



Fluid Clutch Fluid Clutch
Hydraulic Fluid Hydraulic Fluid
Brake Fluid Brake Fluid
Shock Absorber Shock Absorber
General Damping General Damping
Meter Damping Meter Damping
Timing Devices Timing Devices
Magnifying Amplifier Amplifier
Pump Pump
Surfactant Surfactant
Hydrophobicity Hydrophobicity
Flow Control Flow Control
Wetting Wetting
Radiation Resistance
Sonobuoy
Sound Coupling Sound Coupling/Lensing
Optical Coupling Optical Coupling Fluid
Artificial Fog Agent
Heat Treatment Bath
Constant Temperature Bath
Temperature Measurement Temperature Measurement
Electro-Rheology Rheology
Closed Loop Heating Heating
Transformers, Rectifiers Rectifiers
Capacitors
Magnetic
Dielectric Impregnation
Mold Release
Aluminum Machining and Extruding Aluminum Machining and Extruding
Die Casting Die Casting
Ball Bearing and Gear Lubrication Ball Bearing and Gear Lubrication
Airborne Radar
Rubber/Plastic Contact Rubber/Plastic Contact
Fiber/Plastic Contact Fiber/Plastic Contact
Metal/Plastic Contact Metal/Plastic Contact
Grease Grease

Geldest

SILICONE FLUIDS:

**STABLE,
INERT MEDIA**

ENGINEERING AND
DESIGN PROPERTIES
FOR:

*Heat Transfer,
Mechanical,
Lubrication,
Smart Fluid,
Dielectric and
Optical Applications*

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	Page 18	Page 19	Page 20	Page 22	
Thermal Silicone Fluids	Organic Compatible Silicone Fluids	Fluorosilicone Fluids	Hydrophilic and Polar Silicone Fluids	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 x 10 ⁵	500-1 x 10 ⁴	80-1 x 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	1.336-1.578	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

Definitions and Terms	4
Introduction	5
Selection Guide.....	6
Fluid Properties.....	8
Viscosity Conversion Chart	23
Blending Chart.....	24
Conversion Factors	25

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SILICONE FLUIDS: Stable, Inert Media



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Materials For:

Dielectric
Heat Transfer
Mechanical
Optical
Lubrication
Smart Fluids

Supplement to the Gelest Catalog, "Silicon, Germanium & Tin Compounds,
Metal Alkoxides and Metal Diketonates" which is available upon request.
General Conditions of Sale of Gelest Inc. are published therein.

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 shear stress.
Glass Transition Temperature	The temperature associated with a change from a glassy state to a plastic state. For silicones the T _g 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 /s. A centistoke, cSt. = .01 St. = 1mm. 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): $\log M_w \text{ PDMS}/M_w \text{ PST} = 1.1813 + 0.0769V$, 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 $\pm 10\%$ for fluids $\leq 100,000$ cSt and $\pm 15\%$ for fluids $> 100,000$ cSt. Reported viscosities for copolymer fluids are $\pm 20\%$.
Temperature	When not indicated, reported properties for silicone fluids are at 25°C (298.15°K).

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:

■	Conventional Fluids.....	page 8
■	Thermal Fluids.....	page 16
■	Organic Compatible Fluids.....	page 18
■	Fluorosilicone Fluids.....	page 19
■	Hydrophilic & Polar Fluids.....	page 20
■	Low Temperature Fluids.....	page 22

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.

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 or Emulsion
	Aluminum Machining and Extruding	Organic Compatible
	Die Casting	Organic Compatible
	Ball Bearing and Gear Lubrication	Organic Compatible Thermal or Fluorosilicone
	Airborne Radar	Low Temperature
	Rubber/Plastic Contact	Conventional or Organic Compatible
	Fiber/Plastic Contact	Hydrophilic
	Metal/Plastic Contact	Organic Compatible Thermal or Fluorosilicone
	Metal/Metal Contact	Organic Compatible Thermal (Chlorophenyl)
	Grease	Conventional, Thermal or Fluorosilicone

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

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 indefinitely 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

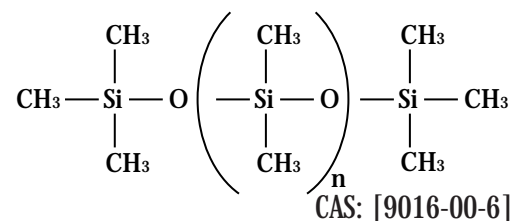
3rd character=viscosity to 1 significant figure

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

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: ACOUSTICAL, DENSITY, ELECTRICAL, MECHANICAL, MOLECULAR WEIGHT, OPTICAL, RADIATION RESISTANCE, REACTIVITY, RHEOLOGY, SOLUBILITY, THERMAL PERMEABILITY.



