Recommendations
For

Avoiding Glass Failure

Published by:

INTERNATIONAL WINDOW FILM ASSOCIATION

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ASSOCIATION OF INDUSTRIAL METALIZERS, COATERS, AND LAMINATORS -
Window Film Committee

Revised Edition
April 1998

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Recommendations for Avoiding Glass Failures

This publication addresses the association of window film with two highly publicized glass failure problems: thermal stress fracture and insulating glass seal failure and attempts to provide a procedure for assisting in examining the advisability of installing window film in a specific situation. For the purposes of the discussion presented herein, window film is divided into two different types: clear safety film and heat-absorbing solar control film. Heat-absorbing solar control film can be any combination of tinted, coated, or spectrally selective film. The procedure presented for determining the advisability of installing window film in a specific situation involves the investigation of several important points regarding the glazing conditions and characteristics of the window installation. Based on the results of this investigation, a conservative decision may be able to be made as to whether or not it is advisable to install window film in a particular application. If the use of window film is judged to be a poor risk based on criteria presented herein, it is recommended that the window film manufacturer be contacted regarding the proposed installation or film choice. More rigorous analyses performed by manufacturer representatives or informed consultants can further assist in making a particular determination and may result in more liberal recommendations for the use of window film. The window film manufacturer should be considered a primary authority on whether or not to install window film and the proper type of window film to be installed, since no two sets of circumstances are identical, and a film manufacturer's data and experience may be great aids in making the end decision.

Thermal Stress Fracture

Thermal stress fractures are the result of uneven temperature distributions across the surface of a glass plate. The most common cause of uneven temperature distribution is unequal heating of the glass as the result of exposure to sunlight. Thermal stress fractures tend to originate at the edges of glass plates as the result of the interaction of thermally induced tensile stresses with edge flaws or damage. In addition, severe surface damage or flaws can also trigger thermal stress fractures. This problem can be exacerbated by the type of glass, surface or edge damage, the heat absorption characteristics of the glass, edge bite, unfavorable interior shading devices, and exterior shading conditions.

Provided that the fabrication and installation of the glass is acceptable, thermal stress fracture is usually not a problem with heat-treated glass (heat-strengthened or tempered), and it usually does not become a problem with properly fabricated and installed annealed glass until the solar absorption of the glazing in-fill exceeds about 50%-60%. Clear safety film adds little to the heat absorption characteristics of glass so its application to annealed glass should have little effect. However, the application of heat-absorbing film to annealed glass may, in some instances, increase the total solar absorption of the glazing in-fill to a level that may promote the occurrence of thermal fracture. This can be more of an issue if the glass in question is improperly fabricated or installed.

Insulating Glass Seal Failures

Insulating glass (IG) units are constructed by enclosing a sealed gas space between two or more glass plates which are separated by spacers of constant thickness. The purpose of the seal is to minimize the migration of water vapor into the gas space. In addition, a desiccant is incorporated into the edge construction of the IG unit to absorb moisture which migrates through the IG seal. An IG seal failure can occur when the desiccant used to keep the gas space dry no longer absorbs migrating moisture or other vapors. This can happen because of the natural aging process of and IG unit or because of a less than satisfactory glazing system design that allows moisture to be entrapped near the edges of the IG units. The result of a seal failure is the condensation of excess moisture on the gas space glass surfaces. This may eventually cause the IG unit to have a hazy or fogged appearance. While film is often blamed as a cause for IG seal failures, there is little objective data to support this assertion.

Glass Type

For purposes of this discussion, glass type is defined as either annealed glass or heat-treated glass as discussed below.

Annealed Glass

The basic flat glass product that is available is commonly referred to as annealed float glass or simply annealed glass. Annealed glass is manufactured in a process where molten glass is poured continuously onto a bed of molten tin. The molten glass tends to seek a level configuration as it floats on the surface of the molten tin. Because the melting point of the tin is much less than that for glass, the glass solidifies as it slowly cools on top of the molten tin. Once the glass solidifies, it is fed into an annealing lehr where it is slowly cooled so that the residual stresses are minimized. This process results in the production of an annealed glass product which is very flat and with nearly parallel surfaces. Because annealed glass has a minimum amount of residual surface compression, care must be exercised in the use of this product to minimize the potential for thermal stress fractures.

Heat-Treated Glass

The strength of annealed glass can be greatly increased by subjecting it to a heat-treatment process. In this process, annealed glass is heated to a temperature which is near its softening point, and then it is quenched in a controlled manner. During the quenching operation the surface of the glass cools quicker than the interior of the glass so that a residual compression stress is locked into the surface of the glass. These residual compression stresses must be overcome before the glass can fracture due to tensile stresses. The level of the residual compression stress is controlled by the rate of quenching. Glass that has a high level of residual surface compression is referred to as tempered glass, and glass that has a medium level of residual surface compression is referred to as heat-strengthened glass. Both heat-strengthened and tempered glass have sufficient residual surface com pression to make failure due to typical thermal stress conditions unlikely.

