PRESSGLASS

LEADING IN EUROPE

COMPANY STANDARD

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1. Basic glass

Types of glass	The glass type and quality shall be agreed upon between the customer and the supplier prior to order execution. 1. Basic glass products: – float glass (EN 572-2), – polished wired glass (EN 572-3), – drawn sheet glass (EN 572-4), – patterned glass (EN 572-5), – wired patterned glass (EN 572-6), – laminated glass and laminated safety glass (EN ISO 12543-1, -2, -3, -4, -5 and -6), – coated glass (EN 1096-1), – surface processed glass (e.g. sandblasted, acid-etched, etc.). 2. Other types of glass included or not included in the European standards.

2. Glass cutting

<table>
<tr><td>Standard</td><td colspan="4">EN 572, EN ISO 12543</td></tr>
<tr><td>Type of glass</td><td colspan="4">Monolithic, laminated, fire-resistant laminated</td></tr>
<tr><td>Glass shapes</td><td colspan="4">Monolithic glass – catalog, non-catalog, templates
Laminated, fire-resistant laminated – individual request</td></tr>
<tr><td rowspan="11">Tolerances for monolithic glass</td><td colspan="4">Table 1</td></tr>
<tr><td colspan="4">Tolerance on the dimensions for rectangular glass panes [mm]</td></tr>
<tr><td rowspan="2">Glass thickness [mm]</td><td colspan="3">Dimensions (H – height, B – width)</td></tr>
<tr><td>(H, B) ≤ 1500</td><td>1500 < (H, B) ≤ 3000</td><td>(H, B) > 3000</td></tr>
<tr><td>3, 4, 5, 6</td><td>± 1.0</td><td>± 1.5</td><td>± 2.0</td></tr>
<tr><td>8, 10, 12</td><td>± 1.5</td><td>± 2.0</td><td>± 2.5</td></tr>
<tr><td>15</td><td>± 2.0</td><td>± 2.5</td><td>± 3.0</td></tr>
<tr><td>19</td><td>± 2.5</td><td>± 3.0</td><td>± 3.5</td></tr>
<tr><td colspan="4">Table 2</td></tr>
<tr><td colspan="4">Limit on the difference between diagonals for rectangular glass panes [mm]</td></tr>
<tr><td rowspan="2">Glass thickness [mm]</td><td colspan="3">Difference between diagonals (H – height, B – width)</td></tr>
<tr><td>(H, B) ≤ 1500</td><td>1500 < (H, B) ≤ 3000</td><td>(H, B) > 3000</td></tr>
<tr><td>3, 4, 5, 6</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>8, 10, 12</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>15, 19</td><td>5</td><td>6</td><td>8</td></tr>
<tr><td colspan="4">For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 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>
<tr><td rowspan="6">Tolerances for laminated glass and fire-resistant laminated glass</td><td colspan="4">If fire-resistant laminated glass panes are purchased, the tolerances comply with the glass supplier's tolerances.</td></tr>
<tr><td colspan="4">Table 3</td></tr>
<tr><td colspan="4">Tolerance on the dimensions for rectangular glass panes [mm]</td></tr>
<tr><td colspan="4">Dimensions L – length, H – height</td></tr>
<tr><td rowspan="2">Nominal dimension L or H [mm]</td><td rowspan="2">Nominal thickness of laminated glass ≤ 8 mm</td><td colspan="2">Nominal thickness of laminated glass > 8 mm</td></tr>
<tr><td>Each glass pane < 10 mm nominal thickness</td><td>At least one glass pane ≥ 10 mm nominal thickness</td></tr>
<tr><td>≤ 2000</td><td>+3.0/-2.0</td><td>+3.5/-2.0</td><td>+5.0/-3.5</td></tr>
</table>

	≤ 3000	+4.5/-2.5	+5.0/-3.0	+6.0/-4.0
	> 3000	+5.0/-3.0	+6.0/-4.0	+7.0/-5.0

Table 4

Limit on the difference between diagonals for rectangular glass panes [mm]

Nominal dimension *L* or *H* [mm]	Nominal thickness of laminated glass ≤ 8 mm	Nominal thickness of laminated glass > 8 mm	
		Each glass pane < 10 mm nominal thickness	At least one glass pane ≥ 10 mm nominal thickness
< 2000	6	7	9
< 3000	8	9	11
> 3000	10	11	13

For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 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 5

Limit deviations of the interlayer for laminated glass with a film interlayer [mm]

Interlayer thickness	Deviations
≤ 2	± 0.1
> 2	± 0.2

Limit deviations of the interlayer thickness for fire-resistant laminated glass [mm]

Interlayer thickness	Deviations
< 1	± 0.4
≥ 1 to < 2	± 0.5
≥ 2 to < 5	± 0.6
≥ 5	± 1.0

Displacement (*L* – length, *H* – height)

Displacement value *d*	
L,*H* ≤ 1000 mm	2 mm
1000 mm < *L*,*H* ≤ 2000 mm	3 mm
2000 mm < *L*,*H* ≤ 4000 mm	4 mm
L,*H* > 4000 mm	6 mm

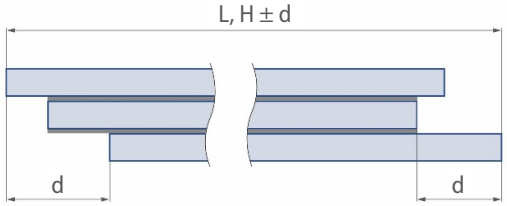


Fig. 1 Displacement

Zone which is not subject to quality assessment after cutting

Values of length of section *z* for the glass thickness *d* and its corresponding sharp angle values *α*

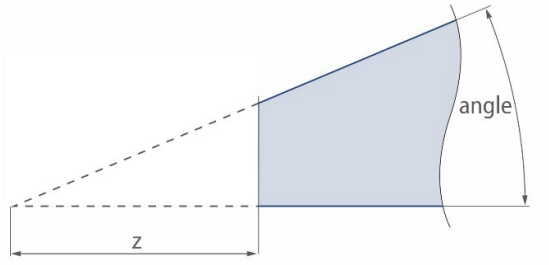


Fig. 2 Length of section *z*

Angle α [°]	Monolithic $d < 8$ [mm]	Monolithic $d \geq 8$ [mm]	Need to cut off the corners
	Laminated $d < 66.x$	Laminated $d \geq 66.x$	
12.5 ≤ α < 15	90	180	Yes
15 ≤ α < 20	75	149	Yes
20 ≤ α < 35	55	110	No
35 ≤ α < 45	29	57	No

Bevel - monolithic glass

Maximum permissible bevel

Maximum bevel *d* [mm]	Glass thickness *e* [mm]
1	3, 4, 5 , 6
2	8, 10
3	12
4	15, 19

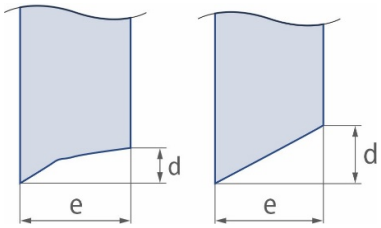


Fig. 3 Bevel – monolithic glass

Shells or nicks at the edges

Maximum size of shells or nicks on the glass edge

h_1	<	(*e*-1) mm
p	<	(*e*/4) mm
d	<	(*e*/4) mm

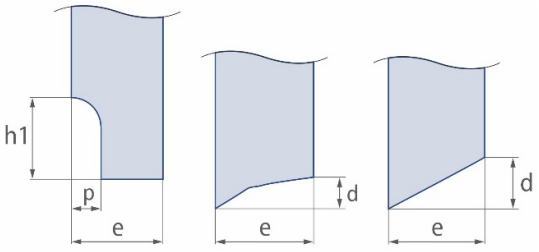


Fig. 4 Edge defects

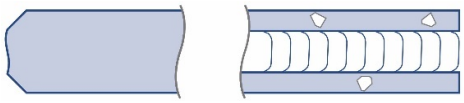
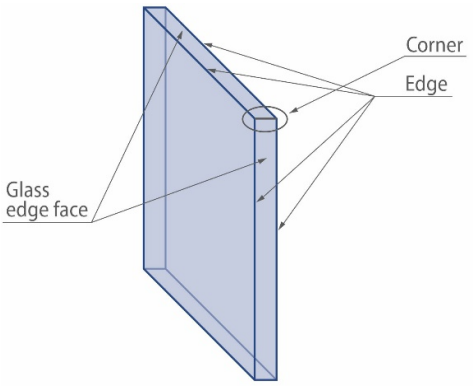
Coating removal

Table 6

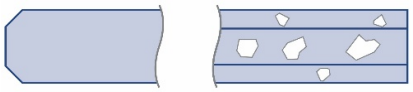
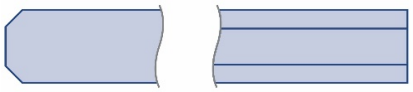
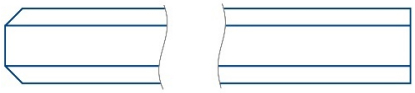
Coating removal width tolerances [mm]	
± 1.0	for coating removal width up to 11 mm
+2.0/-1.0	for coating removal width over 11 mm
+3.0/-1.0	for glass coated with EasyPro protective film or TPF, regardless of the coating removal width

	As a result of mechanical coating removal visible hairline scratches, streaks, stains or discolorations can occur which are not glass defects. The ground coating appearance may vary for each edge, depending on the process. The abovementioned effects are not subject to complaint.

3. Glass edge arrissing

Standard	None	 Fig. 5 Arrissed (blunt) edge
Type of glass	Monolithic and laminated	
Glass shapes	Catalog, non-catalog, templates	
Tolerances	Tolerances for glass with this kind of edgework are the same as for glass after cutting (applies to side and diagonal length tolerances).	
Quality	Arrissing bevels uniform on all edges, with non-processed areas.	
Edge at the corner, glass pane corner	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. 6 Glass pane description

4. Glass edge grinding and polishing

Standard	None	
Type of processing	Grinding - the glass edge face and edges are smooth, with acceptable blank spots	 Fig. 7 Grinding
	Smooth grinding - matt glass edge face and edges of the glass over the whole length	 Fig. 8 Smooth grinding
	Polishing - shiny glass edge face and edges of the glass over the whole length	 Fig. 9 Polishing
Type of glass	Monolithic and laminated	
Glass shapes	Catalog, non-catalog, templates	
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	The appearance of the processed surfaces can be diverse for the same kind of process. This effect is not subject to complaint. The glass corner is not processed.	

5. Glass edge mitering

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

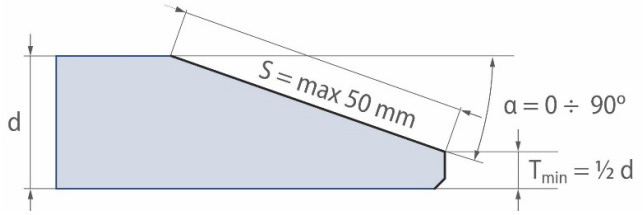


Fig. 10 Glass edge mitering

6. Drilling holes

Standard	None		
Type of glass	Monolithic and laminated		
Glass shapes	Catalog, non-catalog, templates		
Tolerances	Diameter tolerance for drilled holes in monolithic glass		
	± 1 mm for ∅ ≤ 20 mm		
	± 2 mm for 20 mm < ∅ ≤ 70 mm		
	Diameter tolerance for drilled holes in laminated glass		
	Tolerance extended by the displacement value for laminated glass		
Limitations	Minimum edge processing – grinding		
	D_{min}	≥	d
	D_{max}	≤	$1/3 \times W$
	W	≥	$8d$
	a_1	≥	$2d$
	a_2	≥	$4d$
	b	≥	$2d$
	c	≥	$6d$
	d – glass thickness		
	Limitations related to making holes in laminated glass		
	Parameter		Parameter minimum value
	h		2 mm
	m		1.5 mm
	v		$(\varphi_{mitre} - \varphi_{core})/2$

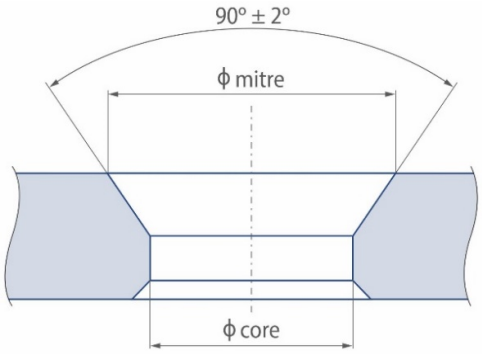


Fig. 11 Drilled hole

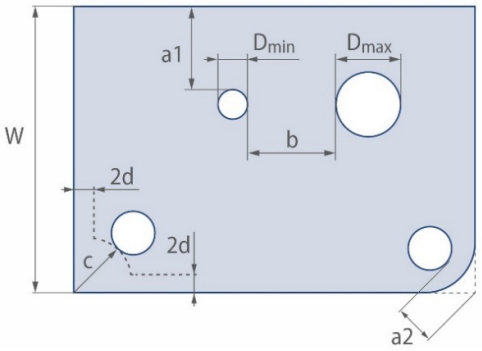


Fig. 12 Drilled hole limitations

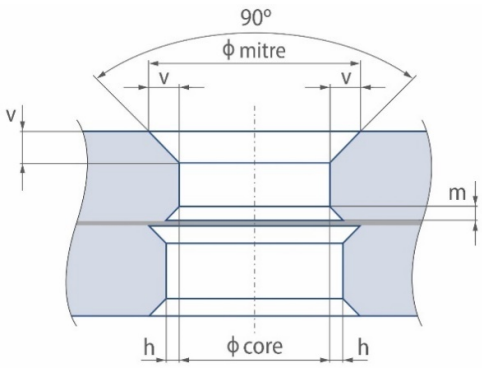
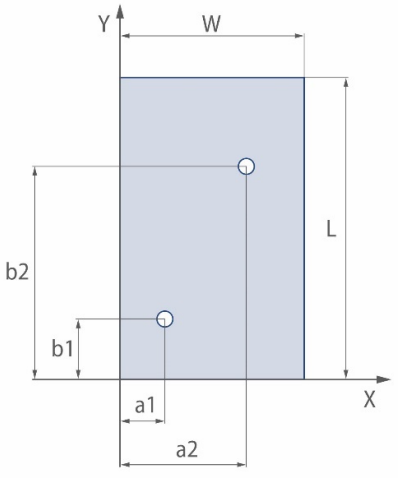
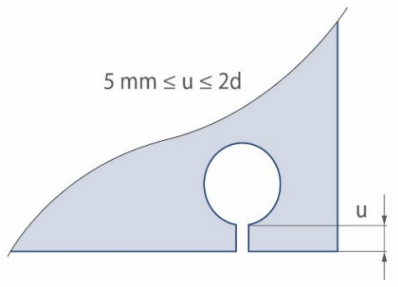


Fig. 13 Limitations related to making holes in laminated glass

Hole positioning	Hole positioning shall be given and made always in reference to one corner, according to Fig. 14	 Fig. 14 Hole positioning
	Hole positioning tolerance (applies to dimensions "$a_{1\text{-}2}$" and "$b_{1\text{-}2}$")	
	±1 mm/m but no less than ± 2.5 mm for glass thickness $d \leq 12$ mm	
	±1 mm/m but no less than ± 3.0 mm for glass thickness $d > 12$ mm	
Process notch	For holes situated on the glass pane below the minimum values, a process notch has to be made. If the notch is made from the edge to the hole (Fig. 15) the notch height (u) has to meet the condition: 5 mm ≤ $u \leq 2d$, where d – glass thickness [mm].	 Fig. 15 Process notch

7. Cut-outs

Standard	None		
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		
Tolerances	Cut-out tolerance		
	$h_{1\text{-}4}$ and $c_{1\text{-}4}$		± 3.0 mm
Limitations	Minimum edge processing – grinding		
	$h_{1\text{-}4}$	≤	$1/3 \times L$
	$c_{1\text{-}4}$	≤	$1/3 \times W$
	a	≥	$1/2 \times c_1$
	b	≥	$1/2 \times h_1$
	r	≥	7 mm
	k	≥	$1/2 \times h_3$ when $h_3 > h_2$
	100 mm < $j_3 \geq 1/2 \times h_3$		
Cut-out positioning	Cut-outs shall be positioned according to Fig. 16. Cut-out positioning tolerance is the same as for drilled holes (applies to dimensions "a" and "b"). Cut-out positioning on the glass pane shall be given always in reference to one corner.		

