

From Wired Glass to Clear Solutions: Designing with Fire Rated Glass Today

Presented by SAFTI FIRST Fire Rated Glazing Solutions

ABSTRACT: This white paper provides readers with a solid understanding of fire rated glass (FRG) based on the two types of FRG recognized in the IBC – fire protective and fire resistive glazing. The discussion includes the advancement of FRG from traditional wire glass to technologically advanced clear solutions, recent code changes, the updated 2012 IBC Chapter 7 Tables outlining the requirements for FRG applications, and fire-rated framing considerations. The white paper is intended to give readers the ability to specify the correct, code-approved FRG product for particular applications based on the most up-to-date version of the IBC.

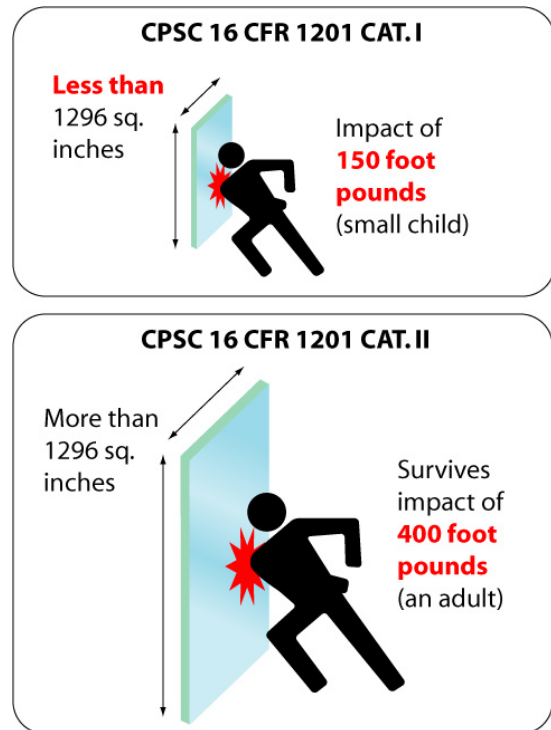
For Years, Wired Glass Was the Only Fire Rated Glass Product Available

Wired glass was the only fire rated glass (FRG) product available for over 100 years. In traditional wired glass, the embedded wires hold annealed glass in place during the fire test to achieve a fire rating. While the wires give the illusion of increased strength and impact resistance, the opposite is true. Wired glass is not safety glazing. The wires actually weaken the glass, making it half as strong as ordinary window glass. Wired glass breaks easily on human impact, exposing razor sharp wires that can trap a victim's limb in the opening and increase the severity of the injury. Alarmingly, wired glass is the most commonly used FRG product found in educational facilities, leading to over 2,500 wired glass impact injuries in schools every year.

In 1977, the Consumer Product Safety Commission (CPSC) enacted a federal safety glazing standard (16 CFR 1201) to protect people from injury due to accidental impact with glazing. The building codes apply the CPSC standard to require that glazing used in hazardous locations, such as doors and sidelites, must meet minimum Category I and II impact standards, depending on the size of the glazing panel. Smaller glazing panels in sizes up to 1296 square inches must meet the Category I impact test of 150 ft. lbs. Larger glazing panels must meet the higher Category II standard impact test of 400 ft. lbs. of impact resistance.

At the time the federal standard was enacted, wired glass manufacturers alleged they lacked the technology make a fire rated product that could meet the new CPSC standards. Since wired glass was the only FRG product available in 1977, the IBC granted wired glass a temporary exemption from meeting the CPSC standard. This exemption allowed wired glass used in fire assemblies to meet a lower ANSI Z97.1 impact standard of 100 ft. lbs., which the CPSC acknowledged was inadequate to protect anyone except children under five.

