



Novec™

Brand

trans-dichloroethylene (t-DCE)

A safe, sustainable component in 3M™ Novec cleaning solutions

Introduction

3M™ Novec™ Engineered Fluids are nonflammable, non-ozone depleting, have very low global warming potentials, and provide a large margin of safety to help assure a safe working environment. Now in their third decade, Novec products have already made a substantial contribution in enabling users to dramatically reduce their emissions of ozone-depleting substances (ODSs), hazardous air pollutants (HAP), volatile organic compounds (VOCs)¹ and, at the same time, reduce their climate footprint.

Trans-dichloroethylene (t-DCE) (CAS No. 156-60-5) is a chlorinated solvent that is incorporated into several of the Novec engineered fluids used in precision cleaning applications. T-DCE is clearly differentiated from traditional chlorinated solvents such as trichloroethylene (TCE), perchloroethylene (PERC), and methylene chloride (MC), on the basis of human health and environmental properties. Also, testing has shown that t-DCE-containing Novec products remain stable in use, eliminating concerns found with TCE, MC, PERC, and n-propyl bromide (nPB). This differentiation has allowed t-DCE to be formulated with 3M Novec hydrofluoroether (HFE) chemistry to create a synergistic combination of properties. Azeotropic blends containing hydrofluoroethers and t-DCE utilize the most favorable properties of each of the components. For instance, t-DCE dramatically expands the range of cleaning power and the HFE components render the blends nonflammable² and more compatible in cleaning complex geometries.

¹ Novec 7100, 7200, 7300, and 7500 have been determined to have negligible photochemical activity and therefore classified as VOC-exempt per the US EPA under 40 CFR § 51.100(s).

² The blended fluids do not exhibit a closed-cup flash point.

This data sheet more fully details the human health, safety, and environmental properties of t-DCE and its HFE azeotropes, providing a clear differentiation from traditional chlorinated solvents and the basis for incorporating this chemistry under the umbrella of the Novec brand as safe, sustainable chemistry. These same properties also dictate a more favorable regulatory landscape for use of t-DCE relative to the chlorinated solvents controlled under the U.S. Federal NESHAP for halogenated solvent cleaning.

Table 1. t-DCE Physical/Chemical Properties

Material	Unit	t-DCE
Chemical Names		trans-1,2-dichloroethylene, t-dichloroethylene
Chemical Formula		C ₂ H ₂ Cl ₂
Boiling Point	°C (°F)	48 (118)
Freezing Point	°C (°F)	-49.4 (-56.9)
Molecular Weight	g/mol	96.95
Specific Gravity @ 25°C		1.27
Vapor Pressure @ 25°C	kPa	44.8

Table 2. Flammability Characteristics of 3M™ Novec™ Engineered Fluids containing t-DCE

Not for specification purposes.

Product	Novec 71DE	Novec 71DA	Novec 72DE	Novec 72DA	Novec 73DE
Nominal Composition	50% t-DCE 50% C ₄ F ₉ OCH ₃	44.6% t-DCE 57.2% C ₄ F ₉ OCH ₃ 2.7% Ethanol	70% t-DCE 10% C ₄ F ₉ OCH ₃ 20% C ₄ F ₉ OC ₂ H ₅	68% t-DCE 10% C ₄ F ₉ OCH ₃ 20% C ₄ F ₉ OC ₂ H ₅ 2% IPA	85% t-DCE, 15% C ₆ F ₁₃ OCH ₃
Flash Point (Closed-cup) ³	None	None	None	None	None
Flame Limits ⁴	None	5.1 – 12.7%	6.7 – 13.7%	5.9 – 14.5%	7.5-15%

³ Closed-cup flash point method (ASTM D3278-96e1, method e-1).⁴ Flame limit method (ASTM E681-15, per Annex A1, closed vessel test method for difficult to ignite materials).

