

3M™ Novec™ Engineered Fluids

The science of precision & electronics cleaning



3M *Innovation*

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A balanced solution.

Today's fast-changing regulatory and competitive landscapes have made choosing a cleaning solvent more difficult than ever. Users of these materials must reconcile demands for improved performance at lower cost. Lower environmental impact. Fewer regulatory hassles. A safer, healthier workplace.

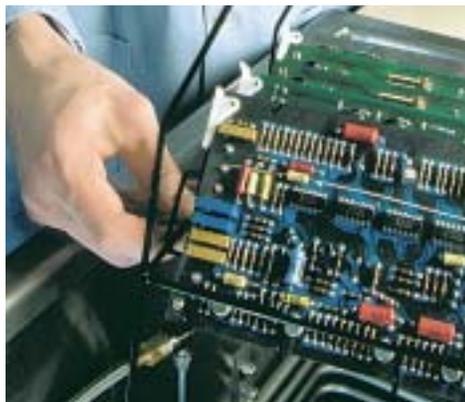
3M™ Novec™ Engineered Fluids strike an outstanding balance between all these needs. They're characterized by good cleaning performance, zero ozone depletion potential, low global warming potential and low toxicity. Low emissive losses and low drag-out losses contribute to cost savings. And because Novec fluids are nonflammable, they can be used safely in a wide variety of applications.

Technology for today's world

This favorable balance of properties is largely due to the unique structure of the base molecules. The base molecules in Novec cleaning fluids are HFEs (segregated hydrofluoroethers). The presence of the ether oxygen in the chemical makeup of these compounds, combined with the effect of segregating the hydrogens and fluorines around that oxygen, results in an ideal combination of properties. And the **right balance** of vapor pressure, low surface tension, low heat of vaporization and solvency makes them excellent cleaning solvents.

Novec fluids can be used in traditional vapor degreasing and immersion systems. Or they can be used in aerosol or even hand-wipe cleaning. Which is why they're finding widespread use in electronics, in aerospace, in automotive...even in the motion picture industry.

The following pages contain product suggestions for cleaning specific soils, suggestions for certain cleaning processes and successful cost saving measures. Each precision cleaning application is unique, however. Please contact a 3M representative for an evaluation, samples of Novec engineered fluids or for assistance in helping you determine which products and processes are right for your application.



Types of Soils Cleaned

Light oils
Halogenated compounds
Particulates
Release agents

Suggested Products

3M™ Novec™ Engineered Fluid HFE-7000
3M™ Novec™ Engineered Fluid HFE-7100
3M™ Novec™ Engineered Fluid HFE-7200
3M™ Novec™ Engineered Fluid HFE-71IPA

Light-duty cleaning.

Pure 3M™ Novec™ Engineered Fluids can be used “neat” to remove light hydrocarbon and silicone oils. As highly-fluorinated compounds, Novec fluids are ideal for cleaning halogenated oils and greases. These solvents function effectively in the removal of particulate from components and final assemblies. And, when needed, Novec fluid HFE-71IPA (an azeotropic blend of HFE and isopropyl alcohol) offers some improvement in solvency while maintaining excellent materials compatibility.

Novec fluids are most often used in vapor degreasing machines or in specialized cleaning machines with ultrasonic agitation. Their ability to penetrate tight spaces on complex parts allows for thorough cleaning of precision components.

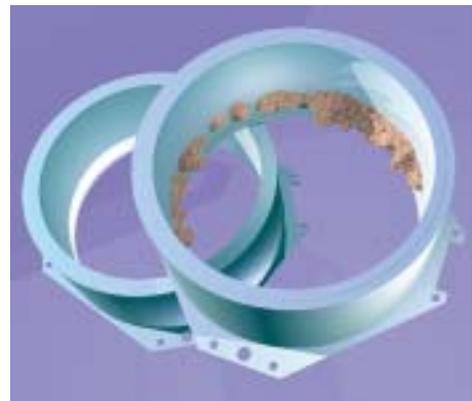
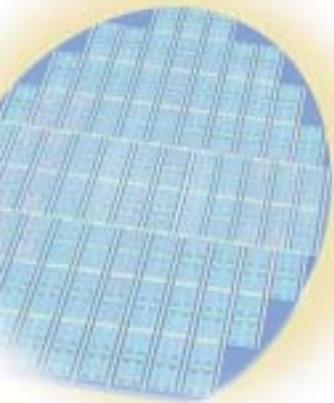
A combination of factors, including density, surface tension and viscosity, is responsible for this penetration, and contributes to the cleaning ability of Novec fluids HFE-7100 and HFE-7200. The low heat of vaporization of these fluids ensures rapid drying after the cleaning process.

