GLASS ASSOCIATION OF NORTH AMERICA

Glass Informational Bulletin **GANA 01-0300**

Proper Procedures for Cleaning Architectural Glass Products

Architectural glass products play a major role in the comfort of living and working environment of today's homes and commercial office spaces. By providing natural daylight, views of the surroundings, thermal comfort and design aesthetics, glass usage and condition often affect our selection of where we live, work, shop, play and seek education.

Architectural glass products must be properly cleaned during construction activities and as a part of routine maintenance in order to maintain visual and aesthetic clarity. Since glass products can be permanently damaged if improperly cleaned, glass producers and fabricators recommend strict compliance with the following procedures for properly cleaning glass surfaces.

As dirt and residue appear, interior and exterior glass surfaces should be thoroughly cleaned. Concrete or mortar slurry which runs down (or is splashed on) glass can be especially damaging and should be washed off as soon as possible. Before proceeding with cleaning, determine whether the glass is clear, tinted or reflective. Surface damage is more noticeable on reflective glass as compared with the other glass products. If the reflective surface is exposed, either on the exterior or interior, special care must be taken when cleaning, as scratches to the reflective glass surface can result in coating removal and a visible change in light transmittance. Cleaning tinted and reflective glass surfaces in direct sunlight should be avoided, as the surface temperature may be excessively hot for optimum cleaning. Cleaning should begin at the top of the building and continue to the lower levels to reduce the risk of leaving residue and cleaning solutions on glass at the lower levels. Cleaning procedures should also ensure that the wind is not blowing the cleaning solution and residue onto already cleaned glass.

Cleaning during construction activities should begin with soaking the glass surfaces with clean water and soap solution to loosen dirt or debris. Using a mild, non-abrasive commercial window washing solution, uniformly apply the solution to the glass surfaces with a brush, strip washer or other non-abrasive applicator. Immediately following the application of the cleaning solution, a squeegee should be used to remove all of the cleaning solution from the glass surface. Care should be taken to ensure that no metal parts of the cleaning equipment touch the glass surface and that no abrasive particles are trapped between the glass and the cleaning materials. All water and cleaning solution residue should be dried from window gaskets, sealants and frames to avoid the potential for deterioration of these materials as the result of the cleaning process.

It is strongly recommended that window washers clean a small area or one window, then stop and examine the surface for any damage to the glass and/or reflective coating. The ability to detect certain surface damage, i.e. light scratches, may vary greatly with the lighting conditions. Direct sunlight is needed to properly evaluate a glass surface for damage. Scratches that are not easily seen with a dark or gray sky may be very noticeable when the sun is at a certain angle in the sky or when the sun is low in the sky.

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The glass industry takes extreme care to avoid glass scratches by protecting all glass surfaces during glass manufacturing and fabrication, as well as during all shipping and handling required to deliver the glass to the end user. A large percentage of damaged glass results from non-glass trades working near glass. This will include painters, spacklers, ironworkers, landscapers, carpenters and others who are part of the construction process. They may inadvertently lean tools against the glass, splash materials onto the glass and/or clean the glass incorrectly, any of which can permanently damage glass.

One of the common mistakes made by non-glass trades people, including glass cleaning contractors, is their use of razor blades or other scrappers on a large portion of the glass surface. Using 2, 3, 4, 5 inch and larger blades to scrape a window clean carries a large probability for causing irreparable damage to glass.

The entire industry of glass manufacturers, fabricators, distributors, and installers neither condones nor recommends widespread scraping of glass surfaces with metal blades or knifes. Such scraping will often permanently damage or scratch the glass surfaces. When paint or other construction materials cannot be removed with normal cleaning procedures, a new 1" razor blade may need to be used only on non-coated glass surfaces. The razor blade should be used on small spots only. Scraping should be done in one direction only. Never scrape in a back and forth motion as this could trap particles under the blade that could scratch the glass. This practice may cause hairline concentrated scratches, which are not normally visible when looking through the glass, but may be visible under certain lighting conditions.

Jobsite storage and construction conditions can lead to stains on the glass surface. Cleaning and removal of such stains may require the use of a more aggressive cleaning solution and procedure. If conditions are found that cannot be cleaned using the above procedures, contact the glass supplier for guidelines on stain removal.

Members of the Glass Association of North America (GANA) publish information relating to jobsite protection and cleaning of architectural glass products. In order to ensure long-term performance of the glass in a building, GANA encourages glazing contractors, general contractors, building management and owners to be aware of conditions that can damage glass and to follow the handling and cleaning guidelines provided by their glass producer and fabricator.

Consult the GANA website (www.glasswebsite.com) for additional information on glass and glazing applications and links to members providing additional technical resources.

The Glass Association of North America (GANA) has produced this Glass Information Bulletin solely to provide general information as to basic proper procedures for cleaning architectural glass products. The Bulletin does not purport to state that any one particular type of glass cleaning process or procedure should be used in all applications or even in any specific application. The user of this Bulletin has the responsibility to ensure the cleaning instructions from the glass supplier are followed. GANA disclaims any responsibility for any specific results relating to the use of this Bulletin, for any errors or omissions contained in the Bulletin, and for any liability for loss or damage of any kind arising out of the use of this Bulletin.

