3 GLAZING

ESSENTIAL KNOWLEDGE

The performance of windows has increased significantly since the energy crisis of the 1970's with the use of multiple glazing layers and new glazing technology. Such insulating glass provides air space(s) between the layers to reduce the transmission of heat, cold, and sound through the window assembly. This space is typically filled with air or inert gases such as argon or krypton, to further reduce the heat transmission. New glazing coatings and films enable windows to selectively transmit the majority of visible light but reflect heat and ultra-violet (UV) radiation. Such glazing can reduce heating and/or cooling costs (total solar transmittance), lighting costs (visible light), damage to contents subject to UV degradation, and can improve comfort.

Single-glazed windows with storms and screens have steadily lost market share since 1965 to insulating glass, which now represents approximately 90% of all new window glazing in the U.S. A window with a low U-value (such as 0.33) or, inversely, a high R-value (such as 3.0) will reduce the transmission of heat and save energy. In addition to reducing the heating/cooling demand, a well insulated window will minimize the effects of thermal air movement associated with drafts and greatly reduce the potential for condensation on the window or door, which can progressively deteriorate some frame materials, as well as surrounding wall finishes and furnishings. Insulating glass units have a limited lifetime due to the vulnerability of the seals, and are typically warranted for 10 to 20 years. A better performing window will not only often pay for itself but will provide increased comfort to the inhabitant.

Glazing also has a visible transmittance value—a measure of how much of the light is perceived to pass through it. Glazing with a high visible transmittance is generally desirable in most areas because it allows a clear view through the window with minimal distortion or tint and reduces the need for lighting. There are many types of low-emissivity (low-e) coatings. All low-e coatings improve the U-value but they can be formulated to have varying solar heat gain coefficients (SHGC). Selecting the best type of low-e for your condition represents a trade-off between the ability to reject unwanted heat from the sun during cooling periods and accepting heat during heating periods. Selection must be made for geographic region and window orientation. A low-e coating is typically placed on the interior surface of glazing for protection and attached to the surface closest to the source of heat to be reflected, either surface #2 for cooling climates or #3 for heating climates (Fig. 1). Some very high performance window units use multiple coatings on either additional glazing layers or intermediary plastic films to achieve a cumulative effect. As of 1996, low-e coatings were used on 40% of all new windows. This percentage is anticipated to rise now that the industry has developed the capacity to produce such coatings at a very small cost premium.

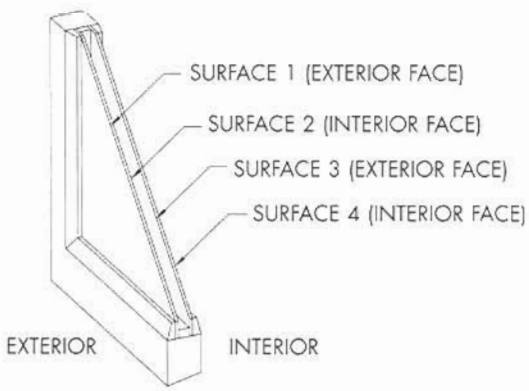

FIGURE 1 GLAZING NUMBERING SYSTEM

WINDOWS & DOORS

VOLUME 4 OF THE REHAB GUIDE

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There are three primary types of low-e coatings: high transmission low-e coatings are typically most appropriate for heating climates allowing the most solar heat to enter the building; selective low-e coatings are suitable where heating and cooling are required because they allow the greatest amount of daylight and moderate heat transmission; low transmission low-e coatings are suitable for cooling climates, allowing the least amount of heat to enter the building and reducing the amount of visible light transmission to control glare. The NFRC rating is the simplest means of assessing the performance of each type of coating, which is often not readily identified on the unit itself.

Within the same climate different low-e glazing materials may be desirable. In a cold climate, a home may use a window with a low SHGC on elevations other than south facing to preserve as much heat as possible where there is little opportunity for the sun's penetration, but may utilize a high SHGC at the south facade to benefit as much as possible from solar gains where exposed to the direct sunlight.

