



Fluorinert™ Electronic Liquid FC-770

Introduction

3M™ Fluorinert™ Electronic Liquid FC-770 is a thermally stable, fully-fluorinated liquid that has ideal properties for use as a heat transfer fluid in a variety of industries.

The inertness of Fluorinert liquid FC-770 permits its use as a direct contact single and two-phase coolant in certain supercomputers and sensitive military electronics. Its high dielectric strength and electrical resistivity are ideal for applications in high voltage transformers and power electronics.

In the semiconductor manufacturing industry, its wide liquid range makes Fluorinert liquid FC-770 suited for cooling ion implanters, dry etchers and CVD machines. Its low pour point also permits its use in thermal shock and test equipment.

Physical Properties

Not for
specification
purposes.

All values are
determined at
25°C unless
otherwise
specified.

Properties	FC-770
Appearance	Clear, colorless
Average Molecular Weight	399
Boiling Point (1 atm)	95°C
Pour Point	-127°C
Calculated Critical Temperature	511 K
Calculated Critical Pressure	2.47×10^6 pascals
Vapor Pressure	6.568×10^{-3} pascals
Latent Heat of Vaporization (at normal boiling point)	85.9 J/g
Liquid Density	1793 kg/m ³
Kinematic Viscosity	0.79 centistokes
Absolute Viscosity	1.359 centipoise
Liquid Specific Heat	1038 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.063 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.00148 °C ⁻¹
Surface Tension	14.8 dynes/cm
Refractive Index	1.27
Water Solubility	14 ppmw
Solubility in Water	1.3 ppmw

3M™ Fluorinert™ Electronic Liquid FC-770 Electrical Properties

Properties	FC-770
Dielectric Strength	>40 kV, 0.1" gap
Dielectric Constant	1.9
Electrical Resistivity (ASTM D-257)	>3 x10 ¹⁴ ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, density, viscosity and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-770 at various temperatures.

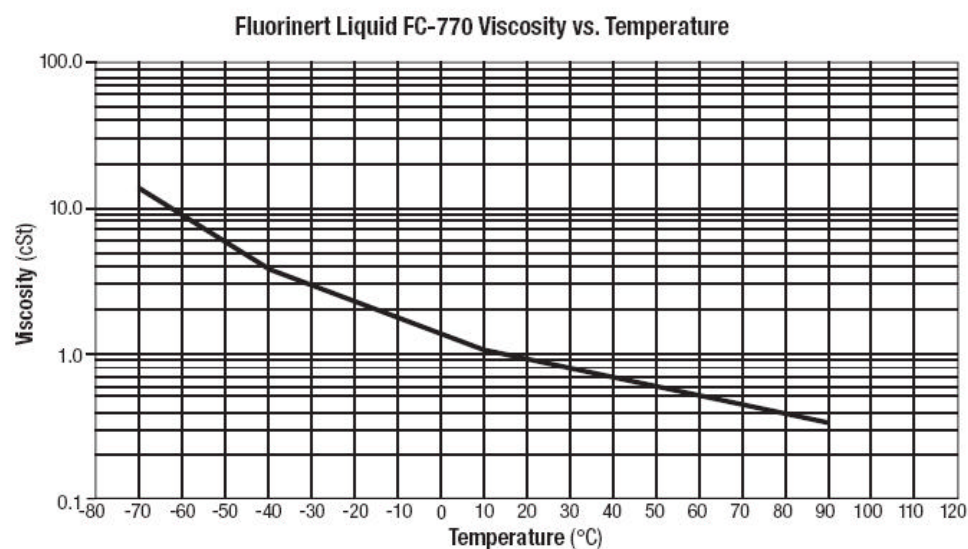
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C)} = 997 + 1.615 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1860 - 2.66 (T, ^{\circ}\text{C})$$

$$\text{Vapor Pressure (mm Hg)} = \text{EXP} [16.21 - 3028.88/(T, ^{\circ}\text{C} + 221)]$$

$$\text{Kinematic Viscosity cSt} = \text{EXP} [834.8/(T, ^{\circ}\text{C} + 196) - 4.0]$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-770 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-770 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-770 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Perfluorocarbons (PFCs) have been thoroughly tested in mammalian toxicity studies. In general, these materials are not irritants, sensitizers or mutagens. PFCs are low in toxicity through normal routes of industrial exposure. A material toxicity summary sheet is available upon request and MSDSs are available upon request or from the 3M website.

Safety and Handling

Before using this product, please read the current product Material Safety Data Sheet and the precautionary statement on the product package. Follow all applicable precautions and directions. Fluorinert liquid FC-770 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use.

Environmental Properties

Fluorinert liquid FC-770 has zero ozone depletion potential. The material is not defined by the U.S. EPA, nor is it regulated, as a volatile organic compound (VOC). FC-770 liquid does not contribute to ground-level smog formation.

Fluorinert liquid FC-770, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, its use should be carefully managed to minimize emissions.

3M recommends that users of Fluorinert liquid FC-770 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-770 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this service provider helps protect 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-770 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-770 in the U.S., call 3M Performance Materials, 800.810.8513, or visit our web site at: www.3M.com/electronics.

Product Use: All statements, technical information and recommendations contained in this document are based upon tests or experience that 3M believes are reliable. However, many factors beyond 3M's control can affect the use and performance of a 3M product in a particular application, including the conditions under which the product is used and the time and environmental conditions in which the product is expected to perform. Since these factors are uniquely within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for the user's method of application.

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Fluorinert™

Electronic Liquid

FC-87

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-87 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-87 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes Fluorinert liquid FC-87 an ideal fluid for many electronics applications, including thermal management.