Wet Cleaning of Dry Etcher Parts

In recent years, 3M Novec fluids have proven to be highly effective for wet cleaning of semiconductor dry etcher parts. Because of their cleaning speed and favorable safety and environmental profiles, they are frequently used to replace conventional solvents, such as IPA and acetone, for cleaning fluoropolymer deposits formed during dry etching of dielectric films.

These advanced, nonflammable materials are useful for wipe cleaning of chamber and for parts cleaning baths.

The low surface tension of Novec fluids allows greater penetration than conventional solvents, providing excellent cleaning performance on metallic or non-metallic parts. Although the high cleaning efficiency of Novec fluids may not require added mechanical force, heat or agitation, scrubbing and ultrasonics can be used to help remove very stubborn deposits, or to speed cleaning time.



Typical Physical Properties (All values at 25°C unless noted)

HFE-7000	34	-123	1.41	12.4	484	0.45	33.9
HFE-7100	61	-135	1.52	13.6	202	0.61	30
HFE-7200	76	-138	1.43	13.6	109	0.61	30
HFE-711PA	54.8	-42 ¹	1.48	14.5	207	0.75	39.5

¹ Critical solution temperature

² cal/g @ boiling point

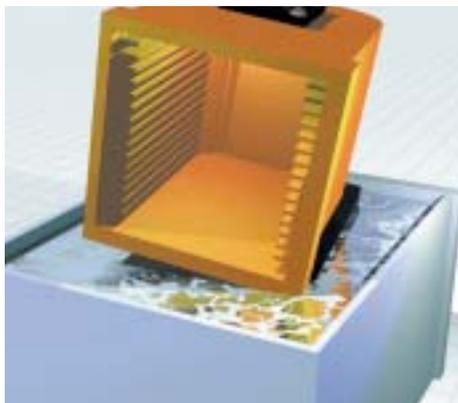
Boiling Pt. °C
Freeze Pt. °C
Liquid Density (g/ml)
Surface Tension (dyne/cm)
Vapor Pressure (mm Hg)
Viscosity (cP)
Heat of Vaporization²

Cleaning of Hard Drive Components And Assemblies

3M™ Novec™ Engineered Fluids are excellent in meeting the demanding cleaning requirements of the hard disk drive industry. These fluids are used for cleaning light oils and particulate from many parts of the drive, including MR heads, HGAs, suspensions and media.

Hand Wipe and Aerosol Cleaning

Novec fluids are excellent for removing fine particulates during hand wiping of critical components found throughout electronics manufacturing facilities. The solvent evaporates quickly and completely, leaving behind no residue. Because they are non-reactive, highly stable and nonflammable, they can also be incorporated into aerosol spray cleaners where they act as both carrier solvents and cleaning agent. The low toxicity of Novec fluids makes them ideal for use in aerosol formulations because of the increased potential for skin contact and inhalation of overspray in this method of application. (See page 14 for additional safety/toxicity information.)



Types of Soils Cleaned

Medium- to heavy-duty oils
Lubricants
Low MP waxes
Polishing fluids
Buffing compounds
RMA flux
No Clean Flux

Suggested Products

3M™ Novec™ Engineered Fluid HFE-71DA
3M™ Novec™ Engineered Fluid HFE-71DE
3M™ Novec™ Engineered Fluid HFE-72DA
3M™ Novec™ Engineered Fluid HFE-72DE

Medium-to heavy-duty

3M has developed a number of products that effectively clean medium- to heavy-duty soils. These products—azeotropes or blends of azeotropes—have much higher solvency than pure 3M™ Novec™ Engineered Fluids HFE-7100 or HFE-7200, and are useful on soils ranging from hydrocarbon and silicone oils to greases. Their higher solvency means they can even clean flux residues and low melting point waxes.

