A Brief Guide of Protective Glazing for Stewards and Caretakers of Leaded and Stained Glass Windows

As part of our industry's Reference and Technical Manual, first published by the Stained Glass Association of America (SGAA) in 1988 and updated in 1992, the issue of Protective Glazing was tackled according to the leaving research and practices of the day. The same philosophies, materials, and information are still valid today (2020). In the 30 years since publication, however, misinformation and confusion has continued to dominate the conversation in regards to protective glazing solutions. This might be the result of the fact that there is no "one-size-fits-all" solution. There is no magic solution for increased efficiency, and protective glazing is not a replacement for actual restoration.

To try to provide some relief from the misinformation that abounds for stewards and caretakers trying to make a decision, we have put together a brief guide based on the continuing, valid information presented in Chapter 20, Section A, Number 4 "Protective Glazing" Chapter in our 1992 "SGAA Reference & Technical Manual" in combination with today's best practices and material information about the most commonly available options utilized across the country. This guide is not intended to be exhaustive but should be an adequate reference when used in conjunction with trusted advice from an industry expert, such as an Accredited Professional Studio.

In this guide, you find information on the basic philosophy of Environmental Protective Glazing, sometimes referred to interchangeably as 'Secondary Glazing' or simply 'Protective Glazing.' You will also see information on an overview of information in regards to ventilation, condensation, materials commonly used, their pros and cons and the lifespan of those materials, and a note on energy efficiency.

Environmental Protective Glazing

Philosophy: Stained glass windows are installed for the purpose of elevating the human spirit and beautifying our man-made environment. They are designed to be appreciated for color, line and texture. Beyond the possible structural problems that inappropriate protective glazing may cause, it can dramatically detract from the aesthetic of the windows.

Our first recommendation as a professional trade association is not to use it at all unless there is sufficient cause to protect the windows from certain damage from man-made or weather-related events, or properly installed, to protect a significant cultural window which cannot be easily repaired (such as a 7-layered LaFarge).

Protective glazing is not a substitute for repair, restoration or continued maintenance. In fact, incorrectly installed, it can actually accelerate the deterioration of the leaded glass, supporting frame and surrounding architectural elements.

It is crucial to identify the real cause of damage to the windows in question. Is it man-made or natural deterioration? Is it a permanent condition or one that is temporary or can be rectified? *It is better to take the knife away from the child than to keep buying bandaids.*

Of course, in this unfortunate age of increasingly violent weather events and in areas of increased vandalism and instability, it is sometimes necessary to take extraordinary precautions to protect our treasured art works. In this capacity, protective glazing serves an important role. Correctly installed, this secondary glazing can maximize the protection of the stained glass while having a minimal impact on the window's aesthetic.

What Is It?: In recent history (not many storm windows on Medieval Cathedrals), protective glazing is the generic term for any application of a rigid material to the exterior or interior of a stained glass window for the purpose of protecting it from damage. Early in the 20th century, plate glass and metal screens were the materials of choice. Today, although we have many additional options, the favorite choice remains glass whenever possible, and plastics when economic concessions must be made.

Materials:

1. **Glass**

    a. Glass has the following advantages: it remains flat; it is easily cleaned and with minor maintenance will retain its clarity, allowing the stained glass to be seen through the glazing. The main disadvantage of glass is its relative fragility.

    b. <u>*However,*</u> structural advantages can be gained by using the following:

        i. ***Plate glass***: Plate glass in large sheets offers the most economical solution, but the one with the least impact resistance. However, if this glass is cut and leaded together to form an exterior leaded protective glazing, it is most aesthetically pleasing to the window and the architecture of the building. Dramatic impact resistance can also be gained by tempering (see below) the glass before leading up. This method is very popular in the Cathedrals of Europe, where it was developed.

        ii. ***Tempered glass***: Glass can be tempered through a heat process or hardened by a chemical process. The result is that the glass becomes up to ten times more resistant to impact than annealed glass (the protective transparent barriers on professional hockey rinks are tempered glass). The glass maintains all of the attributes discussed in the general section. The disadvantages are the inability to adjust the glass sizes after they have been tempered. This necessitates additional template and measuring work, which translates into a greater expense.

        iii. ***Laminated glass***: This glass is composed of two sheets of annealed glass that have been laminated with a polyvinyl butyl inter-layer. While the individual glass sheets are still subject to breakage, the strong inter-layer will prevent most projectiles from passing through, thereby protecting the stained glass panels. It is tricky to cut the laminated sheets in the field, but it can be done. Custom shapes can be fabricated in the shop, and they are only as limited as is the skill of the cutter. Certain inter-layers, such as Monsanto's Safeflex, will block 99.9%

of the ultra violet light, while maintaining total clarity. This is important if the use of epoxies has been specified in the restoration of the stained glass, or there are light sensitive textiles within the building.

