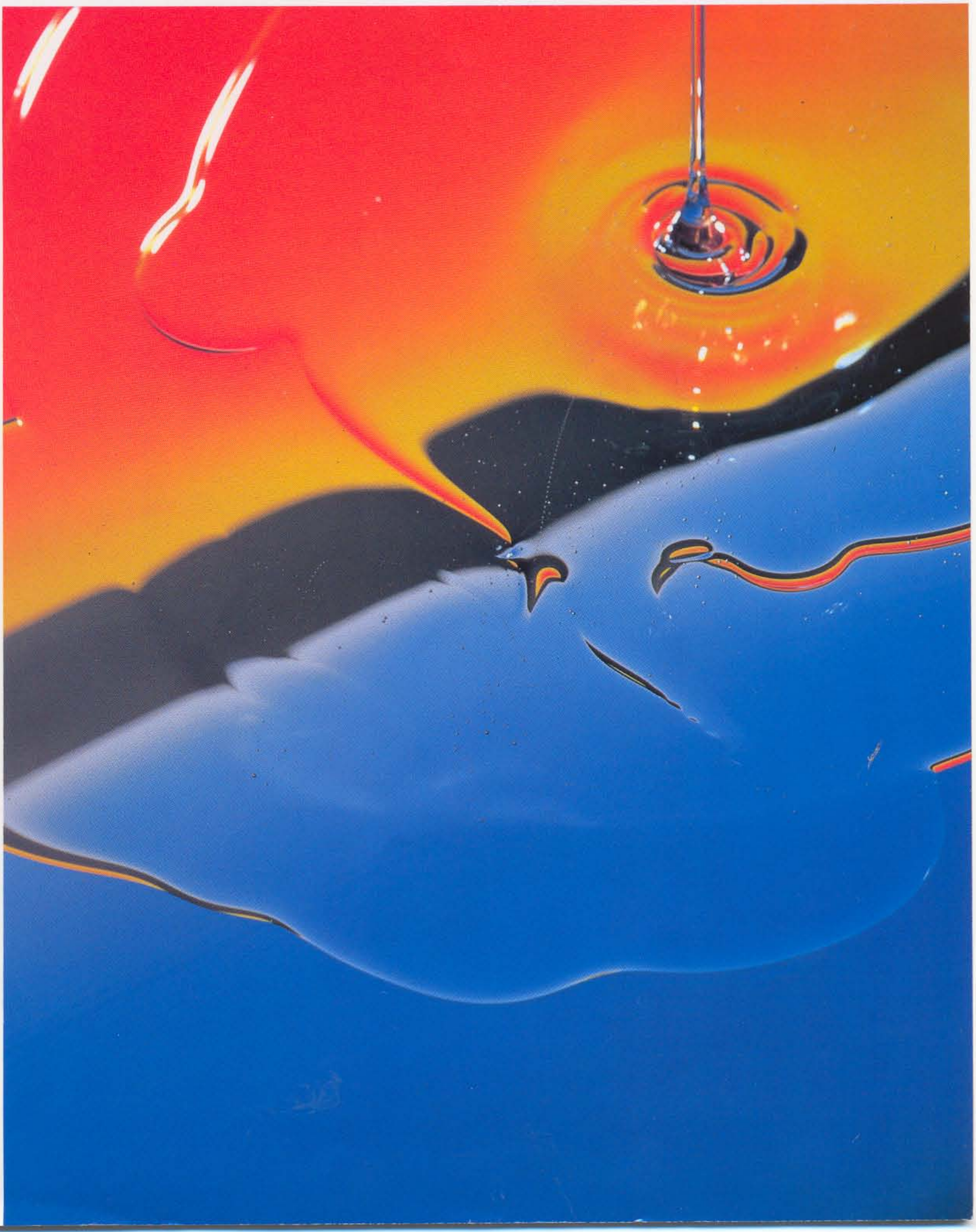
Shin-Etsu Silicone

DM-FLUID



Shin-Etsu Chemical is a leading silicone manufacturer in Japan, and we are proud of our supply of more than 3,000 different products. These products are well accepted in various industries.

Shin-Etsu Silicones of America is a 100% subsidiary company of Shin-Etsu Chemical, and we are eager to satisfy our customer's needs, no matter how specialized the technology.

Contents

* Data are based on single lots; not intended for use in preparing specification.

Shin-Etsu DM-FLUID

The Shin-Etsu DM-FLUID series is a clear, tasteless dimethyl silicone based liquid, available in viscosities of 0.65 to 1,000,000 centistokes. They are used in many branches of industry because of small viscosity changes with variation in temperature, high thermal oxidative stability, high resistance to shear breakdown, high compressibility, excellent water repellency, high chemical and physiological inertness, and non-stick characteristics.

TYPICAL PROPERTIES

	Grade	Viscosity centistokes (cSt) 25°C (77°F)	Specific gravity 25°C (77°F)	Volatile matter (%) 150°C (302°F), 24 hrs.	V.T.C.*	Refractive index 25°C (77°F)	Pour point °C (°F)	Flash point °C (°F)
DM-FLUID- (Low Viscosity)	0.65CS	0.65±0.065	0.755~0.760	B.P 100±2°C	0.31±0.01	1.374~1.376	–68 (–90)	–1 (30)
	1.0CS	1.0±0.1	0.816~0.820	B.P 153±5°C	0.37±0.01	1.381~1.383	–86 (–123)	35 (95)
	1.5 CS	1.5±0.15	0.850~0.855	B.P 195±5°C	0.46±0.01	1.386~1.388	–76 (–105)	50 min. (122)
	2.0CS	2.0±0.2	0.870~0.875	B.P 230±5°C	0.48±0.01	1.390~1.392	–84 (–119)	75 min. (167)
	5.0CS	5.0±0.5	0.910~0.920	—	—	1.385~1.410	—	90 min. (194)
DM-FLUID- (Medium Viscosity)	10CS	10±1	0.930~0.940	50.0 max.	0.55±0.01	1.398~1.400	–60 max. (–76)	160 min. (320)
	20CS	20±2	0.945~0.955	5.0 max.	0.57±0.01	1.400~1.401	–60 max. (–76)	240 min. (464)
	30CS	30±3	0.950~0.960	1.5 max.	0.58±0.01	1.401~1.402	–50 max. (–58)	260 min. (500)
	50CS	50±2.5	0.955~0.965	0.5 max.	0.59±0.01	1.401~1.403	–50 max. (–58)	300 min. (572)
	100CS	100±5	0.960~0.970	0.5 max.	0.59±0.01	1.402~1.403	–50 max. (–58)	300 min. (572)
	300CS	300±15	0.965~0.975	0.5 max.	0.60±0.01	1.402~1.404	–50 max. (–58)	315 min. (599)
	350CS	350±17	0.965~0.975	0.5 max.	0.60±0.01	1.402~1.404	–50 max. (–58)	315 min. (599)
	500CS	500±25	0.965~0.975	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	1,000CS	1,000±50	0.965~0.975	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	3,000CS	3,000±150	0.965~0.975	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
DM-FLUID- (High Viscosity)	6,000CS	6,000±300	0.970~0.980	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	10,000CS	10,000±500	0.970~0.980	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	12,500CS	12,500±620	0.970~0.980	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	30,000CS	30,000±1,500	0.970~0.980	0.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	50,000CS	50,000±2,500	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	60,000CS	60,000±3,000	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–50 max. (–58)	315 min. (599)
	100,000CS	100,000±5,000	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–45 max. (–49)	315 min. (599)
	300,000CS	300,000±15,000	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–45 max. (–49)	315 min. (599)
	500,000CS	500,000±25,000	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–45 max. (–49)	315 min. (599)
	1,000,000CS	1,000,000±50,000	0.970~0.980	1.5 max.	0.60±0.01	1.403~1.404	–45 max. (–49)	315 min. (599)

