

trans-dichloroethylene (trans DCE)

A safe, sustainable component in Novec cleaning solutions

3M™ Novec™ branded products 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 second decade, the Novec branded products have already made a substantial contribution in enabling users to dramatically reduce their emissions of ozone-depleting substances (ODSs), air toxins, volatile organic compounds (VOCs) and, at the same time, reduce their climate footprint.

Trans DCE is a chlorinated solvent that is incorporated into several of the Novec engineered fluids used in precision cleaning applications. Trans DCE is clearly differentiated from traditional chlorinated solvents such as trichloroethylene (TCE), perchloroethylene, and methylene chloride, on the basis of human health and environmental properties. Also, testing has shown that Novec products with trans DCE remain stable in use, eliminating the compatibility concerns found with TCE, MeCl, Perc and nPb. This differentiation has allowed trans DCE to be formulated with 3M™ Novec™ branded hydrofluoroether chemistry to create a synergistic combination of properties. Azeotropic blends containing hydrofluoroethers (HFE) and trans DCE exploit the most favorable properties of each of the components. For instance, trans DCE dramatically expands the range of cleaning power and the HFE component renders the blends nonflammable and more compatible in cleaning complex geometries.

This data sheet more fully details the human health, safety, and environmental properties of trans 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 trans DCE relative to the chlorinated solvents controlled under the Federal NESHAP for halogenated solvent cleaning.

Table 1. trans DCE Physical/Chemical Properties

	Unit	trans DCE
Chemical Names		trans-1,2 DCE; 1,2 dichloroethene, trans-1,2 dichloroethylene
Chemical Formula		CClHCClH
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
Pounds per Gallon at 20°C (68°F)	lbs/gal	10.53
Vapor Pressure	@ 25°C mm Hg	336
	@ 87°F mm Hg	400

Flammability Characteristics

Trans DCE by itself is a flammable liquid with a flash point of 2°C (36°F). As outlined in Table 2, the azeotropic blends sold under the Novec brand are nonflammable. Because these Novec products are azeotropic blends, maintaining a constant composition at the boiling point, the nonflammable characteristics are preserved throughout the use of the product.

Table 2. Flammability Characteristics of trans DCE/HFE Azeotropes

Product	Novec 71DE	Novec 71DA	Novec 72DE	Novec 72DA
Composition	50% trans DCE 50% C ₄ F ₉ OCH ₃	44.6% trans DCE 57.2% C ₄ F ₉ OCH ₃ 2.7% Ethanol	70% trans DCE 10% C ₄ F ₉ OCH ₃ 20% C ₄ F ₉ OC ₂ H ₅	68% trans DCE 10% C ₄ F ₉ OCH ₃ 20% C ₄ F ₉ OC ₂ H ₅ 2% IPA
Flash Point	None	None	None	None
Flame Limits	None	5.1 – 12.7%	6.7 – 13.7%	5.9 – 14.5%

trans DCE Safety Assessment

The safety profile of trans DCE has been well characterized over the past 15 years. Unlike other ODSs such as n-propyl bromide (nPB), the safety assessment of trans DCE has survived the test of time and additional scrutiny. The safety data produced since its introduction into the solvent cleaning market has solidified trans DCE as a safe, sustainable replacement for ODSs, hazardous air pollutants, HFC-based substitutes and nPB. Robust summaries of the human health and environmental studies conducted on trans DCE have been submitted to the U.S. EPA High Production Volume (HPV) Challenge Program and can be reviewed at <http://www.epa.gov/hpv/pubs/summaries/trnsdcl/c14348tc.htm>.

The U.S. EPA website contains a wealth of information on the safety and environmental properties of trans DCE. Perhaps the most relevant study for assessing the safety of trans DCE in the work environment is the 90-day inhalation study conducted on rodents. This study is important in assessing the safety of trans 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 ACGIH exposure guideline of 200 ppm (8 hr 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 trans DCE is a key differentiator relative to other solvents. Table 3 provides a convenient comparison of exposure guidelines for some of the traditionally used solvents.

