

3M™ Novec™ 7000 Engineered Fluid

Introduction

3M™ Novec™ 7000 Engineered Fluid, 1-methoxyheptafluoropropane, is a nonflammable, low global warming potential (GWP) heat transfer fluid capable of reaching -120°C. It is also useful as a direct expansion refrigerant.

Applications

- Semiconductor
 - Ion implanters
 - Dry etchers
 - CVD/PVD tools
 - Electronic Automated Test Equipment (ATE)
- Industrial/Pharmaceutical
 - Chemical reactors
 - Freeze dryers
 - VOC capture
- Fuel cells
- Electronic Cooling
 - Supercomputers
 - Sensitive military electronics
 - High voltage transformers
- Electronics
 - Reliability testing
 - Temperature calibration
- Autocascade refrigeration
 - HCFC-123 replacement

Benefits

- Low GWP (370, 100-year ITH)
- Excellent dielectric properties
 - In event of leakage or other failure, will not damage electronic equipment
- Zero ozone depletion potential (ODP)
- Good materials compatibility
- Low toxicity
- Nonflammable
- Non-corrosive
- Good thermal stability
- Useful at extreme low temperatures
 - Viscosity is less than 20 cSt at -120°C

Material Description

| Ingredients | Novec™ 7000 Engineered Fluid |
|---|------------------------------|
| Methoxy-nonafluorobutane (C ₄ F ₉ OCH ₃) ¹ | 99.5% by weight |
| Appearance | 20% by weight |
| Non-volatile residue (NVR) | 1.0 ppm maximum |

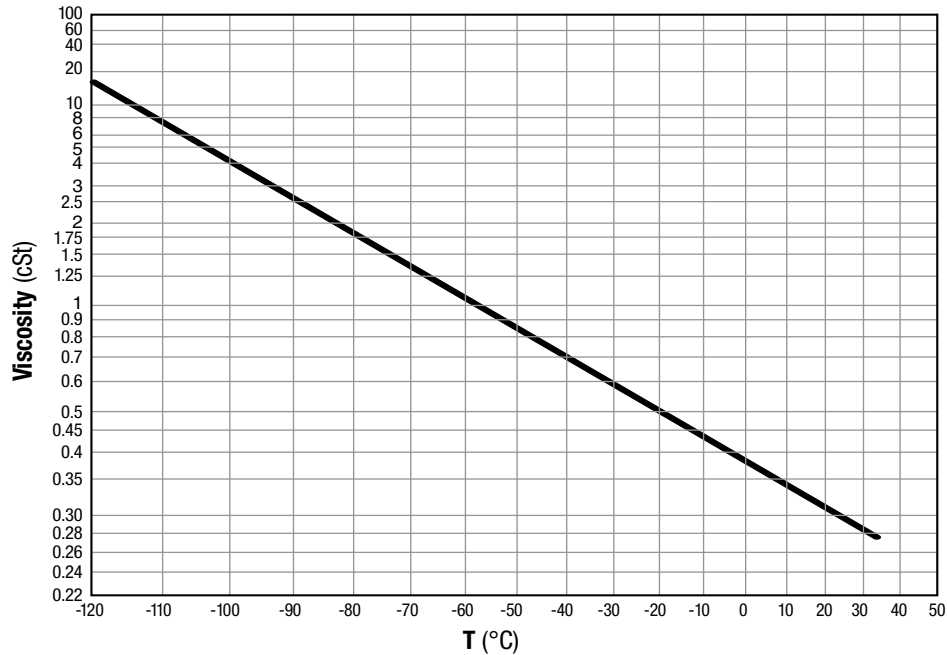
¹Novec 7100 fluid (C₄F₉OCH₃) consists of two inseparable isomers with essentially identical properties. These are (CF₃)₂CFCF₂OCH₃ (CAS No. 163702-08-7) and CF₃CF₂CF₂CF₂OCH₃ (CAS No. 163702-07-6).

Typical Physical Properties

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

| Properties | 3M™ Novec™ 7000 Engineered Fluid |
|--|----------------------------------|
| Molecular Weight (g/mol) | 200 |
| Boiling Point @ 1 atmosphere (°C) | 34 |
| Freeze Point (°C) | -122.5 |
| Liquid Density (kg/m ³) | 1400 |
| Kinematic Viscosity (cSt) | 0.32 |
| Kinematic Viscosity @ -80°C (cSt) | 2.0 |
| Kinematic Viscosity @ -120°C (cSt) | 17 |
| Coefficient of Expansion | 0.00219 K ⁻¹ |
| Critical Density (kg/m ³) | 553 |
| Critical Pressure (MPa) | 2.48 |
| Critical Temperature (°C) | 165°C |
| Dielectric Constant | 7.4 |
| Dielectric Strength (kV) | ~40 |
| Latent Heat of Vaporization (kJ/kg) | 142 |
| Solubility of water in fluid (ppmw) | ~60 |
| Solubility of air in fluid (vol %) | ~35 |
| Specific Heat (J·kg ⁻¹ ·K ⁻¹) | 1300 |
| Surface Tension (dynes/cm) | 12.4 |
| Thermal Conductivity (W·m ⁻¹ ·K ⁻¹) | 0.075 |
| Vapor Pressure (kPa) | 64.6 |
| Volume Resistivity (ohm-cm) | 108 |

