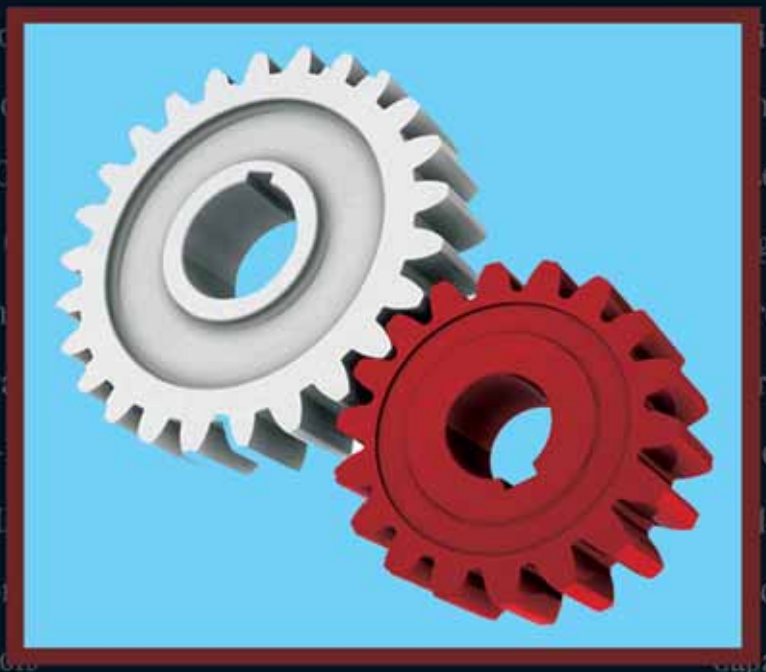

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SILICONE FLUIDS Property Profile Guide

		Comment	Conventional Silicone Fluids
Thermal Properties	High Temp °C	1,000 hours in air, max.	175°
	High Temp °C	indefinite O_2 free, max.	200°
	Low Temp °C	pour point, low value	-70°
Rheological Properties	Viscosity, cSt.	range	3 - 2.5 x 10^6
	Visc.-temp. coeff.	low value	0.51
Electrical Properties	Dielectric Strength volts/mil	range	360-400
	Dielectric Constant	range, 100Hz	2.50-2.77
Mechanical Properties	Compressibility, %	@ 20,000 psi	9.1
	Density, g/cc		0.90-0.98
Compatibility Properties	Water solubility		insoluble
	Hydrocarbon solubility	aromatic/ aliphatic	soluble/ partial
Optical Properties	Refractive Index n_D^{25}	range	1.393-1.403
Release & Wettability Properties	Surface Tension, dynes/cm	range	19.2-21.6
Wear/Lubricity Properties	Four ball wear, mm at 75°C, 40 kg. load steel on steel, one hr.		2-3

Notes:
All data on this table are for comparative purposes. The classes of fluids have a range of properties that do not represent the performance of an actual fluid.

Values reported for fluids including the paraffin hydrocarbon oil are without additives such as EP agents or stabilizers.

Page 16 Thermal Silicone Fluids	Page 18 Organic Compatible Silicone Fluids	Page 20 Fluorosilicone Fluids	Page 21 Hydrophilic and Polar Silicone Fluids	Page 23 Low Temperature Silicone Fluids	Typical Hydrocarbon (Paraffin) Fluids
260°	150°	190°	135°	235°	130°
280°	—	230°	—	260°	—
-73°	-50°	-47°	-50°	-100°	-30°
50 - 3.0×10^5	500 - 1×10^4	80 - 1×10^4	20-5,000	4-400	—
0.61	0.75	0.84	—	0.5	—
400-420	—	175-200	—	300-400	—
2.78-2.95	2.5-3.0	6.95-7.35	—	—	—
5.5	approx. 5-8	7.5	approx. 7	11.9	4.4-4.9
0.98-1.15	0.88-1.04	1.25-1.30	1.00-1.07	0.76-1.09	0.8-0.9
insoluble	insoluble-partial	insoluble	insoluble-soluble	insoluble	insoluble
soluble/soluble	soluble/soluble	insoluble/insoluble	partial/insoluble	soluble/soluble	soluble/soluble
1.428-1.582	1.443-1.493	1.336-1.387	1.441-1.454	1.335-1.588	1.410-1.430
20.5-28.5	22.0-39.5	25.7-28.7	23.6-27.0	15.9-26.7	21-28
1.8-2.5	0.7	0.8	2-6	0.9-2.5	0.7

TABLE OF CONTENTS

SILICONE FLUIDS
Stable Inert Media

An introduction to silicone fluids and their uses

Silicone fluids have unique properties because they are not products of petroleum or organic chemistry. They were the first, and are still the only, major class of polymers that are products of inorganic chemistry. Silicone fluids consist of a broad range of different materials with the following characteristics:

- Wide Service Temperature Range
- Low Viscosity Changes vs. Temperature
- Thermal Stability
- Low Flammability
- Shear Stability
- Dielectric Stability
- High Compressibility
- Chemical Inertness
- Low Surface Tension
- Low Toxicity

These features have facilitated the adoption of silicones as dielectric, hydraulic, heat transfer, power transmission and damping fluids. They have found applications when incorporated as additives into plastics and rubbers as process and release aids, into coatings for flow and level control and into process streams as antifoams. Other unique properties have led to their introduction in acoustical applications such as ultrasonic sensor and sonar buoys. Light refractive and index matching properties have allowed the use of silicones in fiberoptics and optoelectronics. This proliferation of applications has engendered many improvements and refinements of silicone fluids.

Silicone Fluids can be divided into six general classes:

The conventional fluids, also referred to as polydimethylsiloxanes, exhibit all the properties of the silicone family. The other classes of fluids can be considered modifications of the conventional fluids in which one set of properties has been enhanced, but generally other properties are altered or sacrificed.

DEFINITIONS AND TERMS

Centistoke — A unit of kinematic viscosity, equaling 1 mm^2/sec.

Consistency — The resistance offered by a real fluid to deformation.

Fluid — A substance which undergoes continuous deformation when subjected to sheer stress.

Glass Transition Temperature — The temperature associated with a change from a glass state to a plastic state. For silicones the Tg is usually substantially below room temperature.

Kinematic Viscosity — Differs from viscosity in that it is the measure of volume flow of a liquid, defined as a stoke (St.) A stoke equals 1 $cm.^2$/sec. or $10^{-4}m^2$/sec. A centistoke, cSt. = .01 St. = 1 $mm.^2$/sec. Kinematic viscosity of a liquid (stokes) can be converted to viscosity (poise) by multiplying by the density of the fluid.

Non-Newtonian Fluid — A fluid with consistency which varies as a function of shear stress as well as temperature and pressure.

Pascal-Second — Pa·s, the SI unit for viscosity, equalling 1 kg(m·s) or 10 Poise.

Saybolt Viscosity — A measure of kinematic viscosity. To convert from SSU to St., apply the following formula for SSU > 100: St. = .00220(SSU) − 1.35/t.

Relative Viscosity — For a fluid polymer solution, the ratio of solution viscosity to solvent viscosity at the same temperature; $\mu_r=\mu/\mu_0$.

Viscosity — Constant consistency under fixed pressure and temperature of simple liquids or gases. Perfect or ideal fluids offer no resistance to shear and have zero consistency. Viscosity dimensions are force per area x time. The unit of viscosity is the poise (p.) = 1g/(cm.)(sec.) and is a measure of mass flow of a liquid. One poise is equal to 0.1Pa·s in SI units.

Viscosity-Temperature Coefficient — A measure of the change of fluid viscosity over the temperature range 38°C to 99°C; V.T.C. = 1-(viscosity @99°C/viscosity @ 38°C). Thus, the lower the V.T.C. the less the change in viscosity over the temperature range.

NOTES AND SPECIFICATIONS

Molecular Weights — Reported values are derived from kinematic viscosity measurements and correlate to number average molecular weight. GPC Number average molecular weights for dimethylsiloxanes have been related to polystyrene standards according to Pekala (American Laboratory 15, 4 1983): log Mw PDMS/MwPST = 1.1813 + 0.0769V, where V is retention volume.

Compositional Percentages — All copolymer percentages are mole %; graft and block polymer percentages are weight %.

Viscosities — Reported values for kinematic viscosities for homopolymer fluids are ± 10% for fluids ≤100,000 cSt and ± 15% for fluids>100,000 cSt. Reported viscosities for copolymer fluids are ±20%.

Temperature — When not indicated, reported properties for silicone fluids are at 25°C (298.15°K).

R&D only — Indicates that the product is not registered with the EPA for commercial or industrial use. Products not listed as R&D only are registered for industrial use - TSCA listed.

Silicone Fluid Selection Guide

Selecting a silicone fluid

There are two approaches to selecting the proper silicone fluid for an application. The fluid class can be chosen by comparing specific physical property requirements in the property profile by class chart located inside the front cover or by comparing function and application requirements in the following table. Once the fluid class is selected, a specific grade can be determined on the next few pages by following the color key.

Function	Application	Fluid Class
Dielectric Coolant/Fluid	Transformers, Rectifiers Capacitors	Conventional
	Magnetron	Conventional Thermal
	Dielectric Impregnation of Porous Substrate	Conventional
Lubrication	Mold Release	Conventional Organic Compatible Emulsion
	Aluminum Machining and Extruding	Organic Compatible
	Die Casting	Organic Compatible
	Ball Bearing and Gear Lubrication	Organic Compatible Thermal Fluorosilicone
	Airborne Radar	Low Temperature
	Rubber/Plastic Contact	Conventional Organic Compatible
	Fiber/Plastic Contact	Hydrophilic
	Metal/Plastic Contact	Organic Compatible Thermal Fluorosilicone
	Metal/Metal Contact	Organic Compatible Thermal (Chlorophenyl)
	Grease	Conventional, Thermal or Fluorosilicone

Function	Application	Fluid Class
Working Media	Fluid Clutch	Conventional Thermal
	Smart Fluids	Conventional Organic Compatible
	Hydraulic Fluid	Low Temperature, Conventional Thermal
	Brake Fluid	Conventional (Intermediate Viscosity)
	Shock Absorber	Conventional Thermal or
	General Damping	Conventional Thermal Fluorosilicone
	Meter Damping	Conventional
	Timing Devices	Conventional Thermal
	Magnetic Amplifier	Thermal
	Diffusion Pump	Thermal (Oligomeric)
Performance Additive	Surfactant/Antifoam	Conventional (Low Viscosity), Hydrophilic Fluorosilicone
	Hydrocarbon Compatibility	Organic Compatible
	Flow Control	Conventional (Low Viscosity)
	Wetting	Hydrophilic
	Radiation Resistance	Thermal
Acoustical	Sonobuoy	Conventional (Reduced Volatility)
	Sound Coupling/Lensing	Fluorosilicone
Optical	Optical Coupling Fluid	Thermal
	Anti-fog Agent	Hydrophilic
	Gloss Enhancement	Conventional (Low-Intermediate Viscosity)
Heat Transfer	Heat Treatment Bath	Thermal
	Constant Temperature Bath	Conventional (Intermediate Viscosity) Thermal
	Temperature Measurement Device	Conventional, (Intermediate Viscosity), Thermal Fluorosilicone
	Closed Loop Heating	Thermal
	Refrigerated Systems	Low Temperature

Conventional Silicone Fluids

Conventional fluids are the well-known general purpose silicones described in chemical notation as polydimethylsiloxanes. They are commercially produced in viscosities ranging from 0.65 to 2,500,000 cSt.

Conventional silicone fluids are composed of polymer chains with unique flexibility. Polydimethylsiloxane has virtually no energy barrier for rotation. This results in one of the lowest glass-transition temperatures of any polymer. The liquid surface tension of polydimethylsiloxane is lower than the critical surface tension of wetting (24 dynes/cm). This causes polymers to spread over their own adsorbed films. An important consequence of the low intermolecular forces in polysiloxanes is the highest permeability coefficients of any polymer for oxygen and nitrogen.

The fluids are thermally stable indefinately at 150°C in air. Fluids with viscosities of 50 cSt. or greater have negligible vapor pressure.

At viscosities greater than 1,000 cSt. correlating to molecular weights greater than 30,000, polymer chain entanglement occurs, resulting in leveling of physical property change vs. viscosity. Refractive index, surface tension, density and viscosity-temperature coefficients are strikingly flat.