* Viscosity at 25°C in terms of mm^2/s is the same viscosity expressed in cSt.
* V.T.C. (viscosity temperature coefficient) is frequently used as the factor that shows viscosity change with temperature. The smaller the V.T.C., the lower the viscosity change.
* V.T.C. is calculated from the formula.

$$\text{V.T.C.} = 1 - \frac{\text{Kinematic viscosity at 210°F (98.9°C)}}{\text{Kinematic viscosity at 100°F (37.8°C)}}$$

The chemical structure and properties of low-molecular weight dimethyl siloxane.

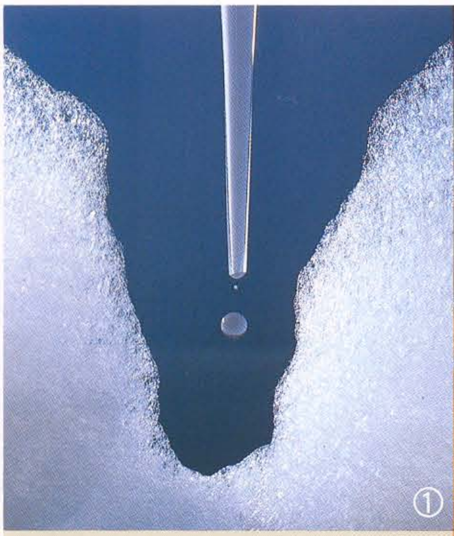
Chemical structure	Chemical name	Number of silicon atoms	Boiling point °C (°F)	Viscosity (cSt) 25°C (77°F)	Molecular weight
$(CH_3)_3Si{-}O{-}Si(CH_3)_3$	Hexamethyl disiloxane	2	100 (212)	0.65	162.38
$(CH_3)_3Si{-}O{-}Si(CH_3)_2{-}O{-}Si(CH_3)_3$	Octamethyl trisiloxane	3	153 (307)	1.04	236.60
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_2Si(CH_3)_3$	Decamethyl tetrasiloxane	4	194 (381)	1.53	310.70
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_3Si(CH_3)_3$	Dodecamethyl pentasiloxane	5	229 (444)	2.07	384.86
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_4Si(CH_3)_3$	Tetradecamethyl hexasiloxane	6	141 (286) (20mmHg)	2.63	459.02
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_5Si(CH_3)_3$	Hexadecamethyl heptasiloxane	7	165 (329) (20mmHg)	3.24	533.17
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_6Si(CH_3)_3$	Octadecamethyl octasiloxane	8	186 (367) (20mmHg)	3.88	607.33
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_7Si(CH_3)_3$	Eicosamethyl nonasiloxane	9	199 (390) (16mmHg)	4.58	681.50
$(CH_3)_3Si{-}O[Si(CH_3)_2{-}O]_8Si(CH_3)_3$	Docosamethyl decasiloxane	10	203 (397) (10mmHg)	–	755.65

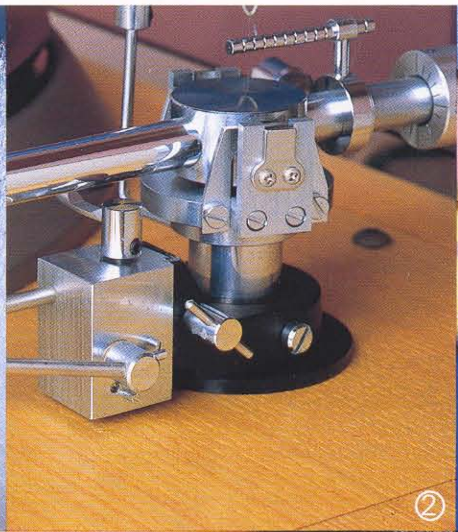
Physical properties of DM-FLUID

Viscosity (cSt) 25°C (77°F)	Specific heat (cal/g°C) 25°C (77°F)	Thermal conductivity w/m • °C{cal/cm·sec.°C} 25°C (77°F)	Surface tension mN/m{dyne/cm} 25°C (77°F)	Coefficient of expansion (cc/cc/°C) 25~150°C (77~302°F)
0.65	0.47	0.10{2.4×10^{-4}}	15.9{15.9}	0.00135
5	0.42	0.12{2.8×10^{-4}}	19.7{19.7}	0.00109
10	0.40	0.14{3.3×10^{-4}}	20.1{20.1}	0.00106
20	0.39	0.15{3.5×10^{-4}}	20.8{20.8}	0.00104
50	0.36	0.15{3.7×10^{-4}}	20.8{20.8}	0.00096
100	0.36	0.16{3.8×10^{-4}}	20.9{20.9}	0.00095
350	0.35	0.16{3.8×10^{-4}}	21.1{21.1}	0.00095
500	0.35	0.16{3.8×10^{-4}}	21.1{21.1}	0.00095
1,000	0.35	0.16{3.8×10^{-4}}	21.2{21.2}	0.00094
10,000	0.35	0.16{3.8×10^{-4}}	21.3{21.3}	0.00094
30,000	0.35	0.16{3.8×10^{-4}}	21.3{21.3}	0.00094
60,000	0.35	0.16{3.8×10^{-4}}	21.3{21.3}	0.00094
100,000	0.35	0.16{3.8×10^{-4}}	21.3{21.3}	0.00094
1,000,000	0.35	0.16{3.8×10^{-4}}	21.3{21.3}	0.00094

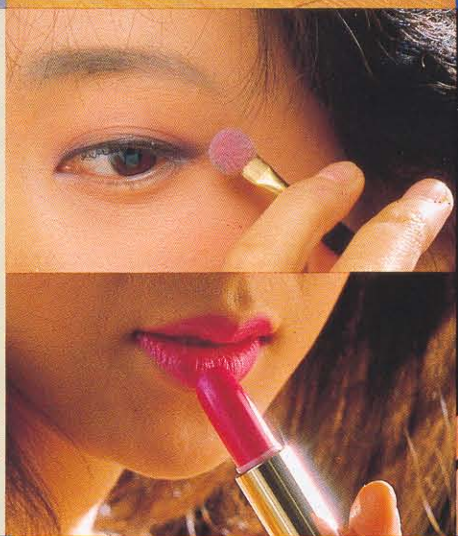
* Viscosity at 25°C in terms of mm^2/s is the same viscosity expressed in cSt.

