



Safe
Sustainable
Cooling
Performance

Dielectric heat transfer
solutions for the
electronics industry

Reliable performance. Environmentally sustainable options.



Thermal management issues are becoming increasingly important to electronics and semiconductor manufacturers. New designs put more demands on the dielectric fluids used to maintain proper temperatures. Environmental issues have become a critical factor in fab/plant operating decisions. And system maintenance is always an issue. In short, selection of a heat transfer fluid for your semiconductor processing and electronics equipment can no longer be an afterthought. Long-term, high-performance solutions are needed.

Whether for single-phase or two-phase systems, 3M has a broad range of thermal management fluids and technical support you need to make the right choice for your particular needs. Customers have used 3M products in many applications, including thermal test and immersion cooling of electronics. 3M experts are available to help you choose the right thermal management fluid to improve reliability, address environmental concerns, and lower your overall operating costs.



Cool Solutions for Today's Electronics

3M™ Thermal Management Fluids Properties

3M™ Novec™ Engineered Fluids

	Unit	Novec 7000	Novec 7100	Novec 7200	Novec 7300	Novec 7500	Novec 7600
Boiling Point	°C	34	61	76	98	128	131
Pour Point	°C	-122	-135	-138	-38	-100	-98
Molecular Weight	g/mol	200	250	264	350	414	346
Critical Temperature	°C	165	195	210	243	261	260
Critical Pressure	MPa	2.48	2.23	2.01	1.88	1.55	1.67
Vapor Pressure	kPa	65	27	16	5.9	2.1	0.96
Heat of Vaporization	kJ/kg	142	112	119	102	89	116
Liquid Density	kg/m ³	1400	1510	1420	1660	1614	1540
Coefficient of Expansion	K ⁻¹	0.0022	0.0018	0.0016	0.0013	0.0013	0.0011
Kinematic Viscosity	cSt	0.32	0.38	0.41	0.71	0.77	1.1
Absolute Viscosity	cP	0.45	0.58	0.58	1.18	1.24	1.65
Specific Heat	J/kg-K	1300	1183	1220	1140	1128	1319
Thermal Conductivity	W/m-K	0.075	0.069	0.068	0.063	0.065	0.071
Surface Tension	mN/m	12.4	13.6	13.6	15.0	16.2	17.7
Solubility of Water in Fluid	ppm by weight	~60	95	92	67	45	410
Solubility of Fluid in Water	ppm by weight	<50	12	<20	<1	<3	<10
Dielectric Strength, 0.1" gap	kV	~40	~40	~40	~40	~40	~40
Dielectric Constant @ 1kHz	–	7.4	7.4	7.3	6.1	5.8	6.4
Volume Resistivity	Ohm-cm	10 ⁸	10 ⁸	10 ⁸	10 ¹¹	10 ⁸	10 ¹⁰
Global Warming Potential	GWP	420	297	59	210	100	700

For test methods and variability, contact 3M Technical Service

3M™ Fluorinert™ Electronic Liquids

	Unit	FC-3284	FC-72	FC-84	FC-770	FC-3283	FC-40	FC-43
Boiling Point	°C	50	56	80	95	128	155	174
Pour Point	°C	-73	-90	-95	-127	-50	-57	-50
Molecular Weight	g/mol	299	338	388	399	521	650	670
Critical Temperature	°C	161	176	202	238	235	270	294
Critical Pressure	MPa	1.94	1.83	1.75	2.47	1.22	1.18	1.13
Vapor Pressure	kPa	35	30	11	6.6	1.4	0.43	0.19
Heat of Vaporization	kJ/kg	105	88	90	86	78	68	70
Liquid Density	kg/m ³	1710	1680	1730	1793	1820	1850	1860
Coefficient of Expansion	K ⁻¹	0.0016	0.0016	0.0015	0.0015	0.0014	0.0012	0.0012
Kinematic Viscosity	cSt	0.42	0.38	0.53	0.79	0.75	1.8	2.5
Absolute Viscosity	cP	0.71	0.64	0.91	1.4	1.4	3.4	4.7
Specific Heat	J/kg-K	1100	1100	1100	1038	1100	1100	1100
Thermal Conductivity	W/m-K	0.062	0.057	0.060	0.063	0.066	0.065	0.065
Surface Tension	mN/m	13	10	12	15	15	16	16
Solubility of Water in Fluid	ppm by weight	14	10	11	14	7	<7	7
Solubility of Fluid in Water	ppm by weight	<5	<5	<5	<5	<5	<5	<5
Dielectric Strength, 0.1" gap	kV	>40	>40	>40	>40	>40	>40	>40
Dielectric Constant @ 1kHz	–	1.9	1.8	1.8	1.9	1.9	1.9	1.9
Volume Resistivity	Ohm-cm	10 ¹⁵						

For test methods and variability, contact 3M Technical Service

For discussion on GWP, refer to additional content in this brochure.