***Product code Definition**

Prefix:
DMS=DiMethylSiloxane

Suffix:
1st character=Trimethylsiloxy terminated
2nd character=viscosity in decades, i.e. 10^{x}
3rd character=viscosity to 1 significant figure

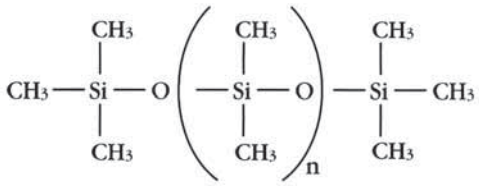
Polydimethylsiloxanes, Trimethylsiloxy Terminated

Properties

Product Code*	Viscosity cSt.	Viscosity Temp. Coefficient	Pourpoint °C	Specific Gravity	Refractive Index
DMS-T00	.65	.32	-68	.761	1.3750
DMS-T01	1.0	.37	-85	.818	1.3825
DMS-T01.5	1.5	.46	-75	.853	1.3880
DMS-T02	2.0	.48	-80	.873	1.3900
DMS-T03	3.0	.51	-70	.898	1.3935
DMS-T05	5.0	.54	-65	.918	1.3970
DMS-T07	7.0	.55	-65	.930	1.3980
DMS-T11	10	.56	-65	.935	1.3990
DMS-T12	20	.59	-65	.950	1.4000
DMS-T15	50	.59	-65	.960	1.4015
DMS-T21	100	.60	-65	.966	1.4025
DMS-T22	200	.60	-60	.968	1.4030
DMS-T23	350	.60	-60	.970	1.4031
DMS-T25	500	.60	-55	.971	1.4033
DMS-T31	1,000	.61	-50	.971	1.4034
DMS-T35	5,000	.61	-48	.973	1.4035
DMS-T41	10,000	.61	-48	.974	1.4035
DMS-T41.2	12,500	.61	-46	.974	1.4035
DMS-T43	30,000	.61	-43	.976	1.4035
DMS-T46	60,000	.61	-42	.976	1.4035
DMS-T51	100,000	.61	-41	.977	1.4035
DMS-T53	300,000	.61	-41	.977	1.4035
DMS-T56	600,000	.61	-41	.978	1.4035
DMS-T61	1,000,000	.62	-39	.978	1.4035
DMS-T63	2,500,000	.62	-38	.978	1.4035
DMS-T72	20,000,000	.62	-35	.979	1.4035

Viscosity specifications for polydimethylsiloxanes: ± 10% for fluids 100,000 cSt. and less; ± 15% for fluids >100,000 cSt.

Data in the above table provide properties that vary significantly with viscosity and molecular weight. Many of the properties of polydimethylsiloxanes do not vary significantly when viscosity is greater than 10 cSt. Tables and graphs on the next pages provide information on the following properties: ACCOUSTICAL, DENSITY, ELECTRICAL, MECHANICAL, MOLECULAR WEIGHT, OPTICAL, RADIATION RESISTANCE, REACTIVITY, RHEOLOGY, SOLUBILITY, THERMAL PERMEABILITY.



CAS: [9016-00-6] and [63148-62-9]

Coeff. of Thermal Expansion x10⁻⁴	Thermal Conductivity cal/cm. sec. x10⁻⁴ °C	Surface Tension	Dielectric Constant	Dielectric Strength	Flashpoint C°	Molecular Weight	PRICE 100g	1 gallon container	5 gallon container
13.4	2.4	15.9	2.20	300	-1	162	$13.00	2.5kg/$106.00	14kg/$350.00
13.4	2.4	17.4	2.30	350	39	237	$30.00	2.5kg/$245.00	14kg/$610.00
13.4	2.5	18.0	2.39	350	63	340	$33.00	2.5kg/$274.00	15kg/$650.00
11.7	2.6	18.7	2.45	350	79	410	$39.00	2.5kg/$274.00	15kg/$650.00
11.4	2.7	19.2	2.50	350	100	550	$33.00	2.5kg/$274.00	15kg/$650.00
11.2	2.8	19.7	2.60	375	135	770	$13.00	3kg/$132.00	15kg/$330.00
11.0	3.0	19.9	2.65	375	150	950	$13.00	3kg/$132.00	15kg/$330.00
10.8	3.2	20.1	2.68	375	163	1,250	$11.00	3kg/$105.00	16kg/$280.00
10.7	3.4	20.6	2.72	375	232	2,000	$11.00	3kg/$105.00	16kg/$280.00
10.6	3.6	20.8	2.75	400	285	3,780	$11.00	3kg/$105.00	16kg/$280.00
9.3	3.7	20.9	2.75	400	315	5,970	$11.00*	3kg/$92.00	16kg/$245.00
9.3	3.7	21.0	2.75	400	315	9,430	$11.00*	3kg/$105.00	16kg/$280.00
9.3	3.8	21.1	2.75	400	315	13,650	$11.00*	3kg/$105.00	16kg/$280.00
9.3	3.8	21.1	2.75	400	315	17,250	$11.00*	3kg/$105.00	16kg/$280.00
9.3	3.8	21.2	2.75	400	315	28,000	$11.00*	3kg/$105.00	17kg/$300.00
9.3	3.8	21.3	2.75	400	315	49,350	$15.00	3.5kg/$121.00	17kg/$300.00
9.3	3.8	21.5	2.75	400	315	62,700	$15.00	3.5kg/$121.00	17kg/$300.00
9.3	3.8	21.5	2.75	400	315	67,700	$21.00	3.5kg/$135.00	17kg/$306.00
9.3	3.8	21.5	2.75	400	315	91,700	$21.00	3.5kg/$135.00	17kg/$335.00
9.2	3.8	21.5	2.75	400	315	116,500	$21.00	3.5kg/$135.00	17kg/$335.00
9.2	3.8	21.5	2.75	400	321	139,000	$32.00	3.5kg/$215.00	17kg/$635.00
9.2	3.8	21.5	2.75	400	321	204,000	$32.00	3.5kg/$215.00	17kg/$635.00
9.2	3.8	21.6	2.75	400	321	260,000	$32.00	3.5kg/$215.00	17kg/$635.00
9.2	3.8	21.6	2.75	400	321	308,000	$43.00	3.5kg/$290.00	17kg/$745.00
9.2	3.8	21.6	2.75	400	321	423,000	$53.00	3.5kg/$396.00	17kg/$895.00
9.2	3.8	21.6	2.75	400	321	>500,000	$43.00	3.5kg/$375.00	—

*Available in drop-wise dispenser bottle ($4.00 additional).

Drum pricing available upon request.

Properties of Conventional Silicone Fluids (Polydimethylsiloxanes) – continued

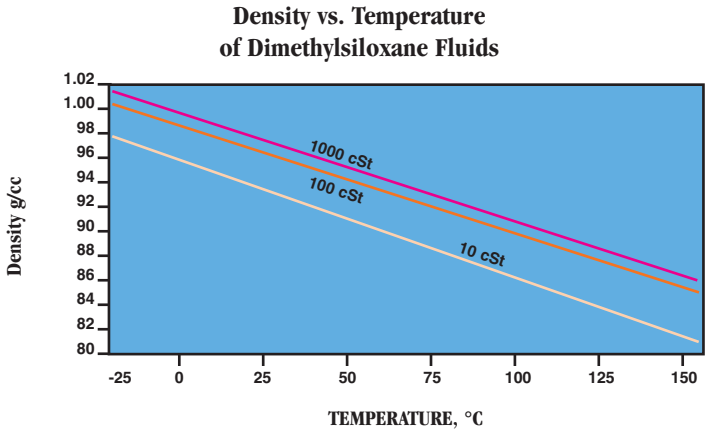
Polydimethylsiloxane properties that do not vary significantly for fluids with viscosities greater than 10 cSt. are listed below.

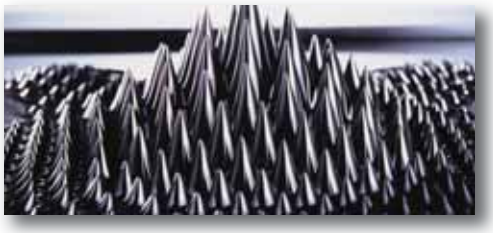
Acoustical*

Fluid Viscosity (cSt.)	Velocity of sound, m/s	
	30°C	50.7°C
0.65	873	795
2.0	931	863
20	975	918
100	985	930
1,000	987	933

* for additional information see: Pouey, M. et al, Phys. Chem. Chem Phys., 2003, 5, 73

Density



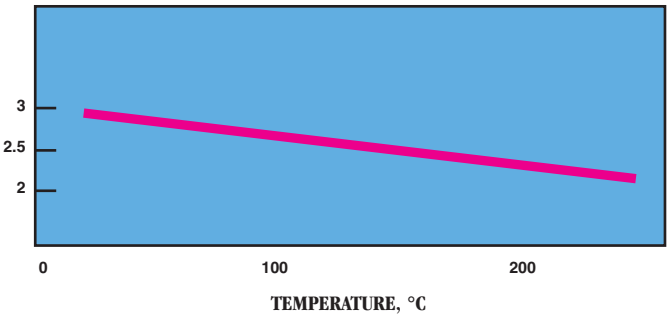


Dimethylsiloxane used in smart magnetic & electrorheological fluids.

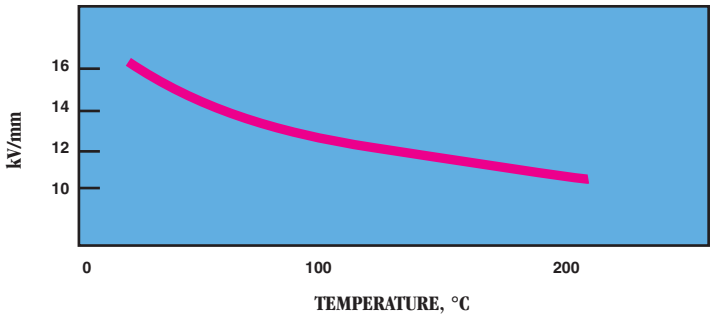
Electrical

Dielectric Strength	350-400V/mil
Dielectric Constant 10^2-10^6Hz, 20°C	2.44-2-2.76
Dissipation Factor	0.0001
Volume Resistivity	1x10^{15}ohm-cm at 20°C

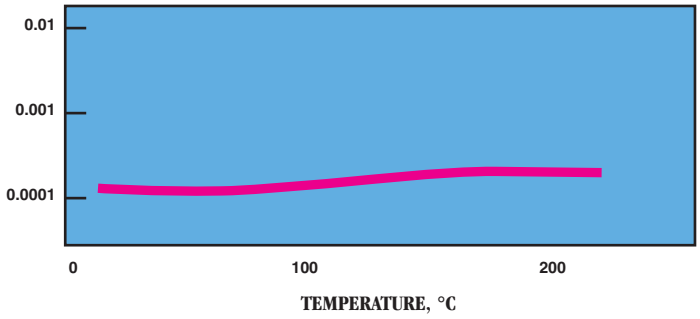
Dielectric Constant



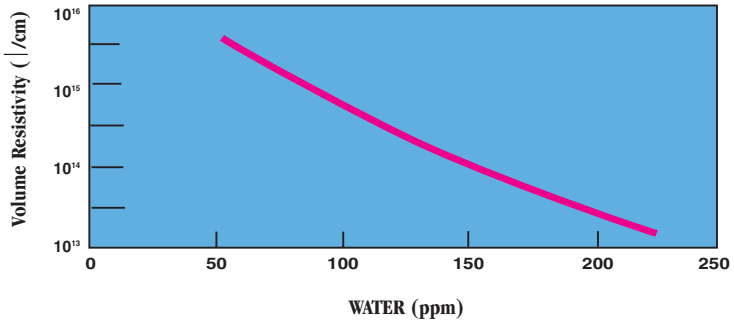
Dielectric Strength in kV/mm



Power Factor

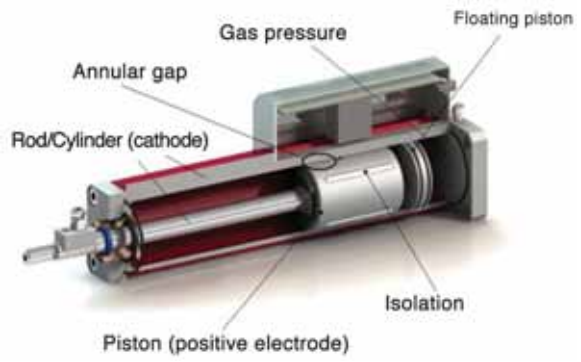


Moisture Absorption vs. Resistivity



Mechanical

Coefficient of adiabatic compressibility	1.10×10^{-10} cm²/dyne
Volume reduction of 100 cSt. fluid	
at 1,000 psi	0.70-0.75%
at 10,000 psi	5.50-5.90%
at 20,000 psi	9.00-9.20%
at 40,000 psi	13.30-13.80%



