PRESSGLASS

COMPANY STANDARD

Edition 8.1
December 2024

Contents

1. Basic glass

Type of glass	The glass type and quality shall be agreed upon between the customer and the fabricator prior to order execution. 1. Basic glass products: - float glass (ASTM C1036-21), - patterned glass (ASTM C1036-21), - laminated glass and laminated safety glass (ASTM C1172-19), - coated glass (ASTM C1376-21), - surface processed glass (e.g. sandblasted, acid-etched, ect.). 2. Other types of glass included or not included in the ASTM standards.

2. Glass cutting

<table>
<tr><td>Standard</td><td colspan="2">ASTM C1036-21, ASTM C1172-19</td></tr>
<tr><td>Type of glass</td><td colspan="2">Monolithic, laminated</td></tr>
<tr><td>Glass shapes</td><td colspan="2">Monolithic glass – catalog, non-catalog, templates; Laminated – individual request</td></tr>
<tr><td rowspan="11">Tolerances for monolithic glass</td><td colspan="2">Table 1 – ASTM C1036</td></tr>
<tr><td colspan="2">Tolerance on the dimensions for rectangular glass panes</td></tr>
<tr><td>Glass thickness</td><td>Length and Width Tolerance</td></tr>
<tr><td>1/8, 5/32, 3/16, 1/4″
(3, 4, 5, 6 mm)</td><td>± 1/16″
(± 1.6 mm)</td></tr>
<tr><td>5/16″
(8 mm)</td><td>± 5/64″
(± 2 mm)</td></tr>
<tr><td>3/8″
(10 mm)</td><td>± 3/32″
(± 2.4 mm)</td></tr>
<tr><td>1/2"
(12 mm)</td><td>± 1/8″
(± 3.2 mm)</td></tr>
<tr><td>5/8″
(16 mm)</td><td>± 5/32″
(± 4 mm)</td></tr>
<tr><td>3/4"
(19 mm)</td><td>± 3/16″
(± 4.8 mm)</td></tr>
<tr><td colspan="2">Table 2 – ASTM C1036</td></tr>
<tr><td colspan="2">Limit on the difference between diagonals for rectangular glass panes</td></tr>
<tr><td>Glass thickness</td><td>Squareness (D1-D2)</td></tr>
<tr><td>1/8, 5/32, 3/16, 1/4″
(3, 4, 5, 6 mm)</td><td>5/64″
(2 mm)</td></tr>
<tr><td>5/16″
(8 mm)</td><td>7/64″
(2.8 mm)</td></tr>
<tr><td>3/8″
(10 mm)</td><td>1/8″
(3.4 mm)</td></tr>
<tr><td>1/2"
(12 mm)</td><td>11/64″
(4.5 mm)</td></tr>
<tr><td>5/8″
(16 mm)</td><td>7/32″
(5.7 mm)</td></tr>
<tr><td>3/4"
(19 mm)</td><td>1/4″
(6.8 mm)</td></tr>
</table>

For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 0.118″ (3.0 mm) for each glass thickness. The templates are stored for a period of 30 days from the date of glass manufacture. Any complaints concerning glass dimensions will not be accepted after the aforementioned period.

Table 3 – ASTM C1172

Tolerance on the dimensions for rectangular glass panes, 2-ply Laminated Glass, Including Mismatch up to 75 ft²

Length and Width Tolerances

Laminate Thickness Designation, *d*	Transparent Glass, *t*	Patterned Glass, *t*	Heat Treated Glass, *t*
d ≤ 1/4″ (d ≤ 6.4 mm)	+5/32″, –1/16″ (+ 4 mm, - 1.6 mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+7/32″ –3/32″ (+ 5.6 mm, - 2.4 mm)
1/4 < d ≤ 1/2″ (6.4 < d ≤ 12.7 mm)	+1/4″, –1/16″ (+ 6.4 mm, - 1.6 mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+1/4″, –1/8″ (+ 6.4 mm, - 3.2 mm)
1/2 < d ≤ 1″ (12.7 < d ≤ 25.4 mm)	+1/4″, –1/8″ (+ 6.4 mm, - 3.2 mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+5/16″, –1/8″ (+ 7.9 mm, - 3.2 mm)

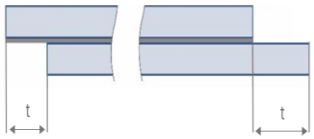


Fig. 1 Dimensional pane tolerance, t

Table 4

Limit deviations of the interlayer for laminated glass with a film interlayer

Interlayer thickness	Deviations
≤ 0.787″ (2 mm)	± 0.0039″ (0.1 mm)
> 0.787″ (2 mm)	± 0.0079″ (0.2 mm)

Table 5

Tolerance on the dimensions for rectangular glass panes, 3-ply Laminated Glass, Including Mismatch up to 75 ft²

Length and Width Tolerances

Laminate Thickness Designation, *d*	Transparent Glass, *t*	Patterned Glass, *t*	Heat Treated Glass, *t*
d ≤ 5/8″ (d ≤ 16 mm)	+1/4″, –3/20″ (+ 6 mm, - 3.6 mm)	+3/8″ –3/16″ (+ 9.9 mm, - 5.2 mm)	+7/32″ –5/32″ (+ 7.6 mm, - 4.4 mm)
5/8″ < d ≤ 1″ (16 < d ≤ 25 mm)	+5/16″, –3/20″ (+ 8.4 mm, - 3.6 mm)	+3/8″ –3/16″ (+ 9.9 mm, - 5.2 mm)	+5/16″, –3/16″ (+ 8.4 mm, - 5.2 mm)
1″ < d ≤ 1-5/8″ (25 < d ≤ 41 mm)	+5/16″, –3/16″ (+ 8.4 mm, - 5.2 mm)	+3/8″ –3/16″ (+ 9.9 mm, - 5.2 mm)	+3/8″, –3/16″ (+ 9.9 mm, - 5.2 mm)

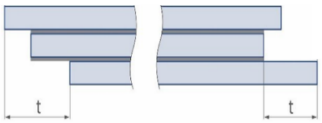


Fig. 2 Dimensional pane tolerance, t

Zone which is not subject to quality assessment after cutting

Values of length of section z and its corresponding sharp angle values

Angle [°]	Monolithic *z*	Laminated *z*
≤ 12.5	1.18″ (30 mm)	2.5″ (65 mm)
≤ 20.0	0.71″ (18 mm)	1.40″ (35 mm)
≤ 35.0	0.47″ (12 mm)	0.47″ (12 mm)
≤ 45.0	0.32″ (8 mm)	0.32″ (8 mm)

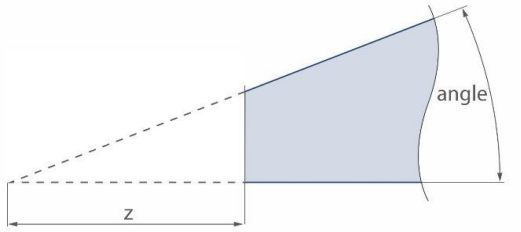


Fig. 3 Length of section z

Shells or nicks at the edges

Maximum size of shells or nicks on the glass edge

h1	≤	2*d*
p	≤	*e*/2
d	≤	e *or 6mm, whichever is greater*

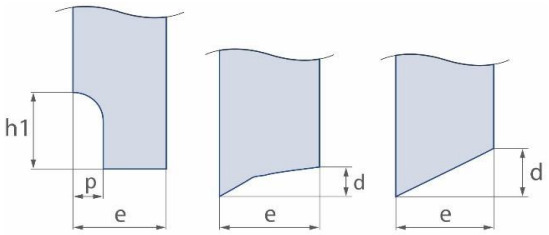


Fig. 4 Edge defects

Edge deletion

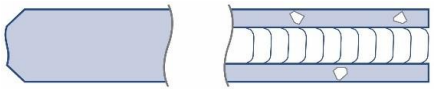
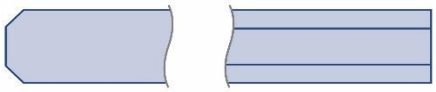
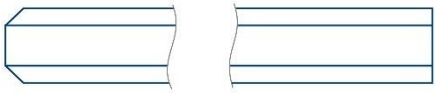
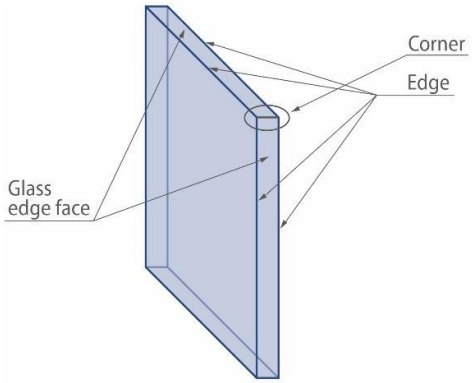
Table 6

Edge deletion width tolerances

± 0.039″ (± 1 mm)	for edge deletion width up to 0.433″ (11 mm)
+0.079″, - 0.039″ (+2 mm, -1 mm)	for edge deletion width over 0.433″ (11 mm)
0.118″, -0.039″ (+3 mm, -1 mm)	for glass coated with EasyPro protective film or TPF, regardless of the edge deletion width

As a result of mechanical edge deletion, visible hairline scratches, streaks, stains or discolorations can occur which are not glass defects. The ground coating appearance may vary for each edge. The above-mentioned effects are not subject to complaint.

3. Glass edge processing

Standard	None	
Type of processing	Seaming (SEAM) - Seaming bevels uniform on all edges, with non-processed areas.	 Fig. 5 Seam Edge
	Flat Edge Grind (FE)- matte glass edge finish, face and edges of the glass over the whole length.	 Fig. 6 Ground Edge
	Flat Edge Polished (FEP) - polished glass edge finish, face and edges of the glass over the whole length.	 Fig. 7 Polished Edge
Type of glass	Monolithic and laminated	
Glass shapes	Catalog, non-catalog, templates Any piece of glass ground or polished must be a catalog shape.	
Tolerances	Tolerances for glass with this kind of edgework is the same as for glass after cutting (applies to side and diagonal length tolerances).	
Quality	Seaming bevels uniform on all edges, with non-processed areas. The appearance of the processed surfaces for grinding and polishing can vary for the same kind of process. This effect is not subject to complaint. The glass corner is not processed.	
Seamed edge at corners	The edge at the glass pane corner can be characterized by greater material removal as compared to the remaining part of the glass edge. This effect is not subject to complaint. The glass pane corner and glass edge face are not processed.	 Fig. 8 Glass pane description

4. Glass edge mitering

Standard	None
Type of glass	Monolithic
Glass shapes	Individual request
Limitations	Individual request

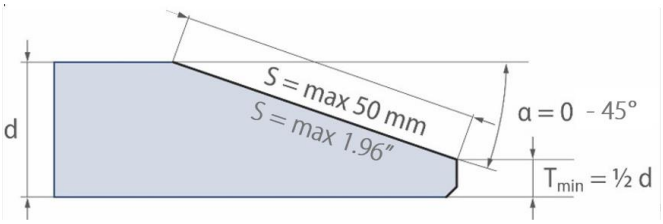


Fig. 9 Glass edge mitering

5. Drilling holes

Standard	ASTM C1048-18		
Type of glass	Monolithic and laminated		
Glass shapes	Catalog, non-catalog, templates		
Tolerances	Diameter tolerance for drilled holes		
	± 1/16″ (1.6 mm)		
Limitations	Minimum edge processing – grinding		
	Dmin	≥	*d* or 1/4″ (6 mm) Whichever is greater
	Dmax	≤	1/3 × *W*
	W	≥	8*d*
	a1	≥	2*d* or 1/4″ (6 mm) Whichever is greater
	a2	≥	6.5*d*
	b	≥	2*d* or 3/8″ (10 mm) Whichever is greater
	c	≥	6.5*d*
	e1	≥	2d or 1/4″ (6 mm) Whichever is greater
	d – glass thickness *D* – hole diameter		

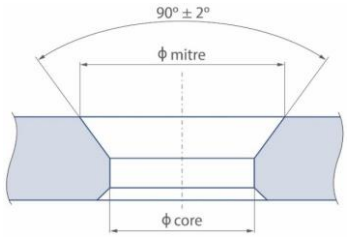


Fig. 10 Drilled hole

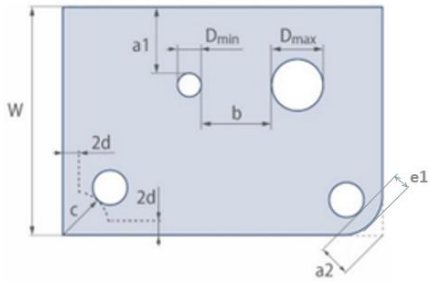


Fig. 11 Drilled hole limitations

Minimum tolerances for drilled holes in laminated glass	
Parameter	Parameter minimum value
h	0.0787″ (2 mm)
m	0.06″ (1.5 mm)
v	(*φmitre* − *φcore*) / 2

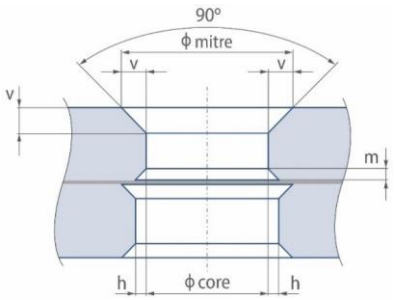


Fig. 12 Limitations to making holes for laminated glass

Hole positioning

Hole positioning shall be given and made always in reference to one corner, according to Fig. 13

Hole positioning tolerance
(applies to dimensions "a1-2"" and "b1-2″)

±0.012 in/ft (1 mm/m) but no less than ±0.01″ (2.5 mm) for glass thickness d ≤ 1/2″ (12 mm)

±0.012 in/ft (1 mm/m) but no less than ± 0.118″ (3 mm) for glass thickness d > 1/2" (12 mm)

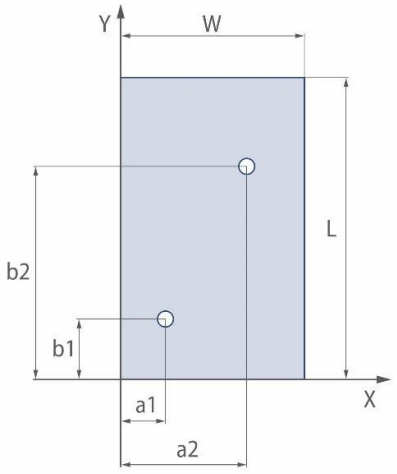


Fig. 13 Hole position

Relief Cut

For holes situated on the glass pane below the minimum values, a relief cut must be made. If the relief cut is made from the edge to the hole (Fig. 14)

The cut height (u) must meet the condition:
u ≤ 2d, where d = glass thickness.

