Images courtesy SaftiFirst

Fire-rated Glass and Safety in Canada

By Jeff Griffiths, CSI

Although it may resemble clear, ordinary glass, new fire-rated glazing products can help successfully protect occupants from fire, smoke, and radiant heat. Virtually unlimited design make-ups are also possible, including various materials that are laminated, insulated, tinted, ultraviolet (UV)-resistant, decorative, mirrored, or curved.

With such a wide variety of options, it is crucial the design/construction professional understands the most suitable product for a project, especially as some fire-rated glass types can be dangerous or insufficient when used improperly. This article examines various fire-rated glass products and also takes a hard look at Canada's current codes in the context of safety.

Glazing options

Choosing the appropriate glazing means the specifier must fully understand the features required of the application. This goes beyond fire rating and also touches on elements such as esthetics, energy efficiency, and safety.

Wired glass

Traditional wired glass relies on fine, embedded wires to hold annealed glass in place during a fire test. These wires provide no protection against impact, rather, they weaken the glass and substantially reduce its impact resistance. Over the last six years, code modifications in the United States have restricted traditional wired glass to only those locations not normally requiring impact-resistant glazing.

Safety wired glass has the same appearance as its traditional counterpart, but is either laminated or filmed to achieve a safety impact rating compliant with the latest building codes. Although more costly than traditional wired glass, it is still one of the most inexpensive options for certain applications.

Highly tempered, special edge-treated products

Widely used in Europe and Asia for 20-minute applications, this clear, highly tempered, special edge-treated product is made from annealed glass through a thermal and edging process that improves thermal shock qualities. Relatively low in cost, it is able to withstand a much greater thermal differentiation without fear of shattering.

Highly tempered, reflective, special edge-treated products

Highly tempered, reflective, special edge-treated products are fire-rated from 20 to 60 minutes and provide additional defence against radiant heat transfer by reflecting the heat back toward the fire source. In comparison to other safety-rated, fire-protective products, this material is approximately twice the cost of other non-ceramic materials (though still less expensive than ceramic glazing). However, it offers the benefit of being clear while providing greater safety.

Special laminated glass

Non-wired, imported glazing is rated to 20 minutes and provides some protection from radiant heat transfer. Both the special laminated and the highly tempered, reflective, special edge-treated protective glazing do not meet the stringent fire-resistive ASTM International E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* which limits the temperature rise on the non-fire-side to 139 C (250 F) over ambient conditions.

In addition to its low cost, an advantage of special laminated glass is it can be cut and stocked. However, its level of impact resistance limits its use to smaller applications and door lites.

A visual comparison of two safety-rated wired glass products.

Ceramics

Ceramic is similar to the materials used in stove tops that allow heat transfer while tolerating high temperatures without cracking (due to a low thermal expansion and a high melting point). Introduced to the North American market as an alternative to wired glass, ceramic products have a fire rating of 20 minutes to three hours, but should not be confused with fire-resistive products. In fact, ceramics 'pump' radiant heat through to the non-fire side, rather than blocking its transfer.

Since ceramics are brittle, they must be laminated or filmed for impact resistance in hazardous locations, such as doors. Further, due to its manufacturing process, achieving optical clarity can be difficult. While polishing improves surface quality, most ceramics have a slight tint and some surface irregularity. Of all the fire-protective glazing products, ceramics are the most expensive.

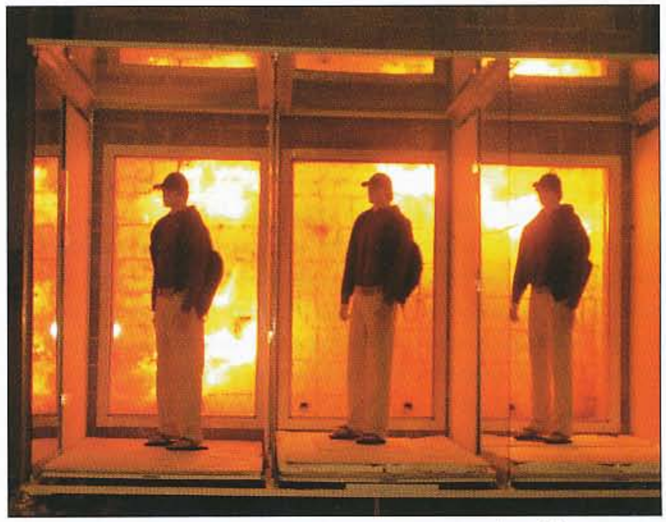
Fire-retardant-filled units

These products are composed of two tempered glass lites with the sandwiched cavity filled with a clear, semi-solid fire retardant. (The thickness of the fire retardant determines the fire rating.) During a fire, the lite facing the fire breaks away and the exposed fire retardant material becomes an opaque, insulating, fire-resistive barrier that prevents the transmission of flames, smoke, and radiant heat.

