

3M™ Novec™ 649 Engineered Fluid

Introduction

3M™ Novec™ 649 Engineered Fluid is a clear, colorless and low odor fluid, one in a line of 3M products designed as replacements for ozone depleting substances (ODSs) and compounds with high global warming potentials (GWPs) such as sulfur hexafluoride (SF₆) and hydrofluorocarbons (HFCs), such as HFC-134a and HFC 245fa.

3M Novec 649 Engineered Fluid is an advanced heat transfer fluid, balancing customer needs for physical, thermal and electrical properties, with desirable environmental properties.

Typical Applications

Novec 649 fluid is an effective heat transfer fluid with a boiling point of 49°C. Novec 649 fluid is useful in heat transfer particularly where non-flammability or environmental factors are a consideration.

Examples of systems which benefit from use Novec 649 fluid include:

- Organic Rankine Cycle
 - Diesel Engines
 - Generators
 - Geothermal Applications
 - Solar Applications
- Electronics Cooling (Single or Dual Phase)
 - Power Electronics such as IGBTs or inverters
 - Transformers and other equipment (SF₆ replacement)
- Computer/Data Center Cooling

Properties Description

Composition of 3M™ Novec™ 649 Fluid

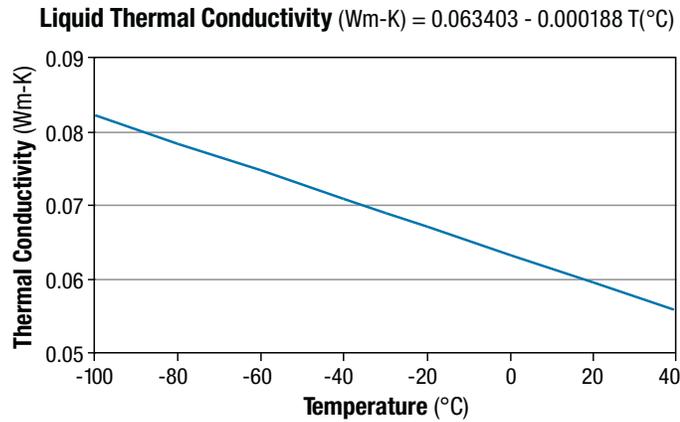
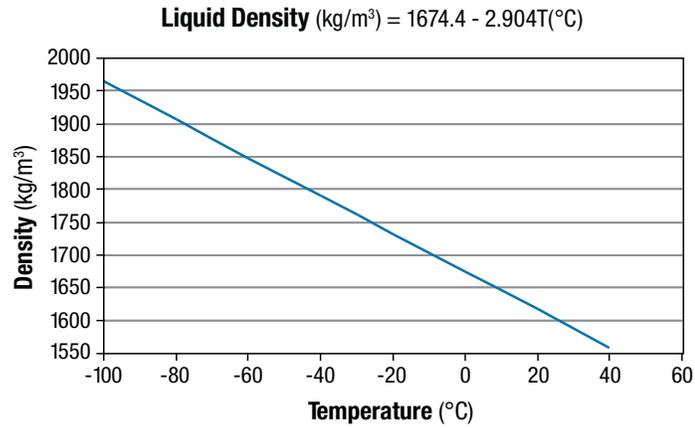
Dodecafluoro-2-methylpentan-3-one	99.0 mole %, minimum
Chemical Formula	CF ₃ CF ₂ C(O)CF(CF ₃) ₂

Typical Physical Properties

	3M™ Novec™ 649 Fluid
Boiling Point(°C)	49
Pour Point (°C)	-108
Molecular Weight (g/mol)	316
Critical Temperature (°C)	169
Critical Pressure (MPa)	1.88
Vapor Pressure (kPa)	40
Heat of Vaporization (kJ/kg)	88
Liquid Density (kg/m ³)	1600
Coefficient of Expansion (K ⁻¹)	0.0018
Kinematic Viscosity (cSt)	0.40
Absolute Viscosity (cP)	0.64
Specific Heat (J/kg-K)	1103
Thermal Conductivity (W/m-K)	0.059
Surface Tension (mN/m)	10.8
Solubility of Water in Fluid (ppm by wt)	20
Dielectric Strength, 0.1" gap (kV)	>40
Dielectric Constant @ 1kHz	1.8
Volume Resistivity (Ohm-cm)	10 ¹²
Global Warming Potential (GWP)	1