Coeff. of Thermal Expansion x 10 ⁻⁴	Coeff. of Thermal Conductivity x 10 ⁻¹⁰ °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	\$12.00	2.5kg/\$96.00	14kg/\$272.00
13.4	2.4	17.4	2.30	350	38	237	\$27.00	2.5kg/\$220.00	14kg/\$556.00
13.4	2.5	18.0	2.39	350	63	340	\$30.00	2.5kg/\$248.00	15kg/\$606.00
11.7	2.6	18.7	2.45	350	79	410	\$30.00	2.5kg/\$248.00	15kg/\$606.00
11.4	2.7	19.2	2.50	350	100	550	\$30.00	2.5kg/\$248.00	15kg/\$606.00
11.2	2.8	19.7	2.60	375	135	770	\$12.00	3kg/\$120.00	15kg/\$300.00
11.0	3.0	19.9	2.65	375	150	950	\$12.00	3kg/\$120.00	15kg/\$300.00
10.8	3.2	20.1	2.68	375	163	1,250	\$10.00	3kg/\$96.00	16kg/\$256.00
10.7	3.4	20.6	2.72	375	232	2,000	\$10.00	3kg/\$96.00	16kg/\$256.00
10.6	3.6	20.8	2.75	400	285	3,780	\$10.00	3kg/\$96.00	16kg/\$256.00
9.3	3.7	20.9	2.75	400	315	5,970	\$10.00*	3kg/\$96.00	16kg/\$256.00
9.3	3.7	21.0	2.75	400	315	9,430	\$10.00*	3kg/\$96.00	16kg/\$256.00
9.3	3.8	21.1	2.75	400	315	13,650	\$10.00*	3kg/\$96.00	16kg/\$256.00
9.3	3.8	21.1	2.75	400	315	17,250	\$10.00*	3kg/\$96.00	16kg/\$256.00
9.3	3.8	21.2	2.75	400	315	28,000	\$10.00*	3kg/\$96.00	17kg/\$272.00
9.3	3.8	21.3	2.75	400	315	49,350	\$14.00	3.5kg/\$110.00	17kg/\$272.00
9.3	3.8	21.5	2.75	400	315	62,700	\$14.00	3.5kg/\$110.00	17kg/\$272.00
9.3	3.8	21.5	2.75	400	315	67,700	\$19.00	3.5kg/\$124.00	17kg/\$306.00
9.3	3.8	21.5	2.75	400	315	91,700	\$19.00	3.5kg/\$124.00	17kg/\$306.00
9.2	3.8	21.5	2.75	400	315	116,500	\$19.00	3.5kg/\$124.00	17kg/\$306.00
9.2	3.8	21.5	2.75	400	321	139,000	\$29.00	3.5kg/\$196.00	17kg/\$578.00
9.2	3.8	21.5	2.75	400	321	204,000	\$29.00	3.5kg/\$196.00	17kg/\$578.00
9.2	3.8	21.6	2.75	400	321	260,000	\$29.00	3.5kg/\$196.00	17kg/\$578.00
9.2	3.8	21.6	2.75	400	321	308,000	\$39.00	3.5kg/\$264.00	17kg/\$680.00
9.2	3.8	21.6	2.75	400	321	423,000	\$48.00	3.5kg/\$360.00	17kg/\$816.00

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

Drum pricing available on request.

Low Volatility Grades p. 14
 Volatile Cyclic Silicones p. 14
 Emulsions p. 15
 Colored Silicone Fluids p. 15
 Branched Methyl Fluids p. 22

Properties of Conventional Silicone Fluids (Polydimethylsiloxanes) – continued

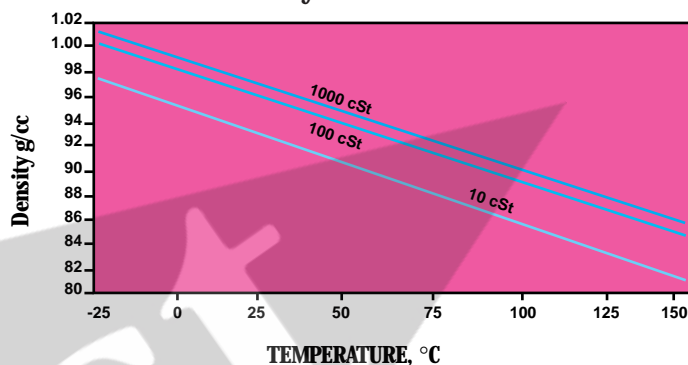
Polydimethylsiloxane properties that do not vary significantly for fluids with viscosities greater than 10 cSt. are listed below.

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

Density

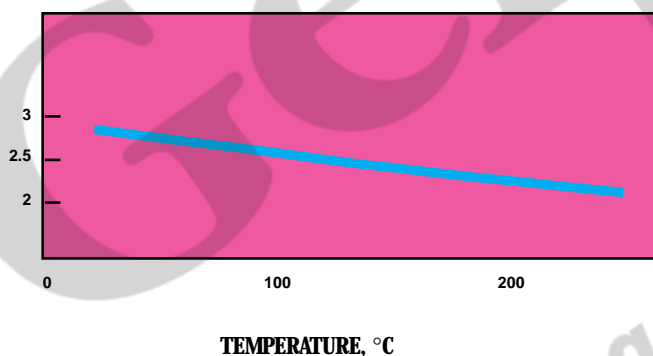
Density vs. Temperature of Dimethylsiloxane Fluids



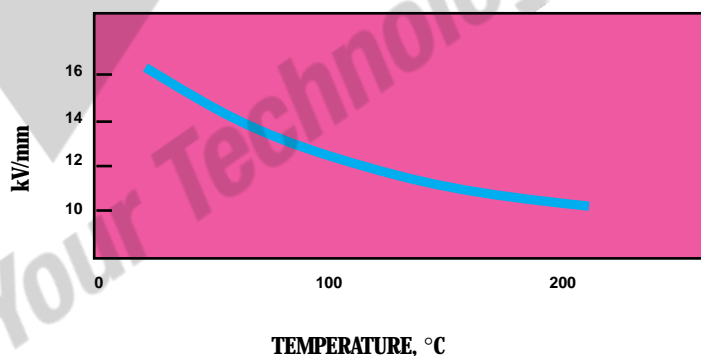
Electrical

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

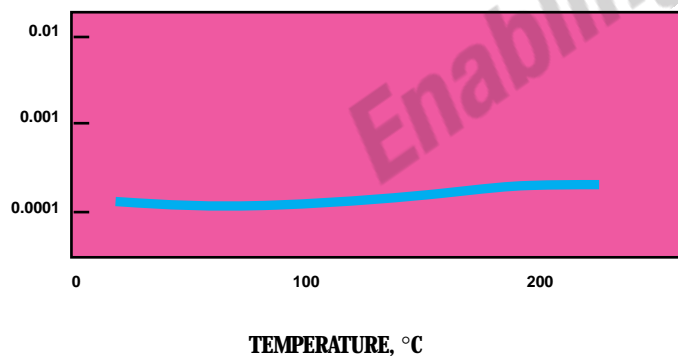
Dielectric Constant



Dielectric Strength in kV/mm

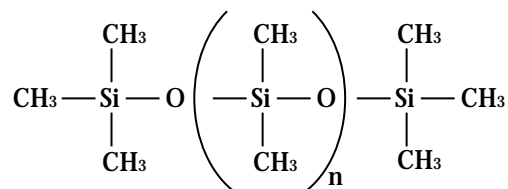


Power Factor



Mechanical

Coefficient of adiabatic compressibility	1.10x10 ⁻¹⁰ cm ² /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%

