



Special to *Licensed Architect*

Glass Solutions for Today's Design Challenges

by Ken Brenden, American Architectural Manufacturers Association



The best possible glass solution for each project will represent an optimized accommodation of requirements for structural integrity, safety, security, energy efficiency, interior comfort, aesthetics and budget.

Learning Objectives:

After taking this course, developed by AAMA Glass Material Council, the reader will have a better understanding of:

1. The uses of glass in a commercial building, as well as the functionality and performance this versatile material can provide.
2. The manufacturing and fabrication processes used to produce different types of glass and the applications for these products.
3. Various kinds of fabricated glass solutions to enhance basic glass performance, including insulating units, safety glass, and fire-rated glass.
4. Methods of measuring and evaluating glass performance to help you make smarter glass choices.

The myriad of glass choices available today make it easier than ever for architects to meet the unique demands of every application. But, the number of product choices, which must be matched to a wide range of design parameters, also makes product specification very complex.

The best possible glass solution for each project will represent an optimized accommodation of requirements for structural integrity, safety, security, energy efficiency, interior comfort, aesthetics and budget. Obviously, a "one-glass-fits-all" approach to meeting these needs does not consider the increasingly varied and complex array of architectural options.

GLASS TYPES

The architectural glass found in most buildings today is commonly referred to as "float glass," which consists primarily of silica sand, soda and lime – to which pigments may be added to create tinted glass. In the float manufacturing process, these materials are heated to their molten state, then drawn over a liquid bath of tin before the mixture is cooled under controlled conditions. Because tin has a higher specific gravity than molten glass, the glass "floats" on the tin, forming a flat layer. Specialized coatings may be added before or after cooling.

ADDING STRENGTH

All float glass is annealed (slowly cooled) during manufacturing to remove residual stresses. This makes the glass better able to resist both mechanical stresses (such as high wind loads) and thermal stresses (including heat build-up between lites in an insulating glass unit), and thus more resistant to breakage.

Beyond this, the specific type of heat treatment required is usually dictated by building codes or industry safety standards.

Heat-strengthened glass, which is twice as strong as annealed glass, is produced when annealed glass is reheated to a high temperature, then cooled quickly in a process called "quenching."

Tempered glass is made in a manner similar to heat strengthening, but cooled with a much more intense airflow during the "quench" phase. This makes it four times stronger than annealed glass.

Tempered glass has the unique property of breaking into small pebble-like pieces instead of shards, resulting in a significantly diminished safety hazard. Tempered glass is frequently specified to ensure safety in large glass installations—for example, when there is a vertical wall of glass with no guardrail. It is excellent for commercial storefronts, entryways, display cases, railings, skylights, sliding glass doors and overhead lighting fixtures.

Applications for laminated glass products include safety, security, impact resistance and sound control. Laminated lites can be annealed, heat-treated and/or coated to meet specific performance and aesthetic targets.

Architects can mix and match the many combinations of glass types and framing options to meet the design considerations and unique characteristics of virtually any project.



In commercial buildings, the ideal energy-conserving glass would let in the majority of the visible portion of the solar energy-- thus allowing reduced lighting requirements in the building, while blocking most or all of the UV radiation and infrared night.

Heat-soaked glass is created when tempered glass is reheated to a lower temperature - about 550°F - for a period of time, then cooled slowly. This process accelerates the growth of any nickel sulfide inclusions in the glass so that any spontaneous breakage (the risk of which increases with the size of the glazed expanse) will occur during heat soaking instead of after installation. While many international building codes demand heat-soaked glass, this trend is only beginning to impact North American architecture.

Laminated glass consists of a "sandwich" of two or more lites of glass bonded together by an interlayer, polyvinyl butyral is the most common. Although the glass may be broken upon impact, the shards and fragments remain bonded to the interlayer and are retained within the framing system, reducing the hazard potential and keeping the window openings closed to wind forces which in extreme cases could otherwise contribute to building destruction.

STRUCTURAL CONSIDERATIONS

The primary design factor is the everyday strength of the glass to withstand expected site conditions. Loads on architectural glass include mechanical stresses caused by high winds and/or snow accumulation. These are typically addressed by local building codes. Thermal expansion stresses caused by temperature cycling must also be considered. Vertical, sloped, overhead and flooring installations of glass products all include their own special set of concerns and product requirements for extra strength and safety.