Quick-Reference Guide to Cleaning Architectural Glass Products

The following "Do's" and "Do Not's" are offered as a supplement to the Glass Association of North America (GANA) Glass Informational Bulletin – *Proper Procedures for Cleaning Architectural Glass Products*:

The following are things to DO:

- DO clean glass when dirt and residue appear
- DO determine if coated glass surfaces are exposed
- DO exercise special care when cleaning coated glass surfaces
- DO avoid cleaning tinted and coated glass surfaces in direct sunlight
- DO start cleaning at the top of the building and continue to lower levels
- DO soak the glass surface with a clean water and soap solution to loosen dirt and debris
- DO use a mild, non-abrasive commercial window cleaning solution
- DO use a squeegee to remove all of the cleaning solution
- DO dry all cleaning solution from window gaskets, sealants and frames
- DO clean one small window and check to see if procedures have caused any damage
- DO be aware of and follow the glass supplier's specific cleaning recommendations
- DO caution other trades against allowing other materials to contact the glass
- DO watch for and prevent conditions that can damage the glass
- DO read the entire GANA bulletin on glass cleaning before starting to clean glass

The following are things to NOT do:

- DO NOT start cleaning without reading the entire GANA bulletin on glass cleaning
- DO NOT use scrapers of any size or type for cleaning glass
- DO NOT allow dirt and residue to remain on glass for an extended period of time
- DO NOT begin cleaning glass without knowing if a coated surface is exposed
- DO NOT clean tinted or coated glass in direct sunlight
- DO NOT allow water or cleaning residue to remain on the glass or adjacent materials
- DO NOT begin cleaning without rinsing excessive dirt and debris
- DO NOT use abrasive cleaning solutions or materials
- DO NOT allow metal parts of cleaning equipment to contact the glass
- DO NOT trap abrasive particles between the cleaning materials and the glass surface
- DO NOT allow other trades to lean tools or materials against the glass surface
- DO NOT allow splashed materials to dry on the glass surface

This bulletin was developed by the GANA Tempering Division - Construction Subcommittee and approved by the Tempering Division - Standards & Engineering Committee and GANA Board of Directors. This is the original version of the document as approved and published in March 2000.

ASSOCIATION OF NORTH AMERICA

Glass Informational Bulletin **GANA TD 02-0402 (Reapproved 2008)**

Heat-Treated Glass Surfaces Are Different

Industry Cleaning Procedures Must be Followed to Avoid Glass Damage

As the use of glass increased over recent years, issues of strength, safety and thermal performance became increasingly important design considerations. The availability of tinted and coated glasses had a dramatic impact on glass use in building projects. The vastly expanded aesthetic options, combined with the improved energy conserving and comfort capabilities of tinted and coated glasses allowed architects to use more glass, as well as larger sizes in their designs. A consequence of this trend was a corresponding increase in the use of tempered and heat-strengthened glass in order to meet both thermal and windload design requirements. The demand for tempered glass further increased with the passing of safety glazing legislation in 1977, which mandated its use in certain locations.

Currently, there are two types of heat-treated glass as defined in the American Society for Testing and Materials (ASTM) C 1048 - *Standard Specification for Heat-Treated Flat Glass – Kind HS, Kind FT Coated and Uncoated Glass*. The two types are heat-strengthened (Kind HS) and fully tempered (Kind FT). Both types of glass are produced using the same equipment. A majority of the heat-treated glass produced over the last 30 years has been fabricated in horizontal roller hearth furnaces. The preparation stage for the heat-treatment process requires annealed float glass to be cut to the required final size, the edges to be treated according to the specified finish (commonly seamed or polished) and the glass to be washed. The process then requires the glass to be transported on horizontal rollers through an oven and heated to approximately 1,150° F (621° C). Upon exiting the furnace, the glass is rapidly cooled (quenched) by blowing air uniformly onto both surfaces simultaneously. The cooling process leaves the surfaces of the glass in a state of compression and the central core in compensating tension.

The color, clarity, chemical composition and light transmission characteristics of glass remain essentially unchanged after heat-treating. Likewise, hardness, specific gravity, expansion coefficient, softening point, thermal conductivity, solar optical properties and stiffness remain unchanged by the heat-treating process. The only physical properties that change are improved flexural and tensile strength, and improved resistance to thermal stresses and thermal shock. Under uniform loading, heat-treated glass is stronger than annealed glass of the same size and thickness. The heat-treating process does change the break pattern of the glass, i.e. fully tempered glass disintegrates into relatively small pieces meeting the safety glazing requirements and thereby greatly reducing the likelihood of serious cutting or piercing injuries.

As mentioned, the heat-treating process typically involves the transport of very hot glass on rollers. As a result of this soft glass-to-roller contact, some glass surface changes will occur. Minute glass

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particles (fines) from the glass cutting and edging process, typical manufacturing plant air-borne debris or dust, refractory particles from the tempering oven roof, as well as external airborne dirt and grit carried into the plant by the large volumes of quench air used in the process, may adhere to one or both glass surfaces. Also, the physical contact of the soft glass surface with the rollers may result in a marking or dimpling of the glass surface. Current glass quality specifications contained in ASTM C 1036- *Standard Specification for Flat Glass*, establish the size and number of glass imperfections allowed based on specific visual inspection criteria. The glass surface conditions listed above are not usually visible to the eye under normal visual circumstances. These surface conditions do not threaten the visual nor structural integrity of the product, and are not reason for rejection of glass under the ASTM consensus standards.