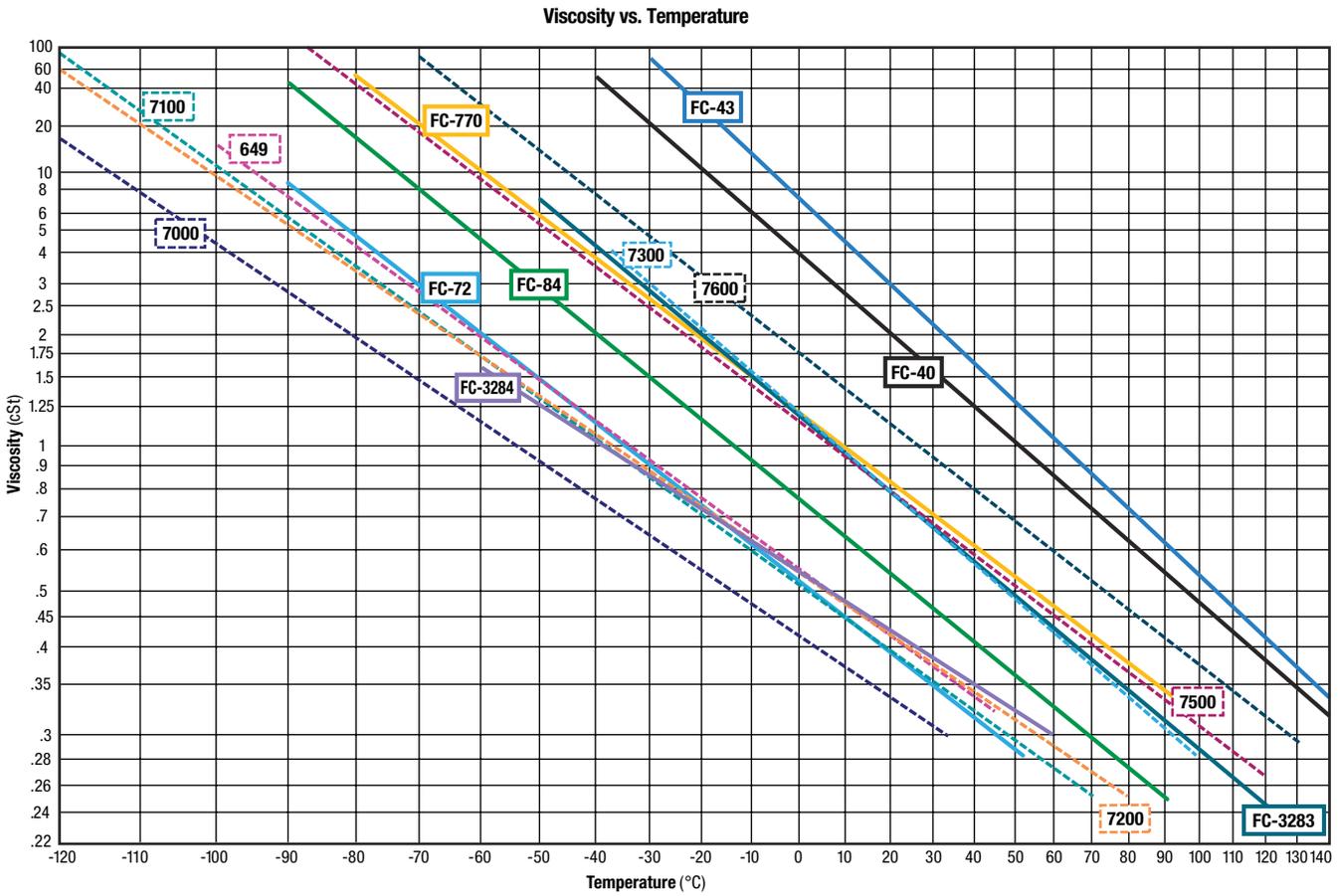
3M™ Novec™ 649 Engineered Fluid

	Unit	Novec 649
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

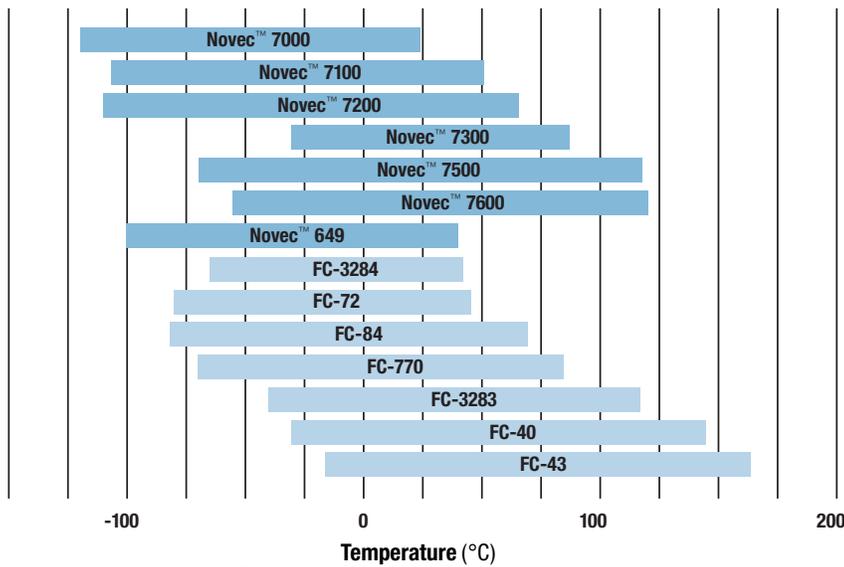
Novec 649 fluid is an advanced heat transfer fluid with the lowest Global Warming Potential (GWP) in the Novec family. It belongs to a new class of fluoroketone fluids which are being explored for their use in thermal management applications such as direct and indirect heat transfer systems and Organic Rankine Cycle (ORC) systems.

