



FALL CONFERENCE

SEPTEMBER 11-14, 2018



Edge Grinding: *Safety vs. Aesthetics*

Fall Conference

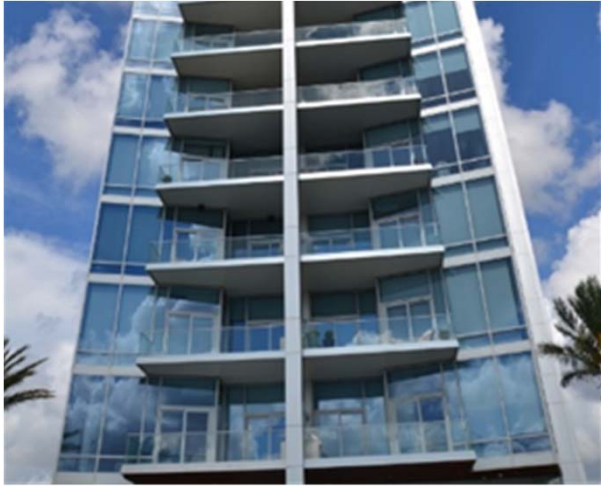
Las Vegas, NV

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Background

- Growing interest in minimally-supported glass applications
- facades, skylights, interior partitions and glass balustrades
- trend is for less metal around the edges of the glass



Glass breakage with no retention

IBC 2015 - Glass Railing Code Requirement

- Section 2407.1
 - *Glass used in a handrail, guardrail or a guard section shall be **laminated** glass constructed of fully tempered or heat-strengthened glass and shall comply with Category II or CPSC 16CFR Part 1201 or Class A of ANSI Z97.1. Glazing in railing in-fill panels shall be of an approved safety glazing material that conforms to the provisions of Section 2406.1.1. For all glazing types, the minimum nominal thickness shall be ¼ inch (6.4 mm).*
 - *Exception – Single fully tempered glass complying with Category II of CPSC 16 CFR Part 1201 or Class A of ANSI Z97.1 shall be permitted to be used in handrails and guardrails where there is no walking surface beneath them or the walking surface is permanently protected from the risk of falling glass.*

Glass Retention

- laminated glass is being used for its ability to provide post-breakage glass retention.



Minimal Supports with Laminated Glass

- resulting in exposed edges
- laminated glass edge quality and fabrication
 - alignment of the glass plies
 - edge polishing before and after fabrication
 - interlayer appearance



Exposed Edge Applications

- heat-treated laminate with one or more exposed edges that meets the aesthetic requirements
- covered laminated glass edges are not visible
 - not an aesthetic concern after installation
- when the edges are exposed, the alignment of glass plies and overall appearance of the laminate edge are likely to be critical to the designer and building occupant in most applications



Exposed Edge Applications

- According to ASTM C1048, heat-treated exposed-edge glass *shall be polished prior to heat-treating*. If the specification calls for monolithic tempered glass, the polished edge will not look any different after the heat-treating process.
- The industry currently has no generally accepted exposed-edge tolerances to offer as guidelines beyond what appears in ASTM C1036, C1048, and C1172.

Fabrication Techniques for Laminated Glass with Exposed Edges per ASTM Standards

- Fabricators developed techniques to produce laminates with alignment tolerances tighter than those listed in ASTM C1172.
 - Edging glass prior to heat treating
 - During lamination process, techniques are used to ensure tighter edge alignment on multiple edges
- laminates with edge alignment intended to meet the customer's expectations without the need for post-fabrication processing which is known to weaken the glass.

ASTM C1036 - *Standard Specification for Flat Glass*

- Provides the cut size tolerance for each ply of glass in the laminated construction
- ASTM C1036 Table 4, Dimensional Tolerances for Rectangular Shapes of Type 1-Transparent Flat glass, provides the length/width and out of square tolerances based on the glass thickness.

