly vaporize and evenly distribute throughout the protected space.

Properties Description

Not for specification purposes. All values @ 25°C (77°F) unless otherwise specified.

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Properties	Novec™ 1230 Fluid
Chemical Formula	CF ₃ CF ₂ C(O)CF(CF ₃) ₂
Molecular Weight	316.04
Boiling Point @ 1 atm	49.2°C (120.6°F)
Freezing Point	-108.0°C (-162.4°F)
Critical Temperature	168.7°C (335.6°F)
Critical Pressure	18.65 bar (270.44 psi)
Critical Volume	494.5 cc/mole (0.0251 ft ³ /lbm)
Critical Density	639.1 kg/m ³ (39.91 lbm/ft ³)
Density, Sat. Liquid	1.60 g/ml (99.9 lbm/ft ³)
Density, Gas @ 1 atm	0.0136 g/ml (0.851 lbm/ft ³)
Specific Volume, Gas @ 1 atm	0.0733 m ³ /kg (1.175 ft ³ /lb)
Specific Heat, Liquid	1.103 kJ/kg°C (0.2634 BTU/lb°F)
Specific Heat, Vapor @ 1 atm	0.891 kJ/kg°C (0.2127 BTU/lb°F)
Heat of Vaporization @ boiling point	88.0 kJ/kg (37.9 BTU/lb)
Liquid Viscosity @ 0°C/25°C	0.56/0.39 centistokes
Vapor Pressure	0.404 bar (5.85 psig)
Relative Dielectric Strength, 1 atm (N ₂ =1.0)	2.3

Physical Properties (continued)

Although 3M™ Novec™ 1230 Fire Protection Fluid is a liquid at room temperature, its vapor pressure is sufficient for the agent to readily achieve vapor extinguishing concentrations in air. At 25°C, one could form vapor concentrations with Novec 1230 fluid up to 39 volume percent prior to reaching saturation. Typical fire suppression design concentrations for most applications are in the range of 4 to 6 percent by volume of the protected space. That large differential between design and saturation concentrations dictates that condensation of vapor will not occur.

Minimum design concentration based upon cup burner results $\times 1.3$

Design Concentrations

Flammable Liquid	Design Concentration (vol%)
Acetone	5.6
Ethyl alcohol	7.2
n-heptane	5.9
Technical heptane	5.6
Diesel fuel	4.5
Methanol	8.5
Methyl ethyl ketone	5.9

Like other halocarbon halon alternatives, Novec 1230 fluid extinguishes principally by removing heat from the fire. Upon discharge, Novec 1230 fluid creates a gaseous mixture with air. This agent/air mixture has a heat capacity much larger than that of air alone. A higher heat capacity means that this gas mixture will absorb more energy (heat) for each degree of temperature change it experiences. At the system design concentration, the agent/air mixture absorbs sufficient heat to upset the conditions required for combustion to occur. The amount of heat the fire loses to the surroundings is increased by the presence of the agent. This causes the combustion zone to cool to the point that the fire extinguishes. Novec 1230 fluid has the highest heat capacity of the commercially available halon alternatives resulting in the lowest extinguishing concentrations for a given fuel. The design concentration for Class A fuels is a minimum of 4.2 vol% for designs based on UL 2166 in the USA. Different design concentrations may be required in other countries based on local approvals.

Typical Applications

Novec 1230 fluid can effectively be applied in total and localized flooding, inerting and explosion suppression applications in the following areas:

- Data Processing Centers
 - Computer Rooms
 - Data Storage Facilities
- Telecommunications
 - Cellular Sites
 - Switching Centers
- Commercial and Military Aviation
 - Engine protection
- Commercial Marine
 - Control and Paint Rooms
 - Engine Rooms
 - Storage Rooms
- Military Systems
 - Combat Vehicles
 - Marine Engine Rooms
- Oil & Gas Petrochemical Facilities
 - Pumping Facilities
 - Gas Compressor Rooms
 - Offshore Oil Exploration Rigs
- Transportation
 - Merchant Marine Vessels
 - Mass Transit Vehicles
- Recreation
 - Pleasure Craft
 - Race Cars
- Cultural Facilities
 - Museums
 - Libraries
 - Archives
- Medical Facilities
- Manufacturing Facilities
- Storage Areas

Environmental Properties

Once emitted to the environment, there are a number of ways for organic compounds to be removed from the atmosphere. Studies conducted on 3M™ Novec™ 1230 Fire Protection Fluid have determined the atmospheric loss rates via these removal mechanisms and the effect on the atmospheric lifetime of this compound. The very low water solubility of Novec 1230 fluid and the low degree to which it partitions into liquid water was found to preclude atmospheric hydrolysis from being a meaningful removal mechanism. The principal atmospheric sink for Novec 1230 agent is photolysis. It exhibits strong absorption of energy at near UV wavelengths, resulting in a very short atmospheric lifetime. The rate of photolysis under atmospheric conditions and the mechanism of decomposition of this compound have been investigated by two different research groups^{1,2}. The photolysis rate of the fluoroketone leads to an atmospheric lifetime of approximately 1 week, which is consistent with the 3M study that found the atmospheric lifetime of Novec 1230 fluid to be on the order of 5 days.