Specifiers should ensure that glass suppliers have conducted adequate product testing to ensure that their products meet these requirements.

In addition, it may be necessary to meet building codes or project specs where hurricane resistance, security or safety is of concern.

IMPACT RESISTANCE

Many coastal areas now have building codes in place that require the use of impact-resistant glazing. Laminated glass, used in conjunction with appropriate hurricane-resistant framing, can meet this increasing demand. Such systems also may incorporate insulating glass, low-E coatings and aesthetic features depending upon energy codes and other demands.

SECURITY

Laminated glass products offer the best blast hazard mitigation and ballistic protection. Because it tends to retain broken glass pieces in the frame, it can prevent flying and

(Continued on page 36)



(Continued from page 35)



As windows become larger-- and the demand for natural light grows-- glass plays an ever-increasing role in the overall appearance of commercial buildings.

falling glass shards following breakage – the leading cause of personal injury in such events. Specialized laminated products are available that also protect against forced entry as well as electronic eavesdropping and electromagnetic interference.

SAFETY

Tempered glass, with its characteristically safer breakage pattern, often is used as safety glazing in commercial and residential construction. Building codes often require laminated safety glass for storefronts, entrance doors, sliding glass doors and overhead glazing applications.

FIRE-RATED GLASS

To help meet fire safety codes and protect the safety of building occupants, architects can select from a wide variety of fire-rated glazing solutions. Wired glass—flat glass with wire embedded in the middle during the manufacturing process—has been specified as a safety glass in the past. However, more sophisticated glasses are now available: ceramic glass (rated for 20 to 90 minutes of protection) and glass with intumescent interlayers. The latter features

interlayers that thicken at about 250°F, transforming into a rigid and opaque shield that effectively blocks both convected and radiated heat transmission for a protection rating of up to 120 minutes.

ENERGY EFFICIENCY AND GREEN COMPLIANCE

Green buildings are taking center stage in the built environment and many expect the sector to lead the entire industry out of the current downturn.

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED)® Green Building Rating System™, which includes guidelines and recommendations for specifying windows, recognizes not only energy efficiency, but also indoor environmental quality - considering thermal comfort, as well as ample daylight and views. In addition, LEED may award green rating points for manufacturers' recycling practices and their proximity to job sites (decreasing the transportation costs and use of fuel).

In terms of energy performance codes, the International Energy Conservation Code® (IECC) prescribes energy performance requirements based on a map that defines eight U.S. climate zones. Glass and window products can be specified based upon their "fit" for the annual heating/cooling demands of the region in which they will be installed. These climate zones have now been adopted as the foundation for the energy performance



requirements set forth by other organizations, including the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Building America, and ENERGY STAR®.

The primary means of improving energy efficiency is to minimize heat conduction (as measured by the U-factor [BTU/hour/square foot/°F]), while optimizing solar heat gain (SHG) as appropriate for the climate (whether predominantly heating or cooling).

CONTROLLING HEAT CONDUCTION

The lower the U-factor, the greater a window's resistance to heat flow - and the better its overall insulating value. Indoor condensation is also less likely to occur. For fenestration systems, it is more meaningful to consider the U-factor of the entire window unit, because of the significant impact that frame and spacer materials may have on the overall performance. In colder Northern regions, a U-factor of 0.35 or less is generally desired to maximize year-round energy efficiency.

Insulating glass units are the primary tool for reducing U-factor. Insulating glass (IG) consists of two or more lites of glass assembled to create a hermetically sealed insulating space - typically 1/4-inch to 5/8-inch across - that reduces heat gained and lost between a building's interior and exterior. Custom-tailored IG units can incorporate various glass types, thicknesses, coatings or tinted substrates to create buildings that are energy-efficient, wind-resistant and attractive.

Important factors in enhanced IG performance are gas infills and energy-efficient spacer systems. The most common IG airspace is filled with ordinary air, while more efficient designs use an inert gas infill - typically argon - whose lower thermal conductivity slows the transfer of heat across the interpane space. Edge seals preserve the gas filling, protect against moisture intrusion and ensure the structural integrity of the IG unit.

Space between the glass lites is created and maintained by a spacer system, composed of a spacer, desiccant and sealants. The spacer provides structural integrity; acts as a carrier for the desiccant to dry the infill gas and prevent moisture condensation; and supports the sealants to retain gas fills and maintain the hermetic seal around the IG perimeter. Newer "warm edge" spacer technology reduces heat conduction through the spacer itself.