TABLE 4 Dimensional Tolerances for Rectangular Shapes of Type 1—Transparent Flat Glass

Nominal Designation		Thickness Range				Length and Width Tolerance ^A				Squariness (D1–D2)			
SI Designation ^B	Traditional Designation	mm		in.		Cut Size		Stock Sheet		Cut Size		Stock Sheet	
mm		min	max	min	max	± mm	(± in.)	± mm	(± in.)	mm	(in.)	mm	(in.)
1.0	micro-slide	0.79	1.24	0.031	0.049	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
1.5	photo	1.27	1.78	0.05	0.07	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
2	pictura	1.80	2.13	0.071	0.084	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
2.5	single	2.16	2.57	0.085	0.101	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
2.7	lumi	2.59	2.90	0.102	0.114	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
3 ^C	double, 1/8 in.	2.92	3.40	0.115	0.134	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
4	1/2 in.	3.78	4.19	0.149	0.165	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
5	3/8 in.	4.57	5.05	0.18	0.199	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
6	1/2 in.	5.56	6.20	0.219	0.244	1.6	(¹ / ₁₆)	6.4	(¹ / ₄)	2.0	(⁵ / ₁₆)	3.0	(¹ / ₂)
8	3/4 in.	7.42	8.43	0.292	0.332	2.0	(⁵ / ₁₆)	6.4	(¹ / ₄)	2.8	(⁷ / ₁₆)	6.0	(¹ / ₂)
10	1 in.	9.02	10.31	0.355	0.406	2.4	(³ / ₁₆)	6.4	(¹ / ₄)	3.4	(¹ / ₂)	6.0	(¹ / ₂)
12	1 1/2 in.	11.91	13.49	0.469	0.531	3.2	(¹ / ₂)	6.4	(¹ / ₄)	4.5	(¹⁵ / ₁₆)	10.0	(³ / ₂)
16	2 in.	15.09	16.66	0.595	0.656	4.0	(⁵ / ₁₆)	6.4	(¹ / ₄)	5.7	(⁷ / ₁₆)	12.0	(¹ / ₂)
19	2 1/2 in.	18.26	19.84	0.719	0.781	4.8	(³ / ₁₆)	6.4	(¹ / ₄)	6.8	(¹ / ₂)	14.0	(³ / ₄)
22	3 in.	21.44	23.01	0.844	0.906	5.6	(⁷ / ₁₆)	6.4	(¹ / ₄)	7.9	(¹⁹ / ₁₆)	16.0	(⁵ / ₄)
25	1 in.	24.61	26.19	0.969	1.031	6.4	(¹ / ₂)	6.4	(¹ / ₄)	9.0	(¹⁵ / ₁₆)	18.0	(³ / ₂)

^A Length and width of cut size and stock sheets of flat glass include flares and bevels.

^B These designations apply only to ASTM International and may not reflect other international standards.

^C Within the 3.0 designation there are some applications that may require different thickness ranges such as DST. (Typical minimum thickness for DST is 0.120 in.)

ASTM C1048 - Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass

- Provides guidance that fabrication techniques that alter the glass surface, thickness or edge shall be performed *prior* to heat treating to avoid a reduction in glass strength

ASTM C1048

7. Fabrication

7.1 *Fabrication*—All fabrication, such as cutting to overall dimensions, edgework, drilled holes, notching, grinding, sandblasting, and etching, shall be performed before heat-strengthening or tempering and shall be as specified (see Section 6 and 7.8). After the glass has been heat-strengthened or tempered, it shall not be modified except as recommended by the fabricator; for example, some Condition C coatings. No modification shall be made that will affect its structural characteristics or integrity as specified in this standard.

7.8 *Fabrication Guidelines*—Heat-strengthened and fully tempered flat glass cannot be cut after the heat-treating process. Fabrication altering the glass surface, thickness, or edges shall be performed before heat-treating to avoid a reduction of glass strength.

7.8.1 Heat-strengthened and fully tempered glass can be furnished with holes, notches, cutouts, and bevels. Fabrication involving other methods of modification should be discussed with the fabricator/manufacturer.