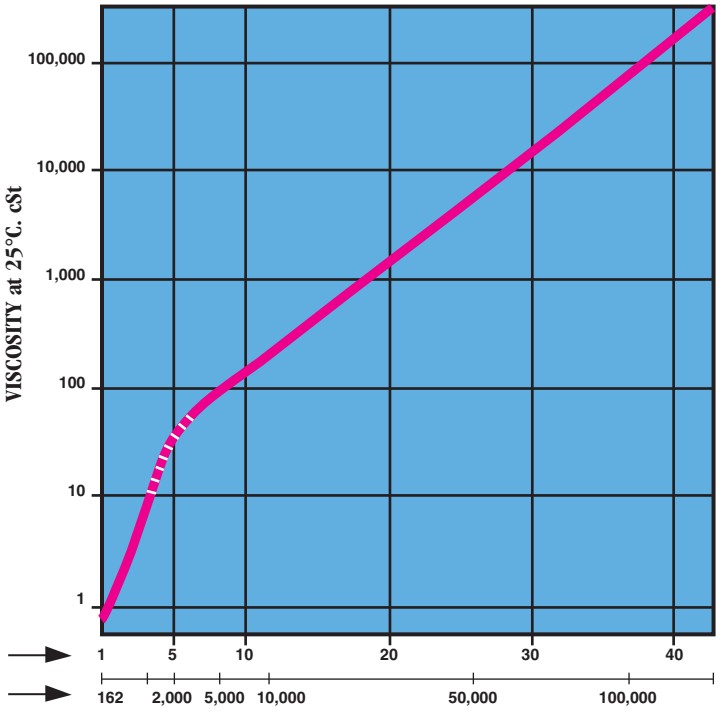
Fluid dampeners utilize electrorheological fluids that contain polydimethylsiloxane

Molecular Weight

Viscosity, μ, of Polydimethylsiloxanes as a function of a degree of polymerization "n".

Note: The straight portion of the slope corresponds to A.J. Barry's relationship on molecular weights>2,500:

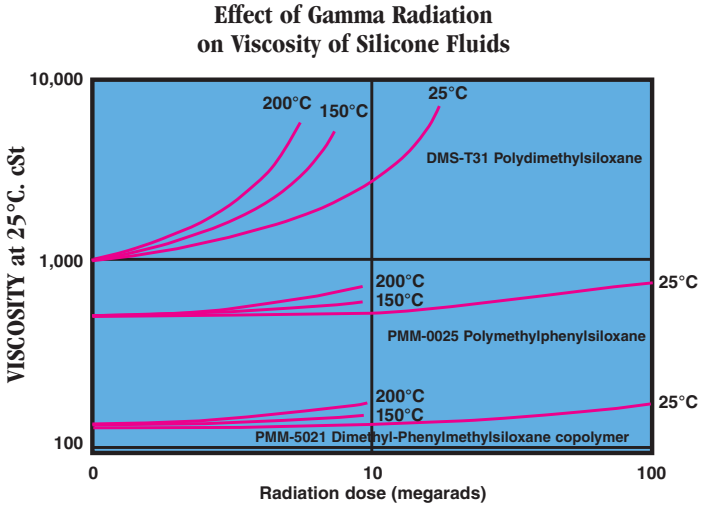
$$\log \mu_{cSt} = 1.00 + 0.0123M^{0.5}$$



Optical

Refractive index, 25°C	1.397-1.404
Verdet constant of magnetic rotary power	$16.2\text{-}16.9 \times 10^{-3}$ mm/gm/cm

Radiation Resistance



Properties of Conventional Silicone Fluids (Polydimethylsiloxanes) – continued

Polydimethylsiloxane properties that do not vary significantly for fluids with viscosities greater than 10cSt. are listed below

Reactivity

While they exhibit low reactivity under many conditions, certain environments are destructive to silicone fluids. Hydrogen fluoride, for example, attacks the silicon-oxygen bond to produce dimethylsilyl fluorides and water, which generate corrosive gases. Strong bases such as methanolic potassium hydroxide destroy silicone fluids and create resinous byproducts.

Thermal degradation at elevated temperatures causes rearrangement of the silicon-oxygen bonds to product volatile byproducts. Free-radical reaction of the methyl groups to form cross-linked materials by oxidation with peroxy compounds increases fluid viscosity and causes the fluid to gel.

Solubility of Fluids

Methylene chloride, chlorofluorocarbons, ethyl ether, xylene and methylethyl ketone are typical solvents for dimethylsiloxanes. Low viscosity polymers are also soluble in acetone, ethanol, dioxane and dihexyladipate. They are insoluble in methanol, cyclohexanol and ethylene glycol. The solubility parameter for 100 cSt. fluid is 7.4.

Solubility of Water

The equilibrium water absorption of silicones is 100-200ppm at 50-85% relative humidity. Drying of fluids is recommended for maximum performance in electrical applications. A typical drying protocol is to apply 1mm vacuum for 1 hour, which typically reduces water levels below 25ppm.

Solubility of Gases

Gas	ml gas/ml liquid @25°C
Nitrogen	0.16-0.17
Carbon Dioxide	1.00
Air	0.16-0.19
Hydrogen	0.11-0.12

Gaseous Permeability of Polydimethylsiloxane

Gas	P* x 10^9	Gas	P* x 10^9	Gas	P* x 10^9
H_2	97	N_2O	650	*n*-C_6H_{14}	1410
He	52	NO_2	1140	*n*-C_8H_{18}	1290
NH_3	885	SO_2	2250	*n*-$C_{10}H_{22}$	645
H_2O	5400	CS_2	1350	HCHO	1665
CO	51	CH_4	142	CH_3OH	2085
N_2	42	C_2H_6	375	$COCl_2$	2250
NO	90	C_2H_4	200	Acetone	835
O_2	90	C_2H_2	3960	Pyridine	2865
H_2S	1500	C_3H_8	615	Benzene	1620
Ar	90	*n*-C_4H_{10}	1350	Phenol	3150
CO_2	410	*n*-C_5H_{12}	3000	Toluene	1370

*$cm^3/s \cdot cm^2 \cdot$ cm Hg
values adjusted from filled silicone membranes

Thermal

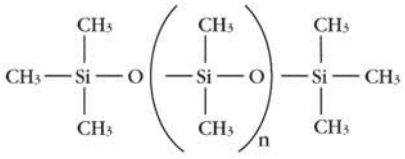
Specific heat	0.35-0.37 cal/gm/°C
Heat of formation	-2.41 kcal/gm
Heat of combustion (>50 cSt.)	6.13 kcal/gm
Glass transition temperature	-128°C
Gel time, 150°C	indefinite
Gel time for intermediate viscosity fluids, 200°C	200 hours
Gel time for high viscosity fluids, 200°C	100 hours
Autoignition temperature for fluids >10 cSt.	greater than 460°C

Rheological Behavior Under Shear

At shear rates commonly encountered ($\leq 10^4 s^{-1}$) polydimethylsiloxanes behave, at viscosities up to 1,000 cSt., like Newtonian fluids. Viscosity is constant and independent of the velocity gradient. Apparent viscosity is identical with viscosity extrapolated to zero velocity gradient.

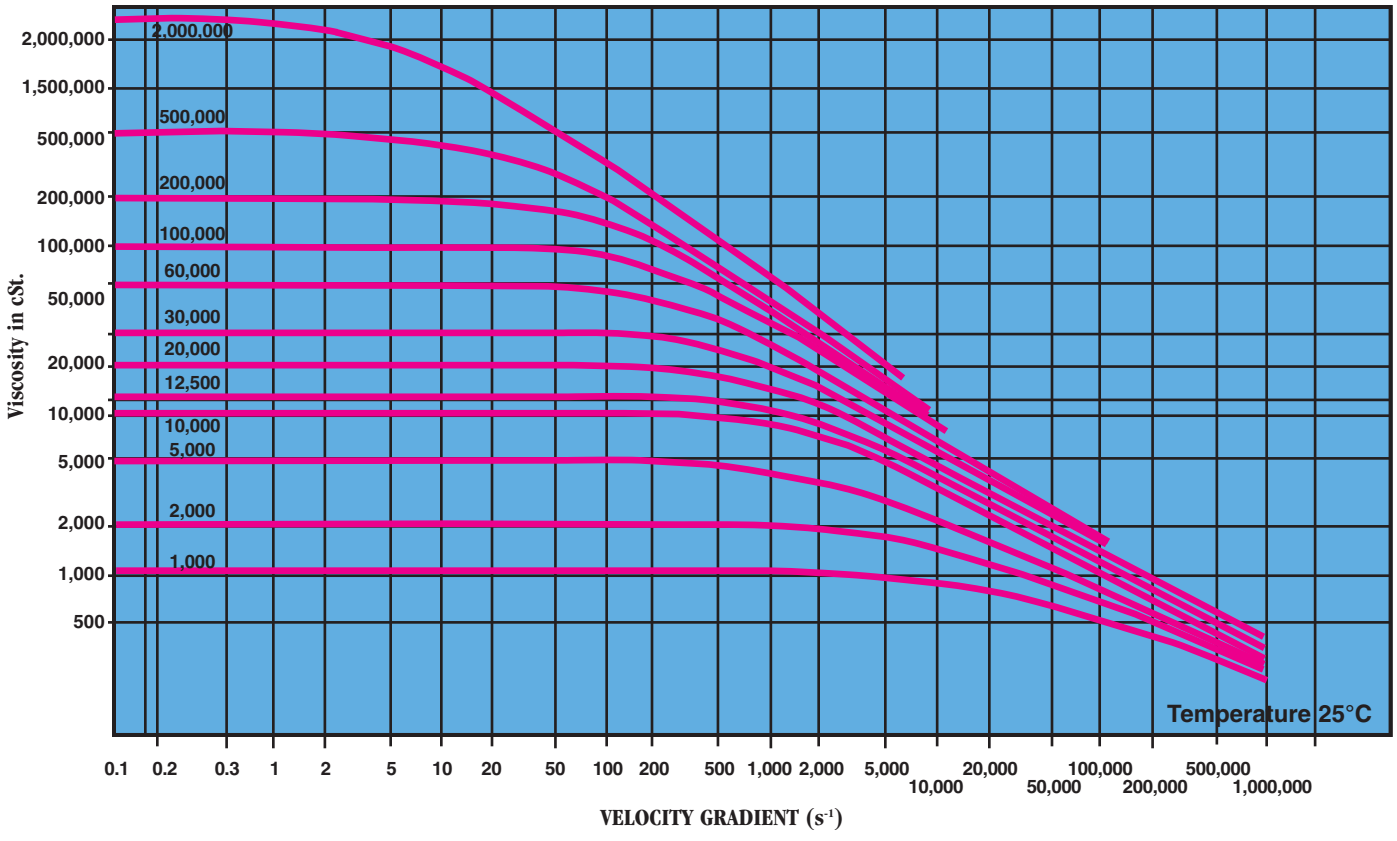
For oils of a higher viscosity than 1,000 cSt., this ratio is only constant for velocity gradients below a certain value. Beyond this value, becoming lower as the product becomes more viscous—the ratio is no longer constant: apparent viscosity falls below real viscosity (extrapolated for a zero velocity gradient) and the behavior is then known as "pseudoplastic." This change is perfectly reversible, and behavior again becomes Newtonian when the velocity gradient falls once more below the critical value. Viscosity returns to its initial level even after intense shearing of long duration.

As a guide, the table indicates the "critical" velocity gradients for polydimethylsiloxanes (where change of rheological behavior occurs) as well as apparent viscosity measured at velocity gradient equal to 10,000 s^{-1}.