The minimum relief cut thickness (y) is 1/8″

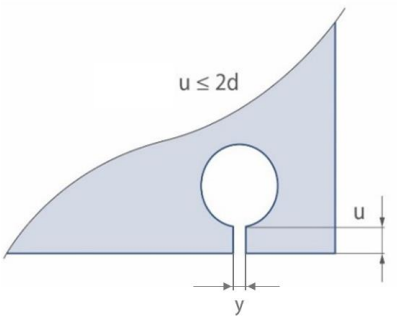


Fig. 14 Relief cut

6. Cut-outs

Standard	ASTM C1048-18		
Types of cut-outs	On the glass surface, on the glass edge, in the glass corner		
Type of glass	Monolithic and laminated		
Glass shapes	Catalog, non-catalog, templates		
Cut-out Tolerance	Glass Thickness	Dimension	Tolerance
	< 1/2" (< 12 mm)	h1 to h4 c1 to c4	± 1/16" (± 1.6 mm)
	≥ 1/2" (≥ 12 mm)	h1 to h4 c1 to c4	± 1/8" (± 3.0 mm)
Limitations	Minimum edge treatment – grinding		
	h1-4	≤	1/3 × *L*
	c1-4	≤	1/3 × *W*
	a	≥	1/2 × *c1*
	b	≥	1/2 × *h1*
	r	≥	*d*
	k	≥	1/2 × *h3* when *h3* > *h2*
	3.94" (100 mm) < j3 ≥1/2 × h3 d – glass thickness		
Cut-out positioning	Cut-outs shall be positioned according to Fig. 15. Cut-out positioning tolerance is the same as for drilled holes (applies to dimensions "a1-2"and "b1-4"). Cut-out positioning on the glass pane shall be given always in reference to one corner.		

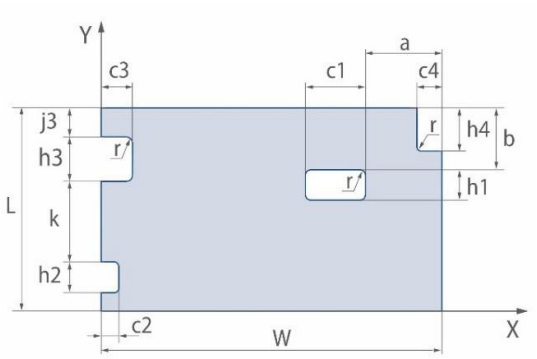


Fig. 15 Cut out positioning and limitations

7. Corner cut-offs

Standard	None	
Type of glass	Monolithic and laminated	
Cut-off processing	Seaming, grinding, polishing	
Tolerance	Glass Thickness	Tolerance
	< 1/2" (< 12 mm)	± 1/16″ (± 1.6 mm)
	≥ 1/2" (≥ 12 mm)	± 1/8″ (± 3.0 mm)
Limitations	Corner cut-offs are used only when, for the particular glass thickness, the shape cannot be cut on the glass cutting table (Fig. 16).	
Monolithic glass	Glass thickness	Maximum length of the cut-off corner *t*
	1/8-5/32″ (3-4 mm)	0.83″ (21 mm)
	3/16″ (5 mm)	1.10″ (28 mm)
	1/4" (6 mm)	1.38″ (35 mm)
	5/16″ (8 mm)	2.24″ (57 mm)
	3/8″ (10 mm)	4.45″ (113 mm)
	1/2-5/8″ (12-16 mm)	5.55″ (141 mm)
	3/4" (19 mm)	6.69″ (170 mm)

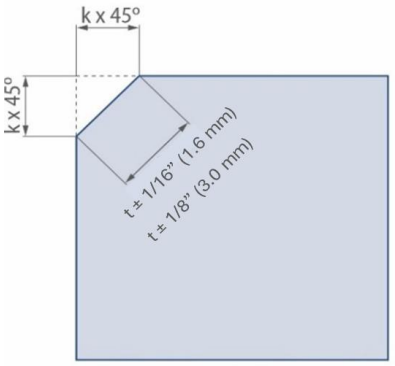


Fig. 16 Corner cut-off

8. Spandrel application with a roller

<table>
<tr><td>Standard</td><td>ASTM C1048-18</td></tr>
<tr><td>Type of glass</td><td>Monolithic</td></tr>
<tr><td>Glass shapes</td><td>Catalog, non-catalog, templates</td></tr>
<tr><td>Spandrel distribution tolerances</td><td>Total coverage - the spandrel covers the whole glass surface and can overlap the glass edges and glass edge face.</td></tr>
<tr><td>Limitations that are not subject to complaint</td><td>The roller coater used to apply the spandrel coating leaves a distinct texture, which becomes visible when the painted side is viewed up-close. Spandrel is not intended to be installed in vision areas. If installed in vision areas, striations, minor imperfections and minor variations in paint thickness from the roller coater may be visible on the painted surface.

Any materials applied directly to the spandrel, e.g. sealants, glues, panels, insulation, mounting hardware, etc. can be seen through the glass (e.g. for very bright colors).

Spandrel painted glass must be subjected to heat treatment (heat strengthening or tempering)
<table>
<tr><td rowspan="2">Minimum glass edge processing</td><td>seaming for 3/16 to 5/16” (5 to 8 mm) thick glass</td></tr>
<tr><td>grinding for 3/8 to 3/4" (10 to 19 mm) thick glass</td></tr>
</table>
- The paint must not be in contact with the coating.
- The painted surface must not be exposed to outdoor atmospheric conditions.
- Spandrel painted glass is not intended for vision area applications. Any application where the painted glass will be seen from both sides must always be consulted with the fabricator.</td></tr>
</table>

9. Digital print

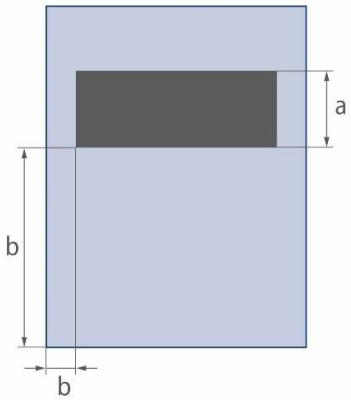
<table>
<tr><td>Standard</td><td colspan="3">ASTM C1048-18</td></tr>
<tr><td>Type of glass</td><td colspan="3">Monolithic</td></tr>
<tr><td>Definition</td><td colspan="3">Multi-color printing of the glass surface using ceramic inks</td></tr>
<tr><td>Glass shapes</td><td colspan="3">Catalog, non-catalog, templates</td></tr>
<tr><td>Print application methods</td><td colspan="3">Total coverage, partial coverage, pattern</td></tr>
<tr><td rowspan="4">Print distribution tolerances</td><td colspan="3">Partial coverage inside the glass pane</td></tr>
<tr><td>Parameter a</td><td>±0.079” (2 mm)</td><td rowspan="3"> 

Fig. 17 Placement of the digital print – partial coverage inside the glass pane</td></tr>
<tr><td>Parameter b</td><td>±0.196” (5 mm)</td></tr>
<tr><td colspan="2">Parameter b – measured from the reference glass edge face</td></tr>
<tr><td colspan="3">Partial coverage around glass pane perimeter, pattern</td></tr>
<tr><td colspan="2">Parameter c – measured from the glass edge face.

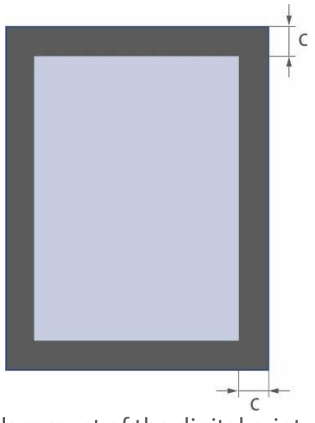
Tolerance for partial print width around the perimeter (parameter c) is ±0.118” (3 mm).</td><td> 

Fig. 18 Placement of the digital print – partial coverage around glass pane perimeter, pattern</td></tr>
</table>

<table>
<tr><td rowspan="4">Limitations that are not subject to complaint</td><td colspan="2">Glass with digital print must be subjected to the selected heat treatment:
– tempering,
– heat strengthening.</td></tr>
<tr><td rowspan="2">Minimum glass edge processing</td><td>seaming for 5/32 to 5/16″ (4 to 8 mm) thick glass</td></tr>
<tr><td>grinding for 3/8 to 3/4″ (10 to 19 mm) thick glass</td></tr>
<tr><td colspan="2">The digital print surface must not be exposed to outdoor atmospheric factors.
Any application where glass with digital print will be seen from both sides must always be consulted with fabricator.

Depending on the print color, intensity and application, small lines in the print direction, occasional "pinholes", shade variation and "slightly blurred stains" are typical for the process. It is particularly visible when the whole surface is printed.

Any materials applied directly to the digital print, e.g. sealants, glues, panels, insulation, mounting hardware, etc. can be seen through the glass (e.g. for very bright colors).</td></tr>
</table>

10. Glass tempering, heat strengthening, heat soaking

<table>
<tr><td>Standard</td><td colspan="2">ASTM C1048-18, EN 14179</td></tr>
<tr><td>Type of glass</td><td colspan="2">Monolithic</td></tr>
<tr><td>Glass shapes</td><td colspan="2">Catalog, non-catalog, templates</td></tr>
<tr><td>Tolerances</td><td colspan="2">Table 7 – ASTM C1048</td></tr>
<tr><td></td><td colspan="2">Tolerance on the dimensions for rectangular glass panes</td></tr>
<tr><td></td><td>Nominal Thickness Designation</td><td>Tolerance</td></tr>
<tr><td></td><td>3/16, 1/4" (5, 6 mm)</td><td>± 1/16″ (1.6 mm)</td></tr>
<tr><td></td><td>5/16″ (8 mm)</td><td>± 5/64″ (2.0 mm)</td></tr>
<tr><td></td><td>3/8″ (10 mm)</td><td>± 3/32″ (2.4 mm)</td></tr>
<tr><td></td><td>1/2" (12 mm)</td><td>± 1/8″ (3.2 mm)</td></tr>
<tr><td></td><td>5/8″ (16 mm)</td><td>± 5/32″ (4.0 mm)</td></tr>
<tr><td></td><td>3/4" (19 mm)</td><td>± 3/16″ (4.8 mm)</td></tr>
<tr><td></td><td colspan="2">Table 8 – ASTM C1036</td></tr>
<tr><td></td><td colspan="2">Limit on the difference between diagonals for rectangular glass panes</td></tr>
<tr><td></td><td>Glass thickness</td><td>Squareness (D1-D2)</td></tr>
<tr><td></td><td>3/16, 1/4″ (5, 6 mm)</td><td>5/64″ (2 mm)</td></tr>
<tr><td></td><td>5/16″ (8 mm)</td><td>7/64″ (2.8 mm)</td></tr>
<tr><td></td><td>3/8″ (10 mm)</td><td>1/8″ (3.4 mm)</td></tr>
<tr><td></td><td>1/2" (12 mm)</td><td>11/64″ (4.5 mm)</td></tr>
<tr><td></td><td>5/8″ (16 mm)</td><td>7/32″ (5.7 mm)</td></tr>
<tr><td></td><td>3/4" (19 mm)</td><td>1/4″ (6.8 mm)</td></tr>
<tr><td></td><td colspan="2">For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 0.118″ (3.0 mm) for each glass thickness. The templates are stored for a period of 30 days from the date of glass manufacture. Any complaints concerning glass dimensions will not be accepted after the aforementioned period.</td></tr>
</table>