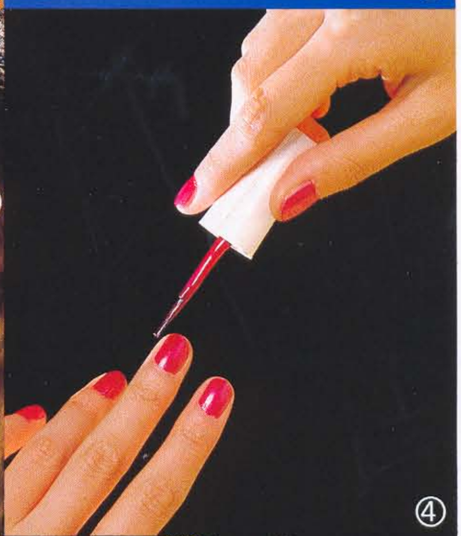
APPLICATION

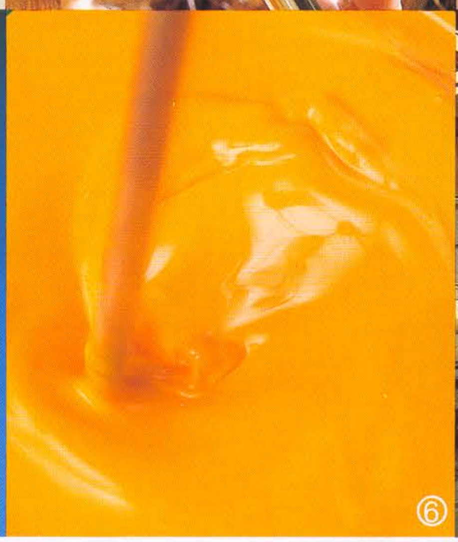


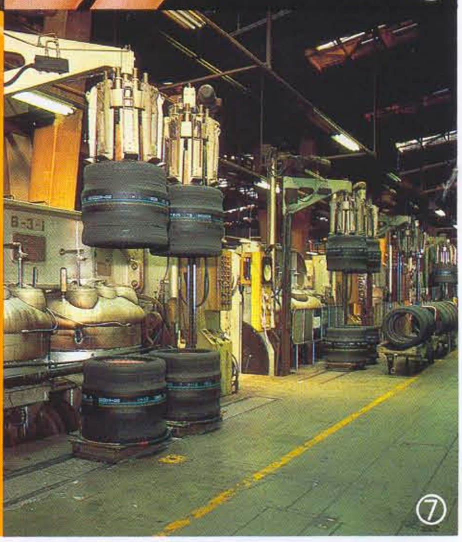


① As a defoaming agent.
② Turntable tone arms.
③ As a textile finishing agent.
④ As cosmetic ingredients.
⑤ As a piston lubricant for metering pumps.
⑥ As a paint additive
⑦ As a mold release agent for tire production.









Shin-Etsu DM-FLUID are used in many branches of industry in the form of pure fluids, solvent dispersants, emulsions and mixed with additives or filling materials.

Applications	DM-FLUID L 0.65~5 (cs)	DM-FLUID 10~3,000 (cs)	DM-FLUID H 6,000~1,000,000 (cs)
Dashpots	○	○	
Measuring instruments	○	○	
Gyrocompass		○	
Heat transfer medium		○	
Oil baths		○	
Thermometers	○		
Liquid springs		○	○
Coolants for transformers rectifiers and vacuum tubes		○	
Filling oil for transistors and condensers		○	
Lubricants for rubbers and plastics		○	○
Release agents		○	○
Defoamers		○	○
Polishes		○	
Textile finishing agents		○	○
Paint additives	○	○	○
Water repellents	○	○	
Cosmetic ingredients	○	○	
Aerosol sprays		○	

As liquid springs

Compared with organic fluids, Shin-Etsu DM-FLUID compresses easily and return to original form when depressurized. Superior to metal coil springs in lightness and durability, DM-FLUID exhibits little tendency to solidify under high pressure making them ideal liquid springs.

As lubricants

Shin-Etsu DM-FLUID is commonly used as lubricants in meters, optical and weather observation instruments. Despite poor border lubricity when used between steel and steel, they exhibit outstanding lubricity in sliding sections between steel and plastic or plastic and plastic. They are used in variable resistors of electrical appliances, switches, and in plastic toothed wheels as lubricants. Moreover, DM-FLUID treatment between conductors and insulation in electrical cable simplifies removal of the outer coating. In addition, DM-FLUID is used in tire molding where their heat stability, resistance to oxidation, and abrasion are advantageous.

As dielectrics

Dried Shin-Etsu DM-FLUID is outstanding insulating-oils, and retain their properties over a wide range of temperatures and frequencies. They are ideal in severe conditions as coolants in transformers, in diodes, vacuum tubes, and transistors, as insulation oils in power cables, as insulation and heat sink oils in germanium transistors, and as impregnating oil in condensers.

As polish ingredients

Polishes made with Shin-Etsu DM-FLUID has three outstanding features: easy application, spread ability and fine gloss. Because of their excellent water repellency, they are ideal as a leather polish. DM-FLUID can be added to wax to achieve easy spreading in automobile, furniture, shoe, glass, rubber, plastic and metal polishes. Table 1 shows the different types and amounts of DM-FLUID used in various polishes.

Table 1

DM-FLUID used in various polishes

Polishes	Viscosity (cSt)	Percent by weight
Auto cleaner-polish (wax type)	300~1,000	5~20
Auto cleaner-polish (emulsion type)	300~500	4~10
Furniture polish (wax type)	300~500	4~7
Furniture polish (emulsion type)	300~500	2~5
Shoe polish	300~500	5~15
Glass polish	100~500	1~5
Metal polish	300~500	3~5
Plastic polish	300~1,000	3~5
Lens polish	100~500	3~5

As release agents

Having outstanding release properties, Shin-Etsu DM-FLUID is used on rubber and plastic molds as release agents. With their resistance to heat and chemicals, DM-FLUID is ideal release agents that will not decompose at high temperatures nor become contaminated by extraneous matter. In the form of solvent solutions, emulsions, aerosols, or mixed with silica or talc, DM-FLUID can be applied easily to mold surface.

As water repellents

Shin-Etsu DM-FLUID play an important role in the treatment of ampoules, glass, china and pottery, and ceramics at extremely high temperatures. The cured coating is physiologically inert and will not solidify blood or degrade vaccines. The coating prevents direct contact between the receptacle and its contents, and causes residue to form globules rather than spread. On syringes, DM-FLUID can be used to improve lubricity. Thus, DM-FLUID is used as surface treatments on medical apparatus ampoules, vaccine tubes, blood tubes, and experimental tubes, and other types of glasswares.

As cosmetic ingredients

With the exception of Shin-Etsu DM-FLUID with viscosities of less than 5 cSt, DM-FLUID is physiologically inert. Colorless, tasteless, odorless, and exhibiting excellent water repellency, release properties, lubricity, and low surface tension, as well as depth of gloss, they are therefore used widely in hand creams, lotions, suntan oils, nutrition creams, hair sprays, lipsticks, body lotions, shaving creams, deodorants, and nail polishes.

Creams and lipstiks containing DM-FLUID help keep out exterior moisture and prevent chapping. DM-FLUID of between 50 ~ 1,000 cs grades are normally used in cosmetics.

As paint additives

DM-FLUID with viscosities of 2 ~ 350 cSt are usually recommend to prevent orange peel effect, improve pigment floatation, ant enrich gloss; DM-FLUID with viscosities of 1,000 ~ 100,000 cSt are recommended to form hammertone patterns, prevent blocking in plywood painting, and improve smoothness; and DM-FLUID-50 CS ~ 500 CS are recommended for defoaming and preventing pinholes. The optimum addition is 10 ~ 500 p.p.m.