	Critical velocity gradient (s^{-1})	Apparent viscosity for a velocity gradient of 10,000 s^{-1} (in cSt.)
1,000	2,500	850
12,500	200	4,700
30,000	150	6,000
100,000	30	8,200

Apparent Viscosity as a Function of Velocity Gradient



Low Volatility PolyDimethylsiloxanes

Volatile, low molecular weight components are present in polydimethylsiloxanes as a consequence of the equilibrium polymerization utilized in their manufacture. Typically, silicones with viscosities below 50 cSt. have >10% volatiles, while those with viscosities greater than 50 cSt. have 0.5-4.0% volatiles. Low molecular weight components can impart undesirable effects in certain critical applications. These can cause outgassing, migration, bleed, plasticization, and stress-cracking in contact with certain plastics and rubbers. Devolatilized silicones are offered in two classes. Reduced Volatility Silicones have >90% low-molecular weight components removed and are generally acceptable for polymer contacting applications. Extreme Low Volatility Silicones have virtually zero volatiles and are suitable for extreme vacuum applications including systems deployed in space exploration and communication. An example of a space application is as a damping fluid for solar panels.

Reduced Volatility PolyDimethylsiloxanes

wt% volatiles measured after 4 hours at 150°C in air

Product Code	Viscosity	wt % Volatiles	Price/1kg
DMS-T07R	7	10	$150.00
DMS-T12R	20	3.0	$200.00
DMS-T21R	100	0.5	$140.00
DMS-T31R	1,000	0.1	$225.00

see also FMS-222R in Fluorosilicone section

Extreme Low Volatility PolyDimethylsiloxanes

<0.01 wt% volatiles measured after 24 hours at 125°C 10^{-5} torr vacuum, according to ASTM-E595-85 and NASA SP-R0022A

Product Code	Viscosity	Price/100g
DMS-T23E	350	$290.00
DMS-T31E	1,000	$290.00
DMS-T41.2E	12,500	$290.00

Volatile Cyclic PolyDimethylsiloxanes - Cyclomethicones

Low molecular weight silicone that possess a cyclic structure rather than a chain structure serve as volatile carriers for a variety of formulations. Low heats of vaporization and the ability to select a desired vapor pressure has led to their use as cosmetic vehicles. While most display a broad range of liquid behavior, the most volatile cyclic dimethylsiloxane, D3, is a solid at room temperature.

Volatile Cyclic Dimethylsiloxanes (Cyclomethicones)

Product Code	Name	Viscosiity, cSt.	Boiling Point, °C	Vapor Pressure, 25°C, mm	Heat of Vaporization Kcal/mole	Specific Gravity	Refractive Index	Molecular Weight	Price/ 100g	Price/ 2kg
SIH6105.0	D3	solid, 65° m.p.	134°	10	9.5	1.02	-	222.46	$18.00	-
SIO6700.0	D4	2.3	175-176°	1.3	10.9	0.96	1.397	296.61	$10.00	$70.00
SID2650.0	D5	3.9	210°	0.4	12.0	0.96	1.398	370.77	$10.00	$96.00
SID4625.0	D6	6.6	245°	0.02	-	0.97	1.402	445.00	$208.00	$1,900.00
SID4075.0	D3-6	2.4	134-245°	1.5	-	0.96	-	222-445	-	$38.00

Silicone Emulsions

Silicone emulsions are easy-to-use, water-dilutable, fine particle dispersions of conventional polydimethylsiloxane fluids. They are employed as release agents and lubricants in a variety of rubber and plastic applications including molding of mechanical rubber parts such as O-rings and footwear, producing shell molds and cores for metal casting, wire and cable extrusion and conveyance devices in high-speed printing. They are usually diluted with water to a final solids concentration of 0.1-3.5% at the point of application.

PolyDimethylsiloxane Silicone Emulsions

emulsifier content: 3-6 wt %

Product Code	Viscosity	wt % Solids	Base fluid Emulsion Type	Price/100g	Price/3kg	Price/18kg
DMS-T21M50	100	53-56	Non-ionic	$15.00	$75.00	$320.00
DMS-T31M50	1,000	54-58	Non-ionic	$12.00	$65.00	$250.00
DMS-T41M50	10,000	51-55	Non-ionic	$12.00	$65.00	$250.00
DMS-T51M35	>100,000	33-36	Anionic	$15.00	$78.00	$330.00

Silicone Fluid Blends

Very high viscosity silicone fluids are difficult to apply as thin films. Solutions in volatile low viscosity silicones are easy to handle and facilitate film spread.

PolyDimethylsiloxane Fluid Blends

Product Code	High Viscosiity, Component, cSt	wt % Solids	Blend Viscosity, cSt	Price/100g	Price/3kg
DMS-T51B20	100,000	20	200-500	$32.00	$210.00
DMS-T72B15	15-20x10^6	15	4,000-8,000	$42.00	$280.00

Colored Silicone Fluids

Dyes in silicone fluids provide coloration without compromising transparency. The fluids may be used directly in applications such as gauge fluids or as tint additives for silicone fluids and elastomers.

Product Code	Description	Price/100g	Price/1kg
DMS-T21BLU	Blue Dye in 100 cSt. fluid	$20.00	$75.00
DMS-T21RED	Red Dye in 100 cSt. fluid	$20.00	$75.00

Thermal Silicone Fluids

Thermal Silicone Fluids for Mechanical and Heat Transfer Applications (Aromatic siloxanes)

DiPhenylsiloxane-DiMethylsiloxane Copolymers CAS: [68083-14-7]

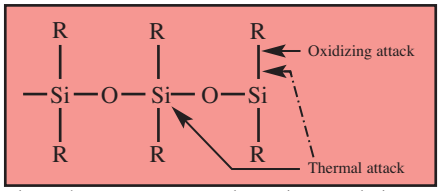
Product Code	Viscosity 25°C cSt.	Viscosity, 99°C cSt.	Viscosity Temp. Coeff.	Pour-Point, °C	Transition Temp.,Tg °C	Gel time, hours 250°C in air*
PDM-0421	100	29	0.62	-73	-	150-200
PDM-0821	100-125	30-32	0.63	-70	-	1200-1500
PDM-1922	150-250	26-28	0.78	-40	-	1500-2000
PhenylMethylsiloxane-DiMethylsiloxane Copolymers						CAS: [63148-52-7]
PMM-1015	50	14	0.61	-70	-121	220-260
PMM-1021	100	35	0.62	-70	-121	210-230
PMM-1025	500	180	0.62	-70	-121	180-200
PMM-1043	30000	5500	0.63	-65	-121	<100
PMM-5021	125	20	0.78	-51	-100	1000-1400
PMM-6025	500	60	0.79	-34	-	1500-1900
PhenylMethylsiloxane Homopolymers						CAS: [9005-12-3]
PMM-0011	10-20	<5	-	-55	-	>flashpoint**
PMM-0021	100-200	14-20	0.79	-	-	1600-2100
PMM-0025	500	35	0.88	-20	-86	1500-2000
PhenylMethylsiloxane-Diphenylsiloxane Copolymers						CAS: [308073-01-0]
PMP-5025	300-600	-	-	-10	-	-
PhenylMethylsiloxane Oligomers - Diffusion Fluids						
1,1,5,5-Tetraphenyl-1,3,3,5-tetramethyltrisiloxane						CAS: [3982-82-9]
PDM-7040	35-40	<5	-	-35	-	>flashpoint**
1,1,3,5,5-Pentaphenyl-1,3,5-trimethyltrisiloxane						CAS: [3390-61-2]
PDM-7050	170-5	6	-	-15	-	>flashpoint**
Tetrachlorophenylsilsesquioxane-Dimethylsiloxane Copolymers						CAS: [68957-05-1]
PTT-1117	70	18	0.68	-73	-	270-280

*The gel time for conventional fluids (DMS-T31) is <10 hours; coking time for mineral oil is <2 hours
**Unsafe operating temperature in air.

The thermal silicone fluids are described in chemical notation as aromatic siloxanes because of the presence of phenyl groups.

High phenyl content fluids are utilized as heat-exchange fluids, dielectric coolants, impregnants for sintered metal bearing, and base oils for high temperature fluids. Low phenyl content fluids are utilized at lower temperatures than high phenylsilicones and find extended temperature service applications as lubricating oils for critical devices such as timers and systems involving rubber, plastic and aluminum mating surfaces.

At elevated temperatures, and in the presence of oxygen, silicone polymers are subject to two types of degradation:



Phenyl groups provide enhanced thermal properties by two mechanisms:

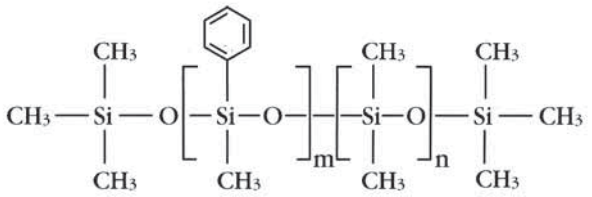
1. Better protection of the chain Si—O—Si—O by steric hindrance.
2. The lower susceptibility of the phenyl group to oxidative attack.

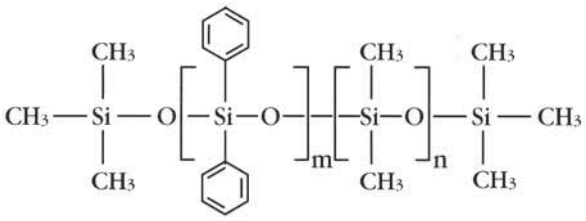
As phenyl groups replace methyl groups in a polysiloxane, several changes occur. Oxidation resistance, thermal stability and shear resistance are enhanced. For polyphenylmethylsiloxane the service temperature is -55°C to 290°C. The gel time of several fluids is provided in the accompanying table. In closed oxygen-free systems the polyphenylmethylsiloxanes are stable for thousands of hours at 250°C. The materials are used in heating baths.

The phenyl group also introduces rigidity in the silicone chain. When substitution exceeds 75 mole percent, the polymers are solid. Refractive index also increases with phenyl concentration. At 15-16 mole percent phenyl concentrations, the refractive index matches that of optical fibers and amorphous silica allowing "invisible" connections and transparent blends.

Low viscosity phenyl fluids, PDM-7040 and PDM-7050, are used as diffusion pump fluids. Chlorinated aromated siloxanes provide superior lubrication for metal-metal contact. The polyphenylmethylsiloxanes also exhibit good radiation resistance, remaining serviceable up to 200 megarads exposure. (See page 11.)

The compressibility of phenyl containing siloxanes is reduced in comparison to dimethyl fluids. The compressibility of selected thermal fluids at 20,000 psi are as shown in the accompanying table.





Specific Gravity	Refractive Index	Surface Tension	Dielectric Constant	Flashpoint °C	Ignition Temp., °C	Comonomer mole %	Molecular Weight	Price 100g	Price 1kg	Price 10kg
0.98	1.422	22.6	2.75	280	484	4-6*	3,500-4,000	$15.00	$108.00	$755.00
0.99	1.436	22.8	2.78	280	484	7-10*	2,800-3,200	$13.00	$92.00	$647.00
1.05	1.490	24.5	2.83	285	488	18-22*	1,600-2,400	$24.00	$176.00	$1232.00
*Diphenylsiloxane										
1.00	1.425	25.0	2.77	275	482	8-12**	1,500-1,600	$20.00	$139.00	$972.00
1.00	1.425	24.5	2.79	280	482	8-12**	3,000-4,000	$28.00	$193.00	$1183.00
1.00	1.425	24.4	2.80	285	482	8-12**	9,000-11,000	$23.00	$165.00	$1155.00
1.00	1.425	24.8	2.82	285	482	8-12**	40,000-50,000	$64.00	$451.00	-
1.07	1.500	24.5	2.87	296	482	45-50**	2,000-2,200	$23.00	$165.00	$1155.00
1.08	1.507		2.89	285	482	58-62**	3,500-4,000	$22.00	$139.00	$972.00
**Phenylmethylsiloxane										
1.01	1.470	-	-	220	420	-	350-450	$99.00	$693.00	-
1.09	1.520	-	2.93	280	484	-	700-1200	$86.00	-	-
1.11	1.533	28.5	2.95	300	487	-	2,500-2,700	$23.00	$165.00	$1155.00
1.10	1.543	-	-	300	-	45-55**	600-800	$123.00	-	-
**Phenylmethylsiloxane										
1.07	1.556	37.3	-	221	425	-	485	$42.00	$290.00	$2266.00
1.09	1.588	36.5	-	245	440	-	547	$57.00	$400.00	$2803.00
1.05	1.428	21.0	2.90	300	480	-	1,600-3,000	$35.00	$242.00	$1694.00

Thermodynamic Properties*

Thermal Expansion, (25-150°C), cc/cc/°C:	7.5-9.4 x 10^{-4}
Thermal Conductivity, cal/(sec.)(cm^2)(°C/cm):	3 x 10^{-4}
Specific Heat, 38°C, cal/gm/°C:	0.34-0.39

Electrical Properties*

Volume Resistivity, Ω-cm:	25°C: 1-4 x 10^{14} 50°C: 1-5 x 10^{12}
Dielectric Strength, kV/mm:	14
Dissipation Factor:	at 10^2 Hz: 1.1-5.1 x 10^{-4} at 10^6 Hz: 0.1-1.1 x 10^{-4}

*Properties do not apply to PTT-1117

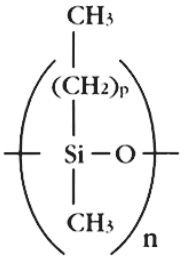
Compressibility at 20,000 psi

Product Code	Compressibility, %	Description
PTT-1117	8.3	(Tetrachlorophenyl)-Dimethylsiloxane Branch Copolymer
PMM-1025	7.9	Phenylmethylsiloxane Dimethylsiloxane Copolymer
PMM-1922	6.5	Diphenyldimethyl-siloxane Copolymer
PMM-0025	5.5	Polyphenylmethylsiloxane

Organic Compatible Silicone Fluids

Alkyl Silicones

Silicones wth alkyl or aromatic substituted alkyl side chains can allow for many of the advantages of silcones to be formulated in organic based formulations. The alkyl modfied silicones offer greater organic compatibility with organic materials, improved lubricity, reduced tack, higher viscosity-temperature coefficients, lower compressibility and decreased oxidation stability when compared to polydimethylsiloxanes. Both ethylene-dimethylsiloxane and alkylsiloxane-dimethylsiloxane copolymers are readily miscible in many hydrocarbons allowing for the introduction of silicone properties.



