Vitro Glass Design Guidelines

Vitro Architectural Glass offers one of the industry's most comprehensive portals for glass research, product selection and specification. By visiting ***vitroglazings.com***, architects, specifiers, glazing contractors and other building professionals gain access to a suite of tools, which includes the Search Tool, Construct IGU Tool, Energy Modeling Tool and Thermal Stress Analysis Tool, for assessing and comparing Vitro architectural glass and glazing products for commercial construction products.

In addition to specifying glass for its aesthetic and energy-related performance, specifiers and design professionals must consider and account for the factors listed below as early as possible in the design/ specification process.

Safety – Appropriate safety glazing materials, such as tempered or laminated glass, must be specified where required by code or when dictated by design judgment based on the intended application.

Thermal Stress – Strengthened glass (heat-strengthened or tempered) may be required to resist thermally induced stresses in specified applications. Such stresses are caused by a number of design factors, including glass type, shading patterns, indoor shading devices and others. Not properly accounting for these factors during the specification process can lead to glass breakage. Thermally induced glass breakage is recognized and well-understood in the glass industry. Procedures to help design professionals evaluate the risk and specify strengthened glass when required have long been offered by PPG. Additional information is available in Vitro's Technical Document **TD-109:** ***"Thermal Stress Update."*** Vitro also offers a computerized thermal stress analysis program. Both are available at ***vitroglazings.com***.

Wind and Snow Loads – The appropriate glass thickness and type (annealed, heat-strengthened or tempered) must be specified to withstand the design's wind and/or snow loads for the application. The current industry-accepted procedure for determining the load resistance of glass is ***ASTM E1300 "Standard Design Practice for Determining Load Resistance of Glass in Buildings."*** Review Vitro Glass Technical Document ***TD-134: "Designing Glass to Resist Wind and Snow Loads,"*** in the Technical Bulletins section of ***vitroglazings.com,*** for a brief tutorial on the use of ASTM E1300. A computerized version of the ASTM E1300 procedure also is available for purchase from the Standards Design Group, Inc. (www. StandardsDesign.com). A computerized version of ASTM E1300-02 is available on the Vitro Glass website for *Vitro Certified® Network* customers.

Surface Orientation – When darker tinted glass materials, such as *Graylite®* II, are specified, it is critical that the glass be fabricated and glazed with consistent surface orientation in order to achieve consistency of appearance. You can review Vitro's Technical Document, ***TD-122: "Surface Orientation of Low Light Transmittance Glasses***" in the technical bulletins section of ***vitroglazings.com*** for additional information.

Energy and Sustainable Design

Since introducing the world's first energy- efficient glass more than 70 years ago, Vitro has been a global leader in advancing glass technology to enhance comfort and save energy. *Solarban*® and *Sungate*® coated glasses by Vitro, along with the Vitro line of spectrally selective tints, can significantly lower energy costs and associated carbon emissions, as well as initial HVAC capital equipment costs.

As the first U.S. glass manufacturer to have its entire product line *Cradle* to *Cradle*CM Certified, Vitro has demonstrated a commitment to environmentally responsible, sustainable design that is unique to the glass industry. Cradle to Cradle Certification signifies a commitment to designing and manufacturing products that not only enhance energy efficiency, but also limit a product's total impact on the environment – from raw material acquisition through manufacture and the building lifecycle, to final recycling and/ or disposal.

Inclusion of Materials in IGU Airspaces

Any material to be utilized inside a hermetically sealed airspace, such as grids (muntins), clips, films, blinds, paints and other coatings, must be tested and approved for such use by that material manufacturer. The compatibility of the material with sealants, as well as the potential release of volatiles into the air space, must be verified. The inclusion of materials in insulating glass unit (IGU) airspaces raises several concerns, including the following:

- The materials may outgas volatiles that then condense on the glass and/or coated glass surface within the gas space. In addition to causing aesthetic issues, the volatiles may cause coating degradation. Coating degradation or color change caused by volatiles will void any applicable warranty.
- Damage to the low-emissivity (low-e) coating will likely result should any physical contact occur between a material located inside the airspace of the IGU and the low-e coating.
- Materials located inside the airspace of an IGU often have a negative impact on the thermal performance of the IGU by reducing its insulating value.
- Materials that may have an impact on localized glass temperatures have the potential to increase glass breakage due to thermal stress. In addition, while uniform elevated temperatures may not have an immediate effect, they can reduce the overall durability/longevity of the hermetic seal.