Multi-laminates

Multiple sheets of annealed glass can be laminated together using special intumescent interlayers that swell during a fire to prevent the transfer of smoke, flames, and radiant heat. Adding multiple layers of laminate increases the material's thickness, providing for higher ratings.

Multi-laminates can be factory-cut by a special diamond blade, whereas fire-retardant units cannot be trimmed to size. On the other hand, multi-laminate units can be thicker, weigh more, and may also be more susceptible to breaking or edge damage because they use annealed glass.



Glazing samples (from left to right: ceramic, wired, and heat reflective specialty tempered) in front of the test furnace.

Safety and security

Canada may be perceived as behind the times when it comes to fire-rated glazing. Not having any manufacturers to call its own, the country imports virtually all its fire-rated glass from sources in the United States, Japan, the United Kingdom, or continental Europe.

The danger of polished wired glass was first addressed 30 years ago in the United States. For decades, traditional wired glass occupied a unique position within the marketplace of glazing products. Its industrial appearance conveyed a sense of safety and security. However, it was perceived by some as being 'institutional' because its affordability and fire-rating made traditional wired glass the first choice for schools, hospitals, and governmental buildings.

As more stringent U.S. federal impact standards were developed in 1977 and imposed by the Consumer Products Safety Commission (CPSC 16 CFR 1201), the fragility of standard wired glass became more apparent. Being no more than annealed float glass with an embedded wire mesh, the product was found to be doubly dangerous as its impact resistance was extremely low and the wire repeatedly trapped the limbs of those who penetrated the glass. In some cases, these sorts of injuries were exacerbated when accident victims attempted to extract themselves from the entanglement of prickly wire and jagged shards of glass.

The product's manufacturers first lobbied the CPSC for an exemption from the new U.S. safety standards, and then sued to obtain a 25-year reprieve. They lobbied local jurisdictions to accept a voluntary standard (American National Standards Institute [ANSI] Z 97.1, *Safety Glazing Materials Used in Buildings–Safety Performance Specifications and Methods of Test*) drafted in large part by advocates for the wired glass industry—and openly rejected by the CPSC—that required glass to withstand only the theoretical force generated by a child under five years old (approximately 135 N [100 ft-lb]).

As a result of pressure from within the U.S. fire-rated glazing industry, in combination with consumer protection advocates, the International Code Council (ICC) took steps in 2002 to remove the exemption from their model codes. (The ICC produces model codes local authorities can modify to whatever extent and adopt as their own.)

The results of testing based on the setup shown on page 56. At left, the mannequin behind the wired glass spontaneously ignites at approximately nine minutes. On the right, the mannequin behind the ceramic glass ignites at around the 11-minute mark.

The 2003 edition of the *International Building Code (IBC)* required wired glass to comply with CPSC Category I and II requirements in educational and athletic facilities. In the 2004 *IBC* Supplement, this requirement was extended to all building types. The *IBC* 2006 model code solidified the mandatory compliance with CPSC safety standards for all types of glass located in hazardous locations as defined by the code, whatever the occupancy type.

In contrast, the Canadian General Standards Board (CGSB) performance guidelines for wired safety glass (CAN/CGSB-12.11-M90) are far more lenient. Canadian impact testing procedures for safety glazing are essentially identical to those employed in the United States, from the test equipment through required weights and distances. However, this is where the similarities end with respect to polished wired glass.

In his article entitled "How Safe is Safety Glass?," Ralph Southward, P.Eng., recipient of the Canadian Standards Association's (CSA's) Award of Merit, delves into the differences between 'safety glass' and 'wired safety glass' as defined by the CGSB.[1]

Southward reviews the origin of the CGSB's current standard for safety glazing, noting 12-GP-1, *Tentative Specification for Safety Glass,* was published in 1936 as a document to assist the federal government when purchasing supplies. The introduction to that standard reads:

> This specification applies to glass, other than wired glass, so treated or combined with other materials as to reduce in comparison with ordinary sheet or plate glass, the likelihood of injury to persons by objects from exterior sources or by fragments when the glass is cracked or broken.