These products are mixtures of Novec fluids and one or more organic solvents. Once combined, these azeotropes exhibit desirable physical properties for precision and electronics cleaning applications, with fairly high density, low viscosity, low surface tension and favorable environmental properties.

Their excellent chemical and thermal stability coupled with constant composition during boiling makes them ideal for immersion defluxing and degreasing applications.

Novec fluid HFE-71DA—

- Cleaning of oils, greases, waxes, handling oils, solder flux residue, ionic contaminants

Novec fluid HFE-71DE—

- Cleaning of oils, greases, waxes

Novec fluid HFE-72DA—

- Cleaning of medium- to heavy-duty solder flux residue, oils, greases, waxes, ionic components

Novec fluid HFE-72DE—

- Cleaning of medium- to heavy-duty oils, greases, waxes



Typical Physical Properties (All values at 25°C unless noted)

HFE-71DA	40	-29	1.33	16.4	381	0.45	50
HFE-71DE	41	-24	1.37	16.6	383	0.45	48
HFE-72DA	44	-38	1.27	18	360	0.40	60
HFE-72DE	43	N/A	1.28	19	350	0.45	52

Boiling Pt. °C

Freeze Pt. °C

Liquid Density (g/ml)

Surface Tension (dyne/cm)

Vapour Pressure (mm Hg)

Viscosity (cP)

Heat of Vaporization'

cleaning.

Vapor Cleaning Optimization

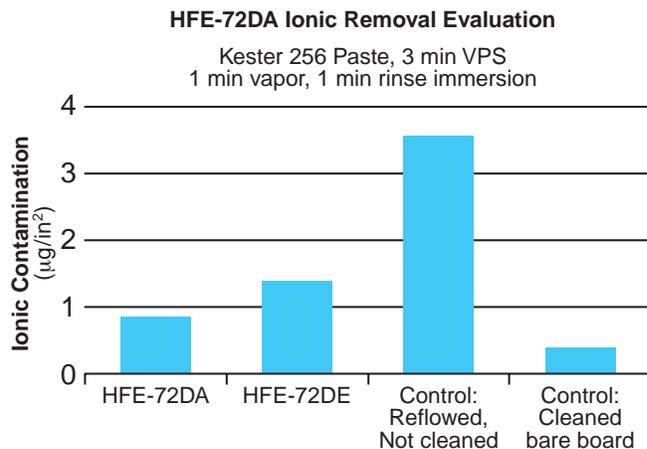
3M™ Novec™ Engineered Fluids can be used as a drop-in replacement for nearly any cleaning solvent. To improve cleaning performance in some applications, however, it may be beneficial to make slight modifications to the vapor degreaser. In addition, 3M urges customers to implement procedures that will minimize vapor emissions. 3M technical service engineers can help you optimize your process to minimize fluid consumption. See *Reducing Fluid Usage* on page 12 for more information.

Removing Flux Residue

Liquid fluxes, paste fluxes, Type RMA, RA or R, No Clean Fluxes... with such a wide variety, recommending a single cleaning solvent is very difficult. 3M™ Novec™ Engineered Fluid HFE-72DA does an admirable job cleaning most of these flux residues (see graph below), but numerous process variables can affect cleaning performance:

- solder reflow profile
- time between soldering and cleaning
- orientation of the board

Taking these variables into account, 3M technical service engineers can help you modify your process slightly to improve cleaning performance... whether you choose to use Novec fluid HFE-72DA or an alternate Novec engineered fluid.