Modification of the alkyl chain length allows for varying the organic characteristics of the siloxanes. A longer alkyl chain translates to higher compatibility with hydrocarbon oils and increases in pour point. The series moves from liquid at room temperature (octyl) to pour points just above room temperature (tetradecyl) to creamy solids at room temperature (octadecyl and higher).

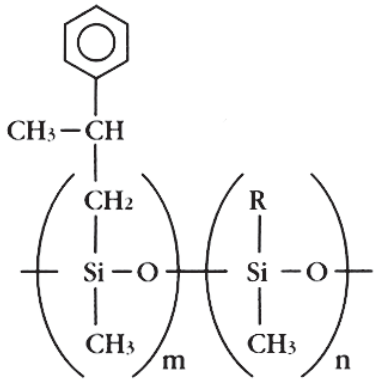
AlkylMethylsiloxane Homopolymers

Product Code	Viscosity cSt.	Pour-Point, °C	Specific Gravity	Refractive Index	Surface Tension	Flashpoint °C	Price 100g	Price 1kg	Price 10kg
polyOctylMethylsiloxane								CAS: [68440-90-4]	
ALT-143	600-1000	-44	0.91	1.445	30.4	250	$15.00	$108.00	$755.00
polyTetradecylMethylsiloxane								CAS: [76684-67-8]	
ALT-173	700-1200	30	0.89	1.455	35.0	-	$21.00	$143.00	$836.00
polyOctadecylMethylsiloxane						(solid at room temperature)		CAS: [68607-75-0]	
ALT-192	250-500 (50°C)	50	0.89 (50°C)	1.443	39.5	-	$21.00	$163.00	$977.00
AlkylMethylsiloxane DiMethylsiloxane Copolymers									
(45-55% HexadecylMethylsiloxane) - (DiMethylsiloxane) Copolymer								CAS: [191044-49-2]	
ALT-281	40-70	19	0.86	1.448	-	-	$21.00	$163.00	$977.00
(27-33% OctadecylMethylsiloxane) - (DiMethylsiloxane) Copolymer						(solid at room temperature)		CAS: [67762-83-8]	
ALT-292	25-50 (40°C)	40	0.89	1.440	-	-	$42.00	$293.00	-
(1-2% TriacontylMethylsiloxane) - (DiMethylsiloxane) Copolymer								CAS: [17525-30-0]	
ALT-561	2000-4000 (100°C)	75	-	-	-	-	$66.00	$462.00	-
Alkyl Terminated PolyDiMethylsiloxanes									
Butyl Terminated PolyDiMethylsiloxane								[R&D Only]	
DMA-021	10-15	-40	0.92	1.413	-	>150	$38.00	$175.00	-
Octadecyl Terminated PolyDiMethylsiloxane								CAS: [128446-57-1]	
DMA-091	20-30 (35°C)	14	0.88	1.434	-	>150	$42.00	$293.00	-
Hexacosyl Terminated PolyDiMethylsiloxane								[R&D Only]	
DMA-131	65 (55°C)	44-5	0.87	1.415	-	>150	$45.00	$305.00	-
MonoHexacosyl Terminated Polydimethylsiloxane								CAS: [1283601-17-1]	
MMA-131	45	18-9	0.89	1.428	-	>150	$42.00	$148.00	-

Alkyl fluids improve plastic on plastic lubrication and have greater compatibility during processing and molding.

Aryl-Alkyl Silicones

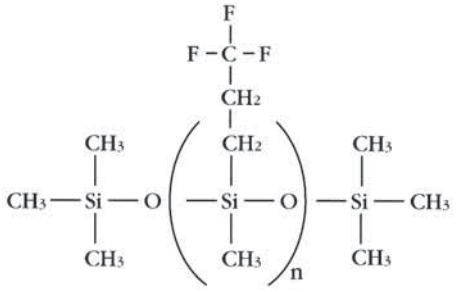
Aryl-alkyl silicones exhibit an extended range of organic compatibility and lubricity when compared to dimethyl silicones. They behave as broad spectrum compatibilizing agents for silicone/hydrocarbon/fatty acid formulations in the lubricant and cosmetic industries. Fluids with methyl and 2-phenylpropyl groups maintain excellent release properties without interfering with paintability, making them preferred in mold release agent formulations for rubber and plastics and die casting. Other uses for organic compatible silicone fluids include surfactants or de-airing molded urethane and epoxy parts during fabrication and die-cast metal lubrication.



AlkylMethylsiloxane-ArylalkylMethylsiloxane Copolymers

Product Code	Viscosity cSt.	Pour-Point, °C	Specific Gravity	Refractive Index	Flashpoint °C	Price 100g	Price 1kg	Price 10kg
poly(2-Phenylpropyl)Methylsiloxane							CAS: [71329-48-1]	
APT-133	1000	-	1.02	1.480	258	$21.00	$163.00	$977.00
(75-85% EthylMethylsiloxane) - (15-25% 2-PhenylpropylMethylsiloxane) Copolymer							CAS: [68037-77-4]	
APT-213	1200-1600	-	1.01	1.462	209	$21.00	$163.00	$977.00
(45-55% HexylMethylsiloxane) - (45-55% 2-PhenylpropylMethylsiloxane) Copolymer							CAS: [68952-01-2]	
APT-233	1500-2000	-	1.04	1.493	275	$18.00	$123.00	$862.00
(60-70% DodecylMethylsiloxane) - (30-40% 2-PhenylpropylMethylsiloxane) Copolymer							CAS: [68037-76-3]	
APT-263	1100-1300	-	0.91	1.464	277	$21.00	$163.00	$977.00

Fluorosilicone Fluids



Many advantages of fluorocarbons and silicones are combined in fluorosilicones. The materials are useful from -40° to 230°C in a wide range of aggressive service environments. They have achieved a number of unique applications due to their chemical and solvent resistance to lubricity.

Fluorosilicones are not miscible with fuels or oils. They have a solubility parameter of 9.6. They have been employed in mechanical vacuum pumps where exposure to high temperature moisture and oxygen is encountered.

The fluids are excellent lubricants under extreme pressure applications. This characteristic, considered with resistance to fuels has led to many automotive and aerospace lubrication applications, since they are not easily leached by fuels from mechanical joints. In addition, fluorosilicones, particularly the copolymers, have been employed as lubricants for electrical contacts and precision timing devices. Greases formulated from fluorosilicones and solid fluoropolymer thickeners have been used in sealed transmission and other extreme pressure applications.

The high density of these fluids has led to their use as a flota tion medium for inertial guidance systems. Acoustic velocities in fluorosilicones are lower than conventional silicones, allowing sonar lens development. Trifluoropropylmethylsiloxane homopolymers have a compressibility of 7.5% at 20,000 psi. Volume resistivity for fluids >500cSt: 10^{13} ohms-cm.

Fluorosilicones

Poly (3,3,3-Trifluoropropylmethylsiloxane) CAS: [63148-56-1]

Product Code	Viscosity, cSt.	Viscosity Temp. Coeff.	Pour-Point,°C	Transition Temp., Tg°C	Specific Gravity	Refractive Index	Surface Tension	Dielectric Constant	Dielectric Strength	Flashpoint Temp.,°C	Molecular Weight	Price 25g	Price 100g	Price 1kg
FMS-121	80-120	-	-47	-	1.24	1.382	-	-	-	-	900-1000	$40.00	$130.00	$911.00
FMS-123	300-350	0.84	-47	-74	1.25	1.381	25.7	6.95	200	260	2400	$25.00	$82.00	$578.00
FMS-125	400-500	0.84	-44	-74	1.26	1.381	25.7	6.95	200	270	3000	$32.00	$89.00	-
FMS-131	1000	0.85	-40	-74	1.28	1.382	26.1	7.35	200	290	4600	$13.00	$42.00	$292.00
FMS-141	10,000	0.87	-30	-74	1.30	1.383	28.7	7.35	175	315	14,000	$13.00	$42.00	$292.00

Specialty Fluorosilicones

Product Code	Viscosity, cSt.	Viscosity Temp. Coeff.	Pour-Point,°C	Transition Temp., Tg°C	Specific Gravity	Refractive Index	Surface Tension	Dielectric Constant	Dielectric Strength	Flashpoint Temp.,°C	Molecular Weight	Price 25g	Price 100g	Price 1kg
(48-52% 3,3,3-Trifluoropropylmethylsiloxane) - (48-52% Dimethylsiloxane) Copolymer														CAS: [115361-68-7]
FMS-221	80-120	-	-55	-103	1.16	1.387	21.4	-	-	-	1,800	$14.00	$43.00	$302.00
(48-52% 3,3,3-Trifluoropropylmethylsiloxane) - (48-52% Dimethylsiloxane) Copolymer														CAS: [115361-68-7]
FMS-222R*	140-200	-	-55	-103	1.17	1.388	21.4	-	-	-	2,000	$27.00	$88.00	$620.00
(25-35%-Nonafluorohexylmethylsiloxane) - (65-75% Dimethylsiloxane) Copolymer														CAS: [882878-48-0]
FMS-411	8-12cSt	-	-40	-	1.22	1.365	-	-	-	-	1,000	$48.00	$156.00	$1100.00
(15-20%-Tridecafluorooctylmethylsiloxane) - (80-85% Dimethylsiloxane) Copolymer														CAS: [115340-95-9]
FMS-736	4000-7000	-	-	-	1.21	1.375	-	-	-	315	40,000	$57.00	$185.00	$1298.00
1,3-Bis(Tridecafluorooctyl)Tetramethyldisiloxane												[R&D only]		CAS: [71363-70-7]
SIB1816.0	6-7	-	-	-	1.46	1.337	-	-	-	-	826	$103.00	$336.00	

*reduced volatility grade (<2% volatiles measured after 4 hours at 150°C)

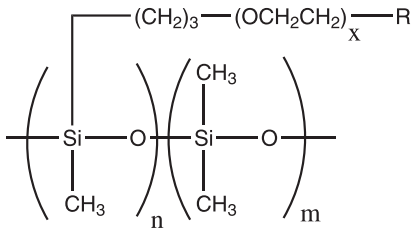
Fluorocarbon - Fluorosilicone Light Grease

Product Code	Penetration 60 Stroke	Dropping-point, °C	4-ball wear-mm, 232°C	Price 100g	Price 1kg
PP1-LUB01	320-340	200-210	1.60-1.65*	$155.00	$1075.00

*1200rpm, 40kg, 2hrs, M-10 steel

Hydrophilic Silicones

Polyalkylene Oxide Silicones



Hydrophilic silicones differ from conventional silicones by demonstrating a much greater compatibility with aqueous systems. They have slight to complete solubility in water. They are composed of dimethylsiloxane molecular backbones in which some of the methyl groups are replaced by polyalkylenoxy or pyrrolidone groups linked through a propyl group to the silicone atom.