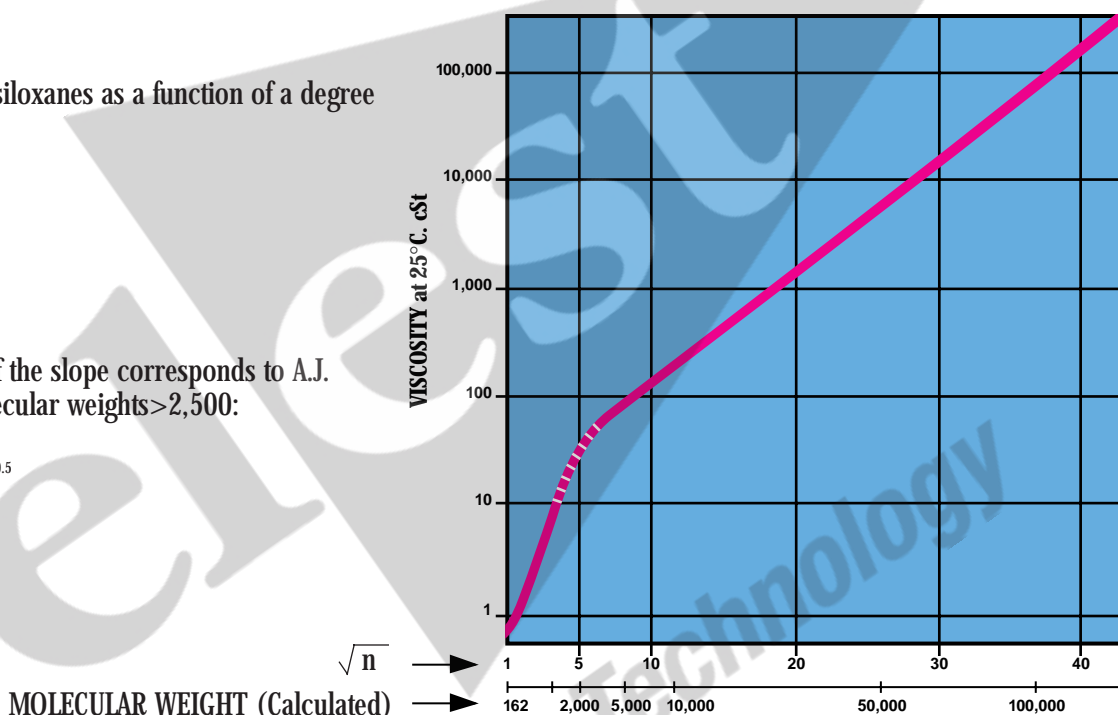


Molecular Weight

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:

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

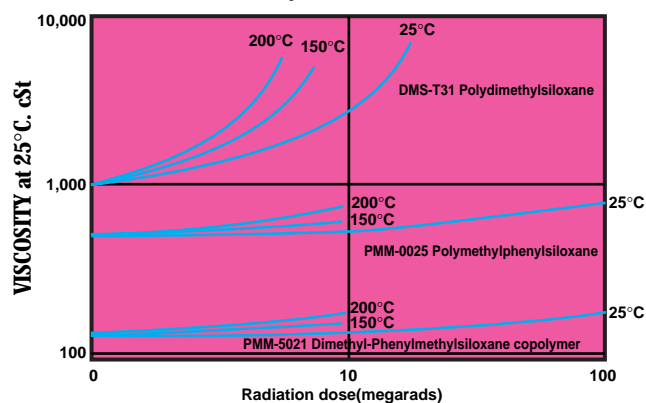


Optical

Refractive index, 25°C	1.397-1.404
Verdet constant of magnetic rotary power	16.2-16.9x10 ⁻³ mm/gm/cm

Radiation Resistance

Effect of Gamma Radiation on Viscosity of Silicone Fluids



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.

Reactivity

While they exhibit low reactivity under many conditions, certain environments are destructive to silicone fluids. Hydrogen fluoride, for example, attacks the silicone-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 silicone-oxygen bonds to produce 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 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 ₂ O	650	n-C ₆ H ₁₄	1410
He	52	NO ₂	1140	n-C ₈ H ₁₈	1290
NH ₃	885	SO ₂	2250	n-C ₁₀ H ₂₂	645
H ₂ O	5400	CS ₂	1350	HCHO	1665
CO	51	CH ₄	142	CH ₃ OH	2085
N ₂	42	C ₂ H ₆	375	COCl ₂	2250
NO	90	C ₂ H ₄	200	Acetone	835
O ₂	90	C ₂ H ₂	3960	Pyridine	2865
H ₂ S	1500	C ₃ H ₈	615	Benzene	1620
Ar	90	n-C ₄ H ₁₀	1350	Phenol	3150
CO ₂	410	n-C ₅ H ₁₂	3000	Toluene	1370

*cm³/s · cm² · cm Hg
values adjusted from filled silicone membranes

Thermal

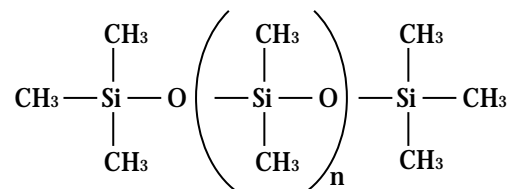
Specific heat	0.35-0.37 cal/gm/°C
Heat of formation	-2.41 Kcal/gm
Heat of combustion (>50 cSt.)	6.13 Kcal/gm
Glass transition temperature	-128°C
Gel time, 150°C	indefinite
Gel time for intermediate viscosity fluids, 200°C	200 hours
Gel time for high viscosity fluids, 200°C	100 hours
Autoignition temperature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

Rheological Behavior Under Shear

At shear rates commonly encountered ($\leq 10^4 \text{ s}^{-1}$) 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.