Table 3: Comparison of Solvent Workplace Exposure Guidelines

Product	Repeat Dose NOAEL (ppm)	8 hr. TWA (ppm)
trans DCE	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)	5-10 *

* The State of California recommends an exposure guideline at 5 ppm. The American Conference of Governmental Industrial Hygienists recommends an EG at 10 ppm.

Trans DCE provides a margin of safety 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™ Engineered Fluids 7100, Novec 7200, and trans DCE. Information regarding the monitors is available through 3M upon request.

Environmental Considerations

Because trans DCE is short-lived in the atmosphere, it has an inconsequential impact on either stratospheric ozone or global climate change. Much like traditional chlorinated/brominated solvents, trans 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 branded products containing trans DCE has been instrumental in enabling 3M customers to achieve substantial reductions in their use and emissions of ozone depleting substances, compounds with high global warming potential and air toxins.

Regulatory Considerations

Clearly the differentiated Environmental Health and Safety (EHS) profile of trans DCE is an important consideration for the regulations that address use and emissions in the solvent markets. Unlike methylene chloride, perchloroethylene or trichloroethylene, trans DCE is not regulated under 40 CFR Part 63 – Subpart T – National Emission Standards for Halogenated Solvent Cleaning (<http://www.epa.gov/ttn/atw/degrea/fr03my07.pdf>).

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

Trans 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 trans 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 Novec Fluids Containing trans DCE

Unlike chlorinated and brominated solvents, the Novec azeotropes of hydrofluoroethers with trans DCE do not decompose during operation in vapor degreasers. In the 15+ year history of these blends, there is no evidence of vapor degreasers “going acid.” 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.

This is an important factor that separates Novec azeotropic blends containing trans DCE from other chlorinated (TCE, 1,1,1-TCA) and brominated (nPB) solvents. There is no need to passivate cleaning baths or add stabilizer packages to prevent corrosion in the cleaning equipment or on the parts being cleaned. Only a few current Novec users test their cleaning systems for acid acceptance.

The trans 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 cleaning performance equal to solvents such as TCE, nPB and MeCl. Table 4 shows test results performed by an independent test laboratory, Scientific Materials International, demonstrating the compatibility of the Novec 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 and 72DA have been tested to and conform to the requirements of the following ASTM tests:

Effect on Painted Surfaces (ASTM F502)	Cadmium Removal Test (ASTM F483)	Flash Point (ASTM D56)
Residue Test (ASTM F485)	Hydrogen Embrittlement (ASTM F519, 1C)	Immersion Corrosion Test (ASTM F483)
Sandwich Corrosion Test (ASTM F1110)	Low-Embrit. Cadmium Plate (ASTM F1111)	Stress Corrosion (modified) (ASTM D945)

Table 5: Physical Properties of 3M™ Novec™ 7100, 7200 and Azeotropes with trans-dichloroethylene

	Novec 7100	Novec 7200	Novec 71IPA	Novec 71DE	Novec 71DA	Novec 72DE	Novec 72DA
Boiling Point, °C	61	76	55	41	40	43	44
Density, g/ml	1.52	1.43	1.48	1.37	1.33	1.28	1.27
Surface Tension, dynes/cm	13.6	13.6	14.5	16.6	16.4	19	18
Viscosity, cps	0.61	0.61	0.75	0.45	0.45	0.45	0.4
Wetting Index, lbs	183	172	136	183	180	150	176
Heat of Vaporization, cal/g @ b.p.	30	30	39.5	48	50	52	60
LSHC	9	12	10	15	14	22	22
KB Value	10	10	–	27	33	52	58
Silicone Oil	Immiscible	Immiscible	<0.1%	Miscible	Miscible	Miscible	Miscible
Mineral Oil	Immiscible	–	<0.5%	16%	16%	–	–
Skydrol®	Immiscible	–	–	Miscible	–	Miscible	–
RA Flux	Co-Solvent	–	Co-Solvent	–	Good	Good	Excellent
RMA Flux	Co-Solvent	–	Co-Solvent	–	Good	–	Excellent
No Clean Flux	Co-Solvent	–	Co-Solvent	–	–	–	Good

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 www.3M.com/Novec for more information regarding Novec Engineered Fluids.

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 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

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