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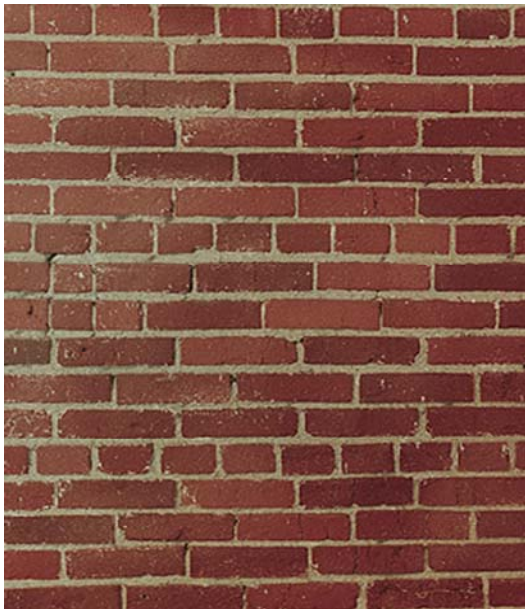
After the International Code Council (ICC) studied wired glass injury data in 2001, the ICC adopted code changes to eliminate the safety glazing exemption for wired glass. Since 2003, the IBC has required that all glazing in potentially hazardous locations within educational facilities must comply with CPSC impact-safety standards. In 2004, traditional wired glass was banned in fire assemblies in hazardous locations in all building types. Replacement of wired glass panels in existing installations must now meet Category I and II standards as required by the size of the vision area. At the same time the IBC wired glass exemption was removed, the ICC passed a code change that increased the safety glazing requirements for gymnasiums and athletic facilities, requiring glazing used in areas subject to human impact load to meet the more stringent Category II impact test requirement, regardless of the size of the glazing panel.

Industry Innovation Leads to Improved Impact and Fire Safety

Industry innovation was the main driving force behind IBC changes to strengthen safety glazing requirements. In 2000, USA-based manufacturer SAFTI FIRST developed and tested a filmed wired glass product that met both the fire and the CPSC impact safety requirements of the code. In 2002, SAFTI FIRST introduced SuperLite I-W, a listed and labeled filmed safety wired glass. Although it looks like traditional wired glass, SuperLite I-W is able to successfully pass both the fire test requirements and the stringent CPSC Category II impact safety standard.

Before that innovation, SAFTI FIRST also introduced clear, non-wired fire and safety rated glazing options in the U.S. market. These products meet all the fire and safety requirements of the code while outperforming wired glass in many ways. Clear and affordable, specialty-tempered products like SuperLite I and SuperLite I-XL both meet CPSC Category II, the highest federal impact safety standard. SuperLite I-XL also gives additional partial protection from the dangerous transmission of radiant heat, a benefit that neither wired glass nor ceramics provide. Clear and affordable specialty fire protective glazing like SuperLite X-90 can also be used in 60 and 90 minute temperature rise doors up to 100 square inches because this product meets CPSC impact safety requirements.

For the ultimate in design flexibility, clear fire-resistive options, such as SuperLite II-XL, combine large clear view areas with maximum fire and impact safety. Before, the only option for 1 and 2 hour walls would have been a conventional solid wall. With advanced fire rated glazing like SuperLite II-XL able to perform just like a gypsum or brick wall, designers can now have large areas of clear transparent FRG that increases security, provides lighting, reduces noise and allows aesthetic design flexibility.



Old Solution: Conventional wall with no views



New Solution: Maximum views with SuperLite II-XL and GPX Framing by SAFTI FIRST

While the advent of advanced FRG products have given architects the opportunity to design with glass like never before, there is still a lot of confusion about the correct and code-approved use of FRG. The following sections aim to clarify this confusion by focusing on the overall performance of these products and the IBC code requirements that govern their use.

Understanding the Difference Between Fire Protective and Fire Resistive Glazing

The key to understanding FRG products and their applications lies in distinguishing between the two fire performance categories in the IBC – fire protective and fire resistive. Each category has its own set of performance features, test standards and allowed applications. Simply relying on the fire endurance rating (20, 45, 60, 90, 120 and 180 minutes) or whether a product is “thick” or “thin” can lead to faulty specifications and misapplications of the product.

Fire protective glass is designed to compartmentalize smoke and flames and is subject to application, area and size limitations under the IBC. Fire protective glass is typically used in doors and openings up to 45 minutes and cannot exceed 25% of the total wall area because it does not block radiant heat transmission. These products are also subject to the following test standards:

- NFPA 252, Standard Methods of Fire Tests of Door Assemblies
- NFPA 257, Standard on Fire Tests for Window and Glass Block Assemblies
- UL 9, Standard for Safety Fire Tests of Window Assemblies
- UL 10B, Fire Tests of Door Assemblies
- UL 10C, Positive Pressure Fire Tests of Door Assemblies

Fire protective glass products include:

