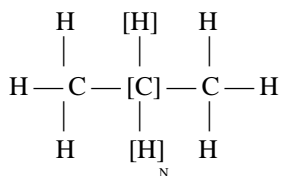




## Introduction to Silicone Fluids

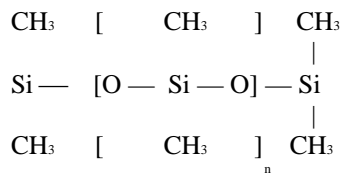
<p>Clearco Silicones offers a complete line of silicone fluids, which have a combination of properties that give superior performance in a wide variety of applications.</p> <p><b>Unique Chemical Structure</b> In chemical structure, Polydimethylsiloxane or PDMS silicone fluids are quite different from all other fluids. Where organic hydrocarbon fluids are based on a backbone of carbon-to-carbon atoms, silicone fluids have a backbone of silicon-oxygen linkages similar to the Si-O linkages in high-temperature inorganic materials such as quartz, glass and sand. This molecular backbone is much stronger than the typical carbon-to-carbon chain and is more resistant to attack by temperature extremes, oxidation, shear stresses and chemicals. See sample structures at the bottom of this page.</p> <p><b>Unique Combination of Properties</b> This chemical structure gives silicone fluids a profile of properties, which permits them to perform in applications where other fluids would not be suitable. Some of the outstanding properties shared by most silicone fluids are:</p> <p><b>Low-Viscosity-Temperature Change</b> All fluids show some degree of change in viscosity with temperature change, but silicone fluids exhibit a much smaller degree of change over a wider temperature range than non-silicone fluids.</p>	<p><b>Wide Temperature Range</b> Low temperature limits and high temperature capabilities of silicone fluids far surpass those of conventional fluids.</p> <p><b>Thermal Stability</b> Silicone fluids show excellent stability when exposed to high temperatures for extended periods of time.</p> <p><b>Oxidation Stability</b> The oxidation stability of silicone fluids is excellent. Absence of copper-induced oxidation is especially important and contrasts with the sludging that occurs with mineral oils, especially at high temperatures.</p> <p><b>Chemical Inertness</b> Silicone fluids are chemically inert to most common materials of construction.</p> <p><b>Low Flammability</b> Flash points in the range of 205°C to 260°C (400°F to 500°F) and auto-ignition temperatures in the range of 438°C to 460°C (820°F to 860°F) are typical for PDMS silicone fluids with viscosity &gt; 50cSt.</p> <p><b>Low Surface Tension</b> Silicone fluids have unusually low surface tensions, which help provide easy and efficient spreading, high surface activity and low internal cohesive energies. Lower viscosities provide lower surface tensions than higher viscosities.</p> <p><b>Compressibility</b> Silicone fluids of 10 centistokes or more exhibit compressibility of 1.34% at pressures of 2,000 psi at room temperature. Lower viscosities exhibit higher compressibility than higher viscosities.</p>	<p><b>Shear Stability</b> Silicone fluids have unusually high resistance to breakdown by mechanical shearing. The shear stability of silicone fluids can be as much as twenty times that of quality petroleum oils, providing longer life at higher speeds and loadings.</p> <p><b>Thermal Conductivity</b> The thermal conductivity of silicone fluids over a wide temperature range is comparable to hydrocarbon fluids.</p> <p><b>Dielectric Properties</b> Electrical grade silicone fluids offer excellent dielectric properties, which are maintained for prolonged periods, even under adverse operating conditions.</p> <p><b>Non-Corrosive</b> Silicone fluids contain no acid producing chemicals to cause staining or corrosion.</p> <p><b>Food Grade Silicone Fluid</b> Clearco PSF-350cSt is registered with the NSF/USDA as an H1 lubricant for incidental contact in food processing and food packaging applications.</p> <p>All of these properties are found in the basic family of dimethyl silicone fluids, which are available in a wide range of viscosities.</p> <p>To meet other specific application needs, Clearco Silicones provides additional silicone fluids.</p>
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### Organic Fluid



(Hydrocarbon Polymer)

### Silicone Fluid



(Polydimethylsiloxane)