Internal blinds also can be added to architectural IG units. Not only do these integral blinds reduce cleaning and maintenance requirements, they can control the contamination of blinds in healthcare settings while still offering privacy and light-control options.

CONTROLLING SOLAR ENERGY

Energy-conscious and green-savvy designers seek to control the three types of incident solar radiation: ultraviolet (UV), visible light, and infrared. In commercial buildings, the ideal energy - conserving glass would let in the majority of the visible portion of the solar energy - thus allowing reduced lighting requirements in the building, while blocking most or all of the UV and infrared radiation.

The Solar Heat Gain Coefficient (SHGC) is the fraction of primarily infrared solar radiation that is transmitted through architectural glass - expressed as a number between zero and one. The lower a window's SHGC, the less solar energy it transmits - and the greater its shading ability. Generally, a low SHGC is desirable in warm climates, and a higher SHGC is desirable in colder regions, where passive solar energy is a benefit. In commercial buildings, a low SHGC is desirable in most regions. Most commercial buildings have large interior heat loads, such as lighting, computers and other office equipment as well as a higher number of occupants which also adds to the heat load. With this increased heat load, keeping the solar energy out becomes paramount, thus for commercial buildings, a glass design with a low SHGC is usually a more energy-efficient design.

In addition to SHGC, the Light-to-Solar Gain (LSG) index is emerging as an important gauge of the efficiency of a glass product in transmitting daylight while blocking solar heat gain. LSG is the ratio between visible light transmittance (VLT) and SHGC ($LSG = VLT/SHGC$). The higher the LSG, the more energy-efficient the glass product.

The U.S. Department of Energy defines "spectrally selective" glass as that with a LSG ratio of 1.25 or higher. Spectrally selective glass takes advantage of natural daylight while lowering solar heat loads, minimizing reliance on artificial cooling and lighting in a commercial building and lowering building operating costs.

Options for controlling the thermal effects of solar gain include tinted glass, reflective coatings and low emissivity coatings.

TINTED GLASS

Float glass can be clear or tinted, with the latter grouped according to their level of solar transmittance; i.e., how much energy from the sun passes through them. Since the tint is integral to the material, as the glass gets thicker it will appear darker.

Coatings can be combined with clear or tinted substrates for various enhancements in both performance and aesthetics.

REFLECTIVE COATINGS

Reflective glass coatings are metallic layers applied to float glass that reflect solar energy back into the atmosphere. Highly reflective coatings absorb the largest portion of direct solar energy not reflected. This is a disadvantage, as the glass gets very hot, but the interior spaces remain cooler and more comfortable and air conditioning expenses are reduced.

(Continued on page 38)



(Continued from page 37)

LOW-E COATINGS

Low emissivity – or "low-E" – coatings are a relatively recent innovation that has revolutionized solar heat gain management. Emissivity is a measure of a material's ability to re-radiate absorbed infrared radiation, so low-E indicates an ability to reduce heat absorption.

Low-E coatings are metallic layers applied to float glass to reflect radiant energy back toward its source. The heat stays outside during the summer, and inside during the winter.

If low-E coated products designed for hotter climates are used in insulating glass units, the radiation transfer between the warm exterior and cool interior space is reduced. The opposite occurs in cold climates when the interior is warmer than the exterior. The low-E coatings can be spectrally selective allowing for the use of passive solar energy in cold climates.

Note that glass surfaces are numbered, with #1 representing the exterior or "weather" surface of a glass panel or insulating unit. The SHGC is generally lower with low-E coatings on surface 2. Thermal stresses are higher with the low-E coating on surface 2 than on surface 3 – particularly if tinted exterior lites are used. This increase in thermal stress usually requires heat-strengthening or tempering to avoid breakage from the thermal stress.

SOUND CONTROL

A comfortable indoor environment includes freedom from unwanted noise. In addition to its many other benefits, laminated glass – particularly when used in insulating glass units – provides outstanding acoustic insulation by dampening sound transmission and glass vibration at certain frequencies, making it a good choice for windows and doors in buildings near highways, airports, railroads or manufacturing plants. The multi-layer configuration significantly increases Sound Transmission Loss (STL) to improve Sound Transmission Class (STC) and Outdoor-Indoor Transmission Class (OITC). Laminated products can also be used in sound studios and other production environments.