They are widely used as surfactants and emulsifiers. By altering the amounts of hydrophile and lipophile, the desired surfactant properties may be balanced. The higher the alkylene oxide content the higher the hydrophilicity. Materials with ethylene oxide contents of 75% and higher are freely soluble in water.

DBE-712 is the lowest molecular weight material containing 6-8 EO units and is miscible with water in all concentrations. It is used as an anti-fog treatment for glass and optical surfaces. It is also used to facilitate wetting and spread of developers on lithographic plates. At the other extreme, DBE-224 is a water-insoluble copolymer used as a lubricant in plastic on metal wear applications and as a lubricant for fibers. Anti-tack and mar resistance are imparted to urethane coatings. High molecular weight copolymers, such as DBE-224, are excellent emulsifiers. DBE-821 reduces static charge generation during fiber processing. It has also been incorporated into rolling oil formulations for metal drawing and stamping. DBE-712 and DBP-732 provide slip in flexographic and gravure inks.

CMS-832 is a high refractive index fluid that provides gloss and smooth touch in polishes.

Hydrophilic Silicones (R=OMe)

Dimethylsiloxane-Ethylene Oxide Block/Graft Copolymers

Product Code	Wt % Non-Siloxane	Glycol	Glycol Capping	Viscosity Cst.	Molecular Weight	Specific Gravity	Refractive Index	Pour Point,°C	CAS#	Price 100g	Price 1kg	Price 10kg
DBE-224*	25	EO	OMe	400	10,000	1.02	1.414	-29	68938-54-5	$18.00	$106.00	$739.00
DBE-311***	30-35	EO	OMe	10	800-1,200	0.97	1.425	-	68938-54-5	$25.00	$165.00	-
DBE-411***	45-50	EO	OMe	5-10	400-500	0.94	1.425	-	68938-54-5	$25.00	$165.00	-
DBE-621**	50-55	EO	OMe	100	2,500	1.03	1.434	-15	68938-54-5	$18.00	$106.00	$739.00
DBE-712‡	60-70	EO	OMe	20	600	1.01	1.442	0	27306-78-1	$12.00	$84.00	$546.00
DBP-732	65-70	EO/PO (40/60)	OMe	1800	20,000	1.02	1.446	-50	67762-85-0	$12.00	$84.00	$546.00
DBE-713	75	EO	OAc	30	600-750	1.03	1.446	-	125997-17-3	$72.00	-	-
DBE-814‡	80	EO	OMe	40-50	1000	1.04	1.452	-14	117272-76-1	$25.00	$165.00	$1240.00
DBE-821‡	80-85	EO	OMe	100-120	4400	1.07	1.454	0	68938-54-5	$12.00	$84.00	$546.00
DBE-921	85-90	EO	OMe	100-120	5000	1.08	1.451	0	68938-54-5	$48.00	$288.00	$1995.00

*~10 mole% EO Substituted; DP~100 **~25% EO Substituted; DP~15 ***R&D only ‡ reduced volatility grades available

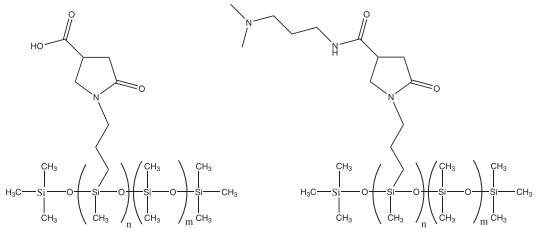
Hydroxylic Silicones (R=OH)

Product Code	Wt % Non-Siloxane	Glycol	Glycol Capping	Viscosity Cst.	Molecular Weight	Specific Gravity	Refractive Index	CAS#	Price 100g	Price 1kg	Price 10kg
CMS-221	20-25	EO	OH	125-150	4,000	1.00	1.419	68937-54-2	$20.00	$176.00	-
CMS-222	20	PO	OH	150-200	5500-6500	0.98	1.411	68957-00-6	$40.00	$238.00	$1628.00
DBP-C22	45-55	PO	OH	400-300	2500-3200	0.99	1.434	161755-53-9	$46.00	$277.00	$1049.00
DBE-534	55	EO/PO (60/40)	OH	4,000	30,000	0.98	1.414	68937-55-3	$18.00	$106.00	$739.00
CMS-832*	50-60	EO	OH	1000-2000	2000-5000	1.09	1.505	200443-93-2	$48.00	$336.00	-
DBE-C25	60	EO	OH	400-450	3500-4500	1.07	1.450	68937-54-2	$29.00	$174.00	$720.00
CMS-626	65	EO	OH	550-650	4500-5500	1.09	1.458	68937-54-2	$39.00	$234.00	$1320.00

*(Hydroxypolyethyleneoxypropyl)methylsiloxane-(3,4-Dimethoxyphenylpropyl)methylsiloxane-Dimethylsiloxane terpolymer

Polar Silicones

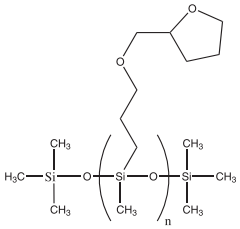
Polar silicones are utilized in specialty applications where readily swellable materials such as soft rubber have poor dimensional stability in contact with other lubricants. Pyrrolidone functional silicones are the most hydrophilic silicones that are not derived from polyethylene glycols (PEGs). Furan functional silicones are hydrophilic and have compatibility with most conventional silicones. Cyanoalkylsilicones have even less tendency to swell substrates than fluorosilicones and, in thin films, facilitate ion transport. Fluorosilicones are the most common polar silicones, but are usually considered as a class by themselves.



Polar Silicones

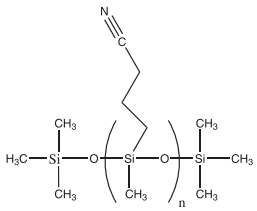
(N-Pyrrolidonepropyl)Methylsiloxane - Dimethylsiloxane Copolymers

Product Code	Pyrrolidone Substitution	Viscosity cSt.	Specific Gravity	Water Solubility	Refractive Index	CAS#	Price 100g	Price 1kg
YAD-122	dimethylaminopropylcarboxamide	150-300	0.96	-	1.406	179005-02-8	$118.00	$831.00
YBD-125	carboxylate	400-600	0.98	-	1.405	179005-03-9	$62.00	$432.00



Tetrahydrofurfuryloxypropylmethylsiloxane

Product Code	Mole % Tetrahydrofurfuryloxypropyl-methylsiloxane	Viscosity cSt.	Specific Gravity	Water Solubility	Refractive Index	CAS#	Price 100g	Price 1kg
DCF-405	100	5	0.93	-	1.426	1361237-41-3	$67.00	$475.00



CyanopropylMethylsiloxane

Product Code	Mole % Cyanopropylmethylsiloxane	Viscosity cSt.	Specific Gravity	Water Solubility	Refractive Index	CAS#	Price 10g	Price 100g
YMS-T31	100	800-1400	1.07	-	1.459	67762-86-1	$79.00	$554.00

Amphiphilic Silicones

Silicone fluids which are both hydrophilic and olephilic are said to be amphiphilic. This is in distinction to the more general definition that considers an amphiphile to be a material which is both hydrophilic and hydrophobic. Amphiphilic silicones have the ability to form stable water-in-oil emulsions allowing formulation of a wide range of gels and creams. They are also useful as surface treatments for dispersion of polar particles in hydrocarbon media.

Amphiphilic Silicones

DodecylMethylsiloxane-HydroxypolyalkyleneoxypropylMethylsiloxane, Copolymer CAS: [145686-74-4]

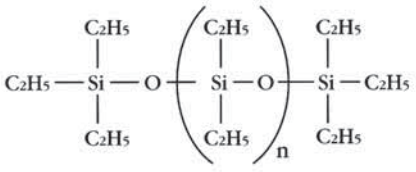
Product Code	Viscosity cSt.	Molecular Weight	Mole % Hydroxypolyalkyleneoxy-propylMethylsiloxane	Active %	Specific Gravity	Price 100g	Price 1kg
ABP-263	1000-4000	1800-2000	30-40	80-85	0.85	$46.00	$323.00
contains 15-20% isostearyl alcohol							

▶▶▶▶ Gelest, Inc.

Low Temperature Fluids

Comparative Low Temperature Properties

Product Code	Description	Viscosity 25° C, cSt.	Viscosity 0° C, cSt.	Viscosity -20° C, cSt.	Viscosity -40° C, cSt.	Viscosity -80° C, cSt.
DMS-T15	PolyDiMethylsiloxane	50	60	108	205	frozen
DES-T11	PolyDiEthylsiloxane	10	17	30	70	fluid
DES-T15	PolyDiEthylsiloxane	50	69	143	340	fluid
FMS-123	Fluorosilicone	300	5,500	10,500	20,000	frozen
MTT-1015	Methyl-T-Branched PDMS	50	90	180	380	fluid
SIM6559.0	MethylTriHexylSilane	6	19	48	150	fluid
SIM6577.0	MethylTriOctylSilane	19	62	200	frozen	frozen
SIP6827.0	PhenylTris(trimethylsiloxy)silane	4	6.5	12	20	frozen
SAE10	Petroleum Oil	100	500	11,000	235,000	frozen



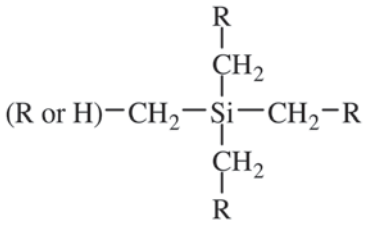
PolyDiEthylsiloxanes

Polydiethylsiloxanes offer improved metal-metal lubrication and low temperature properties when compared to polydimethylsiloxanes. They are oxidatively stable to 150°C and thermally stable under inert atmospheres to 225°C. These fluids are often used in low temperature aerospace hydraulics or as performance addine to synthetic hydrocarbons.

PolyDiethylsiloxanes, Triethylsiloxy terminated CAS:[63148-61-8]

Product Code	Viscosity cSt.	Pour Point,°C	Thermal Conductivity, W/m°C	Density	Refractive Index	Flashpoint °C	Molecular Weight	Price 100g	Price 1kg
DES-T02	2	-115	-	0.844	1.434	76	245	$46.00	$275.00
DES-T03	3-5	-115	-	0.844	1.436	80	275-325	$48.00	$288.00
DES-T11	7-12	-110	3.177	0.913	1.439	110	350-400	$48.00	$288.00
DES-T12	15-20	-110	3.296	0.93	1.439	125	400-500	$70.00	$420.00
DES-T15	40-50	-110	3.392	0.958	1.442	170	500-800	$30.00	$205.00
DES-T23	200-400	-96	3.750	0.991	1.447	256	1300-2000	$38.00	$225.00

Other Properties: Glass Transition Temperature: -139°C Specific Heat, 20-100°: 0.40-0.47 cal/mole°C
Surface Tension: 25-28 dynes/cm Viscosity Temperature Coefficient: 0.77 Volume Resistivity: 10^{13}-10^{14} ohm-cm@20°C



Silahydrocarbons

Silahydrocarbons are low molecular weight fluids that have a remarkable ability to provide excellent lubrication and liquid behavior at low temperatures. Low viscosity and hydrocarbon compatability allows use of these material as internal lubricants in ink-jet and microfluidic applications.

Silahydrocarbons

Product Code	Name	CAS	Viscocity, cSt.	Density	m.p.	b.p.	Refractive Index	flashpoint °C	Price/100g
SIM6559.0	METHYLTRI-n-HEXYLSILANE	[3429-60-5]	6	0.81	<-80°	255°	1.445	>110°	$160.00
SIM6577.0	METHYLTRI-n-OCTYLSILANE*	[3510-72-3]	19	0.81	<-31°	380°	1.452	>110°	$120.00
SIT7082.0	TETRA-n-BUTYLSILANE	[994-79-6]	10	0.80	-56°	230°	1.447	75°	$220.00

*4-ball wear (440C SS), 23°: 0.03-0.04 x 10^{-9} x mm^3/mm @100 rpm, 200N in vacuum

Branched Fluids

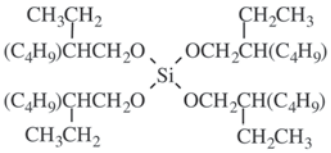
Branched and low viscosity silicone fluids offer properties that are significantly different than higher molecular weight versions since chain entanglements are limited and end-groups have influence on properties. Apart from the obvious mechanical advantage of the low viscosity in many applications, they offer higher purity levels, discrete vapor pressures and more linear rheology as a function of pressure and temperature.