With a boiling point of 30°C, Fluorinert liquid FC-87 is ideal for low temperature heat transfer and two-phase cooling applications.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-87
Appearance	Clear, colorless
Average Molecular Weight	288
Boiling Point (1 atm)	30°C
Pour Point	-115°C
Estimated Critical Temperature	423 K
Estimated Critical Pressure	2.13 x 10 ⁶ pascals
Vapor Pressure	81.1 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	103 J/g
Liquid Density	1650 kg/m ³
Kinematic Viscosity	0.27 centistokes
Absolute Viscosity	0.45 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.056 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0015 °C ⁻¹
Surface Tension	9 dynes/cm
Refractive Index	1.238
Water Solubility	7 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-87 Electrical Properties

Properties	FC-87
Dielectric Strength	48 kV, 0.1" gap
Dielectric Constant	1.73
Electrical Resistivity	5.6×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity and density of 3M™ Fluorinert™ Electronic Liquid FC-87 at various temperatures.

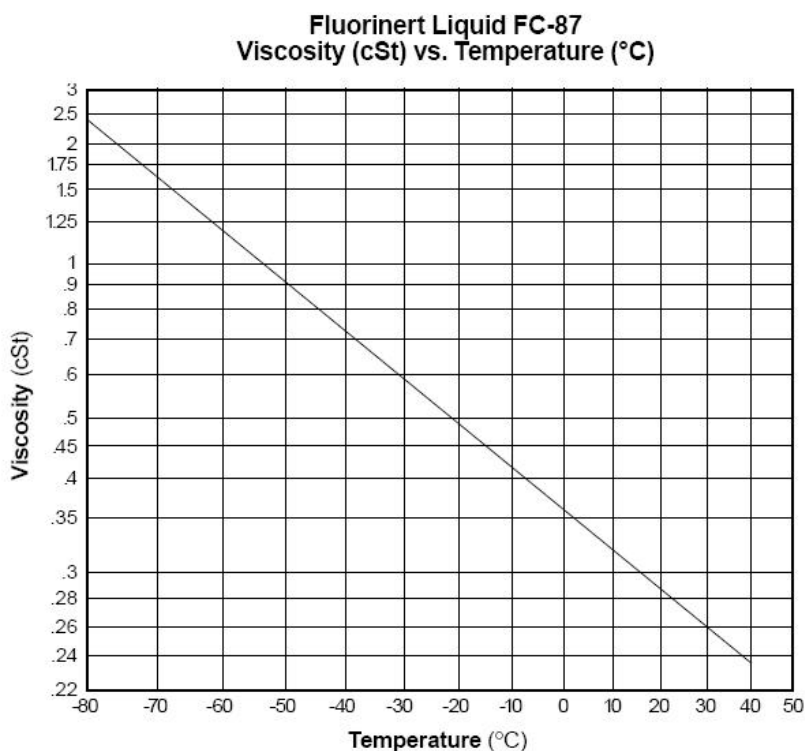
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.059 - 0.00015 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3) = 1710 - 2.5 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.102 - (1548/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-87 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-87 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-87 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-87 is non-irritating to the eyes and skin, is practically non-toxic orally and is not a mutagen (ames). A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-87 liquid is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-87 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-87, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-87 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-87 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-87 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-87 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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.



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Fluorinert™

Electronic Liquid

FC-104

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-104 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-104 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes FC-104 liquid ideal for many electronics applications, including thermal management testing applications.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-104
Appearance	Clear, colorless
Average Molecular Weight	435
Boiling Point (1 atm)	101°C
Pour Point	-65°C
Estimated Critical Temperature	502 K
Estimated Critical Pressure	1.66 x 10 ⁶ pascals
Vapor Pressure	3.8 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	94 J/g
Liquid Density	1760 kg/m ³
Kinematic Viscosity	0.75 centistokes
Absolute Viscosity	1.3 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.063 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0014 °C ⁻¹
Surface Tension	13 dynes/cm
Refractive Index	1.271
Water Solubility	11 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-104 Electrical Properties

Properties	FC-104
Dielectric Strength	41 kV, 0.1" gap
Dielectric Constant	1.86
Electrical Resistivity	8.4×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity and density of 3M™ Fluorinert™ Electronic Liquid FC-104 at various temperatures.

$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

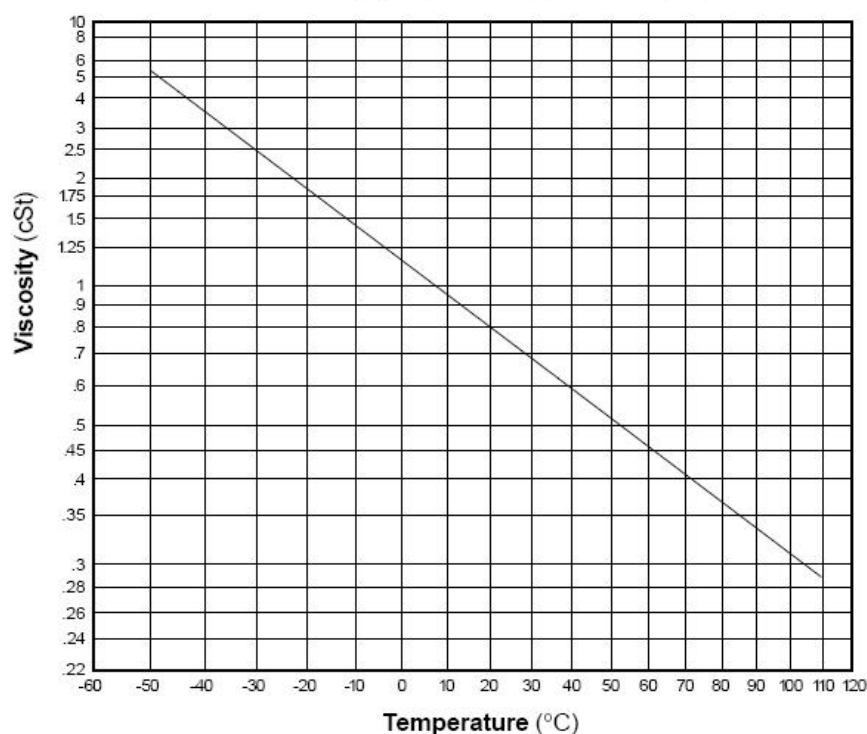
$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.065 - 0.00008 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1819 - 2.48 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.711 - (2126/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-104 over the indicated temperature range.