ASTM C1172 - Standard Specification for Laminated Architectural Flat Glass

- Provides a similar statement about fabrication techniques needing to be done *prior* to heat-treating. There is an additional statement, “After the glass has been strengthened or tempered, it shall not be modified except as recommended by the fabricator.”
 - Intended to allow only minor alterations, such as coating edge deletion or logo application, of the lite for processes as discussed in ASTM C1048

ASTM C1172 Table 3

- Length and Width Tolerances for Rectangular Shapes of 2-ply Laminated Glass Including Mismatch up to 75 ft²

Laminate Thickness Designation, t in. (mm)	Heat-Strengthened and Tempered Glass Size Tolerance including Mismatch in. (mm)
$t < \frac{1}{4}$ ($t < 6.4$)	$+ \frac{7}{32}, - \frac{3}{32}$ (+5.6, -2.4)
$\frac{1}{4} < t < \frac{1}{2}$ ($6.4 < t < 12.7$)	$+ \frac{1}{4}, - \frac{1}{8}$ (+6.4, -3.2)
$\frac{1}{2} < t < 1$ ($12.7 < t < 25.4$)	$+ \frac{5}{16}, - \frac{1}{8}$ (+7.9, -3.2)

- For other than 2-ply laminated glass, or laminates larger than 75 ft², contact the laminator for size tolerances.*
- Size includes cutting and fabrication tolerances as well as mismatch.*
- For exposed edge applications, consult the supplier to determine their capabilities.*

Post-Fabrication Finishing

- Post-fabrication finishing processes **do not comply** with the current industry standards, ASTM C1048 and C1172.
 - It can weaken the glass
- **GANA and NGA do not endorse post fabrication** finishing and support these industry standards, as well as ASTM C1036



Glass Informational Bulletin

Heat-treated Laminated Glass Exposed Edges



FB59-18

Glass Informational Bulletin

GANA TD 04-1207 (Reapproved 2012)

The Importance of Fabrication Prior to Heat-Treatment



Summary

Laminated glass is being required by the building codes in more applications due to its post-breakage (glass retention) properties.

The exposed edges of heat-treated laminated glass will have a different appearance than that of monolithic glass.

Until the industry establishes acceptance guidelines or criteria (mismatch tolerances, interlayer appearance, etc.) for heat-treated laminated glass used in exposed edge applications, the glazing contractor and glass specifier should continue to discuss the project needs with the glass fabricator on a case by case basis.