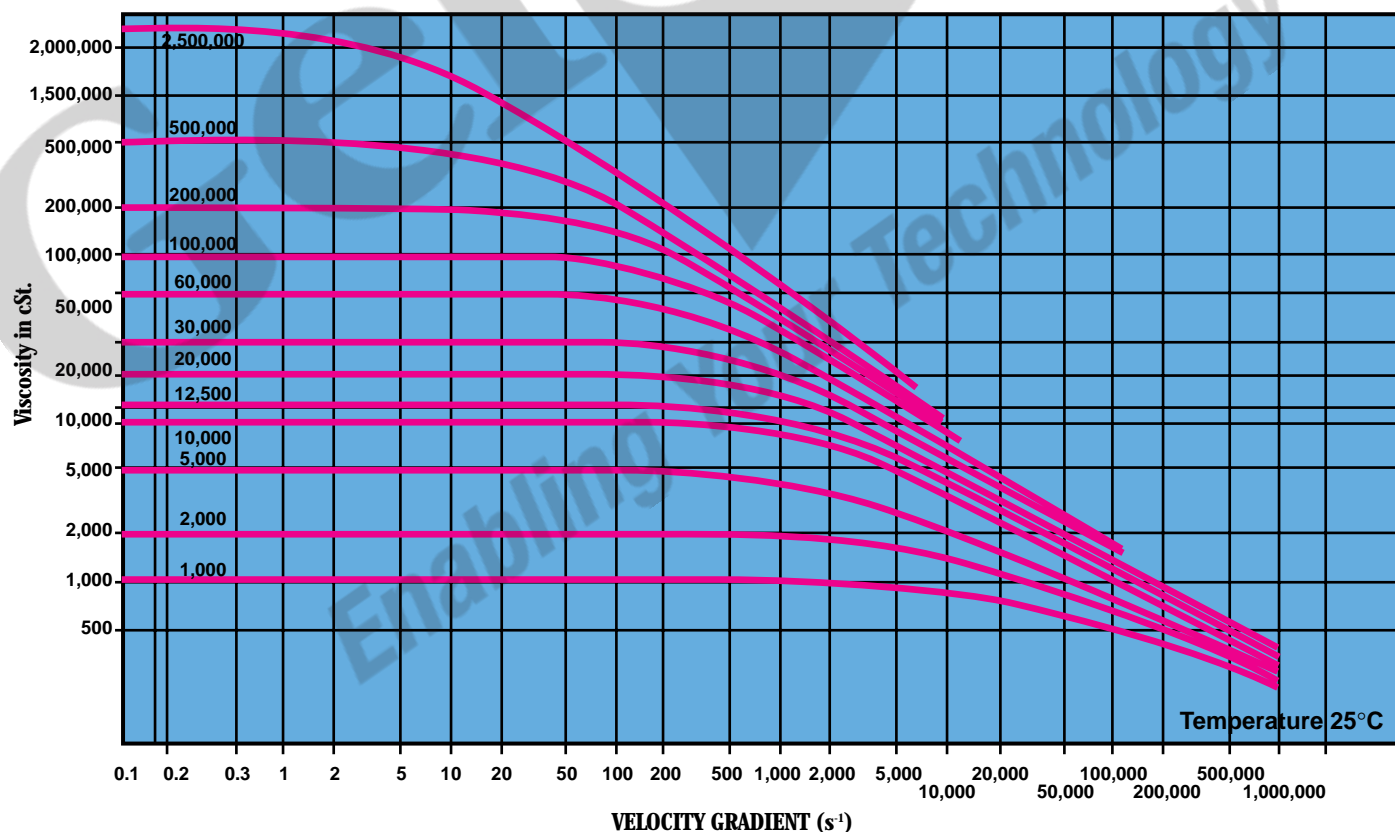
For oils of a higher viscosity than 1,000 cSt., this ratio is only constant for velocity gradients below a certain value. Beyond this value, becoming lower as the product becomes more viscous—the ratio is no longer constant: apparent viscosity falls below real viscosity (extrapolated for a zero velocity 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 $10,000 \text{ s}^{-1}$.



	Critical velocity gradient (s^{-1})	Apparent viscosity for a velocity gradient of $10,000 \text{ s}^{-1}$ (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 include outgassing, migration and, in contact with certain plastics and rubbers, bleed, plasticization and stress-cracking. 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.

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

Reduced Volatility PolyDimethylsiloxanes

% volatiles measured after 24 hours at 125°C in air

Product Code	Viscosity	% Volatiles	Price/1kg
DMS-T07R	7	8	\$120.00
DMS-T12R	20	0.5	\$110.00
DMS-T21R	100	0.05	\$110.00

Extreme Low Volatility PolyDimethylsiloxanes

<0.01% 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	\$260.00
DMS-T31E	1000	\$260.00
DMS-T41.2E	12,500	\$260.00

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, pro-

ducing 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%

Product Code	Base fluid Viscosity	% Solids	Emulsion Type	Price/100g	Price/3kg	Price/18kg
DMS-T21M50	100	53-56	nonionic	\$10.00	\$60.00	\$246.00
DMS-T31M50	1000	54-58	nonionic	\$10.00	\$60.00	\$246.00
DMS-T41M50	10,000	51-55	nonionic	\$10.00	\$60.00	\$246.00
DMS-T51M35	>100,000	33-36	anionic	\$10.00	\$78.00	\$328.00

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 Viscosity Component	% Solids	Blend Viscosity	Price/100g	Price/3kg
DMS-T51B20	100,000 cSt.	20	200-250 cSt.	\$29.00	\$196.00
DMS-T72B15	15-20x10 ⁶ cSt.	15	4000-8000 cSt.	\$39.00	\$264.00

Colored Silicone Fluids

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

PolyDimethylsiloxane Fluid Blends

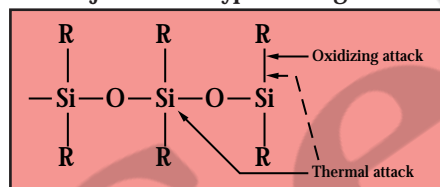
Product Code	Description	Price/100g	Price/1kg
DMS-T21BLU	Blue Dye in 100 cSt. fluid	\$15.00	\$64.00
DMS-T21RED	Red Dye in 100 cSt. fluid	\$15.00	\$64.00

Thermal Silicone Fluids

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 bearings, 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 substitu-

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	160-230	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-1025	500	180	0.62	-70	-121	180-200
PMM-1043	30000	5500	0.63	-70	-121	<100
PMM-5021	125	20	0.78	-51	-100	1000-1400

PhenylMethylsiloxane Homopolymers CAS: [9005-12-3]

PMM-0011	10-20	<5	-	-	-	>flashpoint**
PMM-0021	100-150	14-17	0.79	-	-	1600-2100
PMM-0025	500	35	0.88	-20	-86	1500-2000

