# Safety Glazing

By DOUGLAS HANSEN

**Glass in some form or another has been used since the dawn of civilization. It appears naturally as obsidian, and the first man made glass objects date from 3500 B.C.**

THE ROMANS WERE THE FIRST TO USE IT as an architectural material, with semi-clear glass in windows beginning around 100 B.C. Glass production required highly-skilled workers and was a labor-intensive process. In the middle ages, stained glass was developed by adding different minerals to molten glass, and there are stunning examples of the technology throughout Europe, some dating back to the 13th century. Mirrors with decent effectiveness were not developed until the late 17th century. The technology used for modern mass-production glass is relatively new, dating from around the time of WWI.

The subject of glazing comprises many aspects, including emissivity (heat transmission), light transmission, insulating value, leak prevention, wind-resistance, acoustics, sealants, and architectural considerations.

The scope of this article is safety glazing and the areas where inspectors look at the hazards posed by glazing.

## The danger

When a person accidentally impacts glass, there are two immediate dangers. The first is from lacerations due to the large shards that might slice into the skin. There have been numerous instances of people who have died from injuries, such as a severed femoral artery. Unless pressure is brought to bear immediately on such a wound, the victim can bleed to death in as little as five minutes.

The second danger is from the "rebound" effect. The first reaction to impacting glass is to pull back. By then the glass is broken, and during the rebound, the person is pulling away from the sharp broken edges. The result can be deep lacerations that tear off large flaps of skin.

## Causes of impact

Most accidents with glass are due to one or more of three contributing factors:

1. Failure to see the glass,
2. Slips and falls – even knowing the glass was there, and
3. Intentional breakage.

The rules in building codes and federal standards typically are based on one or more of these factors. Historically, the greatest number of injury accidents has been from shower doors or patio doors. In addition to direct human impact, other situations can pose a hazard. Windows that slam shut or are broken by wind or seismic activity can shatter and injure the occupants.

## From courtroom to codes

Building codes were silent on the subject of safety glazing until the 1960s. Glass manufacturers found themselves the subject of numerous lawsuits, and they recognized the need for uniform standards for the industry. The National Safety Council formed a task group with the National Glazing Association, and their studies found an average of 320,000 injuries per year from people impacting glass in doors and windows.

The group worked to form a standard for impact resistance of glass. In 1966, it was accepted as a National Standard and given the designation ANSI Z97.1.

From 1968 to 1973, the Glazing Industry Code Committee attempted to lobby states directly for adoption of this standard as part of state building codes for glazing in ▸▸

hazardous locations — those that are subject to human impact. It achieved a small measure of success with some form of adoption in 32 of 50 states, though in many cases the standard only applied to commercial construction.

Such codes did not address where the greatest number of injuries were occurring – in residential applications, specifically patio doors and shower enclosures. At the same time, the building code adoption process was complicated by fragmentation among various regional code authoring agencies.

The Consumer Product Safety Commission (CPSC) had been created in 1972. When it opened its (glass) doors in 1973, one of its first tasks was to address the hazards of glass.

As the commission worked, there continued to be ample proof that codes and standards needed to be improved. In 1975, 73,000 people were treated in hospital emergency departments for injuries with architectural glass.

**The Consumer Product Safety Commission (CPSC) had been created in 1972. When it opened its (glass) doors in 1973, one of its first tasks was to address the hazards of glass.**

The commission went beyond ANSI Z97.1 and developed a two-tiered standard.

A person will typically bear more of his or her body weight in impact with a large piece of glass than he or she would with a smaller piece. The CPSC standards resulted in Category I glass rated at 150-foot-pounds of impact, and Category II rated at 400 pounds. These standards became known as CPSC 16 CFR 1201, and they became law on July 6, 1977. These designations may sound familiar, as they are seen on the identifying "bug" used in tempered glazing today *(see Figure 1)*.

Since then, the ANSI standard has changed and now includes three impact categories.

Class A is similar to CPSC Category II, Class B is similar to CPSC Category I. Class C has a 100-pound rating and only applies to fire-rated non-safety glass.

This voluntary standard did not require the classification to be marked on the glass until the 2004 edition. Beginning in 2009, building codes began allowing glass that is marked with only an ANSI label in areas other than the doors or enclosures, i.e. showers, tubs, whirlpools, steam rooms, saunas or hot tubs.