The level of residual surface compression induced in tempered glass is generally sufficient to assure that this product qualifies as safety glazing. As such, most tempered glass products are marked with a clearly visible corner etching stating that the glass complies with safety glazing standards. The presence of this marking indicates that the glass is fully tempered.

If there is no corner etching, a direct way to tell the difference between annealed glass and heat-treated glass in a field situation is through the use of two sheets of polarized film. One sheet should be positioned on each side of the glass plate, and the character of the light that shines through the glass is examined. Annealed glass will exhibit a neutral appearance, while heat-treated glass will exhibit a mottled display of residual stress patterns.

Glass Color

Window units are commonly fabricated with clear, tinted, or coated glass. Variations in the tinting and coating processes influence the solar, optical, and heat absorption properties of the glass. Of most importance in this discussion is the influence of the total absorptance properties on the development of high thermal stresses. If the total solar absorptance of filmed annealed glass exceeds 50-60%, thermal stresses may become extremely important. The only reliable method currently available for estimating the total solar absorptance of filmed glass is through laboratory testing or by computer modeling in conjunction with lab test data.

Clear safety film can be applied to coated or tinted glass without substantially changing the risk of thermal fracture. However, as with insulating glass, the glass may be in a state which is near failure prior to the application of the film. In such a case, failures that occur after the application of the film may wrongly be associated with the film application. Therefore, if the solar absorptance of the glass without the film is near the critical point, it may be advisable to not apply window film to such glass.

Clear Glass

Clear glass is manufactured with a minimum amount of nonglass constituents so that it is colorless with a high light transmission which ranges from 75% to 92%. The total solar absorptance of clear glass is dependent on its thickness and generally varies from 3% to 41%.

Tinted/Coated Glass

Tinted glass is manufactured by adding colorants to a clear glass batch to create the desired color so that the colorants become an integral part of the glass matrix. The visible light transmission of tinted glass ranges from 14% to 83%. The total solar absorptance of tinted glass depends upon the thickness of the glass, and the amount and type of colorants that are added to the glass. The total solar absorptance of tinted glass generally varies from 3% to 41%.

Coated glass is manufactured by chemical vapor deposition during the on-line float glass process or through various vacuum deposition technologies in an off-line process. Coated glass is often referred to as reflective glass. This type of glass would include low-e coatings which reflect primarily long-wave infrared radiation. The coatings affect both the solar/optical properties of the glass as well as the aesthetics of the installation.

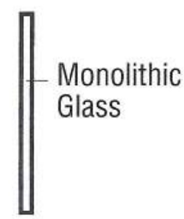
The value of the total solar absorptance of a particular piece of tinted or coated glass should be determined from manufacturer's literature. If the total absorptance is unknown, it is recommended that window film not be applied to annealed glass.

Glass Construction

For purposes of this discussion, glass constructions are divided into four major groups: monolithic, insulating, laminated, and miscellaneous as defined below.

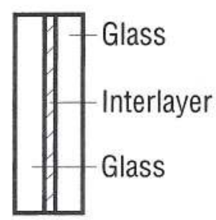
Monolithic

Monolithic glass is the primary glass product that is produced. It consists simply of a flat piece of glass of constant thickness. In the past, monolithic glass was produced using either sheet or plate glass processes. However, virtually all monolithic glass produced in the world today is produced using the float glass process. Monolithic float glass can be annealed or heat-treated as described in the glass type section.



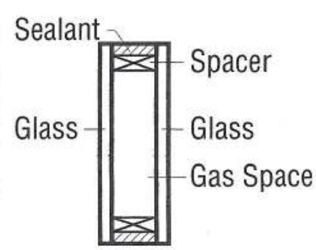
Laminated

Laminated glass is manufactured by bonding multiple layers of glass together through the use of layer(s) of polyvinyl butyral (PVB) or, in some cases, the use of liquid resins. Usually, laminated glass involves two pieces of glass of the same thickness and a single interlayer as shown below. The primary function of the interlayer is to securely fasten the layers of glass together. When laminated glass is broken, the interlayer helps to hold broken pieces of glass together.



Insulating

Insulating glass is manufactured by enclosing a sealed gas space between two or more pieces of glass which are separated by spaces of constant thickness. The seal between the glass plates is accomplished through the use of a variety of different types of materials and sealants. In addition, a desiccant is incorporated into the edge seal technology to absorb water vapor that migrates across the seal. The concept of IG seal failure is fully discussed in the Insulating Glass Seal Failure section.



While no amount of effort can assure the production of a trouble-free IG unit, there are certain IG manufacturers who participate in insulating glass certification programs to assure the production of a quality product. These certification programs administer independent testing of IG units based on ASTM standards to assure that the IG units produced meet performance test requirements and review quality control standards of the fabricators. The filming of certified IG units might present less of a risk than that of filming uncertified IG units.