However, despite being invisible, such surface conditions can be detectable to the touch. This difference in "feel", between annealed and heat-treated glass, can lead to issues during cleaning of the glass, as glass cleaning workers attempt to remove microscopic particles. With the best of intentions, they may attempt to scrape particles that can be felt, but not seen, and very often end up scratching and chipping the glass surface.

Additionally, once the glass is delivered to the construction site, construction materials and debris may be deposited on the glass. Paint, stucco, concrete, adhesives, and other materials may be splattered on the glass and left there for long periods of time. These materials and the methods for removing them may also damage the glass surface.

It is important to note that the recommended cleaning procedures for heat-treated glass are the same as for annealed glass. The use of scrapers, abrasives, and harsh chemical cleaning agents is not recommended for any glass product because they can cause irreparable damage. With the best of intentions, window cleaners, and other tradesmen, may attempt to remove construction dirt and debris from the glass surface by scraping the surface. This can lead to glass damage, such as scratching and chipping if any microscopic particles have adhered to the surface and are dislodged and transported across the glass in the scraping process.

Acceptable cleaning procedures are available from glass manufacturers and fabricators. In addition, the Glass Association of North America has published a Glass Information Bulletin entitled, *Proper Procedures for Cleaning Architectural Glass Products,* which includes industry recommended cleaning procedures, as well as a list of Do's and Do Not's.

Heat-treated glass products are critical components of today's high-performance coated, insulating, laminated, spandrel, safety glazing, bullet-resistant, blast-resistant, and hurricane-resistant fenestration products. Millions upon millions of square feet of heat-treated glass have been installed and have provided trouble free performance for almost 50 years. Continued use of acceptable cleaning practices, combined with good judgment, will prevent glass damage and enable the glass to maintain its original attractive appearance for years to come.

This bulletin was developed by the GANA Tempering Division - Construction Subcommittee and approved by the Tempering Division - Standards & Engineering Committee and GANA Board of Directors. The document was originally published in April 2002. This edition of the bulletin provides the most recent update and published in May 2008.

Oldcastle BuildingEnvelope

GLAZING INSTRUCTIONS

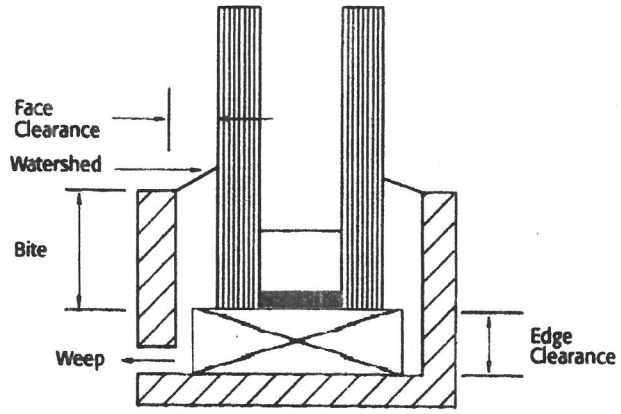
OLDCASTLE BUILDINGENVELOPE® INSULATING GLASS UNIT WARRANTY IS DEPENDENT UPON STRICT ADHERENCE TO THESE GLAZING INSTRUCTIONS

CAUTIONS

1. The Oldcastle BuildingEnvelope® Insulating Glass Unit (IGU) warranty will be void under any of the following circumstances: if glass breakage occurs; if the IGU is installed in a glazing system that retains any liquid near, or in contact with the IGU edge; if an IGU with a non-silicone secondary seal is used in either a sloped glazing application or 4-sided structural silicone glazing (SSG); if there is any chemical or physical damage to the IGU primary and/or secondary sealants; if an acetoxy silicone sealant is used in close proximity to a neutral cure silicone IGU; or if capillary breather tubes are installed in the IGU's but the Oldcastle BuildingEnvelope® proper closing procedure is not strictly followed.
2. The Oldcastle BuildingEnvelope® Insulating Glass Unit (IGU) warranty will be void under any of the following circumstances without a technical project review and written acceptance of the application: if solar-absorbing film, shades, blinds, or any foreign material are used on or near the surface of the glass that causes higher thermal or mechanical stresses; if all sides of the IGU are not fully supported (including, but not limited to, butt-glazed without interior mullion support); if the IGU is installed in high humidity environments (including, but not limited to, swimming pool enclosures and greenhouses) or high vibration environments.
3. Failure of any Oldcastle BuildingEnvelope® product due to incompatibility with any other product not supplied by Oldcastle BuildingEnvelope® (including, but not limited to, blocks, gaskets, glazing sealants, spacers, tapes, plasticizing oils and solvents) voids all warranties and exonerates Oldcastle BuildingEnvelope® from any liabilities.
4. Setting blocks and anti-walk blocks must be silicone for IGUs used in 4-sided SSG, sloped glazing, and with IGUs that have gray silicone secondary sealant. Silicone or silicone compatible EPDM setting blocks and anti-walk blocks can be used in conventional 4-sided captured glazing and vertical 2-sided SSG.
5. Do NOT use razor blades or broadknife blades of any kind to clean glass. Oldcastle BuildingEnvelope® is not responsible for scratches and/or damage caused by window cleaners or other construction tradesmen.
   Follow GANA *Proper Procedures for Cleaning Architectural Glass Products*, available at http://www.glasswebsite.com/techcenter/default.asp.
6. Use of all abrasives, chemicals, or other surface treatments should be spot tested and evaluated under actual use conditions and under various lighting extremes before proceeding with use.