Ozone Depletion Potential

Novec 1230 fluid, which contains no chlorine or bromine, has an ozone depletion potential of zero.

Global Warming Potential

The Global Warming Potential (GWP) is an index that provides a relative measure of the possible climate impact due to a compound that acts as a greenhouse gas in the atmosphere. The GWP of a compound, as defined by the Intergovernmental Panel on Climate Change (IPCC), is calculated as the integrated radiative forcing due to the release of 1 kilogram of that compound relative to the warming due to 1 kilogram of CO₂.

The potential for Novec 1230 fluid to have a climate impact is limited by its very short atmospheric lifetime and low global warming potential. The GWP of Novec 1230 fluid is calculated to be 1 or less using the IPCC 2007 method and a 100-year integration time horizon³, including both the direct effect from the agent as well as the indirect effect from decomposition products. Taniguchi et al.¹ and D'Anna et al.² have concluded that “the global warming potential of the compound is negligible.”

Potential for Reducing GHG Emissions

The fire protection industry has made considerable progress in reducing emissions from the relatively high levels experienced during the use of halon. However, the high GWP of the HFCs used in these applications combined with their growing installed base results in continually increasing greenhouse gas emissions. A single discharge of an average sized fire protection system containing HFCs is meaningful in itself. Based upon an average sized halon 1301 system containing 200 kg, an equivalent sized system using, for example, HFC-227ea, contains approximately 347 kg of agent. A GWP of 3220 results in CO₂ equivalent emissions of 1,110,000 kg when this HFC agent is discharged. This is equivalent to the emissions from more than 240 typical automobiles in the USA driven for an entire year!

Discharge of a fire protection system using Novec 1230 fluid in place of an HFC extinguishing agent results in significantly reduced greenhouse gas emissions. Due to the dramatically lower GWP, greenhouse gas emissions from discharge of Novec 1230 fluid are reduced by more than 99.9% compared to any of the HFCs used in fire protection. As a result, Novec 1230 fluid is a low GWP alternative that can reduce emissions of greenhouse gases in fire protection applications and help to further the environmental goals of the industry.

Not for specification purposes.

All data other than those for Novec 1230 fluid were compiled from published sources.

Environmental Properties Comparison

Properties	Novec 1230	Halon 1211	Halon 1301	HFC-125	HFC-227ea
Ozone Depletion Potential (ODP) ¹	0.0	4.0	12.0	0.0	0.0
Global Warming Potential–IPCC ²	1	1890	7140	3500	3220
Atmospheric Lifetime (years)	0.014	16	65	29	34.2
SNAP (Yes/No)	Yes	N/A	N/A	Yes	Yes

¹ World Meteorological Organization (WMO) 1998, Model-Derived Method.

² Intergovernmental Panel on Climate Change (IPCC) 2007 Method, 100 Year 1TH.

Safety Considerations

The safety of 3M™ Novec™ 1230 Fire Protection Fluid has been thoroughly evaluated through both acute and repeat dose toxicity testing. A full series of toxicological tests has been completed using this compound. In each case, Novec 1230 fluid has been demonstrated to be very low in toxicity and to have a large margin of safety in use as a clean extinguishing agent. Key testing of Novec 1230 fluid was conducted at independent laboratories as shown in the following table.

Toxicity testing results

Properties	Novec 1230
4-hour Acute Inhalation	Practically Non-Toxic (LC ₅₀ >100,000 ppm)
Cardiac Sensitization	Not a Sensitizer (NOAEL = 100,000 ppm)
Acute Dermal Toxicity	Low Toxicity (LD ₅₀ >2000 mg/kg)
Ames Assay	Negative
Primary Skin Irritation	Non-Irritating
Primary Eye Irritation	Minimally Irritating
Acute Oral Toxicity	Low Toxicity (LD ₅₀ >2000 mg/kg)
Skin Sensitization	Not a Skin Sensitizer
28-Day Inhalation Study	NOAEL of this study: 4,000 ppm
Chromosomal Aberration	Negative

The no observable adverse effect level (NOAEL) for any end point of acute toxicity has been determined to be 10 volume percent (100,000 ppmv) in air. With a NOAEL of 10%, there is consensus that Novec 1230 fluid is not only safe for its intended end use but that it provides a large margin of safety relative to the typical design concentrations of fire protection systems. Typical design concentrations in the range of 4.2 to 5.9 volume percent result in safety margins of 69 to 138%.