As defoaming agents

Shin-Etsu DM-FLUID, with their excellent surface active properties is effective even in very low concentrations. Extremely small amounts of fluid effectively control foam in many processing operations, especially in such hydrocarbon systems as petroleum, lubricants, damping fluids; synthetic fluids, and other non-aqueous fluids. The optimum addition is 5 ~ 20 p.p.m.

As textile finishing agents

Because of their excellent lubricity and water repellency, Shin-Etsu DM-FLUID is widely used in the textile industry. A solvent solution or emulsion of DM-FLUID imparts softness and lubricity to nylon, polyester and other fabrics. They are also used on many synthetic fabrics, fibers, threads, and yarns as lubricants to prevent thread breakage and enable higher sewing speeds.

Other applications

Shin-Etsu DM-FLUID is commonly used as heat-transfer mediums, coolants, and as surface conditioners for a broad range of materials. Although DM-FLUID is already used in many industries, new applications are constantly being discovered.

Shin-Etsu DM-FLUID is clear, tasteless, odorless, and neutral.

Stable viscosities

The viscosity* of Shin-Etsu DM-FLUID shows very little change with temperature variation. DM-FLUID and DM-FLUID H exhibit outstanding resistance to temperature extremes.

- **Standard viscosities**
  DM-FLUID is available in 25 standard viscosities, from 0.65 cSt to 1,000,000 cSt. This allows for a wide range of application.

- **Intermediate viscosities**
  When a viscosity of non-standard grade is required, it can be obtained by blending two standard grades. A given viscosity of DM-FLUID (n cs) can be obtained by blending A grams of DM-FLUID (n_1 cs) with B grams of DM-FLUID (n_2 cs) according to the following formula,

$$\log n = \frac{A \log n_1 + B \log n_2}{A + B}$$

- **Effects of temperature on viscosity**
  One of the most striking properties of DM-FLUID is the low variation in viscosity with temperature change. DM-FLUID of more than 10 cSt exhibits minimum change of viscosity compared to other types of silicone fluids, mineral oils, and synthetic fluids.

Specific gravity

The specific gravities of Shin-Etsu DM-FLUID are lower than that of water and range between 0.760 ~ 0.980 at 25°C (77°F).

- **Effects of temperature on specific gravity**
  Changes in specific gravity of DM-FLUID with temperature variation are greater than that of other synthetic fluids and mineral oils.

- **Effects of temperature on volume**
  Volume change of DM-FLUID with temperature variation is also greater than that of other synthetic fluids and mineral oils.

Specific heat

The specific heat of Shin-Etsu DM-FLUID with viscosities of less than 20 cSt and viscosities of more than 50 cSt is 0.39 ~ 0.47 cal/g·°C; and 0.35 ~ 0.36 cal/g·°C, respectively. This value is approximately one third that of water, and low compared to organic fluids.

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* Viscosity is the internal resistance to flow exhibited by a fluid. A liquid has a viscosity of one poise if a force of one dyne per square centimeter causes two parallel liquid surfaces one square centimeter in area and one centimeter apart to move past one another at a velocity of one centimeter per second. One poise equals 100 centipoises (cp). Viscosity in centipoises divided by the liquid density at the same temperature gives kinematic viscosity in centistokes (cSt). One hundred centistokes equal 1 stoke. To determine kinematic viscosity, the time is measured for an exact quantity of liquid to flow by gravity through a standard capillary. Water is the primary viscosity standard with an accepted viscosity at 20°C (68°F) of 0.01002 poise.

$$\text{Kinematic viscosity (stokes)} = \frac{\text{Absolute viscosity (g/cm·sec)}}{\text{Density (g/cm}^3\text{)}} = [\text{cm}^2/\text{sec}]$$

$$\text{Absolute viscosity} = \text{Kinematic viscosity (cm}^2/\text{sec)} \times \text{Density (g/cm}^3\text{)} = [\text{g/cm·sec}]$$

Thermal conductivity

Thermal conductivity of Shin-Etsu DM-FLUID is one quarter that of water and similar to benzene and toluene. For DM-FLUID with viscosities of less than 20 cSt, the value is 2.4 ~ 3.5 x 10^{-4} cal/cm·sec·°C, and 3.7 ~ 3.8 x 10^{-4} cal/cm·sec·°C when viscosities are more than 50 cSt.

Refractive index

The refractive index of Shin-Etsu DM-FLUID measured by the D line of sodium at 25°C (77°F)is 1.374 ~ 1.392 when viscosities are less than 2.0 cSt, and 1.398 ~ 1.404 When the viscosities are more than 10 cSt.

Volatility

DM-FLUID with viscosities of more than 10 cSt do not contain volatile low-molecular-weight silicone. DM-FLUID with viscosities of less than 5 cSt are volatile without solvent.

Vapor pressure

DM-FLUID with viscosities of more than 10 cSt exhibit low vapor pressure, (20 cSt below 1.0 mmHg at 220°C [428°F]. There is little variation of vapor pressure when the viscosity is more than 1,000 cSt.

Flash point and auto-ignition point

The flash point of Shin-Etsu DM-FLUID with viscosities of more than 50 cSt is over 300°C (572°F), and will not burn continuously without a constant supply of heat high enough to continuously decompose the silicone structure. The autoignition point of DM-FLUID is approximately 450°C (842°F).

Cold resistance and pour point

The pour point of Shin-Etsu DM-FLUID is below –45°C (–49°C), but DM-FLUID with viscosities of less than 2 cSt have freezing points. The excellent cold resistance of DM-FLUID enables their use over a wide range of temperature.

Thermal and oxidative resistance*

Shin-Etsu DM-FLUID shows excellent heat and oxidative stability, and are almost permanently serviceable when used at up to 150°C (302°F). Though they gradually degrade at temperatures over 150°C (302°F), they are, in practice, serviceable up to 180°C (356°F). At elevated temperatures, the degree of deterioration of DM-FLUID in air is defferent from when in inert gases like nitrogen or carbon dioxide. In contact with atmospheric oxygen, the Si-C chemical bond of DM-FLUID breaks, and cross-linking causes viscosity to increase. On the other hand, the viscosity of DM-FLUID is decreased by heat-decomposition in inert gas. Gelation time of DM-FLUID 100 CS grade in air is over 5,000 hours at 175°C (347°F), 200 hours at 200°C (392°F), and 40 hours at 250°C (482°F).

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* Oxidation mechanism of DM-FLUID at high remperature.

Oxidative degradation of silicone fluids occurs at high temperatures through oxygen attack of the organic side group. DM-FLUID series fluids are dimethyl silicone fluids. These methyl groups are attacked by oxygen to form the following main degradation products: p-formaldehyde, formic acid, water, carbon dioxide, carbon monoxide, hydrogen and highly crosslinked polymers.