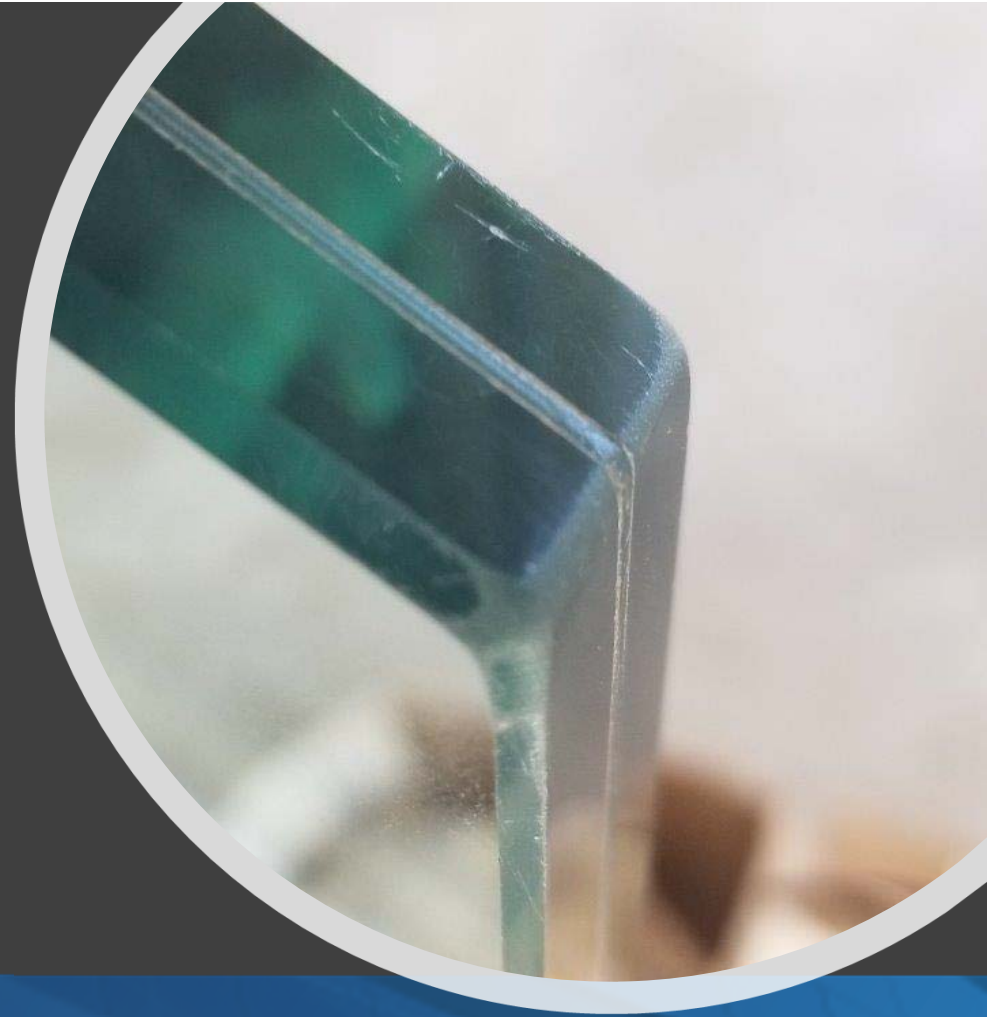
Summary

Glazing contractor and glass specifier should first consult with their fabricator-suppliers to discuss the best methods to *meet exposed glass edge aesthetic requirements*.

GANA and NGA support the applicable ASTM industry standards for heat-treated and laminated glass and do not endorse any post fabrication finishing of heat-treated glass edges.

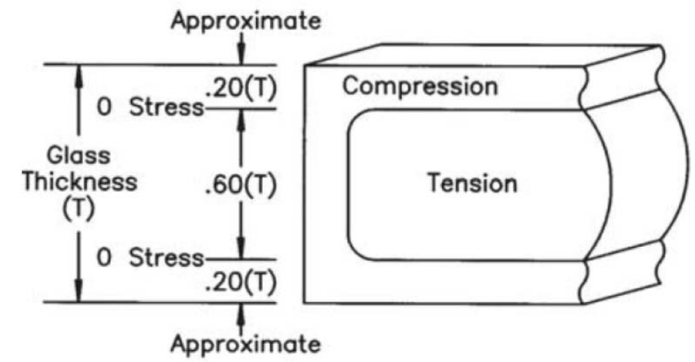
What happens now?

- Architects, specifiers, building owners want glass designed with safety in mind, however, still want the clean lines with minimal framing
- Do fabricators post-polish?



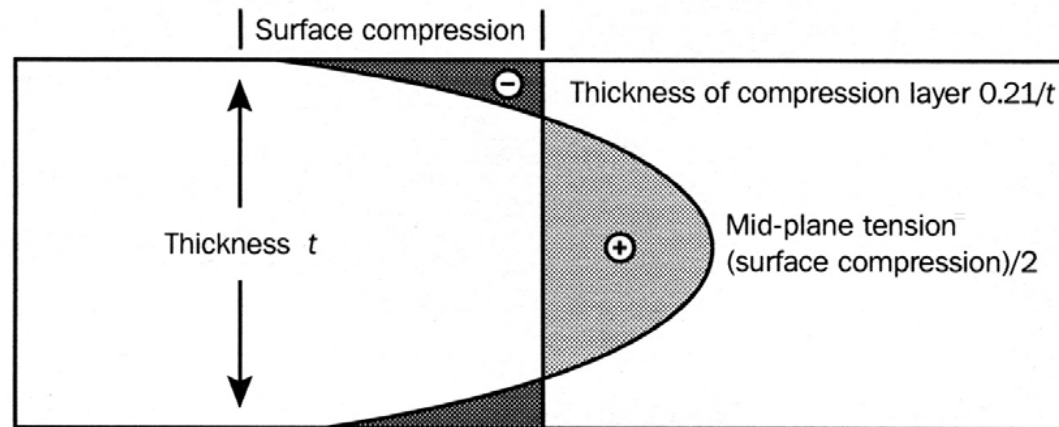
Concerns of post-fabrication procedure

- Reduction in edge compression of the tempered glass lites
- Reduction in the depth of the edge compression layer and thus, in edge strength of the heat-treated (heat-strengthened or tempered) edges
- The effects of heat, liquid coolants, and polishing compounds from the post-fabrication finishing processes upon interlayer material
- Reduction in glass strength due to the post-fabrication finishing process may not be in compliance with the strength references in the ASTM E1300 load resistance and compression levels in the C1048 standard or specific project specifications