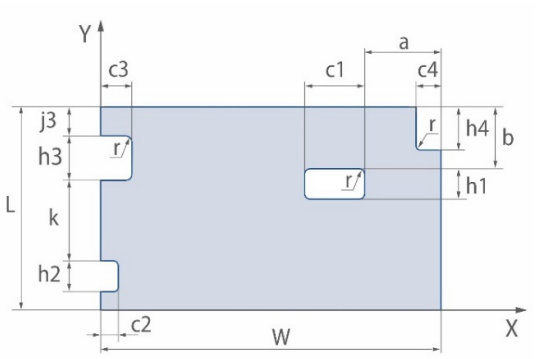


Fig. 16 Cut-out positioning and limitations

8. Corner cut-offs

Standard	None	
Type of glass	Monolithic and laminated	
Cut-off processing	Arrissing, grinding, smooth grinding, polishing	
Tolerance	$t \pm 2.0$ 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. 17).	
Monolithic glass	Glass thickness [mm]	Maximum length of the cut-off corner t [mm]
	3-4	21
	5	28
	6	35
	8	57
	10	113
	12-15	141
	19	170
Laminated glass	No limits	85

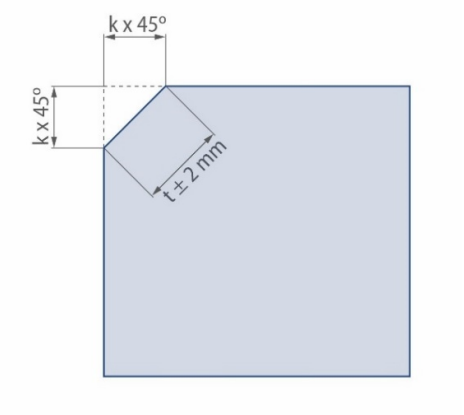


Fig. 17 Corner cut-off

9. Enamel application with a roller

<table>
<tr><td>Standard</td><td colspan="2">None</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>Enamel application methods</td><td colspan="2">Total coverage, partial coverage around pane perimeter</td></tr>
<tr><td rowspan="3">Enamel distribution tolerances</td><td colspan="2">Total coverage - the enamel covers the whole glass surface and can overlap the glass edges and glass edge face.</td></tr>
<tr><td colspan="2">Partial coverage around glass pane perimeter</td></tr>
<tr><td>Partial coverage (Fig. 18) - the enamel is applied around pane perimeter and can overlap the glass edges and glass edge face.

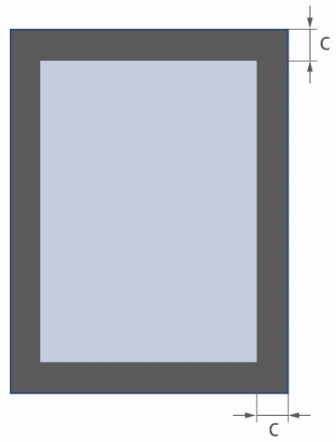
Tolerance for partial coverage width around the perimeter (parameter c) is ±3 mm.</td><td> 

Fig. 18 Partial coverage around glass pane perimeter</td></tr>
<tr><td rowspan="3">Limitations that are not subject to complaint</td><td colspan="2">The grooves (circumferentially arranged) left by the rubber roller spreading the enamel over the glass surface can be seen when looking at the enamelled side up-close.

Due to the process, there is more enamel on glass pane edges, which can be slightly wavy / irregular, especially along the edges parallel to the rollers.

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

Enamelled glass must be subjected to the selected heat treatment:
– tempering,
– heat strengthening.</td></tr>
<tr><td rowspan="2">Minimum glass edge processing</td><td>arrissing for 4 to 8 mm thick glass</td></tr>
<tr><td>grinding for 10 to 19 mm thick glass</td></tr>
<tr><td colspan="2">The enamel must not be in contact with the coating.
The enamelled surface must not be exposed to atmospheric factors.
Any application where enamelled glass will be seen from both sides must always be consulted with supplier.</td></tr>
</table>

10. Enamel screen printing

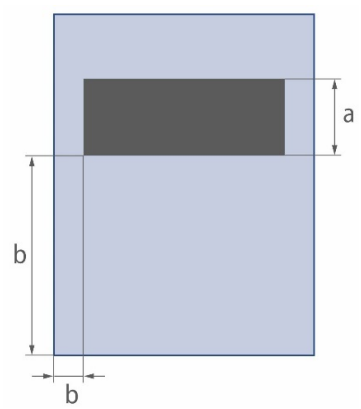
<table>
<tr><td>Standard</td><td colspan="3">None</td></tr>
<tr><td>Type of glass</td><td colspan="3">Monolithic</td></tr>
<tr><td>Glass shapes</td><td colspan="3">Catalog, non-catalog, templates</td></tr>
<tr><td>Enamel application methods</td><td colspan="3">Total coverage, partial coverage, pattern.
It is possible to apply two coatings of enamel in the case of 100% coverage of the entire surface of the glass pane with enamel (note: does not apply to patterns).</td></tr>
<tr><td rowspan="8">Enamel distribution tolerances</td><td colspan="3">Total coverage - the enamel covers the whole glass surface; in screen printing the edges and glass edge face are not usually printed.</td></tr>
<tr><td colspan="3">Partial coverage inside the glass pane</td></tr>
<tr><td>Parameter a</td><td>± 3 mm</td><td rowspan="3"> 

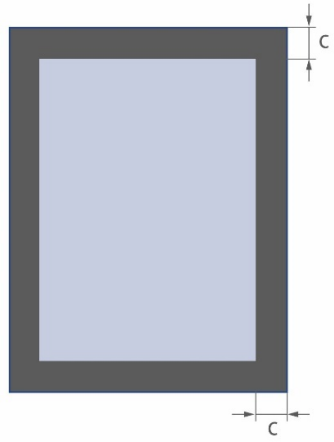
Fig. 19 Partial coverage inside the glass pane</td></tr>
<tr><td>Parameter b</td><td>± 5 mm</td></tr>
<tr><td colspan="2">Parameter b – measured from the reference glass edge face</td></tr>
<tr><td colspan="3">Partial coverage around glass pane perimeter, pattern</td></tr>
<tr><td colspan="2">Parameter c – measured from the glass edge face</td><td rowspan="2"> 

Fig. 20 Partial coverage around glass pane perimeter, pattern</td></tr>
<tr><td colspan="2">Tolerance for partial coverage width around the perimeter (parameter c) is ±3 mm.</td></tr>
</table>

<table>
<tr><td rowspan="4">Limitations that are not subject to complaint</td><td colspan="2">Enamelled glass must be subjected to the selected heat treatment:
– tempering,
– heat strengthening.</td></tr>
<tr><td rowspan="2">Minimum glass edge processing</td><td>arrissing for 4 to 8 mm thick glass</td></tr>
<tr><td>grinding for 10 to 19 mm thick glass</td></tr>
<tr><td colspan="2">The enamel must not be in contact with the coating.
The enamelled surface must not be exposed to atmospheric factors.
Any materials applied directly to the enamel, e.g. sealants, glues, panels, insulation, mounting hardware, etc. can be seen through the glass (e.g. for very bright colors).
Any application where enamelled glass will be seen from both sides must always be consulted with supplier.</td></tr>
</table>

11. Digital printing

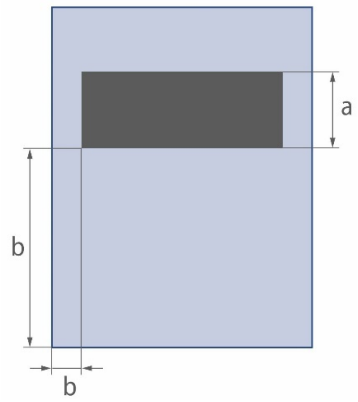
<table>
<tr><td>Standard</td><td colspan="3">None</td></tr>
<tr><td>Type of glass</td><td colspan="3">Monolithic</td></tr>
<tr><td>Definition</td><td colspan="3">Multi-color printing of the glass surface using ceramic inks</td></tr>
<tr><td>Glass shapes</td><td colspan="3">Catalog, non-catalog, templates</td></tr>
<tr><td>Print application methods</td><td colspan="3">Total coverage, partial coverage, pattern</td></tr>
<tr><td rowspan="5">Print distribution tolerances</td><td colspan="3">Partial coverage inside the glass pane</td></tr>
<tr><td>Parameter a</td><td>± 2 mm</td><td rowspan="3"> 

Fig. 21 Placement of the digital print – partial coverage inside the glass pane</td></tr>
<tr><td>Parameter b</td><td>± 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.

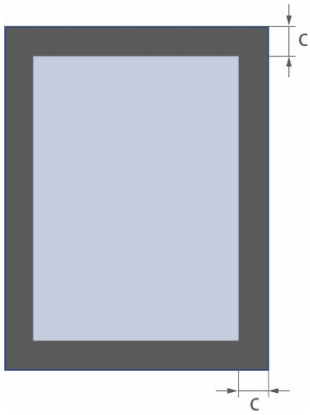
Tolerance for partial print width around the perimeter (parameter c) is ±3 mm.</td><td> 

Fig. 22 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>arrissing for 4 to 8 mm thick glass</td></tr>
<tr><td>grinding for 10 to 19 mm thick glass</td></tr>
<tr><td colspan="2">The digital print surface must not be exposed to atmospheric factors.
Any application where glass with digital print will be seen from both sides must always be consulted with supplier.

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.

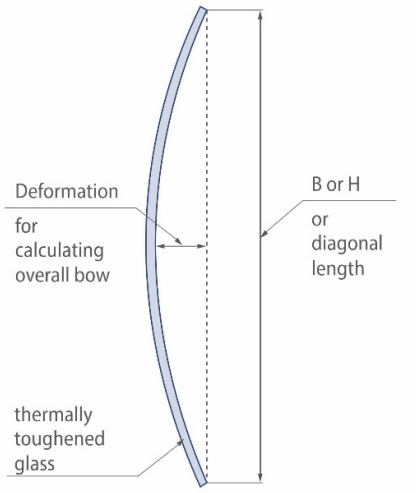
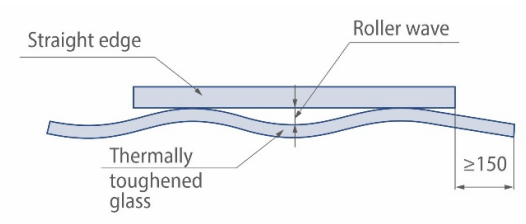
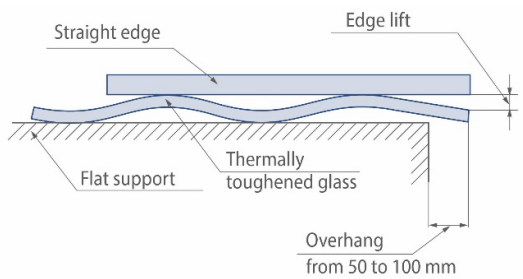
Any materials applied directly to the digital print, e.g. sealants, glues, panels, insulation, mounting hardware, etc. can be seen through the glass (e.g. for very bright colors).</td></tr>
</table>

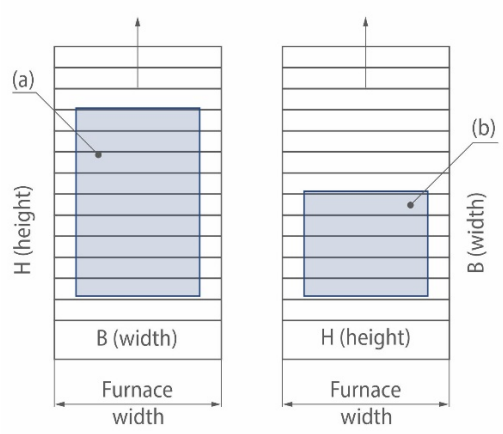
12. Sandblasting

Standard	None	
Type of glass	Monolithic, laminated	
Definition	Sandblasting is a mechanical process, producing a matt white glass surface, using a stream of sand under high pressure. The abrasive material removes the top layer of glass, leaving a matt surface which looks like frosting (hence "frosted glass"). The effect can be applied to the whole glass surface or any part of it (including patterns).	
Glass shapes	Catalog, non-catalog, templates	
Tolerances for sandblasted surface distribution	Full coverage - the whole glass area is sandblasted	
	Partial sandblasting inside the glass pane - the tolerances for sandblasting are the same as those of enamel applied with a print screen method - see Section 10, Fig. 19	
	Parameter *a*	± 3 mm
	Parameter *b*	± 5 mm
	Parameter *b* – measured from the glass edge face of the reference edges.	

13. Glass tempering, heat soaking

Standard	EN 12150, EN 14179		
Type of glass	Monolithic		
Glass shapes	Catalog, non-catalog, templates		
Tolerances	Table 7		
	Tolerance on the dimensions for rectangular glass panes [mm]		
	Width or height (B or H) [mm]	Glass thickness $d \leq 8$ mm	Glass thickness $d > 8$ mm
	≤ 2000	± 2.0	± 3.0
	2000 < B, H ≤ 3000	± 3.0	± 4.0
	> 3000	± 4.0	± 5.0
	Table 8		
	Limit on the difference between diagonals for rectangular glass panes [mm]		
	Width or height (B or H) [mm]	Glass thickness $d \leq 8$ mm	Glass thickness $d > 8$ mm
	≤ 2000	≤ 4	≤ 6
	2000 < B, H ≤ 3000	≤ 6	≤ 8
	> 3000	≤ 8	≤ 10
	For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 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.		
Flatness	By the very nature of the toughening process, it is not possible to obtain a product as flat as annealed glass. This difference in flatness depends on the type of glass (float / coated), glass dimensions (nominal thickness, dimensions, and ratio between the dimensions) and the toughening process employed.		
Overall bow	Maximum permissible values		
	3 mm/m	float glass	
	4 mm/m	other	

	For enamelled glass that is not fully covered with enamel, contact the supplier.	 Fig. 23 Overall bow
Roller wave	Maximum permissible values	 Fig. 24 Roller wave
	0.3 mm — float glass	
	0.5 mm — other	
	For enamelled glass that is not fully covered with enamel, contact the supplier.	
Edge lift	Maximum permissible values	 Fig. 25 Edge lift
	0.4 mm — float glass 4-5 mm	
	0.3 mm — float glass 6-19 mm	
	0.5 mm — other	
	For enamelled glass that is not fully covered with enamel, contact the supplier.	

Limitations	**Directional tempering** Due to the presence of roller waves, it is possible to choose direction of tempering – width of glass pane parallel or perpendicular to the rollers of the tempering furnace. 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 heat treated in a direction different to the other glass panes in the order. In 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 supplier to process the glass without considering tempering direction.	 Fig. 26 Directional tempering

Minimum edge processing	
Glass edge arrissing	for glass thickness ≤ 8 mm
Glass edge grinding	for glass thickness ≥ 10 mm

Table 9

Maximum dimensions for 4 and 5 mm thick tempered glass	
1700x2500 mm	for 4 mm thick float glass
2000x3000 mm	for 5 mm thick float glass
1500x2500 mm	for 4 mm thick soft-coated float glass
1700x2500 mm	for 5 mm thick soft-coated float glass

For 4 and 5 mm 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.

Minimum dimensions of tempered glass

600x600 mm for 4-19 mm thick glass

It is possible to make smaller glass panes than mentioned above. The workmanship tolerances specified in this standard do not apply to smaller dimensions.

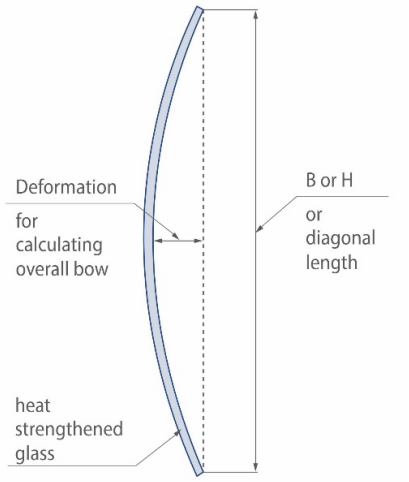
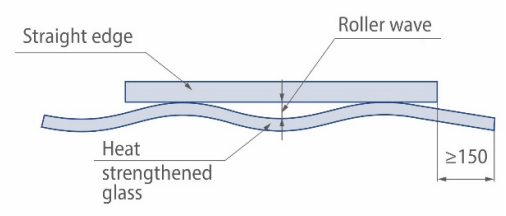
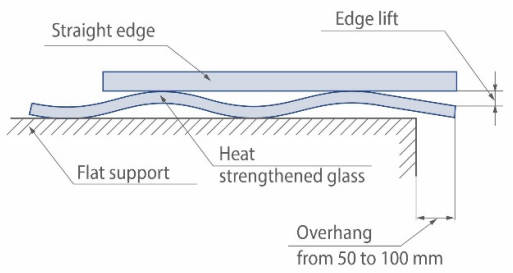
Limitations of the side ratio

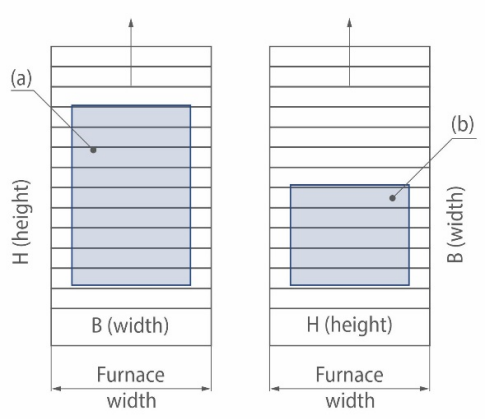
If glass panes with the side ratio 1:10 or higher are tempered, the tolerances specified in this standard do not apply.

Glass marking	According to EN 12150 tempered glass shall be permanently marked. 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. In the case of glass with enamel applied (any technology), the thermal treatment mark is placed on the edge of the glass. In certain cases, it is possible to mark enamelled glass on the surface, but only on the basis of individual arrangements with the customer.
Heat soak testing	Due to the possible occurrence of spontaneous cracks in tempered glass as a result 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 glass cracks occurrence by 99%.
Furniture glass	Tempered glass for furniture applications are thermally toughened safety panes. They have an improved mechanical strength as compared to standard non-toughened panes and when cracking, they crack into fine particles with blunt edges. An order for such panes should contain a clause informing about their application in furniture. Otherwise, the glass panes will be permanently marked.