2. **Plastics**

    a. _General Properties_: For the most part, the plastics are more resistant to impact than all of the glass options. Plastic can be cut into complex shapes without risking its integrity. There are numerous trade-offs for this increased strength. Plastic tends to bow and distort, especially in large sheets. While the degree to which they are affected varies depending on individual composition, all plastics are subject to scratching. In the advanced stage, the plastic becomes cloudy, restricting light transmission.

    b. _Specific Types_: The two most common generic types used are acrylics and polycarbonates. Both of these have relatively high coefficients of expansion. This must be accounted for when designing the installation.

        i. ***Acrylics (Plexiglas®)***: Acrylics have a harder surface than polycarbonates and tend to be less flexible. They are more resistant to scratching. They are affected by sunlight, tending to yellow and become brittle with age. However, the plastics field is one of constant research, developing new products all the time. If I were to use acrylics on a project, I would speak to the technical people at the manufacturing plant and not base my expectations on the words of the salesman. Any claim that they are not willing to put in writing is one to be ignored.

        ii. ***Polycarbonates (Lexan®)***: Polycarbonates are softer than acrylics, and thereby more subject to scratching. They are also more flexible, which contributes to their great resistance to impact. If used in the correct thickness and installed correctly, polycarbonates are virtually unbreakable. The installer or a representative of the owner should inform the local fire department whenever polycarbonate sheeting is installed on windows. Firemen can be severely injured when trying to vent buildings by applying the axe to polycarbonate.

Installation: When designing the installation details of a protective glazing system, the following factors must be considered: the existing condition of the window and its surround; the effect on the aesthetics of the window and the building; the appropriate materials to use; the venting of the inter-space; and the ease with which the system can be maintained.

1. _Existing Conditions_: Make sure that the owner has a complete condition report of the windows to be covered. If one does not exist, suggest that you can provide it. Remember that protective glazing does not fix anything; it only covers it up. Carefully examine the leaded glass, the supporting frame and the window surround for signs of deterioration.

2. Aesthetic Ramifications: Always cover as little of the existing framing members of the window as possible. This will make maintenance work easier as well as maintain the original architectural interest of the building. To my mind, few things are as ugly as a Gothic Revival church where the windows have been covered with great sheets of bowed plastic and massive aluminum framing members. Design the scale of the individual panels to harmonize as much as possible with the surrounding architecture.

   Carefully align any necessary horizontal or vertical members with the existing mullions and muntins of the window. If they are clerestory windows and there is some space between the inner and outer glazing, place the muntins of the exterior slightly above the muntins of the interior, so that they will align when viewed from the floor of the interior.

3. Venting the Inter-space: Protective glazing systems must always allow for the venting of the inter-space that exists between the inner and outer glazing levels. There are three primary reasons for venting: to allow any condensate to evaporate and leave the inter-space; to equalize the pressure in the inter-space with that of the local atmosphere; and to minimize the temperature gradient to which the leaded glass will be exposed.

   Where and how the glazing gets vented depends on the type of installation and the local environment. A key scientific premise to understand is that of relative humidity. Relative humidity (as opposed to moisture content) is not a finite measurement of the amount of moisture in a given volume of air. It is the ratio of the actual moisture content of a given volume of air divided by the maximum possible moisture content of an equal volume of air at a given equal temperature. The relative humidity of a given volume of air is inversely proportional to the temperature of the air. As the temperature of the air increases, its ability to hold more water increases.

   Some examples of how to vent are given below.

   a. Northern Temperate Climate: This climate, such as found in much of Europe and the United States, calls for venting of the inter-space to the exterior of the building. This theory has been supported by testing in many European countries This can be accomplished as follows:

      i. Applied Frames: If applied frames are used to support the protective glazing, holes can be drilled through tl1e members of the frame to allow air movement. The holes must be at the top and bottom of the window, placed in such a way as to discourage the infiltration of rainwater.

      ii. Plastic: If plastic glazing is used, holes can be drilled through tl1e plastic. Place them at the top and bottom of tl1e lancet, and angle tl1em up to prevent rain from coming in.

iii. Glass: If the exterior glazing is leaded, vent panels (stainless steel screens) can be glazed into the window during fabrication. If laminated glass is used, the corners can be cut off (or the top three inches of a Gothic Head), and a hooded vent screen made from glass, stainless steel screening and lead came, can be fitted to the system.

b. Southern Temperate Climate: In hot, humid sections of the United States, venting to the interior should be considered if the building is constantly air-conditioned. The venting needs of particular windows may vary greatly. The amount of venting required is dependent on the micro-environment in which the window is placed. Unfortunately, there is no present set of guidelines to determine this. One must use common sense, and be willing to constantly review the results of past work. It is often easy to add more holes if condensation occurs after installation.