Table 9 – ASTM C1048

Overall Bow, Maximum												
Nominal Thickness Designation	Edge Dimension, in. (cm)											
	0-20 (0-50)	>20-35 (>50-90)	>35-47 (>90-120)	>47-59 (>120-150)	>59-71 (>150-180)	>71-83 (>180-210)	>83-94 (>210-240)	>94-106 (>240-270)	>106-118 (>270-300)	>118-130 (>300-330)	>130-146 (>330-370)	>146-158 (>370-300)
	Maximum Bow, in. (mm)											
3/16″ (5 mm)	0.12 (3.0)	0.16 (4.0)	0.20 (5.0)	0.28 (7.0)	0.35 (9.0)	0.47 (12.0)	0.55 (14.0)	0.67 (17.0)	0.75 (19.0)	…	…	…
1/4″ (6 mm)	0.08 (2.0)	0.12 (3.0)	0.16 (4.0)	0.20 (5.0)	0.28 (7.0)	0.35 (9.0)	0.47 (12.0)	0.55 (14.0)	0.67 (17.0)	0.75 (19.0)	0.83 (21.0)	0.94 (24.0)
5/16″ (8 mm)	0.08 (2.0)	0.08 (2.0)	0.12 (3.0)	0.16 (4.0)	0.20 (5.0)	0.24 (6.0)	0.31 (8.0)	0.39 (10.0)	0.51 (13.0)	0.59 (15.0)	0.71 (18.0)	0.79 (20.0)
3/8″ (10 mm)	0.08 (2.0)	0.08 (2.0)	0.08 (2.0)	0.16 (4.0)	0.20 (5.0)	0.24 (6.0)	0.28 (7.0)	0.35 (9.0)	0.47 (12.0)	0.55 (14.0)	0.67 (17.0)	0.75 (19.0)
1/2–3/4" (12–19 mm)	0.04 (1.0)	0.08 (2.0)	0.08 (2.0)	0.08 (2.0)	0.16 (4.0)	0.20 (5.0)	0.20 (5.0)	0.28 (7.0)	0.39 (10.0)	0.47 (12.0)	0.55 (14.0)	0.67 (17.0)

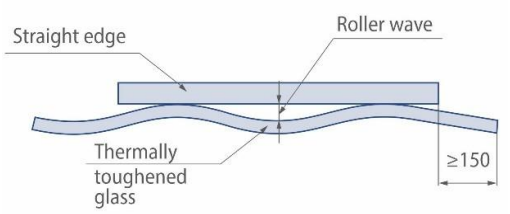
<table>
<tr><td>Roller wave</td><td>Maximum permissible values<table><tr><td>0.003″
(0.076 mm)</td><td>float glass
3/16-3/4″
(5-19 mm)</td></tr></table>For spandrel painted glass that is not fully covered with spandrel, contact the fabricator.</td><td> 

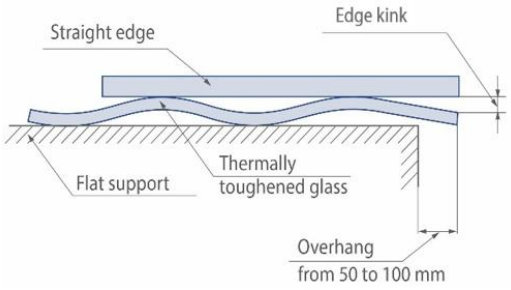
Fig. 19 Roller wave</td></tr>
<tr><td>Edge kink</td><td>Maximum permissible values<table><tr><td>0.008″
(0.203 mm)</td><td>float glass
3/16-3/4″
(5-19 mm)</td></tr></table>For spandrel painted glass that is not fully covered with spandrel, contact the fabricator.</td><td> 

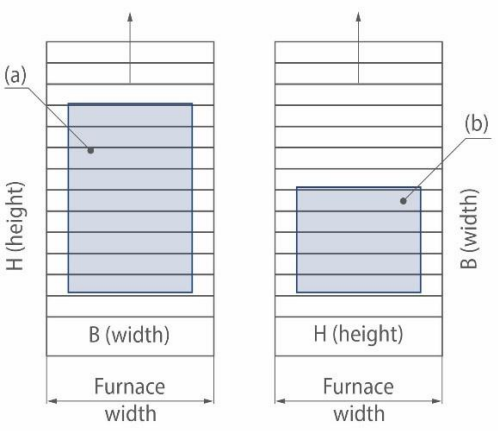
Fig. 20 Edge kink</td></tr>
<tr><td>Limitations</td><td>Directional tempering
Due to the presence of roller waves, the tempering direction must be specified as either parallel or perpendicular to the rollers in the tempering furnace, relative to the width of the glass pane. Directional glass tempering is not possible for glass panes whose B or H dimension exceeds the furnace width. In such case, the glass pane will be tempered in a direction different to the other glass panes in the order. To perform directional tempering, the direction of tempering should be specified by the customer on each order. Failure to specify the tempering direction authorizes the fabricator to process the glass without considering tempering direction.</td><td> 

Fig. 21 Directional tempering</td></tr>
<tr><td></td><td>Minimum edge processing</td><td></td></tr>
<tr><td></td><td>Glass edge seaming</td><td>for glass thickness ≤ 5/16″ (8 mm)</td></tr>
<tr><td></td><td>Glass edge grinding</td><td>for glass thickness ≥ 3/8″ (10 mm)</td></tr>
</table>

Limitations

Table 10

Maximum dimensions for 3/16 inch (5 mm) thick tempered glass

78.7 x 118.1" (2000x3000 mm)	for 3/16" (5 mm) thick float glass
66.9 x 98.4" (1700x2500 mm)	for 3/16" (5 mm) thick, soft-coated float glass

For 3/16" (5mm) thick glass tempering can be made exceeding the abovementioned dimensions, but always subject to individual confirmation. The workmanship tolerances specified in this standard do not apply to larger dimensions.

Table 11

Minimum dimensions of tempered and heat strengthened glass

Treatment	Thickness	Dimension
Tempered	3/16 – 3/4" (5-19 mm)	14" x 14" (304.8 x 101.6 mm)
Heat Strengthened	3/16 – 3/8" (5-10 mm)	17.75" x 8" (304.8 x 101.6 mm)

For glass sizes smaller than indicated above, contact fabricator.

Limitations of the side ratio

If glass panes with the side ratio 1:10 or higher are tempered, the tolerances specified in this standard do not apply.

Glass marking

Heat treated glass shall be permanently marked according to ASTM C1048, or safety glass as applicable.

Heat soak testing

Due to the possible occurrence of spontaneous breakage in tempered glass because of nickel sulfide (NiS) inclusions, it is recommended to perform the Heat Soak Test (HST) according to EN 14179. The test reduces the risk of spontaneous breakage occurrence by 99%.

11. Glass laminating

Standard	ASTM C1172-19
Definition	An assembly consisting of two or more sheets of glass joined together with one or more interlayers.
Type of glass	Monolithic
Glass shapes	Catalog, non-catalog, templates
Tolerances	Table 12 – ASTM C1036

Limit on the difference between diagonals for rectangular glass panes

Glass thickness	Squareness (D1-D2)
1/8, 5/32, 3/16, 1/4″ (3, 4, 5, 6 mm)	5/64″ (2 mm)
5/16″ (8 mm)	7/64″ (2.8 mm)
3/8″ (10 mm)	1/8″ (3.4 mm)
1/2" (12 mm)	11/64″ (4.5 mm)
5/8″ (16 mm)	7/32″ (5.7 mm)
3/4" (19 mm)	1/4″ (6.8 mm)

For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 0.118″ (3.0 mm) for each glass thickness. The templates are stored for a period of 30 days from the date of glass manufacture. Any complaints concerning glass dimensions will not be accepted after the aforementioned period.

Table 13 – ASTM C1172

Tolerance on the dimensions for rectangular glass panes, 2-ply Laminated Glass Including Mismatch up to 75 ft2

Length and Width Tolerances

Laminate Thickness Designation, *d*	Transparent Glass, *t*	Patterned Glass, t	Heat Treated Glass, *t*
d ≤ 1/4 “ (d ≤ 6.4 mm)	+ 5/32″, –1/16″ (+ 4 mm, - 1.6mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+7/32″ –3/32″ (+ 5.6 mm, - 2.4 mm)
1/4 < d ≤ 1/2 “ (6.4 < d ≤ 12.7 mm)	+ 1/4″, –1/16″ (+ 6.4 mm, - 1.6 mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+ 1/4″, –1/8″ (+ 6.4 mm, - 3.2 mm)
1/2 < d ≤ 1 “ (12.7 < d ≤ 25.4)	+1/4″, –1/8″ (+ 6.4 mm, - 3.2 mm)	+5/16″ –1/8″ (+ 7.9 mm, - 3.2 mm)	+5/16″, –1/8″ (+ 7.9 mm, - 3.2 mm)

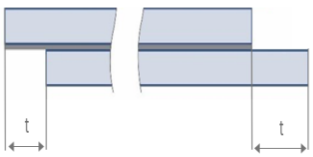


Fig. 22 Dimensional pane tolerance, t

Table 14

Tolerance on the dimensions for rectangular glass panes, 3-ply Laminated Glass Including Mismatch up to 75 ft2

Length and Width Tolerances			
Laminate Thickness Designation, *d*	Transparent Glass, *t*	Patterned Glass, *t*	Heat Treated Glass, *t*
d ≤ 5/8" (d ≤ 16 mm)	+1/4", –5/32" (+ 6 mm, - 4.0 mm)	+3/8" –3/16" (+ 9.9 mm, - 5.2 mm)	+7/32" –5/32" (+ 7.6 mm, - 4.4 mm)
5/8" < d ≤ 1" (16 < d ≤ 25 mm)	+5/16", –5/32" (+ 8.4 mm, - 4.0 mm)	+3/8" –3/16" (+ 9.9 mm, - 5.2 mm)	+5/16", –3/16" (+ 8.4 mm, - 5.2 mm)
1" < d ≤ 1-5/8" (25 < d ≤ 41 mm)	+5/16", –3/16" (+ 8.4 mm, - 5.2 mm)	+3/8" –3/16" (+ 9.9 mm, - 5.2 mm)	+3/8", –3/16" (+ 9.9 mm, - 5.2 mm)
Glass Marking	Shall be marked according to ASTM C1172 for laminate and SGCC certification requirements for laminate safety glass.		

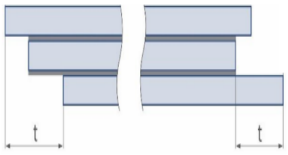


Fig. 23 Dimensional pane tolerance, t

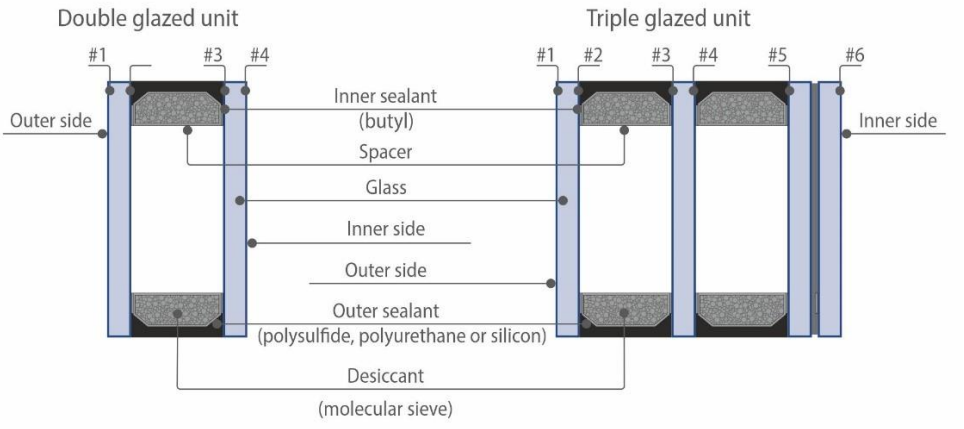
Table 15 – ASTM C1172

Maximum Allowable Overall Bow for Laminated Glass

Edge Dimension	Laminate Make-up Two Glass Lites of the following:				
	1/8-3/16″ (3-5 mm)	1/4" (6 mm)	5/16″ (8 mm)	3/8″ (10 mm)	1/2-3/4″ (12-19 mm)
0-18″ (0-460 mm)	1/8″ (3.2 mm)	1/16″ (1.6 mm)	1/16″ (1.6 mm)	1/16″ (1.6 mm)	1/16″ (1.6 mm)
>18-36″ (>460-910 mm)	3/16″ (4.8 mm)	1/8″ (3.2 mm)	3/32″ (2.4 mm)	3/32″ (2.4 mm)	1/16″ (1.6 mm)
>36-48″ (>910-1220 mm)	9/32″ (7.1 mm)	3/16″ (4.8 mm)	5/32″ (4.0 mm)	1/8″ (3.2 mm)	3/32″ (2.4 mm)
>48-60″ (>1220-1520 mm)	3/8″ (9.5 mm)	9/32″ (7.1 mm)	7/32″ (5.6 mm)	3/16″ (4.8 mm)	1/8″ (3.2 mm)
>60-72″ (>1520-1830 mm)	1/2" (12.5 mm)	3/8″ (9.5 mm)	9/32″ (7.1 mm)	1/4" (6.4 mm)	3/16″ (4.8 mm)
>72-84″ (>1830-2130 mm)	5/8″ (15.9 mm)	1/2" (12.7 mm)	11/32″ (8.7 mm)	5/16″ (7.9 mm)	1/4″ (6.4 mm)
>84-96″ (>2130-2440 mm)	3/4" (19.0 mm)	5/8″ (15.9 mm)	7/16″ (11.1 mm)	3/8″ (9.5 mm)	9/32″ (7.1 mm)
>96-108″ (>2440-2740 mm)	7/8″ (22.2 mm)	3/4" (19.0 mm)	9/16″ (14.3 mm)	1/2″ (12.7 mm)	3/8″ (19.0 mm)
>108-120″ (>2740-3050 mm)	1.0″ (25.4 mm)	7/8″ (22.2 mm)	11/16″ (17.5 mm)	5/8″ (15.9 mm)	1/2" (12.7 mm)
>120-132″ (>3050-3350 mm)	…	1.0″ (25.4 mm)	13/16″ (20.6 mm)	3/4″ (19.0 mm)	5/8″ (15.9 mm)
>132-144″ (>3350-3660 mm)	…	1 1/8″ (28.6 mm)	15/16″ (23.8 mm)	7/8″ (22.2 mm)	3/4" (19.0 mm)
>144-156″ (>3660-3960 mm)	…	1 1/4" (31.8 mm)	11/16″ (27.0 mm)	1.0″ (25.4 mm)	7/8″ (22.2 mm)