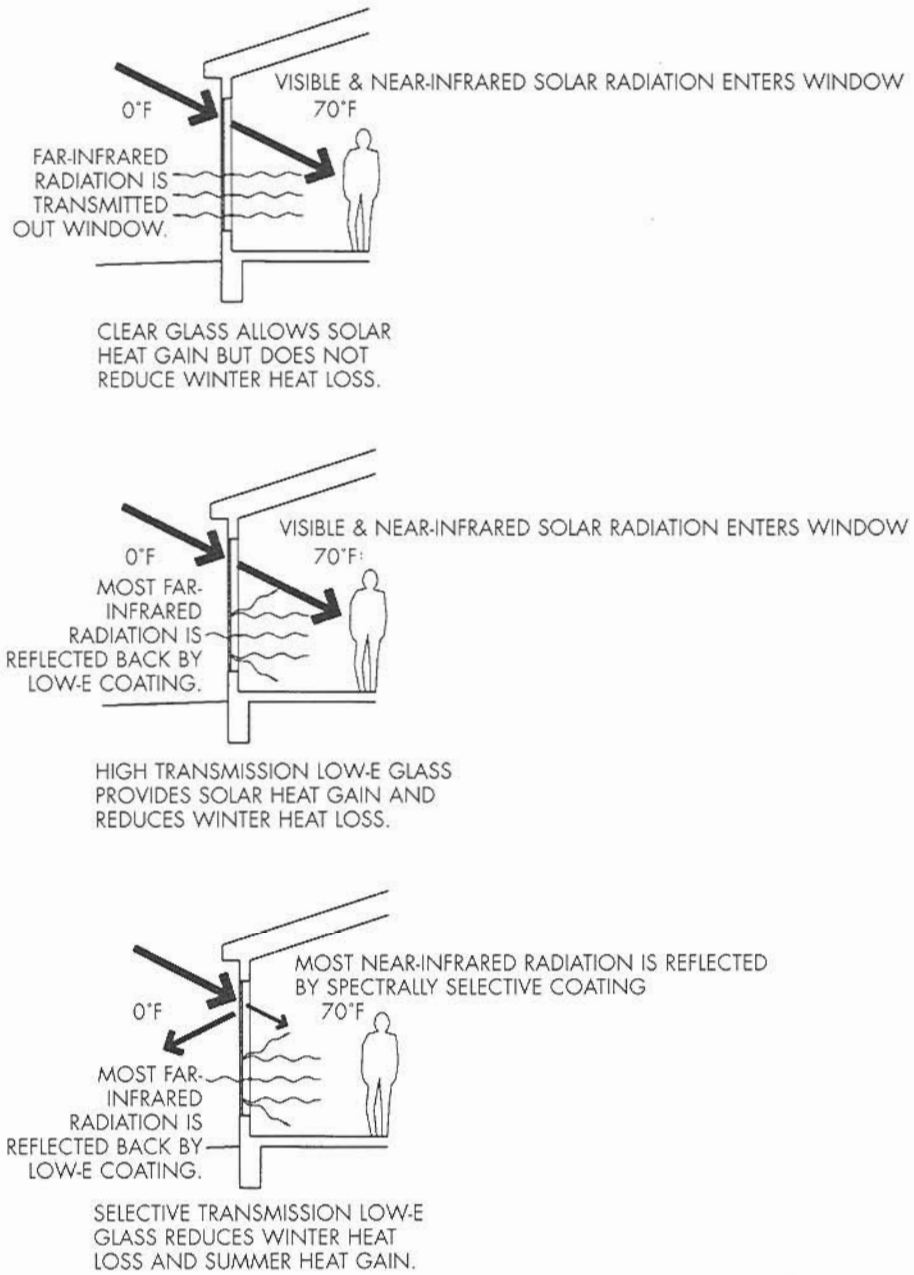

FIGURE 2 LOW-EMISSIVITY COATING HEAT TRANSFER PROPERTIES

In addition to energy performance, glazing must also meet minimum code requirements for impact, wind, and fire resistance. The applicable codes vary by locality and should be referenced in the selection of new glazing for all types of fenestration. Numerous products and standards have been developed recently to address concerns such as high wind and theft resistance. These new products are made of acrylic and polycarbonate in corrugated and cellular forms to increase strength and insulation and reduce weight. Plastics, either by themselves or in combination with glass, improve impact resistance. New plastic materials have also been developed that provide increased fire resistance greater than glass but must be incorporated in an equally resistant frame.

Various specialty glazing products suitable for matching existing glazing materials, such as stained, textured, and salvaged glass, are available from sources identified in *Traditional Building* magazine and *Old House Journal*. An example of textured glass that is decorative and functional is prismatic glass. Prismatic glazing, characterized by a surface of textured small tile shapes assembled in a structural grid, projects light in a specific direction to illuminate areas deep in a space. Primarily used in commercial applications or street pavement lights, this material is also found in older homes. The material was employed in canopy applications appropriate for windows that are in close proximity to adjacent structures. However, the concentrating effect increases heat and glare. Prismatic glass is no longer manufactured due to the introduction of electricity and difficulty of cleaning, but can be obtained through salvage sources.