Miscellaneous Glass

There are a number of different miscellaneous types of glass that may be encountered in the marketplace including wired. textured, and patterned glass. The manufacturing processes associated with these types of glass typically introduce surface and edge flaws that may make the filming of these products risky.

Simplified Frost Point Test

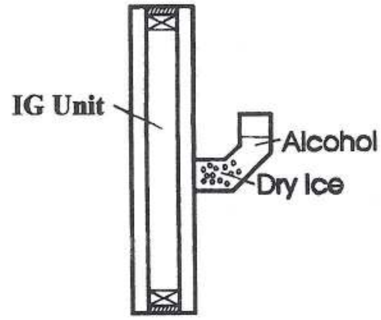
IG seal failure is one situation that this publication is intended to address. As noted previously, we are unaware of any technical information available that establishes a causal link between the application of window film and the failure of the IG seal. It is widely accepted that, when properly researched and tested, the addition of coatings or tinting to ordinary glass does not create a seal failure problem for IG units. It can be inferred that the effects of window film would be similar to the effects of coatings and tintings in glass. This notwithstanding, there is sometimes and an incorrectly perceived link between the application of window film and the observation of the signs of seal failure. This link could very well be nothing more than the effects of added attention on the IG units as a result of the application of the window film.

The first thing that must be realized about IG units is that all IG unit seals allow water vapor to migrate into the gas space at some rate. Water vapor can begin to migrate through the IG seal as soon as the IG unit is manufactured. The migration of water vapor through the IG seal is not the result of abuse or failure of the IG seal; it is simply the nature of the product. Quality IG units are manufactured with quality materials and have multiple seals which greatly retard the migration of water vapor through the seal and thus extend the useful life of the IG unit. The water vapor migration through the IG seal continues until the IG dessicant becomes saturated. At this point. the excess water vapor that migrates through the IG seal is no longer absorbed. It is then only a matter of time until the build-up of water vapor in the IG unit reaches a point where condensation becomes apparent on the inside surfaces of the IG units. The overall thermal performance of the IG unit is minimally affected by the build-up of water inside the gas space of the IG unit, unless the gas space was filled with an inert gas such as argon or krypton. However, the IG unit may appear to have failed, since it has become aesthetically altered.

With respect to such an IG issue, a film installer should properly inform the consumer of the inherent character of IG units, and he should avoid application of window film to IG units which appear to be in a state of imminent failure.

An important indicator of the condition of an IG unit is a measurement of the frost point of the IG unit. The frost point of an IG unit is determined through the application of a fairly straightforward test whereby a very cold metallic surface is placed into contact with the exterior surface of one of the glass plates that is incorporated in the IG unit. This contact is maintained as heat flows from the glass to the metal surface. The temperature at which water vapor contained within the IG gas space condenses and freezes to the inside surface of the glass plate is then recorded. This temperature is referred to as the frost point of the IG unit. The lower the frost point, the lower the content of moisture or moisture vapor within the IG unit gas space will be. A precise determination of the frost point of an IG unit is a very complicated and detailed procedure that involves the use of highly precise, expensive equipment and detailed test procedures. The administration of a controlled frost point test for every IG situation where a film application is under consideration is generally time-consuming and costly for the average film installer. Therefore, a simplified frost point test has been devised to identify those IG units that appear to be in a state of imminent failure.

To perform the simplified frost point test requires the use of a frost point instrument. The frost point instrument consists of a device that is fabricated of rigid copper tubing. The end of the tubing that is to be placed in contact with the IG unit is plugged, and the other end is fitted with a vented removable cap. The entire assembly is fitted with an exterior wrapping of insulation so that the energy gain through the sides of the pipe is minimal.



To use the frost point instrument, it is necessary to remove the cap from the copper pipe and fill the pipe with several chips of dry ice and ethyl alcohol. The removable pipe cap should then be replaced. During this operation, the operator should be careful to avoid direct contact with the copper pipe or the dry ice. Dry ice is solid carbon dioxide that vaporizes instead of melting. It is a convenient clean refrigerant to obtain subzero temperatures when used in an alcohol bath. Gloves or hand protection should be used to avoid any contact with the copper pipe, cold alcohol, or dry ice. Dry ice reaches a temperature of -109.1^{o}F (-78.5^{o}C).

The sealed end of the frost point tester should be held in contact with the exterior surface of the IG unit for a period of two minutes for 1/8" (3.0mm) or thinner glass, or four minutes for 1/4" (6.0mm) or thicker glass. At the end of this time, the frost point tester should be removed, and the contact surface of the IG unit should be quickly wiped with a cloth or tissue dampened with alcohol. Any accumulation of ice, fog, or water over 1/2" diameter on the gas space surface of the glass will indicate a leak in the seal of the IG unit. Film should not be applied to this window, unless the owner of the building issues a waiver of responsibility for the use of window film. If there is no observable buildup of ice, fog, or water on the inside surface of the glass, it does not mean that the IG unit will never fail. As stated earlier, all IG units will eventually fail as a result of excess moisture in the gas space. It does mean, however, that the unit is not in immediate danger of failure