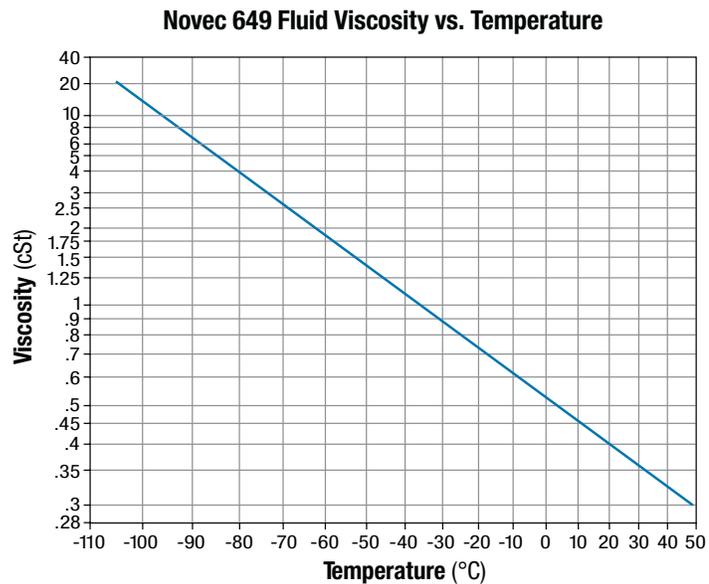
Thermophysical Properties

Not for specification purposes.



Liquid Specific Heat (J/kg-K) = $1091.9 + 0.3419 T(^{\circ}\text{C}) + 0.0039T^2$

Vapor Pressure $\ln(P[\text{Pa}]) = -3545.3/T(\text{K}) + 22.492$



Features

The environmental profile, margin of safety, low viscosity, high molecular weight, low pour point and heat transfer performance of 3M™ Novec™ 649 Engineered Fluid make it an ideal candidate for a variety of heat transfer applications.

Novec 649 fluid is compatible with a wide range of materials of construction and requires no special piping or handling systems, and is very stable in storage. Its high dielectric constant makes it safe for direct contact in most electronics/computing applications.

Physical Properties

Properties	3M™ Novec™ 649 Fluid	SF ₆	HFC-245fa	HFC-134a
Ozone Depletion Potential (ODP) ¹	0.0	0.0	0.0	0.0
Global Warming Potential ²	1	23900	1030	1,300
Atmospheric Lifetime (years)	0.014	3200	7.6	140

¹ World Meteorological Organization (WMO) 1998, Model-Derived Method.

² Intergovernmental Panel on Climate Change (IPCC) 2007 Method, 100 Year 1TH.

Stability

Novec 649 fluid should be used in a sealed system to prevent interaction with water. Fluoroketones like Novec 649 fluid, though reactive with liquid water (ie. a separate water phase), are remarkably stable in its absence to over 300°C. 3M's applications engineers are available to discuss system design and trade-offs for Novec 649 fluid vs. alternative heat transfer fluids or solutions.

Environmental, Health and Safety

Studies by a third party laboratory (Massachusetts Institute of Technology) have shown that Novec 649 fluid has an estimated atmospheric lifetime of five days due to photolysis in sunlight.¹

The potential for Novec 649 fluid to impact the radiative balance in the atmosphere (i.e., climate change) is limited by this very short atmospheric lifetime. [Using a measured IR cross-section and the method of Pinnock et.al., the instantaneous radiative forcing for Novec 649 fluid is calculated to be 0.50 Wm⁻²ppbV⁻¹.] This radiative forcing and a 5-day atmospheric lifetime result in a GWP value of about 1 [using the WMO 1999 method over a 100-year integration time horizon].

The photolysis of Novec 649 fluid is expected to rapidly produce fluorinated alkyl radicals similar to those produced by other fluorochemicals. Studies of the atmospheric chemistry of these radical species and their degradation products have concluded that they have no impact on stratospheric ozone. This combined with its very short atmospheric lifetime, leads to the conclusion that Novec 649 fluid has an ozone depletion of zero.¹

Before using this product, please read the current product Material Safety Data Sheet (available online or through your 3M sales or technical service representative) and the precautions and directions for use on the product package. Follow all applicable precautions and directions for use.

¹ N. Taniguchi, T.J. Wallington, M.D. Hurley, A.G. Guschin, L.T. Molina and M.J. Molina, *Atmospheric Chemistry of C₂F₃C(O)CF(CF₃)₂: Photolysis and Reaction with Cl Atoms, OH Radicals and Ozone*. J Phys Chem A, 2003, 107, 2674 – 2679.

Toxicity Profile

3M carefully characterizes the toxicity of new materials early in the product development process. These early studies and the subsequent studies conducted by independent laboratories indicate that Novec 649 fluid is very low in both acute and repeat dose toxicity. The No Observed Adverse Effect Level (NOAEL) for all endpoints of acute toxicity is 10% (100,000 ppmV) based on a cardiac sensitization study and a 4-hour acute inhalation study. The 8-hour time weighed average (TWA) exposure guideline for Novec 649 fluid is 150 ppmV. On this basis, foreseeable use under normal operating conditions results in a large margin of safety between anticipated exposure and the exposure guideline.