Glass block is enjoying a revival, and has the advantages of security, noise absorption, and light diffusion. The material is available with many of the same efficiency strategies as windows, employing reflective glass and fibrous inserts, with R-values equaling and exceeding some insulating glass. The mortar layers or frame material between units also serve as a shading device. Traditional glass block has been adapted for mortar-less application with the use of a rigid frame material and silicone sealants. This new generation of glass block has been adapted to provide up to 90-minute fire ratings. Available as an acrylic product, the reduced weight has significantly simplified the installation process (Fig. 3). This reduced weight also allows it to be installed as an interior partition without structural modification, and can be used in operable casement window units.

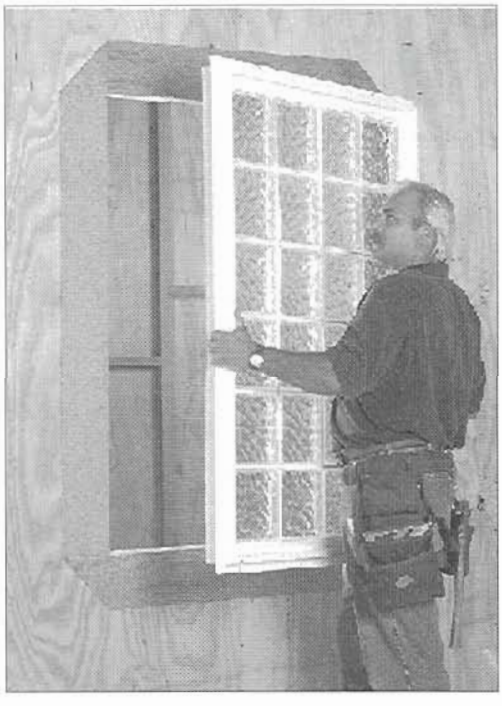

FIGURE 3
INSTALLATION OF ACRYLIC BLOCK WINDOW UNIT AS MANUFACTURED BY HI-LITE PRODUCTS, INC.

1. CLEAN AND POLISH EXISTING DAMAGED GLAZING.

Damage can occur from either physical abuse or caustic chemicals resulting in stains, etching, or discoloration. Physical abuse might include a branch brushing repeatedly against a window or impacts of airborne debris such as fine sand. Acid rain, alkyds from cleaning solutions, or exposure to water or rain runoff from concrete and masonry building materials are typical caustic assaults. Minimally damaged glazing often can be restored with a simple cleaning solution such as ammonia-based solution, xylene, toluene, or trisodium phosphate. Damaged glass not readily replaceable can be repaired by a mechanical polishing method with the use of compounds such as cerium oxide paste. In all instances the source of damage should be identified and corrected before rehabilitation.