Glass Thickness

For purposes of this discussion, there are three basic types of glass: monolithic, laminated, and insulated. Complet definitions of each of these glass types are presented in an earlier section. The true thickness of monolithic glass i defined as the overall thickness of the plate. Its value can be found through the use of a micrometer, a reflectiv thickness gauge, or an ultrasonic thickness device. Each of these instruments can provide reliable measurements fo the purposes of the current discussions. It should be noted that the true thickness of glass as determined through direc measurement is usually slightly less than the nominal thickness of glass that is used for commercial identification o the glass. The following table presents the relationship between nominal glass thickness and the minimum tru thickness of glass for glass thickness of interest. For example, a piece of glass with a true thickness of 0.223" (5.66mm should be referred to as 1/4" (6.0mm) glass.

Glass Thickness Table

Nominal Thickness in. (mm)	Minimum Thickness in. (mm)	Nominal Thickness in. (mm)	Minimum Thickness in. (mm)
3/32 (2.5)	0.085 (2.16)	1/4 (6.0)	0.219 (5.56)
lami (2.7)	0.012 (2.59)	5/16 (8.0)	0.292 (7.42)
1/8 (3.0)	0.115 (2.92)	3/8 (10.0)	0.355 (9.02)
5/32 (4.0)	0.149 (3.78)	1/2 (12.0)	0.469 (11.91)
3/16 (5.0)	0.180 (4.57)	3/4 (19.0)	0.719 (18.26)

The thickness of an IG unit is defined as the individual thickness of the monolithic glass plates that make up the IG unit. Thus, if an IG unit is constructed using two pieces of 1/8" (3.0mm) monolithic glass, its thickness should be recorded as 1/8" (3.0mm).

The nominal thickness of a laminated glass unit is found by doubling the nominal thickness of the glass plates that are incorporated into the laminated glass unit. Thus, if a laminated glass unit is constructed using two pieces of 1/8" (3.0mm) monolithic glass, the glass thickness of the laminated glass unit should be recorded as 1/4" (6.0mm). It should be noted that an ultrasonic thickness measurement made on a piece of laminated glass will provide the thickness of only one of the layers of the glass that is incorporated in the unit. A micrometer or optical measurement will provide the total thickness of the laminated glass plate (thickness of both glass plates plus the interlayer thickness).

As a general rule:

- The use of solar control film is not recommended for clear annealed glass if the thickness of the glass exceeds 3/8" (10.0mm).
- The use of solar control film is not recommended for tinted annealed glass if the thickness of the glass exceeds 1/4" (6.0mm).
- The use of solar control film is not recommended for clear or tinted annealed laminated glass of any thickness.

Check your film manufacturer's guidelines for specific recommendations regarding these special glass types.

Window Size

The window size is defined as the area of the glass. This area is calculated from the rectangular dimensions of the glass plate as determined through direct measurement using a standard tape measure of appropriate length. Once the dimensions of the window have been determined, the area of the window is calculated by multiplying the glass length by the glass width.

As a general rule:

- The use of solar control film is not recommended for monolithic annealed glass with areas in excess of 100 sq. ft.
- The use of solar control film is not recommended for annealed insulating glass units with areas in excess of 40 sq. ft.
- The use of solar control film is not recommended for annealed laminated glass of any thickness

Check your film manufacturer's guidelines for specific recommendations regarding these special conditions.

Framing Systems

Framing systems serve to minimize the edge deflection of the glass, keep water and air out of the building, and provide a method of cushioning as well as thermal isolation for the glass.

Wood, vinyl, and aluminum are commonly used for residential applications and, on occasion, for commercial use. Aluminum and steel are mostly used in commercial applications, with aluminum use found to be in the majority of the designs because of the diversity of shapes and ease of fabrication.

The framing system should be inspected to make sure that the glass will be given proper support and that the materials used are performing, not showing signs of deterioration that will lead to problems with other components.

In addition, it is important to check the amount of glass that is encapsulated in the frame and gasket assembly. This is typically referred to as edge bite. If the edge bite exceeds 1/2" for annealed glass, the risk of thermal breakage is greatly enhanced whether or not window film is applied. Therefore, window film should not be applied in this case.

Moisture in the Glazing System

One very important contributing factor to failures of insulating glass (IG) is from moisture and moisture vapor that penetrates the IG edge seals. This can occur from moisture that enters directly into the glazing system and does not exit in a short period of time. Some systems may also have condensation accumulation in the glazing system that becomes trapped, thus allowing moist conditions that can cause moisture vapor to enter into the IG unit more easily. Once the desiccant materials in the unit construction become saturated, the IG unit will exhibit the fogging and water droplets that indicate the presence of a seal that has failed.