Accordingly, Vitro strongly recommends that careful consideration be given to these issues prior to incorporating materials inside the hermetically sealed airspace. The burden of proof regarding compatibility or fitness for use of any material lies with the manufacturer of that material.

Color Shift

Responsible design professionals must consider how the combination of materials in an IGU or in laminated glass will impact the transmitted and reflective color of the glass, as well as its transmitted and reflective clarity. Transmitted and reflective color shifts and color differences may result when various coatings and tints are incorporated into the glass design, such as a low-e coating, opacifier coating, clear or tinted interlayer materials or other design alternatives. It also is likely that a coating used in an IGU will look different than that same coating used in a laminated construction. Combining standard clear glass with light-colored opacifier coatings or interlayers will make such appearance disparities especially evident. To enhance color consistency, Vitro recommends maintaining consistent glass product constructions throughout a project and viewing a full-size mock-up at the job site and retaining it as a basis for acceptable product.

Aesthetics and Mock-Up – Vitro offers a broad selection of clear and tinted glass products that can be used as standalone products for their aesthetics and performance, or combined in IGUs to create deeper and richer hues and improved performance. Many additional aesthetic, environmentally friendly and energy-control solutions can be achieved by including a Vitro high-performance glass coating in a building design, such as a visibly reflective coating, a non-reflective low-e coating or one of Vitro's many non- reflective, solar control low-e coatings. These glass combinations can be further enhanced through custom fabrication with multiple glass lites, ceramic frits, laminates and other design options, which can produce an almost infinite number of installed glass products.

The ultimate glass solution for any project marries the desired aesthetic to enhance the building façade with design considerations related to performance, safety, wind/snow loads, thermal stress and other design considerations. Virtually any individualized design concept can be fully achieved with Vitro glass products, which represent the broadest selection of architectural glass products in North America.

Once all design considerations have been appropriately addressed, **Vitro strongly recommends the viewing of a full-size mockup**, preferably at the job site, prior to making final design decisions. **Note:** Due to production tolerances, variations in viewing angle and light conditions, not all color differences may be captured in a mock-up.

Availability – Available software, such as the LBNL Window program, permits users to simulate practically unlimited combinations of glass, gas-cavity gaps, and gas fills in IGUs. It is the design professional's responsibility to ensure that the specified products are available and in the desired sizes and configurations. You can use the Vitro Construct Tool to design custom IGUs for your next project, at ***construct.vitroglazings.com***.

Large IGU Considerations

For more complete information on all issues and design considerations related to the fabrication, installation and performance of large IGUs, please review **TD-140: "Large Insulating Glass Units"** in the technical bulletins section of ***vitroglazings.com***.

Fabrication – Large IGUs can be more difficult to handle than smaller pieces during the fabrication process. They are also more vulnerable to issues with spacers and seal ruptures, distortion and damage within the sealed air cavity.

Weight – Due to the increased weight of large IGUs, the risk of damage during the fabrication, handling and glazing processes also increases.

Field Issues – Large IGUs can be difficult to handle, which requires those who work with them to be more careful to prevent breaking or damaging the edges, and from exposing them to extreme temperatures, which can also cause breakage.

Glazing – Large IGUs require a glazing system that is specifically designed for these units so that the system can support the increased weight of the glass. Cost and budget should be considered, as the costs of different glazings vary. Vitro recommends weighing the cost of a particular glazing against the benefit it provides.

Heat-Treating – With large IGUs, the glass will likely need to be heat-treated. Although heat-treating does render glass more resistant to wind loads and thermal stress, it also increases the chance of distortion.

PPG Glass Technical Documents

TD-101 Gas Space Convection Effects on U-Values in Insulating Glass Units
This document discusses how U-value changes correlate to changes in air/gas space thickness within an IGU, as well as the effects of different gas types on an IGU's insulating value.

TD-102 Outdoor Condensation on Glass
This document explains why condensation sometimes occurs on outdoor glass surfaces.

TD-103 Capillary Breather Tubes in Insulating Glass Units
This document reviews the use of breather tubes in IGUs.