Both the ANSI standard and the CPSC rules provided guidelines for building codes, which existed to identify the specific areas where safety glazing is required.

Historically, building codes are developed from the ground up. Proposals are initiated by individual building officials or groups of building officials, and the proposals work their way up through committees to an eventual vote by the entire conference of the code-making body. When safety-glazing codes were first developed, there were three major code-making organizations, ICBO, BOCA, and SBCCI. ICBO's Uniform Building Code 1961 edition was the first to require safety glazing for shower doors. Even before the eventual merger of the old territorial codes into the ICC, safety glazing became fairly consistent in part by following the "top down" federal guidelines.

### Test procedures

For the CPSC and the ANSI test, a piece of glass is secured to a vertical frame, and a punching bag filled to 100 pounds with lead shot is suspended a half inch in front of the glass.

For Class I glass, the bag is lifted away and released at a point where its vertical drop is 18 inches.

For Class II, the test requires a vertical drop of 4 feet (400 foot pounds).

The glass must either not break, or break into such small shards that the 10 largest do not add up to 10 square inches.

In the case of laminated glass that is subjected to the same test, a hole punched in the glass must not allow passage of a 3-inch steel ball rolled over the glass.

Further details on the test procedure are available in the Code of Federal Regulations on the Web. (See the links at the end of this article.) They were also specified in UBC Standard 24-2.

### Standards of Practice

ASHI's standards require an inspector to report items that are unsafe. Unsafe is defined as "A condition in a readily accessible, installed system or component that is judged to be a significant risk of bodily injury during normal, day-to-day use; the risk may be due to damage, deterioration, improper installation, or a change in accepted residential construction standards."

When it comes to issues such as safety glazing, there is no "grandfathering" of existing non-conforming conditions. Just as the glass isn't going to stop and read the code before it decides to cut you, inspectors can't be concerned with the age of the property in deciding whether to report this safety condition.

Inspectors are often asked whether a specific glass installation met code at the time of construction, and if replacing the glass would be considered a necessary repair or an upgraded safety enhancement. The answer to that question is a real estate negotiation, not an inspection issue. The inspector's job is to make a recommendation to mitigate the hazard. Likewise, Realtors® or landlords probably would not be putting themselves in a good position if they fought to keep a dangerous situation and later saw it result in a serious injury.

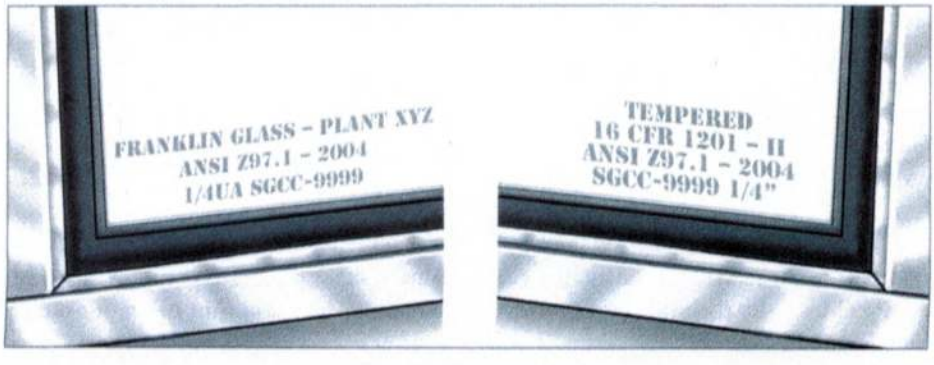



*Figure 1 – Safety glazing labels*

ILLUSTRATION © DOUGLAS HANSEN

*Figure 2 – Broken tempered glass door*

PHOTO © TXPETER

The inspector's role is to point out the defect, not to decide who fixes it. Most things that inspectors report as defects in safety glazing conformed to code at the time of construction.

The person with greatest liability would be the installer if he violated the standards of the glazing industry. Often, the glazing industry will be following a newer and more restrictive code before the local jurisdiction has adopted it.

## Types of glazing

Before looking at the specific locations deemed hazardous, here's a review of several types of glass:

- **Annealed glass (float glass)** is the ordinary glass that is cut into stock sheets for packaging and shipping. It can be cut again, and it possesses none of the properties of safety glazing. It breaks into sharp shards. A heavier form of this glass is plate glass, which is formed between high-pressure rollers. In some thicknesses, it obtains relatively high strength, though it is not safety glass.