Many glazing systems have a weep system incorporated in the framing system to avoid having moisture accumulate around the IG seals for prolonged periods of time. The weep system can consist of holes or slots that will normally drain away any unwanted moisture by gravity to the exterior of the building into a collection system whereby the moisture is deposited where it will not be harmful to the IG unit or building contents. Look for a weep system usually at the base or horizontal sill of the glazing system. Check to see what size the holes or slots are, where they are positioned, and whether or not they are operating properly. Some of the telltales as to whether a weep system works is when a stream or water marks show on the building exterior. When the system is malfunctioning or does not work, look for water stains around the glazing system or on the building interior, usually around the jambs and sill. Stains can occur at the ceiling and on interior wall finishes that may indicate there is water that is entering the glazing system that passes through as well as stays in the system. It is a sure bet that if some water is passing through, some also stays in the glazing channels that contribute to seal failures. One way to check a weep system is to pour water into the glazing channel and observe the weep holes/slots to see if the water exits.

The systems using insulating glass that do not have weep systems need to be examined as well, to be certain that moisture does not accumulate that will or is causing seal failures. Some of the basic inspection methods can be used as referenced in the previous paragraphs to determine if the system is performing adequately or if there may be problems.

Glazing Materials

Glazing materials such as gaskets, sealants, and tapes are used to provide a seal, glass cushion, and thermal isolation between the glazing material and the framing system. The function of the glazing material is to keep air, water, and other items from entering the frame/sash area that can cause deterioration of the insulating glass or the building interior along with other parts of the building wall system. Three common glazing materials are discussed.

Gaskets can be made of solid or foam sections and may be made of neoprene, EPDM, vinyl silicone, and other rubber type materials. Gaskets will need to be resistant to the elements and be able to maintain their elastic and hardness properties to properly seat and cushion the glass used in the system. Gaskets can be keyed or wedge type depending on the system and design requirements. Many systems use an interior and exterior gasket with the thickness, hardness, and profile engineered to apply a proper pressure on the glass with consideration given to tolerance of the glass, frame material, and gasket dimensions.

Sealants can be used individually or in combination with gaskets or tapes. Materials commonly used are silicones, polysulfides, polyurethanes, butyls, acrylics, and other materials that are gunnable and can be tooled to provide a designed shape. The proper choice of sealant will depend on such items as the joint size, expansion/contraction expectations, materials joined/sealed, and the environmental conditions that the material may encounter. Many sealant types come with various capabilities that require careful consideration to make certain that breakdown, loss of adhesion, improper support, or lack of proper isolation do not occur. Close attention to the performance characteristics and material compatibility with various surfaces, such as metal finishes, painted substrates, and other gasket/tapes must be considered for proper design of sealants used in a building wall system.

Tapes are commonly used in the design of a window system and provide similar functions as sealants and gaskets. Tapes are provided in solid and foam materials, usually having a rectangular cross-section. Tapes can be supplied with adhesive backing on one or two faces and can also be obtained in a butyl form with or without a sham. The design of a window system using tapes will require the tape to meet the pressure conditions as well as environmental and compatibility requirements of the building. Many designs utilize tapes as a backup to a sealant application, a temporary cushioning material while sealants are curing. These tapes can also provide a holding method prior to applying a final gasket.

Condition of Glazing Materials

When examining a window system, it is important to review and determine the condition of the glazing materials. This should be from the interior and exterior of the building. When the glazing materials do not appear to be functioning properly or have failed, the possibilities of thermal stress fracture and/or seal failure of insulating glass are drastically increased. The site inspection should include close examination to see if the glazing gaskets, sealants, or tapes are of the type that are shown on the drawings or as called out in glazing system specifications. When written documentation is not available, the glazing materials should still be carefully observed to determine if deterioration or lack of functionality is occurring. When sealants have lost adhesion to joining material or show splitting and cracking, the material is not likely doing the specified job anymore. This can allow water into the frame or cause loss of thermal isolation.

Gaskets and tapes can be disengaged or squeezed out of the original position. This can cause glass-to-metal contact and allow a metal frame to be in direct contact with glass, a situation which will worsen thermal stress conditions.

Check the dimensional thickness of the glazing material around the perimeter of the frame for uniformity. Inconsistent glazing material may lead to conditions of inadequate support and poor thermal isolation and may allow air and water infiltration.

Solar Exposure

When glass is subjected to the effects of solar radiation, the immediate result is an increase in the temperature of the glass. Depending upon shading and support conditions, the influx of solar radiation can lead to significant variations in temperature across the surface of the glass. Variations in glass surface temperature may lead to the introduction of thermally induced stresses.

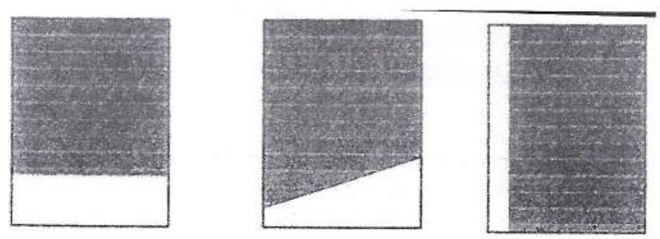
The level of solar exposure depends, to a large extent, on orientation of the glass. North-facing glass receives the least amount of solar exposure; as a result, thermal fractures associated with northerly facing glass tend to be rare. All other exposures tend to experience sufficient solar isolation to experience significant, thermally induced stresses. Glass that has a southerly exposure tends to experience the most dramatic overall heat buildup during the course of a day. Depending upon the conditions associated with the installation, thermal fractures can be expected on glass with southerly exposure.

