

3M™ Novec™ 7700 Engineered Fluid

A unique heat transfer fluid with favorable environmental properties

Introduction

3M™ Novec™ 7700 Engineered Fluid is a nonflammable fluid with very low global warming potential for use in heat transfer applications. Novec 7700 fluid shares many of the inerting and dielectric properties of perfluorocarbons (PFCs) and perfluoropolyethers (PFPEs), and is a viable option for replacing them in a wide array of applications.

Semiconductor

This engineered fluid can be used in cooling of ion implanters, dry etchers and CVD machines in semiconductor and flat panel display manufacturing facilities.

Test Equipment

The fluid can be used to cool semiconductor thermal shock and test equipment.

Electronic Cooling

Because Novec 7700 fluid is compatible with most electronic components, it can be used in direct contact cooling of supercomputers and sensitive military electronics, and to cool high voltage transformers and power electronics.

Industrial/Pharmaceutical

Novec 7700 fluid is not manufactured under Good Manufacturing Practices (GMP) but it may be used as an alternative to commonly used fluids in pharmaceutical and chemical manufacturing processes, such as freeze drying and reactor cooling, where the fluid is completely removed from the device, equipment or product prior to the regulated use.*

The primary advantage of Novec 7700 fluid over a comparable PFC or PFPE, however, is reduced Global Warming Potential (GWP). Novec 7700 fluid has been developed as a low-GWP alternative to perfluorocarbon and perfluoropolyether heat transfer liquids.

Novec 7700 fluid is non-ozone-depleting and has been exempted from the U.S. EPA definition of a volatile organic compound (VOC) because it does not contribute to the formation of photochemical smog.

*See the 3M EMMD Medical Device Policy on page six of this document.

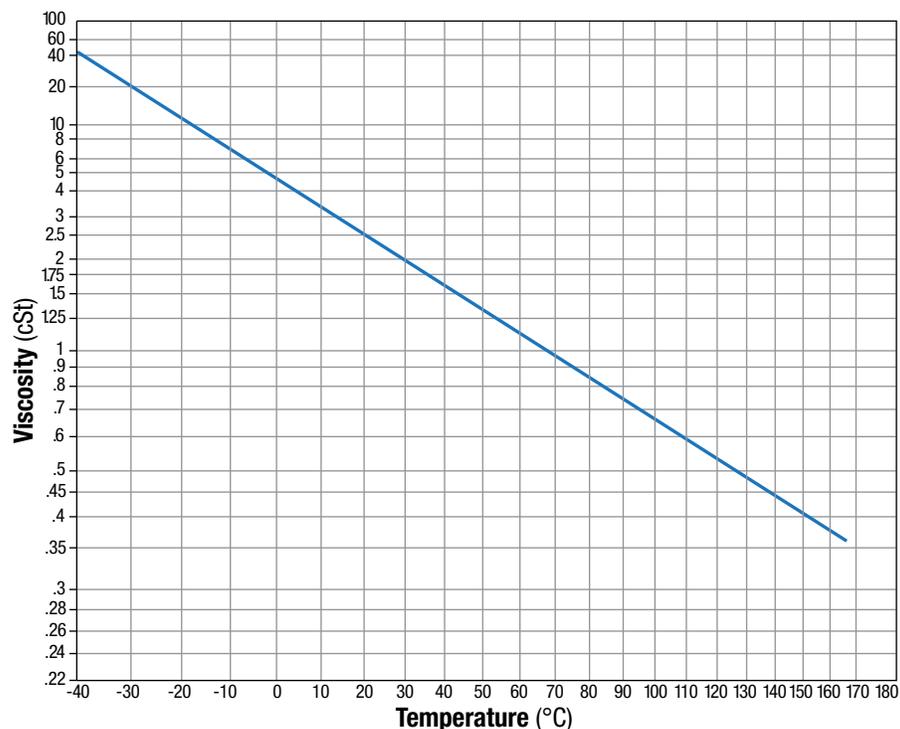
Not for specification purposes. All values @ 25°C unless otherwise specified.

Typical Physical Properties

Not for specification purposes. All values @ 25°C unless otherwise specified.

