



Technical Bulletin

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GLASS SELECTION

Summary

The correct choice of glass for a particular application requires the consideration of a number of different characteristics for most installations, the following glass properties should be evaluated:

1. Color and appearance
2. Visible light transmission and reflection (from both sides)
3. Solar transmission (Solar Heat Gain Coefficient) and absorption
4. Thermal insulation
5. Acoustic insulation
6. Strength and deflection under load
7. Fire rating
8. Electromagnetic shielding
9. Applicable, code or safety requirements
10. Other properties such as flatness, durability and ease of cleaning may need to be considered

COLOR AND APPEARANCE

There is a wide choice of colors available in today's glasses. In general, glass colors are subtle and need to be carefully evaluated. The viewing of a full-scale mock-up, observed on the actual building site, with the proper orientation, is the only fully satisfactory evaluation method. The apparent color of glass is the combination of the glass color (clear, blue, blue-green, green, bronze, grey, dark grey, etc.), plus the color of incident light (midday sun or dawn and dusk), plus the color of any objects seen through the glass (drapes, blinds or insulation), plus the color of reflected objects (sky, clouds, etc.). Clearly the total appearance will continuously change as these individual components change.

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Note that the color and appearance of tinted glass will change with thickness because thicker glasses absorb more transmitted light.

The use of coatings, such as a light silver, color-neutral, Pilkington **Eclipse Advantage™** Solar Control Low-E on the second surface (room side) of an exterior light, enhances the base glass color when viewed from the exterior. Coatings such as Pilkington **Eclipse™** Gold can add their own color.

Combining different glasses in insulating and laminated units will typically change the overall color and appearance.

Reflections in glass will change in appearance depending on: heat treatment to the glass; sealed insulating glass air space pressures; and on the distances of the viewer and the reflected objects from the glass. At certain oblique viewing angles, a faint pattern from the quench process can often be seen in heat treated glass on blue-sky days. The use of a mock-up will help evaluate all these effects.

VISIBLE LIGHT TRANSMISSION

Interior daylight levels will be determined by this value. Residential applications generally require higher levels than in commercial buildings. Note that if a high light level is needed with solar control, then Pilkington **Optifloat™** Blue-Green tint, Pilkington **Arctic Blue™**, or Pilkington **EverGreen™** tinted glass can be used to give nearly as much visible transmission as clear glass, while giving even better solar control than bronze or grey glass. Increased solar control, when using reflective coated tinted glasses, reduces the visible light transmitted.

SOLAR TRANSMISSION AND ABSORPTION

The Solar Heat Gain Coefficient (SHGC) is the best measure of how much solar energy is admitted through a glazed opening. The SHGC compares the total solar heat gain through the glazing in question to the solar energy shining on the glazed area. Low SHGC values reduce the solar gain and save on air conditioning costs in cooling dominated climates.

A similar but now obsolete, and less accurate measure of heat gain is the Shading Coefficient (SC). The SC compares the solar energy admitted to that coming through a piece of non-defined 3 mm (1/8") clear glass. Note: the greater the SC value, the less is the effective "shading" from the sun's heat.

Residential glazing can use solar gain to advantage in winter. A high SHGC is desirable to maximize free passive solar heat gain in buildings where heating costs are greater than air conditioning costs.

Solar absorption makes a glass hot and causes thermal stress which, when excessive, can cause breakage of annealed glass. Reflective glasses also have some solar absorption which cannot be ignored. Note that the visible and solar values, for both transmission and reflection, usually differ from each other because glass absorbs differing amounts of energy at different wavelengths.

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THERMAL INSULATION

The U-Factor measures the thermal conductivity (from air to air on each side) of a glazing. Lower

U-Factors are achieved by multiple glazing layers, the use of low emissivity coatings, and insulating gas filling in sealed insulating glass.

Different standards for the calculation of the U-Factor give different results for North America (ASHRAE and NFRC) and Europe (EN) methods. The North American standard more easily recognizes the effects of different climate conditions, e.g. summer vs. winter.

The reciprocal of the U-Factor equals the R-value which measures thermal resistance (the R-value measure is more often used in wall and roof insulation materials where the calculation is made with surface to surface temperatures). A Low-E coated, sealed unit, with a U-Factor of 0.33 Btu/hr.sq ft.deg F has an R-value of 1/0.33 or 3.0 hr.sq ft.deg F/Btu. While this is less than the R value of most wall and roof materials, the U-Factor and R-values alone do not indicate the daylight transmission and beneficial passive solar heat gain which only glass can offer.

