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PenTech FAQ # 10 by Gary G. Sanders, Director of Engineering

Shielding Glass for Gage Glass / Sight Glass

Glass

Background
Structurally, glass is essentially a silica lattice with alkali oxides as fluxing agents. As a containment material, glass tends to resist corrosion by most process materials. However, there are two primary mechanisms by which glass may be corroded:
1) Leaching (acid effect) where hydronium ions are exchanged for the alkalis in the glass; and
2) Etching (alkali effect) usually by hydroxyl ions acting upon the anions Na^+, K^+ and B^{+++} followed by dissolution. The rate of etching increases by 2 to 3 fold per pH unit increase. Temperature will increase the rate of either reaction by 2 to 2 1/2 times per each 10°C increase.

For glass, the most corrosive acid is HF (hydrofluoric acid), followed by hot H_3PO_4 (phosphoric acid). Any process that produces free hydroxyl ions $[OH]^-$ should also be considered corrosive, with the alkali metal (group 1) anionic solutions being the most corrosive. Some other less corrosive chemicals (a non-inclusive list) are: citrates, perborates, oxalates, peroxides, tartrates, EDTA and certain other -amin- groups, malates, etc., especially if they are in an alkaline environment. Even very pure water (e.g., > 18 MΩ) is considered corrosive due to unbuffered dissociated $[OH]^-$.

To protect glass, industry standard shielding is either mica, generally considered for high temperature applications or PCTFE for low temperature use.

Mica

Background
Natural muscovite mica [hydrous potassium aluminum silicate $H_2KAl_3(SiO_4)_3$] (a.k.a. ruby mica, potash silicate, Muscovy glass) occurs as monoclinic crystals. In plane bonding is the silica tetrahedral, inter-laminate bonding is by weak ionic attraction. The water of hydration is ≈ 5% which dissociates as the temperature exceeds 1000°F [540°C] and the mica calcinates. The index of refraction is ≈ 1.58, and its hardness is ≈ 3 (Mohs scale). Muscovite mica is an excellent shielding material for glass since although attacked by HF and H_3PO_4, it resists essentially all other acids and alkalis, however, caution should be used with peroxides. Within the context of gage glass use, mica is considered non-compressible and immune to cold-flow. Therefore, its application does not change the pressure or temperature rating of the gage glass / sight glass on which it is used.

Another common form of mica, phlogopite (a.k.a. amber mica, magnesium mica) should never be used. Its properties for gage glass use are considerably diminished compared to muscovite; e.g., it decomposes in H_2SO_4. Phlogopite is also easily synthesized.

Mica Failure

Mica is a natural product with minor surface imperfections. The imperfections will eventually allow delamination to occur. Primary causes of accelerated delamination are:

1. oils (and other lubricating non-polar substances) in the process fluid which interrupt the weak inter-laminate bonding
2. high velocity blowdown flowstreams which open surface irregularities with subsequent delamination.
3. rapid temperature changes and/or rapid pressure changes, either tends to cause expansion of trapped air in the laminate with subsequent loss of laminar bonding.

Mica should be carefully examined at each maintenance teardown and replaced at least every second teardown interval.

Visual indication of mica failure

Impending mica failure is indicated when a milky to opaque white appearance occurs. This appearance is due to differential optical density refraction at delimination sites. Mica failure follows rapidly. If a milky or white area (or entire surface) is observed on mica protected glass, the apparatus should be removed from service immediately. If allowed to remain in service, glass failure / blowout is eminent.

Mica Specifications

For gage glass use, controlling documents are: ASTM D351, ASTM D2131 and MIL-G-18498C(SH). Rev C of 18498 sets the mica thickness for gage glass use at 9 to 12 mils [0.23 to 0.3 mm] formed from either one or two pieces of mica. If two are used to develop full thickness then the thinnest must be > 4 mils [0.1 mm] and placed on the glass side. 18498 states for boiler gage glass use, mica shall be grade V4 [good, stained] or better with air content at grade V2 [clear and slightly stained] or better as specified by D351. D351 sets the visual grading system (V1 through V12).