Glass that faces toward the East has the possibility of experiencing the early morning effects of solar exposure. Such exposure can be extremely critical during winter months when glass that has had several hours to reach a very low temperature on a cold winter night is suddenly subjected to a blast of early morning sunlight. This situation often leads to thermal fracture if the conditions associated with the glass are conducive to glass failure. West-facing glass is subjected to the afternoon effects of the sunlight, which, depending upon conditions of the installation, can lead to similar significant thermal stresses. Therefore, it is important to note the exposure (N, NE, E, etc) of each glass plate. The possibility for thermal fracture can usually be discounted for glass plates with NW, N, or NE exposures in the Northern Hemisphere and the SE, S, or SW exposures in the Southern Hemisphere. However, it must be considered for all other exposures.

Exterior Shading Conditions

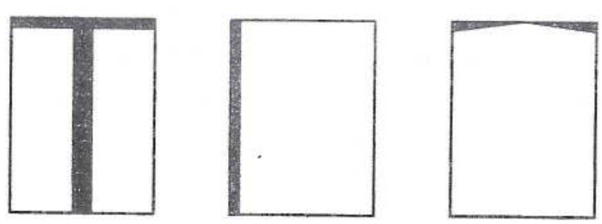
As stated in the preceding section, it is the uneven heating of glass (high temperature gradient) that leads to the introduction of thermal stress of sufficient magnitude to induce thermal fracture in glass. One way that a high temperature gradient can be introduced in glass is through uneven heating of the glass caused by exterior shading. Guidelines are widely available in the glass and film industries for the identification of critical exterior shading patterns. These guidelines can be summarized as follows:

1) It is generally accepted in the glazing industry that shading patterns that result in straight-line shadow boundaries on the glass where the shadow pattern encompasses most of the glass are acceptable for clear annealed glass. Even straight-line shadow patterns may, in some instances, cause problems for tinted or coated annealed glass, depending upon the dimension of the shadow and the time that it remains on the glass.



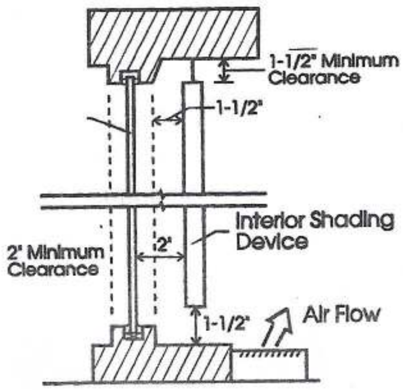
2) Shading patterns that result in angular or L-shaped shading patterns of moderate width around the perimeter are generally deemed acceptable for clear annealed glass and only marginally acceptable for tinted or coated glass.

3) Shading patterns where the shadow area is very narrow around the perimeter of the glass are generally deemed marginally acceptable for clear annealed glass and not acceptable for tinted or coated glass.



Interior Shading Devices

It is possible that interior window treatments and shading devices such as venetian blinds, draperies, etc. can create a heat trap next to a window that will exacerbate the temperature gradient problem. To alleviate heat trap problems, it is recommended that there be a minimum of a 2" clearance between the window treatment and the glass at all points. In addition, it is recommended that there be a minimum of 1½" clearance at the top and bottom of the window treatment, or a minimum of 1½" clearance at the bottom and one side of the window treatment. Finally, it is recommended that all heating and cooling outlets must be to the room side of the window treatment.



Glass Surface Condition

Glass is a brittle material whose strength is controlled almost completely by the character and distribution of flaws across the surface and edges of the glass. Some of the flaws are created in the manufacturing and fabrication, some are created during the handling and installation of the glass, and some are created during the in-service tenure of the glass. The in-service flaws are created by a wide variety of mechanical and environmental exposures that the glass surface comes into contact with while it is being installed in the building. It is known that the normal in-service conditions associated with typical glass plates can reduce the strength of glass by as much as 50 percent over the period of a few years. This strength reduction occurs with time and is the result of washing, cleaning, and normal exposures.

If the glass is subjected to more severe exposures, even further strength reductions can result. These more severe exposures are usually the result of extreme mechanical contact that results in abrasion, scratching, scarring, or other visible surface degradations. Hence, the appearance of visible surface or edge damage indicates that the strength of the glass may have been significantly reduced by the in-service conditions to which it was exposed. It is not recommended that window film be applied to glass with obvious signs of surface damage.