Types of Soils Cleaned

Heavy-weight oils
Greases
Waxes

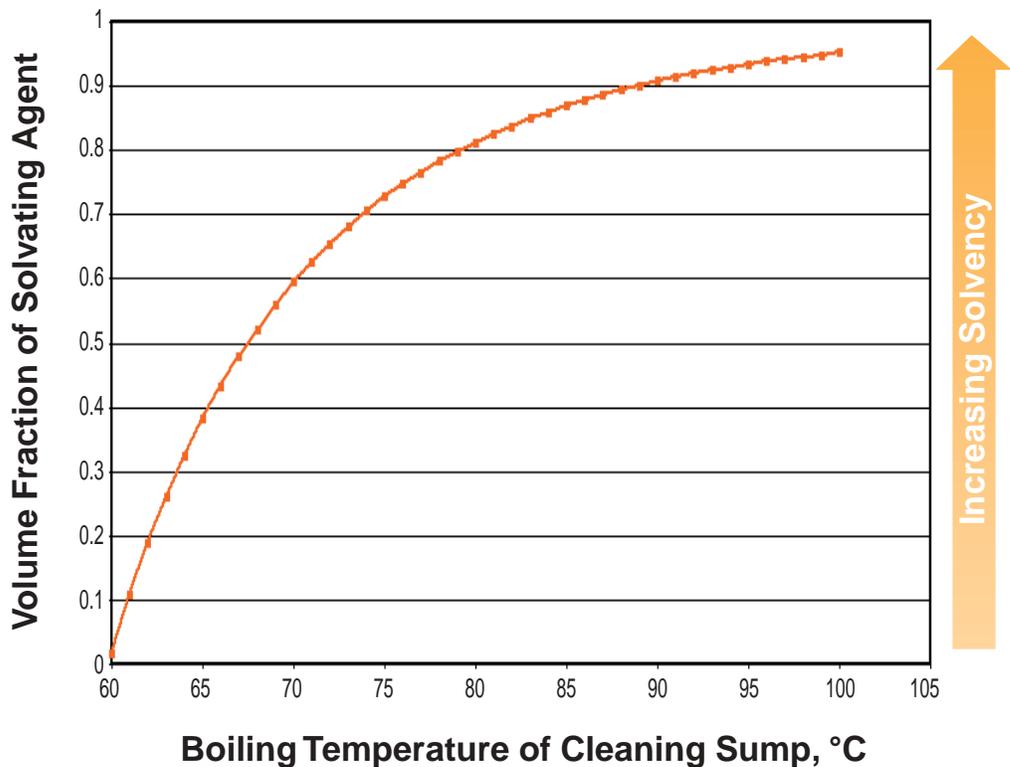
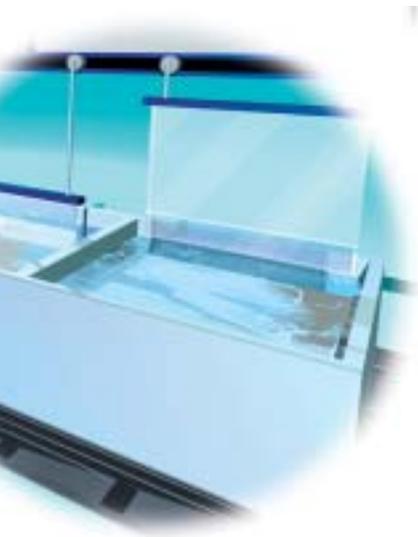
Suggested Products

3M™ Novec™ Engineered Fluid HFE-7100
3M™ Novec™ Engineered Fluid HFE-7200
3M™ Novec™ Engineered Fluid HFE-71IPA

Co-solvent cleaning.

Removal of the most challenging soils, such as heavy oils, greases and waxes, can be accomplished with the 3M™ Novec™ Engineered Fluid co-solvent process.

This cleaning process combines two fluids: a low volatility organic solvent that dissolves soils from part surfaces, and 3M™ Novec™ Engineered Fluid HFE-7100, HFE-7200, or HFE-71IPA which function as effective rinsing agents to flush solvating agents and soils from part surfaces. A variety of low volatility, high solvency organic solvents are available for use in a co-solvent process, with the optimum choice depending on the application. Solvating agents recommended by 3M include Petroferm Solvating Agents SA-70 and SA-24, which have been tested and approved for use with Novec fluids HFE-7100, HFE-7200, and HFE-71IPA.



Co-solvent cleaning is inherently flexible and easy to operate. The process allows you to vary the boiling point of the vapor degreaser (see chart at left) as the situation requires. In addition, the environmental and safety profile of the process is similar to the neat or azeotropic cleaning process.

