

Internet Address:
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Viscosity and Hardness

Viscosity

Viscosity is a measure of the internal resistance or friction when a fluid moves against itself. Viscosity can be effected by the chemical structure of the resin, the molecular weight or Epoxy Equivalent Weight (EEW) of the resin or the type and amount of filler added. The lowest viscosity materials are unfilled, short chained and have low EEW.

The internal resistance or viscosity is typically measured using a rotating spindle instrument, such as the Brookfield viscometer. The amount of force needed to turn the spindle (torque) is recorded in Poise or centipoise. There are different surface area spindles which are used to measure different ranges of viscosities. The higher the measured torque value, the higher the viscosity. Poise is a measurement of force, 1.0 Poise (P) equals 0.10 Newton-seconds/meter². Low viscosity materials are commonly expressed in centipoise (cP). The temperature that a viscosity measurement is taken at is very important, especially for epoxies.

Silicone materials are not generally effected by temperature. Epoxies, on the other hand, can be effected tremendously by temperature. For some epoxy systems, the change can be a 10% change in viscosity per °C. As temperature rises, the viscosity drops and as temperature drops, the viscosity rises.

Measuring viscosity does not always fully describe flow properties. Some resin systems have an apparent shear rate dependence. Materials can be Newtonian (the apparent viscosity remains constant as the shear rate increases), thixotropic (the apparent viscosity decreases as shear rate increases) or dilatant (the apparent viscosity increases as the shear rate increases). Epoxies are usually non-newtonian and are thixotropic in nature at least to some degree. Very few epoxies are dilatant. Thixotropy may be demonstrated by reporting a viscosity at two or more different shear rates (such as 1 and 10 RPM).

This chart gives the viscosities of well known, common liquid materials so that you will have a better idea of what viscosity values look like. They are approximate and given in centipoise.

Viscosity Comparisons

Water	1 cP
Kerosene	10 cP
SAE #10 Motor Oil	500 cP
Castor Oil	1,000 cP
Corn Syrup	5,000 cP
Honey	10,000 cP
Hot Fudge Syrup	25,000 cP
Molasses	50, 000 cP
Heavy Molasses	100,000 cP

(See other side for hardness discussion)

Hardness

Hardness is a measure of the resistance of a cured material to withstand indentation. When specially shaped points are applied to a surface with a controlled, measured force, the penetration depth is measured. The hardness can be expressed in a number of scales. The Shore 00 scale is for very soft gel materials, the Shore A scale is for soft materials, the Shore D scale for harder materials and Rockwell M for even harder materials, usually metals.

Typically the hardness testers are the most accurate in the middle of their range. For example, if the scale was 0-100, the hardness numbers would be most accurate in the 20-80 range. Other Shore and Rockwell scales exist but are generally not used for epoxies and silicones.

The following chart compares the Shore A, D and Rockwell M scales and compares the conversion among these methods of measuring hardness.

Hardness Conversion Table		
Shore		Rockwell
A	D	M
50	10	
70	15	
90	32	
100	45	
	74	0
	78	32
	82	63
	86	95
	90	125

Some other methods for measuring hardness are; Barcol which is another penetration test used for harder material, pencil hardness which is normally used for coatings/inks, Sward hardness which is also used for coatings, Moh which is used for minerals, and Taber which measures abrasion resistance.

This chart gives the hardnesses of well known, common objects so you will have a better idea of what the hardness values look and feel like.

Hardness Comparisons		
Shore A	Shore D	is Equivalent to:
25-30		Eraser
35-45		Pink Pearl®* eraser
45-55		Rubber stamp
55-65		Pencil eraser
65-75		Rubber heel
75-85	25-30	Rubber sole
85-95	30-40	Typewriter roller
95-100	40-50	Pipe stem
	50-60	Textbook cover
	60-65	Office desktop
	65-70	Telephone
	70-75	Wooden ruler
	75-80	Fountain pen

* Pink Pearl is the registered trademark of Faber Castell.

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■ **Europe**
 Nijverheidsstraat 7
 B-2260 Westerlo
 Belgium
 ☎ : +(32)-(0) 14 57 56 11
 Fax: +(32)-(0) 14 58 55 30

■ **North America**
 46 Manning Road
 Billerica, MA 01821
 ☎ : 978-436-9700
 Fax : 978-436-9701

■ **Asia-Pacific**
 100 Kaneda, Atsugi-shi
 Kanagawa-ken, 243-0807
 Japan
 ☎ : (81) 46-225-8815
 Fax : (81) 46-222-1347