Type	Fire Rating	CPSC Safety Rating	Appearance	Typical Application
Specialty Tempered	20 minutes	CPSC Cat. II	Optically clear. No wires or tints.	Doors (max. size tested)
Specialty Tempered, Heat Reflective	20-60 minutes AHJ approval is required for 45-60 minute applications.	CPSC Cat. II	Optically clear. No wires or tints.	20-45 min. Doors (max. size tested); 60-90 min. Doors (100 sq. in.); 45 min. Sidelites, Transoms and Windows

Specialty Fire Protective	90 minutes	CPSC Cat. I or Cat. II	Optically clear. No wires or tints.	90 min. Doors (100 sq. in.)
Traditional Wired Glass	20-90 minutes	none	Annealed glass with embedded wires.	45 min. Transoms and Windows where safety is not a requirement
Safety Wired Glass	20-90 minutes	CPSC Cat. II	Wired glass with surface applied safety film	20-45 min. Doors (max. size tested); 60-90 min. Doors (100 sq. in.); 45 min. Sidelites, Transoms and Windows
Ceramic	20-90 minutes	none	Wire-free with amber tints	45 min. Transoms and Windows where safety is not a requirement
Filmed Safety Ceramic	20-180 minutes	CPSC Cat. II	Ceramic with surface applied safety film. Wire-free with amber tints.	20-45 min. Doors (max. size tested); 60-90 min. Doors (100 sq. in.); 45 min. Sidelites, Transoms and Windows
Laminated Safety Ceramic	20-180 minutes	CPSC Cat. II	Laminated ceramic. Wire-free with amber tints.	20-45 min. Doors (max. size tested); 60-90 min. Doors (100 sq. in.); 45 min. Sidelites, Transoms and Windows

It is important to note that while there are fire protective products rated from 60 to 180 minutes, their application is limited to door vision panels, and size limitations may apply.

For 180 minute doors, fire protective products may be listed for 100 square inches, although the IBC does not permit any vision panel in a 3-hour rated fire door. For 60 and 90 minute doors in exit enclosures and exit passageways, fire protective products are limited to 100 square inches whether or not the building is fully sprinklered. This important provision is a result of successful code change submitted by SAFTI FIRST in the 2009 code development cycle, and will be included in the 2012 IBC. More information on the code change and the 2012 IBC are discussed in following sections.

In addition, fire protective glass, such as ceramics and wired glass, have limited use in 1-hour walls, and are prohibited altogether as sidelites, transoms and windows in 2-hour interior walls because they cannot block radiant heat. These limitations are recognized in the IBC, and recent revisions to the 2012 IBC give end-users clear guidance in applying those limits.

Fire resistive glass is not limited in application or size. This type of FRG compartmentalizes smoke and flames, *and* blocks the transmission of dangerous levels of radiant heat through the glazing. As a result, it can be used in wall and door applications 60 minutes and above without the size limitations that apply to fire protective glass. The following test standards apply to fire resistive glass:

- ASTM E-119, Standard Methods for Fire Tests of Building Construction and Materials
- NFPA 251, Standard Methods of Tests of Fire Resistance of Building Construction and Materials
- UL 263, Fire Tests of Building Construction and Materials

These standards apply to all fire-resistive wall materials, where the temperature rise on the non-fire side cannot exceed an average of 250 degrees Fahrenheit. The intent is to block the dangerous transmission of radiant heat, which can cause paper, drapes, clothing and other combustible materials within 20 feet to ignite without coming in contact with the actual fire. Imagine the devastating effect unrestricted radiant heat has on building occupants attempting to exit past a large glazed area during a fire. By effectively compartmentalizing smoke, flames and radiant heat, fire resistive glass insures safe egress, no matter how large the glazed area.

Fire resistive glass products include:

Type	Fire Rating	CPSC Safety Rating	Appearance	Typical Application
Fire retardant filled units	Up to 2 hours	CPSC Cat. II	Optically clear. No wires or tints. Comprised of 2 tempered lites with the cavity filled with a clear fire retardant.	Walls; 60-90 min. Doors (max. size tested); 60-120 min. Sidelites and Transoms
Multilaminates	Up to 2 hours	CPSC Cat. II	Optically clear. No wires or tints. Multiple sheets of annealed glass with an intumescent interlayer.	Walls; 60-90 min. Doors (max. size tested); 60-120 min. Sidelites and Transoms