Heat-Treated Glass Compression and Tension Zones

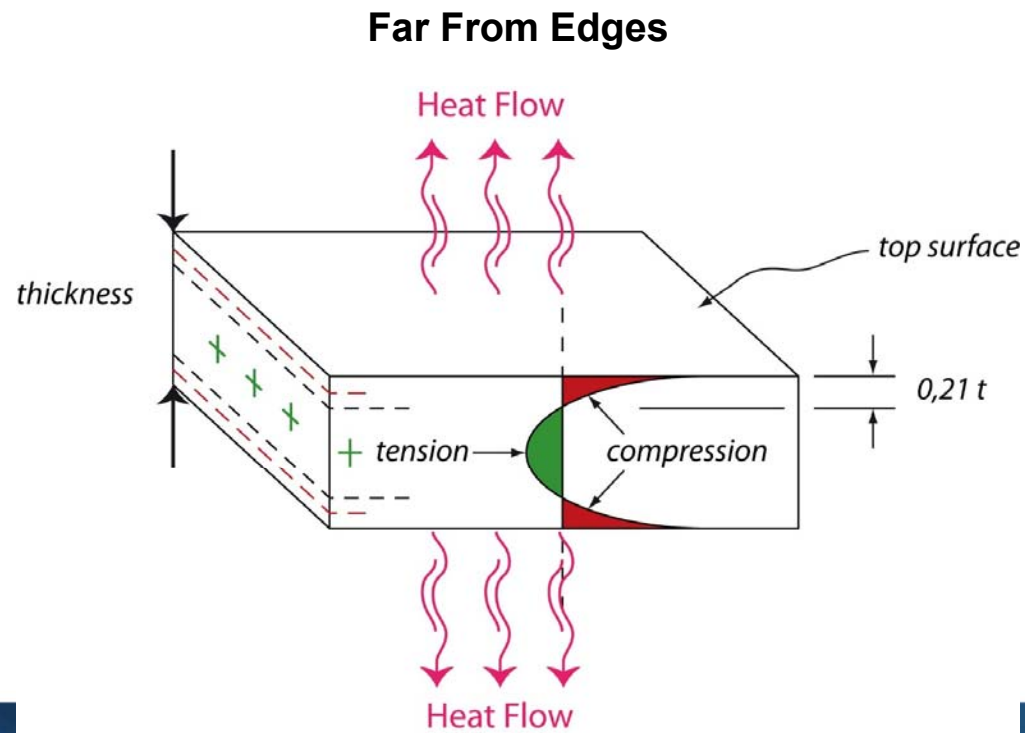
How do Residual Stresses in Glass Develop?



Stress distribution through thickness

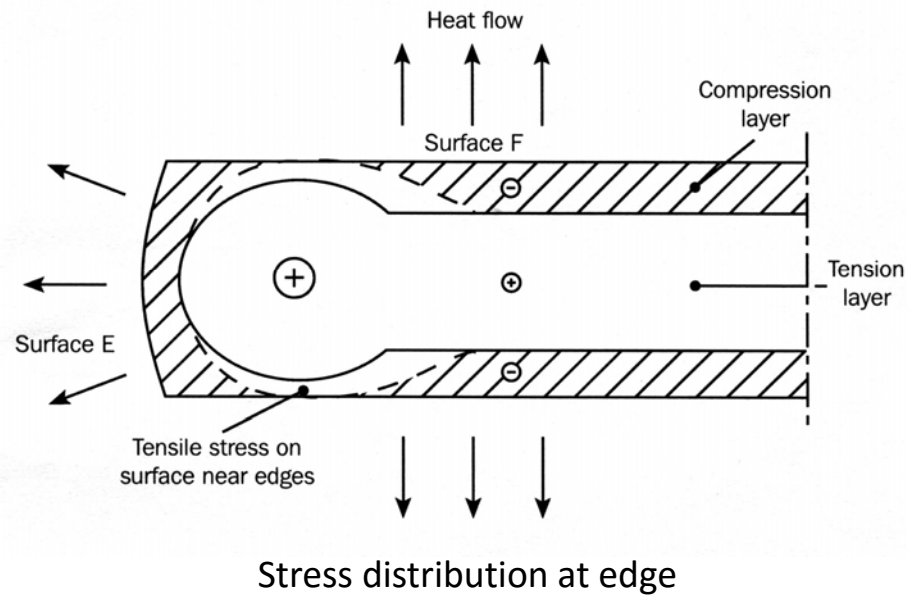
Courtesy of Strainoptics, Inc.