The following Glazing Instructions are intended to assist the design professional and installer. Additional glazing recommendations and guidelines provided by GANA, AAMA and IGMA must also be followed. If there is any variation in glazing recommendations, the more stringent guideline will apply.

1. **Glass Handling & Protection** - Care must be exercised in the handling and the glazing of glass to prevent edge damage. The glass must not contact the framing members, or other metal components such as screws, during glazing. Glass must be protected from weld splatter, blasting and other impact damage. Alkali or fluorinated materials released from concrete or masonry during rainstorms can stain or etch glass. Weathering steel releases oxides while aging which can result in stained glass if proper periodic cleaning is not done. Solutions used to restore or neutralize masonry surfaces can attack glass and first surface pyrolytic reflective coatings.
2. **Glass Storage** - Glass should be kept on a lean of 5-7° from vertical using broad, sturdy uprights. Never store glass in sunlight without using an opaque cover to protect it. Glass should be stored in a dry, clean and cool location where the temperature is above the dew point. Circulation of dry, cool air is required especially after periods of high humidity and cyclic temperatures. If glass must be stored outdoors, use tarps or plastic coverings to protect it from getting wet, and vent periodically to prevent moisture accumulation. Repeated wetting and drying of glass surfaces can result in staining or etching of the glass.
3. **Glazing Frames** - Frames must be square, in plane, free of any internal obstructions and structurally adequate.
   a. Squareness: 1/8" maximum diagonal difference
      i. Bow: 1/16" maximum per any 4' length
      ii. Plumbness: 1/16" per 6' length
      iii. Corner Joint Offset: must not exceed 1/32" of adjoining members
   b. Design Load Deflection: Unless applicable codes or the design professional establish a more stringent requirement, deflection of framing members supporting glass shall not exceed the length of the unsupported span divided by 175 (L/175).
   c. Dead Load Deflection: Horizontal Framing Member deflection should not reduce glass bite by more than 25% of design dimension, nor reduce edge clearance of glazing below to less than that required to prevent glass to metal contact. Refer to the chart on the following page for recommended clearance and bite values.
   d. Dead Load Twisting: Twisting of the horizontals due to the weight of glass should not exceed 1°, measured between ends and center of each span.
   e. Edge and Face Clearance, and Bite: The glazing system must have adequate edge and face clearance to 'cushion' the glass, thermally isolate the glass from framing members, and prevent glass-to-metal contact. An adequate bite is required to provide proper seal; however, excessive bite could increase thermal stresses. Refer to the chart on the following page for recommended clearance and bite values, and exceptions.
4. **Glazing Weep System** –The glazing system should be designed so that any liquid entering the glazing channel drains out quickly. Setting blocks must not hinder the flow of liquid from the glazing channel. Retention of any liquid at close proximity to the IGU edge may lead to seal failure and void the IGU warranty.
5. **Glass Installation**
   a. Setting Blocks – All lites of glass should be set on 2 identical setting blocks with a Shore A durometer hardness of 80 to 90. The preferred location is at 1/4 points of the sill. In some cases it may be necessary to move the blocks equally closer to the corner of the unit but not closer than 1/8 points or 6" from the edge, whichever is greater. The setting blocks should be sized to provide 0.1" of length per square foot of glass but not less than 4" long. Setting blocks should be wider than the IGU thickness in a conventional framing system. In an SSG application, the setting block must support a minimum of half of the outer lite thickness. Setting blocks should not block the weep holes or prevent water from exiting the frame quickly. The thickness of the setting block should provide the recommended nominal bite and minimum edge clearance for the glass. When a lock strip gasket glazing system is used, each setting block should be sized to provide 0.4" of length per square foot of glass area, but not less than 6" long. The lock strip gasket manufacturer should recommend the height of the blocks. Any deviation from the setting block requirements must be approved by Oldcastle BuildingEnvelope® in writing.
   b. Edge Blocks, or anti-walk Blocks – All dry-glazed lites of glass should have at least one edge block per jamb that has a Shore A durometer hardness between 50 to 70. Blocks should be a minimum of 4" long, placed in the vertical channel and sized to allow a nominal 1/8" clearance between the edge of the glass and block.
6. **Dry-Glazing Methods**
   a. Pressure-Plate Gaskets: These gaskets must apply pressure onto the glass uniformly between 1/8" to 9/16" from the unit edge. The sealing pressure should be in the range of 4 to 10 pounds per linear inch, which should be achieved by tightening the pressure plate fasteners with torque controlled wrenches. The fasteners should be tightened at quarter points of sill, then quarter points of head, then quarter points of jambs, and then the remaining bolts. Excessive torque on the pressure plate fasteners may contribute to glass breakage, or cause squeeze out of the PIB into the vision area.
   b. Wedge Gasket Glazing: Wedge gaskets must be properly sized and installed so that the gasket is crowded, not stretched. Refer to the system manufacturer's instructions for proper sizing and installation procedure.
   c. Structural Gasket Glazing (Lock Strip Glazing): This system must have a continuous wet sealant applied as a cap bead to the exterior glazing leg.
7. **Capillary Tubes** - IGUs that experience an elevation difference of 2,500 feet or more in transportation or installation location from the IGU manufacturing elevation may require capillary tubes. These tubes will be installed on the IGU vertical edge and must be cut, sealed, and then pointed downwards after the IGUs have stabilized for 72 hours (or until flat) at final destination. Oldcastle BuildingEnvelope® Closing Procedure for Capillary Tubes is available on request from any Oldcastle BuildingEnvelope® plant. Failure to follow the Oldcastle BuildingEnvelope® closing procedure will void the IGU warranty.