PhenylMethylsiloxane-Diphenylsiloxane Copolymers [R&D only]

PMP-5053	200,000-500,000	-	-	20	-	-
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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
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* The gel time for conventional fluids (DMS-T31) is <10 hours; coking time for mineral oil is <2 hours

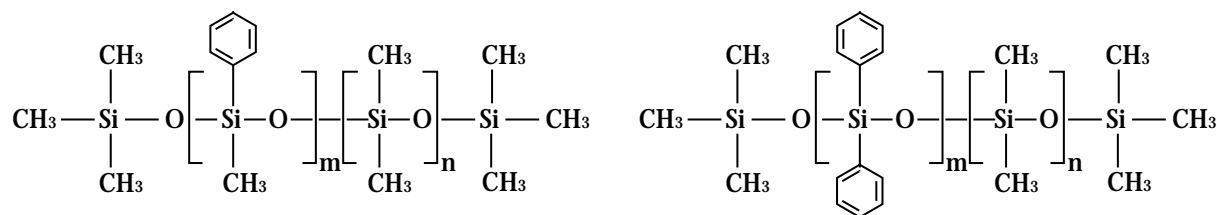
** Unsafe operating temperature in air.

tion 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 aromatic silox-

anes 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 %	Molecular Weight	Price 100g	Price 1kg	Price 10kg
0.98	1.422	22.6	2.75	280	484	4-6*	-	\$14.00	\$98.00	\$686.00
0.99	1.436	22.8	2.78	280	484	7-10*	-	\$12.00	\$84.00	\$588.00
1.05	1.490	24.5	2.83	285	488	18-22*	1600-2400	\$22.00	\$160.00	\$1120.00

*Diphenylsiloxane

1.00	1.425	25.0	2.77	275	482	8-12**	1500-1600	\$18.00	\$126.00	\$884.00
1.00	1.425	24.4	2.80	285	482	8-12**	-	\$21.00	\$150.00	\$1050.00
1.00	1.425	24.8	2.82	285	482	8-12**	-	\$48.00	\$336.00	-
1.07	1.500	24.5	2.87	300	482	49-52**	2000-2200	\$21.00	\$150.00	\$1050.00

**Phenylmethylsiloxane

1.01	1.470	-	-	220	420	-	350-450	\$120.00	-	-
1.09	1.520	-	2.93	280	484	-	700-900	\$78.00	-	-
1.11	1.533	28.5	2.95	300	487	-	2500-2700	\$21.00	\$150.00	\$1050.00

1.15	1.582	-	-	300	-	45-55**	-	\$116.00	-	-
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**Phenylmethylsiloxane

1.07	1.556	37.3	-	221	425	-	485	\$38.00	\$264.00	
1.09	1.588	36.5	-	245	440	-	547	\$52.00	\$364.00	

1.05	1.428	21.0	2.90	300	480	-	1600-3000	\$32.00	\$220.00	\$1540.00
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Thermodynamic Properties*

Thermal Expansion, (25-150°C), cc/cc/°C: 7.5-9.4 x 10⁻⁴

Thermal Conductivity, cal/(sec.)(cm²)(°C/cm): 3 x 10⁻⁴

Specific Heat, 38°C, watt/m.°K: 1.50-1.56

Electrical Properties*

Volume Resistivity, Ω-cm: 25°C: 1-4 x 10¹⁴
50°C: 1-5 x 10¹²

Dielectric Strength, kV/mm: 14

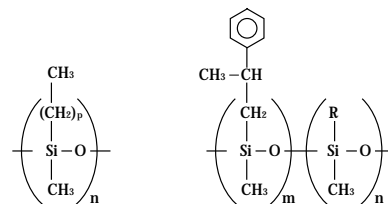
Dissipation Factor: at 10² Hz: 1.1-5.1 x 10⁻⁴
at 10⁶ Hz: 0.5-1.1 x 10⁻⁴

*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
PDM-1922	6.5	Diphenyldimethyl- siloxane Copolymer
PMM-0025	5.5	Polyphenylmethylsiloxane

Organic Compatible Silicone Fluids



Organic character is imparted to silicones by incorporating alkyl groups or aromatic substituted alkyl (aryl-alkyl) groups. The alkyl modified siloxanes more closely resemble hydrocarbons. In addition to their greater compatibility with organic materials, they have greatly improved lubrication characteristics, higher viscosity-temperature coefficients, lower compressibility and decreased oxidation stability, when compared to polydimethylsiloxanes.

Polyoctylmethylsiloxane is useful as a lubricant for soft metals such as aluminum, zinc and copper. It is also useful as a rubber and plastic lubricant especially when mated against steel or aluminum. It can be employed in aluminum machining operations. It also behaves as a process aid and plasticizer in polyolefin and SEBS rubbers.

As the pour point of the alkyl modified siloxanes increase, the resemblance and compatibility with hydrocarbon oils increases. Polytetradecylmethylsiloxane has a high degree of hydrocarbon compatibility and maintains liquid behavior at room temperature. Polyoctadecylmethylsiloxane and Triacetylmethylsiloxanes are creamy solids with melt points just above room temperature. They are compatible with paraffin wax, and can be used as components in thread and fiber lubricant formulations and as process aids in melt spinning. Methylalkylsiloxanes reduce surface tension of many non-aqueous solvents

allowing them to act as wetting and leveling agents in coating and ink formulations. Aromatic substitution extends stability and compatibility of alkylsiloxanes.

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. They are also used as lubricants for die cast metals such as zinc and aluminum and soft metals such as copper and bronze. The incorporation of butylated aryloxypropyl units dramatically improves oxidation stability. Copolymers of this type are used as lubricants in sintered metal bearings for fans and motors, hydraulic fluids and process fluids for aluminum extrusions. 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 for de-airing molded urethane and epoxy parts during fabrication and die-cast metal lubrication. Alkylsiloxane-dimethylsiloxane copolymers are readily miscible with many hydrocarbons, introducing silicone properties to hydrocarbons. Smart fluids can be formulated with low viscosity organic siloxanes such as Dicyclopentylsiloxane.