Fluorinert Liquid FC-104
Viscosity (cSt) vs. Temperature (°C)



3M™ Fluorinert™ Electronic Liquid FC-104 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-104 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-104 is non-irritating to the eyes and skin, and is practically non-toxic orally. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-104 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-104 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-104, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of Fluorinert liquid FC-104 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-104 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-104 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-104 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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.



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Fluorinert™

Electronic Liquid FC-84

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-84 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-84 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes FC-84 liquid an ideal fluid for many electronics applications, including quality and reliability testing.

Fluorinert liquid FC-84 conforms to Military Specification 883 as a detector fluid in bubble tank or negative ion detection (NID) gross leak testing. It is also an effective fluid for use in environmental stress screening.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-84
Appearance	Clear, colorless
Average Molecular Weight	388
Boiling Point (1 atm)	80°C
Pour Point	-95°C
Estimated Critical Temperature	475 K
Estimated Critical Pressure	1.75 x 10 ⁶ pascals
Vapor Pressure	10.6 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	90 J/g
Liquid Density	1730 kg/m ³
Kinematic Viscosity	0.53 centistokes
Absolute Viscosity	0.91 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.060 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0015 °C ⁻¹
Surface Tension	12 dynes/cm
Refractive Index	1.261
Water Solubility	11 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-84 Electrical Properties

Properties	FC-84
Dielectric Strength	38 kV, 0.1" gap
Dielectric Constant	1.8
Electrical Resistivity	1.2×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-84 at various temperatures.

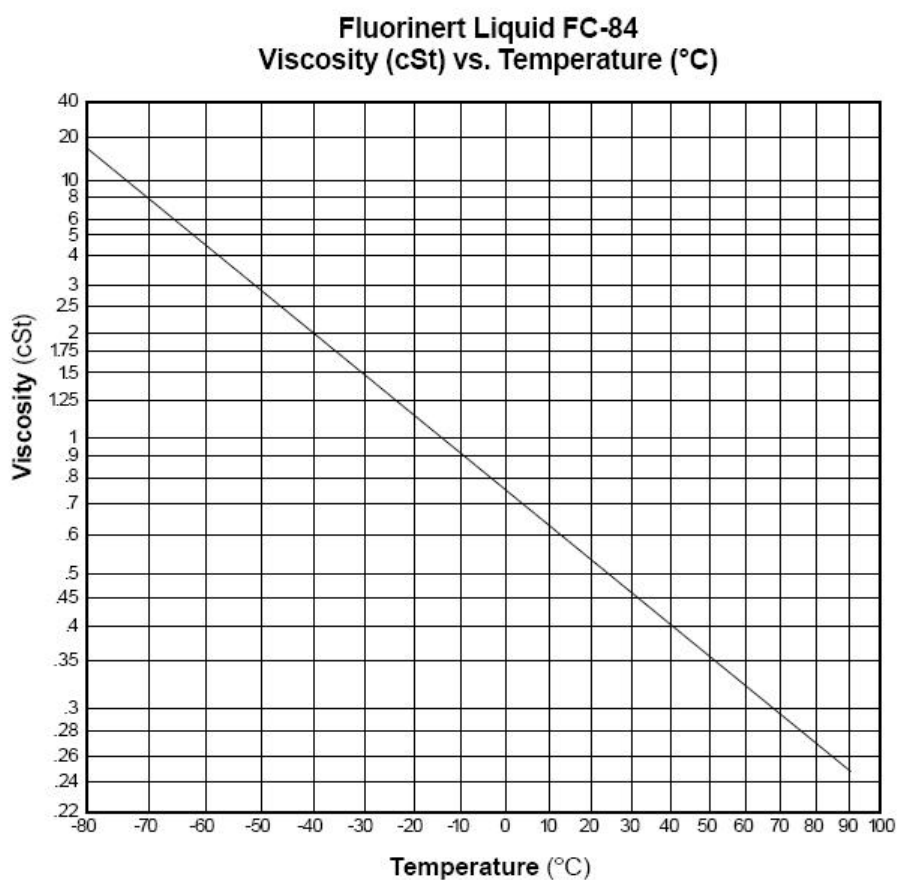
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.063 - 0.00012 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1790 - 2.57 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.142 - (1824/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-84 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-84 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-84 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-84 is non-irritating to the eyes, minimally irritating to the skin, and is practically non-toxic orally. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-84 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-84 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-84, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-84 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-84 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

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Resources

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For other 3M global offices and additional information on Fluorinert electronic liquid FC-84 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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Fluorinert™

Electronic Liquid

FC-43

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-43 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-43 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes Fluorinert liquid FC-43 ideal for many electronics applications, including many electronic quality and reliability tests.

With a boiling point of 174°C, Fluorinert liquid FC-43 is ideal for use in liquid burn-in testing, environmental stress screening and some vapor phase soldering processes. It conforms to Military Specification 883 as an indicator fluid in gross leak testing and as the hot fluid for thermal shock testing.