14. Heat strengthening

Standard	EN 1863		
Type of glass	Monolithic		
Glass shapes	Catalog, non-catalog, templates		
Tolerances	Table 10		
	Tolerance on the dimensions for rectangular glass panes [mm]		
	Width or height (B or H) [mm]	Glass thickness $d \leq 8$ mm	Glass thickness $d > 8$ mm
	≤ 2000	± 2.0	± 3.0
	2000 < $B, H \leq$ 3000	± 3.0	± 4.0
	> 3000	± 4.0	± 5.0
	Table 11		
	Limit on the difference between diagonals for rectangular glass panes [mm]		
	Width or height (B or H) [mm]	Glass thickness $d \leq 8$ mm	Glass thickness $d > 8$ mm
	≤ 2000	≤ 4	≤ 6
	2000 < $B, H \leq$ 3000	≤ 6	≤ 8
	> 3000	≤ 8	≤ 10
	For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 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.		
Flatness	By the very nature of the heat strengthening process, it is not possible to obtain a product as flat as annealed glass. This difference in flatness depends on the type of glass (float / coated), glass dimensions (nominal thickness, dimensions, and ratio between the dimensions) and the heat strengthening process employed.		
Overall bow	Maximum permissible values		
	3 mm/m	float glass	
	4 mm/m	other	

	For enamelled glass that is not fully covered with enamel, contact the supplier.	 Fig. 27 Overall bow
Roller wave	Maximum permissible values 0.3 mm — float glass 0.5 mm — other For enamelled glass that is not fully covered with enamel, contact the supplier.	 Fig. 28 Roller wave
Edge lift	Maximum permissible values 0.4 mm — float glass 4-5 mm 0.3 mm — float glass 6-12 mm 0.5 mm — other For enamelled glass that is not fully covered with enamel, contact the supplier.	 Fig. 29 Edge lift

Limitations	**Directional heat strengthening** Due to the presence of roller waves, it is possible to choose direction of tempering – width of glass pane parallel or perpendicular to the rollers of the tempering furnace. 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 heat treated in a direction different to the other glass panes in the order. In 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 supplier to process the glass without considering tempering direction.	 Fig. 30 Directional heat strengthening

Minimum edge processing	
Glass edge arrissing	for glass thickness ≤ 8 mm
Glass edge grinding	for glass thickness ≥ 10 mm

Table 12

Maximum dimensions for 4 and 5 mm thick heat strengthened glass	
1700x2500 mm	for 4 mm thick float glass
2000x3000 mm	for 5 mm thick float glass
1500x2500 mm	for 4 mm thick soft-coated float glass
1700x2500 mm	for 5 mm thick soft-coated float glass

For 4 and 5 mm thick glass heat strengthening 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.

Minimum dimensions of heat strengthened glass

600x600 mm for 4-10 mm thick float glass.

600x600 mm for 4-8 mm thick coated glass.

It is possible to make smaller glass panes than mentioned above. The workmanship tolerances specified in this standard do not apply to smaller dimensions.

Limitations of the side ratio

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

Glass marking	According to EN 1863 heat strengthened glass shall be permanently marked. 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. In the case of glass with enamel applied (any technology), the thermal treatment mark is placed on the edge of the glass. In certain cases, it is possible to mark enamelled glass on the surface, but only on the basis of individual arrangements with the customer.
Furniture glass	Heat strengthened glass for furniture application has an improved mechanical strength as compared to standard non heat strengthened panes. An order for such panes should contain a clause informing about their application in furniture. Otherwise, the glass panes will be permanently marked.

15. Glass laminating

Standard	EN ISO 12543
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 13

Tolerance on the dimensions for rectangular glass panes [mm]

Dimensions *L* – length, *H* – height

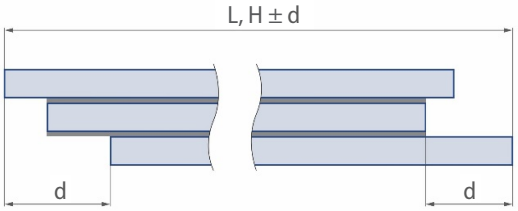
Nominal dimension *L* or *H* [mm]	Nominal thickness of laminated glass ≤ 8 mm	Nominal thickness of laminated glass > 8 mm	
		Each glass pane < 10 mm nominal thickness	At least one glass pane ≥ 10 mm nominal thickness
≤ 2000	+3.0/-2.0	+3.5/-2.0	+5.0/-3.5
≤ 3000	+4.5/-2.5	+5.0/-3.0	+6.0/-4.0
> 3000	+5.0/-3.0	+6.0/-4.0	+7.0/-5.0

Table 14

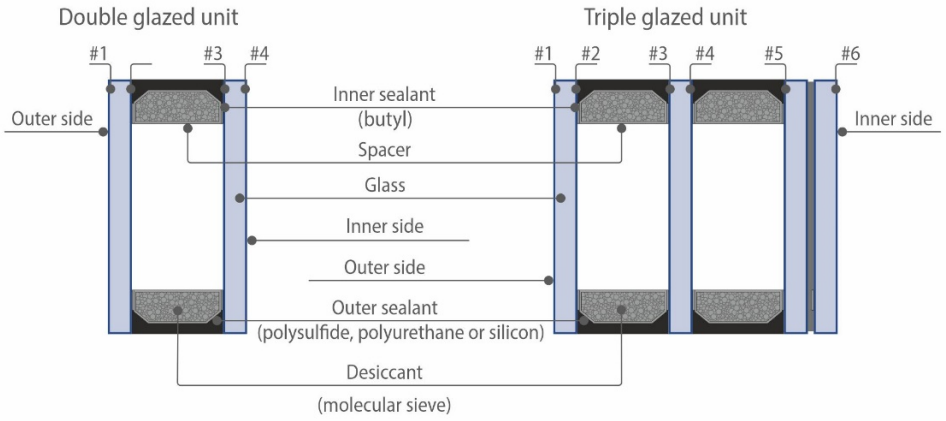
Limit on the difference between diagonals for rectangular glass panes [mm]

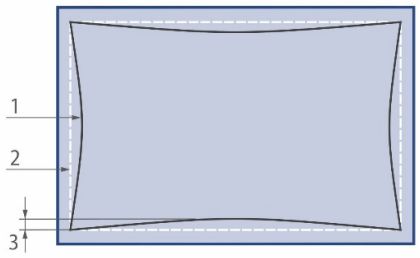
Nominal dimension *L* or *H* [mm]	Nominal thickness of laminated glass ≤ 8 mm	Nominal thickness of laminated glass > 8 mm	
		Each glass pane < 10 mm nominal thickness	At least one glass pane ≥ 10 mm nominal thickness
< 2000	6	7	9
< 3000	8	9	11
> 3000	10	11	13

For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 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.

Displacement	Displacement value *d* *L, H* ≤ 1000 — 2 mm 1000 < *L, H* ≤ 2000 — 3 mm 2000 < *L, H* ≤ 4000 — 4 mm *L, H* > 4000 — 6 mm	 Fig. 31 Displacement
Interlayer treatment at laminated glass edges	**Cutting the interlayer directly at the glass edge face** Regardless of the edge processing – standard. **Removal of interlayer** In the case of a polished edge of laminated glass, it is possible to remove an interlayer. Whenever possible, the interlayer is cut out according to glass bevels from the interlayer side (without a defined recess depth).	
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 characteristics. **Laminated glass made of tempered / heat strengthened glass** Due to roller wave distortion, overall bow and anisotropy, laminated glass quality will be different than the quality of annealed laminated glass. Subsequent glass layers can strengthen the visual perception of anisotropy and lenses (local optical distortion typical of glass thickness < 8 mm). Laminated glass with colored or matt interlayers can change its color with 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, some minor differences in the color of the same glass type from different production batches are also possible. Every interlayer has a slight degree of haze. If the number of interlayer increases, the haze may be more visible. Additional optical effects such as spots, stripes, streaks may be visible.	

16. IGUs manufacturing

Standard	EN 1279
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. 32 IGU structure diagram
Glass unit marking	All glass units are permanently marked inside, on the spacer with the following data: - EN 1279 - European standard / optionally: certificate name, number or symbol - PRESS GLASS - manufacturer's name - 2019/10/11 2:02 - date and time of production - (45069/1) - lauf number and glass unit position in the lauf (in brackets) - Z/133413/2019 - PRESS GLASS order number - p.21 - position number in the order - TH1,1 4 hart/18TERMO7040/FL 4/18TERMO7040/TH1,1 4 hart - description of thicknesses and types of glass panes (typically the first glass pane in the IGU description is an outer pane), spacer width and color - Ar - gas type - A, B, C - glass unit type NOTE: the description on the spacer may optionally contain some additional information agreed upon with the customer. PRESS GLASS keeps a register of all orders in the company's internal IT system. In case of any problems, information about each order can be found.
Examples of marking on the spacer	PN-EN 1279 PRESS GLASS 2019/10/11 02:02 (45069/1) Z/133413/2019 p.21 TH1.1 4 tough/18TERMO7040/FL 4/18TERMO7040/TH1.1 4 tough U=0.5 EN673 Ar 704x655 B Triple glazed unit made according to EN 1279 by PRESS GLASS on October 11, 2019, at 2:02 (lauf No. 45069 pos. 1), PRESS GLASS order number: Z/133413/2019 pos. 21, of Thermofloat (TH) thermally toughened (tough) and float (FL) glass of the same thickness (4 mm), with 18 mm wide spacer (/18/), U=0.5 according to EN673, filled with argon (Ar), dimensions: 704 x 655 mm, glass type - "B" (B).

	PG 2019/10/10 CEKAL 723 L20 (45024/118) Z/148281/2019 P.2 FL8/20TERMO7040/TH1.1 4 Rw=37 Ug=1.1 A Double glazed unit made on October 10, 2019, according to CEKAL requirements by PRESS GLASS (723) at production line No. 20 (lauf No. 45024 pos. 118), PRESS GLASS order number: Z/148281/2019 pos. 2, of 8 mm thick float (FL) glass and 4 mm thick Thermofloat (TH) glass, with 20 mm wide warm edge spacer, dark grey (RAL 7040), with the sound reduction index Rw=37 dB and U=1.1 according to EN673, glass type "A" (A).
IGU type	Type A – IGUs intended for installation without permanent shear load in 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 in 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. Marking the IGUs of type A, B or C is in accordance with EN 1279-5.
CE marking	The CE marking symbol is printed on the product label (or, if this is not possible, on the packaging or on the enclosed documentation). The CE mark shall be accompanied by the website address containing the performance/characteristics of the product according to the standard requirements.
Types of glass	Monolithic, laminated, laminated and fire resistant
Type of sealant	Butyl – inner sealant. Polysulfide, polyurethane – external sealant which must not be exposed to direct UV radiation. 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 (applies to each IGU chamber, maximum surface area of 6 m^2 and rectangular IGUs). Spacer 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 bar connection gap must not exceed 1 mm. Due to various technological processes, there can be additional holes in the spacer used for filling the IGU with noble gas and/or equalize the pressure.
Tolerance on spacer straightness	For a double glazed unit, the tolerance on spacer straightness is 4 mm up to a length of 3.5 m and 6 mm for longer lengths. 1 - actual position of spacer 2 - theoretical position of spacer 3 - deviation  Fig. 33 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 2.5 m. For longer edge lengths, the permissible deviation is 6 mm.

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

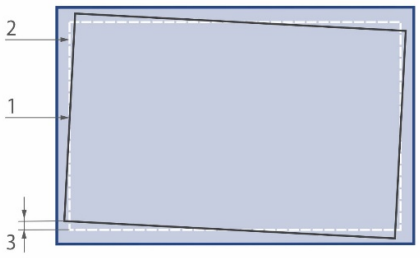


Fig. 34 Spacer deviation

Tolerances and phenomena acceptable in the IGU edge zone

Table 15

Thickness tolerances on the insulating glass units

IGU type	Glass pane	IGU thickness tolerance
double glazing	All panes are annealed float glass	± 1.0 mm
	At least one pane is laminated, patterned or not annealed glass	± 1.5 mm
triple glazing	All panes are annealed float glass	± 1.4 mm
	At least one pane is laminated, patterned or not annealed glass	+ 2.8 mm / – 1.4 mm

If one glass component has a nominal thickness greater than 12 mm in the case of annealed or toughened glass, or 20 mm in the case of laminated glass, please consult the supplier.

Thicknesses are nominal thickness.

Table 16

Tolerances on dimensions and misalignment of IGUs [mm]

Double / triple IGU	Misalignment	Tolerance on *B* and *H*
all panes ≤ 6 mm and (*B* and *H*) ≤ 2000 mm	≤ 2	± 2
6 mm < thickest pane ≤ 12 mm or 2000 mm < (*B* or *H*) ≤ 3500 mm	≤ 3	± 3
3500 mm < (*B* or *H*) ≤ 5000 mm and thickest pane ≤ 12 mm	≤ 4	± 4
1 pane > 12 mm or (*B* or *H*) > 5000 mm	≤ 5	± 5

For catalog shapes, non-catalog shapes and templates, the acceptable tolerances for the side lengths and the differences between diagonals shall be increased by ± 3.0 mm for each glass thickness.
The sealant can protrude beyond the edge seal and be visible in the cavity.
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.

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. When designing, the operating temperatures of the individual components of the IGU must also be taken into account. PRESS GLASS shall not be held liable for verifying the order compliance with the guidelines of the glass installation system selected by the customer. For glass coatings and reflective glass coatings, the location of the coating in the glass unit shall be specified in the order (position according to Fig. 32). Recommended position #2 or #3, and for triple glazed units #2 or #5. For rectangular IGUs, first the width and then the height shall be given. The dimensions shall be given in full millimeters, and the order of the glass components starting from the outer pane. The durability of an IGU is ensured by meeting the requirements of EN 1279. 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. 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.
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 execution. Failure to specify the reference edge (reference point) by the customer, authorizes the supplier to produce the glass without this requirement.
Glass shapes	Production of shaped glass units other than rectangles is acceptable, if so agreed between supplier and the customer (for catalog shapes, non-catalog shapes and 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 supplier on a case-by-case basis.
Georgian bars	Georgian bars To ensure the clearance between Georgian bars and the glass panes (≥ 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 thermal bridge. Visible raw material, fasteners and slight discoloration within the cut are result of the manufacturing process. Number and placement of bumpons depends on the number and length of the Georgian bar fields and remains at the discretion of the supplier. The accuracy of the positioning of Georgian bars is maximum 2 mm from the nominal dimensions. In a triple glazed unit, a decorative Georgian bar is typically placed in the outer cavity (chamber). Any deviations from the standard are acceptable only upon individual arrangements.

* Bumpons are not used with spacers wider than 18 mm (it is not recommended to use Georgian bars for distances between the glass panes greater than 18 mm).

Duplex bars (back-to-back bars)

Application of the Duplex bars with widths other than specified in the current offer is to be agreed in each case. In triple glazed units, Duplex bars are typically placed in both cavities (chambers). Installation in one cavity is possible only upon individual arrangements. Duplex bars are to be used in the interior spacer, leaving a min 2 mm clearance on each side between the bar and glass. When manufacturing arches, the Georgian bar is formed of two spacer bars with a minimum bending radius R ≥ 70 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 design assumptions. 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 4 mm.

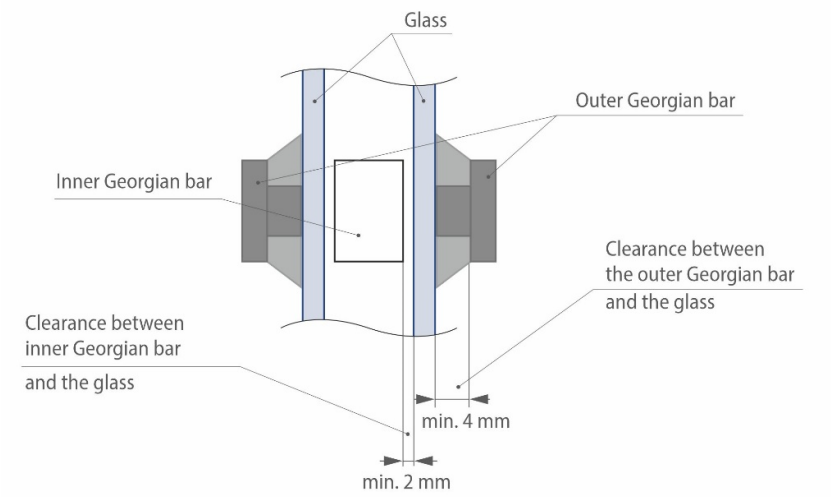


Fig. 35 Installation of inner and outer Georgian bars

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

For 8 mm wide Georgian bar	$R \geq 80$ mm (only arch)**
For 18 mm wide Georgian bar	$R \geq 170$ mm
For 26 mm wide Georgian bar	$R \geq 200$ mm
For 45 mm wide Georgian bar	no bending possible

- combination of various widths of the Georgian bars,
- combination of Georgian bars bent at different angles,
- connection of Georgian bars at different angles (sample solutions are presented in the Georgian bar range).

** Note: 8 mm Georgian bars are connected with the use of key covers and in the case of connecting the arch with a straight section, the bending radius should be R ≥ 160 mm.