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	-50	0.91	1.445	30.4	-	\$16.00	\$112.00	\$784.00
polyTetradecylMethylsiloxane CAS: [76684-67-8]									
ALT-173	1500-2000	30	0.89	1.455	35.0	-	\$35.00	\$245.00	
polyOctadecylMethylsiloxane CAS: [69607-75-0] (Solid at room temperature)									
ALT-192	250-300 (50°C)	50	0.89 (50°C)	1.443	39.5	-	\$16.00	\$112.00	\$784.00

AlkylMethylsiloxane - ArylalkylMethylsiloxane Copolymers

(75-85% EthylMethylsiloxane) - (15-25% 2-PhenylpropylMethylsiloxane) Copolymer CAS: [68037-77-4]									
ALT-213	1200-1600	-	1.01	1.462	-	209	\$19.00	\$148.00	\$888.00
(45-55% HexylMethylsiloxane) - (45-55% 2-PhenylpropylMethylsiloxane) Copolymer CAS: [68952-01-2]									
ALT-233	1500-2000	-	1.04	1.493	-	275	\$16.00	\$112.00	\$784.00
(94-5% DecylMethylsiloxane) - (5-6% Butylated AryloxypropylMethylsiloxane) Copolymer CAS: [68440-89-1]									
ALT-251	40-60	-51	0.89	1.443	26.0	316	\$16.00	\$112.00	\$784.00
(60-70% DodecylMethylsiloxane) - (30-40% 2-PhenylpropylMethylsiloxane) Copolymer CAS: [68037-76-3]									
ALT-263	1100-1300	-	0.91	1.464	-	277	\$19.00	\$148.00	\$888.00

AlkylMethylsiloxane DiMethylsiloxane Copolymers

(27-33% OctadecylMethylsiloxane) - (DiMethylsiloxane) Copolymer CAS: [67762-83-8] (Solid at room temperature)									
ALT-292	230-350	40	0.89	1.440	-	-	\$38.00	\$266.00	
(4-6% Triacetylmethylsiloxane) - (DiMethylsiloxane) Copolymer CAS: [17725-30-0] (Solid at room temperature)									
ALT-563	2000-4000 (100°C)	75	0.85	1.431	-	-	\$60.00	\$420.00	

DiAlkylsiloxane Homopolymers

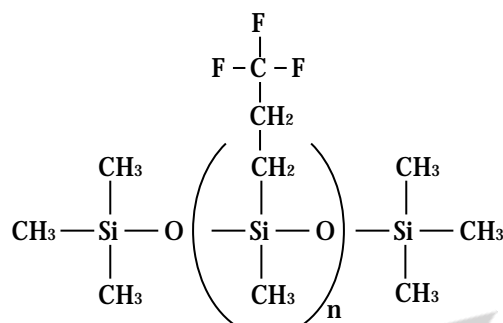
DiCyclopentylsiloxane Homopolymer [R&D only]									
ALT-652	200-300	-	1.03	1.488	-	-	\$160.00		

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 electri-



cal 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 flotation medium for inertial guidance systems. Acoustic velocities in fluorosilicones are lower than conventional silicones, allowing sonar lens development. The fluids have a compressibility of 7.5% at 20,000 psi.

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	\$38.00	\$124.00	\$868.00
FMS-123	300-350	0.84	-47	-74	1.25	1.381	25.7	6.95	200	260	2400	\$24.00	\$78.00	\$550.00
FMS-131	1000	0.85	-40	-74	1.28	1.382	26.1	7.35	200	290	4600	\$12.00	\$40.00	\$278.00
FMS-141	10,000	0.87	-30	-74	1.30	1.383	28.7	7.35	175	315	14,000	\$12.00	\$40.00	\$278.00

Specialty Fluorosilicones

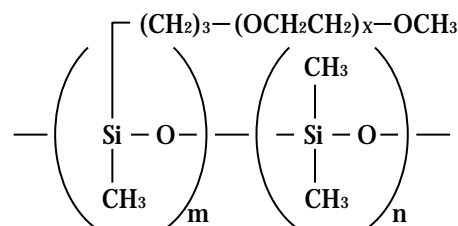
Product Code	Viscosity, cSt.	Viscosity Temp. Coeff.	Pour-point, °C	Transition Temp., Tg°C	Specific Gravity	Refractive Index	Surface Tension	Dielectric Constant	Dielectric Strength	Flashpoint Temp., °C	Molecular Weight	Price 25g	Price 100g	Price 1kg
(48-52% -3,3,3-Trifluoropropylmethylsiloxane) - (48-52% Dimethylsiloxane) Copolymer CAS: [115361-68-7]														
FMS-221	80-120	-	-55	-103	1.16	1.387	21.4	-	-	-	1,800	\$13.00	\$41.00	\$288.00
Bis(Tridecafluorooctyl)Tetramethylsiloxane CAS: [71363-70-7] [R&D only]														
SIB1816.0	6-7	-	-	-	1.46	1.336	-	-	-	-	826	\$98.00	\$320.00	

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*	\$140.00	\$980.00
*1200rpm, 40kg, 2hrs, M-10 steel					

Hydrophilic Silicones

Polyalkylene Oxide and Polar 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.

Polar silicones are utilized in specialty applications where readily swellable materials such as soft rubber have poor dimensional stability in contact with other lubricants. Fluorosilicones are the most common polar silicones, but are usually considered as a class by themselves. Cyanoalkylsilicones have even less tendency to swell substrates than fluorosilicones and, in thin films, facilitate ion transport.

Polyalkylene Oxide Modified Silicones

Dimethylsiloxane-Ethylene Oxide Block/Graft Copolymers

Product Code	% Non-Siloxane	Viscosity cSt	Specific Gravity	Molecular Weight	Pour-point, °C	Water Solubility	Surface Tension	Refractive Index	CAS#	Price 100g	Price 1kg	Price 10kg
DBE-224	25	400	1.02	10,000	-29	-		1.4140	68938-54-5	\$16.00	\$96.00	\$672.00
DBE-621	50-55	100	1.03	3,000	-15	+/-		1.4338	68938-54-5	\$16.00	\$96.00	\$672.00
DBE-712	75	20	1.01	600	0	+	23.6	1.4416	27306-78-1	\$12.00	\$84.00	\$546.00
DBE-814	80	40-50	1.04	1000	-14	+	26	1.4521	11272-76-1	\$12.00	\$84.00	\$546.00
DBE-821	80-85	100	1.07	3600	0	+	27	1.4539	68938-54-5	\$12.00	\$84.00	\$546.00