The wide liquid range of Fluorinert liquid FC-43 makes it an ideal heat transfer fluid. Its inert nature allows for use as a reaction medium.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-43
Appearance	Clear, colorless
Average Molecular Weight	670
Boiling Point (1 atm)	174°C
Pour Point	-50°C
Estimated Critical Temperature	567 K
Estimated Critical Pressure	1.13 x 10 ⁶ pascals
Vapor Pressure	192 pascals
Latent Heat of Vaporization (at normal boiling point)	70 J/g
Liquid Density	1860 kg/m ³
Kinematic Viscosity	2.5 centistokes
Absolute Viscosity	4.7 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.065 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0012 °C ⁻¹
Refractive Index	1.291
Water Solubility	7 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-43 Electrical Properties

Properties	FC-43
Dielectric Strength	42 kV, 0.1" gap
Dielectric Constant	1.9
Electrical Resistivity	3.4×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-43 at various temperatures.

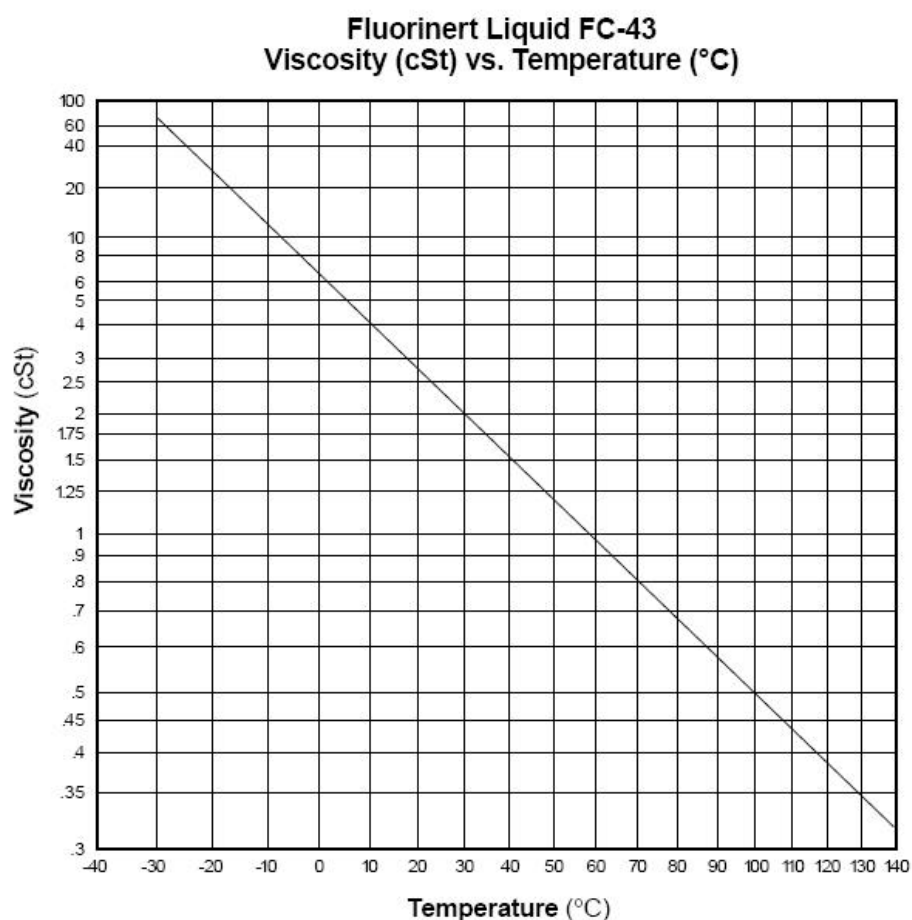
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.067 - 0.00007 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3) = 1913 - 2.18 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.511 - (2453/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-43 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-43 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-43 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-43 is non-irritating to the eyes and skin, and is practically non-toxic orally. The product also demonstrates very low acute and sub-chronic inhalation toxicity. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-43 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-43 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-43, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-43 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-43 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-43 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-43 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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.



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Fluorinert™

Electronic Liquid FC-40

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-40 is a clear, colorless, thermally stable, fully-fluorinated liquid ideal for use in many single phase heat transfer applications in the semiconductor manufacturing industry. Its liquid range (-57°C to 155°C) makes it ideal for a variety of applications such as etchers, ion implanters, testers and others. Because Fluorinert liquid FC-40 is primarily a single compound, its composition will not shift or fractionate with time. This keeps fluid loss to a minimum and insures that transport properties will not change with time.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-40
Appearance	Clear, colorless
Average Molecular Weight	650
Boiling Point (1 atm)	155°C
Pour Point	-57°C
Estimated Critical Temperature	543 K
Estimated Critical Pressure	1.18 x 10 ⁶ pascals
Vapor Pressure	432 pascals
Latent Heat of Vaporization (at normal boiling point)	68 J/g
Liquid Density	1850 kg/m ³
Kinematic Viscosity	1.8 centistokes
Absolute Viscosity	3.4 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.065 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0012 °C ⁻¹
Refractive Index	1.290
Water Solubility	<7 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-40 Electrical Properties

Properties	FC-40
Dielectric Strength	46 kV, 0.1" gap
Dielectric Constant	1.9
Electrical Resistivity	4.0×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-40 at various temperatures.

