PROPERTIES OF FUSED QUARTZ

Silica is found almost everywhere in nature, it represents almost 1/3 the mass of the earth's crust. Vitreous Silica is the generic term used to describe all types of silica glass, with manufacturers referring to the material as either Fused Quartz or Fused Silica.

Manufactured by fusing naturally occuring crystalline silica, either sand or rock crystal, a wide range of products are available. After this process, their appearance will be either opaque, translucent or transparent. If the silicon dioxide is synthetically derived, the material produced is commonly called Synthetic Fused Silica.

Vitreous Silica, in all its forms, offers a variety of properties such as:

- Permeability
- Extreme Hardness
- Very Low Coefficient of Thermal Expansion
- Resistance to High Temperature
- High Chemical Purity
- High Corrosion Resistance
- Extensive Optical Transmission from Ultra-Violet to Infra-Red
- Excellent Electrical Insulation Qualities
- Remarkable Stability Under Atomic Bombardment

PROPERTY	ENGLISH & METRIC SYSTEM VALUE	INTERNATIONAL SYSTEM OF UNITS (SI) VALUE
Density	2.2 gm / cm^3	2.2 x 10^3 kg / m^3
Hardness	5.5–6.5 Mohs' Scale 570KHN$_{100}$	
Design Tensile Strength	7,000 psi	4.8 x 10^7 Pa (N / m^2)
Design Compressive Strength	Greater than 160,000 psi	Greater than 1.1 x 10^9 Pa
Bulk Modulus	5.3 x 10^6 psi	3.7 x 10^{10} Pa
Rigidity Modulus	4.5 x 10^6 psi	7.2 x 10^{10} Pa
Young's Modulus	10.5 x 10^6 psi	7.2 x 10^{10} Pa
Poisson's Ratio	.17	.17
Coefficient of Thermal Expansion	5.5 x 10^{-7} cm / cm • °C (20°C – 320°C)	5.5 x 10^{-7} m / m • °K (293°K – 593°K)
Thermal Conductivity (20° C)	3.3 x 10^{-3} gm cal • cm / cm^2 • °C	1.4 W / m • °K
Specific Heat (20°)	.16gm cal / gm	670 J / kg • °K
Softening Point	1683°C	1956°
Annealing Point	1215°C	1488°
Strain Point	1120°C	1393°
Electrical Resistivity	7(10^7) ohm • cm (350°C)	7(107)ohm-m

Dielectric Properties	(20°C and 1 MHz)	(293°K and 1 MHz)
Constant	3.75	3.75
Strength	5 x 10^7 volts/mil	5 x 10^7 V/m
Loss Factor	Less than 4 x 10^{-4}	Less than 4 x 10^{-4}
Dissipation Factor	Less than 1 x 10^{-4}	Less than 1 x 10^{-4}
Index of Refraction	1.4585	1.4585
Constrigence (Nu value) Fused Quartz	67.56	67.56
Velocity of Sound-Shear Wave	3.75 x 10^5 cm/sec	3.75 x 10^3 m/s
Velocity of Sound-Compression Wave	5.90 x 10^5 cm/sec	5.90 x 10^3 m/s
Sonic Attenuation	Less than 11 db/m • MHz	Less than 11 db/m • MHz
Permeability Constants	(cm • mm/cm • sec • cm of Hg – 700°C/973°K)	
Helium	210 x 10^{-10}	
Hydrogen	21 x 10^{-10}	
Deutrium	17 x 10^{-10}	
Neon	905 x 10^{-10}	

TRACE IMPURITITES

TYPE (PPM)	Al	AS	B	Ca	Cd	Cr	Cu	Fe	K	Li	Mg	Mn	Na	Ni	P	Sb	Ti	Zr	*OH-
GE 124®	14	<.002	<0.2	0.4	<0.01	<0.05	<0.05	0.2	0.6	0.6	0.1	<0.05	0.7	<0.1	<0.2	<0.003	1.1	0.8	<5
GE 214®	14	<.002	<0.2	0.4	<0.01	0.05	<0.05	0.2	0.6	0.6	0.1	<0.05	0.7	<0.1	<0.2	<0.003	1.1	0.8	<5
NSG OZ®	40	–	–	2.5	–	–	.50	0.9	1.7	.06	0.3	.03	2.5	–	–	–	0.8	–	150–200
TYPE (PPB)	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga				
Corning 7980 ®	<150	-40	<5	n.d.	<100	<14	<5	<10	<20	n.d.	<10	<1	<13	<15	n.d.				
	K	Li	Mg	Mn	Mo	Na	Ni	P	Sb	Sr	Ti	U	V	Zn	Zr				
	<21	<1	<25	<10	<5	<150	<7	<100	<5	<3	<40	<1	<10	<30	<30				