- **Heat Strengthened Glass (H.S. Glass)** is annealed glass that has gone through a heating and cooling process designed to double its strength in comparison to ordinary annealed glass. It is heat-resistant, and may not be cut after manufacture. It is not a safety glazing product; it does not meet ANSI Z97.1 or the CPSC standards.

- **Laminated glass** has two separate pieces of annealed, heat-strengthened or tempered glass sandwiched around a layer of clear polyvinyl butaryl (PVB). It was invented more than 100 years ago. The layers are bonded under high pressure. In the United States, it is used in car windshields. It is a safety glass product. One side can shatter from impact without the other side shattering, and when the glass shatters it does not delaminate into shards. Laminated glass is often used for frameless glass railings *(see Figure 6)*.

- **Tempered glass** is used in car windows other than the windshield. It is created during manufacture by rapidly cooling the outer surfaces of a piece of glass while the inner portion, sandwiched between the outer layers, remains viscous. After final cooling, the inner portion of the glass is in tension while the surfaces are in compression. The result is a piece of glass that is four times more resistant to impact than annealed glass. When tempered glass breaks, it fractures perpendicular to the plane of the surface, rather than parallel to it, resulting in harmless small cubes that are less likely to cause significant injury *(see Figure 2)*. All glass is vulnerable to breakage from impact at the edges and tempered glass is even more vulnerable in this regard. Scratch the edge with a file and the entire piece might shatter. Because of this characteristic, tempered glass must be cut to size before the tempering process. Tempered glass has characteristic bows and warps due to the tempering process.

- **Approved plastics** meeting ANSI Z97.1 sometimes are allowed in areas that otherwise require safety glazing. Limitations on its acceptable use arise from fire-resistance ratings. While it may provide safety, a disadvantage of plastic is it easily becomes permanently scratched. High-end acrylics can be durable and scratch-resistant. Expensive acrylics are typically an architectural specialty product and are not common. Plastic often is used in unit skylights.

## Shattering the myth of wired glass

Though wired glass has the advantage of preventing large shards, numerous injuries occur due to the rebound effect. Wired glass has only half the strength of annealed glass due to internal stresses from differing rates of contraction on cooling. It once was used as a form of safety glass, but that application has been abandoned since approximately 1970. Since then, the only prescribed use is for skylights and for windows in areas requiring fire separation.

Wired glass *(see Figure 3, following page)* is commonly used in "vision panes" of swinging doors to allow someone to see persons on the other side. This violates the original CPSC standard, but was allowed until quite recently. When the choice has been between glass with a fire rating and glass with a proper safety rating, the fire rating has taken precedence.

Greg Abel, founder of the Advocates for Safe Glass, came to this issue in a personal way. His son sustained a serious injury from ▸▸

wired glass at his school basketball court. Sadly, this story is not unusual; approximately 2,500 such injuries occur each year in elementary schools alone. Mr. Abel founded a nonprofit organization to raise awareness of this issue and to lobby for enforcement of requirements for impact resistance.

Why did we allow glass that does not meet impact resistance standards in doors and other public areas? A protracted lawsuit from the wired glass manufacturers (all based offshore) tied up the CPSC and resulted in exceptions that remained in the building codes for decades.

Fortunately, Mr. Abel's unrelenting efforts on behalf of public safety eventually paid off with successful amendments to the 2006 codes, and wired glass not meeting the CPSC standard is no longer allowed in locations subject to impact.

There are alternative products that provide both impact resistance and fire resistance. Pyro-Shield "Plus" (Pyro-Shield Safety) meets both test standards and is available. Other manufacturers also have products that are both fire and safety rated, including Inter-Edge, Safe-T (O'Keefe), Vetrotech and others. These alternative products have a safety-glazing bug in the glass, and Warnock-Hersey has an evaluation and label for glass that is both fire rated and tempered.