It is fairly well accepted that the first step in the oxidation of a methyl group proceeds as follows:

1. $SiCH_3 + O_2 \rightarrow SiCH_2\cdot + HO_2\cdot$

A number of steps for the free radical reactions or propagation steps have been postulated. Some logical steps of reaction which can take place to form siloxy radicals are as follows:

2. $SiCH_3 + HO_2\cdot \rightarrow SiCH_2\cdot + 2HO\cdot$
3. $2SiCH_3 + 2HO\cdot \rightarrow 2(SiCH_2\cdot) + 2H_2O$
4. $SiCH_2 + O_2 \rightarrow SiCH_2O_2\cdot \rightarrow SiO\cdot + CH_2O$

Similarly, silyl radicals can be formed as follows:

5. $SiCH_2O_2\cdot + SiCH_3 \rightarrow SiCH_2O_2H + SiCH_2\cdot$
6. $SiCH_2O_2H \rightarrow SiCH_2O\cdot + HO\cdot$
7. $SiCH_2O\cdot \rightarrow Si\cdot + CH_2O$
8. $2\,(SiCH_2\cdot) + O_2 \rightarrow 2\,(SiCH_2O\cdot) \rightarrow$ or $2\,Si\cdot + 2\,CH_2O$

Formic acid, hydrogen and carbon dioxide are formed from further oxidation of formaldehyde as follows:

9. $2\,CH_2O + O_2 \rightarrow 2\,CHOOH \rightarrow 2H_2 + 2\,CO_2$

The siloxy radical formed in (4) and the silyl radical formed in (7) or (8) combine to give molecular crosslinking or intramolecular siloxane bonds. The final residue product of a severely oxidized silicone polymer is a gel consisting of a highly crosslinked polymer. These fluids do not show any signs of oxidation at 180°C (356°F) but have a slow rate of oxidation over it. At temperatures above 204°C (400°F) the oxidation rate becomes appreciable.

R.C. Gunderson and A.W. Hart. Synthetic Lubricants (Chapman & Hall, 1962).

Compressibility

The compressibility of Shin-Etsu DM-FLUID is comparatively high, remaining viscous at pressures under which hydrocarbon oils have already solidifird*. DM-FLUID with viscosities of more than 1.0 cSt at 20°C (68°F) remain viscous pressures as high as 40,000 kg/cm², despite being compressed by about 35%.

* (N-hexadecane solidifies at 420 kg/cm², while hexamethyl disiloxane [DM-FLUID/0.65 CS] does so only at pressures over 4,010 kg/cm²).

Fig. 1* Pressure vs. compression of DM-FLUID at 25°C (77°F)

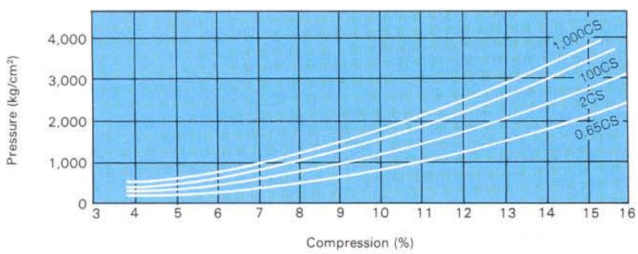
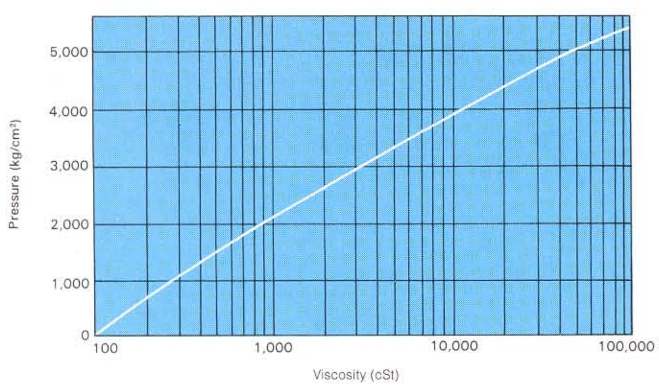


Fig. 2* Pressure vs. viscosity of DM-FLUID 100 cs at 25°C (77°F)



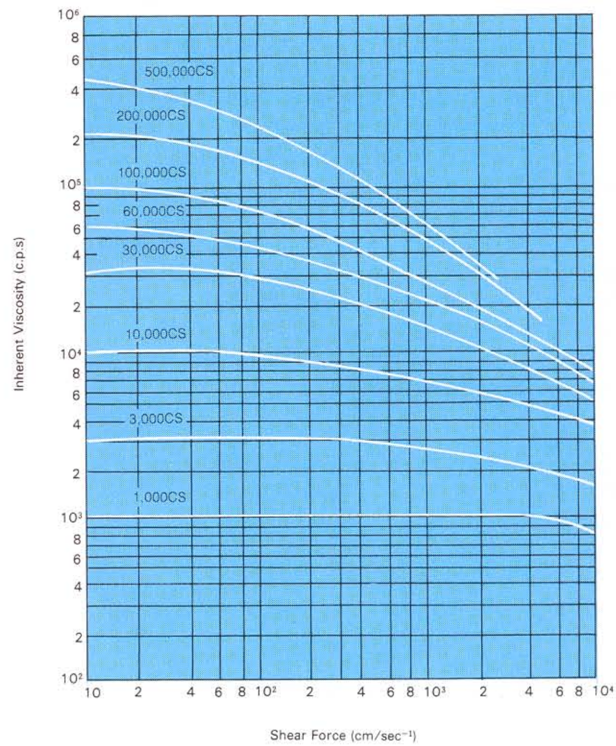
* Fig. 1; Fig. 2:
P.W. Bridgman, American Academy of Arts and Sciences, 77(4), 115(1949)

Resistance to shear stress

Shin-Etsu DM-FLUID also shows high resistance to breakdown by mechanical shearing, and those with viscosities of less than 1,000 cSt show no breakdown whatever. In general, the lower the viscosity, the higher resistance to breakdown by mechanical shearing.

DM-FLUID with viscosities of more than1,000 cSt exhibits pseudoplastic flow and a change in viscosity under shear is temporary. When shear stress is removed, viscosiries return to its original values.

Fig. 3 Viscosity vs. shear stress of DM-FLUID



Lubricity

Stable viscosity and thermal resistance makes Shin-Etsu DM-FLUID ideal lubricants. Special care must be taken when used between steel and steel because of poor border lubricity. However, DM-FLUID exhibits outstanding lubricity between steel and copper, steel and bronze, steel and zinc,steel and cadmium, steel and babbitt, steel and nylon, bronze and nylon, and wood and wood.

Dielectric properties

Shin-Etsu DM-FLUID exhibits excellent dielectric properties that remain stable for prolonged periods; even under varying operation conditions. However, as with organic oils, DM-FLUID is also affected by moisture. It is therefore preferable to remove moisture in DM-FLUID when used as insulation oils. Moisture absorption of DM-FLUID is influenced by humidity, and in general, contain 100 ~ 200 p.p.m. water. Table 2 and figure 4 ~ 11 show the electrical properties of DM-FLUID.

Surface tension

Shin-Etsu DM-FLUID has a low surface tension, ranging between 16 ~ 21 dyne/cm. (Water and general organic oils by comparison are 72 dyne/cm and 35 ~ 40 dyne/cm, respectively.) Their spreading power and high surface activity enable widespread use as release agents, defoamers and cosmetic additives.

Chemical inertness

Shin-Etsu DM-FLUID is chemically inert to metals and most construction materials. At room temperature, they are resistant to dilute acids and bases. However, gelation may occur in contact with acid, alkali, lead, selenium and tellurium at elevated temperatures.