History of Glass Breakage

Often, a building has a history of unexplained glass breakage that could be caused by a wide variety of different factors. If the amount of unexplained glass breakage exceeds 1% of the total amount of glass exposed, caution should be exercised. Window film should not be applied until the causes of the breakage can be logically identified and explained. Many of the causes of glass breakage can stem from conditions that are unique to the building and will continue or be enhanced with the addition of film. Such items as surface and edge damage, shade patterns, or interior shade devices may be the contributors to unexplained breakage; thus, it is important to closely investigate each situation. Past building records should be sought to verify if any clues can be uncovered to ascertain the probable causes of the unexplained glass breakage.

Examination Procedure

Below is a list of factors that need to be considered when the application of window film to a particular set of windows is under consideration. These factors can be applied directly to make a preliminary judgement as to whether or not window film should be applied to a particular window system. This procedure may be utilized if the installation under consideration involves a set of windows with similar characteristics that would occur in a small residential application. In this case, it is recommended that the window film installer carefully examine a representative sample of the windows on which window film is to be applied prior to acceptance of the job. If the number of windows to be filmed is less than twenty, all of the units should be included in the sample. If the number of units to be filmed exceeds twenty, then a representative sample of twenty units should be selected for examination. The representative sample of windows should then be subjected to the examination described below. If any of the window units fail to successfully pass the examination, it is not recommended that window film be applied without consultation with the window film manufacturer.

If the job under consideration is more complicated than a small residential application (i.e. it involves window types, sizes, etc. as may occur with a large residential project or even larger commercial application), it is recommended that a more detailed procedure, as outlined below, be followed.

First, it is recommended that a sketch of the overall project be prepared on the project plan sheets provided at the end of the document. On the sketch, indicate the project name, the date, and the individual's name who is responsible for taking the data. In addition, indicate the approximate scale used in the drawing and provide an accurate indication of North on the sketch based on a reliable compass reading. All of the windows to be filmed should be clearly indicated and labeled with a unique identification number that should be entered in the film decision table described next. If the project involves a one-story structure, the sketch can be presented on a single page. Use additional pages as necessary for large or multi-story structures.

In addition, it is recommended that the film decision table be filled out. This presents a full description of each window identified with a unique number in the sketch of the proposed project. Indicate, in the blanks provided, the project name, the date, and the name of the individual responsible for taking the data. This table incorporates different listings for items that relate to thermal stress fracture or insulating glass seal failures. There are a total of 17 entries in the table. It should be filled out in its entirety for all types of windows to be filmed. Listed below is a discussion of the terms and information needed for table completion. The final entry in the table indicates whether or not it is recommended that film be applied to the window. If any entry in the table is unacceptable, the window film application should not be performed without consultation with the window film manufacturer.

The following provides a brief commentary of the information that is to be recorded in the film decision table for each entry listed.

1) **Window Number.** Enter the unique number that identifies each window examined in the building.

2) **Glass Type.** Enter the type of glass being examined -- annealed or heat-treated.

3) **Glass Color.** Enter the color of the glass -- clear or tinted/coated. If the glass is tinted/coated, enter the total solar absorption of the glass; if the glass color is tinted/coated and the total solar absorption is unknown, window film should likely not be applied.

4) **Glass Construction.** Enter the type of glass construction -- monolithic, laminated, or insulating glass.

5) **Simplified Frost Point Test.** Enter the results of the frost point test if the windows are insulating glass -- pass or fail.

6) **Glass Thickness.** Enter the thickness of the glass. Check the thickness against restrictions presented in this document.

7) **Window Size.** Enter the area of the glass. This is required to determine whether the window is larger than the guidelines for certain types of annealed and insulating glass products.

8) **Framing System.** Enter whether the window frame system is acceptable -- pass or fail. Factors involved in the evaluation of the framing system include edge bite, moisture conditions (whether or not moisture accumulates around insulating glass), as well as overall glass support conditions.

9) **Moisture in the Glazing System.** Enter whether the glazing system has moisture problems or not -- pass or fail. For insulating glass, it is important to establish whether the system retains water or moisture in the vicinity of the glass edge sealants. If it does, the glazing system fails.

10) **Glazing Materials.** Enter a brief description of the glazing materials used to provide perimeter support, cushioning, and sealing for the glass.

11) **Condition of Glazing Materials.** Enter whether the conditions of the glazing materials are acceptable -- pass or fail. The gaskets, sealants, and tapes should be investigated to determine whether or not the glass product provides cushioning and thermal isolation around the perimeter. If these have deteriorated, the glazing materials would likely fail.

12) **Solar Exposure.** Enter the direction of each window to the nearest quarter compass -- N, NE, E, etc.

13) **Exterior Shading Condition.** Enter whether or not the exterior shading conditions are acceptable, based on discussions presented in this document -- pass or fail. Review all shadow conditions that can affect the window.

14) **Interior Shading Device.** Enter whether or not the interior shading device clearances are met as discussed -- pass or fail.

15) **Glass Surface Condition.** Enter whether or not the surface of the glass has obvious damage, scratches, flaws, or other types of surface damage -- pass or fail.