Dimethylsiloxane - (60% Propylene Oxide - 40% Ethylene Oxide) Block/Graft Copolymers

DBP-732	65-70	1,800	1.02	20,000	-50	+	22	1.4456	67762-85-0	\$12.00	\$84.00	\$546.00
DBP-534	50-55	4,000	1.03	30,000	-30	+	22	1.4136	68937-55-3	\$16.00	\$96.00	\$672.00

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	.96	-	1.4061	179005-02-8	\$72.00	\$504.00
YBD-125	carboxylate	400-600	.98	-	1.4052	179005-03-9	\$56.00	\$393.00

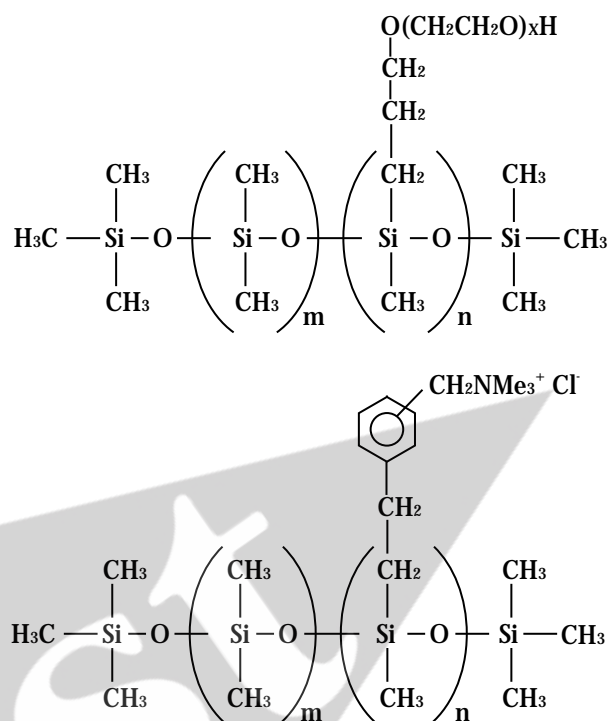
CyanopropylMethylsiloxane

Product Code	% CyanopropylMethylsiloxane	Viscosity cSt	Specific Gravity	Water Solubility	Refractive Index	CAS#	Price 10g	Price 100g
YMS-T31	100%	800-1400	1.07	-	1.4586	67762-86-1	\$72.00	\$504.00

Hydrophilic Silicones

Hydroxylic and Cationic Silicones

Strong polar and ionic interactions can be imparted by introducing hydroxyl groups and quaternary ammonium groups into silicones. Hydroxyl and cationic groups maximize the interaction of silicones with water and other aqueous solutions allowing their use as emulsifiers and polyelectrolytes, respectively. Both classes of materials are stable under conditions of neutral pH and moderate temperature, but sacrifice the broad range of inert behavior typically associated with silicones. They are preferred materials for aqueous formulations that demand not only the properties of silicones, but compatibility with a wide range of other formulation components. Important applications include anti-fogs and anti-stats.



Hydroxylic Silicones

(Hydroxyalkyl functional) Methylsiloxane-Dimethylsiloxane Copolymers

Product Code	Viscosity cSt.	Molecular Weight	Mole % Carbinol functional Methylsiloxane	Hydroxyl class	Specific Gravity	Price 100g	Price 1kg
CMS-626	550-650	4500-5500	40	primary	1.09	\$42.00	\$252.00
0.4 equivalent of hydroxyl/kg (ca. 2 hydroxyethyleneoxypropyl groups/chain)				65% non-siloxane	CAS: [68937-54-2]		
CMS-222	150-200	5500-6500	5	secondary	0.976	\$36.00	\$216.00
0.5 equivalent of hydroxyl/kg (ca. 3 hydroxypropyleneoxypropyl groups/chain)				20% non-siloxane	CAS: [68957-00-6]		

Cationic Silicones

(Cationic functional) Methylsiloxane-Dimethylsiloxane Copolymers

Product Code	Viscosity cSt.	Molecular Weight	Mole % Benzyltrimethyl ammonium chloride siloxane	Active %	Specific Gravity	Price 25g	Price 100g
QMS-435	5000-6000	1800-2000	40	60	1.015	\$64.00	\$208.00
60% milky dispersion of cationic polymer in methoxypropanol - water soluble				[R&D only]			

Amphiphilic Silicones

Silicone fluids which are both hydrophilic and oleophilic 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.

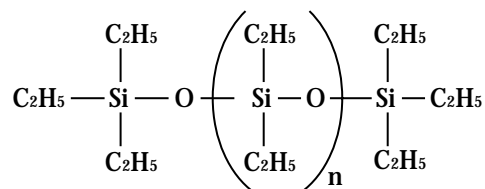
Amphiphilic Silicones

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

Product Code	Viscosity cSt.	Molecular Weight	Mole % Hydroxyalkyleneoxy- propylmethylsiloxane	Active %	Specific Gravity	Price 100g	Price 1kg
ABP-263	1000-4000	1800-2000	30-40	80-85	0.846	\$42.00	\$294.00
contains 15-20% isostearyl alcohol							

Low Temperature Fluids

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.

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-T03	2-4	-115	-	0.844	1.436	80	275-325	\$90.00	\$630.00
DES-T11	7-12	-110	0.133	0.913	1.439	110	350-400	\$90.00	\$630.00
DES-T12	15-20	-110	-	0.93	1.438	125	400-500	\$90.00	\$630.00
DES-T15	40-50	-110	0.142	0.958	1.442	170	500-800	\$90.00	\$630.00
DES-T23	200-400	-96	0.157	0.991	1.447	256	1300-2000	\$90.00	\$630.00

Branched and Low Viscosity 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 significant 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