Fire Protective vs. Fire Resistive Glass

Window / Door Test
FIRE PROTECTIVE
NFPA 257/252



Contains flame and smoke
45 minutes and under

Wall Test
FIRE RESISTIVE
ASTM E119/NFPA 251

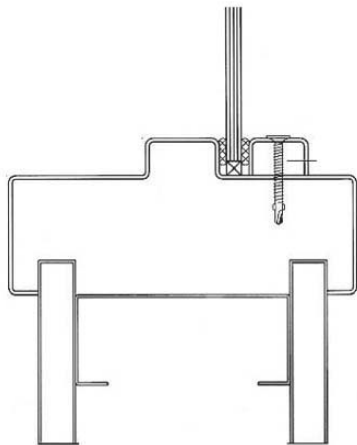


Contains flame and smoke AND
blocks radiant heat for applications
over 45 minutes

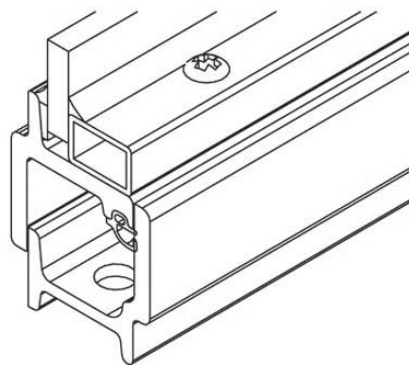
Framing Must Match Glazing Requirements

Because FRG is used in door and wall assemblies, code requirements for framing must also be considered. Simply put, the fire rated framing requirements must match the glazing requirements in order for the assembly to fully meet the requirements of the code.

Fire protective framing, like fire protective glazing, has limited use in applications rated over 45 minutes. The most common frame is hollow metal, such as SAFTIfire HM. This type of framing can be used in doors, sidelites, transoms and interior windows up to 45 minutes. Fire protective, hollow metal frames, like fire protective glazing, fail to block the spread of radiant heat.



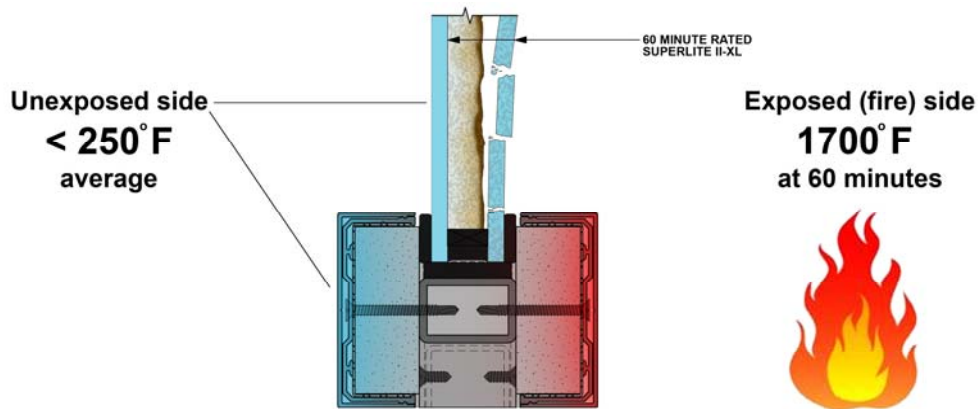
Hollow Metal



Hot Rolled Steel Section

Fire resistive framing, such as SAFTIfire GPX from SAFTI FIRST, has the ability to block the spread of radiant heat. Like fire resistive glazing, this type of framing meets ASTM E-119/NFPA 251/UL 263 requirements. Fire resistive framing can be used in wall and door assemblies (this includes glazing around and over the door, such as sidelites and transoms) rated 60 minutes and above.

Project specifications that configure fire resistive glazing in hollow metal frames in 1 or 2 hour applications fail to meet code, because fire resistive glazing with fire protective framing lowers the overall fire performance rating of the assembly to fire protective. **In 1 or 2 hour applications where meeting ASTM E-119/NFPA 251/UL 263 is required, both the glazing and framing must be fire resistive.**



Fire Resistive Framing: SAFTIfire GPX from SAFTI FIRST

Important Changes in 2012 IBC Code Requirements for FRG

The requirements for FRG can be found in Chapter 7 of the IBC. Over the years, this chapter has been revised to make it easier for designers, code officials, and installers to clearly categorize and apply fire protective and fire resistive glazing. Chapter 7 of the IBC addresses glazing performance characteristics, allowed applications and most importantly, its limitations.

