

leading glass. **sedak**

quality handbook

Handbook of production tolerances and
the visual assessment of glass products

3rd edition 2020/5

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1 foreword

This handbook serves as a basis for the assessment of products manufactured and sold by sedak GmbH & Co. KG. It supplements agreed tolerances subject to order specifications and provides a basis if such agreed tolerances do not exist. This tolerance handbook is based on the here mentioned standards, regulations and data sheets as well as the latest state of technology. Unless otherwise agreed, the state of the underlying document at the time of the offer is valid. Should some parts of the handbook have been replaced by order-specific arrangements, the residual content remains in force.

This handbook constitutes part of the latest version of our General terms and Conditions. By accepting them you also accept our handbook.

If values or dimensions are not specified here or should indicated objects for comparison be exceeded, they are treated as not defined and are to be agreed when an order is placed.

The stated values refer to float glass according to DIN EN 572 for low-iron glass. For different glass types, the values must be arranged.

Should values or test methods not be defined by this handbook, the versions of the mentioned standards, regulations, data sheets and references are valid. If a certain feature is still not defined or characterized, the feature is deemed as not defined and has to be arranged before an order is placed.

sedak GmbH & Co. KG is certified according to ISO 9001:2015. Our certificate can be downloaded on our website.

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2 basic glass

basic glass: EN 572

2.1 Glass thickness

Glass thickness	Tolerance
≤ 6mm	± 0.2mm
≤ 12mm	± 0.3mm
15mm	± 0.5mm
19mm	± 1mm

3 processed glass, single pane

heat strengthened glass: DIN EN 1863, ABZ Z-70.4-215

fully tempered glass: DIN EN 12150

heat-soaked fully

tempered glass: DIN EN 14179

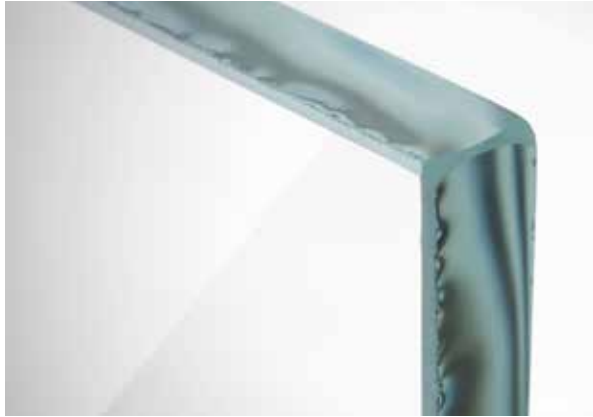
The stated values are valid for panes with an aspect ratio of $\leq 1:15$. Should the aspect ratio be larger, specific values must be arranged. The minimum dimensions are 300 mm x 400 mm. Those dimensions may differ for single production steps. For the maximum dimensions, please refer to the brochure "the fascination of glass".

When using thermally treated glass, there is a risk of nickel sulphide inclusions. This can cause, especially when using fully tempered glass, spontaneous glass breakages also after the installation. In order to reduce this risk, a heat soak test according to EN 14179 is recommended. This test reduces the risk of breakages considerably but does not completely exclude it.

The values of the building physics (e.g. g-value, solar transmission, etc.) are also available on request for laminates and insulating glass provided that the physical values of all components required are available for a calculation according to EN 410 or EN 673. The result will only be valid for elements delivered by sedak GmbH & Co. KG, not for e.g. frame systems by other suppliers. If there are specific data for the elements, data that will influence the values (type and thickness of glass, type and thickness of sheets, for insulating glass: type of coating and gas), the results will be according to those specifications and cannot be influenced considerably by sedak GmbH & Co. KG. Should the requirements of the structure and physical values cannot be brought into accordance, the client is obliged to find a solution. An automatic verification of the required values cannot be presumed.

physical characteristics

3.1 Definition edge types



Edge KGS

arrised edge
cut edge with broken edges;
flakes possible
No dimensional tolerance according to 3.2



Edge KGN

ground edge
ground to the required dimensions;
matt appearance.



Edge KPO

polished edge
shining appearance

Using KGN and KPO, flakes with a length of max. 15 per cent of the glass thickness are occasionally possible. These flakes have to be refinished and must not be sharp. Traces caused by polishing tools can become visible through light reflections.



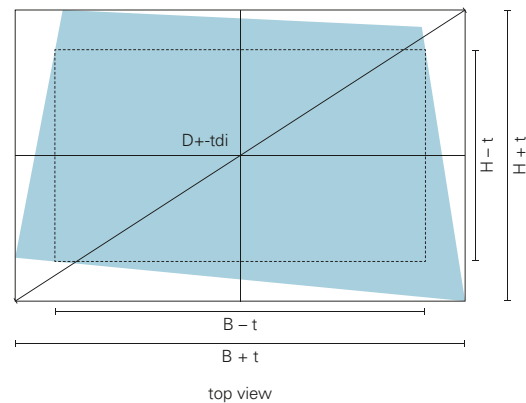
Without any further definition, the edge is executed with a 1.5 x 1.5 mm 45° arris on both sides. The dimensional tolerance for the arris width is ± 0.5 mm.