Limitations that are not subject to complaint	**Stability of laminated glass edges** Exposing laminated glass edges to sealants, chemical or physical factors may deteriorate its quality (e.g. discoloration, reduced adhesion between the glass and the interlayer, delamination). Any materials in direct contact with laminated glass must be compatible with its components. Special attention should be paid to the presence of moisture in direct contact with laminated glass edges. Water vapor condensation or direct exposure to water has a negative impact on the laminated glass. **Laminated glass made of tempered / heat strengthened glass** Due to roller wave distortion, overall bow, and anisotropy, the quality of laminated glass made with heat-treated glass will differ from that of laminated glass made with annealed glass. Subsequent glass layers can strengthen the visual perception of anisotropy and lenses [local optical distortion typical of glass thickness < 5/16" (8 mm)]. Laminated glass with colored or matte interlayers may change color over time due to weather conditions, e.g. UV radiation. Variations in the color impression are possible also due to the iron oxide content of the glass, the coating process, the coating itself, variation in the glass thickness and the laminated glass construction and cannot be avoided. Due to the aforementioned characteristics, minor color differences between production batches of the same glass type are possible due to these factors. Every interlayer has a slight degree of haze. If the number of interlayers increases, the haze may be more visible. Additional optical effects such as spots, stripes, streaks may be visible.

12. IGUs manufacturing

Standard	ASTM E2188-19
Definition	Insulating glass unit (IGU) – assembly consisting of at least two panes of glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.  Fig. 24 IGU structure diagram
Types of glass	Monolithic, laminated
IGU type	Type A – IGUs intended for installation without permanent shear load on the sealant and protected against direct UV exposure on edge seal. Type B – IGUs intended for installation with at least one edge not completely protected against direct UV radiation without permanent shear load on the sealant. Type C – IGUs intended for installation as bonded glazing for doors, windows and curtain walling with possible permanent shear load on edge sealant with or without direct UV radiation exposure. Permanent shear load can be avoided by mechanical support to carry the weight.
Type of sealant	Polyisobutylene (PIB) – primary sealant. Silicone – external sealant which can be exposed to direct UV radiation. If the edges of IGUs and/or stepped IGUs are exposed, minor visible changes in the color of the silicone mix are acceptable, including discoloration, streaks and residue on the edge.
Spacer	Spacers with mechanically bent corners are joined along the sides in maximum 4 places. Spacers may also be welded in corners or cut. Visible raw material (e.g., a silver line), connectors, minor discoloration and scratches in the cutting area result from the production process. The spacer connection gap must not exceed 0.039" (1 mm).

Tolerances on spacer straightness

For a double-glazed unit, the tolerance on spacer straightness is 0.157" (4 mm) up to a length of 11.4 ft (3.5 m) and 0.236" (6 mm) for longer lengths.

1 - actual position of spacer
2 - theoretical position of spacer
3 - deviation

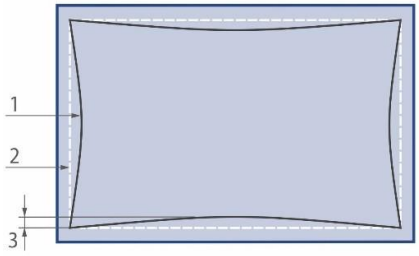


Fig. 25 Spacer straightness

The permissible deviation of the spacer(s) in relation to the parallel straight glass edge or to other spacers (e.g. in triple glazing) is 3 mm up to an edge length of 8.2 ft (2.5 m). For longer edge lengths, the permissible deviation is 0.236" (6 mm).

1 - actual position of spacer
2 - theoretical position of spacer
3 - deviation

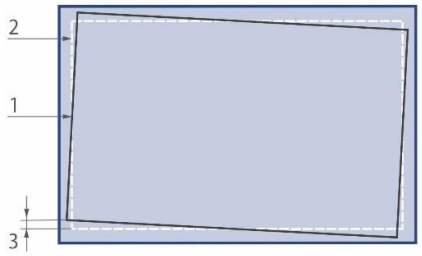


Fig. 26 Spacer deviation

Tolerances

Table 15

Thickness tolerances on the insulating glass units

IGU type	Glass pane	IGU thickness tolerance
double glazing	All panes are annealed float glass	± 0.039" (1 mm)
	At least one pane is laminated, patterned or not annealed glass	± 0.059" (1.5 mm)
triple glazing	All panes are annealed float glass	± 0.055" (1.4 mm)
	At least one pane is laminated, patterned or not annealed glass	+ 0.110", - 0.055" (+ 2.8 mm, – 1.4 mm)

If one glass component has a nominal thickness greater than 1/2" (12 mm) in the case of annealed or heat treated glass, or 3/4" (19 mm) in the case of laminated glass, please contact IGU fabricator.

Thicknesses are nominal thickness.

Tolerances

Table 16

Tolerances on dimensions and misalignment of IGUs

Double / triple IGU	Misalignment (B and H)
all panes ≤ 1/4″ (6 mm) and (B and H) ≤ 78.7″ (2000 mm)	≤ 0.079″ (2 mm)
1/4″ (6 mm) < thickest pane ≤ 1/2" (12 mm) or 78.7″ (2000 mm) < (B or H) ≤ 137.8″ (3500 mm)	≤ 0.118″ (3 mm)
thickest pane ≤ 1/2″ (12 mm) and 137.8″ (3500 mm) < (B or H) ≤ 196.8″ (5000 mm)	≤ 0.157″ (4 mm)
1 pane > 1/2″ (12 mm) or (B or H) > 196.8″ (5000 mm)	≤ 0.197″ (5 mm)

-For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 0.118″ (3.0 mm) for each glass thickness.
-The sealant can protrude beyond the edge seal into the cavity and onto the glass surface.
-Single, non-accumulated foreign bodies are allowed on the spacer, e.g. residues of the desiccant, fine particles of glass, spacer, Georgian bar, etc. that can get inside the IGU during production. These are not subject to complaint.

Glass marking

Marking the IGUs is in accordance with IGCC certification requirements.

Heat treated, safety glass and/or laminated glass shall be permanently marked according to ASTM C1048 and/or ASTM C1172. The differences in the mark location, application method, view (positive-negative) and glass marking positions are not subject to complaint, if they apply to less than 10% of the order.

IGU's composed of annealed glass will only receive markings in accordance with IGCC certification requirements.

Requirements

Selection of the dimensions, composition, type of glass used and the properties of the IGU should be based on the design calculations, taking into account the conditions of its application. For rectangular IGUs, first the width and then the height shall be given. The dimensions shall be given in millimeters, and the order of the glass components starting from the outer pane.

When two coated glass panes are used in a triple glazed unit, and one of them is placed in the middle, tempering of this glass pane is advisable due to potential thermal stress. This also applies for glass with an increased energy absorption index. The final decision and risk belong to the customer.

When designing, the operating temperatures of the individual components of the IGU must also be taken into account. The durability of an IGU is ensured by meeting the requirements of ASTM E2188-19.

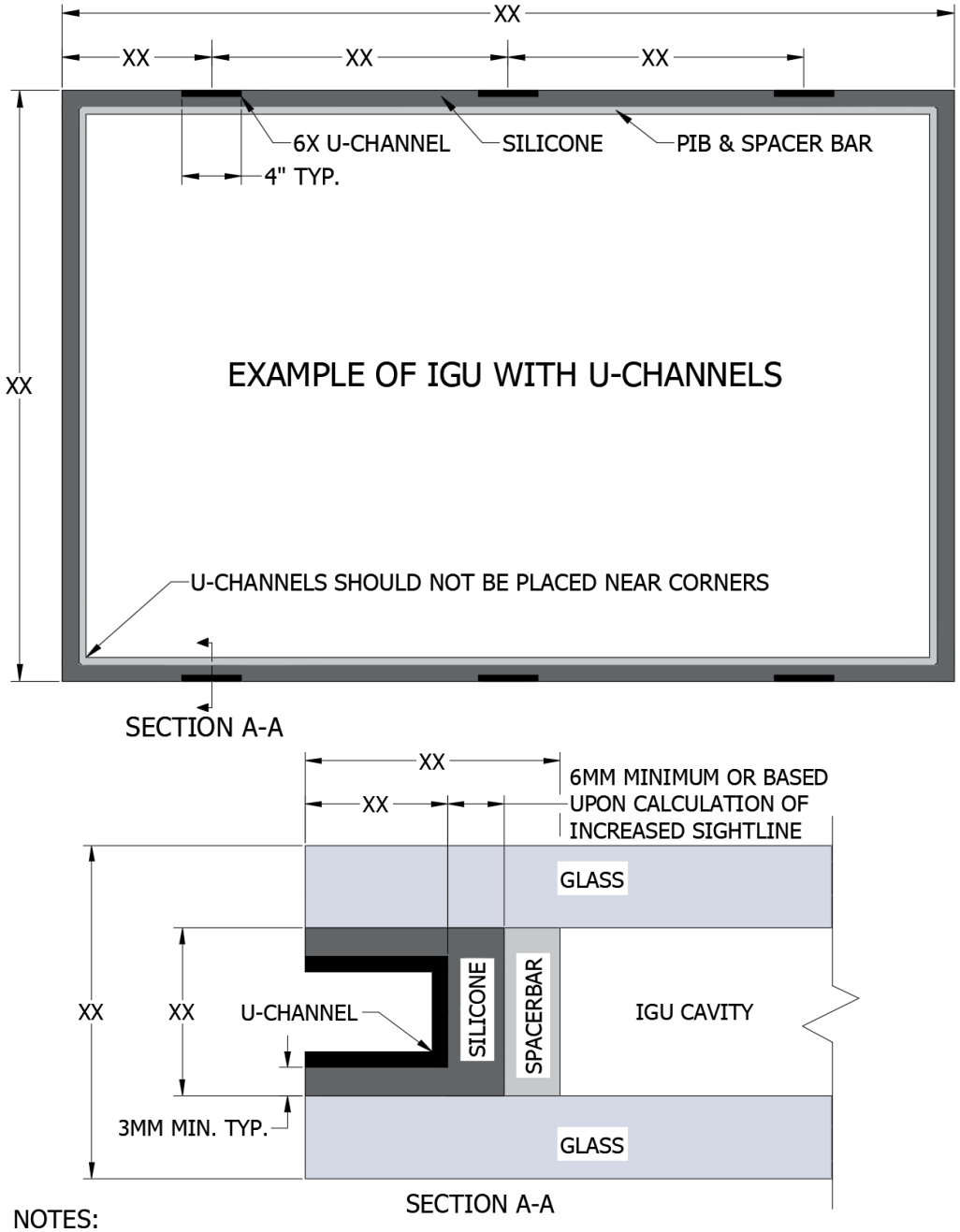
Unless specified, the orientation of the glass pattern for orders including patterned glass shall be placed along the dimension which is the height of the glass in the order.

For reflective glass coatings, the location of the reflective coating in the glass unit shall be specified in the order (position according to Fig. 24). For double glazed units, positions #2 or #3 are recommended, and for triple glazed units positions #4 or #5.