Sound transmission

Sound transmission value of Shin-Etsu DM-FLUID is approximately 1,000 m/sec at 25°C (77°F). Lowering the viscosity, decreases this value.

Table 2
Electrical properties of DM-FLUID

Viscosity (cSt) 25°C (77°F)	Volume resistivity (ohm-cm)	Dielectric strength (KV/0.25 mm)	Dielectric strength (KV/2.5 mm)	Dielectric constant (50 Hz)	Dissipation factor (50 Hz)
5	1×10^{14} min.	10.0	35.0	2.60	0.0001 max.
10	1×10^{14} min.	10.0	35.0	2.60	0.0001 max.
20	1×10^{14} min.	10.0	35.0	2.68	0.0001 max.
50	1×10^{14} min.	10.0	35.0	2.72	0.0001 max.
100	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
350	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
500	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
1,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
5,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
10,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
30,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
60,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
100,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max.
1,000,000	1×10^{14} min.	10.0	35.0	2.75	0.0001 max

Test method: JIS C2101

Fig. 4 Temperature vs. dielectric constant (50 Hz) of DM-FLUID 50 CS

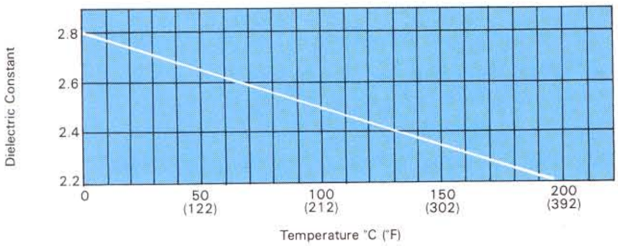


Fig. 5 Temperature vs. dissipation factor (50 Hz) of DM-FLUID

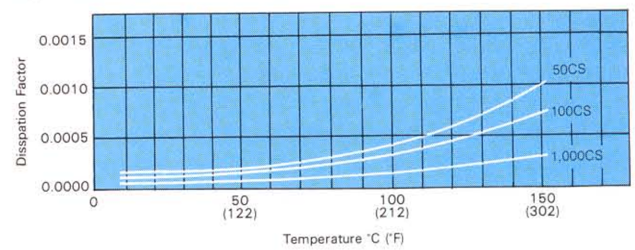


Fig. 6 Frequency vs. dielectric constant (50 Hz) of DM-FLUID at 25°C (77°F)

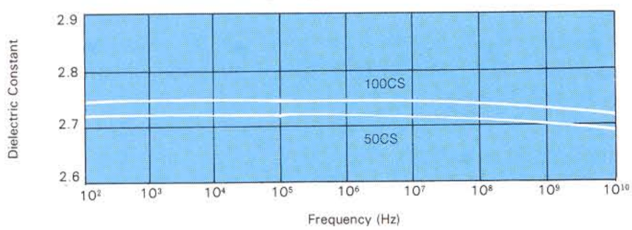


Fig. 7 Frequency vs. dissipation factor (50 Hz) of DM-FLUID at 25°C (77°F)

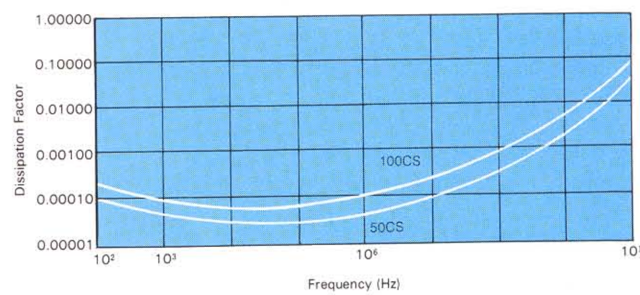


Fig. 8 Water absorption vs. dielectric strength of DM-FLUID 50 CS

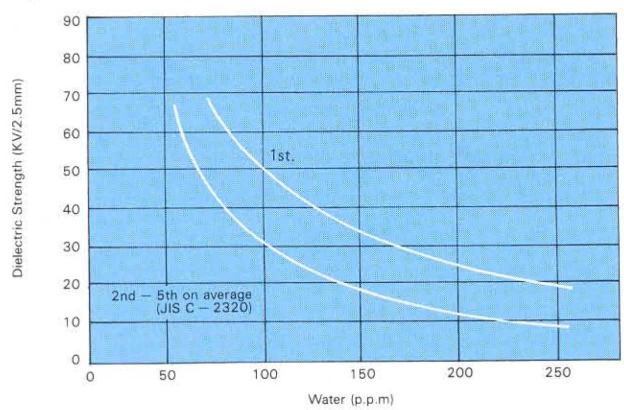


Fig. 9 Water absorption vs. volume resistivity of DM-FLUID 50 CS

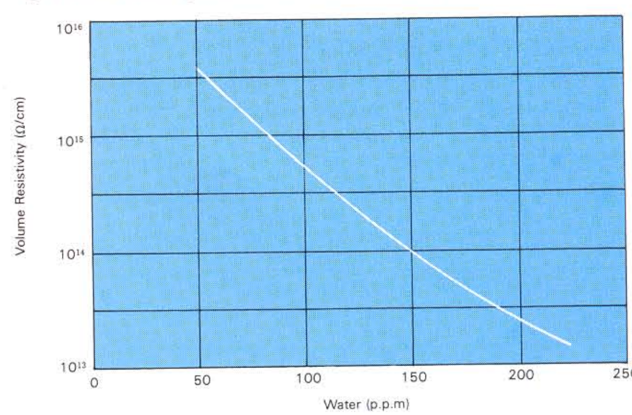


Fig. 10 Water absorption vs. dielectric constant of DM-FLUID

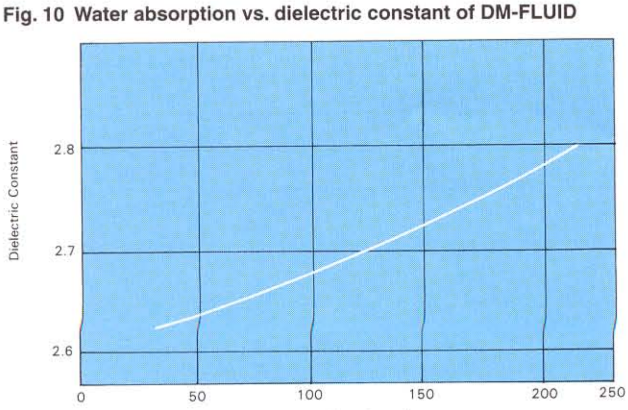
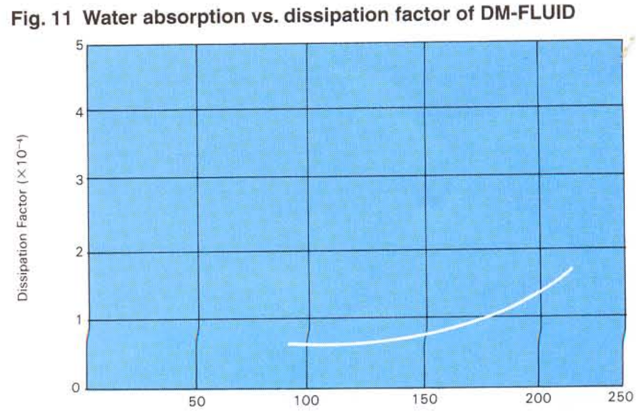


Fig. 11 Water absorption vs. dissipation factor of DM-FLUID



Test method: JIS C2101 (Fig. 4 ~ Fig. 11)

Solubility

- **Solubility with other silicone fluids**
  All Shin-Etsu DM-FLUID is compatible at any blend ratio. Other compatible Shin-Etsu Silicones are KF92, F-6W-9, F-9W-9, KF961 and KF965. Only DM-FLUID with viscosities of less than 100 cSt are soluble in F-5W-0. F-5W-0. KF54, KF56, HIVAC F-4 and F-5 are not compatible with high viscosity DM-FLUID.