16) **History of Glass Breakage.** Enter the percentage of unexplained glass breakage for this type of window. If the percentage exceeds 1%, film should not be applied to this type of window.

17) **Final Recommendation.** Enter whether or not window film should be installed for this type of glass based on the outcome of examination (film/no film). If any of the previous entries are negative, or if any conditions noted are unacceptable based on discussions presented in this document, the entry should likely be "no film". Window film should likely not be applied to this type of glass without detailed consultation with the window film manufacturer.

Once it has been determined that the windows under consideration have no inherent or latent defects, the film manufacturer's guidelines and recommendations should be consulted for individual film types for the application.

1 in. = ___ ft.

Designate North

Building Plan and Location of Windows

Project ________________

Date ________________

Drawn By ______________

Film Decision Table

1. Window Number					
2. Glass Type (Ann, HT)					
3. Glass Color (clear, tint/coated)					
4. Glass Construction (mono, lam, IG)					
5. Simplified Frost Point Test (pass/fail)					
6. Glass Thickness in. (mm)					
7. Window Size in. x in. (mm x mm)					
8. Framing System (pass/fail)					
9. Moisture in the Glazing System (pass/fail)					
10. Glazing Materials (description)					
11. Condition of Glazing Materials (pass/fail)					
12. Solar Exposure (N, NE, E, etc.)					
13. Exterior Shading Condition (pass/fail)					
14. Interior Shading Device (pass/fail)					
15. Glass Surface Condition (damaged/undamaged)					
16. History of Glass Breakage (% unexplained)					
17. Final Recommendation (film/no film)					

Project ________________ Date ________________ Prepared By ________________

Recommended Tool Kit

Thickness Gauge -- This device is a handheld card or a metering-type instrument that determines the thickness of the glass during inspection. Either of the devices is adequate to determine the approximate or exact glass thickness that is being examined.

Magnifier -- At least a 5-power magnifier should be used to examine specific items around the glazing opening, such as identification marks of the glass manufacturer, certain logos on the glass, or other significant items relating to the glazing system that are difficult to detect without magnification.

Measuring Tape -- A 16 ft. or greater measuring tape should be used to determine the overall dimensions of the window. This tape can also be used to determine the actual layout of the building project.

Machinist Scale (6 in.) -- This tool can be used to measure items such as the face clearance and the dimensions around the glazing system relative to the frame, as well as other important parts of the glass and glazing system up close.

Caliper -- This tool can also be used to measure dimension and thickness of parts of the glazing system or glass thickness when the glass is removed or access is available to the edge of the glass.

Glass Bite Tool -- This tool is inserted along the edge of the glass, between the surface and frame if possible, to determine the actual engagement of the glass into the glazing frame.

Polarized Film -- This film is used to observe the actual strain pattern in the glass, which will determine whether or not the glass has been heat-treated. A very specific pattern of dark blotches and other traits will be readily identified in heat-treated glass.

Dew Point/Frost Point Tester -- This testing equipment is to be used in conjunction with dry ice and alcohol to determine whether or not frost point and dew point conditions are of concern with regard to insulating glass.

Ice Pick -- A simple ice pick is needed to chip the dry ice for use in the frost point device.

Gloves -- A pair of leather gloves should be worn by the operator of the frost point device to prevent cold burns to the skin.

Plastic Bowl -- A small plastic bowl is useful to hold dry ice while it is being chipped.

Stop Watch -- A stop watch is useful for timing the contact time of the front point device.

Towels -- Absorbent towels are useful for wiping excess alcohol that may be spilled during the use of the frost point device.

Cooler -- A small cooler is necessary to contain the dry ice while utilizing the dew point/frost point tester.

Compass -- The compass is used to determine the actual orientation of the building project, as well as determining the direction that specific glass units are facing in the building.

Glazing Stick -- This is a nylon or plastic tool that is used to place pressure around the perimeter of the gasketing or sealant system to determine whether or not there is adhesion, as well as to check the elastic condition of the material. It is also used to help seat or remove gaskets on occasion.

Small Hand Tools -- Items such as screwdrivers (flat/Phillips) and a set of pliers are handy to remove any items that can be removed with ease, or, if necessary, to check certain items on the glazing system.

Glass Cleaner and Wipes -- These items are necessary to determine whether or not certain deposits or conditions on the glass surface are permanent or temporary with regard to removal and cleaning.

Camera -- A small handheld camera should be used to photograph any specific condition that may be questionable or desired for record purposes. The camera should also be used to take photos of areas that may be difficult to describe or remember when taking data for the evaluation.

Clipboard/Notepad -- The clipboard and notepad should be used to obtain pertinent data that is to be recorded in the data collection. Also, any additional sketches or notes that need to be taken during the site inspection can be accommodated with this item.

Carrying Case -- This is used to place all the tools and other items that may be necessary to transport to the project site. Other items that should be placed in the carrying case would be a towel and additional wipes, along with miscellaneous tools that are collected and useful during the data collection process and inspection of the glass and glazing system.