Reference edge/ Reference point	For production of glass with special tolerances/requirements, the IGU reference edge (reference point) shall be determined. The reference edge (point) is necessary to verify correct fabrication. Failure to specify the reference edge (reference point) by the customer, authorizes the fabricator to produce the glass without this requirement.
Glass shapes	The production of non-rectangular shaped glass units is allowed, provided it is mutually agreed upon by the fabricator and the customer. This applies to catalog shapes, custom shapes, and designs based on templates. If shape dimensions cannot be specified, a full-size template (1:1 ratio) precisely made of hard and rigid material (e.g. plywood) must be provided. The templates are stored for 30 days from the date of glass manufacture. Any complaints concerning glass dimensions will not be accepted after the aforementioned period. If glass shapes other than rectangles are made (shapes, templates), view orientation ("from the outside" / "from the inside") shall be agreed between the customer and fabricator on a case-by-case basis.
Georgian bars - features that are not subject to complaint	Georgian bars / GBGs To ensure the clearance between Georgian bars and the glass panes (≥ 0.079" (2 mm) per side), transparent so-called bumpons* are used. Due to unfavorable environmental influences, vibration may occur at Georgian bar from time to time. Bumpons, placed at Georgian bars intersections, are designed to reduce the vibration and the formation of a thermal bridge. Visible raw material, fasteners and slight discoloration within the cut are the result of the manufacturing process. The number and placement of bumpons are determined by the number and length of the Georgian bar fields and remains at the discretion of the fabricator. The accuracy of the positioning of Georgian bars is maximum 0.079" (2 mm) from the nominal dimensions. The minimum spacing between grids is twice the width of the grid being used. * Bumpons are not used with spacers wider than 0.709" (18 mm) (it is not recommended to use Georgian bars for distances between the glass panes greater than 0.709" (18 mm). Duplex bars (back-to-back bars) / SDLs Application of the Duplex bars with widths other than specified in the current offer is to be agreed in each case. Duplex bars are to be used in the interior spacer, leaving a min 0.079" (2 mm) clearance on each side between the bar and glass. Minimum spacing between bars (inside to inside) measurement is 5" (127 mm). When ordering glass units designed for attaching external Georgian bars, glass deflection subject to climatic factors (i.e. temperature and pressure) should be taken into account and included in the designed construction. The result will be selection of a suitable thickness of the glass, which will be specified in the order and which will ensure correct installation and operation of this type of glass. Moreover, when external bars are to be glued to the glass, be sure to use the correct adhesive (preferably weather-resistant soft silicone), which adheres the glass with the outer bar, maintaining a minimum distance of 0.118" (4 mm). IGU's that have notches and/or cut outs, SDL placement must be reviewed by PRESS GLASS.

U-Channels

If U-Channels are supplied by the customer, their compatibility with silicone must be verified. Standard U-Channels supplied by PRESS GLASS are in 4" (101.6 mm) sections and cannot be cut to any other length. Silicone 6mm minimum or based upon calculation of increased sightline.



NOTES:

1. THIS DRAWING IS FOR EXAMPLE ONLY.
2. DRAWING DIMENSIONS ARE SHOWN AS "XX".
3. STANDARD U-CHANNEL IS 4" LONG.

Fig. 27 U-Channels

Recessed Spacer Bars	Standard recessed spacer bars will have a tolerance of +0/-2mm and will have a smeared surface. Silicone 6mm minimum or based upon calculation of increased sightline.

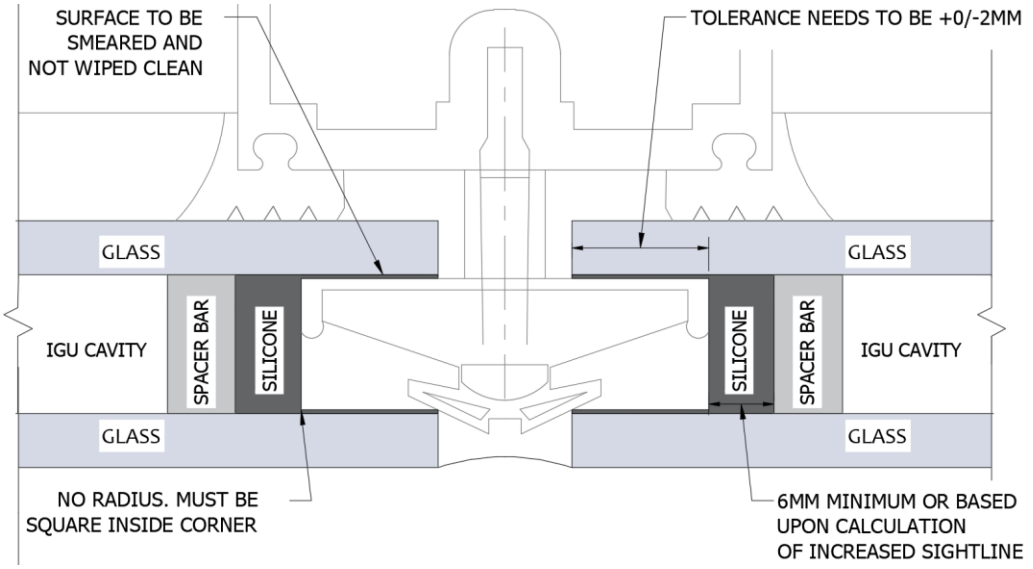


Fig. 28 Recessed Spacer Bars

Georgian Bars

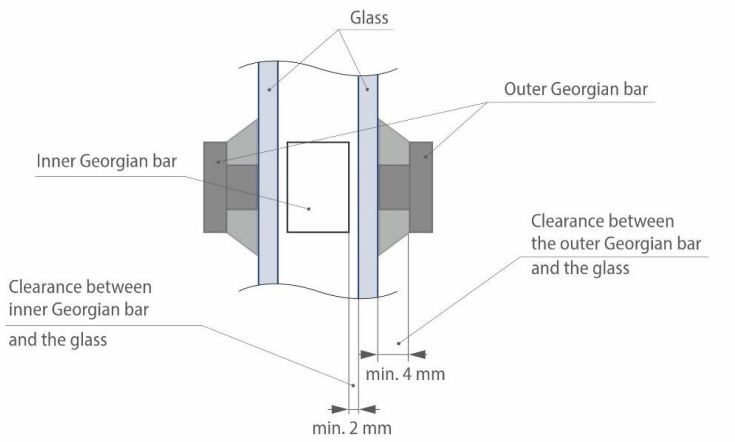


Fig. 29 Installation of inner and outer Georgian bars

When using Georgian bars, the following is possible:
- manufacturing of arched fields, where the minimum bending radius is to be considered:

For 18 mm wide Georgian bar	R ≥ 170 mm
For 26 mm wide Georgian bar	R ≥ 200 mm

- Combination of various widths of the Georgian bars,
- Combination of Georgian bars bent at different angles,
- Connection of Georgian bars at different angles (contact Sales Department for further details).

Table 20

Examples of combinations of connecting Georgian bars

Georgian bar / Connector	0.31″ (8 mm)	0.71″ (18 mm)	1.02″ (26 mm)	1.77″ (45 mm)	Maximum field dimensions
0.31″ (8 mm)	+	-	-	-	27.5 x 27.5″ (700 x 700 mm)
0.71″ (18 mm)	-	+	+	-	47.2 x 47.2″ (1200 x 1200 mm)
1.02″ (26 mm)	-	+	+	-	47.2 x 47.2″ (1200 x 1200 mm)
1.77″ (45 mm)	-	+	+	+	47.2 x 47.2″ (1200 x 1200 mm)

For Duplex bars the maximum permissible field dimension must not exceed 47.2″ (1200 mm).

Table 17

Maximum sizes with less than 1″ deflection

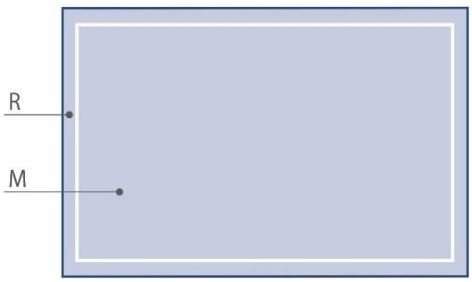
Thickness	Aspect Ratio	Max Width	Max Height	Max Surface Area	IGU Makeup Glass/Spacer/Glass
3/16″ (5 mm)	1 : 8	129.92″ (3300 mm)	53.15″ (1350 mm)	47.95 ft^2 (4.45 m^2)	5-10-5
		137.80″ (3500 mm)	51.18″ (1300 mm)	48.98 ft^2 (4.55 m^2)	5-12-5
1/4″ (6 mm)	1 : 8	137.80″ (3500 mm)	63″ (1600 mm)	60.29 ft^2 (25.6 m^2)	6-10-6
		157.48″ (4000 mm)	59.05″ (1500 mm)	64.58 ft^2 (6 m^2)	6-12-6
5/16″ (8 mm)	1 : 10	137.80″ (3500 mm)	82.68″ (2100 mm)	79.12 ft^2 (7.35 m^2)	8-10-8
		216.54″ (5500 mm)	72″ (1829 mm)	108.27 ft^2 (10.06 m^2)	8-12-8
3/8″ (10 mm)	1 : 10	177.17 (4500 mm)	86.61″ (2200 mm)	106.56 ft^2 (9.9 m^2)	10-12-10
		236.22″ (6000 mm)	78″ (1981 mm)	127.95 ft^2 (11.89 m^2)	10-16-10
1/2" (12 mm)	1 : 10	196.85″ (5000 mm)	106.30″ (2700 mm)	145.31 ft^2 (13.5 m^2)	12-12-12
		236.22″ (6000 mm)	105″ (2667 mm)	172.24 ft^2 (16 m^2)	12-16-12

- When different thickness glass panes are used in IGUs, the area is always limited by the glass with the lower thickness.
- If spacers wider than 5/8″ (16 mm) are used, the same data as for 5/8″ (16 mm) cavity from the table above is applicable.
- For any IGU makeups consisting of laminated pieces please consult the fabricator for maximum sizes.

Maximum dimensions of IGUs presented in the table above apply if the following conditions are met:
- vertical glazing,
- supported on all four sides,
- not applicable to corner glazing of the buildings,
- average wind load in USA is assumed (30 psi)

(!) NOTE: The above data is a suggestion and only considers static loads of the glass units, not the building structure or dynamic loads. Approval by a qualified building engineer certified in relevant construction regulations is required before use.

13. Glass surface assessment – Coated, coated overhead, coated ceramic frit

Standard	ASTM C1376-21		
Type of glass	Monolithic		
Glass shapes	Catalog, non-catalog, templates		
Coated Glass			
Assessment method	The glass shall be assessed from a distance of at least 10 ft (3 m), perpendicular to its surface. During the assessment, the observation should be viewed at an angle of 90° to the specimen. The assessment must be carried out in normal daylight conditions without direct sunlight or artificial lighting, in front of the glass pane, with an opaque background. Observed defects shall not be marked. Glass seen from both sides shall be subject to the same criteria. Defects visible from a distance less than 10 ft (3 m) are not classified as defects.		
Assessment zones	Zone R	Edge Zone R is the remaining perimeter area after defining Zone M.	 Fig. 30 Assessment zones
	Zone M	Main zone considered to form a square or rectangle defined by the center 80% of the length and 80% of the width.	

Acceptable and maximum blemish

Table 18 – ASTM C1376

Blemish	Zone M	Zone R
Pinhole	1/16″ (1.6 mm) max	3/32″ (2.4 mm) max
Spot	1/16″ (1.6 mm) max	3/32″ (2.4 mm) max
Coating Scratch	2″ (50 mm) max length	3″ (75 mm) max length
Mark/Contaminant	2″ (50 mm) max length	3″ (75 mm) max length
Coating rub	None allowed	Length plus width not to exceed 3/4″ (19 mm)
Crazing	None allowed	None allowed
Corrosion	None allowed	None allowed

No more than two readily apparent blemishes are allowed in a 3″ (75 mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12″ (300 mm) diameter circle.

Overhead Coated Glass

Assessment method

The glass shall be inspected, in transmission, at a distance of 15 ft (4.6 m) at a viewing angle of 90° to the specimen against a bright uniform background. If a blemish is readily apparent under these viewing conditions, the above criteria applies.

Assessment zones

Zone R	Edge Zone R is the remaining perimeter area after defining Zone M.
Zone M	Main zone considered to form a square or rectangle defined by the center 80% of the length and 80% of the width.

Fig. 31 Assessment zones

Acceptable and maximum blemish

Table 19 – ASTM C1376

Blemish	Zone M	Zone R
Pinhole	3/32″ (2.4 mm) max	1/8″ (3.2 mm) max
Spot	3/32″ (2.4 mm) max	1/8″ (3.2 mm) max
Coating Scratch	3″ (75 mm) max length	4″ (100 mm) max length
Mark/Contaminant	3″ (75 mm) max length	4″ (100 mm) max length
Coating rub	Length plus width not to exceed 3/4" (19mm)	Length plus width not to exceed 3/4" (19mm)
Crazing	None allowed	None allowed
Corrosion	None allowed	None allowed

No more than two readily apparent blemishes are allowed in a 3″ (75 mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12″ (300 mm) diameter circle.