INTERNAL PRESSURE CALCULATIONS RUPTURE FORMULA FOR TUBING

Because fused quartz is used in applications involving internal pressures, it is helpful to know the maximum pressure that can be applied to a selected fused quartz tube. The formula at right can approximate this information at room temperature. S = pr/t Where: S = Hoop Stress in Pa p = Working Pressure (Pa) r_0 = Inside Radius (mm) t = Wall Thickness (mm)

This formula can not be used when internal pressure exceeds 100 psi.

RUPTURE PRESSURE CALCULATIONS FOR DISCS AND PLATES

Determining pressure differential is required for many applications of stressed fused quartz discs, plates and sight glasses. The formulas below can be used for room temperture applications of parts having either clamped or unclamped edges.

A = Unsupported Area in sq/inches

T = Thickness (inches)

F = Safety Factor (7)

M = Modulus of Rupture (7,000 psi)

P = Pressure (psi)

DISCS

$$P = \frac{3.12 \times M(T^2)}{A \times F}$$

$$T = \sqrt{\frac{P \times A \times F}{3.12 \times M}}$$

PLATES

$$P = \frac{3.48 \times M(T^2)}{A \times F}$$

$$T = \sqrt{\frac{P \times A \times F}{3.48 \times M}}$$

THE ABOVE PRESSURE CALCULATIONS ARE RECOMMENDATIONS ONLY.
ACTUAL PRESSURE POINTS MAY VARY DEPENDING ON USER APPLICATIONS

CLEANING

The cleaning of fused quartz is critical before it is used in any application. The fused quartz should be cleaned by placing it in a 7% maximum solution of Ammonium Bifluoride for no more than ten (10) minutes, or a 10% volume maximum solution of Hydrofloric Acid for no more than five (5) minutes. After cleaning, using the above method, the fused quartz should be rinsed in deionized or distilled water and then dried.

RUNNING IN PROCEDURE

In order to increase resistance to devitrification and sag of your quartzware, an even layer of cristobalite must be formed on the O.D. of quartz tubes. Expose a new tube to a temperature of up to 1200° C and rotate it 90° every two (2) hours for the first 12 to 24 hours.

STORAGE

Space permitting, fused quartz should be stored in its original shipping container. If that is not practical, at least the wrapping should be retained. In the case of tubing, the end coverings should be kept in place until the product is used. This protects the ends from chipping and keeps out dirt and moisture which could compromise the purity and performance of the tubing.

BECAUSE THE PRODUCTS ARE ANNEALED

Both quartz and silica glass are annealed at approximately 1150° C. However, they reach a strain point at about 1120° C. These glass products, if rapidly cooled after use at temperatures above this strain point, will develop strain again. Special care should be taken when using large sized products.

WHEN JOINING FUSED QUARTZ AND OTHER MATERIALS

Quartz and silica glass only slightly expand with increases in temperature, in contrast with other materials. Care must be taken when these glass products are connected to other materials and the temperature rises, in order to avoid the development of cracks.

CARE MUST BE TAKEN DURING FURNACE INSERTION

Quartz and silica glass feature low thermal conductivity. If the glass product comes too close to a heating element, or is put in direct contact with a flame, it may become locally heated and develop cracks. Long glass tubes may also deform at temperatures of 1100° C or higher. Care should be taken to support both glass types, expecially large-sized products.

DEVITRIFICATION

Devitrification of quartz and silica glass means transition from a metastable (vitrified) state to a stable crystallized state of cristobalite. Devitrification occurs when the product is used at high temperatures over a long period of time, or it is heated while impurities adhere to its surface. Even very small impurities on the surface can have a major influence. Under such conditions, devitrification may even occur at temperatures of 1000° C or less. This hardly ever occurs at temperatures of 1150° C or less, if the glass surface is perfectly clean. Devitrification usually starts when the temperature rises to 1200° C or higher, then further develops as the temperature increases.