HFE Solvating Agents

Solvating agents which are miscible at room temperature

- Petroferm™ SA-19
- Petroferm™ SA-24
- Petroferm™ SA-70
- Aromatic 150
- Toshiba™ FRW-1
- Toshiba™ FRW-13
- Dowanol™ PnB
- Purasolv® AL
- Purasolv® EHL
- Topklean™ EL-20A
- Topklean™ EL-20C

Solvating agents which are miscible at boiling temperature

- Actrel® 1140L
- Actrel® 1178L
- P&F Limonene
- NS Clean® 200
- LPA®-142

Solvating agents which have limited solubility

- Actrel® 1111L
- Axarel® 9100
- BioDiesel

Note: Please read and follow the manufacturer's precautions and directions for use before using any solvating agent. User is responsible for evaluating and determining which solvating agents are compatible, suitable, and appropriate for user's particular use and intended application.

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 Actrel is a registered trademark of Exxon Mobil Corporation
 NS Clean is a registered trademark of Nikko Petrochemicals Co., Ltd.
 Axarel is a registered trademark of Petroferm, Inc.
 Topklean is a trademark of Avantec



Reducing waste, reducing costs.

3M™ Novec™ Engineered Fluids can provide cost savings in a number of areas. Due to their low heat of vaporization, these fluids reduce the electrical costs associated with boiling the liquid and drying parts. Because of their favorable environmental properties and low environmental impact, there is likely no need for costly abatement systems.* 3M's nationwide (in the U.S.) Used Fluid Return Program can help reduce disposal costs (see page 15). Novec fluids can also reduce costs associated with regulatory record keeping and reporting requirements when compared to other cleaning solvents.

But the greatest cost savings occur due to reduced emissive and drag-out losses when using Novec engineered fluids.

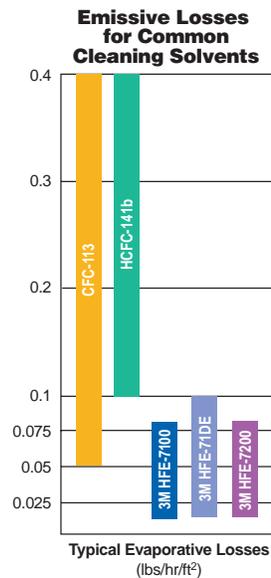
* Consult your local regulations

Emissive Losses

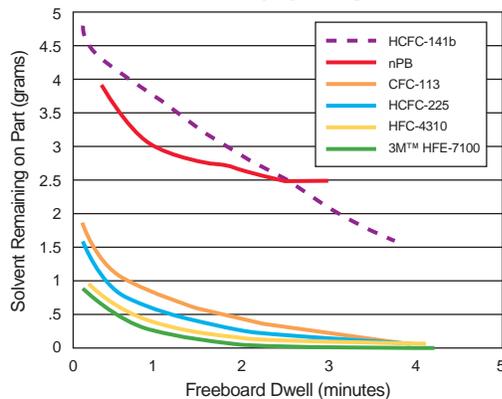
The evaporative loss of Novec fluids when used in vapor degreasing or a similar, recirculating system, is lower than most other solvents for two important reasons: higher molecular weight, and a relatively low vapor pressure. As a consequence, diffusive losses are substantially reduced compared other cleaning solvents.

Drag-Out Losses

The low surface tension, low viscosity, high density and low heat of vaporization of Novec fluids result in reduced



**Drag-out Characteristics of Various Solvents
Simulation for Highly Complex Parts**



drag-out losses compared to other solvents. Alternate solvents tend to cling to complex surfaces after cleaning and rinsing due to surface tension forces, and are drawn out of the cleaning system before they can drip off or evaporate. In contrast, Novec fluids drip away quickly, without becoming trapped in small spaces as a part—like a printed circuit board—is raised through the vapor zone. Further, the lower heat of vaporization means that less energy is required to evaporate the solvent from the part in the freeboard region. This helps to reduce solvent and energy consumption.

