6 Tips for Critical Sight Glass Applications

Sight glass applications require varying levels of consideration during the design phase. In all applications, sight glasses will be subjected to forces involving pressure, temperature, thermal shock, caustics, abrasion, or impact. It is critical to ensure that the design approach to each application takes these conditions into account.

The risks are real. When a sight glass fails, it can be extremely dangerous. When a sight glass fails catastrophically, it can cause severe operator injury and even death.

Furthermore, a catastrophic sight glass failure can create costly downtime. In a system made primarily of metal, the weak spots are generally sealing joints and glass. Typically, the failure of a sight glass on a piece of equipment or within a piping system will halt the whole process until the equipment can be repaired or replaced. Moreover, this failure may lead to scrapping the process media. In the case of a pharmaceutical process, the product loss could cost millions of dollars.

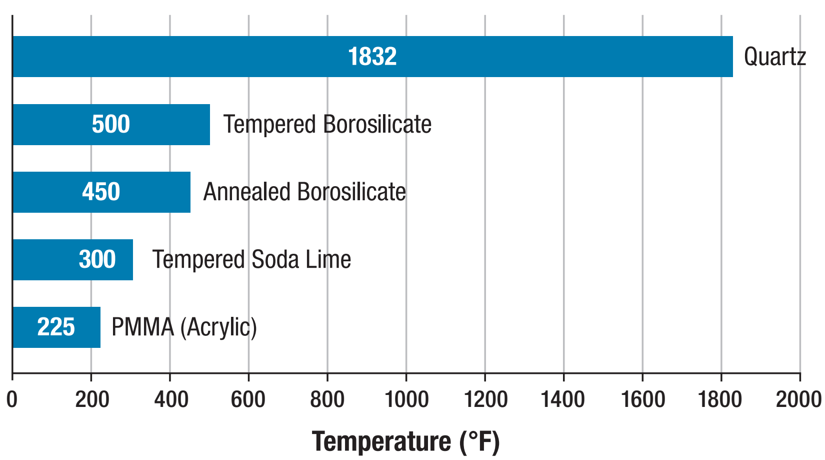
Extreme forces, whether internal or external, can have a detrimental impact on the visibility and strength of the glass components. Even minor cracks, scratches or abrasions of the glass can be a source of weakness within the glass, which will most likely lead to failure.

Sight glasses are highly engineered products. This white paper provides expert advice on how to select a sight glass able to meet the needs of your particular critical application. Six conditions, and how to design for them, are addressed.

Temperature

The temperature within a process system will have an effect on the sight glass. One must consider all possible extremes within which the sight glass must be able to operate. Depending upon the temperature range, certain glass types will perform better than others. At temperatures less than 300°F, standard Soda Lime glass may be used. For applications that involve temperatures up to 500°F, Borosilicate glass may be used. At temperatures greater than 500°F, such as in high temperature steam applications, Quartz or Sapphire glass would be recommended. The following chart lists the recommended temperature ranges for most of the glass types mentioned.

Common Optic Materials
General Temperature Ranges



Thermal Shock

Thermal shock can cause cracking as a result of rapid temperature change. Some glass types are particularly vulnerable to this form of failure, due to their low toughness, low thermal conductivity, and high thermal expansion coefficients. Situations where thermal shock may occur include during washdown, when cold water comes into contact with a sight glass on a heated vessel. Another possibility for thermal shock to occur is from within the vessel. This can take place during startup when hot or cold media is introduced or during CIP/SIP operations. During these situations, media is introduced at a temperature very different than that of the sight glass. Initial contact can cause a rapid temperature change in the glass, resulting in failure. Another thermal shock hazard can occur during autoclaving. If thermal shock is a potential risk within the process system, then at a minimum, borosilicate glass should be specified. Borosilicate glass has a considerably lower thermal coefficient of expansion than Soda Lime glass, making borosilicate glass more tolerant of sudden temperature changes. Fused Quartz has even greater capability for more extreme temperature environments.