Three Tables Modified to Clarify FRG Requirements and Limits

In 2009, The ICC (International Code Council) recognized that the FRG provisions of the IBC were confusing, so it appointed an ad hoc committee comprised of fire and building officials, test agencies, and industry representatives to study the glazing labeling provisions and make recommended code changes. As the result of the ad hoc committee's extensive work over the

course of several months, three tables in the 2012 IBC were revised. This new model building code will be published in April 2011. These are not new code requirements, but rather a clarification of the 2006 and 2009 editions of the IBC.

Even though the new tables will not be adopted locally until jurisdictions accept the 2012 IBC, they are useful today in understanding the 2006 and 2009 IBC glazing requirements. The requirements contained in the new tables have been in effect since the 2006 IBC, and conform to what NFPA 80 provided in the 1999 and 2007 NFPA 80 editions, which are incorporated by reference in the 2012 IBC.

Table 716.3 – Marking Fire Rated Glazing Assemblies

Table 716.3 clarifies recent glazing labeling marking requirements, which mandate that FRG be marked with a letter designation corresponding to the test standard to which the product was tested. *(Please see Appendix for Table 716.3 with recommended product options)*

Fire Test Standard	Marking	Definition of Marking
ASTM E119 or UL 263	W	Meets wall assembly criteria.
NFPA 257 or UL 9	OH	Meets fire window assembly criteria including the hose stream test.
NFPA 252 or UL 10B or UL 10C	D H T	Meets fire door assembly criteria. Meets fire door assembly "Hose Stream" test. Meets 450° F temperature rise criteria for 30 minutes
	XXX	The time in minutes of the fire resistance or fire protection rating of the glazing assembly

- “W” means that the glazing has been tested to the fire wall test standard (ASTM E-119/NFPA 251/UL 263) and thus classified as fire resistive.
- Glazing products that are marked “D” means that the product has been tested to the fire door test standard, NFPA 252, and the marking “H” means that it passes the hose stream procedure. The marking “T” means that the glazing meets the temperature rise limits required for doors used in exit enclosures and passageways.
- Glazing products that are marked “OH” means that the glazing has been tested to the fire window test standard, NFPA 257, and meets both the fire endurance and hose stream requirements of the test standard.

Note that some products have been tested to more than one standard, and will have multiple markings. For example, when a fire resistance glazing product has been tested to the wall fire test, and has also been tested in a fire door assembly, it will carry a dual marking of “W” and “D H T.” This product can be used in large vision panel sizes in 60 and 90 minute doors, where a fire protection rated product, such as safety wired glass or safety ceramic, and marked only DH, would be limited to a 100 square inches.

Table 716.5 – Opening Fire Protection Assemblies, Ratings and Markings

In reviewing the glazing provisions of the code, the ad hoc committee recommended significant changes to the door assembly rating table, 716.5. For the first time, the code lays out, in table form, the vision panel size limits, and adds a column that specifies the sidelite and transom rating requirements. Importantly, the table distinguishes between the use of fire “protection” rated products, and fire “resistance” rated products, and makes it easy for the end user to: identify appropriate size limits affecting fire protective glazing; where fire resistance rated products must be used if glazing is desired in larger sizes; and, where the code would not otherwise allow FRG. (Please see Appendix for Table 716.5 with recommended product options)

TYPE OF ASSEMBLY	REQUIRED WALL ASSEMBLY RATING (HRS.)	MINIMUM FIRE DOOR AND FIRE SHUTTER ASSEMBLY RATING (HRS.)	DOOR VISION PANEL SIZE	FIRE RATED GLAZING MARKING DOOR VISION PANEL ^e	MINIMUM SIDELITE/TRANSOM ASSEMBLY RATING (HRS.)		FIRE RATED GLAZING MARKING SIDELITE/TRANSOM PANEL	
					Fire Protection	Fire Resistance	Fire Protection	Fire Resistance
Fire walls and fire barriers having a required fire resistance rating greater than 1 hour	4	3	Not Permitted	Not Permitted	Not Permitted	4	Not Permitted	W-240
	3	3 ^a	Not Permitted	Not Permitted	Not Permitted	3	Not Permitted	W-180
	2	1-1/2	100 sq. in ^c	≤100 sq. in. = D-H-90 >100 sq. in. =D-H-W-90	Not Permitted	2	Not Permitted	W-120
	1-1/2	1-1/2	100 sq. in ^c	≤100 sq. in. = D-H-90 >100 sq. in. =D-H-W-90	Not Permitted	1-1/2	Not Permitted	W-90
Shaft, exit enclosures and exit passageway walls	2	1-1/2	100 sq. in ^{c,d}	≤100 sq. in. = D-H-90 >100 sq. in. = D-H-T-90 or D-H-T-W-90	Not Permitted	2	Not Permitted	W-120