Solvent cleaning vs. aqueous cleaning: Comparing “Cost-of-Ownership”

Although water is inherently less expensive than fluorinated solvents, it also has a number of serious drawbacks as a cleaning medium for precision and electronic parts. That is why it is so important to compare the total “cost of ownership” of various types of cleaning systems—rather than simply comparing the cost of their fluids.

In general, solvent systems offer a number of important cost and performance advantages over aqueous systems. For example, fluorinated solvents have lower surface tensions than water. This can result in improved cleaning of parts with complex geometries, less hold-up of the cleaning medium and less effect on the next step of your process.

Solvent cleaning eliminates the need for costly drying equipment, while helping prevent parts corrosion and contamination associated with water systems. And because parts cleaned in fluorinated solvents such as 3M™ Novec™ Engineered Fluids emerge from the vapor degreaser clean and dry (and with no surfactant residue), they can move quickly to the next process step.

Of course, every application is unique, and a solvent cleaning system will benefit some users more than others. Calculating your own potential savings involves a variety of factors that influence the cost per part cleaned, including variable operating costs (e.g., fluid loss, electricity, maintenance, recycling); fixed costs (e.g., equipment depreciation, initial fluid fill); and other costs (e.g., downtime, yield effects).

3M can help you compare the cost of cleaning with Novec fluids versus other solvents or even aqueous processes. Contact your local 3M representative for more information.

Advantages of cleaning with fluorinated solvent system

- No waste water treatment
- Reduced power consumption
- Uses standardized equipment
- Smaller equipment “footprint”
- No drying equipment

Ask 3M

3M technical service engineers are available to help you optimize your cleaning process. Please contact us if you have any fluid conservation questions or experience difficulties when modifying your machine.



Reducing Fluid Usage

Cutting vapor loss helps reduce costs and the environmental impact of any solvent cleaning process. Implementing containment and recovery procedures can greatly improve fluid usage.

To help improve fluid conservation when using 3M™ Novec™ Engineered Fluids, the following equipment designs and features should be considered:

- Programmable hoist system
- Chiller coil(s) above the condensing coils
- Halogen leak detection
- 100% to 125% freeboard
- EPDM or fluoroelastomer (depending on the Novec fluid being used) gaskets and non-threaded pipe fittings

For recommendations on equipment and materials for evaluation in your application, consult your 3M representative.

Freeboard (100% to 125%)

Extending the freeboard reduces fluid vapor losses. In most cases, the freeboard addition is fabricated of stainless steel sheet metal and bolted onto the existing freeboard. A bead of silicone caulking is placed between the existing freeboard and the added freeboard to ensure a tight seal. And, if not already present, a sliding cover should be added to the machine. Hinged covers and lift-off covers create a suction action when removed, which can increase the fluid and vapor loss.

Chiller coils

Chiller coils above the primary condenser coils will also reduce vapor losses. The refrigeration system must be capable of maintaining the chiller coils at a temperature of -20°F (-29°C). For optimum condensation, the chiller coils must be placed directly above the condensing coils. Depending upon ambient humidity, the chiller coils may require a defrost cycle to prevent formation of ice and a reduction in cooling efficiency.

EPDM seals and gaskets (for use with Novec fluids 7100, 7200 and 71IPA)

Fluoroelastomer seals and gaskets (for use with Novec fluids 71DA, 71DE, 72DA and 72DE)

Leakage is a source of potential fluid losses. The same properties that allow Novec fluids to penetrate tight spaces for optimum cleaning performance also allow them to escape vapor degreasers through microscopic cracks. Operators can reduce the potential for leaks by using EPDM or fluoroelastomer gaskets and seals.

Vapor degreasers, and other cleaning equipment utilizing Novec fluids, should avoid threaded pipe fittings as well to conserve fluid.

Programmable hoist system

High throughput rates can cause disturbances at the vapor/air interface that result in high vapor losses of Novec fluids. To counteract that, machine manufacturers recommend slower, controlled speeds for work entering and leaving the cleaner—typically less than 3 meters/min (10 ft/min).

Because of the difficulty of controlling these speeds manually, programmed hoists are the best option. These hoists can often be integrated with a motorized, sliding lid. The combination of these two components can help to reduce losses due to the “piston effect” or to sprayers disturbing the vapor blanket.