$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

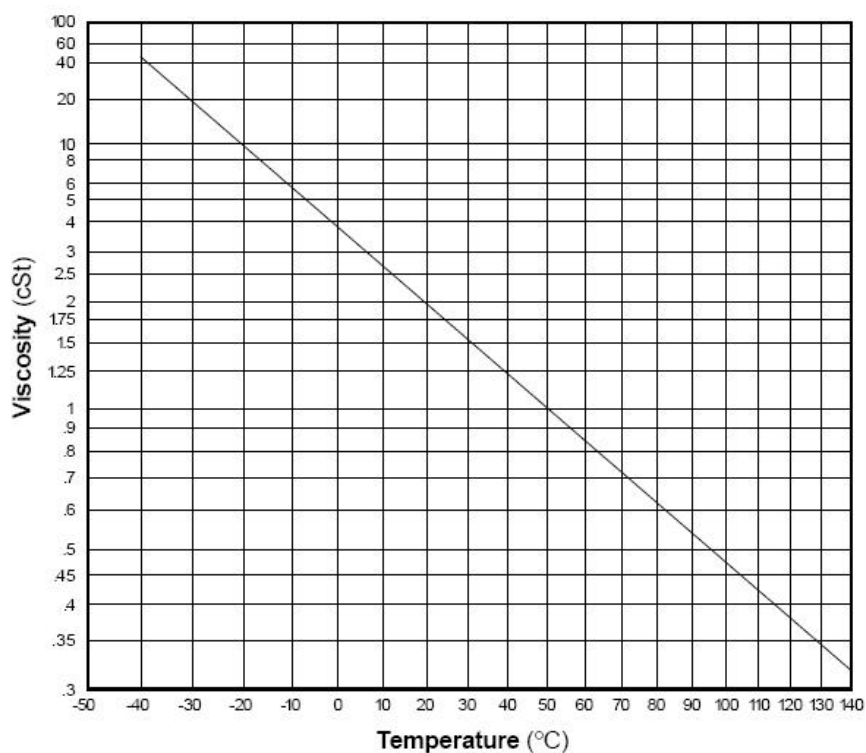
$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.067 - 0.000069 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1903 - 2.15 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.384 - (2310/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-40 over the indicated temperature range.

**Fluorinert Liquid FC-40
Viscosity (cSt) vs. Temperature (°C)**



3M™ Fluorinert™ Electronic Liquid FC-40 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-40 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-40 is non-irritating to the eyes and skin, and is practically non-toxic orally. The product also demonstrates very low acute and sub-chronic inhalation toxicity, and it is not a mutagen (ames). A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-40 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-40 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-40, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-40 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-40 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-40 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-40 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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.



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Product Information

Fluorinert™ Electronic Liquid FC-3283

Introduction

3M™ Fluorinert™ Electronic Liquid FC-3283 is a clear, colorless, thermally stable, fully-fluorinated liquid ideal for use in many single phase heat transfer applications in the semiconductor manufacturing industry. Its liquid range (-50°C to 128°C) makes it ideal for a variety of applications such as etchers, ion implanters, testers and others. Because Fluorinert liquid FC-3283 is primarily a single compound, its composition will not shift or fractionate with time. This keeps fluid loss to a minimum and insures that transport properties will not change with time.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-3283
Appearance	Clear, colorless
Average Molecular Weight	521
Boiling Point (1 atm)	128°C
Pour Point	-50°C
Vapor Pressure	1.44 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	78 J/g
Liquid Density	1820 kg/m ³
Kinematic Viscosity	0.75 centistokes
Absolute Viscosity	1.4 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.066 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0014 °C ⁻¹
Water Solubility	7 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-3283 Electrical Properties

Properties	FC-3283
Dielectric Strength	43 kV, 0.1" gap
Dielectric Constant	1.89
Electrical Resistivity	5×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-3283 at various temperatures.

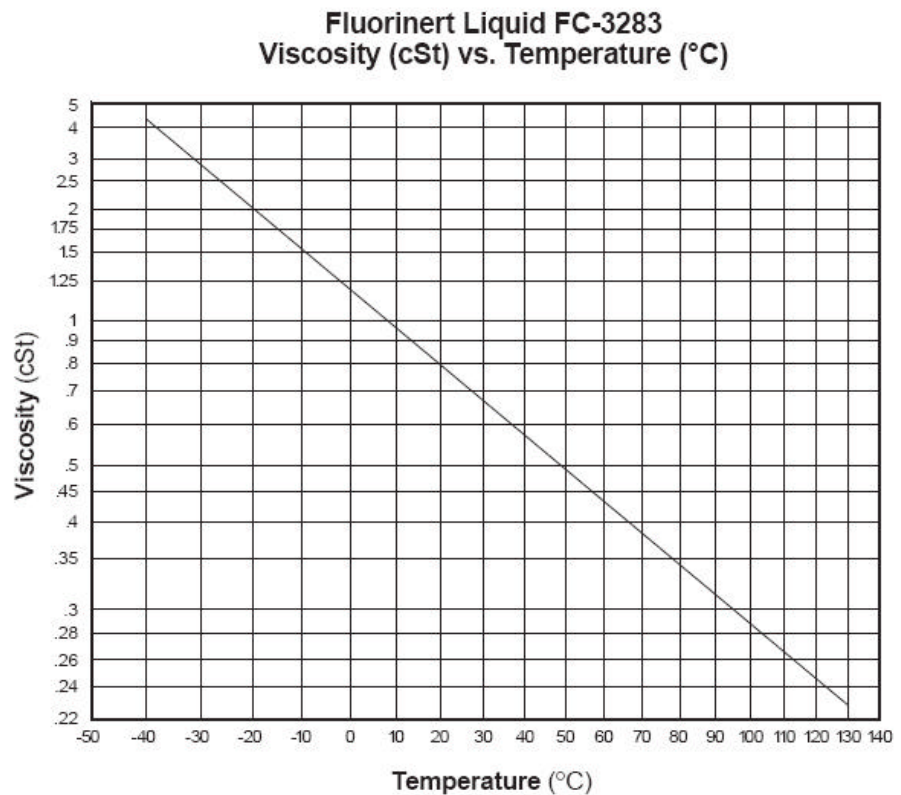
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.065 - 0.000056 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1878 - 2.455 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.237 - (2110/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-3283 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-3283 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-3283 liquid is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-3283 is non-irritating to the skin, minimally irritating to the eyes upon contact, and is practically non-toxic orally. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-3283 liquid is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-3283 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert FC-3283 liquid, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-3283 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-3283 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-3283 customers are supported by global sales, technical and customer sales resources, with fully staffed 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.

