SILICA QUARTZ

Silica (SiO2) is the chief constituent of earth's crust. It is present in various forms, the most common being called Quartz which is crystalline in character. Typical examples are silica sand and rock crystals. Vitreous Silica is the glassy modification of Silicon di-oxide (SiO2) with a purity of atleast 99.8% by weight in the translucent form and over 99.9% (SiO2) in the transparent forms. Depending on the Quartz used as raw material and melting process employed, the resulting material is either opaque, translucent or transparent. In all three cases this material is "Fused Silica". It is also sometimes referred to as vitreous silica, quartz glass, silica glass, fused quartz or fused silica. Commercially the word fused silica is designated to the translucent variety and fused quartz to the transparent variety.

CHEMICAL PROPERTIES

Fused Silica / Quartz is completely unaffected by all halogens and acids regardless of temperature or concentration with the exception of hydro-fluoric and phosphoric acid. The latter affects fused silica only at high temperatures and it is possible, therefore to concentrate phosphoric acid successfully in silica vessels. For all ordinary purposes they can be used with phosphoric acid.

Sulphuric, Nitric and Hydrochloric acids or any mixture of these acids, such as acquaregia, have no action on Infusil even at temperatures upto 1000°C. Strong alkalies react with Infusil. In many instances even where a certain degree of chemical action occurs, good service may be obtained by cleaning Infusil ware regularly.

Salts and basic oxides react at elevated temperatures, particularly above their melting point. The extent of reaction is largely determined by the thermal diffusion of impurities into the fused silica (Vitreous silica) and in this respect the alkali metals have the highest diffusivity and are the most damaging.

THERMAL EXPANSION

The mean value of the coefficient of thermal expansion between 0 and 800°C is 5.5 X 10-7/°C. Fused silica is not sensitive to abrupt temperature changes. Red hot fused silica may be dipped in water without damage.

THERMAL PROPERTIES - APPLICATIONS

Average Co-efficient expansion 0° to 800° C		**5.5 X 10-7/°C**
Thermal Conductivity	**Temp**	**Cal cm-1 Sec-1 °C-1**
	20°C	36 X 10-4
	100°C	38 X 10-4
	250°C	41 X 10-4
	500°C	50 X 10-4
	800°C	57 X 10-4
	1000°C	65 X 10-4
Specific heat	**Temp**	**Cal/g**
	0°C	0.166
	100°C	0.200
	500°C	0.275
	1000°C	0.290
Softening temp.	**1700°C**	
Annealing temp.	**1150°C**	
Working temp.	**1900°C to 2000°C**	
Operating temp. (Continuous)	**1050°C**	
Operating temp. (intermittent)	**1350°C**	

ELECTRICAL PROPERTIES - PHYSICAL PROPERTIES

Dielectric constant	3.70	Cal
Specific resistivity	**Temp Sp.**	**Resistivity ohm-cm**
	°C	**(of the order of)**
	20	1018
	200	1013

	600	108
	1000	106
Electrical breakdown strength at 20ºC 25-400KV-cm		

Density	2.2g/cm3
Hardness	6-7 Mohs
Poisson’s ratio	0.17
Young’s Modulus	7.4 X105 Kgs/cm2
Tensile strength	600 to 700 Kgs/cm2

DEVITRIFICATION

The term **“super-cooled liquid”** refers to the fact that, at least from a thermodynamic equilibrium point of view, quartz glass should actually be a crystalline solid rather than a liquid. This fact is the key to understanding why quartz glass devitrifies. Although the thermodynamically preferred state of quartz glass is crystalline, the high viscosity prevents the structural rearrangement necessary to achieve it. In other words the molecules cannot arrange themselves quickly enough compared to the relatively fast rate of cooling that quartz glass normally experiences. However, under certain conditions this constraint can be removed resulting in the glass reverting to a crystalline state. This usually happens at elevated temperature at the presence of a contaminant that drops the viscosity by breaking up the highly connected silicon-oxygen network as well as acting as a nucleating source. Alkalis like sodium or potassium are the most common contaminants that cause devitrification.

Atmospheres high in water vapor or chlorine also exacerbate this process significantly. The growth of the devitrified layer usually starts in the surface and progresses into the material at a rate that depends exponentially on temperature. The crystalline material formed is a high temperature form of silica known as high cristobalite.

High cristobalite has nearly the same density as glassy silica and thus cannot be seen on the surface. However, upon cooling, high cristobalite undergoes a structural change from a cubic to a tetragonal crystal structure at about 275°C. this is accompanied by a large decrease in density that can result in some cracking and spalling. Refractive index differences resulting from the birefringent tetragonal crystal structure also cause the devitrified spots to turn white.

VISCOSITY

The term **“super-cooled liquid”** is sometimes used to describe quartz glass at lower temperatures but this is not strictly correct. Below 1000°C the material can be regarded as a true solid. The viscosity has an exponential dependence on inverse temperature and thus decreases rapidly as temperature rises. The viscosity is significantly affected by trace impurities. Alkalis and halogens such as sodium and chloride lower viscosity while small amounts of aluminium and refractory metals like molybdenum increase viscosity. The hydroxyl (OH) content lowers the viscosity thus making the method of manufacture an important consideration for defining maximum use temperature.