(1) Specialty glazing system designs such as ones with glazing tape or sealant back-bedding may be designed for reduced face clearance. Deviations from typical clearances should be fully considered within the context of the design and expected performance of the glazing system. Consult glass manufacturer, fabricator, glazing material manufacturer, and/or design professional for relevant performance properties
(2) Annealed glass
(3) Fully tempered and heat-strengthened glass

TYPICAL FACE & EDGE CLEARANCE & BITE

GLASS TYPE	GLASS THICKNESS		MINIMUM FACE CLEARANCE (1)	MINIMUM EDGE CLEARANCE	MINIMUM BITE
	inches	mm	inches	inches	inches
Single Glazing	3/32	2.5	1/16	1/8	1/4
	1/8 (2)	3	1/8	1/8	1/4
	1/8 (3)	3	1/8	1/4	3/8
	5/32	4	1/8	3/16	5/16
	3/16 (2)	5	1/8	3/16	5/16
	3/16 (3)	5	1/8	1/4	3/8
	1/4	6	1/8	1/4	3/8
	3/8	10	3/16	5/16	7/16
	1/2	12	1/4	3/8	7/16
	5/8	16	1/4	3/8	1/2
	3/4	19	1/4	1/2	5/8
	1	25	1/4	1/2	3/4
Spandrel	1/4	6	3/16	1/4	1/2
Insulating Glass	1/2	12	1/8	1/8	1/2
	5/8	16	1/8	1/8	1/2
	3/4	19	3/16	1/4	1/2
	1	25	3/16	1/4	1/2
	1-1/8	28	3/16	1/4	1/2

Thermal Stress

Thermally induced edge stresses are usually the result of the warmer center portion of a glass lite being exposed to solar energy and wanting to expand more than the cooler edges. The amount of thermal stress is dependent on the glass type, size, thickness, and shape, and how it is isolated from the framing system. Other factors are building orientation, interior shading devices, exterior shading patterns, heating register location, etc. Heat-strengthening and tempering increases glass edge strength and decreases the chance for thermal breakage. The following conditions must be taken into account when considering the effects of thermal stress:

1. **Interior Heat Traps** — These situations occur when there is inadequate air circulation to properly remove heat from behind the glass. Spandrel areas are a good example of where glass must be heat-strengthened or tempered to avoid thermal stress breakage. Insulation must be held back from the surface of heat-strengthened spandrel glass a minimum of 1". Placing insulation against the back of spandrel glass is not permitted without a thermal stress review and written approval.

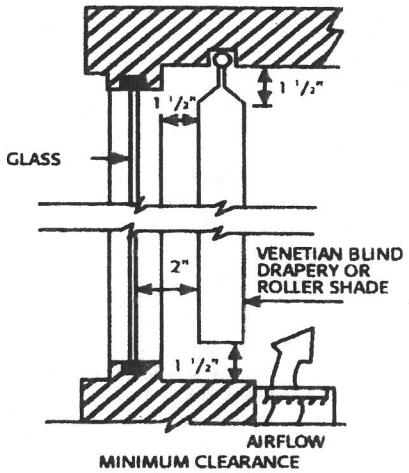
In vision areas, air movement must not be restricted. Suspended ceilings must be well to the room side to allow natural convection. Or the head area should include vents that provide a minimum one square inch of ventilation for each inch of glass width. Or the glass should be heat-strengthened or tempered.

2. **Interior Shading** — Draperies, venetian blinds or other interior shading devices must be hung with space to permit natural air movement over the room side of the glass. The following criteria must be met to avoid formation of a heat trap:

A. Minimum 1-1/2" clearance required top and bottom, or one side and bottom, between the shading device and the surrounding construction.
B. Minimum 2" clearance between glass and shading device.
C. Heating/cooling outlets must be to the room side of the shading device with airflow directed away from the glass.
D. Use mechanical stops to prevent complete closure of blinds to 60% of closed position.

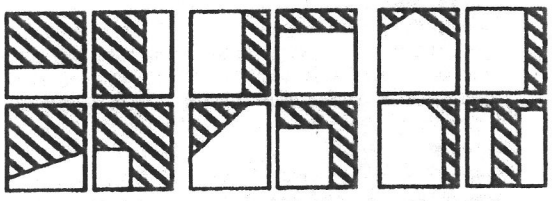
Heat-strengthening or tempering of the glass may be necessary to offset the effects of a lack of adequate ventilation.

3. **Exterior Shading** — Shadows cast by overhangs, light shelves, sunshades, surrounding structures, trees and shrubbery can create shading patterns on the glass, creating thermal edge stress. Maximum stress occurs when 25% or less area of a lite is shaded and the shade includes more than 25% of the perimeter. Generally, horizontal, vertical, and diagonal shading patterns are not as critical as shading that combines several patterns. Double diagonal shading is generally the most critical pattern. See the sketches of typical shading patterns that are labeled "Acceptable", "Marginal", and "Harmful". Oldcastle BuildingEnvelope® Technical Services will offer suggestions on the need to heat-treat the IGU when requested.