North America

3M Specialty Materials
800 810 8513
800 810 8514

Europe

3M Belgium N. V.
32 3 250 7521

Canada

3M Canada Company
800 364 3477

Japan

Sumitomo 3M Limited
81 3 3709 8250

Korea

3M Korea Limited
82 2 3771 4114

Malaysia

3M Malaysia Sdn. Berhad
60 3 706 2888

Singapore

3M Singapore Pte. Ltd.
65 454 8611

Taiwan

3M Taiwan Limited
886 2 2704 9011

China

3M China Limited
86 21 6275 3535

Other Areas

651 736 7123 (U.S.)

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 have been defective when you received 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.



3M Specialty Materials

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www.3m.com/fluids

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Fluorinert™

Electronic Liquid FC-70

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-70 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-70 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes Fluorinert liquid FC-70 ideal for many electronics applications, including vapor phase soldering and thermal management.

An ideal fluid for use in condensation reflow soldering, the saturated vapor generated from boiling Fluorinert liquid FC-70 is very dense and easily contained. The elimination of oxygen allows for use of mild flux compounds, simplifying the cleaning of finished circuit boards.

Other uses for Fluorinert liquid FC-70 include heat transfer, electronics testing and inert reaction media.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-70
Appearance	Clear, colorless
Average Molecular Weight	820
Boiling Point (1 atm)	215°C
Pour Point	-25°C
Estimated Critical Temperature	608 K
Estimated Critical Pressure	1.03 x 10 ⁶ pascals
Vapor Pressure	15 pascals
Latent Heat of Vaporization (at normal boiling point)	69 J/g
Liquid Density	1940 kg/m ³
Kinematic Viscosity	12 centistokes
Absolute Viscosity	24 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.070 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0010 °C ⁻¹
Surface Tension	18 dynes/cm
Refractive Index	1.303
Water Solubility	8 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-70 Electrical Properties

Properties	FC-70
Dielectric Strength	40 kV, 0.1" gap
Dielectric Constant	1.98
Electrical Resistivity	2.3×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-70 at various temperatures.

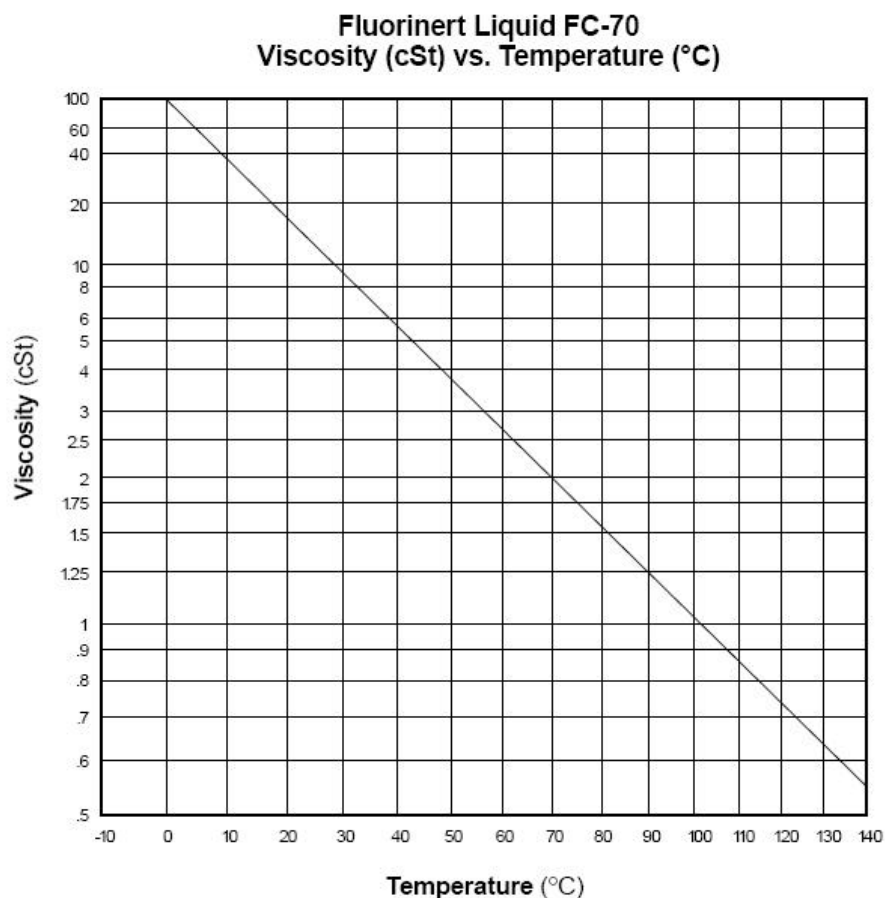
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.07 - 0.00001 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1984 - 1.93 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 11.211 - (2939/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-70 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-70 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-70 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-70 is non-irritating to the eyes and skin, and is practically non-toxic orally. The product also demonstrates very low acute and sub-chronic inhalation toxicity. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-70 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-70 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-70, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-70 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-70 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-70 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-70 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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.