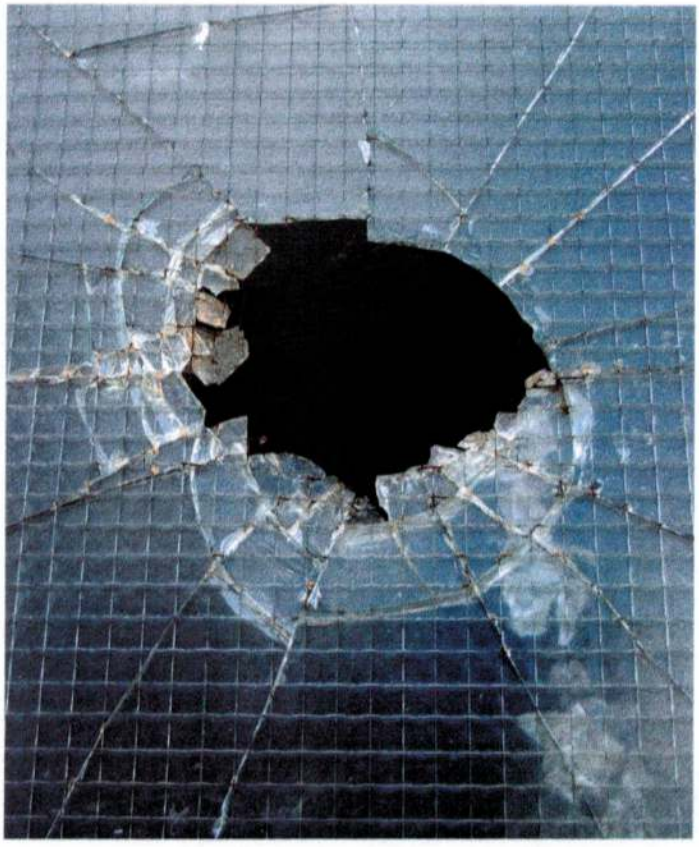


*Figure 3 – Wired glass is commonly used in "vision panes" of swinging doors to allow someone to see persons on the other side. Amendments to the 2006 Code restricted its use.*

PHOTO © DIMITRIS KOLYRIS

**Just because a piece of wired glass has a "bug" on it, do not assume it is safety glass.**

Just because a piece of wired glass has a "bug" on it, do not assume it is safety glass. The "bug" in vision panes in doors that could be subject to human impact might state that the glass was evaluated by UL only for fire-resistance, and not to any other standard.

### Locations subject to human impact

What then, is a "hazardous location" for glazing? First, we should clarify that the use of the words "hazardous location" here means areas subject to human impact. Other parts of the codes use the term for areas containing flammable materials.

The International Building Code and the International Residential Code (IRC) provide us with definitions. These include areas where a person might be aware of the glass yet still slip and fall, such as a shower or walkway. Another hazard is glass that people might not be aware of, such as sliding doors where a person could think the door was open and walk (or run) into the glass. Also, glass that might be broken for forced entry is a hazardous location, such as near a doorknob.

The 2012 editions of the codes do not contain major changes in the rules, though the material is organized in a more readable format. The following explanations of hazardous locations are presented in the same sequence as the 2012 IRC:

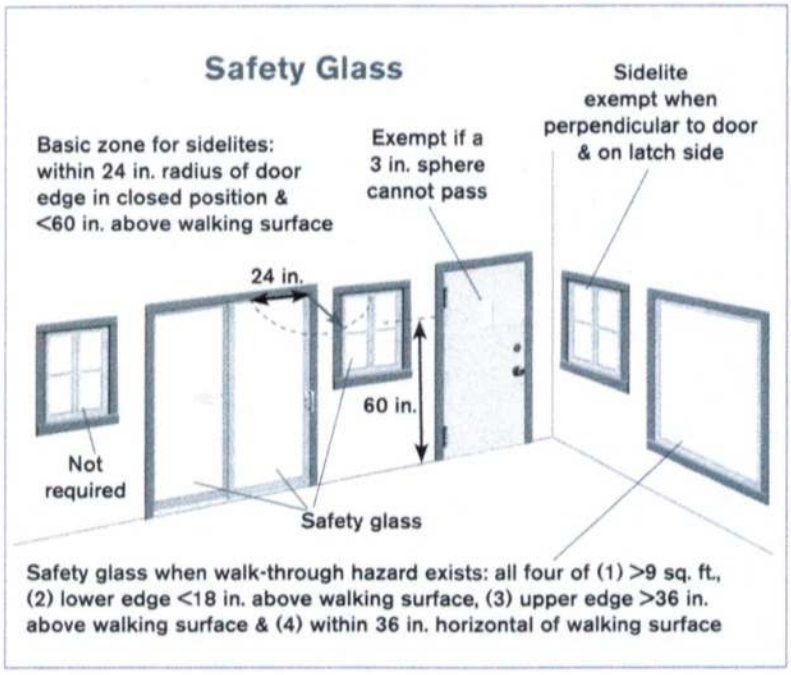
**1. DOORS.** Glass panes in doors are required to be safety glass, including side-hinged, sliding or bi-fold doors. Exceptions are made for lites so small that a 3-inch sphere cannot pass through them *(Figure 4)*, and for decorative glass, such as beveled, etched or Dalle (stained) glass.