Thermal Decomposition

Well over 90% of applications involving the use of halocarbons, like 3M™ Novec™ 1230 Fire Protection Fluid, protect Class A assets, including those related to computer and telecommunication facilities. Continuity of operation is paramount, and those types of assets, typically involving electronic switches and circuit boards, cannot tolerate even a relatively modest fire. System design, therefore, must be such that fire size be kept to a minimum.

Levels of HF produced from fires extinguished by Novec 1230 fluid are similar to those involving other physically acting halocarbon agents. Industry practice over the last decade has demonstrated that fire extinguishing systems using halogenated halon alternatives can be designed to minimize thermal decomposition product formation and avoid adding to the potential toxic threat of a fire event (the hazards created by the combustion products of the fire).

Materials Compatibility

Compatibility of “O” Rings with Novec 1230 Fluid

Exposure Time: 1 Week@ 25°C, 100°C

Elastomer Type	Exposure Temperature	Change in Shore A Hardness	% Change in Weight	% Change in Volume
Neoprene	25°C	-1.8	-0.6	-1.2
	100°C	-2.2	+2.3	+0.8
Butyl rubber	25°C	-2.7	+0.2	+0.1
	100°C	-4.0	+4.3	+4.2
Fluoroelastomer	25°C	-6.2	+0.7	+0.6
	100°C	-12.6	+9.5	+10.6
EPDM	25°C	-4.7	+0.6	+0.3
	100°C	-5.7	+3.3	+2.4
Silicone	25°C	N/A	+3.1	+2.8
	100°C	-5.4	+6.0	+5.1
Nitrile	25°C	-0.7	-0.3	-0.5
	100°C	+2.5	+4.6	+0.7

Effect of Novec 1230 Fluid on Various Metals

Metals	Effect
Aluminum Alloy 6262 T6511	A
Brass Alloy UNS C36000	A
AISI Type 304L stainless steel	A
AISI Type 316L stainless steel	A
Copper UNS C12200	A
ASTM A 516, Grade 70 carbon steel	A

A. No discoloration or destruction of fluid or metal at temperature indicated, 10 days minimum exposure, 48°C.

3M has extensive data on compatibility with various materials. For more information, contact your local 3M technical service representative.

Regulatory Registries

When commercializing 3M™ Novec™ 1230 Fire Protection Fluid, inclusion of the chemistry on a region's or country's chemical registry was required. For example, in Japan, a chemical must attain METI approval and, in the EU, the ELINCS approval must be in place before a chemical may be imported. Local regulatory approvals and listings on chemical registries of key countries are complete. The following table lists eight of the major chemical registry approvals.

Chemical Registry Approvals

Chemical: dodecafluoro-2-methylpentan-3-one CAS#: 756-13-8

Country/Region	Status
USA (TSCA)	Listed
Canada (CDSL)	Listed
EU (ELINCS):	EC# 436-710-6
Australia (AICS)	Listed
Japan (METI)	METI# (2)-4024
Korea (KECI)	KECI# 2002-3-2022
China (IECSC)	Listed
Philippines (PICCS)	Listed

Additionally, both the German Hygiene Institute and Swiss BUWAL approval have been attained. In the USA, Novec 1230 fluid has been approved by the EPA Significant New Alternatives Policy (SNAP) Program for use as a halon replacement in both total flooding and streaming applications.

Industry Approvals

Fire suppression systems containing Novec 1230 fluid are commercially available globally. Major system listings and approvals, with Novec 1230 fluid as a component, are included in the following table. Component recognitions have been attained from US-based Underwriters Laboratories, Inc. and FM Global, as well as EU-based LPCB, VdS and CNPP. Also, the German Amtliche Prüfstelle has approved systems using Novec 1230 fluid. While approval from the SSL in Australia is complete, other AsiaPac approvals are in progress.