Coated Ceramic Frit

Assessment method

The glass shall be inspected, in reflection, at a distance equal to or greater than 15 ft (4.6 m) at a viewing angle of 90° to the specimen under uniform lighting conditions.

The specifications separate the glass by the distance that it will be viewed when installed.
- Range No. 1 is for all glass within a viewing distance of 15 ft (4.6 m) or less
- Range No. 2 is all glass viewed from a distance greater than 15 ft (4.6 m)

Allowable maximum blemish

Table 20 – ASTM C1376

Blemish	Range No. 1	Range No. 2
Pinhole	1/8″ (3.2 mm) max	5/32″ (4 mm) max
Spot	1/8″ (3.2 mm) max	5/32″ (4 mm) max
Coating Scratch	3″ (75 mm) max length	6″ (150 mm) max length
Mark/Contaminant	3″ (75 mm) max length	6″ (150 mm) max length
Coating rub	None allowed	Length plus width not to exceed 3/4" (19 mm)
Crazing	None allowed	None allowed
Corrosion	None allowed	None allowed

No more than two readily apparent blemishes are allowed in a 3″ (75 mm) diameter circle, and no more than five readily apparent blemishes are allowed in a 12″ (300 mm) diameter circle.

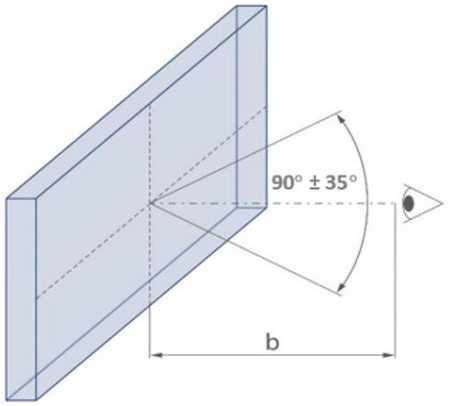
Color

Color variations are caused by many factors and cannot be eliminated. The actual color of the spandrel can be determined by inspecting the fired sample through the glass side in reflection. Differences may occur in colors selected based on standard systems, e.g. RAL.

The following factors affect the assessment of visible color differences between two spandrel glass panes coated with ceramic frit, depending on the specific lighting conditions. Float glass is typically used as substrate and its flat surface reflects the light intensively. Additionally, different kinds of coatings can be applied to glass and the color of basic glass depends on the manufacturer, glass thickness or production batch (e.g. tinted glass, glass with reduced iron content) which affect the final color of spandrel painted glass. The color also depends on the application method. Due to the relatively thin spandrel coating achieved with silk screen or digital print, the coated surfaces are more permeable to light compared to the thicker spandrel coatings applied with a roller. Spandrel painted glass is always assessed after tempering or heat strengthening.

	Ceramic frit spandrel is made of inorganic materials which determine the color. The original color of the spandrel may vary slightly and that is why the spandrel color can be compared only within one production batch. Light constantly changes depending on time of year, time of day and weather conditions. This means that the various components in the visible light spectrum (i.e. wavelengths of 400 – 700 nm) passing through several objects (air, glass), hit the fired ceramic spandrel at varying angles. Depending on the angle of incidence, the surface of the glass reflects part of the light beam to a lesser or greater extent. Light of different wavelengths, which reaches the fired spandrel is partly reflected and/or absorbed. This explains why the impression of color varies depending on lighting conditions. The human eye reacts very differently to different colors. It is very sensitive to even very slight changes in blue, while the same changes in green are not seen as distinctly. Other factors which affect color assessment include: the viewing angle, size of the viewed object and the distance between two compared objects.
	The following essential steps must be performed prior to making an order: a) Assessment of the possibility to fabricate the order within the tolerance limits - based only on the data submitted by the customer (order size, glass availability, spandrel availability, etc.), b) Manufacturing of 1:1 mock-up and its approval by the customer, c) Manufacturing the order according to agreements and/or template/mock-up approved by both parties. The comparison and assessment can be performed only when spandrel painted glass is provided by one supplier. The colors of the spandrel can be compared only for one customer's order, one type of glass and ceramic spandrel. When comparing two pieces of glass covered with spandrel of the same color, the acceptable color difference is $\Delta E \leq 4.0$ (C.I.E. L*a*b) – the measurement is performed on the glass surface. Colors obtained by digital printing will always differ from the indicated colors in the templates and from the colors in the pictures sent (more or less). It is recommended to make a color sample.
Other physical characteristics	Anisotropy – a feature of heat-treated glass. The phenomenon occurs as areas of different stress in the cross section of the glass caused by the rapid cooling of glass during heat treatment. These areas of stress produce a bi-refringent effect in the glass, which is visible in polarized light. When heat-treated glass is viewed in polarized light, the areas of stress show up as colored zones, sometimes known as “leopard spots”. Polarized light occurs in normal daylight. The amount of polarized light depends on the weather and the angle of the sun. The bi-refringent effect is more noticeable either at a glancing angle or through polarized lenses. Anisotropy is not a defect but a visible effect. Roller imprints – during heat treatment of glass thicker than 5/16” (8 mm) or thinner glass panes with a large surface area, small impression marks can become more visible (roller imprints). Such an effect is not subject to complaint. Roller waves – occur as a result of glass tempering/heat strengthening and create an optical distortion which is generally noticed in reflection. Acceptable values of roller wave distortion are given in the section related to glass tempering and heat strengthening.

14. Glass surface assessment - tempered, heat strengthened, heat soak tested glass, ceramic frit glass

Standard	ASTM C1048, ASTM C1036	
Type of glass	Monolithic	
Glass shapes	Catalog, non-catalog, templates	
Assessment method	**Tempered, heat strengthened, heat soaked:** For point blemish detection, samples must be viewed from a distance of 39″ (1 m). For linear blemishes samples shall be viewed at the distance of 130″ (3.3 m). The allowable vision interference angle shall be less than or equal to 35°. **Spandrel Painted Glass:** Glass shall be viewed by light reflected from the outside facing surface as installed against a uniformly opaque background material and in vertical position. View the sample from approximately 10 ft (3 m).	 Fig. 32 Tempered, heat strengthened, and heat soak tempered glass assessment method
	The observer's distance *b* is:	
	39″ (1 m) for point blemish detection	
	130″ (3.3 m) for linear blemish detection	
	12′ (3 m) for ceramic frit glass	
	The assessment shall not last longer than 20 seconds.	

Allowable maximum blemishes

Table 21 – ASTM C1048, ASTM C1036

Allowable Point Blemish Size and Distribution		
Blemish Size	Tolerance	
	Tempered, Heat Strengthened, Heat Soak Tempered Glass	Spandrel Painted Glass
≥ 0.03″ < 0.05″ (≥ 0.80 mm < 1.20 mm)	Allowed	None allowed
≥ 0.05″ < 0.08″ (≥ 0.80 mm < 1.20 mm)	Allowed with a minimum separation of 24″ (600 mm)	
≥ 0.08″ < 0.10″ (≥ 2.0 mm < 2.50 mm)	None allowed	

Table values are for glass, ¼″ (6 mm) and less. For glass thicker than ¼″ but less than or equal to ½″ (12 mm), proportionally larger blemishes are permitted but with the same minimum separation distances. Table 21 does not apply to glass thicker than ½″. Allowable blemishes for thicker glass shall be determined between the customer and PRESS GLASS.

Table 22 – ASTM C1048, ASTM C1036

Allowable Linear Blemish Size and Distribution		
Linear Blemish Size, Intensity Length	Tolerance	
	Tempered, Heat Strengthened, Heat Soak Tempered Glass	Spandrel Painted Glass
Light > 3″ (75 mm)	Allowed	None allowed
Medium ≤ 3″ (75 mm)	Allowed with a minimum separation of 24″ (600 mm)	
Medium > 3″ (75 mm)	None allowed	
Heavy ≤ 6″ (150 mm)	None allowed	

Light = Detection distance of 8″ (0.2 m)

Medium = Detection distance of 39″ (1 m)

Heavy = Detection distance of 130″ (3.3 m)

Edge defects	Seaming	Small nicks on the edge are acceptable. Blank spots – acceptable.
	Grinding	Nicks on the edge – unacceptable.
	Polishing	Matte spots, nicks on the edge – unacceptable.
Definitions of defects	Spot defects	Spherical or semi spherical disturbance of the visual transparency looking through the glass. It can be a solid inclusion, a gaseous inclusion, a pinhole in a coating.
	Linear defects	Faults, which can be on or in the glass, in the form of deposits, marks or scratches that occupy an extended length or area.
	Streaks	Haze typical for heat-treated glass, visible under specific lighting conditions (e.g. direct sunlight or artificial light) and against a dark background. The phenomenon is related to the production process, and it cannot be avoided.
	Stains	Defects larger than spot defects, often irregular, with partly spotted structure.
Color	Color variations are caused by many factors and cannot be eliminated. The following factors (in specific lighting conditions) affect the assessment of visible color differences between two glass panes coated with ceramic spandrel. The actual color of the spandrel can be determined by viewing a fired sample through the glass side in reflection. Differences may occur in colors selected based on standard systems, e.g. RAL. Float glass is typically used as a substrate and its flat surface reflects light. Additionally, different kinds of coatings can be applied to glass and the color of basic glass depends on the manufacturer, glass thickness or production batch (e.g. tinted glass, glass with reduced iron	

	content) which affect the final color of spandrel painted glass. The color also depends on the application method. Due to the relatively thin spandrel coating achieved with silk screen or digital print, the coated surfaces are more permeable to light than those where spandrel is applied using a roller, where the spandrel coating is thicker. Spandrel painted glass is always assessed after tempering or heat strengthening. Ceramic spandrel is made of inorganic materials which determine particular color. The original color of the spandrel may vary slightly and that is why the spandrel color can be compared only within one production batch. Light constantly changes depending on time of year, time of day and weather conditions. This means that the various components in the visible light spectrum (i.e. wavelengths of 400 – 700 nm) passing through several objects (air, glass), hit the fired ceramic spandrel at varying angles. Depending on the angle of incidence, the surface of the glass reflects part of the light beam to a lesser or greater extent. Light of different wavelengths, which reaches the fired spandrel is partly reflected and/or absorbed. This explains why the impression of color varies depending on lighting conditions. The human eye reacts very differently to different colors. It is very sensitive to even very slight changes in blue, while the same changes in green are not seen as distinctly. Other factors which affect color assessment include: the viewing angle, size of the viewed object and the distance between two compared objects.
	The following essential steps must be performed prior to making an order: a) Assessment of the possibility to execute the order within the tolerance limits - based only on the data submitted by the customer (order size, glass availability, spandrel availability, etc.), b) Manufacturing of 1:1 mock-up and its approval by the customer, c) Manufacturing the order according to agreements and/or template/mock-up approved by both parties. The comparison and assessment can be performed only when spandrel painted glass is provided by one supplier. The colors of the spandrel can be compared only for one customer's order, one type of glass and ceramic spandrel. When comparing two pieces of glass covered with spandrel of the same color, the acceptable color difference is $\Delta E \leq 4.0$ (C.I.E. L*a*b) – the measurement is performed on the glass surface. Colors obtained by digital printing will always differ from the indicated colors in the templates and from the colors in the pictures sent (more or less). It is recommended to make a color sample.
Other physical characteristics	Anisotropy – a feature of heat-treated glass. The phenomenon occurs as areas of different stress in the cross section of the glass caused by the rapid cooling of glass during heat treatment. These areas of stress produce a bi-refringent effect in the glass, which is visible in polarized light. When heat-treated glass is viewed in polarized light, the areas of stress show up as colored zones, sometimes known as “leopard spots”. Polarized light occurs in normal daylight. The amount of polarized light depends on the weather and the angle of the sun. The bi-refringent effect is more noticeable either at a glancing angle or through polarized spectacles. Anisotropy is not a defect but a visible effect. Roller imprints – during heat treatment of glass thicker than 5/16” (8 mm) or thinner glass panes with a large surface area, small impression marks can become more visible (roller imprints). Such an effect is not subject to complaint. Roller waves – occur as a result of glass tempering/heat strengthening and create an optical distortion which is generally noticed in reflection. Acceptable values of roller wave distortion are given in the section related to glass tempering and heat strengthening.

15. Glass surface assessment - laminated glass

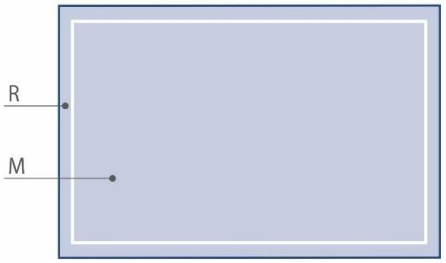
Standard	ASTM C1172-19		
Type of glass	Monolithic		
Glass shapes	Catalog, non-catalog, templates		
Assessment method	The viewer shall look at the sample at an angle of 90° (perpendicular) to the surface using the following lighting unless otherwise specified: daylight (without direct sunlight) or other uniform diffused background lighting that simulates daylight, with a minimum luminance of 160 fc (1700 lx) measured at the surface of the glass facing the light source.		
Assessment zones	Zone R	Edge zone is the remaining perimeter area after defining Zone M.	 Fig. 33 Assessment zones
	Zone M	Main zone is an area formed by an oval or circle whose axes or diameters, when centered, do not exceed 80 % of the overall dimension.	