3M heat transfer fluids, sold under the 3M™ Novec™ Engineered Fluids and 3M™ Fluorinert™ Electronic Liquids brands, are available in a wide range of boiling points (34°C up to 175°C) and freezing points (-38°C down to -138°C), to meet your specific requirements.

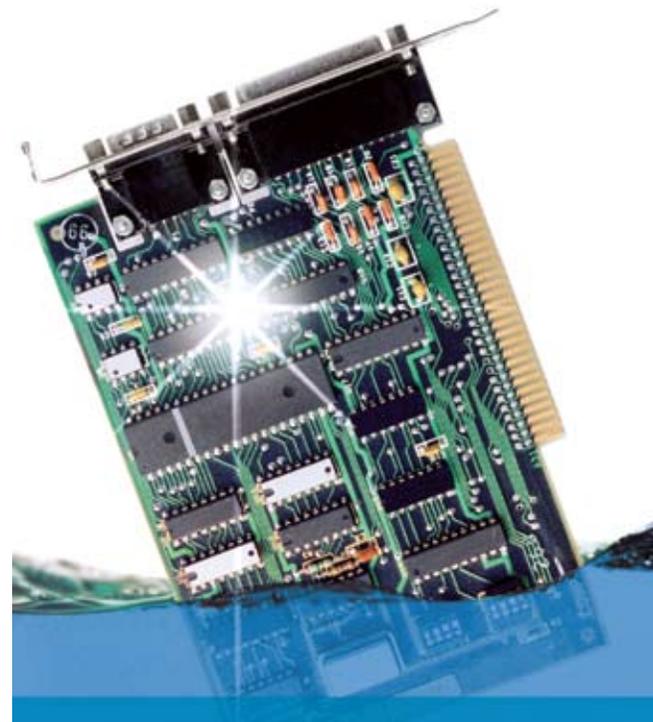
3M™ Thermal Management Fluids Kinematic Viscosity



Recommended Operating Temperature Range*



* For pumped single phase systems.



3M™ Novec™ Engineered Fluids

3M™ Novec™ Engineered Fluids are a family of low-Global Warming materials designed to deliver on the Novec promise of safe, sustainable chemistry.