Branched Fluids *T-structure Siloxanes Organosilsesquioxanes, Trimethylsilyl Terminated Tris(Trimethylsiloxy)Silanes*

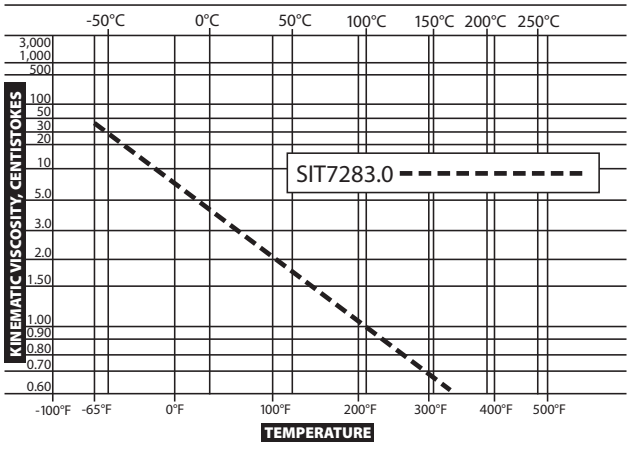
Product Code	Viscosity cSt.	Pour Point,°C	Viscosity Temp. Coefficient	Density	Refractive Index	Flashpoint °C	Molecular Weight	Price 100g	Price 1kg	Price 10kg
Methyltris(trimethylsiloxy)silane								CAS: [17928-28-8]		
SIM6592.0	1.6	-74	-	0.85	1.388	64	311	$21.00	$148.00	$1036.00
Methyl-T-Branched PolyDimethylsiloxane								CAS: [68037-74-1]		
MTT-1015	50-80	-85	0.57	0.97	1.403	285	1650	$30.00	$204.00	$1425.00
Octyltris(trimethylsiloxy)silane							[R&D only]	CAS: [187592-85-4]		
SIO6715.7	4-5	<-76	-	0.86	1.411	106	409	$29.00	$114.00	$1176.00
Octyl-T-Branched Polysilsesquioxane, Trimethylsilyl terminated							[R&D only]	CAS: [187593-69-7]		
OTT-1012	15-30	<-76	-	0.91	1.428	>110	1080	$21.00	$125.00	$878.00
OTT-1023	200-400	<-40	-	0.95	1.444	>110	1000	$30.00	$204.00	-
Phenyltris(trimethylsiloxy)silane								CAS: [2116-84-9]		
SIP6827.0	4	<-60	0.55	0.92	1.437	127	373	$20.00	$124.00	$868.00
Phenyl-T-Branched Polysilsequioxane, Trimethylsilyl terminated								CAS: [73559-47-4]		
PTT-1012	15-25	<-60	-	0.98	1.460	-	500-700	$20.00	$119.00	$832.00
PTT-1022	150-300	-	-	1.01	1.481	-	700-900	$21.00	$125.00	-
PTT-1025	400-600	-	-	1.05	1.489	-	900-1200	$29.00	$172.00	-
Phenethyltris(trimethylsiloxy)silane							[R&D only]	CAS: [211935-21-6]		
SIP6722.8	4	-55	0.68	0.93	1.440	135	401	$96.00	-	-
Tetrachlorophenyl-T-Branched PolyDimethylsiloxane								CAS: [68857-05-1]		
PTT-1117	70-75	-73	0.68	1.05	1.428	300	1600-3000	$35.00	$242.00	$1694.00

Low Temperature Silicate Ester Fluids

Silicate esters are dielectric fluids with thermal stability and low temperature properties that meet the requirements of airborne electronic equipment. Successful long term application of the fluids requires sealed systems to prevent moisture absorption.



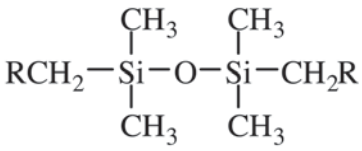
Product Code	Name	Viscosity, cSt.	Density	m.p.	b.p.	Refractive Index	flashpoint °C	CAS	Price/100g
SIT7283.0	TETRAKIS(2-ETHYLHEXOXY)SILANE	10	0.88	<-78°	198°/1mm	1.4388	188°	[115-82-2]	$28.00



Other Properties:

viscosity, 38°: 6.89 cSt;
viscosity, -40°: 310 cSt;
vapor pressure, 25°: <0.1mm
△Hvap: 169 kcal/mole
coefficient of thermal expansion: 0.8 x 10^{-3}
volume resistivity: 1x10^{11} ohm-cm
dielectric constant: 2.46
surface tension: 26.7 dynes/cm
specific heat: 0.48 cal/g/°
autoignition temp.: 304°

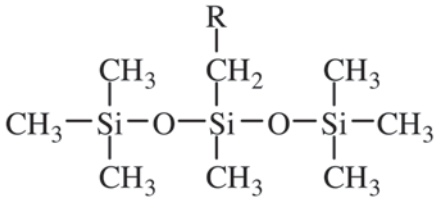
Volatile Low Temperature Fluids



Disiloxanes

Disiloxane fluids are utilized as vehicles and solvents where purity, low temperature or dielectric properties are critical factors. Since they are pure chemicals, rather than polymers, viscosities and other properties have virtually no variation.

Product Code	Name	Viscosity, cSt.	Density	m.p.	b.p./mm	Refractive Index	flashpoint °C	CAS	Price/100g
SIH6115.0	HEXAMETHYLDISILOXANE	0.65	0.764	-67°	99-100°	1.377	-1°	107-46-0	$12.00
SID3418.0	1,3-DIETHYLTETRAMETHYLDISILOXANE	1	0.797	-120°	155-6°	1.401	30°	[R&D only]	$220.00
SIH6070.0	HEXAETHYLDISILOXANE	2.35	0.844	-115°	231°	1.434	76°	999-49-0	$75.00
SID4406.0	1,3-DIOCTYLTETRAMETHYLDISILOXANE	4.11	0.891	-36°	122-5°/0.2	1.474	>110°	[R&D only]	$104.00
SID4588.0	1,3-DIPHENYLTETRAMETHYLDISILOXANE	3.45	0.976	-89°	155-8°/13	1.518	156°	56-33-7	$136.00
SIB1828.5	1,3-BIS(TRIFLUOROPROPYL)TETRAMETHYLDISILOXANE	2	1.085	-88 to -90	75°/10	1.363	-	[R&D only]	$270.00
SIB1709.0	BIS(NONAFLUOROHEXYL)TETRAMETHYLDISILOXANE	3.6	1.331	-89°	150°/45	1.340	156°	122179-35	25g/$72.00
SIB1816.0	1,3-BIS(TRIDECAFLUOROOCTYL)TETRAMETHYLDISILOXANE	6-7	1.460	-40 to -45	81-2°/11	1.337	>150°	[R&D only]	$320.00
SIB1120.0	1,3-BIS(HEPTADECAFLUORO-1,1,2,2-TETRAHYDRODECYL)TETRAMETHYLDISILOXANE	7-10	1.51	-5 to 0	>130°/5	1.335	>110°	129498-18-6	10g/$190.00
SIB1055.0	1,3-BIS(CHLOROMETHYL)TETRAMETHYLDISILOXANE	2	1.05	-90°	204-5°	1.440	73°	2362-10-9	$91.00
SIB1735.0	BIS(PENTAMETHYLDISILOXANYL)ETHANE	2.7	0.82	-52°	254-5°	1.410	-	[R&D only]	$140.00



Trisiloxane Fluids

Trisiloxane fluids are low viscosity materials that have unique wetting, surfactant and solubility characteristics. Their unusual characteristics are derived from having a small "cloud" of silicone hydrophobic groups from which other functionalities extend. While they are considered polymeric fluids, their stuctures are extremely well-defined in chemical terms since they are low molecular weight species. This table identifies the common trisiloxane fluids. Further details are found in Gelest Silicon Compounds literature.

Trisiloxanes

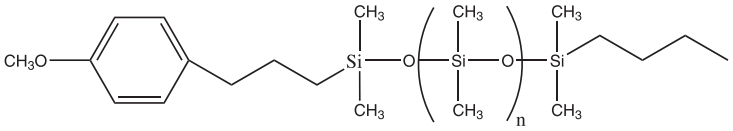
Product Code	Name	Viscosity, cSt.	Density	m.p.	b.p./mm	Refractive Index	flashpoint °C	CAS	Price/100g
SIE4895.0	3-ETHYLHEPTAMETHYLTRISILOXANE	1	0.82	<-60°	172°	1.394	45°	[17861-60-8]	$29.00
SID4627.6	3-DODECYLHEPTAMETHYLTRISILOXANE	5	0.83	14°	180°/0.3	1.422	>120°	[R&D only]	$80.00
SIO6622.0	3-OCTADECYLHEPTAMETHYLTRISILOXANE	13	0.82	-	-	1.433	>120°	[R&D only]	$86.00
SIO6711.5	3-OCTYLHEPTAMETHYLTRISILOXANE	3	0.82	-62°	84°/0.3	1.413	69°	[17955-88-3]	$68.00
SIP6736.2	3-PHENYLHEPTAMETHYLTRISILOXANE	2	0.91	-56°	78°/0.5	1.447	64°	[R&D only]	$150.00

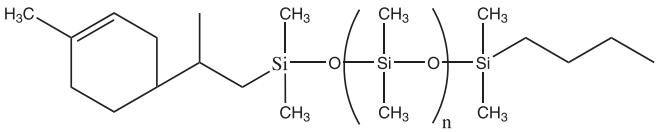
Substituted Trisiloxanes

SIT8365.0	(TRIFLUOROPROPYL)HEPTAMETHYLTRISILOXANE	2	0.93	<-78°	66-8°/10	1.375	69°	[R&D only]]	$179.00
SIA0075.0	2-(ACETOXYPOLYETHYLENEOXYPROPYL)-HEPTAMETHYLTRISILOXANE	30	1.03	-	-	1.446	79°	[12597-17-3]	$72.00
SIC2289.5	(CHLOROMETHYL)HEPTAMETHYLTRISILOXANE	1	0.92	-85°	185-6°	1.406	>65°	[R&D only]	$159.00

SiBrid® Inert Silicones

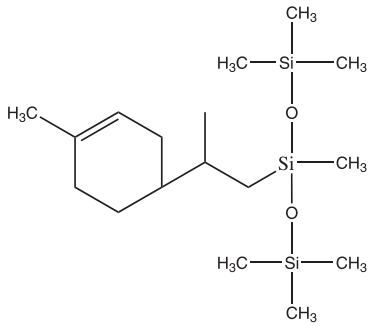
SiBrid® inert silicones are hybrid organic-inorganic liquid polymers that combine on a molecular level structural features associated with conventional organic polymers and silicones. SiBrid® silicones offer the wide range of thermal performance, surface properties associated with silicones, but with compatibility and solubility with organic systems, particularly organic polymers. They can introduce release properties into coating and cosmetic formulations. They behave as internal lubricants and impact modifies for thermoplastics.





