SPECIAL TECHNICAL AND SCIENTIFIC APPLICATIONS OF GLASSES

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Abstract :

Glasses used for special technical and scientific purposes form a mixed group. This group includes the fused silica glasses, pharmaceutical glasses, electrode glasses and special optical glasses for nuclear technology and radiation research. The most important glasses in used in nuclear technology and radiation research are radiation shielding and radiation resistant glasses.

Keyword : Special technical and scientific purpose glasses, Radiation Shielding Glasses, Radiation Resistant Glasses.

Introduction :

The classification of glasses based on composition and its applications have been discussed by various researchers. In this part we have discussed about the glasses which are used for special technical and scientific purposes. This group of glasses includes the fused silica glasses, pharmaceutical glasses, electrode glasses and few special optical glasses for nuclear technology and radiation research i.e., radiation shielding and radiation resistant glasses.

1. Special Glasses :

Glasses used for special technical and scientific purposes form a mixed group. Their compositions differ greatly and involve numerous chemical elements. This group includes the fused silica glasses, pharmaceutical glasses, electrode glasses and special optical glasses for nuclear technology and radiation research.

1.1 Fused Silica Glasses :

Among all the single-component glasses, only SiO_2 glass (quartz glass or fused silica) has technical importance. This is only because of its low coefficient of thermal expansion (α = 5 x 10^{-7} K^{-1}), and high thermal stability (up to almost 1273 K), and extremely high ultraviolet transmission [1,2]. Though these glasses have several advantages but they are very difficult to synthesize, since quartz glasses must be melted at temperature above 2273 K.

Another process for making quartz starts with the boron-enriched, phase-separable alkali-silicate glasses with low melting points [3,4]. When the glass is thermally treated at around 873 K it separates into two phases. The alkali-borate rich phase may be leached out with acids, leaving behind open pores of controllable microscopic sizes. In a subsequent heating process, the remaining high silica (approximately 96%) phase can be transformed into clear glass which is popularly known as Vycor glass [5]. Leached SiO_2 glasses of Vycor type with defined pore size are used as membrane in ultrafiltration, dialysis and carriers for biologically active materials, such as enzymes in the food processing industry [6].

1.2 Pharmaceutical Glasses :

Many pharmaceutical preparations and drugs are packaged in glass containers such as ampoules, vials, and small bottles [7,8]. While ampoules are always made either from glass tubing, small bottles can be made either from tubing or directly off the melting tank.

Fiolax clear, Fiolax brown, Illax, AR-glass are the names of some popular glasses used in pharmaceutical industry [9]. Fiolax clear and Fiolax brown are borosilicate glasses developed by Schott Rohrglas. The coloring agents for Fiolax brown glass are iron and titanium oxide both glasses are well-suited for pharmaceutical use due to their high chemical durability and good processing characteristics [10]. Illax glasses have high chemical durability and generally used for drinking vials, containers for sensitive reagents, tubes for pills which are sensitive to light and air, medicine bottles etc. [11].

The last glass of this group is the AR-glass which is a colorless soda-lime glass containing only 1.5% boric acid and is mainly used for bottles for dry or water free (oily) preparations [12].

1.3 Electrode Glasses :

The understanding of the pH-value of liquids plays a vital role in the control of various chemico-technical processes, such as monitoring drinking water in medical labs, urban areas, hospitals, diaries and many other areas. The exclusive evaluation of acidity and alkalinity of the water can be done by glass electrode chain [13]. A potentials difference is formed at the interface between a glass membrane and liquid electrolyte. The potential difference between the glass and the liquid electrolyte is dependent upon the pH-value and, for certain glass compositions, the alkali-ion concentration of the solution (sodium ion concentration, in particular) [14]. This effect is utilized to measure pH-value, pNa-value, etc. of a solution.

A glass itself cannot serve as an electrolyte; the two-phase glass/solution system is expanded into a multiphase system by adding a metallic end phase (electron conductors). Silver/Silver chloride, calomel, and Thalamid electrodes are used as an internal conductor and reference electrode.

1.4 Special Optical Glasses for Nuclear Technology and Radiation Research :

Radiation shielding glasses and radiation resistant optical glasses form a separate group of glasses that are specially developed for nuclear technology.

1.4 (a) Radiation Shielding Glasses :

In shielding window for hot cell (Fig.1), the absorption of radioactive radiation by lead is exploited. As these lead-containing glasses tend to color under nuclear radiations, they are usually stabilized with small amount cerium oxide to maintain their original optical transmittance [15].