Halogen leak detection

Even when all these suggestions are employed, leakage can still occur. Halogen detectors effectively locate very small leaks in piping and pumps, and are recommended as part of your vapor degreaser maintenance equipment.

Widespread materials compatibility.

If a cleaning solvent is expected to perform at the highest level, it must be compatible with the parts being cleaned as well as with vapor degreasing machinery. To ensure that compatibility, 3M™ Novec™ Engineered Fluids have been tested with a wide variety of metals, plastics and elastomers.

3M™ Novec™ Engineered Fluids HFE-7100 and HFE-7200 were tested on the following substrates by exposing them for one hour at their boiling point, and are compatible.

Materials compatible with Novec Engineered Fluids in a “neat” cleaning process

Metal	Plastics	Elastomers
Aluminum	Acrylic	Butyl Rubber
Copper	Polyethylene	Natural Rubber
Carbon Steel	Polypropylene	Nitrile Rubber
302 Stainless Steel	Polycarbonate	EPDM
Brass	Polyester	
Zinc	Nylon	
Molybdenum	Epoxy	
Tantalum	PMMA	
Titanium	PVC	
Tungsten	PET	
Cu/Be Alloy C172	ABS	
Magnesium Alloy AZ31B		



Materials compatible with Novec Engineered Fluids in an azeotropic cleaning process

Metal	Plastics	Elastomers
Aluminum	Parts containing plastic materials should be evaluated for compatibility prior to cleaning with any Novec fluid azeotropes	Parts containing elastomeric materials should be evaluated for compatibility prior to cleaning with any Novec fluid azeotropes
Copper		
Carbon Steel		
302 Stainless Steel		
Brass		
Zinc		
Molybdenum		
Tantalum		
Titanium		
Tungsten		
Cu/Be Alloy C172		
Magnesium Alloy AZ31B		

The azeotropes, 3M™ Novec™ Engineered Fluids HFE-71DA, HFE-71DE, HFE-71IPA, HFE-72DA and HFE-72DE, need more scrutiny, especially when cleaning plastic or elastomeric parts, because their organic solvent components may not be compatible—depending on the material in question and the temperature and duration of exposure.

Technology for the human environment

Other safety benefits

Extensive toxicity testing has been conducted on Novec fluids. They are not irritating to the eyes or skin, and have tested negative in all mutagenicity screens. In addition, 3M offers technical assistance to help you determine worker exposure levels related to your cleaning process. And Novec fluids and their azeotropes are nonflammable, even when subjected to direct flame or electrical arcs.



Under normal conditions, workers are exposed to a small amount of cleaning solvent during their shift. Studies have shown that typical solvent concentrations in the operator breathing zone around properly functioning vapor degreasers are in the range of 5 to 50 ppm. The advantage of using 3M™ Novec™ Engineered Fluids is that their acceptable exposure limits are much higher than competitive cleaning fluids. Based on extensive toxicity testing, the 8-hour worker exposure guidelines for 3M™ Novec™ Engineered Fluids HFE-7100 and HFE-7200 are 750 ppm and 200 ppm, respectively. Other solvents, with low exposure limits, do not offer nearly this same margin of safety.

Safety/Toxicity	Exposure Guidelines, 8-hr. time-weighted avg. —ppm	Exposure Ceiling
Novec fluid HFE-7100	750	None
Novec fluid HFE-7200	200	None
Novec fluid HFE-71DA	750/200 ¹ /1000 ²	None
Novec fluid HFE-71DE	750/200 ¹	None
Novec fluid HFE-71IPA	750/400 ³	None
Novec fluid HFE-72DA	750/200/200 ¹ /1000 ²	None
Novec fluid HFE-72DE	750/200/200 ¹	None
CFC-113	1000	None
HCFC-141b	500	None
HFC-4310mee	200	400 ppm
HCFC-225ca/cb	50	None
nPB	≤25	Not Deter.

¹ *trans*-1,2-chloroethylene has an 8-hr. TWA exposure guideline of 200 ppm

² Ethanol has an 8-hr. TWA exposure guideline of 1000 ppm

³ Isopropyl alcohol has an 8-hr. TWA exposure guideline of 400 ppm

Designed with the future in mind.