MINIMUM CLEARANCE

EXTERIOR SHADING PATTERNS



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GLASS ASSOCIATION OF NORTH AMERICA
The Voice of the Glazing Industry

International Window Cleaning Association

Glass Informational Bulletin **GANA TD 03-1003 (Reapproved 2010)**

Construction Site Protection and Maintenance of Architectural Glass

Steps Must Be Taken to Avoid Permanent Damage to Glass

Architectural glass products used in windows, doors and skylights for today's residential and commercial building projects are more sophisticated than those used in earlier fenestration applications. Performance requirements call for glass to be coated and used in an insulating glass unit in order to be more energy efficient; and often heat-treated and laminated to provide greater strength, safety, and security. As a result of increased performance capabilities, more high performance glass is being used in both residential and commercial construction. The higher valued products and their greater susceptibility to damage have increased the importance of proper site storage, handling, installation and protection throughout the construction process.

During glass manufacturing, fabrication and installation, products are carefully handled to prevent surface and edge damage. Materials are packaged to provide protection during shipment and delivery. Once finished materials are placed on a construction site, they become exposed to a variety of conditions and influences that can adversely affect product aesthetics and functionality. Irreparable glass damage can occur from improper storage and handling, exposure to chemicals and leaching agents, prolonged exposure to moisture, mechanical attack and breakage, damage related to adjacent construction activities and improper cleaning methods.

Site Delivery and Storage

Windows, doors and skylights for residential construction typically arrive on construction sites preglazed, while commercial construction applications often require glass be delivered to the site and glazed at a later date. In both types of construction, it is vital that materials be properly stored for the duration of the construction process. The complex nature of construction projects and site management requires well-planned and executed material delivery and storage. The following is a list of recommended practices that glazing subcontractors should observe for site delivery and storage of fenestration materials:

- Consult glass and glazing system suppliers for specific recommendations on the site storage, handling, installation, and protection of their materials before any work is started.

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- Coordinate glass deliveries, to the extent practical, to minimize on-site storage durations.

- Work with the general contractor or builder to select on-site under-roof storage locations that avoid direct rain and water runoff, work areas of other trades, and areas of high traffic and to minimize material movement and handling.

- Secure, block, and brace individual cases of glass and preglazed materials to prevent falls.

- Ensure blocks or supports keep the bottom edge of materials well above potential puddles of rainwater or other conditions that could cause damage.

- Provide secure, temporary covering that prevents direct water flow, but ensures ventilation and combats condensation buildup on the glass.

- Clearly mark storage areas of glass cases and preglazed materials using colored ribbons or tape.

- Ensure that glazing components held in storage are not subjected to deposits from concrete and masonry building materials or hard water spotting from various sources of tap water at the job site.

- Ensure that stored materials are not exposed to activities of other trades such as welding, painting, insulating, and fireproofing.

- Establish a program for daily inspection of stored glass and glazing systems to monitor conditions and ensure prompt corrective action when needed.

- Follow manufacturer's guidelines when using temporary protection films.

- Do not allow protective films to remain on the surface beyond their useful life, as removal methods may damage certain types of glass and/or their coatings.

- Do not expose open packs of glass to direct sunlight as the insulating effects of the glass layers may increase the thermal stress in the glass and may result in glass breakage.

Trade Awareness

As fenestration materials are delivered to a residential or commercial construction site, it is recommended that the glazing subcontractor and window cleaner contact the general contractor (in person and follow up in writing) to let him know how important it is that he make all construction trades aware of the potential for permanent damage and their level of responsibility in the event materials are subjected to harmful conditions. In the event of damage, prompt action is required to minimize damage.

Site Handling and Installation

Glass and glazing system manufacturer's recommendations for site handling and installation procedures should be followed. Residential and light commercial windows, doors, and skylights should be installed in accordance with ASTM International document E 2112 – *Standard Practice for Installation of Exterior Windows, Doors and Skylights.* Glass for commercial glazing applications should be handled and installed in accordance with guidelines set forth in the Glass Association of North America (GANA) *Glazing Manual.*

Post Installation Inspection and Protection

After installation, special attention by all trades should be given to construction activities in order to prevent exposure of glass in windows, doors and skylights to weld splatter, paint, plaster, sealants, fireproofing, and alkali and chemical attack. The subcontractor, general contractor, or builder should inspect and document the condition of the glazed materials on a daily basis. At this stage of construction, the glazing subcontractor should request, in writing, that the general contractor or builder remind other construction trades of the potential for irreparable damage to the glazed materials and to implement systems and procedures for protection. The following is a list of common conditions and causes that damage glass after installation:

Condition: Glass surface corrosion often characterized by permanent iridescent or white haze surface staining
Cause: Glass got wet during storage due to reasons such as, but not limited to, being stored outside uncovered, or extended storage with inadequate ventilation and/or improper glass separation

Condition: Glass surface or edge damage
Cause: Inadequate on-site protection; ill-advised or vulnerable storage locations; exposure to other trades

Condition: Chemical attack, surface pitting and hard-to-clean deposits
Cause: Overspray and runoff of chemicals from sealing/cleaning of concrete, masonry, roofing, etc; inadequate protection and/or poor storage location

Condition: Weld-splatter surface damage and reduction in glass strength
Cause: Location of glass near welding; inadequate protection of stored or installed glass

Condition: Stubborn, tenacious surface deposits from concrete and masonry runoff, as well as hard water spotting
Cause: Poor storage and/or protection of uninstalled glass; absence of prompt, interim cleaning of installed glass during construction

Construction Clean-Up

If glass is exposed to harmful materials or conditions during construction, the general contractor or builder and the trade involved, if known, should be immediately advised by the glazing contractor of the potential damage. In the event that damage has already occurred, the glazing contractor and glass fabricator/supplier should be consulted to assess damage, take corrective actions, and mitigate the potential for future damage.