<p><b>Damping Fluids</b> (Meets VV-D-1078) Aircraft Instruments Dashpots Gyros Meters Shock Absorbers Time Delay Relays Timing Devices Torsional Vibration Dampers Diff Oils for motorized cars</p> <p><b>Thermal Bath Fluids</b> (open and closed systems) High temperature baths Low temperature baths Heaters/Chillers</p> <p><b>Power Transmission</b> Controlled Speed Devices Fluid Clutches Hydraulic Systems</p> <p><b>Heat Transfer</b> Heating Baths Heat Exchangers Low Temperature Baths Thermostats</p> <p><b>Liquid Springs and Shock Absorbers</b> Missile Suspension Systems Railroad Cars Trucks</p> <p><b>Polishes</b> Boat Polish Car Polish Furniture Polish Metal Cleaners Vinyl Polish Window Cleaners</p> <p><b>Cosmetics and Pharmaceuticals</b> Anti Perspirants Deodorants Hand Creams and Lotions Hair Sprays Lipstick Make-up or Color Cosmetics Process Aids for Anti- biotic Preparations Shampoos and Conditioners Shaving Creams Sterilization Baths Treatment of Vials and Syringes</p> <p><b>Rust Prevention</b> Decorative Ware Gun Oils Metal Cleaners</p>	<p><b>Calibration Fluids</b> Flow tests Calibration tests Process flow modeling</p> <p><b>High Shear Applications</b></p> <p><b>Hydraulic Fluids</b> Constant Speed Devices Engine Controls High Temperature Plastic Forming Missile and Space Vehicles Systems Naval Hydraulics Systems Supersonic Aircraft</p> <p><b>Dielectric Fluid</b> Capacitors Klystrons Magnetrons Microwave Tubes Power Rectifiers Radar Equipment Transformers (STO-50)</p> <p><b>Release Agents</b> Automobile and Truck Tires Fan Belts Molding Ingot Mold Wash Plastics Rubber Mats Shell Mold and Core Molding Shoe Heels and Soles Wire and Cable Slip Agent</p> <p><b>Water Repellents</b> Textile Underarm Dress Shield</p> <p><b>Antifoams</b> Aromatic Scrubbing, Asphalt High Detergent Motor Oils Petroleum Defoamers</p> <p><b>Paint and Coating Additives</b> Defoaming Natural Gum and Synthetic Resin Varnishes Elimination of Blocking High Gloss Paints Improved Pigment Dispersion Improved Slip or Release Characteristics</p>	<p><b>Lubricants</b> Base Fluids for Greases O-Ring lubricant Rubber and Plastic Parts Plastic-to-plastic Plastic-to-metal Plastic-to-foam Lubrication Gasket lubricant Valve lubricant</p> <p><b>Textile Finishing</b> Thread Lubes Softeners Water Repellants</p> <p><b>Anti-blocking Agents</b> Paper Sheet Plastic Sheet Rubber Wax Cartons for Foods</p> <p><b>EDM Coolants</b></p> <p><b>Food Packaging</b> Anti-blocking Dry Foods Meats Paper Plates Lubricant for foam and saran Prevents sugar build- ups</p> <p><b>Food Processing</b> Antifoaming Dry Food Release</p> <p><b>Particle Treatments</b> Dyes Fillers Fire Extinguisher Particles Pigments</p> <p><b>Rubber and Plastic Additives</b> Elimination of Blocking Extrusion Aids Internal Release Agents Plasticizers</p> <p><b>Photography</b> Projector Lubricant Repair Scratched Negatives</p> <p><b>Gas Chromatography</b> Stationary Phase</p>	<p>Clearco Silicones offers a complete line of silicone fluids in a wide viscosity range to provide maximum latitude in selecting the specific silicone fluid to meet the requirements of a particular industrial, military or consumer application. While it is difficult to recommend the use of any one fluid for an application, this publication lists various applications and indicates the Clearco silicone fluids most frequently used. Generally speaking, it is best to evaluate several possible silicone fluids to determine which will provide the optimum performance in an application. Listed below are descriptions of the commonly used Clearco silicone fluids with examples of the types of applications for which the fluids are designed.</p> <p><b>DIMETHYLS (Polydimethylsiloxanes/ PDMS Silicone Oils)</b></p> <p><b>PSF Fluids (0.65cSt to 2,5 million cSt)</b> Clearco Pure Silicone Fluids are Polydimethylsiloxane Fluids / PDMS Silicone Oils. They are clear, oily fluids; inert, tasteless, and odorless. PSF fluids are available in the viscosity range from 0.65 to 2.5 million cSt. (Viscosities measured at 25C /77F). The actual viscosity is controlled within ±5 percent of the nominal viscosity in the grades of 50 centistokes or higher. The unique combination of properties associated with the PSF fluids makes them suitable for plastic and rubber lubrication, as dampening or heat transfer fluids, as thermal bath fluids, high shear fluids, dielectric applications, and as an oil defoamer. These fluids are also used in chemical specialties, antifoams, paint additives and other similar applications.</p> <p><b>Low Viscosity Fluids (0.65cSt to 20cSt)</b> Low Viscosity Fluids range from 0.65cSt to 20cSt. They are characterized by low molecular weights, low surface tension, volatility (viscosities below 5cSt), high compressibility and excellent low temperature performance. They are often used as base fluids in a wide array of cosmetic ingredients. Other applications include damping applications and low temperature bath fluids.</p> <p><b>High Viscosity Silicones (5,000cSt +)</b> Hi-Viscosity Silicone Fluids are clear, colorless, &amp; Odorless PDMS Silicone Oils / Polydimethylsiloxane fluids with no suspended particulate matter. They are inert, tasteless and odorless. The Hi-Viscosity fluids are available in standard viscosity grades of 5,000, 10,000, 12,500, 30,000, 60,000, 100,000, 300,000, 600,000, 1million and 2million cSt @ 25C (77F). Hi-Viscosity fluids are characterized by relatively small changes in viscosity over a wide temperature range. They have good oxidative stability, high chemical inertness and resistance to breakdown under mechanical shearing. Hi-Viscosity fluids are especially useful for linear and torsional dampeners, viscous drive clutches, speed control devices, liquid springs, dash pots, rubber and plastic lubricants, timing devices, and are the base fluids for silicone compounds.</p> <p><b>Standard Viscosities (50, 100, 200, 350, 500 &amp; 1,00cSt)</b> Like the Low and High viscosities, the Standard viscosities are 100\$ PDMS Silicone Oils / Polydimethylsiloxane Fluids that offer a wide range of thermal stability, high resistance to shear, high oxidative resistance, and low viscosity change from temperature. They are excellent fluids to be used in damping, shearing and thermal applications.</p>
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**Pure Silicone Fluid 350cSt (food grade) NSF H1 Registered**