Old sliding doors are considered so unsafe that some municipalities, such as Los Angeles, require that the glass be replaced or a protective safety film be applied when the property is sold. Courts have upheld liability claims against landlords for injuries caused by unsafe glass in shower doors. When inspecting an older apartment, you might save the tenants from injury, and the landlord from an expensive lawsuit by recommending older glass be replaced with safety glass.

**2. SIDELITES.** These are defined as any glass panel where the vertical edge of the glazing is within a 24-inch arc of either vertical edge of the door in a closed position, and where the lowest exposed edge of the glazing is less than 60 inches above the floor or walking surface.

The following glass is exempt in residential properties:

- Decorative glass
- Glass within the 24-inch arc but separated from the doorway by an intervening barrier, and
- Glass perpendicular to the door and on the latch side *(see Figure 5)*. This exemption seems to imply that the danger is greater when someone could open the door and push an unsuspecting person on the other side into the perpendicular sidelite. Since they would be pushed away from the sidelite on the latch side, it is exempt, while the one on the hinge side is not. The perpendicular sidelite in Figure 10 requires safety glass because it is on the hinge side. This exception does not apply to commercial buildings. When the door is only providing access to a closet less than 3-feet-deep, sidelites also are



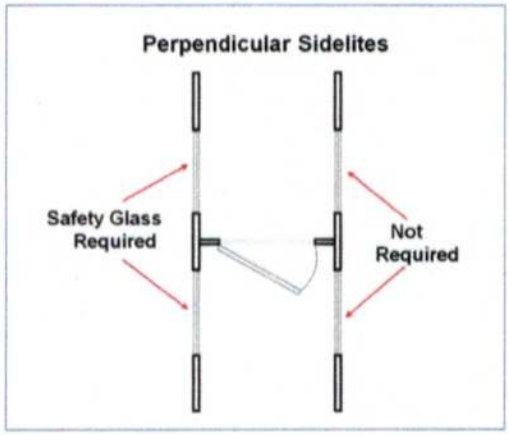




*Figure 4, left – Hazardous locations*

*Figure 5, above – Sidelites perpendicular to door*

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exempt (although they might have to comply with Item 3). Glass adjacent to the fixed side of a sliding door is no longer considered a sidelite *(see Figure 4)*. There had been interpretations that the entire sliding door frame needed to be considered in determining the distance measurement for sidelites. This 2009 code exemption puts that issue to rest.

**3. WINDOWS.** Glazing in individual windows must be safety glass when meeting all four of the following conditions *(see Figure 4)*:

1. Greater than 9 square feet, and
2. Lower edge less than 18 inches from the floor, and
3. Upper edge more than 36 inches from the floor, and
4. A walking surface within 36 inches horizontally of the window.

For these windows, there are exceptions for decorative glass, as well as an exception when a protective bar is installed within 34–38 inches above the floor, and the bar can withstand a horizontal load of 50 pounds per foot without contacting the glass *(see Figure 6)*. The cross-sectional height of the bar must be at least 1½ inches. ▸▸

*Figure 6 – Protective bar in front of window*

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*Figure 7 – Laminated glass in guard infill. All glass in railings and guards is required to be safety glass.*

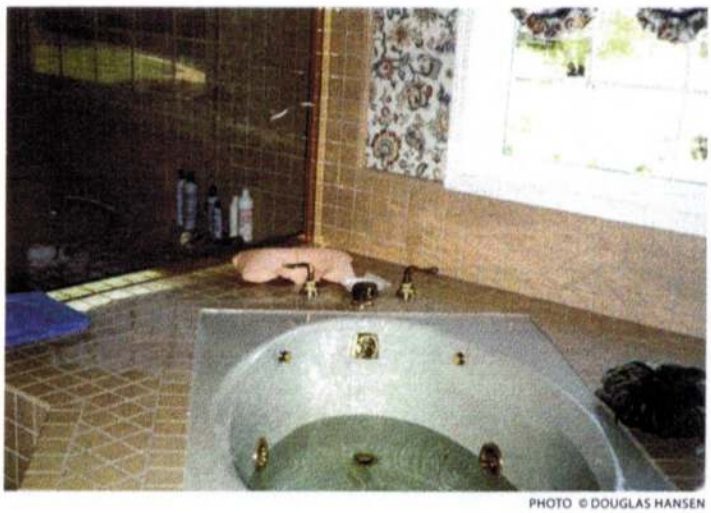

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*Figure 8 – Whirlpool tub with adjacent window.*