The following calculation is used in determining the Thermal Shock Parameter or the resistance of a given material to thermal shock.

$$R_{\mathrm{T}} = \frac{k\sigma_{\mathrm{T}}(1-\nu)}{\alpha E}$$

where: k is thermal conductivity

σ_T is maximal tension the material can resist

α is the thermal expansion coefficient

E is the Young's modulus and

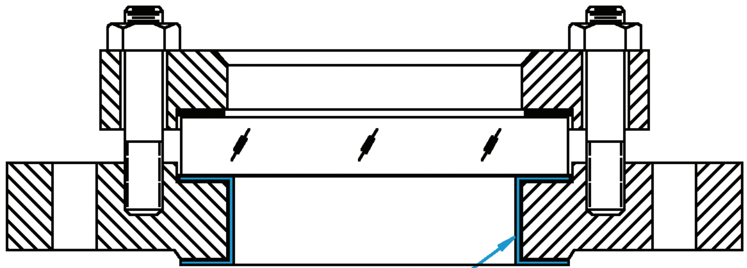
ν is the Poisson ratio.

Corrosion

Laboratory-grade glass is a formulation of minerals and chemicals that is inert to almost all materials with the exception of hydrofluoric acid, hot phosphoric acid and hot alkalis. Certain process media are caustic or acidic and can etch the glass. The result is a cloudy view with weakened integrity that requires the sight glass to be replaced. Hydrofluoric acid has the most serious effect, where even a few parts per million will result in an attack on the glass. Careful consideration of the chemicals present within a cleaning process is necessary to ensure that the glass material will not be impacted. For further details regarding the physical characteristics of Borosilicate glass, ASTM E438 "Standard Specification for Glasses used in Laboratory Apparatus" is available as a reference material. The useful life of a sight glass in these cases may be extended with shields mounted on the process side of the glass. Made of mica, FEP, or Kel-F material, these shields are not as transparent as glass, so there is a tradeoff in visibility.

Corrosion is also a factor with the metal used in a sight glass window. Most system designers know which type of stainless steel must be used in order to handle their caustic or acidic process medium, and they will specify this steel to their sight glass supplier. In some cases, a sight glass may be mounted in such a way that the metal ring does not come in contact with the process fluid, and therefore lower cost steel may be used.

In this cutaway view of a bolt-on sight glass mounted on a vessel, only glass and Teflon are exposed to the process medium. Instead of expensive Hastelloy, lower cost carbon steel may be used in the sight glass ring.



Abrasion

Abrasion, or physical wearing down of surface material, of the glass may occur with fluids that contain granular particles in suspension, or with particles carried in process gasses. This erosion of the glass may limit visibility and affect its strength. When designing for an abrasive environment, it is critical to prepare a routine maintenance schedule to evaluate the glass materials. Inspection of the glass material can be achieved either visually or using ultrasonic equipment, which is a non-destructive way to analyze the wall thickness and determine if the abrasives have reduced the thickness of the glass material. It is also helpful in these conditions to mount a shield on the process side of the window to extend the useful life of a sight glass.