Flammability Characteristics

T-DCE by itself is classified as a flammable liquid with a closed-cup flash point of 2°C (36°F). As outlined in Table 2, the azeotropic blends offered under the Novec brand that contain t-DCE are not classified as flammable liquids.⁵

t-DCE Safety Assessment

The safety profile of t-DCE has been well characterized over the past 25 years. Unlike other ODSs such as nPB*, the safety assessment of t-DCE has survived the test of time and additional scrutiny.⁶ The safety data produced since its introduction into the solvent cleaning market has solidified t-DCE as a safe, sustainable replacement for ODSs, HAPs like TCE, HFC-based substitutes and nPB.

The U.S. EPA website contains a wealth of information on the safety and environmental properties of t-DCE. Perhaps the most relevant study for assessing the safety of t-DCE in the work environment is the 90-day inhalation study conducted on rodents. This study is important in assessing the safety of t-DCE after repeated exposures, such as those experienced in the work environment. The study results indicate that no adverse health effects were observed in rats repeatedly exposed to 4000 ppm, the highest concentration used in the study. The no observable adverse effect level (NOAEL) of 4000 ppm supports the existing American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value(R) exposure guideline of 200 ppm (8 hour time weighted average [TWA]). With a 200 ppm exposure guideline, there is a large margin of safety between the exposure guideline and concentrations likely to be experienced in the workplace. The safety of t-DCE is a key

⁵ Although these blends do not display a closed cup flash point (and therefore are not a flammable liquid), for certain products, flammable air-vapor mixtures may form during use or in the event of a spill. Adequate ventilation must be provided to maintain vapor concentrations below the lower flammability limit, LFL. See SDS for details.

⁶ Regulation (EC) No 1005/2009.

Table 3: Comparison of Solvent Workplace Exposure Guidelines

Not for specification purposes.

Chemical	Repeat Dose NOAEL (ppm)	Exposure Guideline 8 hr. TWA (ppm)
trans-dichloroethylene	4,000 (rat)	200 (ACGIH)
trichloroethylene	400 (rat)	10 (ACGIH)
perchloroethylene	300 (mice)	25 (ACGIH)
methylene chloride	200 (rat)	25 (OSHA)
n-propyl bromide	<100 (rat)	0.1-5*

* The State of California recommends an exposure guideline at 5 ppm. The American Conference of Governmental Industrial Hygienists recommends a TLV(R) of 0.1 ppm

differentiator relative to other solvents. Table 3 provides a convenient comparison of exposure guidelines for some of the traditionally used solvents.

T-DCE provides a margin of safety at an order of magnitude larger than these other chlorinated solvents. Use of organic vapor monitors has been validated as a means of assessing workplace air concentrations to Novec blends containing 3M™ Novec™ 7100 Engineered Fluid, 3M™ Novec™ 7200 Engineered Fluid, 3M™ Novec™ 7300 Engineered Fluid, and t-DCE. Information regarding the monitors is available through 3M upon request.

Environmental Considerations

Because t-DCE is short-lived in the atmosphere, it has a minimal impact on either stratospheric ozone or global climate change. Much like traditional chlorinated/brominated solvents, t-DCE is not exempt from the definitions of a VOC and will enter into reactions that contribute to the formation of photochemical smog. Novec products have been designed to minimize overall impact on the environment.

As is the case with any industrial solvent, management practices and operating conditions should be established to minimize emissions to the environment and prevent any contamination of soil and water.

The commercialization of Novec products containing t-DCE has been instrumental in enabling 3M customers to achieve reductions in their use and emissions of ozone depleting substances, compounds with high global warming potential and hazardous air pollutants.

Regulatory Considerations

Clearly the differentiated Environmental Health and Safety (EHS) profile of t-DCE is an important consideration for the regulations that address use and emissions in the solvent markets. Unlike methylene chloride, perchloroethylene or trichloroethylene, t-DCE is not regulated under U.S. regulation 40 CFR Part 63 – Subpart T – National Emission Standards for Halogenated Solvent Cleaning (<https://www.epa.gov/stationary-sources-air-pollution/halogenated-solvent-cleaning-national-emission-standards-hazardou-0>).

This is a very important distinction for t-DCE. Decisions related to solvent selection need to be careful not to paint all chlorinated solvents with the same broad brush. T-DCE is unique among chlorinated solvents in its EHS properties, and those unique characteristics generate a more favorable regulatory landscape for the sustainable use of t-DCE in precision cleaning.