ADVANTAGES: Preserves original, perhaps unavailable materials; may be most cost effective.

DISADVANTAGES: Often other components, such as sealants, have also deteriorated and favor total replacement. A high degree of skill and experience is required to properly polish glass.

2. APPLY TINTED OR REFLECTIVE FILM TO EXISTING WINDOW GLAZING.

Numerous film products are available from manufacturers such as 3M and Courtaulds to control the amount of daylight and solar gain transmitted through existing glazing. Tinted products can significantly reduce the full spectrum of light, reducing solar heat gain and glare. Reflective products selectively reduce portions of the light spectrum to either accept or reject heat and visible light. Each product is formulated for a specific climate and the selection of film and its specific application will determine the ultimate benefit. All of these products block the majority of UV rays to reduce fading of interior furnishings and provide limited protection from shattered glass.

ADVANTAGES: Application of film is a relatively simple, low-cost means of improving performance relative to replacement. Reduced heating and cooling loads not only provide operational savings and increased comfort but may permit smaller mechanical equipment. Appropriate films may eliminate the need for additional sun control devices, such as blinds and curtains, providing a uniform appearance to the exterior.

DISADVANTAGES: Retrofit film application will not equal the performance of factory applied materials nor will its exposed surface perform as well over time. Low-e coatings are subject to physical and caustic damage from cleaning with ammonia-based products. Replacement of the film is a difficult, labor-intensive process. Application of film to an insulated window unit may aggravate the expansion and contraction of one side of the glazing, increasing stress of the glass and seal. Reduction of transmitted light and heat may be offset by additional heating and lighting requirements if not carefully selected.

3. APPLY SAFETY FILM TO EXISTING WINDOW GLAZING.

All film materials provide limited resistance to shattering—some better than others. Safety film products are manufactured primarily for this purpose and may be combined with sun control properties. The increased resistance provided by these films, similar in principle to laminated glass, may reduce the risk of airborne glass and exposed shards upon impact. Films will provide resistance to accidental impact and storm debris. The resistance of the material is independent of the resistance provided by the window frame, but the preservation of the building envelope during a storm often will prevent costly water damage. The material may also prove to be a deterrence to vandalism and theft.

ADVANTAGES: Safety films may preserve the building envelope during storms. Safety films may provide a cost-effective means of increasing resistance of existing glazing. Areas subject to high winds may also benefit from films, which may preserve the building envelope in moderate storms. In addition to providing safety they may also provide comfort and savings associated with the reduction of sunlight and UV protection of furnishings.

DISADVANTAGES: All components of a building envelope must be of equal resistance in preventing either the entry of a storm or intruder. Safety glazing that is not secured in the frame itself will only maintain integrity with itself and not the window unit. Film will to some extent reduce visible light transmittance and may slightly obscure views.

4. INSTALL INSULATED GLASS INSERTS.

Existing single-layer glazing is replaced with new insulated units with the modification of the existing wood sash and a new track mechanism. Presently, only a Bi-Glass Systems licensed contractor performs this patented process on site in a mobile workshop (Fig. 4). The exterior face of the muntin is removed and the new unit is inserted with a siliconized latex sealant. A new muntin face is applied to match the existing or may be left as a flush surface to provide for easier maintenance. Historic metal windows with deep profiles often can readily accept insulated glazed units, but due to the poor thermally conductive properties of the frame do not provide significant performance gains and are ultimately very expensive relative to the benefit. The effect of heavier insulated units on operable windows should be considered.

ADVANTAGES: Provides improved performance while preserving the original appearance of the window. Replacement of glazing is an opportunity to choose from new technologies, such as low-e glass. The new track mechanism may also provide for ease of operation and cleaning with the addition of a tilt/turn feature. The relative ease of installation is achieved without disturbing surrounding materials and minimizing debris and use of new resources. Cost of such replacement may potentially be lower than replacement of the entire unit.