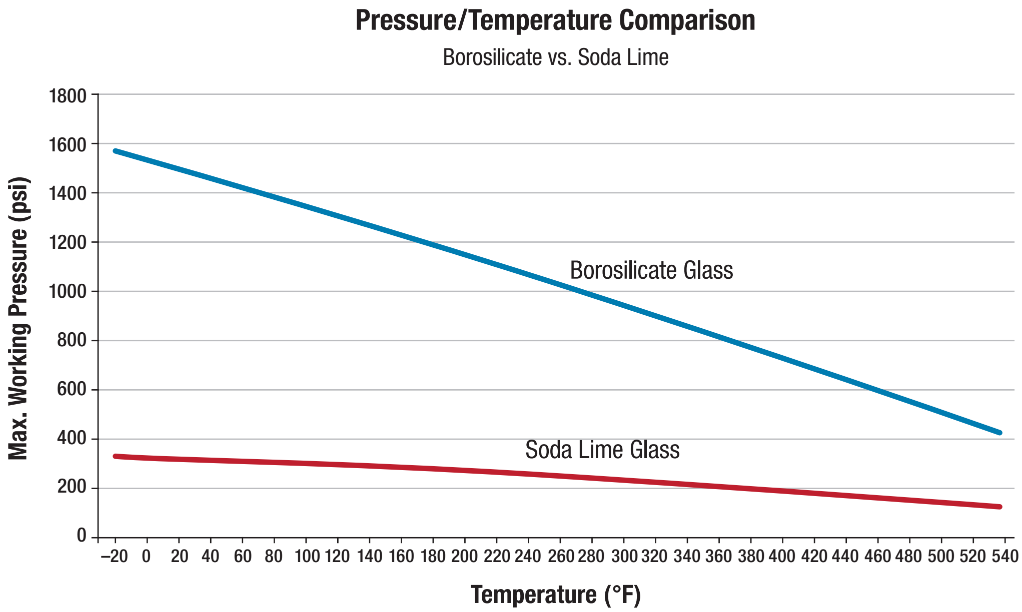
Pressure

Pressure may be specified as *Working*, *Design*, *Test*, or *Burst*. *Working pressure* is the maximum pressure allowable within an operating pressurized environment. *Design pressure* is the maximum pressure that the system has been designed to withhold, including a safety factor typically specified by ASME. *Test pressure* is the value typically specified by an end-user to go above and beyond the vessel design pressure to ensure that the components will not only meet the design criteria, but also incorporate a level of safety that exceeds it. *Burst pressure* is the amount of pressure at which a component will fail. Typically, this test is performed only in highly safety-critical environments such as nuclear facilities. Achieving *Burst pressure* is a costly test as it requires the manufacturer to destroy the component.

The glass materials selected, the unsupported diameter, and the glass thickness all play a role in determining the pressure capabilities of a sight glass assembly.

There are two types of sight glasses: a conventional glass disc and a glass disc fused to a metal ring during manufacturing. Conventional glass typically fails as a result of being subjected to significant tension. With fused sight glass windows, the compressive force of the metal ring exceeds the tensional force (i.e., pressure) and, as a result, the sight glass will not fail. The metal ring squeezes the glass and holds it in radial compression.

Fused sight glass windows offer high pressure ratings and high safety margins. The strongest fused sight glasses are made from duplex stainless steel and borosilicate glass; this combination creates the highest compression.



This chart shows the operating temperature of a fused Borosilicate sight glass and fused Soda Lime sight glass at different temperatures. (From "Compression vs. Fusion in Sight Glass Construction" by Karl Schuller, Herberts Industrieglas GmbH. Used by permission.)

Impact

Some applications involve objects that impact the sight glass. An example is a food mixer in which hard chunks of matter may strike the glass. Another example would be a wrench dropped by a worker that hits the sight glass. While these events are seldom sufficient to cause immediate failure, they can create scratches or gouges that may provide a point for tensional force to concentrate. It is always recommended that scratched sight glasses be replaced immediately. Fused sight glasses offer the greatest protection from these situations. Refer to the details of a fused style sight glass window within the "Pressure" section of this white paper.

Comparison of Sight Glasses for Critical Applications

	Temperature Application	Thermal Shock Resistance	Corrosion Resistance	Abrasion Resistance	Pressure Capability	Impact Resistance
Glass Disc Soda Lime	Up to 300°F	Poor	Poor	Poor	Moderate	Poor
Fused Sight Glass Soda Lime	Up to 300°F	Moderate	Poor	Poor	Good	Good
Glass Disc Borosilicate	Up to 500°F	Good	Good	Good	Good	Good
Fused Sight Glass Borosilicate	Up to 500°F	Good	Good	Good	Excellent	Excellent
Quartz Disc	Above 500°F	Excellent	Excellent	Excellent	Good	Moderate

www.ljstar.com
(330) 405-3040
getmoreinfo@ljstar.com