TD-104 Coatings on *Starphire* Ultra-Clear™ Glass
This document examines the coatings on *Starphire* Ultra-Clear™ glass by Vitro and how to identify which surface of the glass was exposed to the tin bath during glass-making.

TD-105 How to Prevent Glass Corrosion
This document discusses the chemical mechanisms that cause glass corrosion, the conditions under which it can exist, interleaving systems and the restoration of lightly corroded glass.

TD-106 Glass Reactivity and its Potential Impact on Coating Processes
This document examines glass corrosion in glass racks and cases, the damaging effects of glass fines, hard-water silicates and their effect on glass-coating operations.

TD-107 Residue on Glass
This document explains how residues may deposit on exterior glass surfaces and methods for their removal.

TD-109 Thermal Stress Update
This document examines thermal stress issues associated with glass, including a procedure for conducting thermal stress analysis, with resulting glass recommendations.

TD-110 Glass Breakage Analysis I
This document reviews glass breakage caused by thermal or mechanical stresses.

TD-111 Glass Breakage Analysis II
This document analyzes glass-break origins, mirror radius and other glass breaking stresses.

TD-112 Handling Dos and Don'ts to Reduce Glass Breakage
This document explains things to do and not do when storing and fabricating glass.

TD-113 Why Annealed, Heat-Strengthened and Tempered Glass All Deflect the Same Amount
This document reviews the stiffness of glass and the deflection characteristics of annealed, heat-strengthened and tempered glass.

TD-114 Recommendations for Fully Tempered Interior Butt-Glazed Fixed-Glass Panels
This document contains design recommendations for fully tempered, buttglazed, fixed-glass panels. Size, height and deflection guidelines are included.

TD-115 Strain Patterns in Tempered and Heat-Strengthened Glass
This document explains visual strain patterns in tempered and heat strengthened glass, including how and why they occur.

TD-116 Observation Room Windows
This document examines lighting levels and glass selection for observation room windows.

TD-117 Cutting Wheel Selection for Conventional Glass Cutting
This document contains information on selecting cutting-wheel size and edge- angle combinations to help achieve better edge-cut quality in conventional glass- cutting operations.

TD-118 Interference Fringes in IGUs
This document explains the phenomena of interference fringes in IGUs.

TD-119 Guidelines for Glass-Edge Cut Quality
This document reviews glass cut-edge quality characteristics and their effects on glass strength.

TD-120 Flat Glass Trade Thicknesses and Weights
A table of thicknesses, thickness ranges and corresponding weights for flat glass.

TD-121 Center of Glass U-Values for Double- and Triple-Glazed IGUs with *Solarban*® 60 Low-e Glass with 100% Air, Argon, or Krypton, or Mixtures of These Gases
This document demonstrates how U-values vary in double-glazed and triple- glazed IGUs using *Solarban*® 60 solar control low-e glass.

TD-122 Surface Orientation of Low-Light- Transmittance Glasses
This document highlights the importance of consistent surface orientation when fabricating and glazing low-light- transmittance glasses, such as *Graylite*® II glass.

TD-123 Turtle Glass
This document examines the marine turtle protection ordinance and glass products that meet the requirements of the ordinance.

TD-124 Fabrication of Heat-Treated Glass
This document contains PPG recommendations for further fabrication of heat-strengthened and tempered glass.

TD-125 Sandblasting of Tempered Glass
This document examines the effect of sandblasting on tempered glass, including Vitro's recommendation that sandblasting be done before tempering.

TD-126 Argonomics
This document highlights the benefits of using argon in IGUs and the importance of good unit design and workmanship for retaining argon in the unit.

TD-127 V-Grooving
This document examines the strength of V-grooved glass and compares glass that is tempered-then-grooved to glass that is grooved-then-tempered.

TD-128 Laminated Glass-Thermal and Optical Properties
Offers performance tables for selected laminated Vitro glass products.

TD-129 Temporary Protective Overcoat (TPO)
This document discusses the proper handling, washing and disposal of the TPO overcoat, including health and safety issues and proper environmental practices. It also contains graphs showing percentage by weight of TPO dissolved in rinse tanks and detergent tanks.

TD-130 Insulating Glass U-Values in Sloped Glazing Applications
This document explains how U-values change as the slope of the glazing system changes.