Industry Listings and Approvals

Underwriters Laboratories Inc (ULI)	USA
Underwriters Laboratories CA (ULC)	Canada
FM Global (FM)	USA
Loss Prevention Certification Board (LPCB)	United Kingdom
Scientific Services Laboratories (SSL) Also called Certifire Pty Ltd	Australia
VdS Schadenverhütung (VdS)	Germany
Centre National de Prévention et de Protection (CNPP)	France
Korea Fire Institute(KFI)	Korea

Novec 1230 fluid is included in the 2008 edition of NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems and the 2006 edition of ISO 14520, Gaseous Media Fire Extinguishing Systems. In each standard, it is referenced by the generic ASHRAE nomenclature FK-5-1-12.

For one specific industry, commercial marine, numerous approvals for systems using 3M™ Novec™ 1230 Fire Protection Fluid have been attained globally, and are listed below.

Global marine approvals for Novec 1230 fluid

American Bureau of Shipping (ABS)	International
Australian Maritime Safety Agency	Australia
Bureau Veritas (BV)	France
Canadian Coast Guard	Canada
Danish Maritime Authority (DMA)	Denmark
Det Norske Veritas (DNV)	Norway
Germanischer Lloyd (GL)	Denmark
Icelandic Maritime Administration	Iceland
Inland/Sea going acceptance (BZI)	Belgium
Lloyd's Register of Shipping (LR)	International
Maritime and Coastguard Agency (MCA)	UK
Marine Marchant Approval	France
Nippon Kaiji Kyokai (NK)	Japan
Polish Register of Shipping	Poland
Registro Italiano Navale (RINA)	Italy
Shipping Authority Acceptance – Inland/Sea going	Holland
United States Coast Guard (USCG)	USA
Marine Equipment Directive (MED) Module B	EU

Commercial Availability

Six independent original equipment manufacturers (OEMs) have substantially invested to gain the necessary approvals and to commercialize their total flooding systems with Novec 1230 fluid. They are:

- Firetrace International (USA)
- Sevo Systems (USA)
- Tyco Fire & Security (USA)
- Minimax (DE)
- Siemens Systems (CH)
- UTC Fire & Security (USA)

Total flooding system development has been the near term effort of these companies. All have invested heavily to test their systems against recognized test protocols and commercialize their products. Future development is expected to expand into specialty, military, and aerospace clean agent applications as well as handheld portable extinguishers.

Packaging and Availability

Novec 1230 fluid is currently available in 2425 lb. (1100 kg) intermediate bulk containers (IBCs), 661 lb. (300 kg) drums and 11 lb. (5 kg) glass sample jugs.

A cylinder containing Novec 1230 fluid superpressurized with nitrogen varies less than 150 psi (10 bar) over a temperature range of 250°F (120°C). Also, because it is packaged in IBCs and drums, it can be air freighted without the restrictions of gaseous alternatives.

Resources and Distribution

Novec 1230 fluid is supported by global sales, technical and customer service resources, with technical service laboratories in the U.S., Europe, Japan, Latin America and Southeast Asia. Users benefit from 3M's broad technology base and continuing attention to product development, performance, safety and environmental issues.

Extensive OEM policies and equipment design guidelines have been prepared for system retrofit, installers and equipment manufacturers in support of Novec 1230 fluid.

For additional technical information on Novec 1230 fluid in the United States, or for the name of a local authorized distributor, call 3M Electronics Markets Materials Division, **800 810 8513**.

For other 3M global offices, and information on additional 3M products, visit our web site at www.3M.com/novec1230fluid.

References

1. Taniguchi, N., Wallington, T.J., Hurley, M.D., Guschin, A.G., Molina, L.T., Molina, M.J., *Journal of Physical Chemistry A*, 107(15), 2674-2679, 2003.
2. D'Anna, B., Sellevag, S., Wirtz, K., and Nielsen, C.J., *Environmental Science and Technology*, 39, 8708-8711, 2005.
3. IPCC 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp, 2007.

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of patented 3M products. Although each has its own unique formula and performance properties, all Novec products are designed in common to address the need for safe, effective, sustainable solutions in industry-specific applications. These include precision and electronics cleaning, heat transfer, fire protection, lubricant deposition and several specialty chemical applications.

3M™ Novec™ Engineered Fluids • 3M™ Novec™ Aerosol Cleaners • 3M™ Novec™ 1230 Fire Protection Fluid • 3M™ Novec™ Electronic Coatings • 3M™ Novec™ Electronic Surfactants

United States	China	Europe	Japan	Korea	Singapore	Taiwan
3M Electronics Markets Materials Division 800 810 8513	3M China Ltd. 86 21 6275 3535	3M Belgium N.V. 32 3 250 7521	Sumitomo 3M Limited 813 3709 8250	3M Korea Limited 82 2 3771 4114	3M Singapore Pte. Ltd. 65 64508888	3M Taiwan Limited 886 2 2704 9011

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