ACOUSTIC INSULATION

Thicker (heavier) glass transmits less sound than thin glass. Thick glass is very effective at stopping low frequency traffic noise, while thinner laminated glass is effective at controlling the mid-range frequencies of human conversation, etc., especially when incorporating special acoustic pvb interlayers such as in Pilkington **Optiphon™** laminated glass. A laminate of thick layers combines the best of both methods. A full analysis of acoustic responses at different frequencies may be required in some cases.

THICKNESS

Glass thickness is usually decided by the strength and deflection requirements detailed below. While the building codes and ASTM E 1300 "Load Resistance Standard" dictate the glass thickness and type (annealed, heat strengthened or tempered) needed to meet specified loads for a finite breakage probability, there are no code limits on glass deflection, other than avoiding finger pinching potential in horizontal strip glazing with no sealant between adjacent vertical edges. This glazing detail is often seen in the interior of shopping malls. It is a common opinion that center of glass deflections greater than 3/4" (19 mm) relative to the undeflected glass plane are aesthetically objectionable for typical glazing installations.

STRENGTH

The ASTM E 1300 Standard Practice for Determining Load Resistance of Glass in Buildings should be consulted for glass capacity under specified loads. The strength of glass can be doubled by heat-strengthening, or quadrupled by full-tempering. Note that annealed glass suffers a static fatigue effect which makes it only half as strong under long term loads (aquarium loads, snow loads, etc.) as under short term loads, such as wind gusts.

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Laminated glass is 50% to 100% as strong (depending on aspect ratio and framing details) as monolithic glass of the same overall thickness and size when subjected to short duration loads at room temperatures.

Symmetrical insulating glass, where both lights are the same thickness, can carry almost twice the uniform load, as one of the lights on its own.

Glass has a finite probability of breakage under load. Its strength cannot be exactly predicted. For this reason, good design practice, while attempting to prevent glass breakage, will also always consider the possibility and consequences of unanticipated breakage.

Annealed and heat-strengthened glass will break into large pieces when the applied load exceeds the glass strength. Most of the pieces remain in a glazed opening unless further force is applied. Laminated glass can require a considerable load to force it from a glazed opening, when appropriately glazed with adhesive sealants, even when both plies of the laminate are broken. It can, however, be pierced by dense, hard, falling objects. Tempered glass breaks into very small pieces which can easily fall from a glazed opening when subjected to a lateral pressure. These pieces often fall in small, potentially damaging, clumps which do not separate until they hit the ground.

The application of scrim backing to spandrel glass or the use of lamination is required if broken tempered glass must be held in place.

On rare occasions heat-treated (tempered and sometimes even heat-strengthened) glass can break spontaneously, without any applied load, from a particular microscopically small inclusion or stone. Such inclusions would not cause a problem with annealed glass. Good design practice will address this unlikely possibility by appropriate use of laminated glass or heat soaked tempered glass.

DEFLECTION UNDER LOAD

Rectangular glazing, supported on all four edges, does not deflect linearly under load; e.g., doubling the load does not cause twice the deflection. Deflection values can be calculated from ASTM E 1300, or obtained from the Load Resistance program on our web site at: www.pilkington.com in the USA / Building Products / Tools and Calculators section.

On large sizes, the glass thickness needed may be decided by deflection limits rather than glass strength. Note that equal thicknesses of annealed, heat-strengthened and tempered all deflect the same amount (before breaking) under equal loads and equal framing conditions. Laminated glass, at room temperature, of the same thickness as monolithic (non-laminated), will deflect about the same amount for short duration loads (seconds) but will behave as sliding layers and deflect further under long duration loads (hours or days).

FIRE RATING

Ordinary glass does not have a fire rating. Traditionally, wired glass was used to retain broken glass and prevent the passage of flames during a fire but it does not have a safety rating for impact loads. Pilkington **Pyrostop**[®] clear laminated safety glass can offer much longer fire ratings, up to 2 hours duration, and is 'safety' rated for impact loads.

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EMS SHIELDING

Electromagnetic shielding is needed in high security embassy buildings and other applications. Grounded transparent electrically conductive clear coatings (NSG **TEC™** Glass) can be used to create windows which prevent radio wave signals from computers and communications equipment from passing through glass.

SAFETY

Applicable building codes and specifications may determine the glass choice for safety or legal reasons. The appropriate local and regional building codes must always be checked and followed.

The information contained in this bulletin is offered for assistance in the application of Pilkington North America Inc. flat glass products, but **IT DOES NOT CONSTITUTE A WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.** Actual performance may vary in particular applications.

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