PSF-350cSt (food grade) is a clear, colorless and odorless Polydimethylsiloxane / PDMS Silicone Oil with a viscosity of 350cSt @ 25C. The PSF-350cSt is registered with the NSF/USDSA as an H1 lubricant for use in food processing and food packaging applications where incidental contact with food may occur. It is also approved as an antifoam agents contributing no more than 10 ppm of the fluid to food, other than milk and articles intended for the feeding of infants and invalids.

**STO-50 Silicone Transformer Oil**

Chemically, the STO-50 fluid is identical to the PSF fluids, but has been specially processed and controlled to meet electrical grade specifications. It has a viscosity of 50 centistokes fluid at 25C (77F). The actual viscosity is controlled within ±5 percent of the nominal viscosity. The unique properties of STO-50 electrical grade silicone fluid extend its capabilities beyond those of conventional dielectric fluids. This makes the fluid suitable for use in capacitors, pulse transformers, specialty transformers, air-borne and land based radar equipment, television circuit components and in systems where heat transfer properties are as necessary as dielectric behavior.

**PHENYLS**

**Extreme Temperature Fluids –**

Even greater high-temperature resistance has been added by the incorporation of phenyl groups in the silicone molecule. By replacing methyl groups with phenyl groups, temperature stability is increased to 250C (open system) and short periods at 300C.

**PM-125 Phenylmethyl Silicone**

PM-125 is a hi-content phenylmethyl silicone that is a clear, light straw colored liquid which possesses significantly better heat stability than conventional PDMS Silicone Oils. This outstanding heat resistance is combined with low volatility and high flash point to provide a normal useful service temperature range of -25°C to 250°C.

PM-125 is an excellent choice for high temperature heat transfer applications or as a base fluid in high temperature greases. In comparison to PDMS Silicone Oils / dimethyl silicones, it also exhibits better lubricity for metal-to-metal applications, higher resistance to oxidative attack, and a higher refractive index for optical applications.