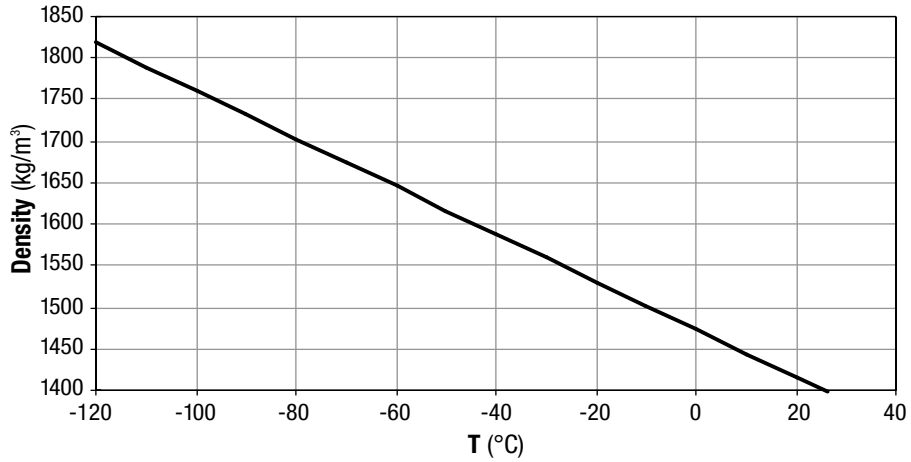
Novec 7000 Kinematic Viscosity



Typical Physical Properties (continued)

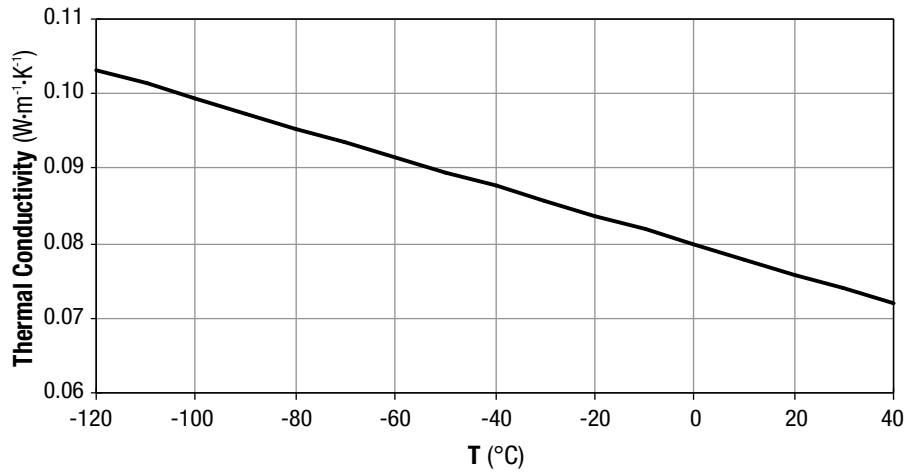
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Novec 7000 Liquid Density



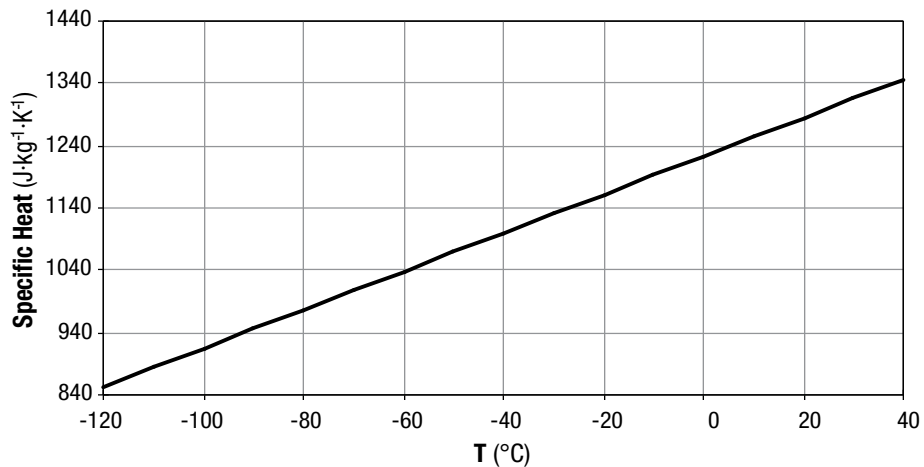
$$\text{Liquid Density [kg/m}^3\text{]} = 1472.6 - 2.880 \cdot T(^{\circ}\text{C})$$

