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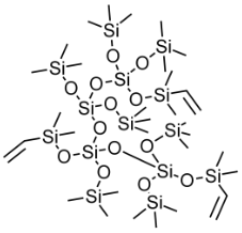
TECHNICAL BULLETIN

Silmer® VQ Resins

DESCRIPTION

Silmer® VQ Resins are the kinetic reaction products of silicates with trimethyl siloxy groups and vinyl dimethyl siloxy groups which generates a silicon-based, cross-linked network having vinyl groups on the surface. A simplified structure is shown to the right.



These types of silicones are often referred to as "MQ resins" because they are built of a network of tetrafunctional silicon atoms (Q group – silicon surrounded by four oxygen groups) end capped with mono functional silicon (M group – silicon with one oxygen group and three alkyls).

Depending on the molecular weights, vinyl content and crosslink densities of the specific structures these are available as pourable liquids or solids diluted in solvents.

PRODUCT COMPARISION

Product	M:Q	Vinyl (%)	Viscosity (cps)	Actives %	Appearance	Solvent
Silmer VQ20	2:1	12.0	1,200	100	Clear liquid	none
Silmer VQ2012	2:1	8.9	90	100	Clear liquid	none
Silmer VQ9 IDD	0.9:1	7.0	20	70	Clear liquid	Isododecane
Silmer VQ9 XYL			20			Xylene
Silmer VQ122 IDD	1.2:1	1.8	10	70	Clear liquid	Isododecane
Silmer VQ122 XYL			10			Xylene

TYPICAL PROPERTIES

Silmer VQ Resins are miscible with most hydrocarbon oils and insoluble in water. **Silmer VQ Resins** reduce the surface tension of oils in which they are dissolved. The vinyl groups are reactive under free radical or certain metal-catalyzed reactions such as hydrosilation.

USES AND APPLICATIONS

Silmer VQ Resins are designed for use in addition cured silicone elastomeric formulations to improve hardness, tensile strength and Young's modulus. This occurs via increasing the cross link density of the elastomer so there is a concomitant reduction in elongation and storage modulus and some reduction in tear strength.

On a continuum where the largest increase in strength and hardness is on the left and the greatest retention of elongation is on the right; one sees the following general trend:

Silmer VQ20 > **Silmer VQ2012** > **Silmer VQ9** >> **Silmer VQ122**

Performance improvements are seen up to about 10% use level of the **Silmer VQ resin.** Above those levels the elastomer becomes very brittle.

Silmer VQ resins can also react into free radical or one-electron transfer reactions such as olefin polymerization or alkyd resins. **Silmer VQ resins** can also be added to thermoset plastic resins before the extrusion step.

APPLICATIONS DATA

Silmer VQ resins have been evaluated in several base addition cured elastomer formulations. The higher vinyl content material, **Silmer VQ20,** gives the maximum increase in hardness and tensile strength but also gives the most reduction in tear strength and elongation. **Silmer VQ9 IDD** or **Silmer VQ9 XYL** often gives the best balance of properties.

Below are two examples to illustrate the key points. Siltech has completed many experiments with similar elastomeric formulations to arrive at the general trends shown herein.

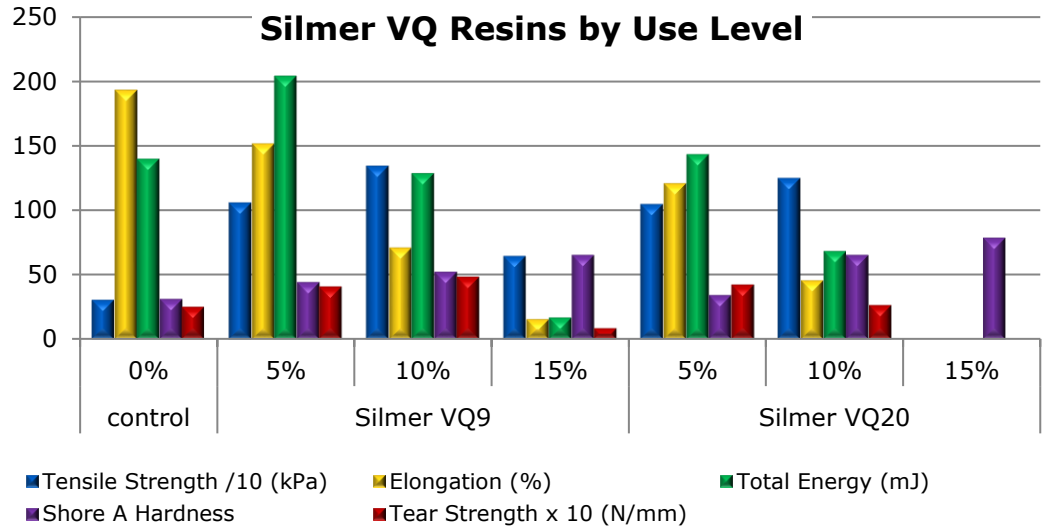
In Table 1 and Chart 1, results are shown in a base formulation made from **Silmer VIN 10,000** and a proprietary **Silmer H** fluid. The hydride to vinyl ratio was kept at 2.5 in this system.