TYPE OF ASSEMBLY	REQUIRED WALL ASSEMBLY RATING (HRS.)	MINIMUM FIRE DOOR AND FIRE SHUTTER ASSEMBLY RATING (HRS.)	DOOR VISION PANEL SIZE	FIRE RATED GLAZING MARKING DOOR VISION PANEL ^e	MINIMUM SIDELITE/TRANSOM ASSEMBLY RATING (HRS.)		FIRE RATED GLAZING MARKING SIDELITE/TRANSOM PANEL		
					Fire Protection	Fire Resistance	Fire Protection	Fire Resistance	
Fire barriers having a required fire-resistance rating of 1 hour: Enclosures for shafts, exit access stairways, exit access ramp, interior exit stairways, interior exit ramps and exit passageway walls.	1	1	100 sq. in. ^{c, d}	≤100 sq. in. = D-H-60 >100 sq. in. = D-H-T-60 or D-H-T-W-60	Not Permitted	1	Not Permitted	W-60	
					Fire Protection				
Other Fire Barriers	1	3/4	Maximum Size Tested	D-H-NT-45	3/4		D-H-NT-45		
Fire Partitions / Corridor Walls	1	1/3 ^b	Maximum Size Tested	D-20	3/4 ^b		D-H-OH-45		
	0.5	1/3 ^b	Maximum Size Tested	D-20	1/3		D-H-OH-20		
Other Fire Partitions	1	3/4	Maximum Size Tested	D-H-45	3/4		D-H-45		
	0.5	1/3	Maximum Size Tested	D-H-20	1/3		D-H-20		
Exterior Walls	3	1-1/2	100 sq. in. ^c	≤100 sq. in. = D-H-90 >100 sq. in. =D-H-W-90	Not Permitted		3		
	2	1-1/2	100 sq. in. ^c	≤100 sq. in. = D-H-90 >100 sq. in. =D-H-W-90	Not Permitted		2		
						Fire Protection			
	1	3/4	Maximum Size Tested	D-H-45	3/4		D-H-45		
Smoke Barriers						Fire Protection			
	1	1/3 ^b	Maximum Size Tested	D-20	3/4		D-H-OH-45		

- a. Two doors, each with a fire protection rating of 1-1/2 hours, installed on opposite sides of the same opening in a fire wall, shall be deemed equivalent in fire protection rating to one 3-hour fire door.
- b. For testing requirements, see Section 716.6.3.
- c. Fire resistance rated glazing tested to ASTM E119 per section 716.2 shall be permitted, in the maximum size tested.
- d. Under the column heading “Fire rated glazing marking door vision panel”, W refers to the fire-resistance rating of the glazing, not the frame.

Table 716.6 – Fire Window Assembly Fire Protection Ratings

The ad hoc committee recommended an expansion of the information in Table 716.6, a table specifying required fire-window ratings. As in Table 716.5, Table 716.6 now clarifies where fire protection rated products are allowed, where fire resistance rated glazing must be used (e.g., in 2-hour interior walls), and where fire protection rated windows are not permitted. Table 715.5 in 2012 IBC further clarifies that fire windows are not permitted in 1-hour fire barriers used as exit enclosures or passageways, but are permitted in fire barriers used as incidental use areas and mixed occupancies. *(Please see Appendix for Table 716.6 with recommended product options)*

TYPE OF WALL ASSEMBLY	REQUIRED WALL ASSEMBLY RATING (hours)	MINIMUM FIRE WINDOW ASSEMBLY RATING (hours)	FIRE RATED GLAZING MARKING
Interior walls			
Fire walls	All	NP ^a	W-xxx ^b
Fire barriers	>1	NP ^a	W-xxx ^b
	1	NP ^a	W-xxx ^b
Incidental use areas (707.3.6), Mixed occupancy separations(707.3.8)	1	¾	OH-45 or W-60
Fire partitions	1	¾	OH-45 or W-60
	0.5	1/3	OH-20 or W-30
Smoke barriers	1	¾	OH-45 or W-60

Exterior walls	>1	1-1/2	OH-90 or W-XXX ^b
	1	¾	OH-45 or W-60
	0.5	1/3	OH-20 or W-30
Party wall	All	NP	Not Applicable

NP – Not Permitted

a. Not permitted except fire resistance rated glazing assemblies tested to ASTM E119 or UL 263, as specified in Section 716.2

b. xxx = The fire rating duration period in minutes, which shall be equal to the fire resistance rating required for the wall assembly.