PHOTO © JEREMY ALLEN

*Figure 9 – Glass in stair landing*

One reason for these windows to be safety glass is because they can be mistaken for a door opening. Many window manufacturers supply windows that have a muntin at the 18-inch height to divide the window into two lites, neither of which is then required to be safety glass.

Absent from this section is any rule for safety glazing for smaller windows close to the floor. Window guards or devices to restrict the opening size are required when the sill of an openable window is less than 2 feet from the floor and the drop outside the window is 6 feet or more. This protective measure is designed to prevent children from falling. The more common situation of children experimenting with their toys by banging them against magical transparent objects is not addressed.

**4. GUARDS AND RAILINGS.** All glass in railings and guards is required to be safety glass, regardless of its height above the walking surface. Laminated glass is usually chosen for these locations *(see Figure 7)*.

**5. WET SURFACES.** Glazing in walls, doors, and enclosures for showers, tubs, saunas, whirlpools, steam rooms, spas, hot tubs, and indoor or outdoor swimming pools must be safety glass. The rule applies whenever the bottom exposed edge of the glazing is less than 60 inches above any standing or walking surface. In earlier editions of some codes, the "standing surface" was considered to be the drain inlet level of the tub or shower. Many tubs today (especially whirlpools) have adjacent surfaces that could serve as a step or other area to stand on, therefore the 60-inch measurement should begin at those surfaces *(see Figure 8)*.

There are basically no exceptions to this rule, although the 2009 codes did introduce a clarification that affects how the rule is measured. Glass that is more than 5 feet horizontally from the water's edge of bathtubs, spas, whirlpools and swimming pools does not automatically have to be safety glass. Suppose there was a freestanding tub in a bathroom. Technically, all of the walls of that room are "enclosing" the tub, and under previous editions of the code would require safety glass even if they were well out of harm's way from anyone slipping near the tub.

The 2012 IRC has a small addition to the rules for wet areas. In a multiple glazing assembly, such as dual-pane or triple-pane glass, all of the

panes must be safety glass, even those on the outboard side of the wet area.

**6. STAIRS AND RAMPS.** Glazing near the walking surface of stairs, landings and ramps must be safety glass when it is within 36 inches horizontally from the walking surface and less than 36 inches above the plane of the walking surface. An exception allows a protective bar as with Item 3 on page 13.

**7. BOTTOM STAIR LANDING.** Glazing adjacent to the bottom landing of stairs must be safety glass when it is within 60 inches horizontally of the bottom stair tread and less than 36 inches above the landing *(see Figure 9)*. The reason for this is that a person falling down the stairs will roll into the landing. There is an exception for guards that intervene between the landing and the glass and are at least 18 inches from the glass.

### Exempt glazing

Jalousie windows (louvered slats) are exempt. Slats must be at least 3/16 inches thick with smooth edges. These windows are becoming less popular even in hot climates in part because they do not completely seal out air and water.

Glass unit masonry that is properly installed is exempt from safety glazing rules, even in showers *(see Figure 10)*. Many are made with acrylics. The top and bottom courses must be secured and they cannot bear any other loads.

Mirrors, including those on wardrobe doors, are exempt if they are on a solid surface that provides a continuous backing support. While the type of support is not defined in the codes, within the glazing industry it is understood that this means an acrylic or fibered backing material. When such a mirror cracks, the glass shards remain adhered to the backing and do not pose an immediate hazard. Mounting an un-backed mirror to a wall with mastic does not qualify as a "continuous backing support."

### Identifying safety glass

An etched label *(see Figure 1, Safety Glazing Labels)* is required for tempered safety glass and has been since the first mention of tempered glass in the codes. A full label is required on at least one lite of multiple pane assemblies. The other lites in the assembly can be marked with only the "16 CFR 1201" designation if they do not exceed one-square-foot in the exposed area. The glass thickness usually is included in the label.

