



Fluorinert™ Electronic Liquids

For Electronic Reliability Testing

Application Information

Introduction

3M™ Fluorinert™ liquids are a family of clear, colorless, odorless, perfluorinated fluids having a viscosity equivalent to water but approximately 75% greater density. These products are thermally and chemically stable, compatible with sensitive materials, including metals, plastics and elastomers, non-flammable and practically non-toxic.

The dielectric strength of perfluorinated liquids is high—in excess of 35,000 volts across a 0.1 inch gap. Water solubility is on the order of a few parts per million. The nominal boiling point of each fluid in this series is determined during their manufacture; Fluorinert liquids are available with boiling points ranging from 30°C to 215°C, and pour points as low as -101°C.

Electronic Reliability Testing

The thermal stability, non-reactivity, high dielectric strength and non-solvent characteristics of Fluorinert liquids make them ideal for electronic quality control testing. Components may be tested both physically and electrically while immersed in a non-conductive fluorocarbon liquid. Tested devices dry quickly with no residue, and no post-test cleaning is required.

Fluorinert liquids have a wide liquid range of approximately 200°C from pour point to boiling point, with good heat transfer properties throughout the range. This means reliability tests can be conducted over an extremely wide temperature range with a single inert, non-flammable and non-explosive liquid. See “Typical Physical Properties” chart for a listing of Fluorinert electronic testing fluids.

Hermetic Seal/Gross Leak Testing

Commercial tests for device hermetic seal integrity generally follow Military Standards 883-1014, 750-1071 and 202-112. Fluorinert liquids conform to these Military Standards.

Three different types of gross leak procedures are included in these Military Standards, confirming reliability to 10^{-5} atmospheres per cc/sec or more. Before the availability of Fluorinert liquids, gross leak testing reliability was limited to 10^{-3} - 10^{-4} atmospheres cc/sec.

With these tests, users can determine the hermetic integrity of electronic device housings. Two procedures are bubble tests and vapor detection, with escaping cavity gas identifying faulty units.

Product Recommendations: Fluorinert Electronic Liquid FC-40/43
Fluorinert Electronic Liquid FC-72
Fluorinert Electronic Liquid FC-84

Thermal Shock Testing

Components can be thermally pre-stressed by means of rapid cycling between temperature extremes, taking advantage of the unique thermal properties of 3M™ Fluorinert™ liquids. Thermal shock tests are followed by secondary testing related to device end use to eliminate components that did not withstand the procedure.

Thermal shock testing is largely concerned with Military Standard 883-1011 specifications that call for five minute exposures to alternating high and low temperatures and a total of fifteen cycles. Fluorinert liquid advantages for this application include precise temperature control, rapid heat transfer due to thermal conductivity, excellent material compatibility and no post-test clean up.

Product Recommendations:

Hot phase: Fluorinert Electronic Liquids FC-40 or FC-43

Cold phase: Fluorinert Electronic Liquids FC-6003 or FC-77

Thermal Shock Testing Liquid 3M™ FC-6003 Typical Properties (Not for Specification Purposes) Low Temperature Reservoir

Density @ 25°C, gm/ml	>1.76
Dielectric Strength, volts/mil	>350
Viscosity @ -75°C	<50
Residue, micrograms/ml	<10
Appearance	Clear/colorless liquid

Other Electronic Tests Using Fluorinert Liquids

- Electrical Environmental Testing
- Temperature Calibration
- Failure Analysis
- High-Voltage Testing of Components and Devices
- Dielectric Testing
- Air/Fuel Ratio Testing

Typical Properties
(Not for Specification Purposes)

All values determined at 25°C unless otherwise specified

3M™ Fluorinert™ Liquid	FC-40	FC-43	FC-72	FC-77	FC-84
Typical Boiling Point, °C	155	174	56	97	80
Pour Point, °C	-57	-50	-90	-95	-95
Density, g/cm ³	1.87	1.88	1.68	1.78	1.73
Density, g/cm ³ , -54°C	□	□	1.90	1.97	1.93
Kinematic Viscosity, cs	2.2	2.8	0.4	0.8	0.55
Kinematic Viscosity, cs, -54°C	□	□	1.9	6.9	4.0
Vapor Pressure, torr	3	1.3	232	42	79
Specific Heat, g-cal/g - °C	0.25	0.25	0.25	0.25	0.25
Heat of Vaporization @ Boiling Point, cal/g	17	17	21	20	19
Thermal Conductivity, watts/(cm ²) (°C/cm)	0.00066*	0.00066	0.00057	0.00063*	0.00060*
Coefficient of Expansion cm ³ /(cm ³)(°C)	0.0012	0.0012	0.0016	0.0014	0.0015
Surface Tension, dynes/cm	16	16	12	15	13
Dielectric Strength, KV(0.01in.gap) KV(2.54 mm gap)	46	42	38	40	42
Dielectric Constant, (1KHz)	1.89	1.90	1.76	1.86	1.81
Volume Resistivity, ohm-cm	4.0x10 ¹⁵	3.4x10 ¹⁵	1.0x10 ¹⁵	1.9x10 ¹⁵	1.2x10 ¹⁵
Solubility of Water ppm (wt.)	7	7	10	13	11*
Solubility of Air ml gas/100 ml liquid	27	26	48	41	43*
Average Molecular Weight	650	670	340	415	388

* Estimated values □ Not measured, due to relative proximity to pour point

Toxicity Profile

Fluorinert liquids are non-irritating to the eyes and skin, and are practically non-toxic orally. They also demonstrate very low acute and sub-chronic inhalation toxicity. These products are not mutagens or cardiac sensitizers.

Safety and Handling

3M™ Fluorinert™ liquids are nonflammable, and are highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheets, which are available upon request.

Environmental

3M™ Fluorinert™ liquids have zero ozone depletion potential. These materials are not defined by the U.S. EPA, nor regulated, as volatile organic compounds (VOCs) and do not contribute to ground-level smog formation.

Fluorinert liquids, which are perfluorocarbon (PFC) materials, have high global warming potentials and long atmospheric lifetimes. As such, they should be carefully managed to minimize emissions.

3M recommends that users of Fluorinert liquids further limit emissions by employing good conservation practices, and by implementing recovery, recycling and/or proper disposal procedures. 3M offers a program for used fluid return. Specific guidelines for the safe handling and use of 3M products are provided in the Material Safety Data Sheets.

Resources

3M has representatives in virtually all regions of the world where electronics are manufactured. In addition, 3M products are supported by global technical and customer service resources, with fully-staffed technical service laboratories in the U.S., Europe, Japan and Southeast Asia. Users benefit from 3M's broad technology base and continuing attention to product development, performance, safety and environmental issues. For assistance, contact:

3M Specialty Materials

3M Center
Bldg. 223-6S-04
St. Paul, MN 55144
800-833-5045

Important Notice to Purchaser: The information in this publication is based on tests that we believe are reliable. Your results may vary due to differences in test types and conditions. You must evaluate and determine whether the product is suitable for your intended application. Since conditions of product use are outside of our control and vary widely, the following is made in lieu of all express or implied warranties (including the warranties of merchantability or fitness for a particular purpose): 3M's only obligation and your only remedy is replacement of product that is shown to be defective when you receive it. In no case will 3M be liable for any special, incidental, or consequential damages based on breach of warranty or contract, negligence, strict tort, or any other theory.



Specialty Fluids
3M Specialty Materials

3M Center, Building 223-6S-04
St. Paul, MN 55144-1000