TD-131 Design Conditions with Low-e Coated Glass
This document details the need to evaluate the effects of building materials on each other.

TD-132 The Differences Between Structural-Silicone Glazing and Butt-Joint Glazing
This document examines the differences between structural-silicone glazing and butt-joint glazing.

TD-133 Condensation on Indoor Glass Surface
This document explains the factors that influence the formation of condensation on the indoor glass surface. It also references test methods to determine AAMA-CRF and NFR-CR, and includes graphs to assist in preliminary product selection.

TD-134 Designing Glass to Resist Wind and Snow Loads
This document describes ASTM E1300- 02 procedures for determining the load resistance of glass under uniform lateral wind and snow loads, including a detailed example. It also references available software based on ASTM E1300-02.

TD-135 Glass Acoustical Performance
This document explains the acoustical properties of glass, methods of rating, applicable standards and the relationship between glass and other glazing components in determining an overall rating.

TD-136 Recycled Glass Use
This document explains how Vitro uses the glass it recycles.

TD-137 Glass, Solar Radiation and Their Effects on Vinyl Cladding Materials
Brief background of subject with link to a published article.

TD-138 Heat-Treated Glass for Architectural Glazing
This document examines the appropriate uses of heat-strengthened and tempered glasses, including the causes of spontaneous breakage and the limitations of heat-soaking tempered glass. Vitro recommendations are included.

TD-139 Field Application of Materials to Glass
This document reaffirms Vitro policy regarding the field-application of materials to glass.

TD-140 Large Insulating Glass Units (IGUs)
This document covers issues and design considerations related to the fabrication, installation and performance of large IGUs.

TD-141 Edge-Deletion of Vitro Coated Glass
This document contains Vitro's recommendations regarding the edge-deletion of Vitro MSVD low-e coated glasses and explains Vitro's non-deletion policy requirements. A discussion of environmental, health and safety considerations is included.

TD-142 Glass Cleaning Recommendations
This document contains recommended cleaning practices for Vitro glass products.

TD-143 Ingredient Disclosure, MSDS & EU RoHS
This document contains information provided as Vitro's response to customer requests for Ingredient Disclosure; Compliance with the European Union (EU) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive; and product/material Safety Data Sheets (SDS) concerning Vitro Glass Products as produced by Vitro.

TD-144 Recommended Techniques for Washing Glass
This documents details procedures and recommendations for cleaning glass using machine-washing techniques. It also describes different types of glass contamination and remedies.

TD-145 Spandrel Glass — Types and Recommendations
This document presents alternatives for glass spandrels, including monolithic, IGU and shadow-box types. It includes descriptions of the three basic spandrel types with sketches and a discussion of potential issues associated with the shadow-box concept.

TD-146 Approved Sealants for Use with Vitro Coated Glass Products in Non-Deleted Applications
This document lists approved sealants that can be used with non-deleted MSVD-coated glass (applies only to IGU assemblies for non-commercial use).

TD-147 Compatible Gloves for Use with Vitro's MSVD *Sungate*® and *Solarban*® Coated Glass Products
This document lists compatible gloves for use when handling MSVD-coated glass products.

TD-148 Reducing Fading Caused By Solar Radiation Exposure
This document describes different measures of fading potential and explains why the traditional focus on UV transmittance may not be the best indicator of protection against interior solar damage.

TD-149 Acceptable Cutting Fluids and Detergents for Use with *Sungate*® and *Solarban*® MSVD-Coated Glass Products by Vitro
This document lists acceptable cutting fluids and detergents for use while fabricating MSVD-coated glass products.

TD-151 Radio and Microwave Attenuation in Glass
This document describes the best window constructions using silver based, low-e coatings for blocking certain radio frequencies and ways to avoid the blocking characteristics when these low-e's are desired for thermal performance, but security of airwave transmission is not a concern. Testing results are displayed showing the attenuation performance of various window constructions as well as the thermal performance of each.

This document is intended to inform and assist the reader in the application, use, and maintenance of Vitro Architectural Glass products. Actual performance and results can vary depending on the circumstances. Vitro makes no warranty or guarantee as to the results to be obtained from the use of all or any portion of the information provided herein, and hereby disclaims any liability for personal injury, property damage, product insufficiency, or any other damages of any kind or nature arising from the reader's use of the information contained herein.