AESTHETICS

In specifying a glass solution, it is rarely necessary to sacrifice a unique aesthetic vision. As windows become

larger – and the demand for natural light grows – glass plays an ever-increasing role in the overall appearance of commercial buildings. Glass coatings can add to "curb appeal" as well as enhance operating performance. Reflective coatings, for example, make a strong and distinctive design statement. Low-E coatings offer more clarity and color neutrality, along with enhanced performance characteristics. Fabricating options – including heat-treating, laminating and insulating – have their own unique implications for the final appearance of a finished building.

Some additional glass fabricating options for enhanced appearance include: silkscreened or rolled (patterned) glass for interior and exterior decorative elements, such as in storefronts, foyers and vestibules, interior partitions, railings and translucent door and window treatments, and spandrel glass to conceal structural components such as floor and ceiling joists and integrate curtain wall facades into a seamless appearance.

Muntins installed inside the IG unit can give the appearance of a true divided lite, without the maintenance and cleaning labor and expense. Pencil brass muntins and contoured muntins are available, providing even more aesthetic choices.

ECONOMICS

While there are many glass options, architects should keep in mind that product customization does come with its costs. Special thicknesses, sizes, colors and configurations can create one-of-a-kind buildings, but it may make sense to choose standard glass sizes and finishing options whenever possible. Architects should partner with glass suppliers to balance creativity with practicality and cost effectiveness.

Customized products also can take time. Architects and building owners should be aware of the impact of specialized glass solutions on the overall project schedule.

Also, keep in mind that while the most energy-efficient glass solutions may require a larger up-front investment, this short-term cost is often offset by the long-term energy savings these products will deliver.

AAMA GLASS CLASS

The American Architectural Manufacturers Association (AAMA), through its Glass Material Council (GMC), has produced a valuable guideline for sorting through glass options, performance metrics and design resources to make better-informed choices when specifying glass. *Glass: The Right Choice* is a one-hour AIA-accredited learning unit that qualifies architects for continuing education credits. For more information on the course, contact AAMA at www.aamanet.org or 847-303-5664. ■

About Ken Brenden

Ken Brenden is the Technical Services Manager of the American Architectural Manufacturers Association (AAMA), a leading trade association dedicated to the promotion of quality window, door, curtain wall, storefront, and skylight products. Founded in 1936, the organization has been developing product performance standards for 70 years and has been certifying products for more than 40 years. The association also engages in product testing, market research, and continuing education programs for industry professionals.



ALA Continuing Education Questionnaire - Licensed Architect - Glass Solutions for Today's Design Challenges

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Program Title:

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- Submit questions with answers, contact information and payment to ALA by mail or fax to receive credit.
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QUIZ QUESTIONS

1. Tempered glass is ___ times stronger than annealed glass.
 - a) two
 - b) three
 - c) four
 - d) none of these

2. Loads on architectural glass include mechanical stresses caused by high winds and/or snow accumulation and are typically addressed by:
 - a) Project managers
 - b) Architects
 - c) National building codes
 - d) Local building codes

3. The Light-to-Solar Gain ratio can be calculated by dividing the Visible Light Transmittance by the Solar Heat Gain Coefficient, (LSG=VLT/SHGC). A higher LSG means?
 - a) Less natural daylight and more solar heat loads
 - b) The u-value will be better
 - c) More natural daylight and lower solar heat loads
 - d) The glass is not spectrally selective

4. When talking about multi surface glass packages, such as double or triple insulating, laminated, or combinations, surface number 1 is always:
 - a) The thickest
 - b) The most energy efficient
 - c) The surface that is outside the structure
 - d) The darkest

5. Solar Heat Gain Coefficient (SHGC) is generally lower with low-E coatings on which surface?
 - a) #1
 - b) #2
 - c) #3
 - d) Any of the above
6. Which is stronger – heat-strengthened glass or tempered glass?
 - a) Tempered
 - b) Heat-strengthened
7. Laminated Glass provides better sound quieting characteristics than regular glass?
 - a) True
 - b) False
8. What two programs promote the use of energy efficient products?
 - a) Energy Star and LEED
 - b) Energy Star and UL
 - c) LEED and UL
9. Choose the selection criteria for choosing the right glass.
 - a) Glass aesthetics
 - b) Performance needs
 - c) Application demands
 - d) Product limitations
 - e) All of the above
10. In specifying a glass solution, it is rarely necessary to sacrifice a unique aesthetic vision.
 - a) True
 - b) False

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