Table 17

Examples of combinations of connecting Georgian bars

Georgian bar / Connector	8 mm	18 mm	26 mm	45 mm	Maximum field dimensions [mm]
8 mm	+	-	-	-	700 x 700
18 mm	-	+	+	-	1200 x 1200
26 mm	-	+	+	-	1200 x 1200
45 mm	-	+	+	+	1200 x 1200

For Duplex bars the maximum permissible field dimension must not exceed 1200 mm.

Integral blinds

It is also possible to mount other elements in the inter-pane space, e.g. integral blinds – per individual inquiry.

Approximate maximum area of IGUs

Table 18

Thickness of the glass component [mm]	Maximum side ratio	Maximum area [m^2]	Maximum side length [mm]	Minimum distance between panes [mm]	Example of IGU composition
3	1:6	1.50	1500	10	3-10-3
4	1:6	2.00	2000	8	4-8-4
		2.50	2500	10	4-10-4
		3.35	2500	12	4-12-4
		3.35	2500	16	4-16-4
5	1:10	2.50	2500	8	5-8-5
		3.50	3000	10	5-10-5
		5.00	3300	12	5-12-5
		5.00	3300	16	5-16-5
6	1:10	3.00	3000	8	6-8-6
		4.50	3000	10	6-10-6
		7.00	3500	12	6-12-6
		7.00	3500	16	6-16-6
8	1:10	4.00	3000	8	8-8-8
		6.00	3000	10	8-10-8
		8.75	3500	12	8-12-8
		10.00	5000	16	8-16-8

10	1:10	13.50	5000	16	10-16-10
12	1:10	13.50	6000	16	12-16-12

When different thickness glass panes are used in IGUs, the area is always limited by the glass pane with the lower thickness.

When calculating laminated glass thickness relative to float glass thickness, a conversion factor of 0.63 should be used (for calculation only the thickness of glass component is used – without interlayer).

If spacers wider than 16 mm are used, the same data as for 16 mm cavity from the Table above is applicable.

Maximum dimensions of IGUs presented in the Table apply if the following conditions are met:

1 - vertical glazing,
2 - glazing height 0 to 8 m above the ground level,
3 - supported on all four sides,
4 - not applicable to corner glazing of the buildings,
5 - average wind load in Poland is assumed (1.2 kN/m2).

NOTE: The above data is only a suggestion and does not take into account the loads of the building structure or dynamic loads placed upon the glass, only static loads of glass units themselves. These suggestions are to be approved prior to their use by an appropriately qualified building engineer certified to design in accordance with the prescribed construction regulations.

IGU with fire resistant glass

The fire resistance classification shall be related to the complete glazed element which incorporates the glass products and all given dimensions and tolerances.
Fire resistant glass units are marked with letter(s) representing the considered functional requirement(s), followed by the performance time expressed in minutes:
R(minutes)/E(minutes)/EW(minutes)/EI(minutes)/S(minutes)
Permanent mark shall be applied in the bottom right corner, ca. 30 mm from the glass edge. Fig. 36 shows marking of glass pane for indoor applications, glass pane for outdoor applications and IGU with fire resistant glass.
For the IGU shown in Fig. 36, the mark should be applied in position 4 so that it could be read from inside.

NOTE: Fire resistant glass is only a component of a fire protection system. The installation companies are responsible for compliance of the fire resistant element used in the entire system with applicable regulations. PRESS GLASS as a glass manufacturing and processing company shall not be held responsible for fire resistant glass applications in systems that do not comply with applicable regulations.
Installation of fire resistant glass must be carried out in accordance with the guidelines of the manufacturer of fire resistant glass and according to the guidelines of the manufacturer of the glazing system.

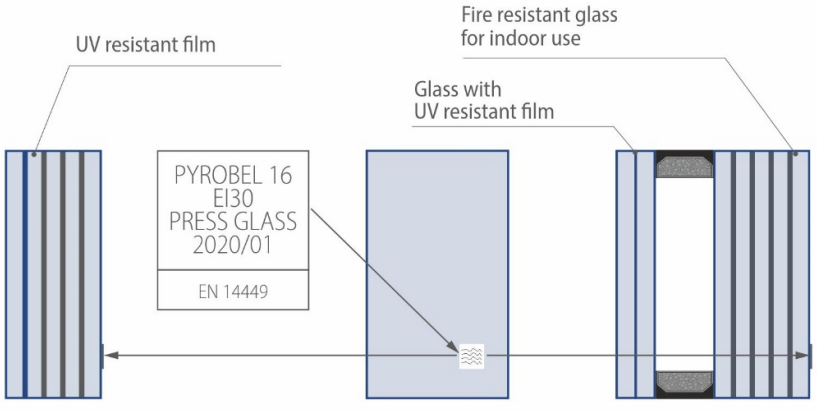
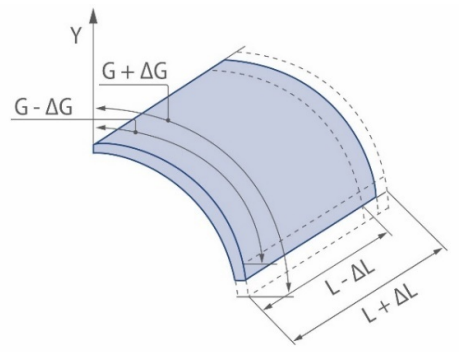
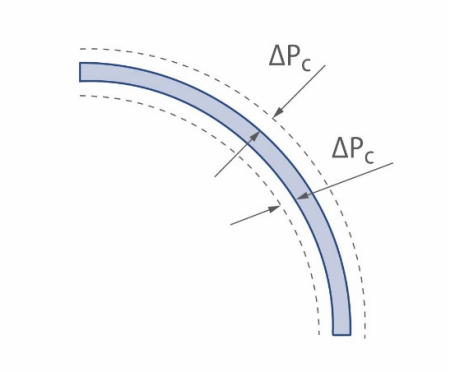


Fig. 36 Marking of fire resistant glass

IGU with explosion resistant glass	Explosion resistance shall be determined and classified in accordance with EN 13541. In those instances when the explosion resistant property of the insulating glass unit is ensured by one component only, there is no need for testing provided that each of the following conditions is fulfilled: – The explosion resistant component is correctly oriented; – The additional glass component(s) are placed in front of the explosion resistant component, on the attack side. In that situation the width of the gas space(s) and the nature of the gas have no influence on the result. The classification of the insulating glass unit shall be the same as for the glass component used. If the identification of the product is clear enough to avoid confusion, the performance of each component can be declared, in the order given by the composition. It is common practice to give the composition starting from the outer IGU component. In those instances when the explosion resistance property of the insulating glass unit is achieved only by the complete unit, this IGU shall be tested and classified in accordance with EN 13541. The nature of the gas has no influence on the result. The explosion resistant glass unit should meet the requirements of EN 1279-5.
IGU with bullet resistant glass	Bullet resistance shall be determined and classified in accordance with EN 1063. In those instances when the bullet resistance property of the insulating glass unit is ensured by one component only, there is no need for testing provided that the conditions 1 and 2, or 1 and 3 are fulfilled: 1. The bullet resistant component is correctly oriented, and 2. When the bullet resistant component is classified “NS”, the additional glass component(s) are placed in front of the bullet resistant component, on the attack side, or 3. When the bullet resistant component is classified “S”, the additional glass component(s) may be placed either on the attack side or on the protected side. In that situation, the width of the gas space(s) and the nature of the gas have no influence on the result. The classification of the insulating glass unit shall be the same as for the glass component used. If the identification of the product is clear enough to avoid confusion, the performance of each component can be declared, in the order given by the composition.

	It is common practice to give the composition starting from the outer IGU component. In those instances when the bullet resistance property of the insulating glass unit is achieved only by the complete unit, this IGU shall be tested and classified in accordance with EN 1063. When adding a glass component to this insulating glass unit, there is no need for further testing provided that conditions 1 and 2, or 1 and 3 are fulfilled: 1. The insulating glass unit is correctly oriented, and 2. When the bullet resistant insulating glass unit is classified "NS", the additional glass component(s) is not placed on the protected side and the gas space width is not reduced. In the case of additional component(s) being placed in the cavity, i.e. when a double insulating glass unit is transformed into a triple insulating glass unit, the sum of the width of the two gas spaces of the triple insulating glass unit is not less than the one of the tested double insulating glass unit, or 3. When the bullet resistant component is classified "S" it may be placed either on the attack side, on the protected side, or between the components of the insulating glass unit. The nature of the gas has no influence on the result. The bullet resistant glass unit should meet the requirements of EN 1279-5.
Types of special purpose IGUs	IGUs for special purposes can be produced in any type – A, B or C.

17. Curved glass, curved laminated glass, curved IGUs

Standard	ISO 11485, EN 1279	
Definition	Thermally curved glass is glass that has been shaped by a heating process. The following types of curved glass can be identified based on its shape: – cylindrically curved glass – with one fixed bending radius, – 3D - glass curved in multi-dimensional shapes. Depending on the heat treatment, thermally toughened curved glass (cylindrical) or annealed glass (3D) can be obtained. Both types of glass can be used to make: – monolithic glass, – enamelled glass or glass with a digital print, – laminated glass, – IGU.	
Type of glass	Monolithic, laminated	
Glass shapes	Individual request	
Tolerances for cylindrically curved monolithic glass	Straight side length tolerance ΔL	
	±2 mm/m for glass thickness 4-8 mm	
	±3 mm/m for glass thickness 10-19 mm	
	Overall girth tolerance ΔG	
	±2 mm/m for glass thickness 4-8 mm	
	±3 mm/m for glass thickness 10-19 mm	
		 Fig. 37 Curved glass dimensions
	Shape accuracy tolerance ΔP_c	
	±2/3 T for glass thickness 4-8 mm	
	±1/2 T for glass thickness 10-19 mm	
	T is the nominal thickness of the finished product.	 Fig. 38 Shape accuracy

Edge straightness deviation ΔR_B

$\Delta R_B \leq$ 3 mm/m or 2 mm, whichever is greater – measured at the glass edge (Fig. 39).

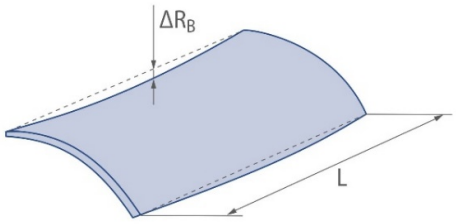


Fig. 39 Edge straightness deviation

Cross-curve deviation

4 mm/m – measured along the vertical edge (perpendicular to the arc) on the concave surface of glass, in sections A-A, B-B, C-C (Fig. 40).

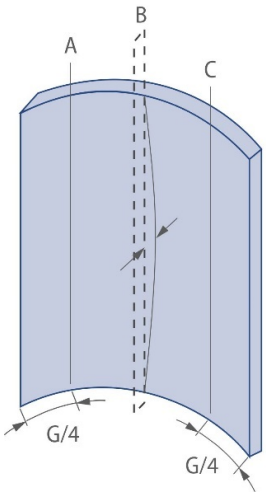


Fig. 40 Measurement of cross-curve deviation

Twist is a deviation of one or more corners from the plane which connects the corners.

Maximum twist deviation V

4 mm	$L \leq 1200$
5 mm	$1200 < L \leq 1500$
6 mm	$1500 < L \leq 2000$
7 mm	$2000 < L \leq 2400$
8 mm	$L > 2400$

L – straight side length

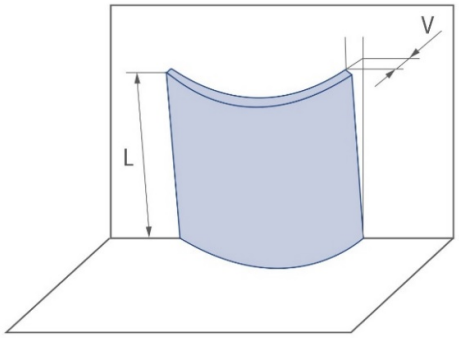


Fig. 41 Twist deviation

Tolerances for cylindrically curved laminated glass

The tolerances for cylindrically curved laminated glass should take into the account tolerances for all components.

Maximum displacement of the components d_1

2 mm for the girth or straight edge length ≤ 1000 mm

2 mm/m for the girth or straight edge length > 1000 mm

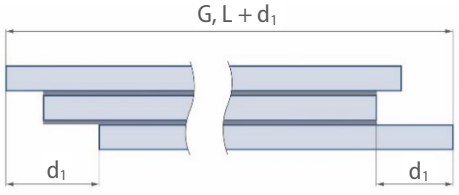


Fig. 42 Displacement for curved laminated glass

<table>
<tr><td rowspan="3">Tolerances for cylindrically curved IGUs</td><td>The tolerances for cylindrically curved IGUs should take into the account tolerances for all components.
The tolerance on shape accuracy for a cylindrically curved IGU equals the sum of the tolerances on the curvature of the components increased by 2 mm:
$\Delta P_C = \Delta P_{C1} + \Delta P_{C2} + 2$ mm
ΔP_{C1} – tolerance on the curvature of the first component of the curved IGU
ΔP_{C2} – tolerance on the curvature of the second component of the curved IGU

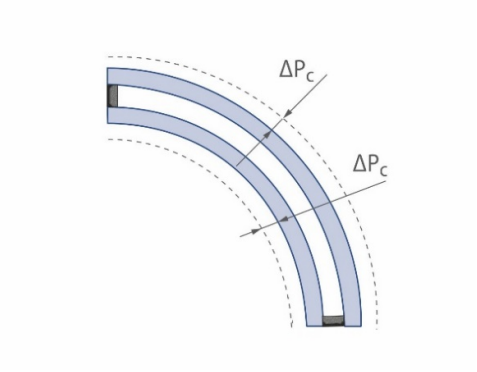
For a triple glazed unit, the tolerance shall be agreed individually.</td><td> 

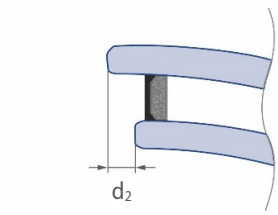
Fig. 43 Shape accuracy of IGU (cylindrically curved)</td></tr>
<tr><td>Maximum displacement of the components d_2
3 mm for the girth or straight edge length ≤ 1000 mm
3 mm/m for the girth or straight edge length > 1000 mm</td><td> 

Fig. 44 Displacement for curved IGU</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Tolerances for 3D glass</td><td colspan="2">The tolerances depend on a number of factors and shall be agreed individually for each order. It is recommended to make a sample to determine the tolerance and visual acceptance.</td></tr>
<tr><td>Curved IGUs</td><td colspan="2">Curved IGUs offered by PRESS GLASS are manufactured according to the requirements of ISO 11485 and meet specific requirements of EN 1279, which allows for their CE marking.</td></tr>
<tr><td>Types of curved IGUs</td><td colspan="2">Curved IGUs can be produced in any type – A, B or C.</td></tr>
</table>

18. Glass surface assessment - enamelled glass or glass with digital print

<table>
<tr><td>Standard</td><td colspan="3">None</td></tr>
<tr><td>Type of glass</td><td colspan="3">Monolithic</td></tr>
<tr><td>Glass shapes</td><td colspan="3">Catalog, non-catalog, templates</td></tr>
<tr><td>Assessment method</td><td colspan="3">Enamelled glass shall be assessed from a distance of at least 3 m, perpendicular to its surface. During the assessment, the observation angle created with the line perpendicular to the assessed glass surface should not be greater than 30°. 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. The assessment is always conducted looking through the glass, viewing the surface without enamel layer. 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 3 m are not classified as defects.</td></tr>
<tr><td>Assessment zones</td><td>Zone R</td><td>edge zone equal to the frame width or edge seal, no less than 15 mm</td><td rowspan="3"> 

Fig. 45 Assessment zones - enamelled glass or glass with digital print</td></tr>
<tr><td>Zone M</td><td>main zone</td></tr>
<tr><td colspan="2">For glass not intended for installing in a frame or for IGU, the requirements for zone R are the same as for zone M.</td></tr>
<tr><td>Acceptable spot defects/ enamel defects</td><td colspan="3">Table 19
<table>
<tr><th>Zone</th><th>Size [mm]</th><th>Tolerances</th></tr>
<tr><td>R</td><td>All sizes</td><td>No limitation</td></tr>
<tr><td rowspan="3">M</td><td>Ø ≤ 1</td><td>Accepted if less than 3 in each area of Ø 200 mm</td></tr>
<tr><td>1 < Ø ≤ 5</td><td>Maximum 3 pcs per m^2, at a distance of ≥ 100 mm</td></tr>
<tr><td>Ø > 5</td><td>Unacceptable</td></tr>
</table>
If the enamelled glass is to be used on a bright background, or will be illuminated on the side opposite to the observer, spots, stains, streaks, or a “starry sky” impression may be visible all of which are result of the manufacturing process. This is because enamel is not totally impervious to light. Such an effect is not subject to complaint.

Fine lengthwise and crosswise stripes and individual slightly blurred stains are characteristic of enamelled glass.</td></tr>
</table>

Acceptable linear defects

Table 20

Zone	Individual lengths	Total of individual lengths	
		Area ≤ 3 m²	Area > 3 m²
R	No limitation		
M	≤ 75 mm	≤ 225 mm	75 mm/m²
	> 75 mm	Unacceptable	

Acceptable streaks and stains

Table 21

Zone	Stains	Streaks
R	No limitation	
M	Ø ≤ 17 mm 1/m²	Acceptable if not visible from the distance specified for glass inspection in daylight conditions

Color tolerance

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 enamel. The actual color of the enamel can be determined by watching a fired sample through the glass. Differences may occur in colors selected based on standard systems, e.g. RAL.