Performance

Novec Engineered Fluids have excellent properties for heat transfer applications:

- Excellent dielectric properties
- Wide range of boiling points
- Good materials compatibility

These fluids require little maintenance and offer dependable performance. They have high resistivity and will not damage electronic equipment or integrated circuits in the event of a leak or other failure.

Environmental profile

Novec Engineered Fluids also offer favorable environmental and worker safety properties:

- Low toxicity
- Nonflammability
- Low Global Warming Potential (GWP)
- Zero Ozone Depletion Potential (ODP)

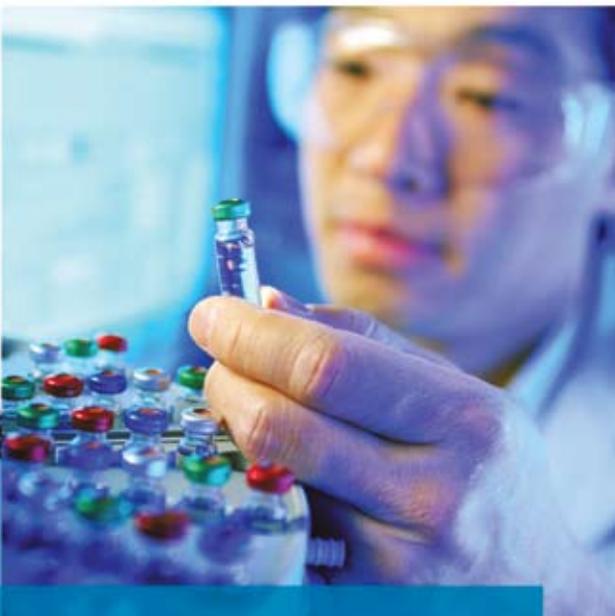
The chemical inertness and non-corrosivity of Novec Engineered Fluids make them safe for workers to handle, while the environmental properties mean they can be used both now and in the future while leaving behind a smaller footprint on the world.



The next generation of heat transfer fluids

The favorable environmental, health and safety properties of Novec fluids have made them a long-term, sustainable solution. Novec fluids have been recognized by a number of industry and regulatory bodies around the world, including 3M™ Novec™ Engineered Fluids 7100 and 7200 being approved for “use without restriction” under the U.S. EPA’s Significant New Alternatives Policy (SNAP).

Novec fluids are already widely used as heat transfer fluids in the semiconductor industry, where they are used for temperature control of manufacturing equipment while reducing a facility’s greenhouse gas emissions. They have also been used in direct contact dielectric test applications.



Safe
Reliable
Sustainable
Chemistries

3M™ Fluorinert™ Electronic Liquids

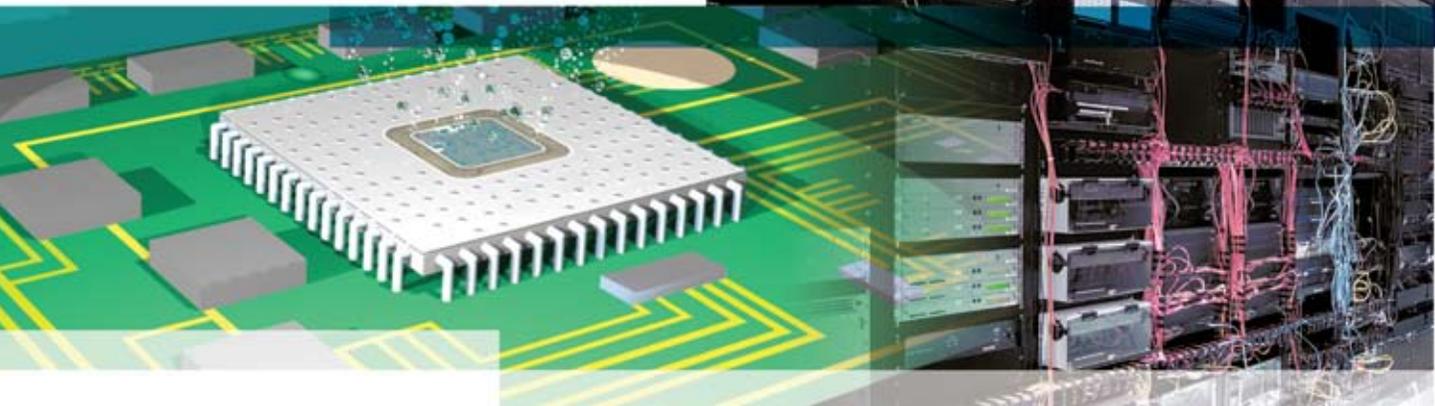
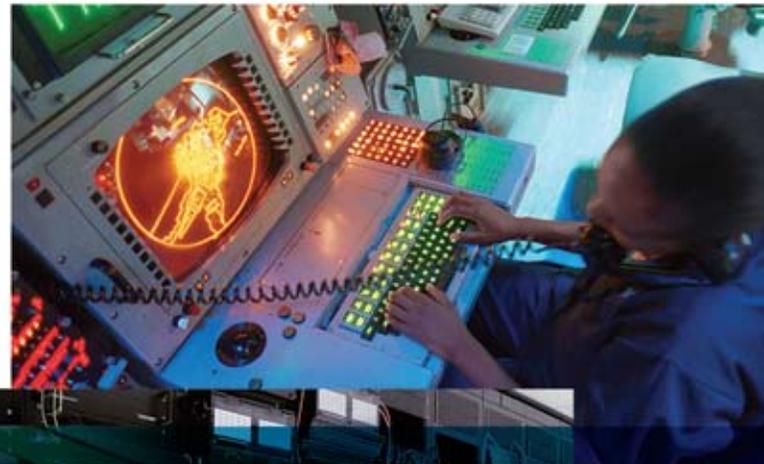
3M™ Fluorinert™ Electronic Liquids are part of a family of fully-fluorinated compounds known as perfluorocarbons, or PFCs. Fluorinert liquids are premier heat transfer fluids, and have long been used as heat transfer media for extreme cooling applications.