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Fluorinert™

Electronic Liquid

FC-72

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-72 is a clear, colorless, fully-fluorinated liquid. Like other Fluorinert electronic liquids, Fluorinert liquid FC-72 is thermally and chemically stable, compatible with sensitive materials, nonflammable, practically non-toxic and leaves essentially no residue upon evaporation. This unique combination of properties makes Fluorinert liquid FC-72 ideal for many electronics applications, including quality and reliability testing.

Fluorinert liquid FC-72 conforms to Military Specification 883 as a detector fluid in a vacuum/pressure vessel used in gross leak testing. Its inert nature makes FC-72 liquid a useful reaction medium.

Physical Properties

Not for specification purposes

All values determined at 25°C unless otherwise specified

Properties	FC-72
Appearance	Clear, colorless
Average Molecular Weight	338
Boiling Point (1 atm)	56°C
Pour Point	-90°C
Estimated Critical Temperature	449 K
Estimated Critical Pressure	1.83 x 10 ⁶ pascals
Vapor Pressure	30.9 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	88 J/g
Liquid Density	1680 kg/m ³
Kinematic Viscosity	0.38 centistokes
Absolute Viscosity	0.64 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.057 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.00156 °C ⁻¹
Surface Tension	10 dynes/cm
Refractive Index	1.251
Water Solubility	10 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-72 Electrical Properties

Properties	FC-72
Dielectric Strength	38 kV, 0.1" gap
Dielectric Constant	1.75
Electrical Resistivity	1.0×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity and density of 3M™ Fluorinert™ Electronic Liquid FC-72 at various temperatures.

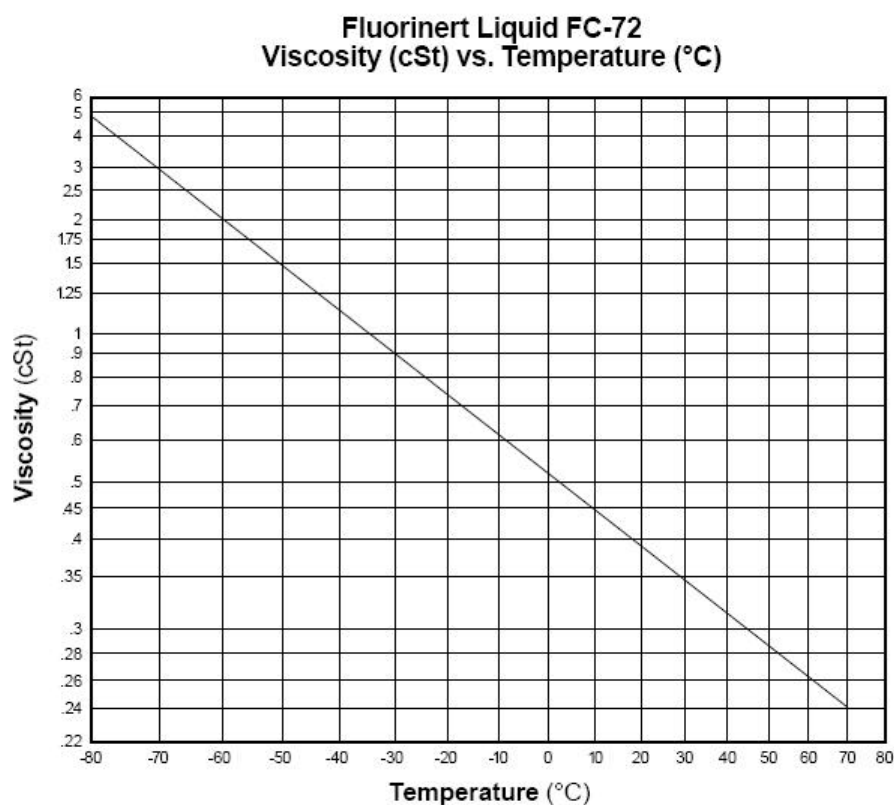
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.060 - 0.00011 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3) = 1740 - 2.61 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 9.729 - (1562/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-72 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-72 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-72 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-72 is non-irritating to the eyes and skin, and is practically non-toxic orally. The product also demonstrates very low acute and sub-chronic inhalation toxicity. It is not a mutagen (ames) or a cardiac sensitizer. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-72 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-72 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-72, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-72 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

3M™ Fluorinert™ Electronic Liquid FC-72 Used Fluid Return Program

3M offers a program for free pickup and return of used 3M Specialty Materials in the U.S. through Safety-Kleen Corporation. A pre-negotiated handling agreement between users and this 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 Materials is required for participation in this free program.

Safety-Kleen Corporation has a network of 156 branch service centers in the U.S. This large fleet will provide timely, economical fluid disposal service.

For additional information on the 3M Used Fluid Return Program, contact Safety-Kleen Corporation at this toll-free line: 1.888.932.2731.

Resources

3M™ Fluorinert™ Electronic Liquid FC-72 customers are supported by global sales, technical and customer sales resources, with fully staffed 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 other 3M global offices and additional information on Fluorinert electronic liquid FC-72 in the U.S., call 3M Performance Materials, 800.833.5045, or visit our web site at: www.3m.com/fluids

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 Materials

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St. Paul, MN 55144-1000

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Fluorinert™

Electronic Liquid

FC-3284

Product Information

Introduction

3M™ Fluorinert™ Electronic Liquid FC-3284 is a clear, colorless, thermally stable, fully-fluorinated liquid ideal for use in many single phase heat transfer applications in the semiconductor manufacturing industry. Its liquid range (-73°C to 50°C) makes it ideal for a variety of applications such as etchers, ion implanters, testers, rectifiers and others. Because Fluorinert liquid FC-3284 is primarily a single compound, its composition will not shift or fractionate with time. This keeps fluid loss to a minimum and insures that transport properties will not change with time.