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 enamelled glass. The color also depends on the application method. Due to the relatively thin enamel coating achieved with silk screen or digital print, the coated surfaces are more permeable to light than those where enamel is applied using a roller, where the enamel coating is thicker. Enamelled glass is always assessed after tempering or heat strengthening.

Ceramic enamel is made of inorganic materials which determine particular color. The original color of the enamel may vary slightly and that is why the enamel 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 enamel 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 enamel 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, enamel 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 enamelled glass is provided by one supplier. The colors of the enamel can be compared only for one customer's order, one type of glass and ceramic enamel. When comparing two pieces of glass covered with enamel of the same color, the acceptable color difference is $\Delta E \leq 3$ (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 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.

19. Glass surface assessment - sandblasted glass

Standard	None		
Type of glass	Monolithic		
Glass shapes	Catalog, non-catalog, templates		
Assessment method	Glass with sandblasted surface shall be assessed from a distance of at least 3 m, perpendicular to its surface. During the assessment, the observation angle created with the line perpendicular to the assessed glass surface should not be greater than 30°. 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. The assessment is always conducted looking through the glass, viewing the non-sandblasted surface. 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 3 m are not classified as defects.		
Assessment zones	Zone R	edge zone equal to the frame width or edge seal, no less than 15 mm	 Fig. 46 Assessment zones - sandblasted glass
	Zone M	main zone	
	For glass not intended for installing in a frame or for IGU, the requirements for zone R are the same as for zone M.		

Table 22

Acceptable spot defects/ sandblasting defects	Zone	Size [mm]	Tolerances
	R	All sizes	No limitation
	M	Ø ≤ 1	Accepted if less than 3 in each area of Ø 200 mm
		1 < Ø ≤ 5	Maximum 3 pcs per m^2, at a distance of ≥ 100 mm
		Ø > 5	Unacceptable

Table 23

Acceptable linear defects	Zone	Individual lengths	Total of individual lengths	
			Area ≤ 3 m^2	Area > 3 m^2
	R	No limitation		
	M	≤ 75 mm	≤ 225 mm	75 mm/m^2
		> 75 mm	Unacceptable	

Acceptable streaks and stains

Table 24

Zone	Stains	Streaks
R	No limitation	
M	∅ ≤ 17 mm 1/m²	Acceptable if not visible from the distance specified for glass inspection in daylight conditions

20. Glass surface assessment - tempered, heat strengthened and heat soak tempered glass

Standard	EN 12150, EN 1863, EN 14179, EN 1096					
Type of glass	Monolithic					
Glass shapes	Catalog, non-catalog, templates					
Assessment method	Assessment with a naked eye, in natural light, against black matt screen background, in transmission and/or reflection, depending on the applied glass and its technical specifications.					
	The observer's distance *b* is:					
	3 m for coated glass					
	2 m for uncoated glass					
	The assessment shall not last longer than 20 seconds.					
Assessment zones	Zone R	edge zone equal to the frame width or edge seal, no less than 15 mm				
	Zone E	zone on the visible area edge, equal to 5% of the edge length, no less than 50 mm				
	Zone M	main zone				
	For glass not intended for installing in a frame or for IGU, the requirements for zone R are the same as for zone E.					
Acceptable spot defects	Table 25					
	Zone	Defect size [Ø in mm] (excluding halo)	Glass area S [m^2]			
			$S \leq 1$	$1 < S \leq 2$	$2 < S \leq 3$	$3 < S$
	R	All sizes	No limitation			
	E	Ø ≤ 1	Accepted if less than 3 in each area of Ø 200 mm			
		1 < Ø ≤ 3	4	1 per meter of perimeter		
		Ø > 3	Unacceptable			

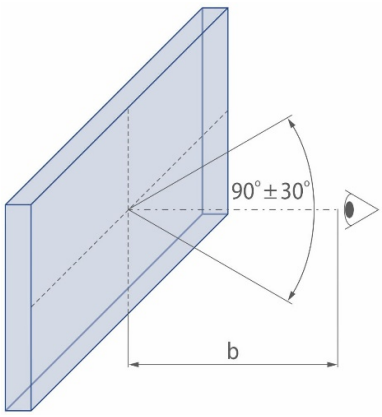


Fig. 47 Heat-treated glass assessment method

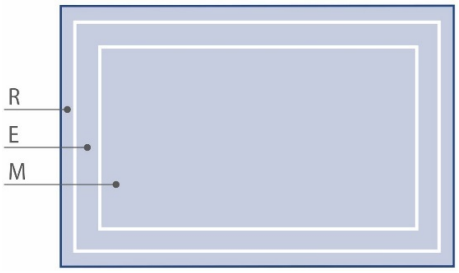


Fig. 48 Assessment zones - tempered, heat strengthened and heat soak tempered glass

	M	Ø ≤ 1	Accepted if less than 3 in each area of Ø 200 mm			
		1 < Ø ≤ 2	2	3	5	5 + 2/m²
		2 < Ø ≤ 3	1/m²			
		Ø > 3	Unacceptable			
	Halo – area locally distorted, generally around a point defect when the defect is included in the glass pane.					

Acceptable linear defects

Table 26

Zone	Individual lengths	Total of individual lengths	
		Area ≤ 3 m²	Area > 3 m²
R	No limitation		
E	≤ 75 mm	≤ 225 mm	75 mm/m²
	> 75 mm		
M	≤ 75 mm	≤ 225 mm	75 mm/m²
	> 75 mm	Unacceptable	

Acceptable streaks and stains

Table 27

Zone	Stains	Streaks
R	No limitation	
E	Ø ≤ 17 mm - 1/m²	No limitation
M	Acceptable if not visible from the distance specified for glass inspection in daylight conditions	

Edge defects	Arrissing	Small nicks on the edge are acceptable. Blank spots – acceptable.
	Grinding	Small nicks on the edge are acceptable provided they are blunt. Blank spots – acceptable.
	Smooth grinding	Nicks on the edge – unacceptable.
	Polishing	Matt 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.
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 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.	

21. Glass surface assessment - laminated glass, fire resistant glass

Standard	EN ISO 12543
Type of glass	Monolithic
Glass shapes	Catalog, non-catalog, templates
Assessment method	The laminated glass is put in a vertical position, in front of and parallel to a matt grey screen and is lit by diffuse daylight or equivalent. The laminated glass is visually inspected perpendicularly at a distance of 2 m from the glass, with the matt screen on the other side of the glass. The matt screen shall be placed behind the glass. Any visible defects that are disturbing shall be marked.

Assessment zones

a	edge zone width
R	edge zone/area
M	main zone/vision area
L	width of pane
H	height of pane
Edge zone	
15 mm	for a glass pane area ≤ 5 m²
20 mm	for a glass pane area > 5 m²

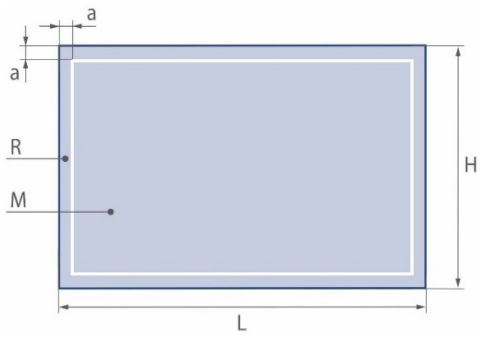


Fig. 49 Assessment zones - laminated glass, fire resistant glass

Acceptable spot defects

Defects less than 0.5 mm shall not be considered. Defects greater than 3 mm shall not be permitted. Admissibility of spot defects in laminated glass is independent of the individual glass thickness. The number of acceptable spot defects shall be increased by one for each individual interlayer which is thicker than 2 mm.

Table 28

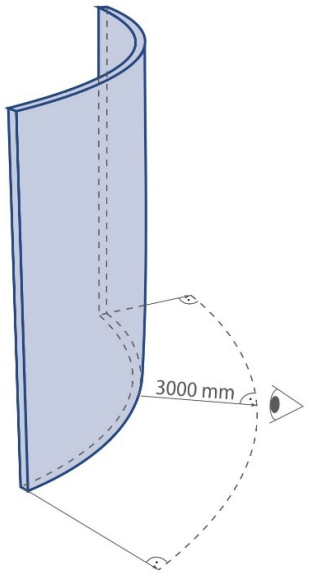
Number of glass compo-nents	Defect size *d* [mm]	0.5 < *d* ≤ 1.0	1.0 < *d* ≤ 3.0			
	Pane area *A* [m²]	for all areas	*A* ≤ 1	1 < *A* ≤ 2	2 < *A* ≤ 8	*A* > 8
2	Number or density of acceptable defects	No limitation (no accumulation of defects)	1	2	1/m²	1.2/m²
3			2	3	1.5/m²	1.8/m²
4			3	4	2/m²	2.4/m²
≥5			4	5	2.5/m²	3/m²

An accumulation of defects occurs if four or more defects are at a distance of < 200 mm from each other. This distance is reduced to 180 mm for laminated glass consisting of three panes, to 150 mm for laminated glass consisting of four panes and to 100 mm for laminated glass consisting of five or more panes.

<table>
<tr><td rowspan="5">Acceptable linear defects in the main zone</td><td colspan="2">Table 29</td></tr>
<tr><td colspan="2">Linear defects shorter than 30 mm are acceptable</td></tr>
<tr><td>Pane area
[m²]</td><td>Number of acceptable defects
> 30 mm</td></tr>
<tr><td>≤ 5</td><td>Unacceptable</td></tr>
<tr><td>5 to 8</td><td>1</td></tr>
<tr><td></td><td>> 8</td><td>2</td></tr>
<tr><td rowspan="4">Other defects</td><td colspan="2">Table 30</td></tr>
<tr><td>Cracks</td><td>Unacceptable</td></tr>
<tr><td>Creases and streaks</td><td>Unacceptable in the main zone</td></tr>
<tr><td>Defects with ∅ ≤ 5 mm</td><td>Acceptable in the edge zone for framed edges</td></tr>
<tr><td rowspan="2">Defects in the edge zone</td><td>Edge zone for framed edges</td><td>Defects which do not exceed 5 mm in diameter are permitted. If there are air bubbles, the area of their presence should not exceed 5% of the edge zone.</td></tr>
<tr><td>Periphery not intended for framing</td><td>Defects are permissible if they do not become obvious.</td></tr>
<tr><td rowspan="4">Definitions of defects</td><td>Spot defects</td><td>Opaque spots, bubbles and foreign bodies.</td></tr>
<tr><td>Linear defects</td><td>Foreign bodies and scratches or grazes.</td></tr>
<tr><td rowspan="2">Other defects</td><td>Glass defects: cracks, vents.</td></tr>
<tr><td>Interlayer defects: creases, shrinkage, streaks.</td></tr>
<tr><td>Marking</td><td colspan="2">According to EN 14449 permanent marking is not required for laminated glass and laminated safety glass.</td></tr>
</table>

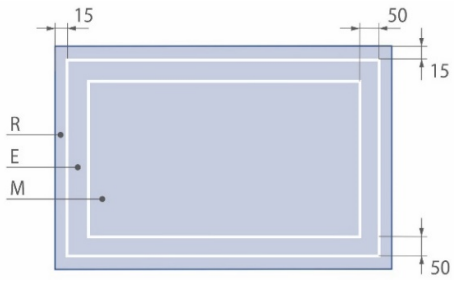
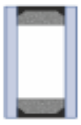
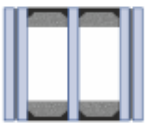
NOTE! Fire resistant glass is only a component of a fire protection system. The installation companies are responsible for compliance of the fire resistant element used in the entire system with applicable regulations. PRESS GLASS as a glass manufacturing and processing company shall not be held responsible for fire resistant glass applications in systems that do not comply with applicable regulations.
Installation of fire resistant glass must be carried out in accordance with the guidelines of the manufacturer of fire resistant glass and according to the guidelines of the manufacturer of the glazing system.

22. Glass surface assessment - curved glass

Standard	ISO 11485, EN 1279	
Type of glass	Monolithic, laminated, IGU	
Glass shapes	Individual request	
Assessment method	Assessment with a naked eye, in natural light, against black matt screen background, in transmission and/or reflection, depending on the applied glass and its technical specifications. The viewing angle shall be as perpendicular to the glass surface as possible. The observer's distance is 3 m. The assessment shall not last longer than 20 seconds.	 Fig. 50 Curved glass assessment method
Optical distortion	Slight deformation of the images seen in reflection or in transmission, inherent to the process of bending glass.	
Surface assessment – cylindrical glass	Visual quality of curved glass, including IGUs, should meet the requirements described in the following sections: 18. *Glass surface assessment - enamelled glass or glass with digital print* 19. *Glass surface assessment - sandblasted glass* 20. *Glass surface assessment - tempered, heat strengthened and heat soak tempered glass* 21. *Glass surface assessment - laminated glass, fire resistant glass* NOTE: The acceptable size of defects given in the abovementioned sections shall be doubled and the quantity tripled, and following aspects taken into account.	
	Nicks	Covered edge – No nicks wider or longer than the nominal thickness of the glass.
		Exposed edge – No nicks adversely affecting performance.
	Imprints	∅ ≤ 2.0 mm

Surface assessment – 3D glass	Individual request It is recommended to make a sample to determine the tolerance and visual acceptance. An area of spot defects which is formed due to the presence of separator cannot be treated as a defect.
Physical phenomena which are not defects	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 ISO 11479-2. 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. If an IGU is installed at significant height above sea level, excessive deflection of the glass panes might reduce the IGU's durability and, in extreme cases, cause the glass to break. In such cases, it is recommended to equalize pressure in the IGU (using an appropriate device) to the value which will ensure its proper performance at the installation site, at the particular height above sea level. For more information, contact the Sales Department. 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, see EN 12150-1, EN 1863-1. 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.

23. IGU assessment

Standard	EN 1279				
Type of glass	Monolithic, laminated				
Glass shapes	Catalog, non-catalog, templates				
Assessment method	These guidelines apply to assessment of the visible quality of insulating glass units made of glass components as defined in EN 1279-1. The optical and visual quality requirements for glass components shall be taken from the appropriate European Standards. The following Tables give the maximum acceptable defects per IGU, as well as the defects that are specific to the assembly. The Tables cover IGUs of types A, B and C. Assessment of IGUs shall be done in transmission and not in reflection (looking "through the glass", not "at the glass") from a distance of minimum 3 m, from the inside to the outside. The viewing angle shall be as perpendicular to the glass surface as possible. The defects shall not be marked on the glass pane. The assessment is carried out under diffuse daylight conditions (e.g. overcast sky), without direct sunlight or artificial lighting. The observation time should not exceed one minute per m^2. IGUs assessed from the outside shall be examined in installed condition, taking into consideration the usual viewing distance with a minimum of 3 m. The viewing angle shall be as perpendicular to the glass surface as possible.				
Assessment zones	Zone R	zone of 15 mm, usually covered by the frame, or corresponding to the edge seal in case of unframed edge	 Fig. 51 Assessment zones - IGU		
	Zone E	zone at the edge of the visible area, with a width of 50 mm			
	Zone M	main zone			
IGU categories for visual assessment	Category I		Category II	Category III	Category IV
	2 glass components		3 glass components	4 glass components	5 glass components
					

Acceptable spot defects

Table 31

Zone	Defect size * [⌀ in mm]	Glass area S [m²]																							
		$S \leq 1$				$1 < S \leq 2$				$2 < S \leq 3$				$3 < S \leq 5$				$5 < S \leq 10$				$10 < S \leq 15$ ***			
		IGU category				IGU category				IGU category				IGU category				IGU category				IGU category			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
R	All sizes	No limitation				No limitation				No limitation				No limitation				No limitation				No limitation			
E	⌀ ≤ 1 **	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
	1 < ⌀ ≤ 3	4	5	6	7	4	5	6	7	5	7	8	9	7	9	11	13	8	10	12	14	12	15	18	21
	⌀ > 3	Unacceptable				Unacceptable				Unacceptable				Unacceptable				Unacceptable				Unacceptable			
M	⌀ ≤ 1 **	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
	1 < ⌀ ≤ 2	2	3	3	4	3	4	5	6	5	7	8	9	11	14	17	20	15	19	23	27	25	32	38	44
	⌀ > 2	Unacceptable				Unacceptable				Unacceptable				Unacceptable				Unacceptable				Unacceptable			

* Excluding halo, i.e. area locally distorted, generally around a point defect when the defect is included in the glass pane.
** Maximum [pcs] in each area of ⌀ ≤ 200 mm.
*** For IGUs with an area of $S > 15$ m² assessment according to EN 1279-1.