Properties	3M™ Novec™ 7700 Engineered Fluid
Boiling Point @ 1 atm	167°C (333°F)
Pour Point	-50°C (-58°F)
Molecular Weight	528
Liquid Density	1797 kg/m ³
Coefficient of Expansion	0.00111 K ⁻¹
Latent Heat of Vaporization @ 1 atm	83.4 kJ/kg
Vapor Pressure	<0.1 kPa
Surface Tension	18 dynes/cm
Viscosity	2.5 cSt
Critical Temperature	290°C (554°F)
Critical Pressure	1.41 MPa
Solubility of Fluid in Water	<1 ppb by weight
Dielectric Strength	35 kV, 0.1" gap
Volume Resistivity	5 × 10 ¹¹ ohm-cm
Dielectric Constant	6.7
Flammability	Nonflammable
GWP	420

3M™ Novec™ 7700 Engineered Fluid Kinematic Viscosity



To determine the viscosity at a given temperature T in Kelvin, calculate

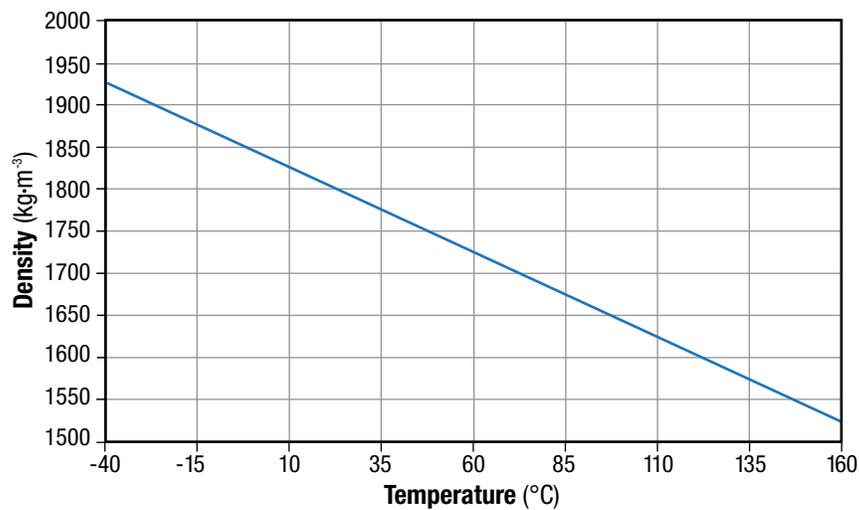
$$Z = 10^{(10^{(11.930 - 4.944 \cdot \log(T[K]))})}$$

$$\text{Then, Viscosity [cSt]} = (Z - 0.7) - \exp(-0.7487 - 3.295(Z - 0.7) + 0.6119(Z - 0.7)^2 - 0.3193(Z - 0.7)^3)$$

Typical Physical Properties

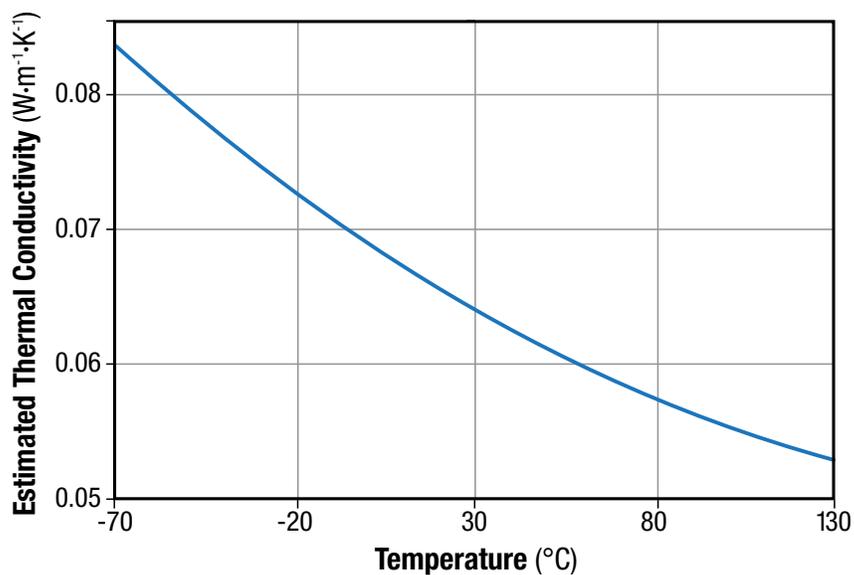
Not for specification purposes. All values @ 25°C unless otherwise specified.