Deep surface scratches, contact by hot weld-splatter and edge damage threaten the structural integrity of glass and may require glass replacement. Surface contact with harmful materials will require prompt cleaning by professional window cleaners, such as members of the International Window Cleaners Association (IWCA).

If harmful exposure results in conditions that cannot be cleaned using typical glass cleaning procedures, a professional window cleaner should be consulted for recommendations on more aggressive glass cleaning procedures. The use of a more aggressive procedure may itself damage the glass. Careful thought and discussion must precede the use of aggressive cleaning procedures.

The general contractor or builder may need to schedule periodic glass cleaning during the construction process. Extended construction schedules and site conditions often result in dirt and debris build-up. Professional cleaning at the initial signs of build-up can decrease the potential for glass damage.

Long-Term Building Maintenance & Performance

Following the completion of the construction project and throughout the life of the building, windows, doors, and skylights should be properly cleaned. Building facades may be exposed to sealant rundown, pollutants, dirt and debris, which can attack and damage glass surfaces over time. Building maintenance schedules should include frequent cleaning to ensure long-term glass aesthetics and performance. Cleaning frequencies should be tailored to the individual characteristics inherent to these conditions as well as the severity of local environmental factors such as acid rain and atmospheric pollutants that vary from region to region.

Building owners should ensure that individuals cleaning fenestration materials are well aware of the glazing products in the building and their unique properties and are knowledgeable about and capable of using proper cleaning procedures and practices recommended by the glazing manufacturer and the glass industry.

Proper protection of glass in windows, doors, and skylights throughout the construction process and the life of a building are essential. Planning and execution of the practices described and recommended in this bulletin will enable the glass to meet the aesthetic and performance expectations and the needs of the building occupants.

Consult the *Tech Center* section of the Glass Association of North America (GANA) website (www.glasswebsite.com) for additional Glass Informational Bulletins and flat glass industry reference resources.

This bulletin was developed by the GANA Tempering Division - Construction Subcommittee and the International Window Cleaning Association and approved by the Tempering Division - Standards & Engineering Committee and GANA Board of Directors and IWCA Board of Directors. The document was originally published in October 2003 then republished in May 2008. This edition of the bulletin provides the most recent update and published in October 2010.

ASSOCIATION OF NORTH AMERICA

Glass Informational Bulletin **GANA LD 01-1003 (Reapproved 2008)**

Design Considerations for Laminated Glazing Applications

Modern architectural designs often require glazing materials that provide enhanced levels of security and safety performance properties. These properties include: resistance to ballistics, blast, hurricane/cyclic wind pressures and physical attack. Applications may also require desirable properties such as sound reduction, fade resistance, and solar & thermal control. Laminated glazing materials consist of multiple plies of glass, interlayers, resins and/or plastic glazing materials (such as polycarbonate sheet or acrylic), which are often complex in nature. They are designed to provide specified levels of performance.

Design professionals and building owners should be aware of the following considerations when selecting and specifying laminated glazing constructions:

Aesthetic Color

Commercial clear float glass is nearly colorless, however, a green or blue-green tint, which is faint in thin glass may become noticeable in glazing applications where the glass thickness exceeds 3/8" (10 mm). Laminated glazing materials, utilized for their impact resistance to ballistics, blast and physical attack and for additional applications such as zoo exhibits and large aquariums incorporate numerous plies of transparent glazing materials. In these applications, the thickness of the glass portion of the laminate often results in a more apparent degree of green. In some instances, the green tint is not as pronounced, as it can be disguised by the blue color of the water or the color of painted walls in an aquarium. The green tint also may not be as apparent in certain constructions such as glass-clad polycarbonate laminates that contain more polycarbonate than glass.

However, in certain applications, the green tint may be regarded as aesthetically displeasing to a designer and owner. For those projects that require the highest level of color clarity, low-iron clear float glass should be considered. Low-iron clear float glass may also assist the designer in providing a closer color match to a less thick glass that is in proximity to the laminated glazing.

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Many laminated glazing components are designed to block ultraviolet light (energy wavelengths from 280nm - 380nm); however, these components also block a portion of the visible light spectrum (wavelengths from 380nm – 420 nm) with a result that there may be a slight yellow appearance. This yellow appearance, not visible in single or thin multiple layers, may become noticeable when these materials are used in thicker or a greater number of multiple layers. This color should be considered in conjunction with color imparted by the glass itself.

There are also design considerations, which must be taken into account when a low e or reflective coating is used in the construction of a laminate. When the coating, applied to the glass substrate, is placed in contact with the PVB, the refractive index of the coating is changed and will result in a perceived color shift. This means that a coating in an IG unit may appear a different color than the same coating in a laminate.

Optical Distortion

Heat-Treated Glass

Images viewed in reflection from and by transmission through laminated glazing materials may be distorted. Both reflected and transmitted optical distortion may result from heat-treatment of glass, thickness variability of the materials used, mechanical stresses applied by the framing system and changes in exterior wind pressure and interior building pressure.