Acceptable residue spots and stains

Table 32

Zone	Defect size and type [⌀ in mm]	Glass area S [m^2]							
		$S \leq 1$				$S > 1$			
		IGU category				IGU category			
		I	II	III	IV	I	II	III	IV
R	All sizes	No limitation							
E	Spots ⌀ ≤ 1	No limitation							
	Spots 1 < ⌀ ≤ 3	4	5	6	7	Per meter of perimeter [pcs]			
						1	2	2	2
	Stain ⌀ ≤ 17	1	2	2	2	1	2	2	2
	Spots ⌀ > 3 and stain ⌀ > 17	Maximum 1							
M	Spots ⌀ ≤ 1	Maximum [pcs] in each area of ⌀ ≤ 200 mm							
		3	4	5	6	3	4	5	6
	Spots 1 < ⌀ ≤ 3	Maximum [pcs] in each area of ⌀ ≤ 200 mm							
		2	3	3	4	2	3	3	4
	Spots ⌀ > 3 and stain ⌀ > 17	Unacceptable							

Acceptable linear defects

Table 33

Zone	IGU category			
	I	II	III	IV
	Individual lengths [mm]			
R	No limitation			
E	30	38	45	53
M	15	19	23	27
	Total of individual lengths [mm]			
R	No limitation			
E	90	113	135	158
M	45	57	68	79

Visual assessment criteria for other IGUs	The above Tables shall not be used for insulating glass unit with at least one component made of patterned glass, wired glass, wired patterned glass, drawn sheet glass, fire resistant laminated glass. The visual quality of thermally toughened safety glass, with or without heat soaking and of heat strengthened glass, when assembled in an insulating glass unit or in a laminated glass which is a component of an insulating glass unit, shall fulfil the requirements of their respective product standard. In addition to these requirements, for heat treated float glass, the overall bow relative to the total glass edge length may not be greater than 3 mm per 1000 mm glass edge length. Greater overall bow may occur for square or near square formats (up to 1:1.5) and for single panes with a nominal thickness < 6 mm.	
Acceptable number of defects for IGUs other than made of two monolithic glass panes	The acceptable number of defects defined for a double glazed IGU made of two monolithic glass panes is increased by 25 % per additional glass component (in multiple glazing or in a laminated glass component). The number of allowable defects is always rounded up. Example 1. To determine the number of acceptable defects for a triple glazed IGU made of 3 monolithic glass panes, the number of acceptable defects given in the Tables shall be multiplied by 1.25. Example 2. To determine the number of acceptable defects for a double glazed IGU made of 2 laminated glasses, with 2 glass components each, the number of acceptable defects given in the Tables shall be multiplied by 1.5.	
Definition 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.
	Residue and stain	Residue is a material that remain on the glass surface, that can have the form of spot or patch. It is usually made of the seal material. Stain is defect larger than punctual defect, often irregularly shaped, partially of mottled structure.
	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.
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 ISO 11479-2. 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.
If an IGU is installed at significant height above sea level, excessive deflection of the glass panes might reduce the IGU's durability and, in extreme cases, cause the glass to break. In such cases, it is recommended to equalize pressure in the IGU (using an appropriate device) to the value which will ensure its proper performance at the installation site, at the particular height above sea level. For more information, contact the Sales Department.

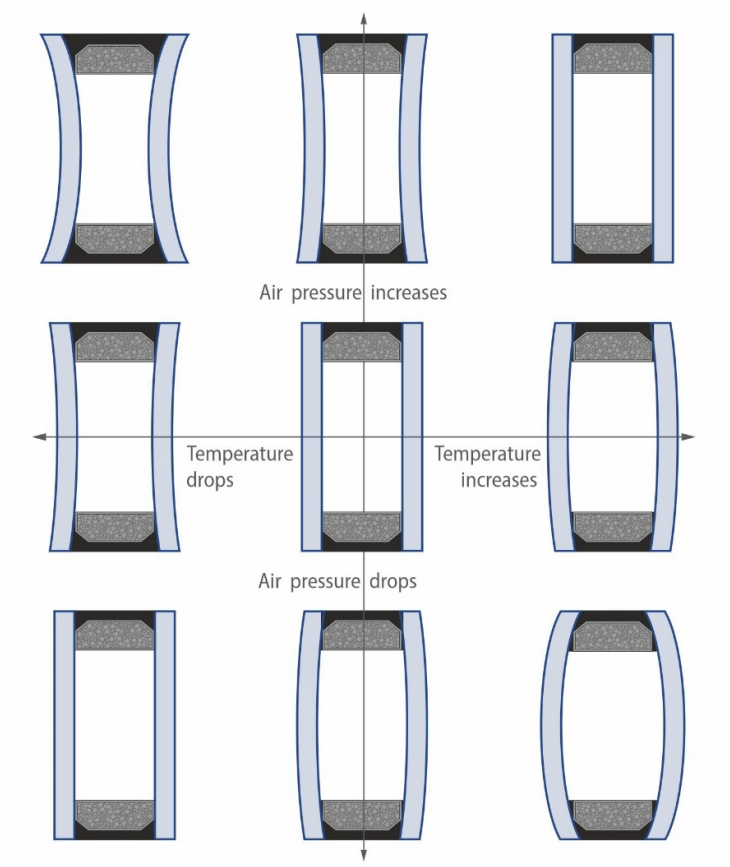


Fig. 52 Glass deflection due to changes in the temperature and barometric pressure

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, see EN 12150-1, EN 1863-1.

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

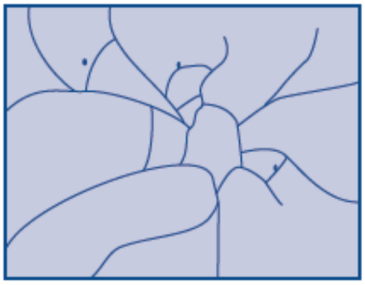


Fig. 53 Impact to the glass surface (e.g. throwing a stone)

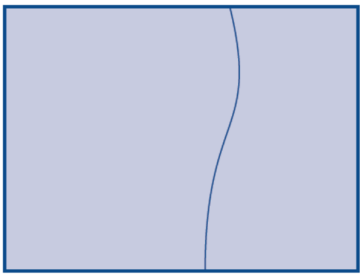


Fig. 54 Torsion breakage

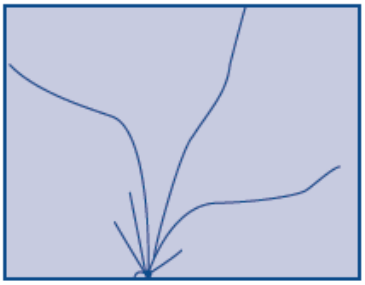


Fig. 55 Impact to the edge

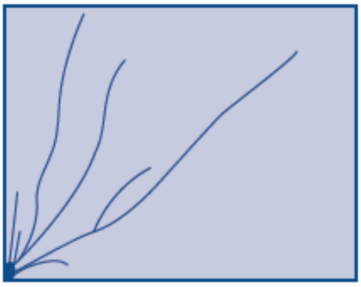


Fig. 56 Impact to the corner

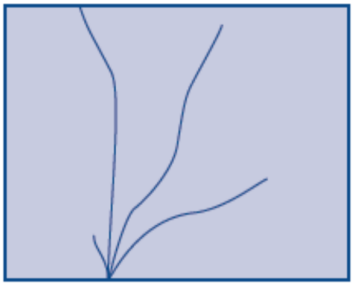


Fig. 57 Pressure on the edge

Fig. 58 Clamping crack

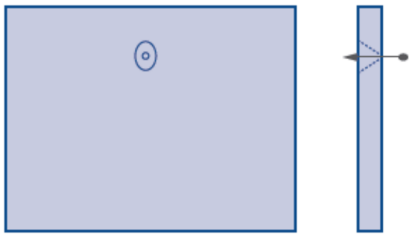


Fig. 59 Gun shot

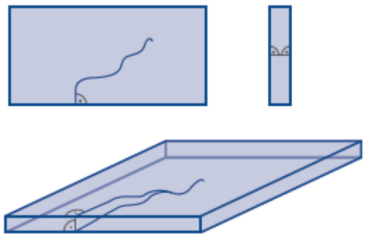


Fig. 60 Thermal crack

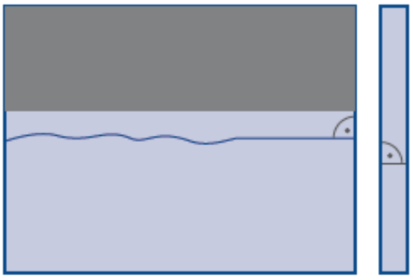


Fig. 61 Thermal crack*

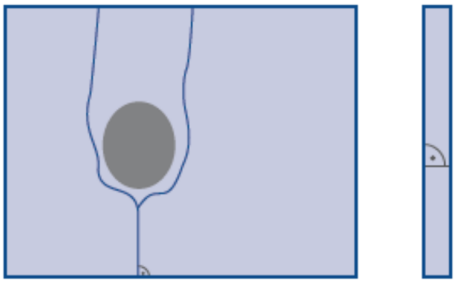


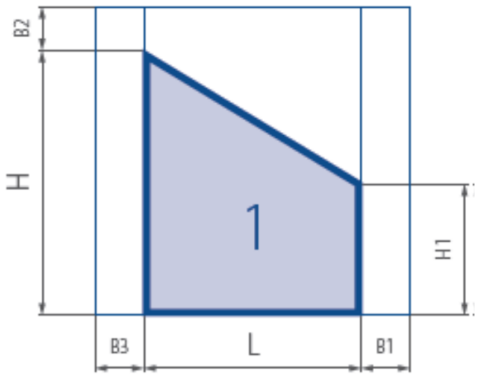
Fig. 62 Thermal crack*

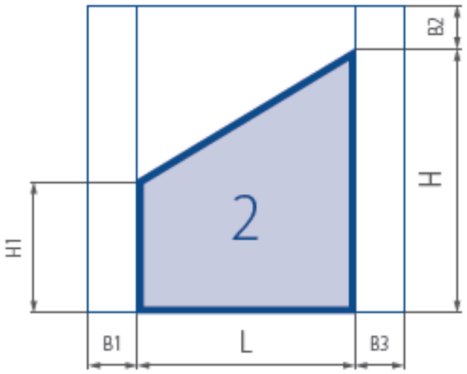
* Fig. 61, 62 – examples of thermal cracks caused by application of decoration or sticker on the glass surface or by its partial shading by blind, tree, part of a roof, etc.

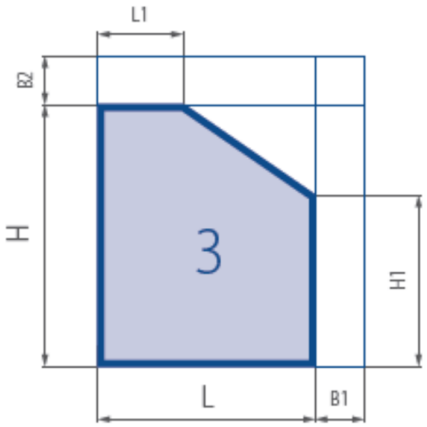
24. Finished product handling

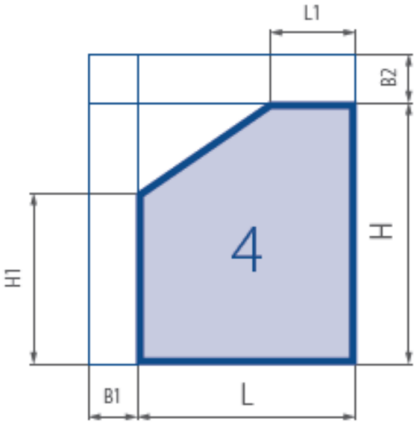
Packing	To transport finished products, A or L type metal stands are normally used. The stand base should form a straight angle with its sides. All metal parts of the stand which come in contact with glass shall be lined with rubber or another shock-absorbing material. Glass placed on stands shall be secured with strapping band to prevent slipping during transport. Cork, cardboard, wood, or other material shall be placed between the glass. Other packaging must be arranged between the customer and the supplier.
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 40 °C. The supplier shall not be liable for any defects caused by improper storage.
Transport	In most cases, the transport is realized with specialized vehicles, designed to carry glass. The customer unloads the stands containing the glass from the truck. The customer is responsible for proper unloading and shall report any defects discovered during delivery. Personal collection of the goods takes place at the 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. Installation and glazing conditions for IGUs are specified in EN 1279-5, Annex C (informative).
Washing and cleaning	Glass washing and cleaning - Clean the glass surface regularly, depending on the degree of soiling. - 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. - Remove sealant and oily residues with alcohol or isopropyl alcohol and then thoroughly rinse with water. - 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. 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 supplier 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.