Stress Profile of Heat-Treated Glass



$$\text{Mid-Layer Tension} = -(\text{Surface Compression})/2$$

How do Residual Stresses in Glass Develop?

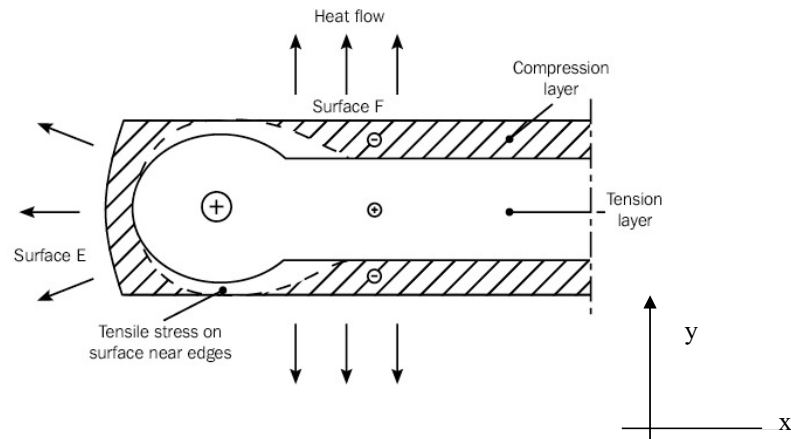