PCTFE

Polychlorotrifluoroethylene, a member of the fluorinated ethylene based family of polymers. When it was manufactured by the 3M Company, it was called Kel-F[tm], a trade name still in common usage.

Background

PCTFE is normally a mixture of amorphous and crystalline forms. The amorphous form tends to be transparent. The crystalline form has excellent chemical resistance and mechanical properties. Although some exists, resistance to cold flow is excellent for this class of materials. PCTFE has the lowest vapor diffusion rate of any polymer. PCTFE's usable temperature range (**at low pressure**) is -453°F to +400°F [-270°C to 205°C].

Use

For shielding glass, Penberthy's standard thicknesses of PCTFE are 6 or 62 mils. The 6 mil thickness is essentially transparent and should be considered for general usage. The 62 mil thickness (somewhat translucent) is normally reserved for highly corrosive materials such as HF and H_3PO_4. While not completely resistant to these materials, PCTFE has better corrosion resistance to these materials than other non-opaque substances. Refer to Penberthy Application Report # 2783 for our suggestions about gage glass in HF service. Although a melt processable polymer, PCTFE is extremely viscous resulting in rather poor surface flatness. To obtain a good seal when using 62 mil PCTFE, a gasket of either PCTFE or ribbon graphite should be used. The restricted high temperature for PCTFE used **under pressure** as in gage glass is +300°F [150°C]. Since PCTFE is much tougher than glass, another good application for PCTFE shields is to protect sight glass from flow erosion (entrained particulate abrasion).

Cautions when using wetted shields

When used as glass shields, either mica or PCTFE must be used in direct physical contact with the wetted side of flat glass. Neither has intrinsic strength so they **must** be supported by the glass. This precludes using wetted shields with reflex glass or in vacuum service.

Non-Wetted Shields

Environmental Shields

Protecting glass against environmental hazards such as equipment strikes, blowing sand, blowing salt crystals, etc. uses PMMA placed on the non-wetted surface of the glass. PMMA shields provide better transparency than glass. The principle is similar to storm door glass replaced by acrylic sheeting. 125 mil [3 mm] thickness is used for blowing particulates. 438 mil [11 mm] thickness PMMA with a silicone seal into the vision slot of gages is used for strike protection (identical to the shielding used with Penberthy's 2600 offshore specification). PMMA use is restricted to about 225°F [107°C] maximum. Other materials (e.g., PC) are also available.

Wavelength Shields

Visualization of certain process fluids may be enhanced by adding color filters. Color filters may be obtained in a variety of center wavelengths and bandwidths. Color filter shields are used externally, i.e., on the non-wetted side of the glass. They may be used with either flat or reflex style glass. The typical material is PMMA at 125 mil [3 mm] thickness.

A subset of color filters in common use is anti-ultraviolet transmission. Certain process fluids may be harmed by exposure to the UV components of sunlight. For example, some monomers will polymerize when exposed to UV. UV has relatively high transmittance through borosilicate and aluminosilicate glass and quartz. To shield against UV radiation in the λ = 5 to 400 nm range, the complementary filter is chosen. Penberthy's standard offering is a selection of four amber complementary filters: $\lambda_o = 510 \pm 30$ nm; $\lambda_o = 550 \pm 10$ nm narrow band; $\lambda_o = 550 \pm 50$ nm wide band and $\lambda_o = 560 \pm 20$ nm. The most popular is the $\lambda_o = 550$ wide band.

Glass Coatings

A wide array of specialty coatings applied directly to the glass (wetted, non-wetted or both sides) is available. These include, but are not limited to; metallic, polymeric, case hardeners, etc. Application is by surface conversion, vacuum sputtering, rf deposition, etc. Since these are specialty coatings, each must be fully specified and the extra processing will require extended lead time.

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Other manufacturers and brand names for some of these products exist. Inclusion in or exclusion from this paper should not be construed as any form of endorsement.

Acknowledgement to all 26 users (I think most of them will recognize their queries) who recently communicated questions about the subject addressed by this FAQ.

Rev A = requested section on visual indication of mica failure added.