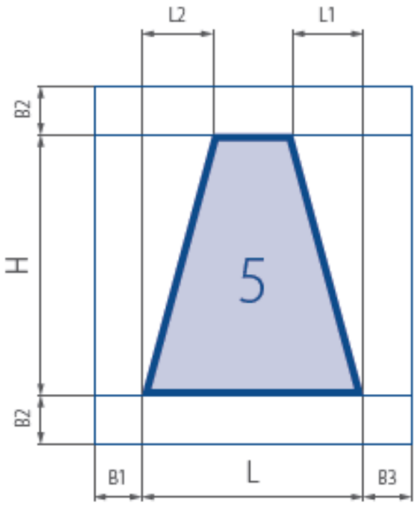
25. Catalog of glass shapes

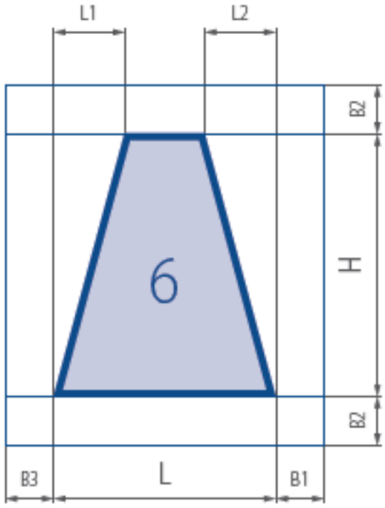


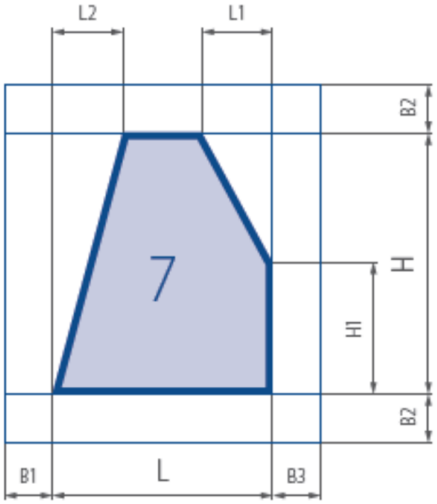


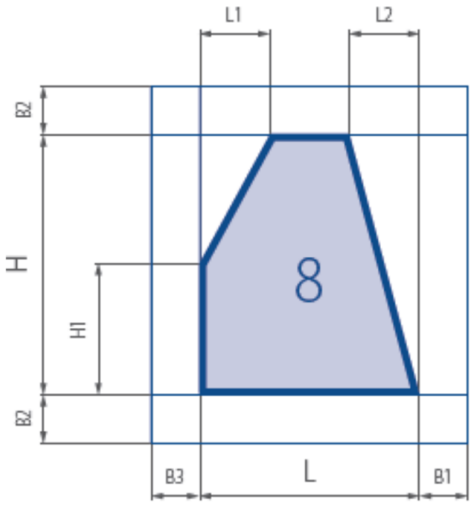


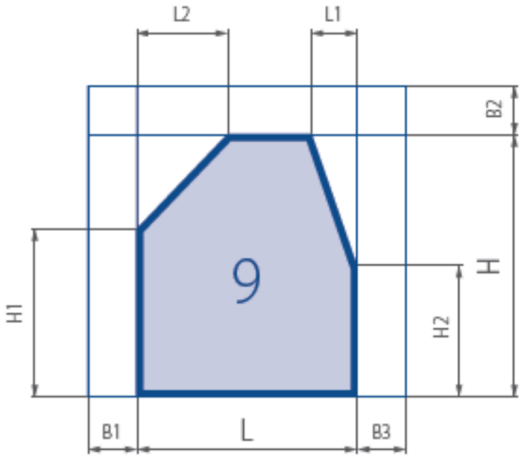


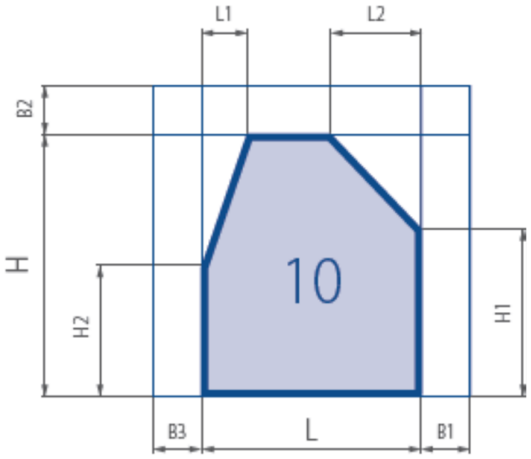


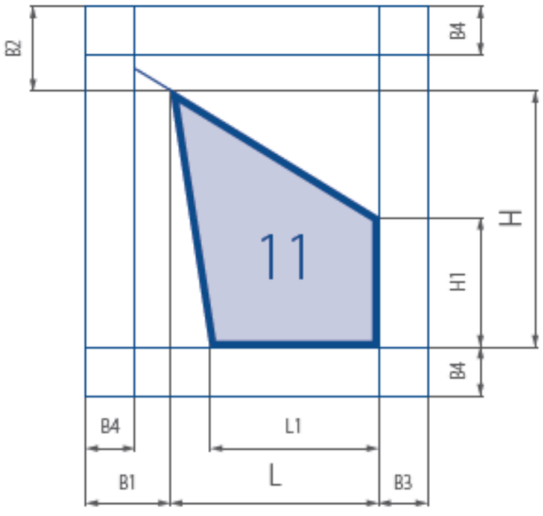


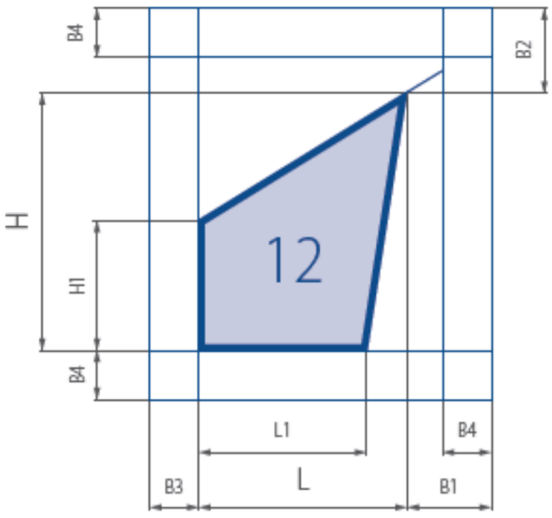


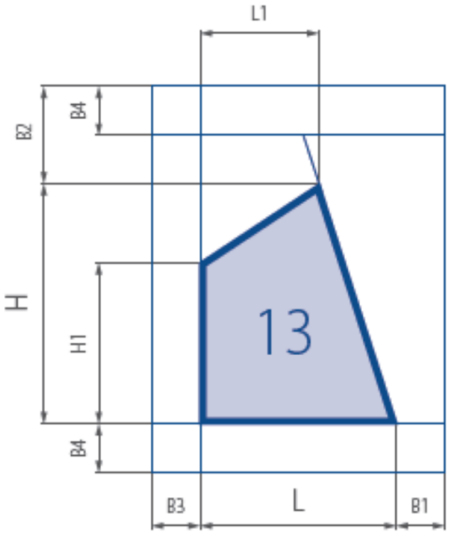


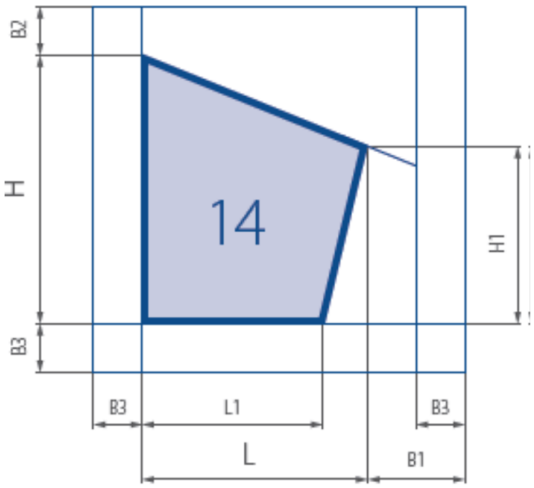


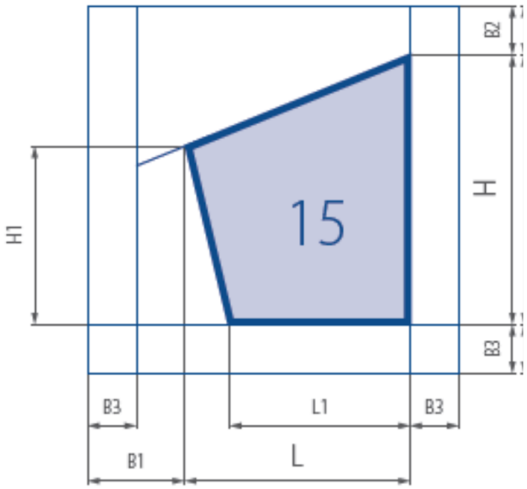


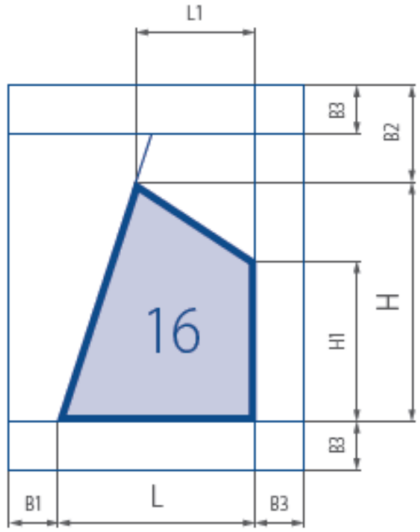


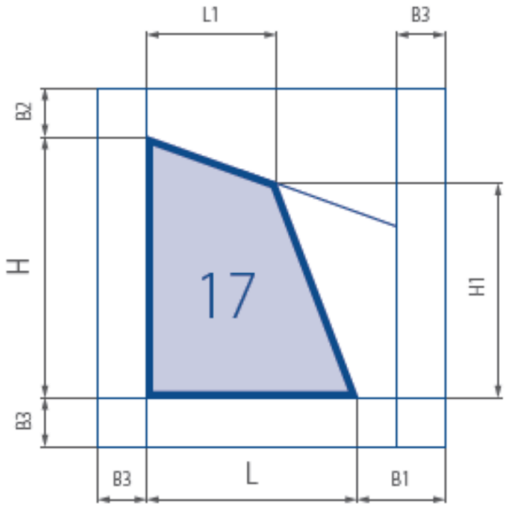


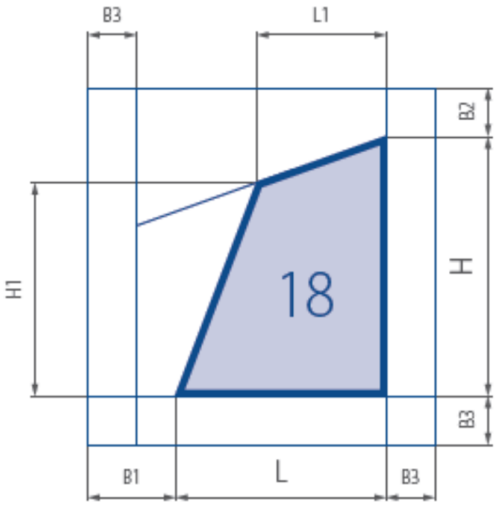


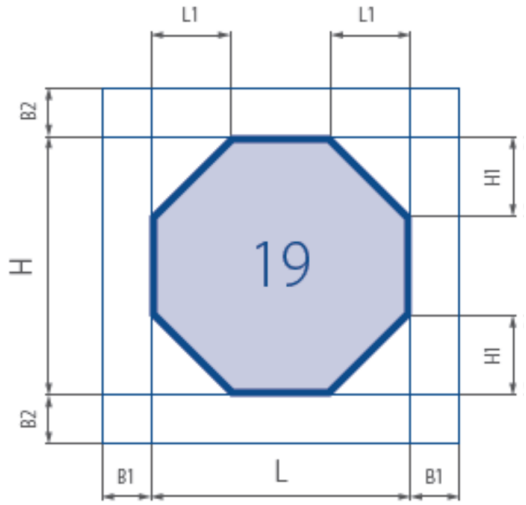


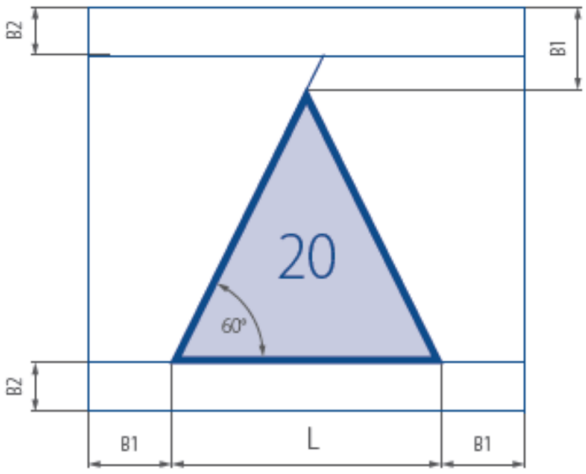


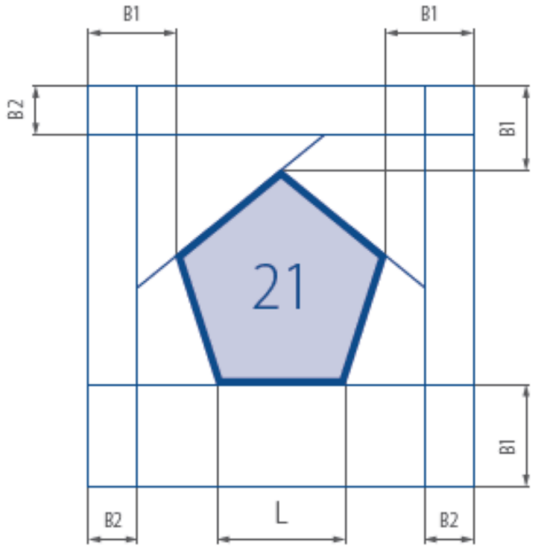


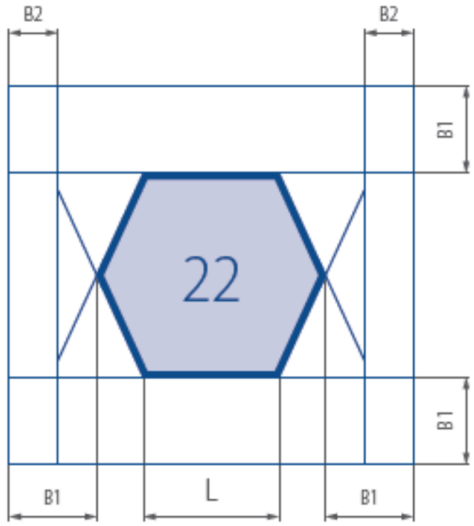


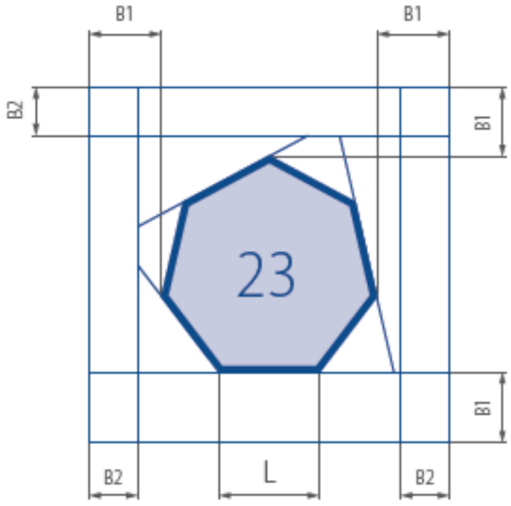


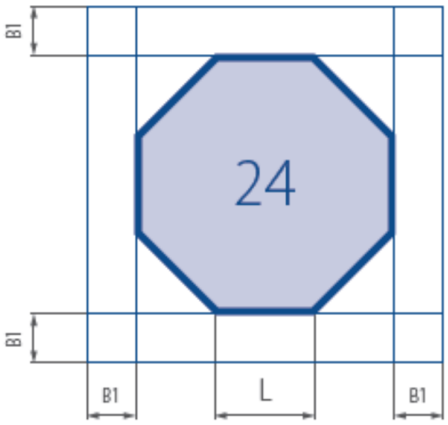


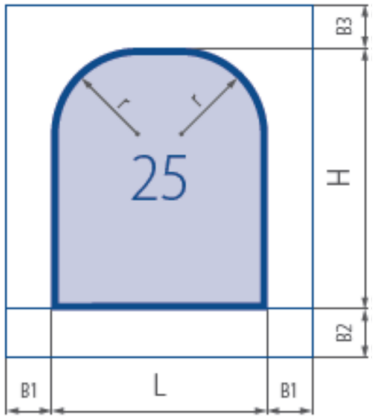


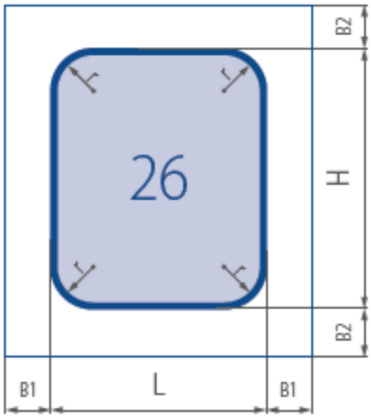


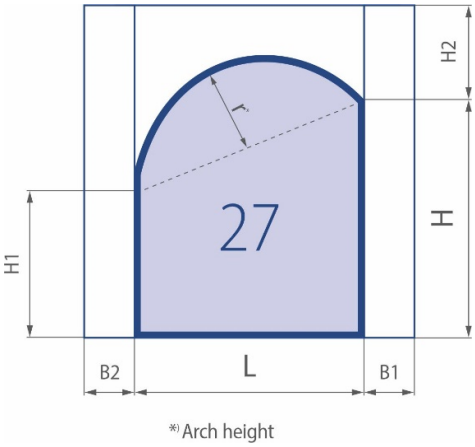


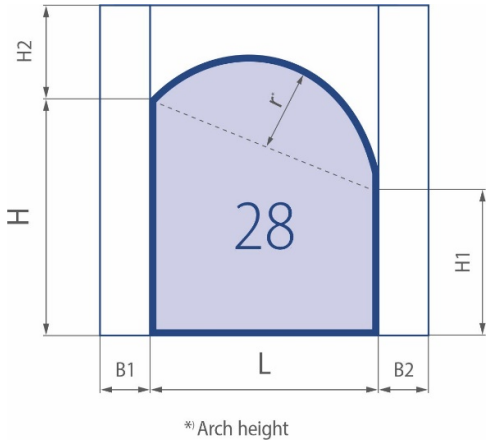


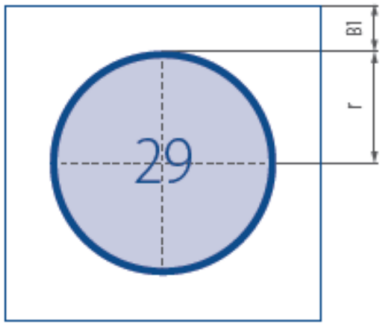


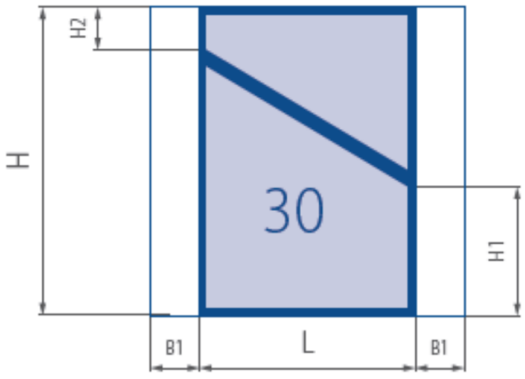