- **Solubility in other organic materials**
  Shin-Etsu DM-FLUID is insoluble in water methanol, ethanol, while soluble with hydrocarbon and chlorinated hydrocarbon solvents, ethers, esters and higher alcohols like butanol.

Physiologically inert

Shin-Etsu DM-FLUID, except in lower viscosities, is very low in toxicity and physiologically inert. Their inertness renders the fluids acceptable as ingredients for cosmetics, and defoamers for food and beverages, as regulated by law. DM-FLUID is for industrial purposes except where specifically indicated.

Water repellency

Shin-Etsu DM-FLUID imparts water repellency similar to paraffin. (Their contact angle*, which is indicative of the degree of water repellency, is over 90°) They are widely used for moisture resistance, increasing surface electrical resistance of ceramic condensors, and imparting water repellency to ampoules and syringes.

Release and anti-stick properties

Shin-Etsu DM-FLUID prevents tackiness on metal surfaces, paper, rubber, and plastics. In addition to excellent heat resistance, this property is important in release applications.

Non-corrosion

Shin-Etsu DM-FLUID has no acid-producing chemicals, and is therefore non-corrosive on virtually all types of materials.

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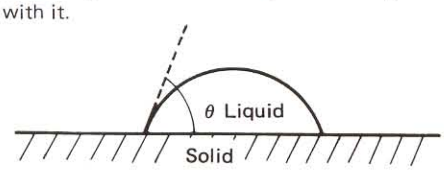
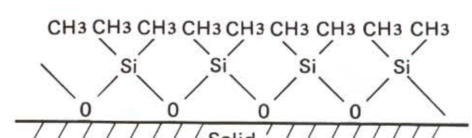
* Contact angle

It is a general and characteristic property of all silicones that they are hydrophobic. By "hydrophoby" is understood that water in the liquid phase wets a silicone/air boundary surface to some extent. This must not be confused with the behavior of water vapor with respect to a silicone: silicones, like all plastics, absorb water vapor and are permeable to it to a certain extent. A measure of the water repellency of a surface, which is important in practice, is the magnitude of the contact angle which small drops of water placed on the surface make with it.



The greatest values of the contact angle that have so far been determined between water and smooth surfaces are 100 ~ 110°C (212 ~ 230°F). Contact angles of this magnitude have been measured on paraffin wax. Silicone surfaces, if they are smooth and suitably treated, exhibit similar figures. They are formed with glass surfaces on which films of silicone oil have been deposited and fixed by heating.



Polydimethylsiloxane molecules spread on a solid surface after desorption of passivating molecules.

These results must be explained on the assumption that a rise in temperature increases the surface forces of the solids through the desorption of passivating films, the polyorganosiloxane chains being forced preferentially into an orientation such that the siloxane dipoles point to the phase boundary while the free surface is covered by methyl groups in close packing. An increase in the density of the packing of the methyl groups increases the hydrophobic effect, and finally, chemical reactions at still higher temperatures increase the adhesion of the film.

Curing treatment

Properly applied and cured onto glass and ceramics, Shin-Etsu DM-FLUID forms an invisible, durable coating. Minimizing adhesion of other materials to the surface, it enhances draining and cleaning.

- **Cleaning**
The surface to be treated must be dry and free of grease and electrolytes. Wherever possible, the silicone treatment should be applied to new, unhandled glass. In this case, no cleaning is necessary. For cleaning, either heat to over 400°C (752°F) for one hour, or clean with solvents. If electrolytes are present on the surface, the articles should be boiled in distilled water for 30 minutes and dried before heat or solvent cleaning. When flammable solvents are used as diluents, adequate ventilation should be provided and fire precautions taken.

- **Applying silicone**
Only a thin coating of DM-FLUID is required, excess should be avoided. Prepare a two percent solution by weight ot DM-FLUID with a recommended solvent, then remove and dry. Air dry in a well-ventilated area at room temperature for half an hour. (Fresh solutions are most effective.)

- **Curing**
After solvent evaporation, the coating must be completely cured. This is accomplished by heating for half an hour at 300°C (572°F) or one hour at 275°C (527°F).

Coloring

Sin-Etsu DM-FLUID is colorless and transparent, and may require coloring with oil-soluble dyes when used as instrument fluids. Solubility of DM-FLUID in oil-soluble dye is 0.01 to 0.02% at room temperature.

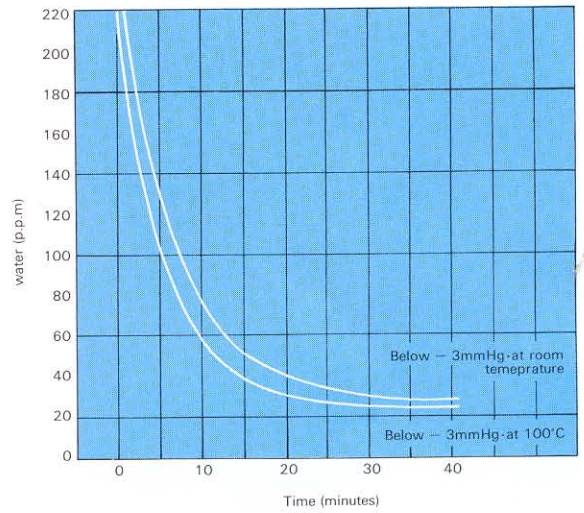
Dehydrating

When used as insulating oils, Shin-Etsu DM-FLUID may contain water at 100 to 200 p.p.m. Dehydrating DM-FLUID is recommended to obtain the optimum electrical properties. Dehydrating methods include heating, heating under vacuum, blowing of dry inert gas or use of dehydrating agents.

- **Dehydrating agents**
When DM-FLUID contains a large amount of water (e.g: evidence of water in the bottom of the container or when fluids appear opaque) water can be removed by dehydrating agents. After removing as much water as possible, add dry silicagel or Glauber's salt, and stir or shake until the silicone is transparent.

- **Dehydrating by heating**
DM-FLUID rendered translucent by water absorption or DM-FLUID that require hydrating below 100 p.p.m. may be dehydrated by heating at 100 ~ 150°C (212 ~ 302°F) under a vacuum or blowing dry inert gas while heating. Spread thinly for best results; transparency after cooling shows dehydration is complete. Since DM-FLUID will absorb water up to 200 p.p.m. under normal conditions, storage in a sealed can or in dry air is recommended.

Fig. 12 Desiccating of DM-FLUID



Removing DM-FLUID

Shin-Etsu DM-FLUID imparts excellent non-stick properties to a surface when treated onto substrates, but these properties are sometimes disadvantageous in a subsequent process. Adhesion and painting to the surface may be difficult. Where adhesion is part of a subsequent process, using either Shin-Etsu KF-410 or KF412 instead of DM-FLUID or cleaning with solvents, soap, or alkali-alcohol is recommended.