Originally used for direct contact cooling due to their stability, Fluorinert liquids are also used in a variety of semiconductor operations such as automated testing, etching, deposition, photolithography and more. Fluorinert liquids offer:

- Excellent dielectric properties
- Wide range of boiling points
- Good materials compatibility
- Low toxicity
- Nonflammability
- Zero Ozone Depletion Potential (ODP)

In addition, you have the assurance that comes from dealing with 3M, a company with over 40 years of experience addressing industrial-strength cooling needs.

While they are non-ozone depleting, high-performance Fluorinert liquids do have high global warming potentials (GWP) and long atmospheric lifetimes. Because emission of materials with these properties could have a significant impact on the environment, users must take care to carefully manage and minimize emissions. 3M recommends that users of Fluorinert liquids limit emissions by employing good conservation practices, and by implementing recovery, recycling and/or proper disposal procedures.



Direct contact cooling with 3M™ Fluorinert™ Electronic Liquids helped enable the development of dense electronics, such as supercomputers and power converters.

Material Compatibility

3M™ Novec™ Engineered Fluids and 3M™ Fluorinert™ Electronic Liquids are compatible with a wide variety of materials used in heat transfer equipment. As with any design, selection of these materials is very important. A 3M specialist in this area can help you make the proper choice.

Polymers

Most of the materials commonly considered “hard” plastics will perform well with both Novec fluids and Fluorinert liquids.

Elastomers

Elastomers should be limited to those that are not heavily plasticized. 3M engineers can assist you with recommendations and testing on specific compounds.



More
Options
More
Answers

The hidden benefit: 3M experience

The use of fluorochemicals in heat transfer systems is a science that 3M has studied like no other company. Bringing this extensive knowledge to bear on your heat transfer equipment is a major part of our Thermal Management program ... and a major benefit of purchasing 3M™ Novec™ Engineered Fluids or 3M™ Fluorinert™ Electronic Liquids.

Here are just some of the services that 3M can provide to help you utilize these innovative fluids in your heat transfer equipment:

Heat Transfer Seminar/Design Assistance

Given free of charge at qualifying customer sites, this seminar teaches appropriate design procedures by discussing material compatibility, sources of leakage, pumping, component selection, environmental issues and more. The content of these seminars can be tailored to the specific interests of the audience. 3M has conducted seminars at numerous customer locations.

Compatibility Testing

3M engineers can evaluate parts with advanced testing methods to help you determine if a component or material is suitable in your design.

On-Site Consultations

Working side-by-side with equipment designers and end users, 3M engineers frequently help customers tighten-up equipment and optimize system performance.

Analytical Services

3M has state-of-the-art analytical resources which are used to help answer customer questions.

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

Important Notice: Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use.

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Electronics Markets Materials Division

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

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98-0212-2649-7

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