**PPM-500 (100% Phenylmethyl Silicone)**

PPM-500 is a 100% phenylmethyl silicone that possesses the highest thermal stability. With 100% phenyl content, it has a higher Refractive Index of 1.533 for optical applications.

**Phenyl Silicone Applications include:** high temperature bath fluids, dielectric coolants for high temperature ultra-sonic coupler, high temperature heat bath and oxide protector for solder baths, hydraulic arrestors, valves and instruments in nuclear power plants.

**Clearco PSF Fluids  
(Polydimethylsiloxane Fluids)  
Viscosity Correlation to Molecular Weight**

Product	Viscosity (cst)	Molecular Weight
PSF	0.65	162
PSF	1	237
PSF	1.5	340
PSF	2	410
PSF	3	550
PSF	5	770
PSF	10	1,250
PSF	20	2,000
PSF	50	3,800
PSF	100	5,970
PSF	200	9,430
PSF	350	13,700
PSF	500	17,300
PSF	1,000	28,000
PSF	5,000	49,300
PSF	10,000	62,700
PSF	12,500	67,700
PSF	30,000	91,700
PSF	60,000	11,6500
PSF	100,000	139,000
PSF	300,000	204,000
PSF	600,000	260,000
PSF	1,000,000	308,000
PSF	2,500,000	423,000

**COSMETIC GRADE SILICONES**

Clearco Polydimethylsiloxane Fluids are classified under INCI (International Nomenclature for Cosmetic Ingredients) as Diemthicones and are used in a variety of skin creams, gels, hair conditioners and other personal care products.

**Cyclomethicones (Volatile Cyclic Silicones)  
Cyclo-2244 (D4), Cyclo-2245 (D5) & Cyclo-2345 (D5/D6 blend)**

Cyclomethicones are unmodified silicones that possess a cyclical structure rather than the chain structures of dimethyl silicones. Low heat of vaporization and the ability to select a desired vapor pressure has led their use as cosmetic vehicles

**Cyclo-2244 fluid** is primarily octamethyl-cyclotetrasiloxane (Tetramer) (D4)  
INCI Name: Cycotetrasiloxane

**Cyclo-2245 fluid** is primarily decamethyl-cyclopentasiloxane (D5)  
INCI Name: Cyclopentasiloxane

Non-polar and insoluble in water, these silicone fluids are completely miscible in the lower alcohols as well as in typical aliphatic, aromatic, and halogenated hydrocarbon solvents.

**Cyclomethicones (cont'd)**...due to these properties, they are used as base fluids in a wide array of cosmetic products such as antiperspirants, deodorants, hair sprays, cleansing creams, skin creams, lotions and stick products, bath oils, suntan and shaving product, make-up and nail products

**Cyclomethicones also come under the classification of "Volatile Fluids":** For those applications where volatility is desirable, the volatile cyclics should be used. The PSF-0.65cSt (hexamethylsiloxane) is a linear silicone that exhibits similar volatility characteristics to the cyclomethicones.

**METHYL ALKYL**

**Outstanding Lubricants, "Paintable" Fluids  
Clearco Pure Paintable Silicone**

The MAPR-L Paintable Silicone Fluid is used in lubricating, die cast and release applications. This fluid is useful in applications requiring paintability and in areas where prevention of secondary paint contamination should be avoided. MAPR-L is also found useful as an internal mold release agent in vinyl slush molding applications, and as an aluminum die cast mold release agent.

**Silicone Grease (PDMS Silicone Compound)**

**Clearco Silicone Grease 3005 (food grade)** is an NLGI II grease-like material containing pure polydimethyl silicone fluid and inert silica filler. It is used in a wide range of applications that require...good thermal stability, high dielectric strength, inertness, corrosion and moisture resistance, low odor, and areas that require good lubricating properties over long periods without drying out. Silicone Grease 3005 is compatible with virtually all O-Ring and Valve materials, including: Aflas, Chemraz, Nitrile, Hydrogenated, Polyurethane, Styrene Butadene, Buna-N (Nitrile), Natural Rubber, Polyurethane, Teflon, Butyl, and Neoprene.

## PROPERTIES

**Weight Loss at Atmospheric Pressure:** The weight loss of silicone fluids is determined in a forced air-circulating oven at atmospheric pressure. The dimethyl fluids are conventionally measured after exposure at 150°C (302°F) for 24 hours. Phenyl fluids, such as PM-125 & PPM-500, may also be measured by this test, although higher temperatures are frequently employed. At very high temperatures, the loss in simple volatiles is compounded by some oxidative effects.