- **Cleaning with solvents**
  DM-FLUID applied to substrates may be cleaned by compatible solvents though these solvents may not be suitable for low solvent resistant plastics like styrol or acrylic resin.

- **Cleaning with alkali-alcohol solutions**

When DM-FLUID is applied to glass, ceramics, and iron, they can be removed by an alkali-alcohol solution. This solution may also be used to remove cured DM-FLUID on the above substrates. A similar effect can be obtained by the addition of 26 parts, by weight, of either sodium hydroxide or potassium hydroxide. Even if no alcohol is included, the mixture will be almost as effective. With heavily contaminated sub-strates, first remove excess fluid by wiping, then clean with solvent. Finally, immerse in alkali-alcohol solution for about one hour and rinse throughly with water.

Typical composition of an alkali-alcohol solution

Sodium hydroxide	13.0 (parts by weight)
Potassium hydroxide	13.0
Modified alcohol	33.0
Methanol	4.0
Water	37.0
Total	100.0

SOLVENTS

The compatibility of Shin-Etsu DM-FLUID with solvents is shown below.

Soluble at room temperature

- Benzene
- Toluene
- Xylene
- Solvent naphtha
- Gasoline for industrial use
- Mineral spirits
- Kerosene
- Cyclohexane
- n-Hexane
- n-Heptane
- Carbon tetrachloride
- Chloroform
- Chlorothene
- Perchloroethylene
- Trichloroethylene
- Ethylene dichloride
- Methylene dichloride
- Liquid methyl chloride
- Chlorobenzene
- Chlorofluoro methanes
- Chlorofluoro ethanes
- Ethyl ether
- Diisopropyl ether
- Hexyl ether
- Ethyl acetate
- Butyl acetate
- Isopropyl laurate
- Isopropyl palmitate
- Isopropyl myristate
- Methyl ethyl ketone
- Methyl isobutyl ketone
- Lauryl alcohol

Slightly soluble at room temperature

- Acetone
- Dioxane
- Isopropanol
- Glacial acetic acid
- Butanol
- 2-Ethylhexanol
- Amyl acetate

Insoluble at room temperature

- Methanol
- Ethanol
- Ethylene glycol
- Carbinol
- Cellosolves
- Glycerin
- Propylene glycol
- Paraffin oil
- Paraffin wax
- Fatty acids
  (except glacial acetic acid)
- Animal and vegetable oil
- Water

All solvents should be used in well ventilated areas. It is necessary to take precautions into consideration, especially flammability and toxicity, during use.

Sample test before high-volume application with solvents.

- **F-6W-9**
Shin-Etsu F-6W-9 is excellent as an additive, and particularly useful as an anti-floating or anti-cratering agent in protective coatings.

- **F-9W-9**
Shin-Etsu F-9W-9 is a methyl hydrogen polysiloxane fluid which imparts water repellency to glass, metal, or fibrous materials.

- **KF961**
Shin-Etsu KF961 is a clear silicone fluid characteristic in its improves border lubricity. KF961 can be used as a lubrication oil for oil pressure instruments and high temperature lubricating oil. There are four viscosities available: 100, 1,000, 10,000 and 100,000 cSt.

- **KF965**
Shin-Etsu KF965 is dark-brown in appearance and has excellent heat and oxidation stability. KF965 can be applied in a wide temperature range -50 ~ 300°C (-58 ~ 572°F), and is suitable for use as a high temperature bath oil or lubricating oil at temperatures higher than 250°C (482°F).

- **F-5W-0**
Shin-Etsu F-5W-0 is a methylphenyl silicone fluid with a pour point lower than DM-FLUID. It is serviceable from –60 ~ 200°C (–76 ~ 392°F).

- **KF54**
Shin-Etsu KF54 is also a methylphenyl silicone fluid with outstanding heat stability and can be used at temperature up to 250°C (482°F).

- **KF56**
Shin-Etsu KF56 is a silicone fluid having outstanding compatibility with organic materials. KF56 is widely used as a cosmetic ingredient because of its inertness, water repellency, and its ethanol compatibility.

- **KF410, KF412**
Shin-Etsu KF410 and KF412 are pale yellow viscous, modified fluids. In general, printing or painting after using silicone release agents was considered difficult, but procedures such as printing and hotstamping with KF410 or KF412 as a release agent have made it easy. KF410 and KF412 can be used in solution diluted with such solvents as toluene and mineral spirits.

- **HIVAC F-4, HIVAC F-5**
Both products are silicone fluids especially developed for diffusion pumps and ultrahigh vacuums. Outstanding oxidation resistance and chemical stability ensure high vacuums stable over long periods. HIVAC F-4 tests to 10^{-7} torr, and 10^{-10} torr when used in nitrogen traps; HIVACF-5 to 10^{-9} torr, and 10^{-11} torr in nitrogen traps.

USAGE AND STORAGE

- Shin-Etsu Silicone fluids are intended for industrial use only.
- Silicone fluids should not be brought into contact with skin. Though not particularly irritating, when contact does occur, remove it with a dry cloth, towel or gauze and wash skin with soap and water.
- Always use eye protection, contact with eyes produces some discomfort, and it is recommended to wash immediately with a large volume of water and consult a physician immediately.
- Some low-viscosity silicone fluids emit vapors and should be handled in well ventilated areas. Keep away from heat, and open flame and sparks.
- In case of fire, use foam, dry-chemical, or carbon dioxide extinguishers.
- Remove spills with cloth or dry sand, according to the viscosity, and incinerated according to law and regulations.
- Silicone fluids are exceptionally stable, but cannot be absolutely free from denaturation by the influence of heat, light, acid or alkali. Accordingly, the best method of storage is to keep the silicone fluid tightly sealed in a dark, cool place.
- Silicone fluids usually contain 200 p.p.m. or less of water dissolved in them and should be dehydrated when applied to electrical appliance manufacturing.
- DM-FLUID With viscosities of less than 10 cSt act as solvents, and will extract plasticizers in rubber and plastics, causing weight and volume loss, or swelling at high temperatures.

Use of Shin-Etsu silicones in food, drugs, or cosmetics

No Shin-Etsu silicone should be used as or as any part of a food, drug, or cosmetic, or any process which may deliberately or unintentionally contact any food, drug, or cosmetic unless the user has predetermined that the product is both safe and legal to use in a food, drug, or cosmetic.

All regulations governing the use of materials in food, drugs, and cosmetics are subject to change. Therefore, it is the user's responsibility to verify that all of the information contained in this brochure is accurate and applicable under the current regulations governing such products and use.

The Cosmetic Ingredients Dictionary lists some of the silicones mentioned in this brochure as components useful in the manufacture of some cosmetics. A few cosmetics however are classified as drug preparations and are therefore subject to regulation by Food and Drug Administration (FDA). Approval by FDA is based not on individual components, but on the safety and effectiveness of the final product. For these drug preparations, e.g. antiperspirants, sunscreens, and acne treatments, please refer to applicable FDA regulations.

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The Development and Manufacture of Shin-Etsu Silicones are based on the following registered quality standards,

Gunma Complex	ISO 9001
Naoetsu Plant	ISO 9001
Takefu Plant	ISO 9002