Code Change Removes Sprinkler Tradeoff for Doors in Exit Enclosures and Passageways

To repeat, nearly all of the modifications to Tables 716.3, 716.5 and 716.6 in the 2012 IBC are intended to clarify requirements and limitations on FRG in effect since the 2006 IBC. These 2012 IBC tables do, however, include one important code change. In the 2009 ICC Code Development Cycle, SAFTI FIRST proposed a successful code change to removed a sprinkler tradeoff for FRG in 60 and 90 minute doors located in exit enclosures and exit passageways. Previous editions of the code provided for an exception that allowed larger fire protective vision panels in fire doors used in exit enclosures and passageways when the building was fully sprinklered. The new 2012 IBC removes that sprinkler exception and will now read as follows:

716.5.5.1 Glazing In doors. Fire protection rated glazing in excess of 100 sq inches (0.065m²) is not permitted. Fire resistance rated glazing in excess of 100 sq inches (0.065m²) shall be permitted in fire door assemblies when tested as components of the door assemblies, and not as glass lights, and shall have the maximum end temperature rise of 450 degrees F (250 degrees C) in accordance with 716.5.5.

Section 716.5.5.1 makes it very clear that fire protective glazing cannot exceed 100 square inches. It further states that fire resistive glazing is allowed in excess of 100 sq. in. as long as it limits the temperature rise to 450 degrees F above ambient after 30 min. of fire exposure. There is no question that fire resistive glazing meets this requirement.

Note that no fire protective glazing product can meet the 450 degrees F above ambient after 30 min. of fire exposure. Therefore, the code makes it clear that it is limited to 100 sq. in. regardless if the building is fully sprinklered.

The ICC made this change in recognition of the hazards of radiant heat transmission, because sprinklers in a building fail to eliminate the life safety and fire spread hazards posed by the unrestricted transmission of radiant heat through large sizes of fire protective glazing panels in 60-and-90-minute doors, especially when those doors are protecting exit enclosures and exit passageways deemed essential for occupant life safety.

The 2012 IBC tables also clarify that sidelites and transoms around 60 and 90 minute exit enclosure and passageway doors must be fire resistive rated equal to the wall. These exit enclosures and passageways are integral to life safety, and occupants need to be protected from dangerous radiant heat levels transmitted through fully glazed exit enclosure doors, sidelights and transoms. It is comforting to note that the cost of fire resistive glazing can be more economical than inappropriately specified fire protective ceramic products.

A Cautionary Note About Fire Rated Glazing Listings

One reason that end users are frequently confused about the proper use of fire protective versus fire resistive rated glazing products is the way in which they are listed by test agencies, such as UL and ITS. It is important for design professionals and code enforcement officials to understand that the listing agencies do not list FRC products in accordance with the codes or limitations on their use. Instead, test agencies simply report the sizes and types of assemblies in which a FRG product has been tested. For example, test agencies often list certain ceramic products in 60 and 90 minute sidelite and transom assemblies that are not permitted under any building code in the United States. Accordingly, listings cannot be relied on for determining accepted code applications of FRG products.

When in Doubt, Seek the Manufacturer's Expertise

Advances in FRG technology over the last 25 years have changed how the building community uses these specialized products. The new generation of clear, fire rated products includes several custom options (*e.g.* ballistic attack or hurricane defense), reduced UV transmission, noise abatement benefits, and various decorative make-ups, affording professionals almost unlimited design possibilities. The codes and testing agencies are working to catch up with technological advances.

Never hesitate to consult the FRG manufacturer if you have questions about product performance, allowed applications, or need help in understanding the code requirements. In some cases, it makes sense to involve the manufacturer in early design phases, especially when dealing with highly technical products such as FRG. With ever-changing codes and rapid advances in material technology, product and industry knowledge in the selection and use of FRG products can help you save time, money and lives.

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