T-DCE has also been reviewed and approved by the U.S. EPA Significant New Alternatives Policy Program (SNAP) as an acceptable substitute for ozone depleting substances. In fact, azeotropes of t-DCE and HFEs have had a dramatic impact on enabling the transition away from solvents that deplete stratospheric ozone.

Acid Stability and Materials Compatibility of 3M™ Novec™ Engineered Fluids Containing t-DCE

Unlike many of the chlorinated and brominated solvents already mentioned, the Novec azeotropes of hydrofluoroethers with t-DCE do not significantly decompose during normal operation in vapor degreasers. Furthermore, testing in 3M's laboratories shows no sign of acid formation or consumption of acid absorbers even when the materials are refluxed for over a month while

loaded with large amounts of pulverized aluminum alloys that are commonly used in aerospace applications.

The Novec fluid and t-DCE azeotropes have successfully replaced chlorinated, brominated, and hydrocarbon solvents as well as aqueous cleaning systems in industrial, military, aerospace, medical, optics and electronics markets. These azeotropes are effective cleaning solvents for cutting oils, greases, wax and RMA solder fluxes. They have shown excellent compatibility with most substrates in these industries, with comparable cleaning performance equivalent to solvents such as TCE, nPB and MC. Table 4 shows test results performed by an independent test laboratory, Scientific Materials International, demonstrating the compatibility of the Novec fluid azeotropes with a variety of aerospace materials. Table 5 highlights the physical properties of some of the Novec cleaning solutions.

Table 4. 3M™ Novec™ 71DE, 72DE, 72DA and 73DE Fluids have been tested to and conform to the requirements of the following ASTM tests:

Effect on Painted Surfaces (ASTM F502)

Residue Test (ASTM F485)

Sandwich Corrosion Test (ASTM F1110)

Cadmium Removal Test (ASTM F483)

Hydrogen Embrittlement (ASTM F519, 1C)

Low-Embrit. Cadmium Plate (ASTM F1111)

Immersion Corrosion Test (ASTM F483)

Stress Corrosion (modified) (ASTM D945)

Table 5: Properties of 3M™ Novec™ Engineered Fluids and Novec blends containing t-DCE

Not for specification purposes.

	Novec 7100	Novec 7200	Novec 71IPA	Novec 71DE	Novec 71DA	Novec 72DE	Novec 72DA	Novec 73DE
Boiling Point, °C	61	76	55	41	40	43	44	48
Density, g/mL	1.52	1.43	1.48	1.37	1.33	1.28	1.27	1.28
Surface Tension, dynes/cm	13.6	13.6	14.5	16.6	16.4	19	18	20
Viscosity, cP	0.61	0.61	0.75	0.45	0.45	0.45	0.40	0.38

The Novec Brand Promise

One commonality throughout all these applications is the promise of the Novec brand. These products have been qualified into these applications with the confidence that accompanies a technology designed to be a long-term answer: a safe, sustainable solution that allows our customers to meet their solvent needs while minimizing their footprint on the environment. Visit 3M.com/NovecCleaning for more information regarding Novec Engineered Fluids.

Smart. Safe. Sustainable.

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of proprietary 3M products. Although each has its own unique formula and performance properties, all Novec products are designed in common to address the need for smart, safe and sustainable solutions in industry-specific applications. These include precision and electronics cleaning, heat transfer, fire protection, protective coatings, immersion cooling, advanced insulation media replacement solutions and several specialty chemical applications.

3M™ Novec™ Engineered Fluids • 3M™ Novec™ Aerosol Cleaners • 3M™ Novec™ 1230 Fire Protection Fluid • 3M™ Novec™ Electronic Grade Coatings • 3M™ Novec™ Insulating Gases

Safety Data Sheet: Consult Safety Data Sheet before use.

Regulatory: For regulatory information about this product, contact your 3M representative.

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Electronics Materials Solutions Division

3M Center, Building 224-3N-11
St. Paul, MN 55144-1000 USA

Web 3M.com/NovecCleaning
Phone 1-800-810-8513

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