Ventilation Summary

- The Stained Glass Association of America (SGAA) guidelines as well as the Secretary of the Interior, recommend that stained glass windows covered with protective glazing, vent to the interior of a building. When venting to the interior is not an option, the alternative recommendation is venting to the exterior. Venting both the top and bottom sections of window panels allows for convection and exchange of air inside the dead airspace with fresh air. The circulation moves hot moist air out and fresh air into the void. When vented to the interior, dry airconditioned air circulates through the space. When vented to the humid exterior air will move through the void, but moving air is preferable to trapped, stagnant air.
- The purpose of venting a window is not to remove heat from the dead air space but to create air circulation. The sunlight's infrared rays (IR) heats the dark-colored surfaces of a stained glass window. The heat gain subsequently, not only heats the surface of the stained glass window but the dead air, best described as a solar-oven. The heated air dries out the waterproofing (glazing) breaking down the seal between the lead and glass. The heat also dries the natural oils from the lead came, prematurely aging the lead. The lead becomes less supple and fatigued. The heat gain from the sun's IR on the stained glass surface is sometimes hot enough to 'heat-crack' glass.
- Blocking the sun's IR can be achieved with insulated glass with solar control Low-e coatings. However, the average life of an insulated window is about fifteen years. Adding Insulated glass to the existing window frames will not work. An alternative is using the existing glass, by applying to the glass a nonmetallic film product by 3M corporation such as their Prestige Film. It rejects up to 60% of the sun's heat and 97% of UV light. Prestige film also is a safety/security film in which it converts annealed glass into safety glass. The reduction of heat will reduce the temperature in the dead airspace and will increase the overall energy efficiency of the windows, increasing the R-value of the windows.

4. Framing Materials: While wood can be used to fabricate frames to hold protective glazing, metal is usually more appropriate. A much larger section must be used with wood, which may obscure part of the stained glass window. Aluminum is the current metal of choice. In strong salt conditions (such as near the ocean) special coatings or alloys may have to be specified so tl1at the aluminum does not corrode.

   All fasteners should be nonferrous. The protective glazing framework should be attached to the surround of the window and be securely anchored. It should not just hang on the existing frame of the stained glass it is to protect. If plastic is used as a glazing material it must be placed into an adequate frame. It cannot be screwed onto the existing one.

5. Ventilators: A common mistake made on many protective glazing projects is the application of the secondary glazing 'piggy-backed' onto existing single-glazed ventilator sections. If operable vents are desired, a custom double-glazed ventilator must be fabricated to accommodate the stained glass and the protective glazing.

Results of Improper Installations: As mentioned before, it is better to not apply protective glazing than to apply it improperly. The most common result of improper installation is condensation. Moisture is trapped between the glazing and condenses, on the stained glass, framing members and surrounds of the window. The moisture promotes corrosion of the glass and the metals, rots the wood and may contribute to spawling of the masonry. Even the lead of the window may be attacked by organic acids produced by microorganisms that live in the condensed water.

Unvented inter-spaces can also be subject to extreme temperatures as solar radiation is absorbed through the day. The absorbed heat is transferred directly to the window augmenting the deleterious effects of the expansion and contraction cycle.

If plastic glazing is used, adequate provisions must be made for the high degree of expansion they experience. Deep glazing grooves and flexible caulk must be used in these applications. If not allowed for, the expansion of the plastic will tear the existing framing apart.

Conclusions: The best protective glazing is none at all. However, if the decision is made that it is absolutely necessary to install secondary glazing, where possible we recommend the use of laminated glass with screened vent hoods. This is the best compromise of protection, aesthetics and cost. If the budget allows, the European the leaded protective glazing approach is the most aesthetically pleasing solution. If absolute protection from vandals is needed, polycarbonate is the material of choice. As in all endeavors, the careful consideration of all existing conditions and needs will result in the most appropriate application.

A final point to make concerns energy efficiency. **To say that adding secondary glazing will increase the energy efficiency of a historic building is often extremely misleading, and is not a reason in and of itself to add protective glazing.** The energy savings gained by the use of secondary glazing offset by the additional total cost of adding secondary glazing, the ongoing maintenance of that additional glazing, and the increased complications of maintaining the stained glass artwork, does not often cause a comparable savings to the lifespan of the windows overall. So the decision to add protective or secondary or environmental glazing must be carefully weighed against the true need to either protect from vandalism or extreme weather events.