Though glass must meet the CPSC and/or ANSI standards, it does not require third-party-testing or certification. The manufacturer applies the markings and may choose to submit its products for third-party testing by the Safety Glazing Certification Council (SGCC). The council maintains a directory of certified products, including contact information for each specific manufacturing site. The identifying mark on the glass will then include the SGCC number *(See Figure 1)*.

A new CPSC rule proposed in 2010 has been interpreted as requiring the labeling to include the manufacturer's contact information. Although this rule is not fully implemented, compliance might be achieved by the voluntary SGCC process.

**Inspectors are often baffled by glass that has a frame obscuring the label, or in the case of shower doors, a soap or hard-water residue obscuring the glass.**

Another labeling exemption is provided for tempered spandrel glass (seldom found in residential applications). It is a type of opaque glass that is heat-strengthened by fusing a ceramic coating to the surface and it is used for commercial curtain walls. An etched label could have a different coefficient of expansion and cause the glass to break, so spandrel glass is allowed to have a removable paper label.

Sometimes laminated glass is labeled, though most codes do not require it to be. When it is labeled, the reference on the "bug" will typically be to DOT – the Department of Transportation. Laminated glass can be identified by the reflection in the glass. If you hold your hand to laminated glass, you will see multiple reflections. With some practice, you should be able to readily distinguish the two reflections from those you might see coming back from the inner and outer surfaces of a single pane of non-laminated glass *(see Figure 11)*.

Inspectors are often baffled by glass that has a frame obscuring the label, or in the case of shower doors, a soap or hard-water residue obscuring the glass. It is possible to verify that tempered glass is present by using a ▸▸

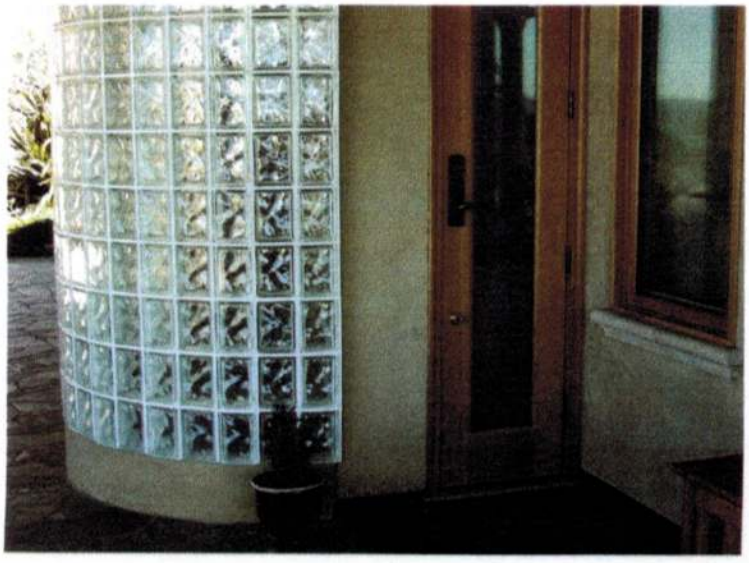

*Figure 10 – Glass unit masonry enclosing a shower. Note: The sidelite at the right would not require safety glass if the door were hinged on the other side.*

PHOTOS © DOUGLAS HANSEN

*Figure 11 – Laminated glass reflections*

pair of polarized light lenses. Normally, if you hold two such lenses over your flashlight and rotate them to where their polarities are at 90 degrees to each other, all light will be blocked. If you do this with a pane of tempered glass between them, distinctive black lines will appear as you rotate the lenses toward total blackness *(see Figure 12)*.

Many owners and architects find the identifying "bugs" to be unsightly. Occasionally a building department will allow them to be omitted on multi-lite doors. Such installations might be for a historical building where a door had custom-made pieces of tempered glass installed without a "bug." Building code sections on glazing have no provision for omitting the "bug;" however, building departments can allow it through the administrative provisions for "Alternate Materials and Methods." In such cases, there must be written documentation on file with the building department.

## Alternatives to replacement

Thousands of houses built in the 50s through the 70s have large floor-to-ceiling windows of ordinary glass and patio doors that are not safety glass. In lieu of replacement, it is possible to strengthen these doors and windows with products such as Scotchshield™ safety film from 3M. Applied properly, the material is durable, effective and does not change the look of the glass.