3M™ Novec™ 7700 Engineered Fluid Liquid Density

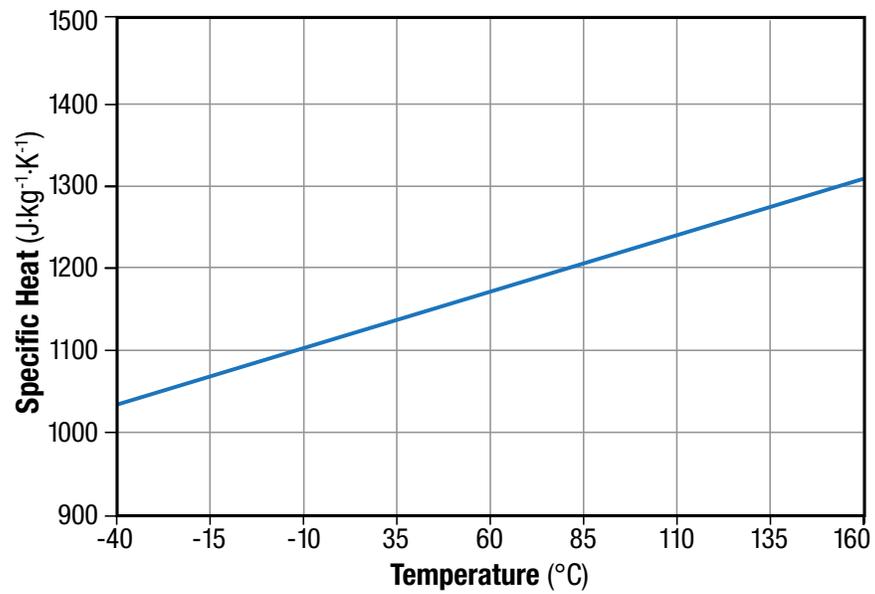


$$\text{Liquid Density [kg/m}^3\text{]} = -2.008 \cdot T[\text{°C}] + 1847.5$$

3M™ Novec™ 7700 Engineered Fluid Estimated Thermal Conductivity



$$\text{Thermal Conductivity [W/m-K]} = 0.069 - 1.798\text{E-}04 \cdot T[\text{°C}] + 4.24\text{E-}07 \cdot T[\text{°C}]^2$$

3M™ Novec™ 7700 Engineered Fluid Liquid Specific Heat

$$\text{Liquid Specific Heat [J/kg-K]} = 1.370 \cdot T(^{\circ}\text{C}) + 991$$

Toxicity Profile

Not for specification purposes.

The toxicological testing completed on 3M™ Novec™ 7700 Engineered Fluid indicates very low overall toxicity. The material is minimally irritating to the skin and eyes and tested negative in two mutagenicity screens. In a 28-day oral toxicity study no adverse effects were observed at 1000 mg per kg body weight.

Toxicological Test Results

Properties	3M™ Novec™ 7700 Engineered Fluid
Acute Oral Toxicity (LD50)	>2000 mg/kg
Acute Inhalation Toxicity (Vapor Saturation Concentration ~ 1,000 ppm)	NOAEL >100 ppm* (6 hour/day for 5 days)
28-Day Oral Toxicity	NOAEL 1000 mg/kg-d*
Reproductive and Development Toxicity	NOAEL 1000 mg/kg-d*

* Highest dose tested

Environmental Properties

Properties	3M™ Novec™ 7700 Engineered Fluid
Ozone Depletion Potential ¹ (ODP)	0.0
Global Warming Potential ² (GWP)	420
Atmospheric Lifetime (years)	5.6
Volatile Organic Compound (VOC)	No

¹ CFC-11 = 1.0

² GWP = pounds equivalent CO₂, 100-year integrated time horizon (ITH), IPCC 2001 method.

Environmental, Health and Safety

Before using this product, please read the current product Safety Data Sheet (available through your 3M sales or technical service representative) and the precautionary statement on the product package. Follow all applicable precautions and directions. 3M™ Novec™ 7700 Engineered Fluid is nonflammable and does not exhibit flammability characteristics under normal operation and storage conditions. The fluid is resistant to thermal breakdown and hydrolysis during storage and use. Recommended handling procedures are provided in the Safety Data Sheet, which is available from your local 3M representative upon request.