Product Code	Viscosity cSt.	Pour- Point, °C	Viscosity Temp. Coefficient	Density	Refractive Index	Flashpoint °C	Molecular Weight	Price 100g	Price 1kg
Methyl-T-Branched PolyDimethylsiloxane CAS: [68037-74-1]									
MTT-1015	50-60	-85	0.57	0.97	1.403	285	1650	\$19.00	\$133.00
Tetrachlorophenyl-T-Branched PolyDimethylsiloxane CAS: [68857-05-1]									
PTT-1117	70-75	-73	0.68	1.05	1.428	300	1600-3000	\$32.00	\$220.00
Phenyltris(trimethylsiloxy)silane CAS: [2116-48-9]									
SIP6827.0	4	<-60	0.55	0.92	1.459	127	373	\$35.00	
Phenethyltris(trimethylsiloxy)silane [R&D Only]									
SIP6722.8	4	-55	0.68	0.93	1.440	135	401	\$96.00	

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
SIP6827.0	PhenylTris(trimethylsiloxy)silane	4	6.5	12	20	frozen
MTT-1015	Methyl-T-Branched PDMS	50	90	180	380	fluid
FMS-123	Fluorosilicone	300	5,500	10,500	20,000	frozen
SAE 10	Petroleum Oil	100	500	11,000	235,000	frozen

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	185,000										
50,000	500	231,000										
60,000	600	277,500										
70,000	700	323,500										
80,000	800	370,000										
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										

*measured at 2° (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.

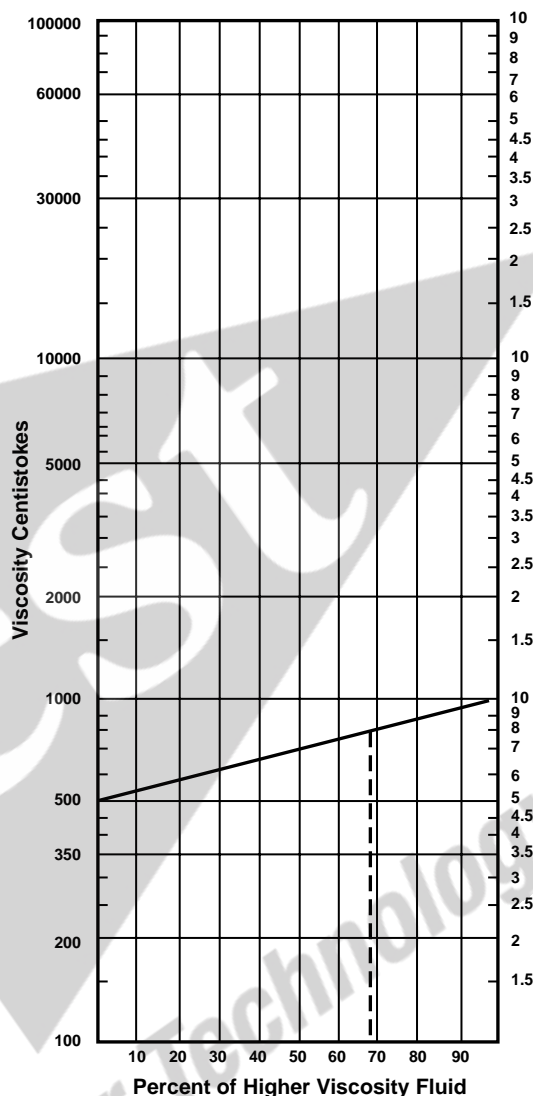
Locate the lower viscosity on the left hand scale.

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.



Glossary of INCI (CTFA) Names

CTFA Name

Cyclomethicone
Dimethicone
Dimethiconol
Phenyltrimethicone

Dimethicone copolyol
Laurylmethicone copolyol
Stearyldimethicone
Trimethylsiloxysilicate
Trimethylsilylamodimethicone
Cetearylmethicone

Proper Name

Volatile Cyclic polyDimethylsiloxanes – see Conventional fluids
polyDimethylsiloxane, trimethylsiloxy terminated – see Conventional fluids
polyDimethylsiloxane, silanol terminated – see Gelest Reactive Fluids
Phenyltris(trimethylsiloxy)silane and higher branched homologs – see Low Temperature Branched Fluids
Polydimethylsiloxane polyether block or graft copolymer – see Hydrophilic Fluids
Dodecylmethylsiloxane-polyalkyleneoxypropylmethylsiloxane – see Hydrophilic Fluids
polyOctadecylmethylsiloxane – see Organic Compatible Fluids
MQ Resin – see Gelest Reactive Fluids
Amino or diaminoalkyl modified polydimethylsiloxane – see Gelest Reactive Fluids
Proprietary mixed branched alkyl, linear alkylmethylsiloxane

Appendix 3 – Factors for Heat, Thermal Conversion to SI units

To convert from	To	Multiply by
Thermal energy		
British thermal unit (Btu) (International Table)	joule (J)	1055.056
calorie (thermochemical)	joule (J)	4.184
Heat flow rate		
Btu per hour	watt (W)	0.2930711
Btu per second	watt (W)	1055.056
ton of refrigeration (12,000 Btu/h)	watt (W)	3517
Density of heat flow rate		
Btu per hour square foot	watt per square meter (W/m ²)	3.154591
Btu per second square foot	watt per square meter (W/m ²)	1.135653 E+04
calorie per square centimeter minute	watt per square meter (W/m ²)	697.3333
calorie per square centimeter second	watt per square meter (W/m ²)	4.184 E+04
Thermal Conductivity		
Btu foot per hour square foot degree Fahrenheit	watt per meter kelvin (W/(m·K)]	1.730735
Btu inch per hour square foot degree Fahrenheit	watt per meter kelvin (W/(m·K)]	0.1442279
Btu inch per second square foot degree Fahrenheit	watt per meter kelvin (W/(m·K)]	519.2204
calorie per centimeter second degree Celsius	watt per meter kelvin (W/(m·K)]	418.4

Appendix 4 – SI prefixes

Multiplication Factor	Prefix	Symbol
10 ²⁴	yotta	Y
10 ²¹	zetta	Z
10 ¹⁸	exa	E
10 ¹⁵	peta	P
10 ¹²	tera	T
10 ⁹	giga	G
10 ⁶	mega	M
10 ³ =1000	kilo	k
10 ² =100	hecto	h
10 ¹ =10	deka	da
10 ⁻¹ =0.1	deci	d
10 ⁻² =0.01	centi	c
10 ⁻³ =0.001	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p
10 ⁻¹⁵	femto	f
10 ⁻¹⁸	atto	a
10 ⁻²¹	zepto	z
10 ⁻²⁴	yocto	y