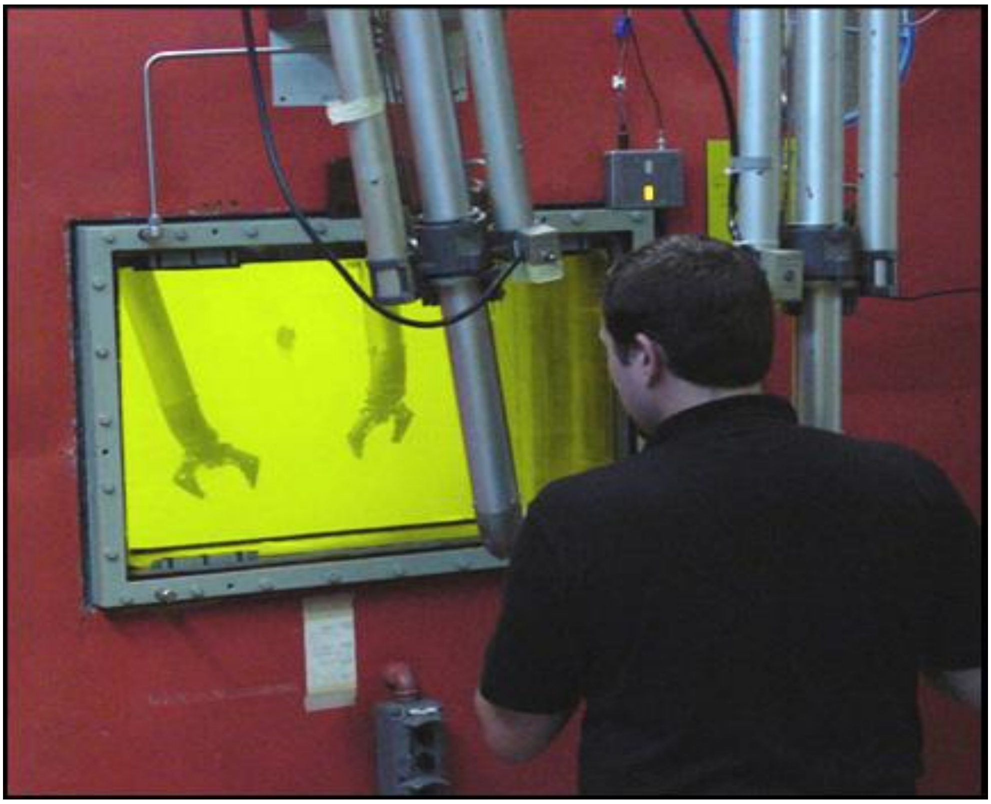

Fig. 1 : Lead shielding glass window of hot cell

Optical lead glasses are used in the field of radiation research to detect and determine the energy of high-speed subatomic particles (electrons, positron, cosmic rays, etc). If such a particle travels through a medium (refractive index n) at the velocity of v which is faster than c/n, the velocity of light in that medium, it produces electromagnetic radiation that expands as conical wave, the so-called Cerenkov radiation. This becomes visible as blue-violet light and can be monitored by using photomultipliers and impulse counters [16].

1.4 (b) Radiation Resistant Glasses :

In space, nuclear power and other scientific applications optical glass may be exposed to high energy radiation like gamma, electron, proton and neutron radiation. With the accumulation of higher doses this radiation changes the transmittance of optical glass especially near the UV-visible edge of the spectrum [17].

Ionization caused by photon and particle radiation changes the transmittance of optical glasses. An absorbed radiation dose of 10 Gy (10^3 rad) gamma radiation leads to recognizable loss in transmittance over the complete visible spectral range. The loss of transmittance is most pronounced at the UV-edge of the spectrum leading to a color change. Most glasses become unusable for optical applications if the radiation is increased to 100 Gy. The intensity of the color change does not only depend on the type of radiation dose but also on the energy of the ionizing radiation and the radiation dose rate [18-25]. Such optical glasses can be stabilized against transmittance loss caused by ionizing radiation by adding cerium to the composition [26-30]. The added cerium changes the intrinsic color of the glass. The transmittance edge is shifted to longer wavelengths. In general, the cerium content is kept low enough to keep this effect small [31]. The extent of stabilization differs from glass type to glass type.

Conclusion :

The employment of special purpose glasses in particular contexts, nuclear technology, has drawn more attention. The use of special purpose glasses with a focus on industries including manufacturing and medicine is very popular in reaction to these trends oriented.

When issues like performance enhancement and weight reduction, design and interface implementation and security enhancements are resolved by ongoing technological progress, more stable and efficient use will be achievable in the future. It is specifically anticipated that the introduction of special purpose glasses into the field at nuclear technology will make it feasible to increase a site's productivity and safety.

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