Compared to the control without **Silmer VQ Resins,** both **Silmer VQ9** and **Silmer VQ20** improve hardness and tensile strength. At 5% and 10% loadings, tear strength is improved over the control, but at 15% properties drop off dramatically with **Silmer VQ20** being too brittle to measure. This effect is due to too much cross-linking in the system at higher use levels and with higher vinyl content resins.

TABLE 1

	Control	5% VQ9	10% VQ9	15% VQ9	5% VQ20	10% VQ20	15% VQ20
Tensile Strength (kPa)	307	1057	1340	643	1044	1245	NA
Elongation (%)	193	152	71	16	121	46	NA
Total Energy (mJ)	140	204	129	17	143	68	NA
Shore A Hardness	31	44	52	65	34	65	78
Tear Strength (N/mm)	2.5	4.0	4.8	0.9	4.2	2.6	NA

CHART 1



In Table 2 and Chart 2, results are shown in a base formulation made from silicones **Silmer VIN 10,000** and **Silmer H T3**. The hydride to vinyl ratio which gave the highest hardness level was determined by experimentation to be at 2:1 and was held constant.

When compared to silica, **Silmer® VQ resins** add more hardness at lower use levels, but do not affect viscoelasticity and clarity. In these examples viscosity was 30,000 cps with shear thickening with 10% of the Aerosil R812; but viscosity was only 4800 to 7500 cps with Newtonian behavior with 6% of the **Silmer VQ resins**. Also, the **Silmer VQ** formulations were all clear to slightly hazy while the R812 formulations were translucent to opaque.

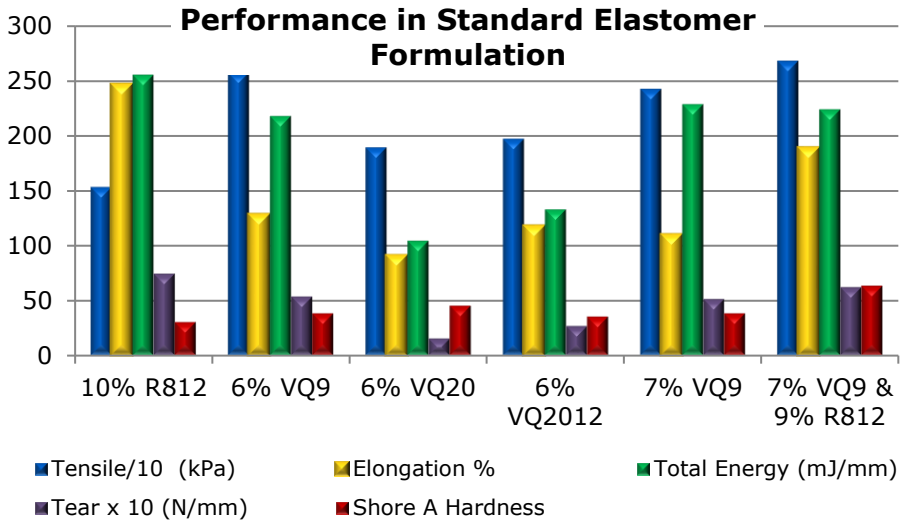
Again**, Silmer VQ9** was found to provide the best balance of increased hardness and tensile strength with minimal compromise of elongation and very little compromise of tear strength.

Since the **Silmer VQ** resins and silica harden by different mechanisms it is possible to use these together as shown in the last two sets of data in Chart 2. This combination gives the ultimate hardness but does have the viscosity and clarity limits of silica alone.

Table 2:

	10% R812	6% VQ9	6% VQ20	6% VQ2012	7% VQ9	7% VQ9 & 9% R812
Tensile Strength (kPa)	1535	2577	1896	1973	2429	2685
Elongation %	247	128	91	118	110	189
Total Energy (mJ/mm)	256	218	104	133	229	224
Tear Strength (N/mm)	7.4	5.4	1.5	2.7	5.1	6.2
Shore A Hardness	30	38	45	35	38	63
Viscosity (cps)	35000	7000	4800	7500	7500	30000

Chart 2:



SAFETY

Before handling, read the Material Safety Data Sheet and container label for safe use, physical and health hazard information.

THIS MATERIAL IS NOT FOR MEDICAL OR DRUG USE.

STORAGE AND SHELF LIFE

When stored in the original, unopened containers between 10 and 40^{0}C, **Silmer VQ20 and VQ 2012** have a shelf life of at least 12 months from date of manufacture.

When stored in the original, unopened containers between 10 and 40^{0}C, **Silmer VQ9 (IDD or XYL) and VQ 122 (IDD or XYL)** have a shelf life of 24 months from date of manufacture.

PACKAGING

Silmer VQ Resins are available in 20kg and 200kg containers.

LEGAL DISCLAIMER

Siltech Corporation believes that the information in this technical data sheet is an accurate description of the typical uses of the product. Siltech Corporation, however, disclaims any liability for incidental or consequential damages, which may result from the use of the product that are beyond its control. Therefore, it is the user's responsibility to thoroughly test the product in their particular application to determine its performance, efficacy and safety. Nothing contained herein is to be considered as permission or a recommendation to infringe any patent or any other intellectual property right.