DISADVANTAGES: Bi-Glass system is presently not available nationwide and is only suitable for existing wood windows. Existing window frame and sash must be in good condition. The system will not correct for perimeter sash leakage, which may account for up to 40% of a home's air leakage.

EXISTING WINDOW MEASURED AND GLASS UNITS FABRICATED

EXISTING SASH REMOVED, CAVITIES INSULATED AND NEW TRACKS INSTALLED

WINDOW SASH IS REMOVED AND MODIFIED TO RECEIVE INSULATING GLASS UNIT, EXISTING MUNTINS APPLIED TO SURFACE

SASH IS INSTALLED WITH NEW HARDWARE PROVIDING FOR TILT-IN OPERATION

FIGURE 4 INSTALLATION OF INSULATED GLASS INSERT

5. REPLACE EXISTING GLAZING WITH BETTER PERFORMING GLAZING.

This method, although rarely used, provides the opportunity to employ new glazing materials in the repair of existing windows. Repair of windows preserves the original appearance and is often the most cost-effective strategy, as new glazing technologies may be employed for little additional cost. New technologies provide increased impact, fire, and thermal resistance and may be applied to previously unavailable curved glazing and decorative glass block.

ADVANTAGES: Particularly cost-effective when trying to address a single attribute such as impact resistance or glare.

DISADVANTAGES: Replacement of glazing itself may be compromised by the existing frame and sash materials. Cost of repair will vary dramatically depending on the region and should be part of a comprehensive repair effort.

FURTHER READING

Guide to Avoiding Glass Failure, Association of Industrial Metallizers Coaters and Laminators, November 1996.

"Low-E Glass - Why the Coating Is Where It Is," *Energy Design Update*, March 1990, pp.5-7.

"No Pane, No Gain (Window Technology: Part One)," *Popular Science*, June 1993, pp. 92-98.

Residential Windows, John Carmody, Stephen Selkowitz & Lisa Heschong, New York: W.W. Norton, 1996.

"Through the Glass Darkly," *Popular Science*, July 1993, pp. 80-87.

Twentieth Century Building Materials: History and Conservation, Thomas C. Jester, New York: McGraw-Hill, 1995.

PRODUCT INFORMATION

Bi-Glass Systems, Inc., 35 Braintree Hill Park, Suite 112, Braintree, MA 02184; 800-729-0742.

Cardinal IG, 12301 Whitewater Drive, Minnetonka, MN 54343; 612-935-1722 (glass manufacturer).

Co-Ex Corp., P.O. Box 326, 41 Hammer Mill Rd., Rocky Hill, CT 06067; 800-888-5364 (single and multiple walled polycarbonate).

Courtaulds Performance Films, P.O. Box 5068, Martinsville, VA 24115; 800-223-4385 (applied performance film products).

Hy-Lite Block Windows, 101 California Ave., Beaumont, CA 92223; 800-827-3691; www.hy-lite.com.

IBP Glass Block Grid System, Acme Brick, 2917 W. 7th St., Fort Worth, TX 76107; 800- 932-2263; www.ibpglassblock.com (aluminum frame glass block).

Libbey-Owens-Ford Co. Building Products, P.O. Box 799, 811 Madison Ave., Toledo, OH 43697; 419-247-4721 (glass manufacturer).

MSC Specialty Films Inc., 10801 75th Street North, Largo, FL 33777-1430; 800-282- 9031 (applied performance film products).

PPG Industries, Inc., One PPG Place, Pittsburgh, PA 15272; 412-434-3533 (glass manufacturer).

Southwall Technologies, 1029 Corporation Way, Palo Alto, CA; 800-365-8794 (applied performance film products).

3M, 3M Center 225-4S-08, P.O. Box 33225, St. Paul, MN 55133-3225; 800-480-1704 (applied performance film products).

Viracon, 800 Park Drive, P.O. Box 248, Owantonna, MN 55060; 507-451-9555 (laminated glass).