In August 1971, the CGSB 12.1 safety glass standard was renamed *Standard for Glass Safety for Building Construction,* but very little else changed. Five years later, it would become the basis of the Canadian National Standard, CAN2-12.1-M76, *Glass Safety, Tempered or Laminated.* CAN2-12.1-M76 was republished in 1979 and 1990, with slightly different titles, but—as Southward puts it—a major philosophical revision. The scope of the 1979 and 1990 standards had been altered to reflect that it:

> specifies requirements for safety glass intended primarily for use in doors and adjacent glass panels and is particularly applicable to glazed exterior and interior passageway doors, storm (combination) doors, patio doors, shower and bathtub doors, and their enclosures.

Southward contrasts the stated intent of the CGSB *Glass Safety* standard with that of the CGSB *Wired Safety Glass* standard, noting the latter:

> applies to flat-rolled glass having an embedded layer of mesh wire completely imbedded in the sheet, intended for use in skylights and general glazing in building construction where fire retardation, security and safety are a consideration.

As Southward points out, it is interesting to note the absence of "doors and adjacent glass panels" in the description of the apparent intended use of wired glass in the later standard. He also says modern tempered and laminated glass can be manufactured to pass the approximately 541-N (400-ft-lb) impact test. Since standards usually qualify the glass for lower impact levels, the 203-N (150-ft-lb) test is often ignored when higher impact tests are passed. Southward speculates the test may only have been introduced because some of the first laminated glass had a thinner plastic interlayer, which prevented it from passing the 400-ft-lb test.

Wired glass, on the other hand, is first tested with a 100-ft-lb impact. It is considered to have passed, regardless of cracks, provided there are no openings allowing the passage of a 76-mm (3-in.) sphere. Curiously, if the glass does not crack at the 100-ft-lb impact level, it is tested with a 150-ft-lb impact; if it succeeds at this level, it is then tested at 400 ft-lb. A stronger wired glass specimen could pass the 150-ft-lb test, but fail at the 400-ft-lb impact level and therefore be unacceptable; a weaker wired glass could pass the test at the 100-ft-lb level.

As a result, Southward argues there is little incentive within the standards to make wired glass stronger due to the inherently flawed reasoning within the code.

In their arguments for the *IBC* safety glazing exemption, proponents of standard wired glass claimed the product was safe when 'used properly' and posed no danger to the general public. To the contrary, numerous wired glass-related injuries were continuing to be reported each year without any obvious confusion over the proper method of setting and glazing the product in place.

Such is the case in Canada as well. For example, the Ontario School Boards' Insurance Exchange (OSBIE) records for the past 20 years show wired glass-related injuries sustained by both students

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As firefighters work to save lives, the flames and smoke are not the only dangers. Radiant heat also poses an invisible threat, and fire-rated glazing decisions should take this into account.

and parents have occurred annually without any interruption.[2] More specifically, OSBIE recorded 33 per cent more glass claims from 1997 to 2006 versus 1987 to 1996. Of even greater concern is the fact the average claim cost incurred has increased by 127 per cent over these same two periods. In 2006, for example, a student or parent was 55 per cent more likely to be injured by wired glass than by plate glass—a clear indication the severity and likelihood of occurrence of an injury involving wired glass should at least be of serious concern to children and parents alike. It also comes as little surprise the overwhelming majority of those recorded injuries occurred at interior and exterior doors.

Canadian options

The most economical alternative to polished wired glass is specialty tempered fire-rated glazing. However, the use of specialty tempered glazing is restricted in both the United States and Canada due to the application of the hose stream test. This test methodology dates back to the late 1800s in response to the susceptibility of cast iron structural members to thermal shock. Since the use of this test has been abandoned by the rest of the world and the economic, esthetic, and safety benefits of specialty tempered products are readily available, North American building codes can appear to be a bit behind the times.

It is estimated 75 per cent of the U.S. fire-rated door market comprises 20-minute rated products, which unlike higher rated glazed assemblies, are exempt from the hose stream test. Given the similarities of code requirements in the U.S. and Canada, one might assume 20-minute door products dominate the Canadian market mix as well. However, unlike the United States, Japan, the United Kingdom, and the majority of European nations, Canada still requires the hose stream test procedure for 20-minute-rated glazed products.

In the hose stream test, a potentially fire-rated glazed assembly is first tested for the duration of fire exposure desired, followed by a specified period of exposure to a relatively high-pressure hose stream from a distance of approximately 6 m (20 ft).