Environmental and Regulatory

In today’s highly-regulated world, good performance simply isn’t enough. The need—driven by product stewardship, government regulations, worker concerns and consumer advocacy—is for safe, environmentally responsible chemistry. Good performance without responsible solutions is not an option.

3M™ Novec™ Engineered Fluids strike an ideal balance between performance and environmental issues. Zero ozone depletion potential and low global warming potential make Novec fluids a long-term, sustainable solution. When compared with other precision cleaning fluids, the environmental advantages are easy to see.

	Ozone Depletion Potential ¹ —ODP	Global Warming Potential ² —GWP	Atmospheric Lifetime—ALT (yrs)
Novec fluid HFE-7100	0.00	320	4.1
Novec fluid HFE-7200	0.00	55	0.8
Novec fluid HFE-71DA	0.00	170	4.1
Novec fluid HFE-71DE	0.00	160	4.1
Novec fluid HFE-71IPA	0.00	300	4.1
Novec fluid HFE-72DA	0.00	43	4.1
Novec fluid HFE-72DE	0.00	43	4.1
CFC-113	0.80	6000	85.0
HCFC-141b	0.10	700	9.2
HFC-4310mee	0.00	1700	17.1
AK-225	0.03	170/530	2.5/6.6
nPB	0.026	0.31	0.03

¹CFC-11 = 1.0 ²GWP—100 year Integration Time Horizon (ITH)

Regulatory agencies around the world have recognized the good environmental properties of Novec engineered fluids and approved their use in a wide variety of applications, including precision cleaning:

- Novec fluids have been accepted for commercial use by regulatory agencies in the United States, Canada, Japan, Korea, Australia, Europe (under the European List of Notified New Chemical Substances), the Philippines and China
- Novec fluids HFE-7100 and HFE-7200 have been approved without restrictions under the Significant New Alternatives Policy (SNAP) program of the U.S. EPA
- Novec fluids HFE-7100 and HFE-7200 have been excluded by the U.S. EPA from the definition of a volatile organic compound (VOC) on the basis that these compounds have a negligible contribution to tropospheric ozone formation
- Novec fluid HFE-7200 has received the Clean Air Solvent Certificate from the South Coast Air Quality Management District (SCAQMD)

Businesses that have converted or will convert from PFCs or HFCs to Novec fluid-based solutions should carefully track the resultant greenhouse gas emissions reductions. These reductions may offer flexibility and, perhaps, “credits” under a future regulatory scheme addressing the issue of global climate change.

Assistance from product to process.

At 3M, we provide our customers with extensive product and process support that begins even before you become a customer.

That support can take many forms, including help with equipment and process design, providing resources for safe product handling, used fluid return/disposal* and a host of other considerations.

3M products are supported by global technical and customer service resources. Users benefit from 3M's broad technology base and continuing attention to product development, performance, safety and environmental issues.

We make these cleaning fluids as easy to work with as possible. You can take advantage of our free Parts Cleaning Evaluation Service, or try 3M™ Novec™ Engineered Fluids yourself with our 30-Day Risk-Free Trial and Acceptance Program.

3M can help support your regulatory specialists with documentation required for regulatory compliance, and with reclamation or disposal—helping you accelerate process development and implementation, and deal with any product or process issues throughout the entire life cycle of the fluid. Although 3M does not provide reclamation/reprocessing of waste fluids from our customers, we can put you in contact with our approved service provider, Safety-Kleen, who can handle these arrangements for you.*

As manufacturers face increasingly stringent regulations in the future, this high level of support will become even more critical to your success. That's just one of the many ways Novec engineered fluids can give you a competitive edge. And another reason why we say 3M™ Novec™ Engineered Fluids are designed for the human environment.

*U.S. and Puerto Rico only. Contact your local 3M office for information about used fluid return programs in your region.

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Malaysia

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60 3 706 2888

Philippines

3M Philippines, Inc.
63 2 813 3781

Singapore

3M Singapore Pte. Ltd.
65 454 8611

Taiwan

3M Taiwan Limited
886 2 2704 9011

Other Areas

651 736 7123 (U.S.)

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