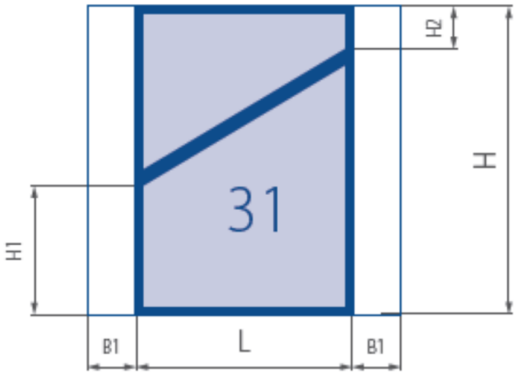


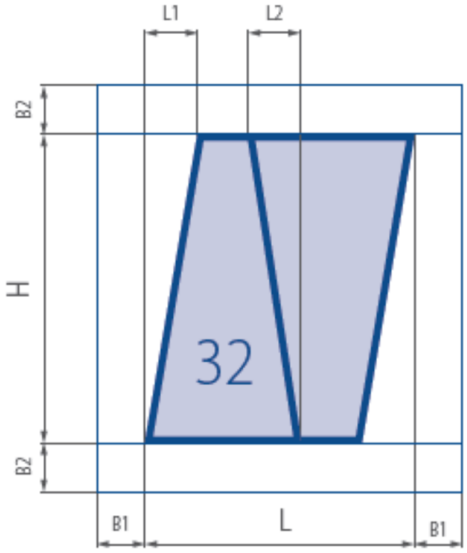


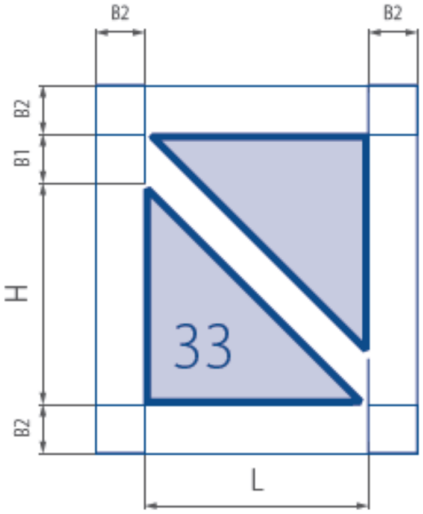


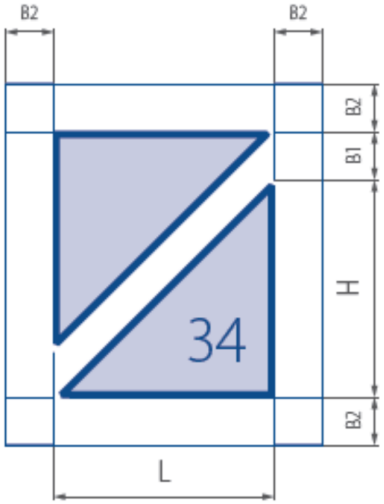


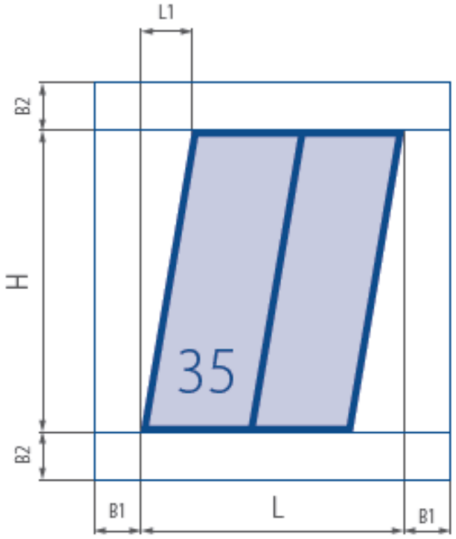


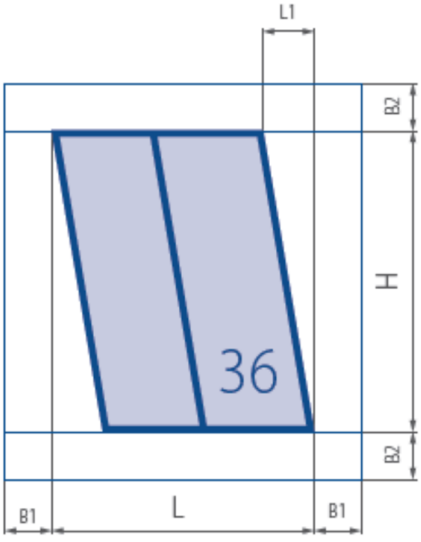


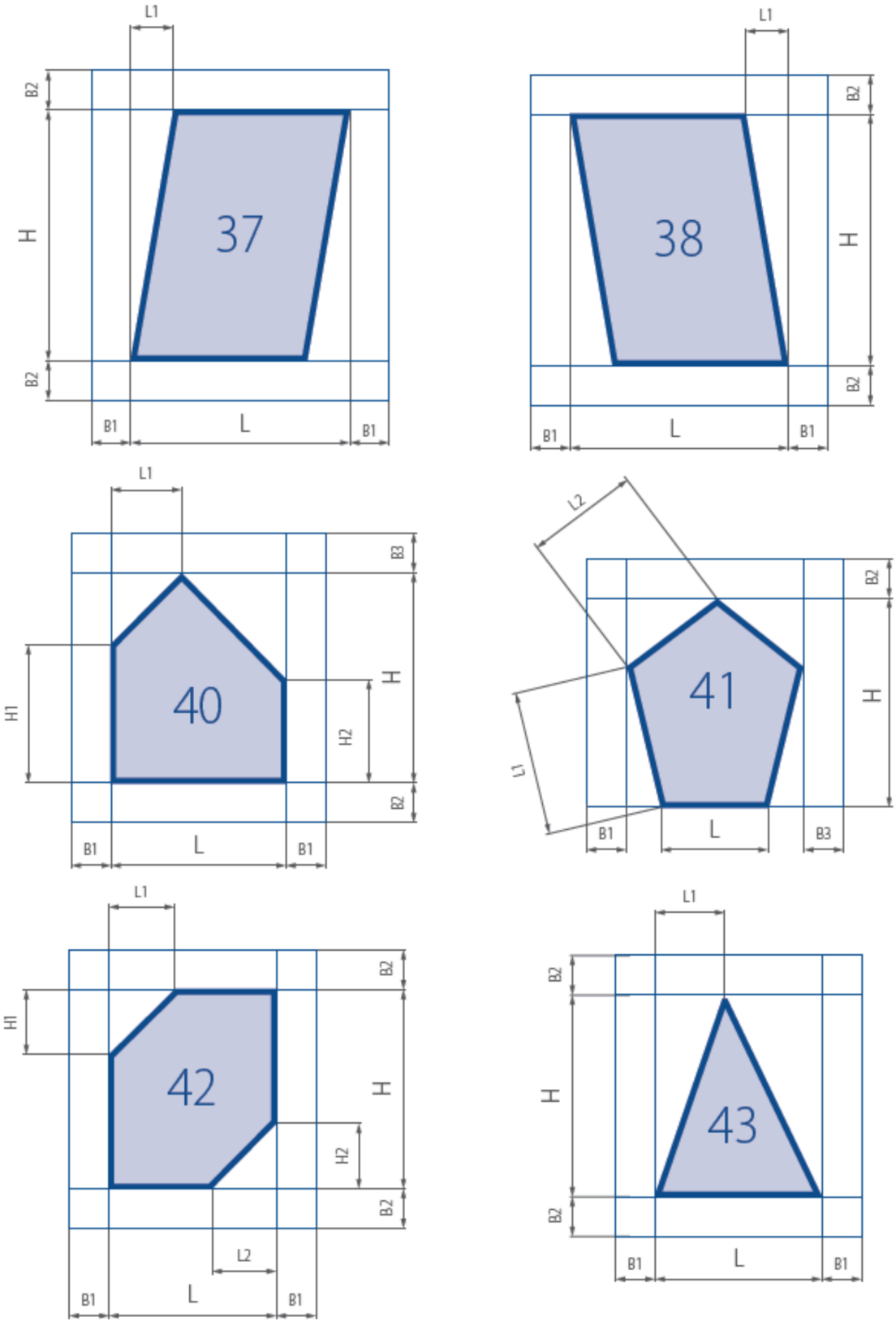


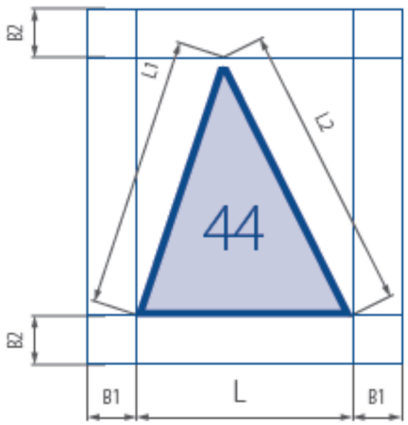


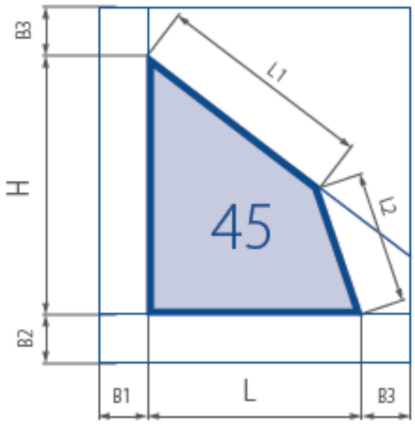


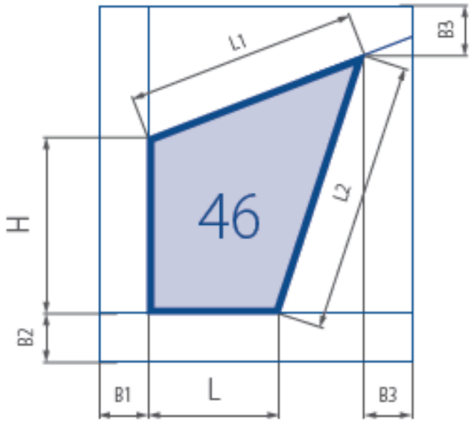


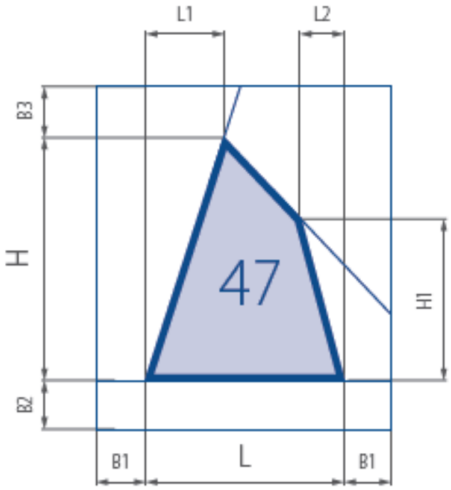


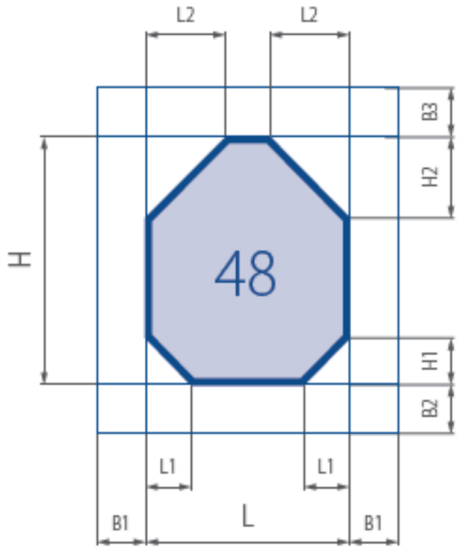


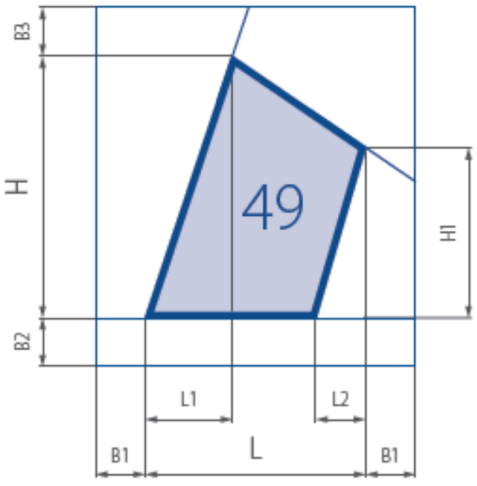


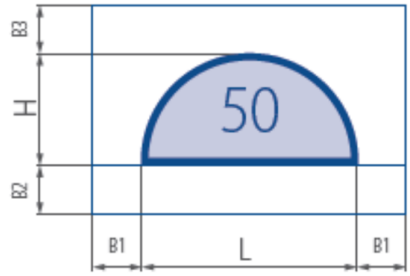


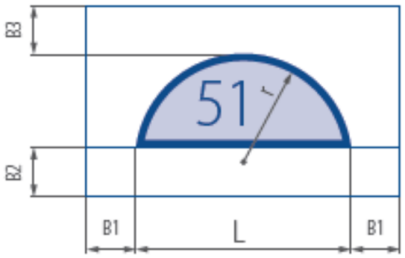


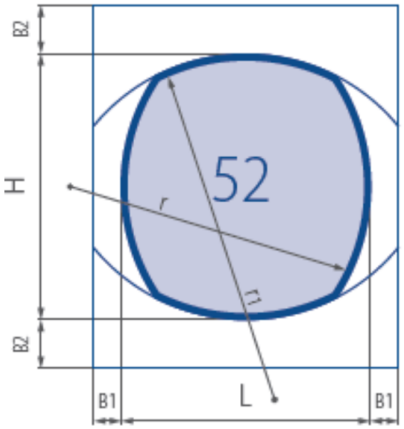


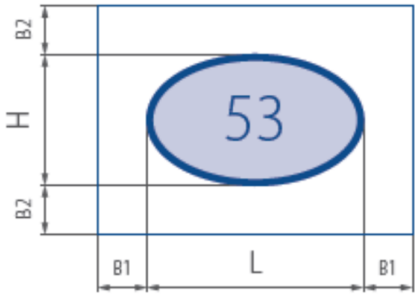


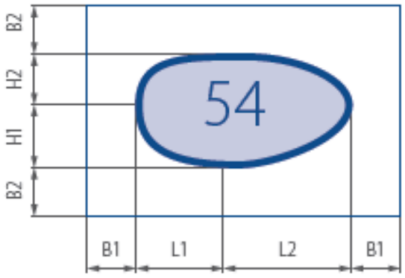


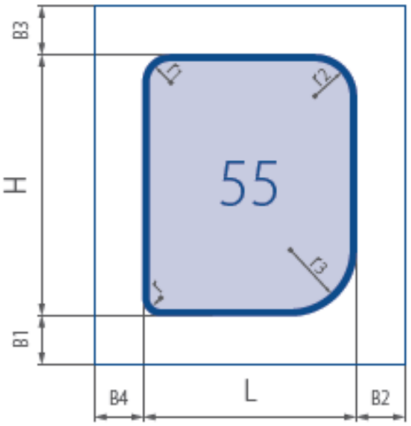


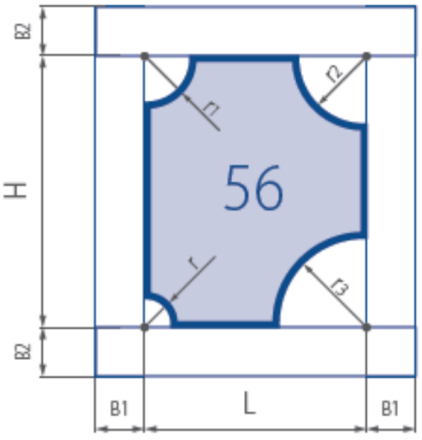


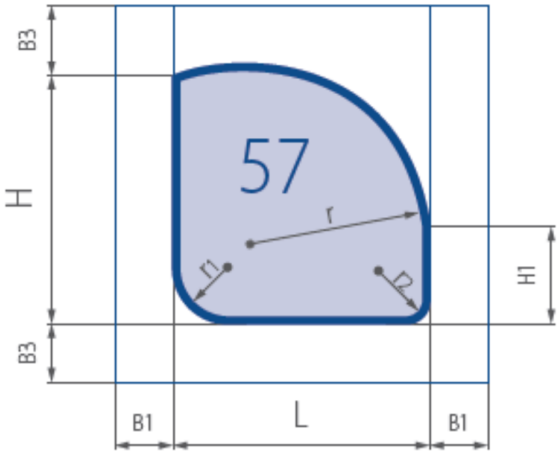


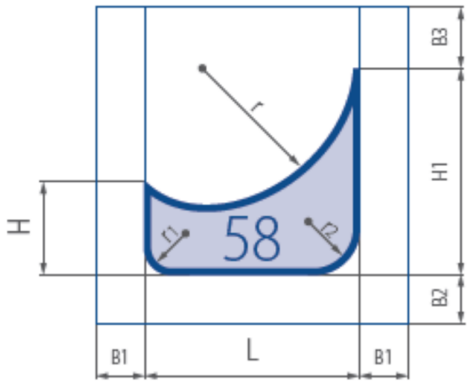


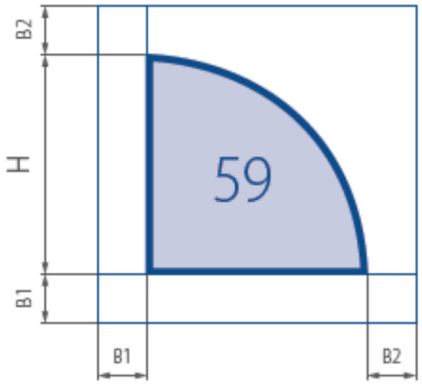


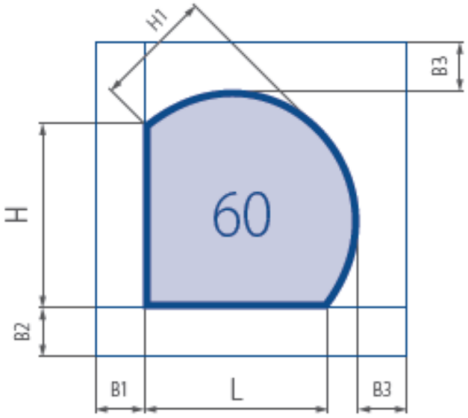


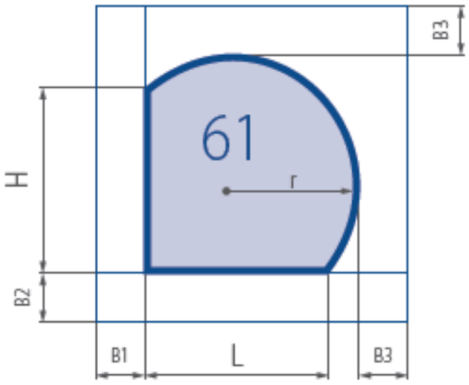


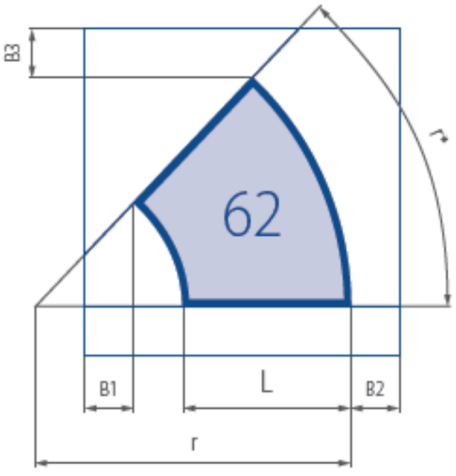












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