Table 23 – ASTM C1172

Laminating Process Blemishes for Vertical Glazing

Blemish	Up to 25 ft²		25 to 75 ft²		Over 75 ft²	
	Zone M	Zone R	Zone M	Zone R	Zone M	Zone R
Boil (Bubbles)	1/16″ (1.6 mm)	3/32″ (2.4 mm)	1/8″ (3.2 mm)	3/16″ (4.8 mm)	1/4" (6.4 mm)	1/4" (6.4 mm)
Blow-in, Edge boil	N/A	CE: 1/4" (6.4 mm) EE: 1/16″ (1.6 mm)	N/A	CE: 1/4" (6.4 mm) EE: 3/32″ (2.4 mm)	N/A	CE: 5/16" (8.0 mm) EE: 1/8″ (3.2 mm)
Fuse	1/32″ (0.8 mm)	1/16″ (1.6 mm)	1/16″ (1.6 mm)	3/32″ (2.4 mm)	3/32″ (2.4 mm)	5/32″ (4.8 mm)
Hair, Lint (single strand)	Light	Medium	Light	Medium	Medium	Medium

Inside dirt (dirt spot)	1/16″ (1.6 mm)	3/32″ (2.4 mm)	3/32″ (2.4 mm)	5/32″ (4.0 mm)	1/8″ (3.2 mm)	3/16″ (4.8 mm)
Lint-area of concentrated lint	Light	Medium	Light	Medium	Medium	Medium
Separation, discoloration	None	None	None	None	None	None
Short interlayer, un-laminated area, chip	N/A	CE: 1/4" (6.4 mm) EE: 1/16″ (1.6 mm)	N/A	CE: 1/4" (6.4 mm) EE: 3/32″ (2.4 mm)	N/A	CE: 1/4" (6.4 mm) EE: 1/8″ (3.2 mm)
Scuff, streak	Light	Medium	Medium	Medium	Medium	Medium

N/A = Not Applicable
CE = Covered edge of glass edge bite, EE = exposed edge (If CE or EE is unknown, use CE tolerances)
Light = Light intensity, barely noticeable at 39″ (1 m)
Medium = Medium intensity, noticeable at 39″ (1 m) but not at 10 ft (3 m)

Note:
- All imperfections noted should be separated by a minimum of 12″ (300 mm)
- Laminates with more than two lites of glass may contain proportionally more blemishes.

Table 24 – ASTM C1172

Laminating Process Blemishes for Overhead Glazing

Blemish	Up to 25 ft^2		25 ft^2 or greater	
	Zone M	Zone R	Zone M	Zone R
Boil (Bubbles)	3/32″ (2.4 mm)	1/8″ (3.2 mm)	3/16″ (4.8 mm)	1/4″ (6.4 mm)
Blow-in, Edge boil	N/A	CE: 1/4" (6.4 mm) EE: 3/32″ (2.4 mm)	N/A	CE: 5/16″ (8.0 mm) EE: 1/8″ (3.2 mm)
Fuse	1/6″ (1.6 mm)	1/6″ (1.6 mm)	3/32″ (2.4 mm)	5/32″ (4.0 mm)

Hair, Lint (single strand)	Medium	Medium	Medium	Medium
Inside dirt (dirt spot)	3/32″ (2.4 mm)	3/32″ (2.4 mm)	5/32″ (4.0 mm)	3/16″ (4.0 mm)
Lint-area of concentrated lint	Medium	Medium	Medium	Medium
Separation, discoloration	None	None	None	None
Short interlayer, un-laminated area, chip	N/A	CE: 1/4" (6.4 mm) EE: 3/32″ (2.4 mm)	N/A	CE: 1/4" (6.4 mm) EE: 1/8″ (3.2 mm)
Scuff, streak	Medium	Medium	Medium	Medium

N/A = Not Applicable
CE = Covered edge of glass edge bite, EE = exposed edge (If CE or EE is unknown, use CE tolerances)
Light = Light intensity, barely noticeable at 39″ (1 m)
Medium = Medium intensity, noticeable at 39″ (1 m) but not at 10 ft (3 m)

Note:
- All imperfections noted should be separated by a minimum of 12″ (300 mm)
- Laminates with more than two lites of glass may contain proportionally more blemishes.

16. IGU assessment

Standard	None
Type of glass	Monolithic, laminated
Glass shapes	Catalog, non-catalog, templates
Assessment method	Assessment of IGUs shall be conducted in accordance with previous processing methods.
Physical characteristics excluded from assessment	Inherent color – variations in the color impression are possible due to the iron oxide content of the glass, the coating process, the coating itself, variation in the glass thickness and the unit construction and cannot be avoided. Difference in IGU color – glazing made of IGUs incorporating coated glass can present different shades of the same color, an effect that can be amplified when observed at an angle. Possible causes of differences in color include slight variations in the color of the substrate onto which the coating is applied and slight variations in thickness of the coating itself. An objective assessment of the differences in color can be done using ASTM C1376. Interference effect – in IGUs made of float glass, interference effects may cause spectral colors to appear. Optical interference is due to superposition of two or more light waves at a single point. The effects are seen as variation in intensity of the colored zones, which change when pressure is applied to the glass. This physical effect is reinforced by the parallelism of the surfaces of the glass. Interference effects occur at random and cannot be avoided. Specific effect due to barometric conditions – an IGU includes a volume of air or other gas, hermetically sealed by the edge seal. The state of the gas is essentially determined by the altitude, the barometric pressure and the air temperature, at the time and place of manufacture. If the insulating glass unit is installed at another altitude, or when the temperature or barometric pressure changes (higher or lower pressure), the panes will deflect inwards or outwards, resulting in optical distortion. To prevent the abovementioned effect, it is recommended to equalize pressure in the IGU (using an appropriate device) to the pressure which will ensure its proper performance at the installation site. For more information, contact the Sales Department.

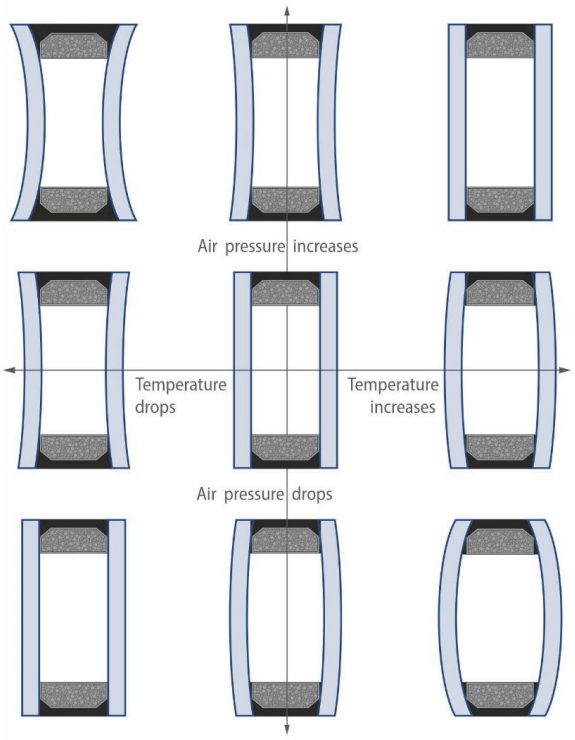


Fig. 34 Glass deflection due to changes in the temperature and barometric pressure

Multiple reflections – multiple reflections can occur in varying intensity at the surfaces of glass units. These reflections can be seen particularly well if the background viewed through the glazing is dark. This effect is a physical property of all IGUs.

Anisotropy (iridescence) – IGUs that contain a heat-treated glass component may show visual phenomena known as anisotropy.

Condensation on the external surface of IGU – condensation can occur on the external glass surfaces when the glass surface is colder than the adjacent air. The extent of condensation on the external surfaces of a glass pane is determined by the U-value, the air humidity, air movement and the indoor and outdoor temperatures. When the ambient relative humidity is high and when the surface temperature of the pane falls below the ambient temperature, condensation at the glass surface occurs.

Wetting of glass surfaces – the appearance of the glass surfaces can differ due to the effect of rollers, fingerprints, labels, vacuum suction holders, sealant residues, silicone compounds, smoothing agents, lubricants, environmental influences, etc. This can become evident when the glass surfaces are wet by condensation, rain or cleaning water.

Glass breakage – glass is a homogeneous, amorphous, solid, brittle and hard construction material. It has negligible internal stress, so it can be cut and processed. It breaks due to thermal or mechanical external factors. These types of glass breakages which occur after glass is delivered to the customer are not subject to complaint. To increase the resistance to breaking caused by thermal or mechanical load, the glass should be tempered, or heat strengthened. This particularly applies to glass with an increased energy absorption.

Examples of mechanical and thermal cracks

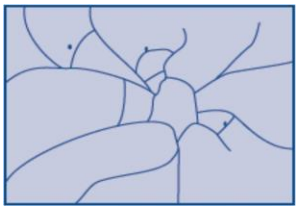


Fig. 35 Impact to the glass surface (e.g. throwing a stone)

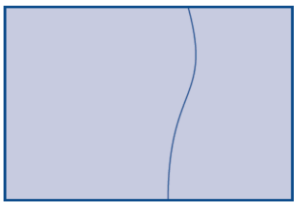


Fig. 36 Torsion breakage

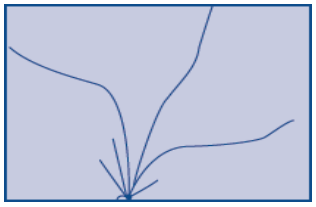


Fig. 37 Impact to the edge

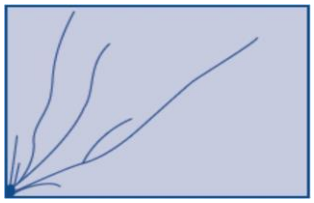


Fig. 38 Impact to the corner

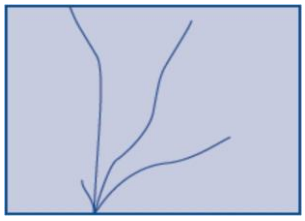


Fig. 39 Pressure on the edge

Fig. 40 Clamping crack

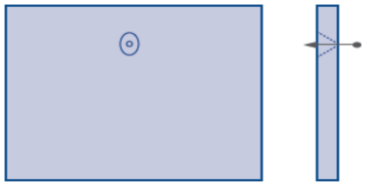


Fig. 41 Gun shot

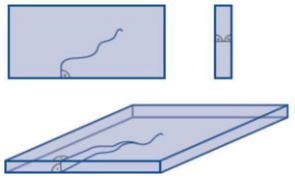


Fig. 42 Thermal crack

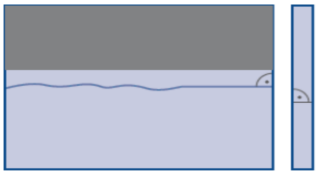


Fig. 43 Thermal crack*

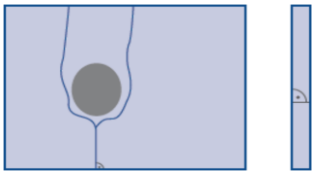


Fig. 44 Thermal crack*

* Fig. 42, 43 – examples of thermal cracks caused by application of decoration or sticker on the glass surface or by its partial shading by blind, tree, part of a roof, etc.

17. Finished product handling

Packing	To transport finished products, A or L type metal racks or wooden crates are normally used. The stand base should form a right angle (90°) with its back side. All metal parts of the rack which come in contact with glass shall be lined with rubber or another shock-absorbing material. Glass placed on rack shall be secured with nylon strapping to prevent movement during transport. The following materials may be placed between the glass to prevent damage during shipment: cork, cardboard, wood, or other materials. Other packaging must be arranged between the customer and the fabricator.
Storage	Finished products (glass panes, laminated glass or IGUs) shall be stored in covered, dry, well-ventilated rooms, protected against rain and direct sunlight, at a temperature not exceeding 104°F (40 °C). The fabricator shall not be liable for any defects caused by improper storage.
Transport	In most cases, glass is delivered using vehicles specifically designed to transport glass. The customer unloads the rack containing the glass from the truck. The customer is responsible for proper unloading and shall report any defects or nonconformance's discovered during delivery. Customer pickup of goods is available upon request and risk of the customer (in terms of breakage and glass damage during transport). If any product returns are agreed, the party returning the goods is responsible for correct packing, protection and loading of the glass.
Installation	Finished products (glass panes, laminated glass or IGUs) are only a component of the whole glazing system. Glazing companies are responsible for ensuring compliance and proper selection of the glass for the window/facade system. PRESS GLASS shall not be held liable for using finished products in glazing systems which do not comply with regulations or with their intended use.
Washing and cleaning	Glass washing and cleaning - Clean the glass surface regularly, depending on the degree of dirtiness. - Never remove solid contamination, such as dry cement; in such cases moisten the glass surface thoroughly with clean water to soak and wash away hard and sharp particles. - Soak the glass with a mixture of clean water and a mild, non-abrasive cleaning solution using a brush or strip washer. - Use a squeegee immediately after soaking to remove the cleaning solution. - Remove sealant and oily residues with alcohol or isopropyl alcohol and then thoroughly rinse with water. Any cleaning fluids that remain on surrounding framing, sealants and gaskets should be dried to prevent deterioration. - To clean reflective coatings on position 1, never use any corrosive and alkaline substances (fluorine, chlorine) or scouring powders as they could damage the coating. Washing should be done using conventional detergents; to remove dirt in the form of greasy stains acetone can be used, following the instructions for use. Suppliers of reflective glass recommend using a suspension containing cerium oxide (50 - 160 g/l water) to clean reflective coatings. It is recommended, especially for coated surfaces (reflective or otherwise), to wash one window only and then examine the surface for damage. For self-cleaning glass coatings and the like, please observe the special cleaning recommendations issued by the suppliers of these products. For more information contact our Sales Department. The fabricator of glass shall not be held liable for any glass defects resulting from incorrect cleaning, use of wrong cleaning agents, the influence of outdoor contaminants (weather or other factors) and the use of tools/objects which can damage the glass e.g. a metal scraper.