Novec 7000 Thermal Conductivity



$$\text{Thermal Conductivity [W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}\text{]} = 0.0798 - 0.000196 \cdot T(^{\circ}\text{C})$$

Novec 7000 Liquid Specific Heat



$$\text{Liquid Specific Heat [J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}\text{]} = 1223.2 + 3.0803 \cdot T(^{\circ}\text{C})$$

Novec 7000 Vapor Pressure

$$\ln(P[\text{Pa}]) = -3548.6/T[\text{K}] + 22.978$$

$$-30^{\circ}\text{C} < T < T_c$$

Toxicity Profile

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

The toxicological testing completed on 3M™ Novec™ 7000 Engineered Fluid indicates low acute and sub-acute toxicity. A 28-day inhalation study conducted at 1000, 10,000 and 30,000 ppm helped establish an exposure guideline of 75 ppmv for an average 8 hour work day. The No Adverse Effect Level (NOAEL) in this study was 1000 ppm. This data suggests there is a large margin of safety for use of this fluid in relatively non-emissive heat transfer systems.

Toxicological Test Results

| Properties | Novec™ 7000 Engineered Fluid |
|--|--------------------------------|
| Acute Lethal Concentration (ppmv) | >30,000 |
| 8 hr Exposure Guideline (ppmv) | 75 |
| Skin Irritation | Negative ¹ |
| Mutagenicity | Negative ¹ |
| Ecotoxicity (water solubility < 2.5 ppb) | Very low aquatic toxicity |
| Acute Oral Toxicity | LD50 > 2000 mg/kg ¹ |
| 28-day Inhalation | NOAEL=1000 ppm |

¹ A. Sekiya and S. Misaki, "The potential of hydrofluoroethers to replace CFCs, HCFCs and PFCs" J. of Fluorine Chemistry, 101, 2000, pp. 215-221.

Environmental Properties

| Properties | Novec™ 7000 Engineered Fluid |
|--|------------------------------|
| Ozone Depletion Potential ¹ (ODP) | 0.0 |
| Global Warming Potential ² (GWP) | 370 |
| Atmospheric Lifetime (years) | 4.9 |
| Flash Point | None |

¹ CFC-11 = 1.0

² GWP 100-year integrated time horizon (ITH)

Environmental, Health and Safety

Before using this product, please read the current product Material 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™ 7000 Engineered Fluid is nonflammable. The fluid is resistant to thermal breakdown and hydrolysis during storage and use. Recommended handling procedures are provided in the Material Safety Data Sheet, which is available from your local 3M representative upon request.

Materials Compatibility

Novec 7000 fluid is compatible with most metals and hard polymers such as:

| Metals | Plastics |
|-----------------|---------------|
| Stainless Steel | Polypropylene |
| Brass | Polyethylene |
| Copper | Nylon |
| Aluminum | Polyacetyl |
| | PEEK |
| | PTFE |

Elastomeric materials should be limited to those compounds that contain the least amount of extractible plasticizer. 3M engineers can suggest appropriate compounds or assist with test procedures.

Heater Selection

The critical heat flux of Novec 7000 fluid is 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 will be 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

Novec 7000 fluid is available for commercial sale in the United States, China, Malaysia, Singapore and Taiwan and is currently under review by regulatory agencies in Europe, Japan, the Philippines and Korea.

Contact your local 3M representative for an update on the regulatory status of Novec 7000 fluid.

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. A pre-negotiated handling agreement between users and our authorized service provider offers users broad 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.

For additional information on the 3M Used Fluid Return Program, contact your local 3M representative or call 3M Customer Service at 800.810.8513.

Resources

3M™ Novec™ Engineered Fluids are supported by global sales, technical and customer service resources, with 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™ 7000 Engineered Fluid in the United States or for the name of a local authorized distributor, call 3M Electronics Markets Materials Division: **800 810 8513**.

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of patented 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

| United States | China | Europe | Japan | Korea | Singapore | Taiwan |
|--|----------------------------------|----------------------------------|--------------------------------------|------------------------------------|---------------------------------------|--------------------------------------|
| 3M Electronics Markets Materials Division 800 810 8513 | 3M China Ltd. 86 21 6275 3535 | 3M Belgium N.V. 32 3 250 7521 | Sumitomo 3M Limited 813 3709 8250 | 3M Korea Limited 82 2 3771 4114 | 3M Singapore Pte. Ltd. 65 64508888 | 3M Taiwan Limited 886 2 2704 9011 |

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