

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.

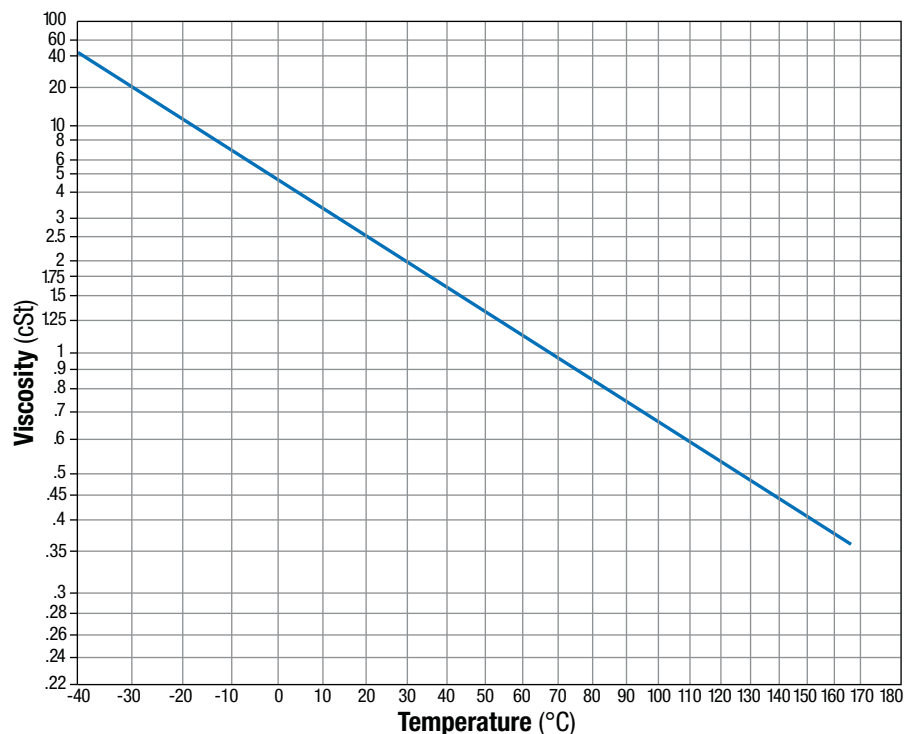
Not for specification purposes. All values @ 25°C unless otherwise specified.

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

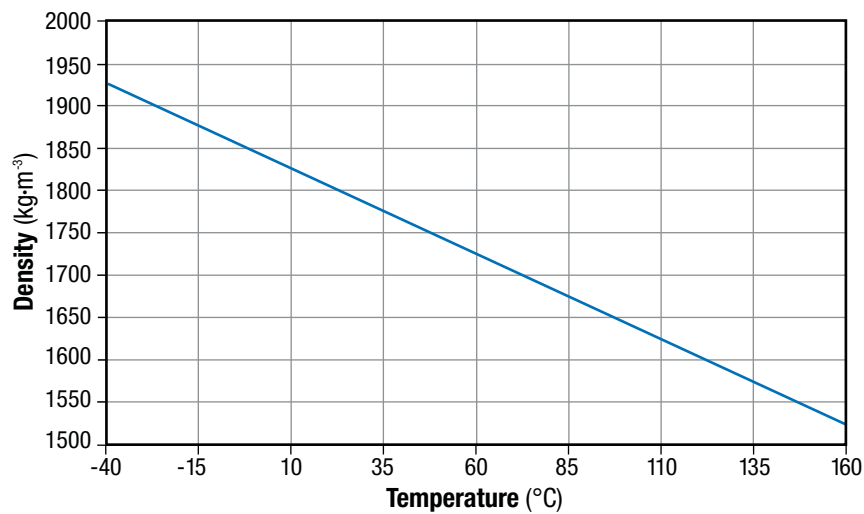
$$Z = 10^{(10^{(11.930 - 4.944 \cdot \log(T[K]))})}$$

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

Typical Physical Properties

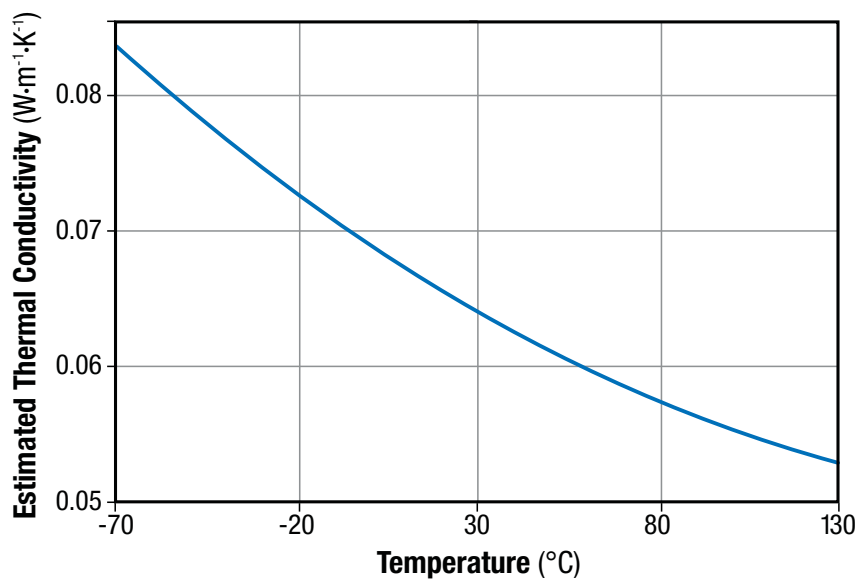
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3M™ Novec™ 7700 Engineered Fluid Liquid Density

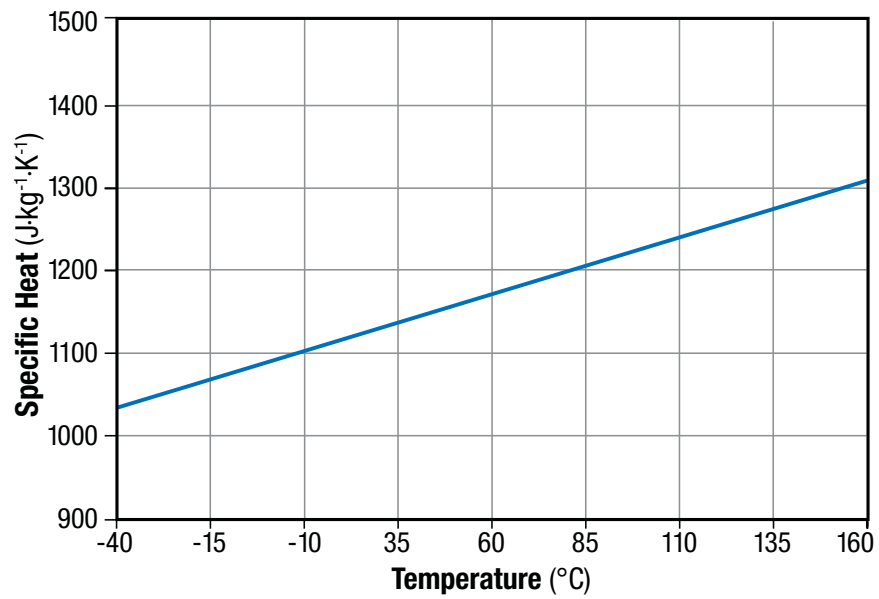


$$\text{Liquid Density [kg/m}^3\text{]} = -2.008 \cdot T[\text{°C}] + 1847.5$$

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.