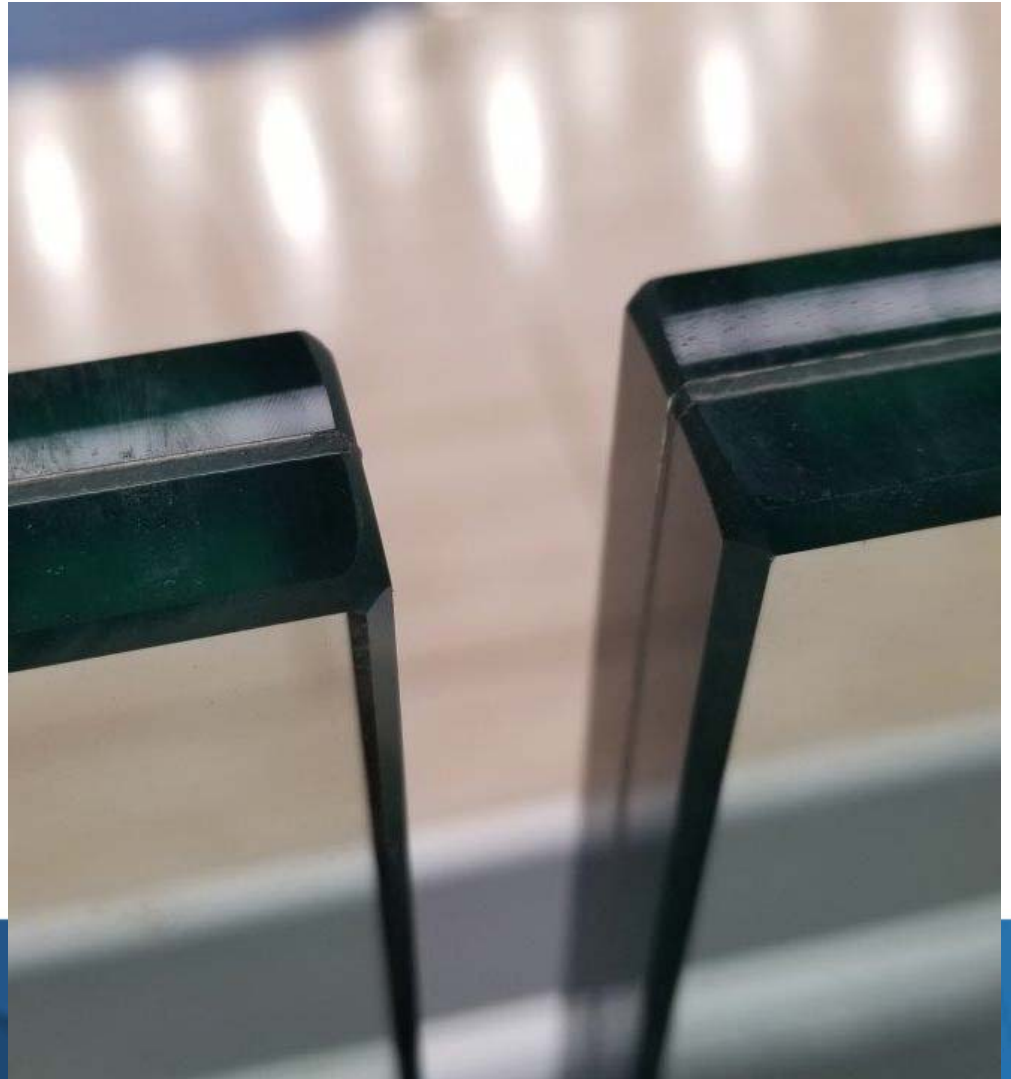
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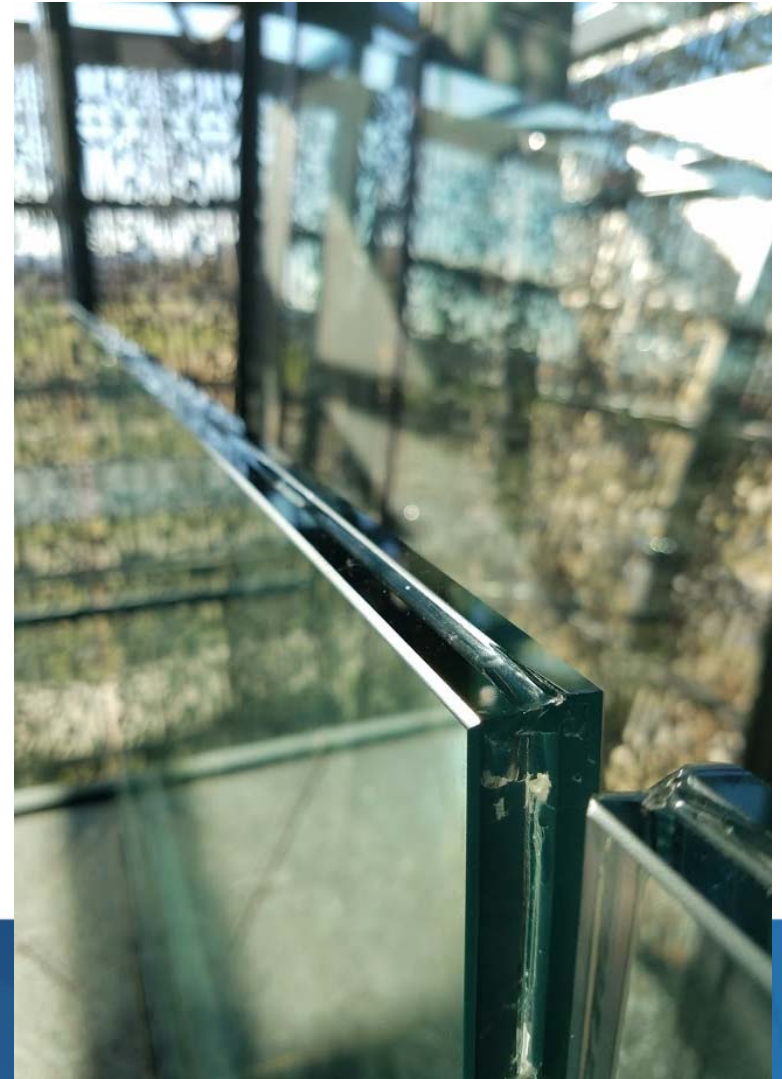
Stress Profile of Heat-Treated Glass