Materials Compatibility

In practice, engineered fluids differ somewhat from PFCs and PFPEs in their ability to dissolve certain oils. This means that Novec 7700 fluid is more likely to extract plasticizers from elastomeric materials. For this reason, elastomeric O-ring and seal materials should be limited to those that contain a low amount of plasticizer. EPDM, EPR and butyl typically fall into this category. 3M engineers can suggest appropriate compounds or assist with test procedures.

Heater Selection

The critical heat flux of Novec 7700 fluid was found to be 18 W/cm² when boiling from a horizontal 0.5 mm diameter platinum wire in a quiescent pool of saturated fluid. The maximum heat flux obtainable in forced convection applications is significantly higher, but depends strongly upon the geometry and flow conditions. A safety interlock between the pump and heater is strongly recommended in applications with heat fluxes exceeding 15 W/cm².

Regulatory Status

The components of this product are in compliance with the chemical notification requirements of the United States (TSCA). Novec 7700 fluid is not acceptable for commercial sale in Japan. Certain restrictions apply. Contact the selling division for additional information.

Contact your local 3M representative regarding the regulatory status of Novec 7700 fluid in other countries.

3M EMMD Medical Device Policy

3M™ Novec™ Engineered Fluids are intended for use as process solvents in applications, such as cleaning and coating, that historically used CFCs and HCFCs. They are not intended, nor approved, for incorporation into medical devices or for use in pharmaceuticals. 3M will not support applications that involve temporary or permanent implantation of the Novec engineered fluid.

Contact your 3M representative for the complete statement of 3M Electronic Markets Materials Division's Global Policy regarding the sale and use of products for medical and pharmaceutical applications.

Recycle and Disposal Options

Used Fluid Return Program

3M offers a program for free* pickup and return of used 3M specialty fluids in the U.S. through Safety-Kleen Corp. A pre-negotiated handling agreement between users and Safety-Kleen offers users protection against future liability for used 3M product. The fluid return program is covered by independent third-party financial and environmental audits of treatment, storage and disposal facilities. Necessary documentation is provided. A minimum of 30 gallons of used 3M specialty fluid is required for participation in this free program.*

Safety-Kleen Corp. has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen at this toll-free line: 1.888.932.2731. Contact your local 3M representative for fluid return programs outside the U.S.

* Must have a 30 or more gallon purchase to participate in the 3M paid program. Used product of 5-30 gallons can be returned through Safety-Kleen at the user's expense.

For Additional Information

To request additional product information or sales assistance, contact 3M Customer Service at one of the numbers below or visit www.3M.com/Novec. For other 3M global offices or information on other 3M products for electronics, visit our website at 3M.com/electronics.

Resources

3M™ Engineered Fluids are supported by global sales, technical and customer service resources, with fully-staffed 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.

For additional technical information on 3M™ Novec™ 7700 Engineered Fluid in the United States, call 3M Customer Service, **800.810.8513**.

For information on additional 3M fluids, coatings and other chemical products for the electronics industry, visit our web site at: www.3M.com/novec.

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, 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™ Electronic Surfactants • 3M™ Novec™ Dielectric Fluids

United States	China	Europe	Japan	Korea	Singapore	Taiwan
3M Electronics Materials Solutions Division 800 810 8513	3M China Ltd. 86 21 6275 3535	3M Belgium N.V. 32 3 250 7521	3M Japan Limited 81 3 6409 3800	3M Korea Limited 82 2 3771 4114	3M Singapore Pte. Ltd. 65 64508888	3M Taiwan Limited 886 2 2704 9011

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

Technical Information: The technical information, recommendations and other statements contained in this document are based upon tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed.

Product Use: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. Given the variety of factors that can affect the use and performance of a 3M product, user is solely responsible for evaluating the 3M product and determining whether it is fit for a particular purpose and suitable for user's method of application.

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Electronics Materials Solutions Division

3M Center, Building 224-3N-11
St. Paul, MN 55144-1000
www.3M.com/novec
1-800-810-8513

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