### SPECIFIC HEAT

Specific heat of most silicone fluids falls in the 0.36 to 0.39 BTU/lb./F range at room temperature.

### DIELECTRIC PROPERTIES

STO-50 electrical grade fluid is a dimethyl silicone fluid processed to provide outstanding dielectric properties. Because of the basic properties of silicone fluids, these electrical properties are maintained for prolonged periods and under adverse operating conditions.

### LUBRICATION PROPERTIES

The dimethyl, methyl alkyl and phenyl fluids are outstanding lubricants suitable for many severe applications at temperatures from -73°C to 232°C (-100F to 450F).

The dimethyl and phenyl silicone fluids are generally not recommended as metal-to-metal lubricants. They lack the lubricity required for most mechanical applications involving sliding friction, although phenyls possess better metal-to-metal lubricity than dimethyls.

On the other hand, dimethyl fluids are the best lubricants in rubber or plastic-to-metal applications.

### SHEAR CHARACTERISTICS

The viscosity of a fluid is defined as the ratio of shear stress to shear rate. In the ideal, or Newtonian fluid, this ratio is constant and is independent of the shear rate. In a non-Newtonian fluid, the ratio is not constant and the apparent viscosity at high shear rates is less than the true viscosity.

The dimethyl fluids (Pure Silicone Fluids) approach Newtonian behavior. The lower the viscosity, the more nearly Newtonian the fluid.

The apparent lowering in viscosity or pseudo-plastic flow at high shear rates of dimethyl silicones is a transitory condition as the fluids will return to their original nominal viscosity on cessation of shear.

Many organic fluids show a drop in nominal viscosity after prolonged shearing action. This is a permanent loss in viscosity resulting from poor shear stability and is different from the recoverable drop in viscosity demonstrated by silicone fluids. The permanent viscosity change results from the molecules being torn apart by the mechanical action. Silicones show extremely good shear stability and retain their original viscosity characteristics as they are not affected by mechanical working

### OXIDATION STABILITY

In the presence of air, oxidation stability becomes an important factor in the high temperature performance of silicone fluids. In oxidative break-down, oxygen reacts with the organic groups of the molecules causing fluids to lose volatiles and increase in viscosity until gelation occurs. The reaction is dependent on the temperature and supply of air.

### Oxidation Threshold

Oxidation Threshold is defined as the temperature at which a significant amount of oxidation by-products start to appear. Below this temperature, some oxidation will occur which will not adversely affect the useful life of the silicone fluids.

The following table compares the Oxidation Threshold of several silicone and organic fluids. This information is offered for comparison purposes only with the suggestion that user perform his own appropriate tests.

FLUID	Oxidation Threshold, Temp °C (°F)
PM-125	271 (520)
PSF Fluids (+100cSt)	204 (400)
Dibasic Acid Ester	66 (150)
Petroleum Oil	66 (150)

### THERMAL STABILITY

In the absence of air, silicone fluids show excellent stability when exposed to high temperatures for long periods of time. In sealed systems or in an inert atmosphere, such as nitrogen or carbon dioxide, high temperatures above their thermal activation points can break the bonds linking silicon and oxygen in the silicone fluid to form lower molecular weight volatile silicones. The activation point for dimethyl fluids is about 316C (600F), and for phenyl-containing fluids it is slightly higher. The useful life of silicone fluids under non-oxidative conditions below their thermal activation points continues for many hundreds of hours.

### TYPICAL GEL TIMES, HOURS

FLUID	149°C (300°F)	204°C (400°F)	232°C (450°F)	260°C (500°F)
PSF- 100cSt	Approx 1-year	250 to 300	40 to 60 hours	20 to 25 hours
PSF- 1,000cSt	Approx 1- year	175 to 225	20 to 30	<15
PSF- 10,000cSt	Approx 1- year	100 to 120	15 to 20	<10

The degradation products that form at or near the thermal activation temperature are completely compatible with the base polymer. In a sealed system, a decrease in overall nominal viscosity is usually experienced when thermal degradation produces low molecular weight fractions, which lower the average molecular weight of the silicone fluid. An increase in vapor pressure in sealed systems results from the formation of volatile silicones.



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