Physical Properties

Not for specification
purposes

All values determined
at 25°C unless
otherwise specified

Properties	FC-3284
Appearance	Clear, colorless
Average Molecular Weight	299
Boiling Point (1 atm)	50°C
Pour Point	-73°C
Estimated Critical Temperature	434 K
Vapor Pressure	35.7 x 10 ³ pascals
Latent Heat of Vaporization (at normal boiling point)	105 J/g
Liquid Density	1710 kg/m ³
Kinematic Viscosity	0.42 centistokes
Absolute Viscosity	0.71 centipoise
Liquid Specific Heat	1100 J kg ⁻¹ °C ⁻¹
Liquid Thermal Conductivity	0.062 W m ⁻¹ °C ⁻¹
Coefficient of Expansion	0.0016 °C ⁻¹
Refractive Index	1.266
Water Solubility	14 ppmw
Solubility in Water	<5 ppmw
Ozone Depletion Potential	0

3M™ Fluorinert™ Electronic Liquid FC-3284 Electrical Properties

Properties	FC-3284
Dielectric Strength	40 kV, 0.1" gap
Dielectric Constant	1.86
Electrical Resistivity	7×10^{15} ohm cm

Heat Transfer Properties

The following formulas can be used to calculate the specific heat, thermal conductivity, density and vapor pressure of 3M™ Fluorinert™ Electronic Liquid FC-3284 at various temperatures.

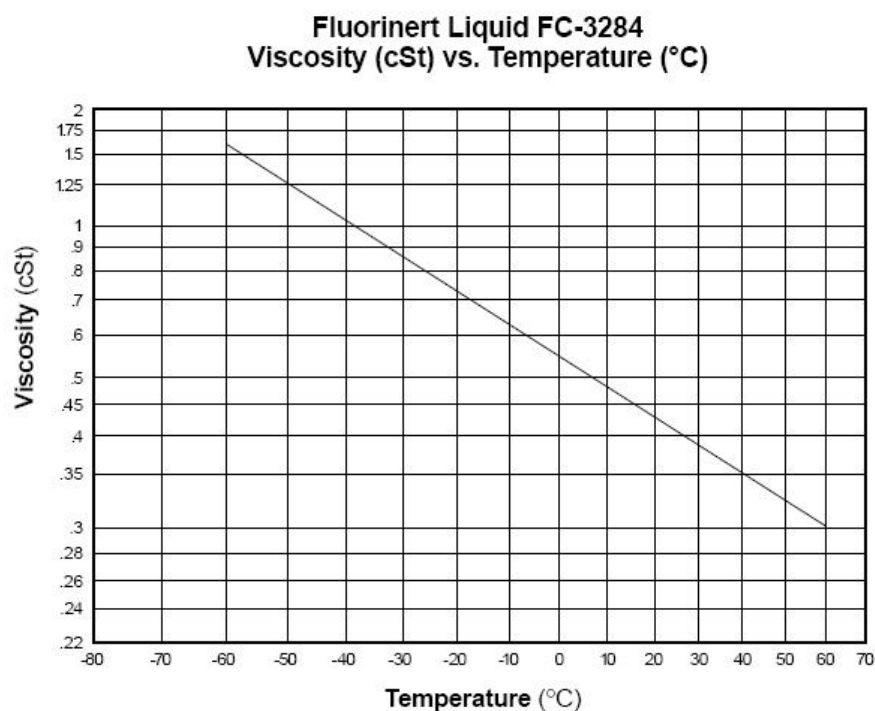
$$\text{Specific Heat (J kg}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 1014 + 1.554 (T, ^{\circ}\text{C})$$

$$\text{Thermal Conductivity (W m}^{-1} \text{ }^{\circ}\text{C}^{-1}) = 0.065 - 0.00013 (T, ^{\circ}\text{C})$$

$$\text{Density (kg/m}^3\text{)} = 1776 - 2.65 (T, ^{\circ}\text{C})$$

$$\text{Log}_{10}(\text{Vapor Pressure (pascals)}) = 10.062 - (1643/(T, \text{K}))$$

The following graph can be used to determine the viscosity of Fluorinert liquid FC-3284 over the indicated temperature range.



3M™ Fluorinert™ Electronic Liquid FC-3284 Materials Compatibility

3M™ Fluorinert™ Electronic Liquid FC-3284 is compatible with most metals, plastics and elastomers.

Toxicity Profile

Fluorinert liquid FC-3284 is non-irritating to the skin, minimally irritating to the eyes and is practically non-toxic orally. The product also demonstrates very low acute and sub-chronic inhalation toxicity, and is not a cardiac sensitizer. A Material Safety Data Sheet is available upon request.

Safety and Handling

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. Fluorinert liquid FC-3284 is nonflammable, and is highly resistant to thermal breakdown and hydrolysis in storage and during use. Recommended handling procedures are given in the Material Safety Data Sheet.

Environmental Properties

Fluorinert liquid FC-3284 has zero ozone depletion potential. The material is exempt from the U.S. EPA and most State definitions of a volatile organic compound (VOC), and does not contribute to ground-level smog formation.

Fluorinert liquid FC-3284, a perfluorocarbon (PFC), has a high global warming potential and a long atmospheric lifetime. As such, it should be carefully managed so as to minimize emissions.

3M recommends that users of FC-3284 liquid 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.

Environmental Policy

3M will recognize and exercise its responsibility to:

- prevent pollution at the source wherever and whenever possible
- develop products that will have a minimal effect on the environment
- conserve natural resources through the use of reclamation and other appropriate methods
- assure that its facilities and products meet and sustain the regulations of all Federal, State and local environmental agencies
- assist, wherever possible, governmental agencies and other official organizations engaged in environmental activities

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