The hose stream was devised to replace the use of weighted bags being swung or dropped against building components such as columns, walls, and floors in an effort to check their structural integrity after a given period of fire exposure. However, it took several iterations of the newly devised procedure before the skewed results stemming from the cooling effects of water were rationalized.

Despite not having any documented reasoning as part of the evolution of the test standard as to how or why glass came to be included in the hose stream requirement, advocates of the test point to an implied level of safety. Given the hose stream is applied approximately 6 m from the test unit and typical corridors protected by fire-rated glazing are only 2 to 3 m (6.6 to 9.8 ft) wide, however, the impact does not replicate the water-jet force from a fire hose in close quarters. No manufacturer of fire-rated glazing has ever demonstrated their product's ability to withstand the hose stream's impact within such close proximity. In light of this simple fact, the argument for compartmentalization seems moot.

As mentioned, the hose stream test is not universally accepted. In 1953, it was dropped from the British Standard (BS) 476, *Fire Tests on Building Materials and Structures,* for various reasons, including the fact the test did not reproduce conditions relative to an actual fire. The International Organization for Standardization (ISO) test standards adopted in Europe and elsewhere followed suit in eliminating the hose stream test.

When faced with challenges to hose stream requirements for fire-protection glazing, debate within reviewing *IBC* code committees has never been unanimous. Given that deaths due to fire in the United States and Canada—the only two countries still imposing the hose stream test—continue to be in the range of two to three times the death rates in the U.K. and Europe, an attempt to equate the hose stream test with fire-rated glazing safety without any corroborating evidence seems to this author to be a stretch of the imagination.[3]

Specialty tempered or laminated fire-rated glazing is used in potentially hazardous impact applications and protects millions of people throughout the world. Such products are produced locally, readily available, and economical in comparison to ceramic glass products produced abroad.

Radiant heat protection

In addition to fire resistance and injuries, another important safety consideration for glazing specifications is the issue of radiant heat. Building code authorities, fire protection engineers, firefighters, and anyone who has encountered a campfire or stove understand the danger of these electromagnetic waves that penetrate and pass through objects, potentially heating materials to the point of spontaneous combustion. Radiant heat transmission is considered by building codes in two basic ways: temperature-rise limitations and radiant heat flux limitations.

Canadian standards again differ from other developed countries. For example, fire protection codes based on British and European models typically recommend limiting temperature-rise to no more than 140 C (284 F) as a basic criterion to insulate

When specifying windows and door lites for school environments, design professionals should be mindful of the dangers presented by accidental impact with the glazing, especially at interior and exterior doors where many injuries happen.

The above photo shows a dangerous application for traditional wired glass. The glass is behind the push bar, and when people miss the bar and press on the glass, the likelihood of injury is high.

against radiant heat transmission. The aforementioned ASTM E 119 cites 121 C as an average temperature rise limit for doors, frames, and glazing. However, Canada's current national building code cites 250 C (482 F) for all fire ratings above 20 minutes for doors.

All these temperature-rise standards have the potential of allowing radiant heat flux conditions to develop that threaten lives and property. Considering human beings experience pain at temperatures well below any of these standards, Canadians could be at risk when faced with radiant heat levels that could easily impair passage along exit corridors and facilitate the rapid spread of fire.

While wired glass and ceramic glazing may fulfil basic life safety requirements dictated by prevailing codes, occupants of multi-storey and heavily populated buildings are especially reliant on safe and reliable exit pathways. In contrast, by providing the additional protection against radiant heat, specialty tempered heat reflective glass, tempered fire-resistant gel-filled insulated glass, and intumescent-laminated glass products all offer a variety of benefits leading to the enhanced safety of Canadians, to say nothing of the economic enrichment derived from local manufacturing. The related benefits of moving away from the use of unsafe traditional wired glass and the continued support of foreign suppliers are undoubtedly worth the additional cost.

Notes

[1] The article is posted on the Advocates for Safe Glass (AFSG) site, www.safeglass.org.

[2] OSBIE glass claim data was current as of the end of August 2006.

[3] See "Clarifying the Issue of Fire Protection Balance," by Richard R. Licht in the November 2003 issue of *Fire Engineering*. Also, see "Fire Death Rate Trends: An International Perspective," a May 1997 report by the Federal Emergency Management Agency's (FEMA's) U.S. Fire Administration's National Fire Data Center.

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