Laminated glazing materials may incorporate multiple plies of heat-treated (e.g. heat strenghtened, tempered) glass in order to achieve high levels of resistance to thermally and mechanically applied loads. Bow, warp and roll wave distortion are inherent characteristics of heat-treated glass. While fabricators take steps to minimize these conditions, they cannot be eliminated. All of these characteristics are accentuated by the use of reflective coatings and tinted glass substrates. Since transmitted distortion is dependent on overall thickness variability, it tends to be exaggerated by multiple plies of glass and other components. The thickness variations of the individual plies is additive. Laminated constructions incorporating annealed glass typically exhibit less reflective and transmitted optical distortion. Distortion in all glazing materials may occur as a result of glazing system, wind load pressures and overall bow and warp.

The visibility of reflective distortion is greatly affected by surrounding conditions and glazing orientation. If the reflected image is a uniform blue sky, the reflective image that appears in the laminated product may appear without distortion. If the same laminate is reflecting multiple gridlines from an adjacent building, the reflection may appear distorted. Roll wave distortion may be more visible by reflectance and transmittance when the direction of the wave pattern is glazed parallel to the jamb or vertical dimension of a window or door. In this application, images of lineal objects (such as building walls, utility and flag poles) and moving objects (such as cars and aircraft) become more visible as the viewing angle changes. In order to decrease the visibility of roll wave distortion in heat-treated laminates, fabricators commonly recommend and design professionals specify that the wave direction (wave's peak) be glazed parallel to the sill of a window or door whenever possible. It is recommended that the manufacturer be notified in writing of these instructions prior to the onset of glass fabrication. Heat-treated glass fabrication equipment

limitations may not allow roll wave orientation to the sill when the width dimension of a lite of glass exceeds the height dimension.

Multiple-Ply Laminates

Multiple ply glazing materials that include non–glass components such as interlayer films and/or plastics sheet products such as polycarbonate or acrylic sheet may also be a source of unwanted optical distortion. Special consideration should be given to these types of laminates.

Both glass (as previously described) and non-glass components may have thickness or flatness variability that creates lens effects, which may cause distortion of images when viewed through the glazing material. The magnitude and spacing of this variability are both important factors when trying to assess the suitability of a multiple-ply laminate for a given application as a precise alignment of the components containing this variability is not possible. Since this distortion is greatly affected by viewing angle, vertical lens lines are generally more objectionable

High performance plastic sheet used in multiple-ply laminates are most often either polycarbonate or acrylic sheet.

Acrylic sheet materials are produced by several processes, which exhibit varying degrees of distortion and thickness variations. Polycarbonate sheet is produced by an extrusion process, and therefore exhibits die lines (ripple direction) on both coated and uncoated polycarbonate, which may produce an objectionable distorted image. This distortion can be minimized by placing the ripple direction horizontal to the plane (when feasible) OR it is often preferable to orientate these die lines horizontally if possible. While plastic sheet manufacturers take steps to minimize these conditions, they cannot be eliminated.

Designers are recommended to further consider other conditions, such as: thermal expansion/contraction properties and changes in humidity, which may cause the plastic glazing material to bow, wan or warp; adequate space within frame systems to reduce perimeter issues due to edge pinch and, localized areas of distortion resulting from small particulate inclusions (fish-eyes) on coated plastic sheet materials. As more individual plastic layers are utilized in the laminate, distortion may become more pronounced.

Multiple-Ply Laminates incorporating both glass and polycarbonate components and their appropriate interlayer(s) are further described within ASTM C1349 *Standard Specification for Architectural Flat Glass Clad Polycarbonate,* and its Appendixes. Additional reference to the plastic sheet components and these types of laminates can also be found within the *GANA Glazing Manual* and the *GANA Laminated Glazing Reference Manual.* Refer to ASTM D 4802 Standard Specification for Poly (Methyl Methacrylate) Acrylic Plastic Sheet for the methods by which acrylic plastic sheet is produced and other specifications.

Iridescence

When viewing laminated glazing constructions, under certain conditions, a pattern of iridescent spots or darkish shadows may become visible. This is commonly referred to as the strain pattern of the heat-treated glass and is related to the stresses introduced in the cooling process of the glass fabrication. While not normally visible, the strain pattern may become more evident by reflectance and in transmittance when viewing the glazing material at severe angles or under polarized light conditions. The potential of the iridescence becoming more pronounced is enhanced as the thickness of the laminated glazing material increases. The strain pattern is inherent in those heat-treated components and is not a result of discoloration or non-uniformity.

Product Awareness

As the design thickness of multiple plies of heat-treated glass and/or glass and polycarbonates increases to meet application requirements, the potential for distortion of images viewed through the glazing also increases. The bonding of multiple surfaces accentuates distortion as a result of the inherent variations in flatness of the component materials. Design professionals and building owners must be particularly aware of these characteristics in applications that involve viewing moving objects through the glass.

It is essential that design professionals consult with fabricators and suppliers in the early stages of design and engineering, given the sophisticated nature of laminated glazing materials required for optimum performance in safety, security, hazard resistant and sound reduction applications. Awareness of the laminated glazing product construction and inherent characteristics of the laminated glazing can dramatically affect the design application. Design professionals and building owners are strongly encouraged to utilize full-size mockups for evaluating the appearance of the glazing system under the specific project conditions, lighting conditions, and surrounding landscape. Utilization of a mockup is an inexpensive and reasonable process to ensure the product(s) and project design(s) meet a client's expectations.

This bulletin was developed by the GANA Laminating Division – Optical Distortion Task Group and approved by the Laminating Division – Technical Committee and GANA Board of Directors. This is the original version of the document as approved and published in October 2003. This edition of the bulletin provides the most recent update and published in July 2008.