An installer can apply a label self-certifying that the glass complies with the CPSC standard *(see Figure 13)*. According to ICC Evaluation Service legacy report 94-41, the product qualifies as safety glass when properly installed. Many jurisdictions accept this, and the label is not likely to be present with a homeowner-applied film. Inspectors can generally tell if film is present because there will be a slight gap at the edges of the glass.

## Safety hazards not addressed by codes

At the beginning of this article, we stated that the codes look at possible sources of impact with architectural glass and provide regulations for mitigating the effects of that impact. The codes alone are not a substitute for inspectors putting on their thinking caps and asking themselves common-sense questions about what constitutes a hazard. Hazardous glazing can be found in many places not regulated by the code.

Though window seats might be designed with cushions and pose an invitation for persons to lean on the glass, safety glazing is not required *(see Figure 14)*. Large pieces of glass that do not meet all the conditions of Item 3 could still become flying shrapnel in high winds or in earthquakes. A home inspector in Virginia once was a party to an injury where a double-hung window with a broken sash cord fell and sent a piece of glass flying into a child, who barely survived. Safety glass is not required in cabinet doors. Fireplace doors are required to be impact and heat resistant per UL 127; however, that does not necessarily mean they will be marked as containing tempered glass. Child burn injuries are another major concern with fireplace doors.

Furniture is another unregulated area. Greg Abel estimates that approximately 20,000 people a year are injured by breaking glass tabletops, including coffee tables. Most of the injured are children. ■

**Acknowledgments and resources**

Special thanks to Greg Abel for proving that a committed individual can make a difference. We will never know how many people will have benefited from his work; his success is in preventing more persons from becoming statistics. Thanks to Jim Katen and Sandy Bourseau for their editorial guidance and contributions.

*Figure 12 – Polarized light testing*


*Figure 13 – Security film label*

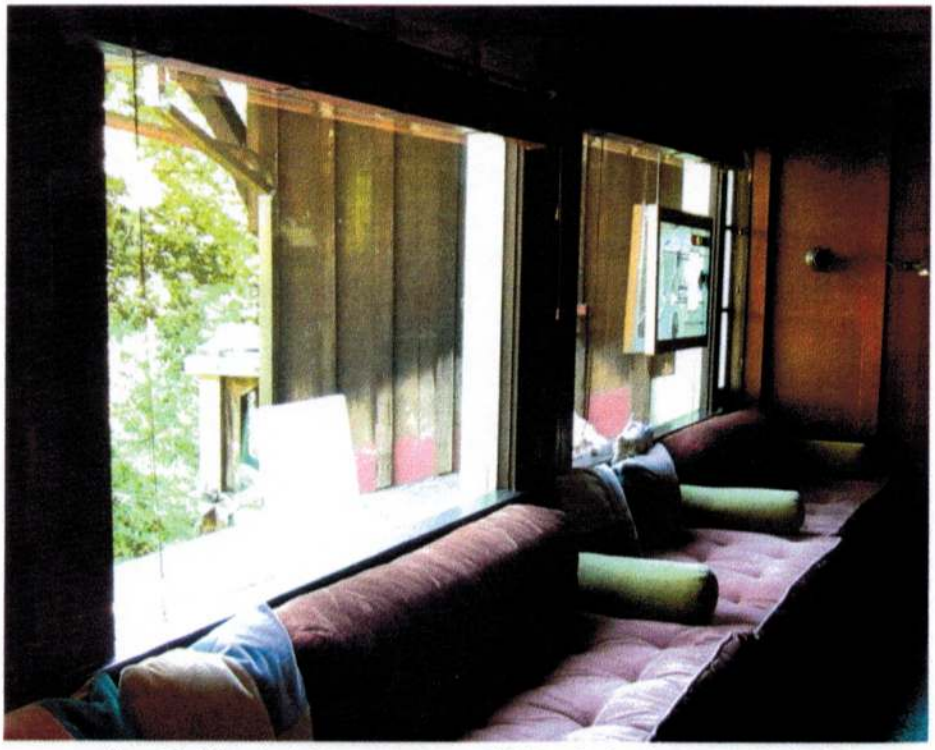

*Figure 14 – Although window seats pose a possible hazard, safety glazing is not required.*

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