18. Catalog of glass shapes

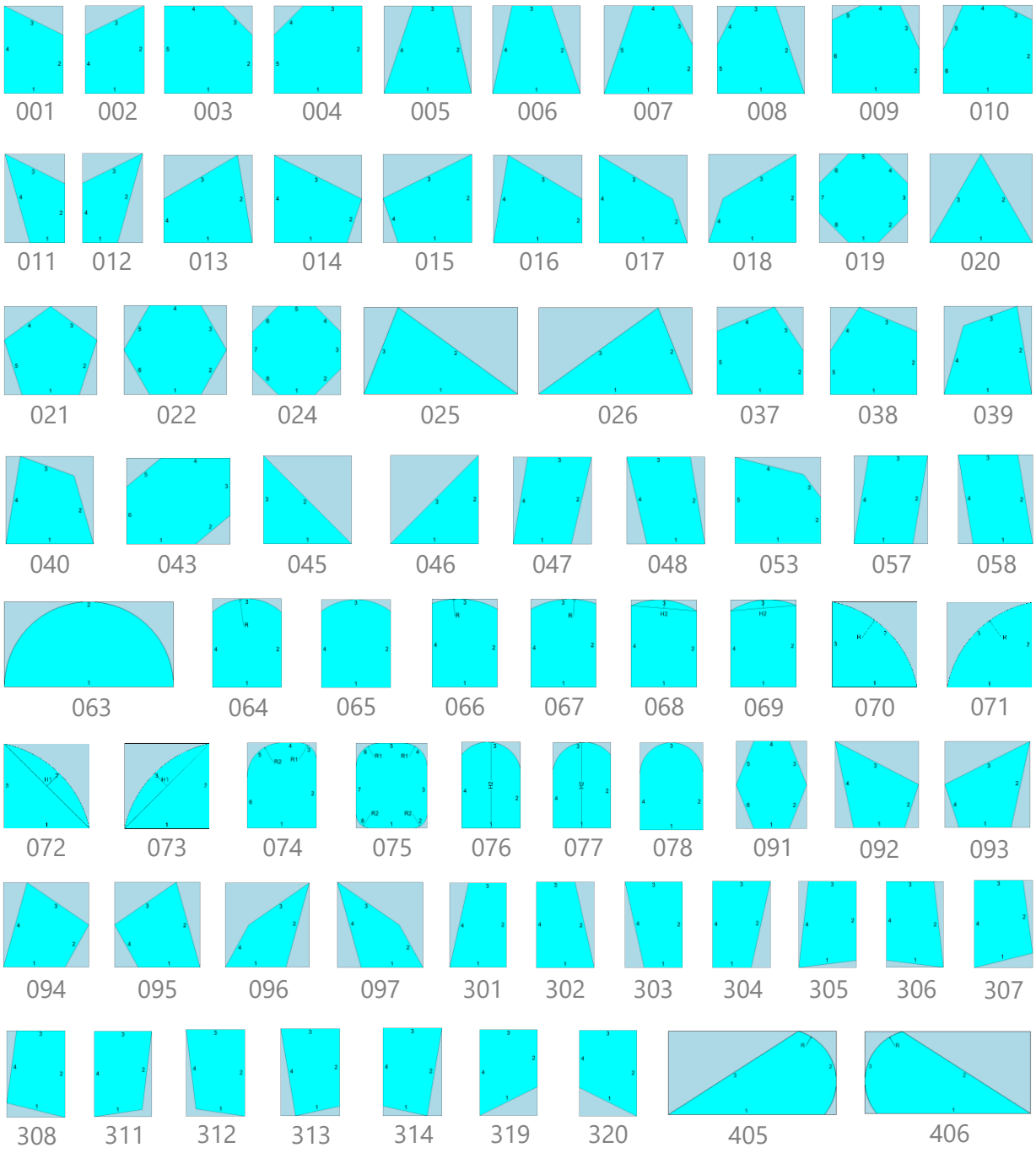


Fig. 45 Shape Catalog

19. Catalog of cutouts, notches and drill holes

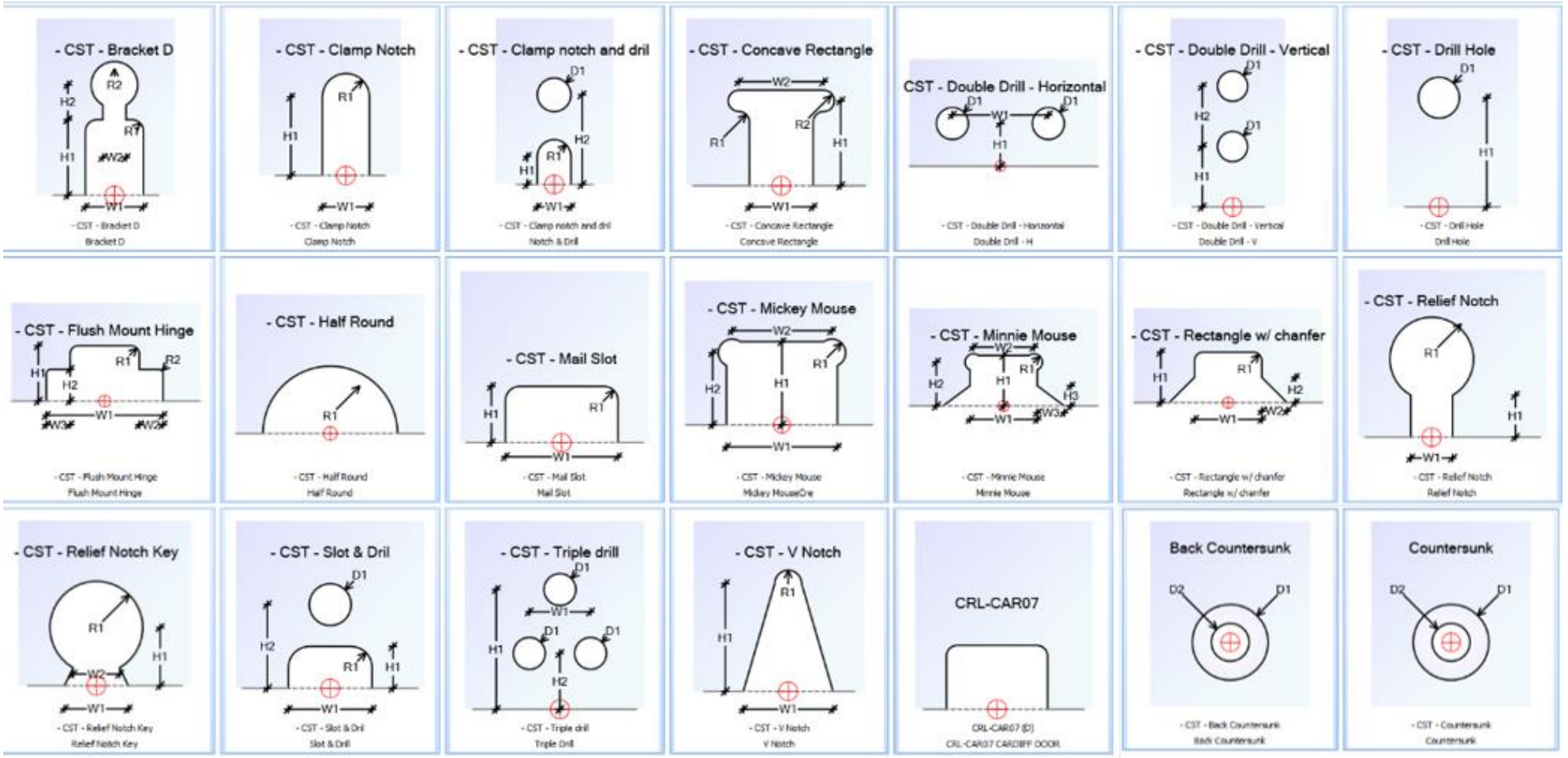


Fig. 46 Cut out, notch and drill hole catalog *(continued next page)*

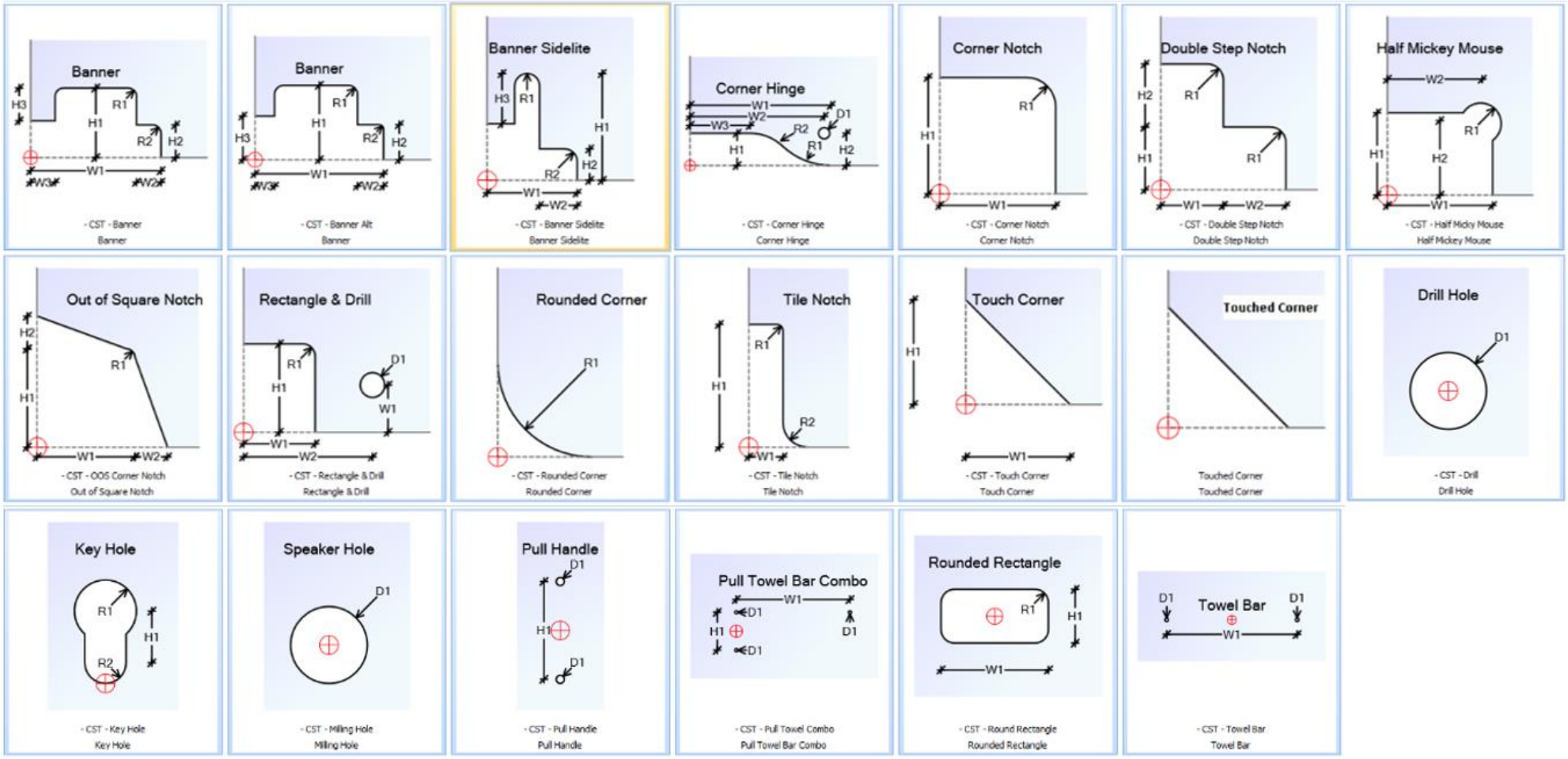


Fig. 47 Cut out, notch and drill hole catalog *(continued)*

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