Naturally Derived Silicones

Product Code	Description	Viscosity	CAS	Specific Gravity	Refractive Index	Molecular Weight	Price/100g	Price/1kg
MCR-NA07	MonoANISYL terminated Polydimethylsiloxane	7-8	1283601-14-8	0.940	1.430	650-850	$135.00	$810.00
MCR-NL07	MonoLIMONENYL terminated Polydimethylsiloxane	7-8	1283601-16-0	0.920	1.424	650-850	$126.00	$756.00
DMS-NL04	LIMONENYLTRISILOXANE	4-5	1263044-0-3	0.880	1.426	358	$135.00	$810.00



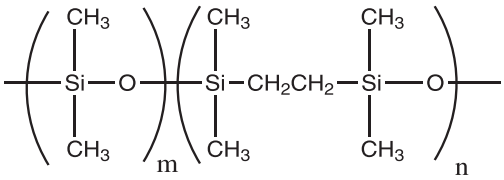
Solubility Panel

Product	DMA-131	DCE-7521	MCR-NA07	MCR-NL07	DMS-NL04	PDMS
D5	S (hot)	S	S	S	S	S
PDMS, 10cSt	S (hot)	S	S	S	S	S
Stearyl Methicone	S	S	S	S	S	S
Hydrogenated Polydecene	S	S	S	S	S	S
10% Microcrystalline wax	S	I	I	I	I	I
Ceresin	S	I	I	I	I	I
Octyldodecyl Stearate	S	S (hot)	S	S	S	I
Triisostearyl Citrate	S	S	S	S	S	I
Ethylhexyl Palmitate	S	S	S	S	S	S
Octyldodecanol	S	I	S	S	S	I
Castor Oil	I	I	I	S	I	I

S = Soluble I = Insoluble

SiBrid® Inert Silicones

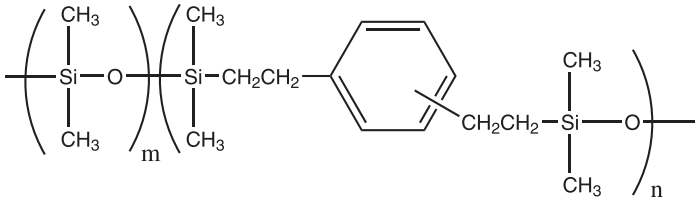
Ethylene Siloxane Copolymers are used as additives to compatibilize or stabilize mixed silicone organic formulations. Incorporation at low levels, typically 1-3%, helps stabilize silicone-organic mixtures that have a tendency to phase separate during storage. Silethylphenylene containing copolymers offer increased thermostability and higher refractive index.



Ethylene - Dimethylsiloxane copolymers

Product Code	Viscosity	Mole % Siloxane	Specific Gravity	Refractive Index	Molecular Weight	Price/100g	Price/1kg
DCE-7007*	7-10	66-70	0.87	1.426	450-650	$48.00	$288.00
DCE-7012*	25-25	66-70	0.89	1.433	750-1000	$48.00	$288.00
DCE-7521**	80-120	75-76	0.92	1.431	>2000	$45.00	$270.00

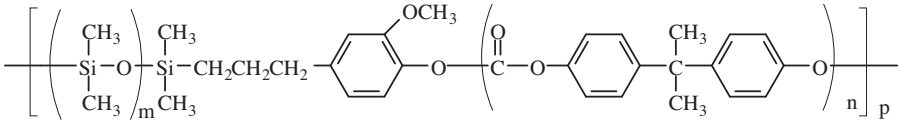
*[1035218-85-9]; **[26710-23-6]



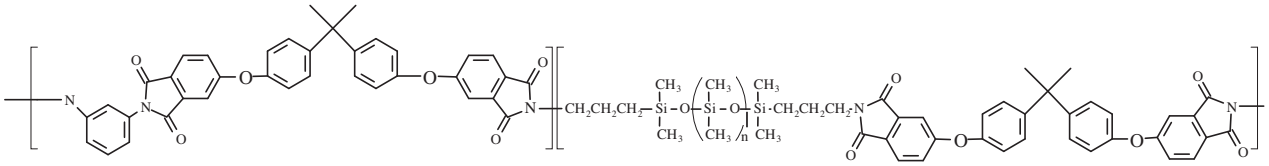
Silethylphenylene - Dimethylsiloxane copolymers

Product Code	Viscosity	Mole % Siloxane	Specific Gravity	Refractive Index	Molecular Weight	Price/100g	Price/1kg
DCS-8024	350-600	78-82	0.98	1.444	5000-6000	$78.00	$468.00

Thermoplastic Resins for Melt Processing or Solution Casting

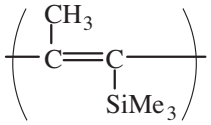


SSP-080
(DIMETHYLSILOXANE)(BISPHENOL -A CARBONATE) copolymer
(15 - 20% polydimethylsiloxane)
thermoplastic; tensile strength: 50MPa Vicat mp: 145° density: 1.19
[202483-49-6] TSCA HMIS: 1-1-0-X 100g/$120.00



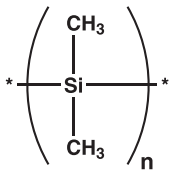
SSP-085
(DIMETHYLSILOXANE)(ETHERIMIDE) copolymer
(35-40% polydimethylsiloxane)phenylenediaminepolyetherimide
thermoplastic; tensile strength: 2800psi Tg: 168°C density: 1.18
[99904-16-2] TSCA HMIS: 1-1-0-X 100g/$120.00

SSP-070
POLY(TRIMETHYLSILYL)PROPYNE

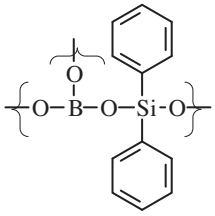


forms viscous 5% solutions in toluene/tetrahydrofuran
high oxygen permeability[1]; PO_2/PN_2 = 1.7
1. Masuda, T.; et al, J. Am. Chem. Soc., **1983**, *105*, 7473.
[87842-32-8] HMIS: 1-1-0-X 10g/$190.00

Pre-Ceramic Polymers



PSS-1M01
Poly(DIMETHYLSILANE)
employed in CVD of SiC films.[1]
1. Scarlete, M., et al; US Patent 7,396,563; 2008 (Label Licensed Gelest Product)
[30107-46-8] TSCA HMIS: 1-1-0-X 100g/$115.00



SSP-040
POLY(BORODIPHENYLSILOXANE) solid, Tg: 95-100°, Tm: 140-1°
employed in preparation of ceramic fibers.[1]
1. Yajima, S.; et al, Nature, **1977**, *266*, 521.
[70914-15-7] TSCA HMIS: 2-0-0-X 25g/$72.00 100g/$234.00

Silicone Fluids for Optical Applications

Gelest offers pure silicone fluids (not blends) with a wide range of refractive indices. Listed below are fluids with refractive indices and viscosities. Fluids with the same product code prefix can be blended to exact refractive index requirements.

Product Code	Refractive Index@25° 589.3nm	Viscosity (cSt)@25°	Price/25g	Price/100g
SIB1120.0	1.335	7-10	$190.00	-
SIB1816.0	1.336	6-7	$98.00	$320.00
SIB1709.0	1.340	3-4	$72.00	$234.00
FMS-736	1.375	6000	$54.00	$176.00
FMS-121	1.382	80-120	$38.00	$124.00
FMS-221	1.387	80-120	$13.00	$41.00
DMS-T12	1.400	20		$10.00
DMS-T21	1.402	100		$10.00
DMS-T22	1.403	200		$10.00
SIO6711.5	1.413	3		$68.00
PDM-0421	1.422	100		$14.00
PTT-1117	1.428	70-75		$32.00
DBE-224	1.430	400		$16.00
PDM-0821	1.436	100-125		$12.00
DES-T12	1.439	15-20		$38.00
ALT-143	1.445	600-1000		$14.00
DBE-814	1.452	40-50		$12.00
APT-213	1.462	1200-1600		$19.00
PMM-0011	1.470	10-20	$28.00	$90.00
APT-133	1.480	1000		$19.00
PDM-1922	1.490	160-230		$22.00
APT-233	1.493	1500-2000		$16.00
PMM-5021	1.500	125		$21.00
SIT8662.0	1.501	15	$78.00	-
PMM-6025	1.506	500-550		$20.00
PMM-0021	1.520	100-200		$78.00
PMM-0025	1.533	500		$21.00
PMP-5025	1.543	400-500	$35.00	$130.00
PDM-7040	1.556	35-40		$38.00
PDM-7050	1.588	170-175		$52.00

Appendix 1 – Viscosity Conversion Chart

Centistokes	Poise	SSU	Zahn #1	Zahn #2	Zahn #3	Zahn #4	Zahn #5	Ford #3	Ford #4	Krebs Units	SAE	Liquid Example
1	.01	.31										Water
10	.10	60	30	16				9	5			
20	.20	100	37	18				12	10			
40	.40	210	52	22				25	18			
60	.60	320	68	27				33	25	33	10	
80	.80	430	81	34				41	31	37		
100	1.0	530		41	12	10		50	34	40	20	olive oil
200	2.0	1,000		82	28	17	10	90	58	52		
300	3.0	1,475			34	24	15	130	74	60		
400	4.0	1,950			46	30	20	170	112`	64	30	glycerine
500	5.0	2,480			58	38	25	218	143	68	40	
1,000	10.0	4,600				69	49	390	264	85	90	castor oil
2,000	20.0	9,400						800	540	103		
3,000	30.0	14,500						1,230	833	121		
4,000	40.0	18,500						1,570	1,060	133		molasses
5,000	50.0	23,500							1,350			corn syrup
6,000	60.0	28,000							1,605			
7,000	70.0	32,500							1,870			
8,000	80.0	37,000							2,120			
9,000	90.0	41,000							2,360			
10,000	100	46,500							2,670			honey
15,000	150	69,400										
20,000	200	92,500										
30,000	300	138,600										
40,000	400	185,600										
50,000	500	231,000										
60,000	600	277,500										
70,000	700	323,500										
80,000	800	370,500										
90,000	900	415,500										
100,000	1,000	462,000										sour cream
125,000	1,250	578,000										molasses*
150,000	1,500	694,000										
175,000	1,750	810,000										
200,000	2,000	925,000										peanut butter

viscosities at 25°C unless otherwise stated

*measured at 2°C (a cold winter day)

Note: The precision of conversion in this table is limited by two factors. It assumes that the density of liquids is 1 so that stokes and poises are the same and that viscosity is independent of shear rate, i.e., the fluid is Newtonian. To correct for density in converting from centistokes to centipoises, multiply specific gravity by centistokes.

Appendix 2 – Blending Silicone Fluids

Any standard viscosity grade of polydimethylsiloxane can be blended together with another viscosity grade of the same fluid to produce an intermediate viscosity. This chart provides a means for determining the proper blend ratio. The chart should be used as follows:

Decide upon the viscosity grades to be blended. For high accuracy, measure the actual viscosity of the blending fluids.

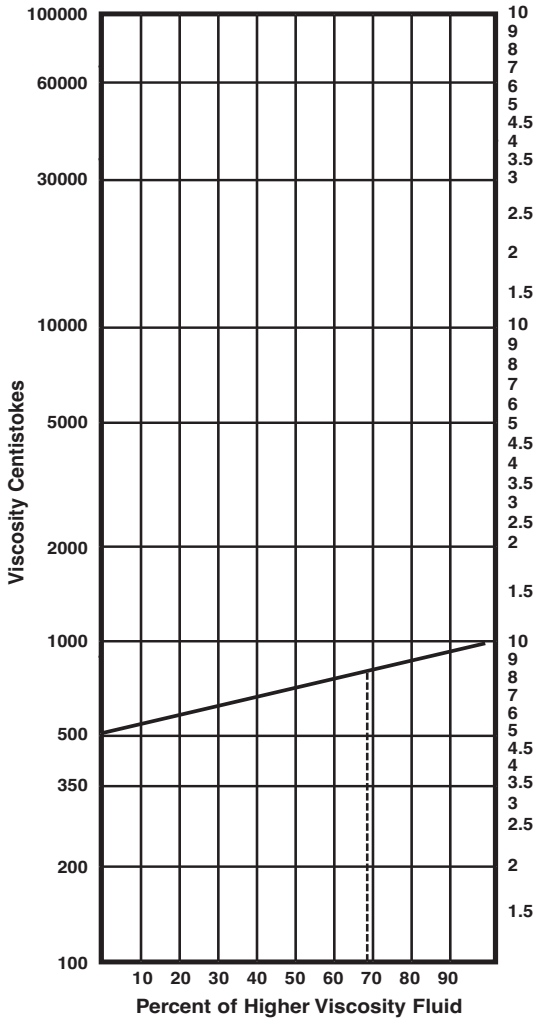
Locate the lower viscosity on the left hand scale.

Locate the higher viscosity on the right hand scale.

Connect these two points with a straight line.

Locate the point where the line indicating the desired blend viscosity intersects the constructed line. From this point, follow down to the horizontal scale to read the percent of the higher viscosity fluid to use in the blend.

This method is reasonably accurate in predicting blend viscosity when the two fluids differ in viscosity by no more than one magnitude (one power of ten). When fluids covering a wider range are blended, the chart will only approximate the finished viscosity. To achieve a viscosity of 800 cSt. as shown in the example, 68% of 1000 cSt. and 32% of 500 cSt. fluids are blended.



The calculation basis for blending is:

$$\log = \frac{A \log^1 + B \log^2}{A + B}$$

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