Near Edges

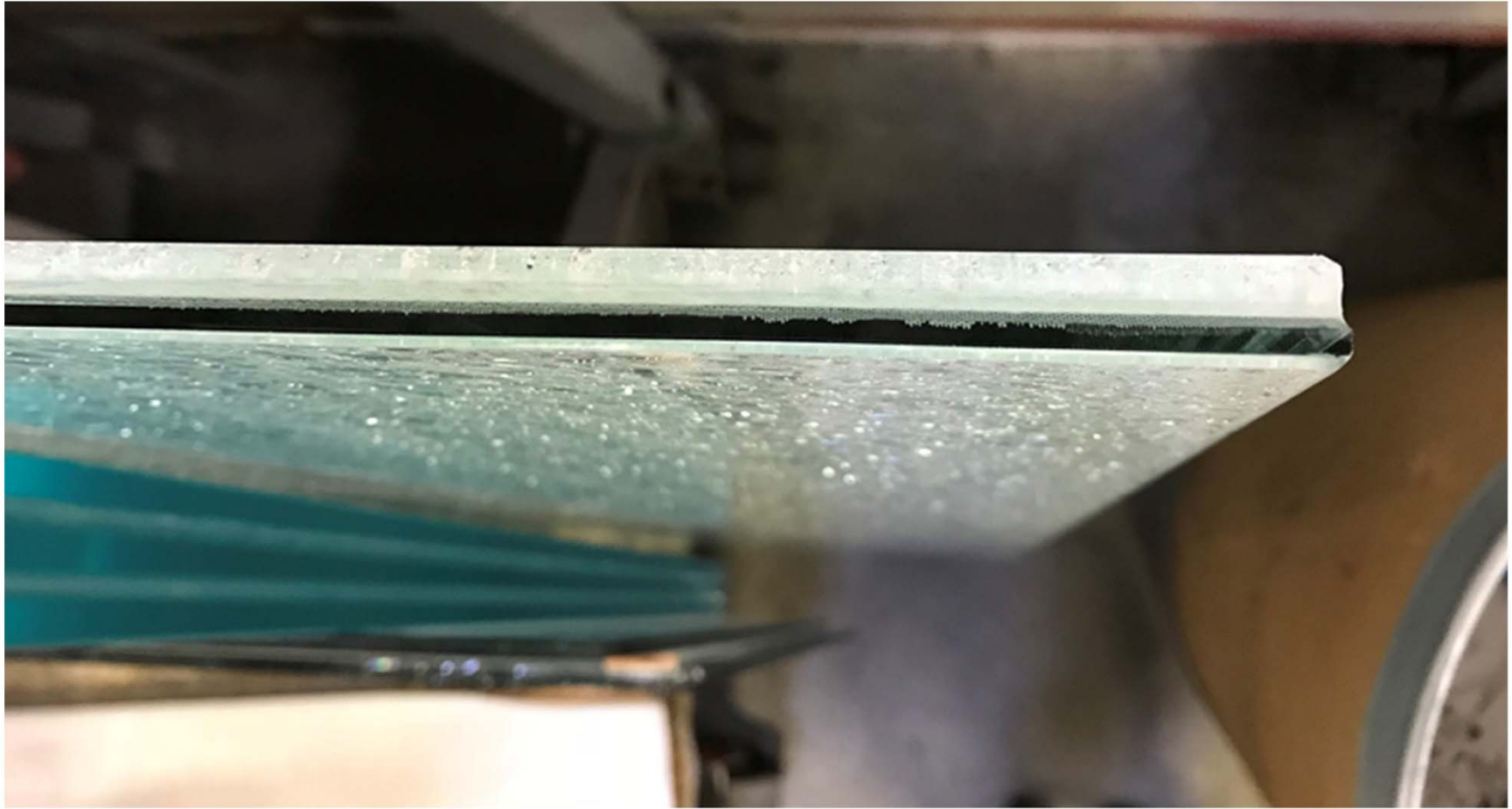
- Near-edge cooling rate differs from cooling rate far from edge.
- Surface F cools at a different rate than Surface E.
- The result is localized increase in tension in the y-direction.











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