3.2 Dimensions

Edge length B or H	Tolerance length (t)	Tolerance diag. (tdi)
≤ 1000 mm	± 2 mm	± 3 mm
≤ 2000 mm	± 2 mm	± 3 mm
≤ 3000 mm	± 3 mm	± 5 mm
≤ 6000 mm	± 4 mm	± 6 mm
≤ 9000 mm	± 4 mm	± 7 mm
≤ 12000 mm	± 5 mm	± 8 mm
≤ 16000 mm	± 6 mm	± 9 mm
≤ 20000 mm	± 8 mm	± 11 mm

When non-rectangular-shaped panes are manufactured, a tolerance of ± 1° for each angle is permissible.

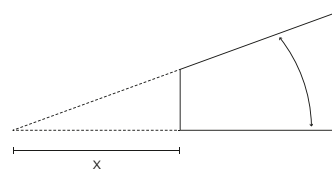
When non-rectangular-shaped panes are processed into a laminate, deviations (e.g. edge offset) caused by the angle tolerance are permissible. This is also the case when the respective max. value stated in the table of 4.2 is exceeded.



3.3 Drill-holes and cut-outs

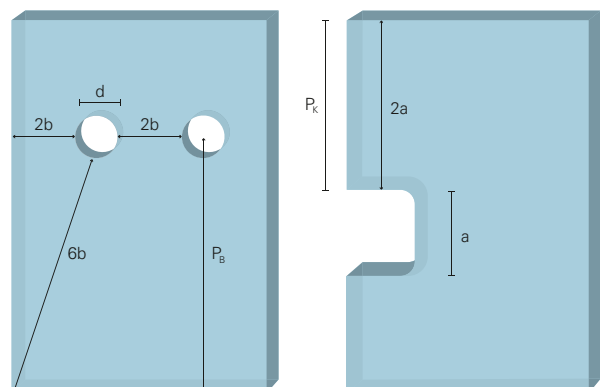
Characteristics	Tolerance length
Position drill-hole (view of the center, deviation of target position) – P _B	± 3 mm
Diameter of the drill-hole – d	12 ≤ Ø ≤ 20 ± 1 mm 20 < Ø ≤ 100 ± 2 mm
Position edge cut-out – P _k	± 2 mm
Size of cut-out – a	± 2 mm

When using acute angles (< 20°), it is necessary to make a cut-back to ensure the stability during the tempering and the further processing. The cut-back (x) is approx. 30mm at an angle of 20°. Smaller angles have to be clarified depending on the order.



The minimal distances of the drill-hole or the cut-out not positioned on the edge are to be arranged when placing an order. A sufficient benchmark for the distance between the edges of the drill-hole and the glass pane, and for drill-holes among each other is the double glass thickness (b). The distance to a corner must be at least six times of the glass thickness. Each irregularly shaped cut-out (not circular, oval or rectangular with rounded edges) must be arranged specifically.

Drill-holes and cut-outs with a radius < 13mm cannot be executed with polished edges. The minimal radius for drill-holes is 6mm. Small radii can perhaps only be achieved by hand. The drill-hole diameter should not fall below the glass thickness.



physical characteristics

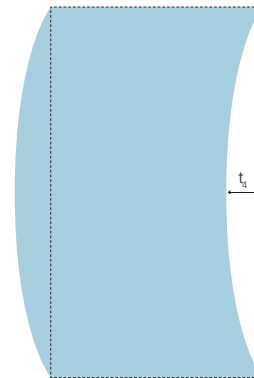
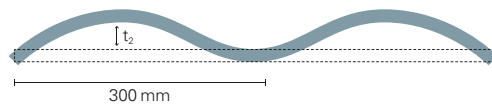
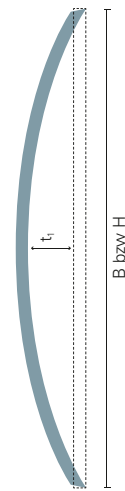
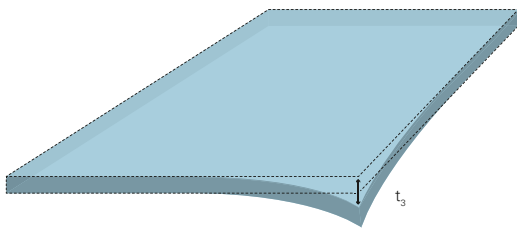
3.4 Tolerances for thermally treated glass (heat-strengthened, fully tempered, heat-soaked fully tempered and others)

Considered are the products manufactured with sedak TVG and sedak ESG. According to DIN EN 1863 for TVG (heat-strengthened glass), according to DIN EN 12150 for ESG (fully tempered glass) and according to DIN EN 14179 for ESG-H (heat-soaked fully tempered glass), those three glass types require a permanent and visible marking (stamp). If not defined differently, the stamp marks the right corner of the bottom edge with a distance of 20mm from the respective edges.

Characteristics		Tolerance length
General warp or deflection – t ₁		3 mm/m
Local warp or roller waves per 300 mm* – t ₂	ESG/ESG-H	0.5 mm
	TVG	0.3 mm
Edge deviation (per glass thickness) – t ₃	6–12 mm	0.3 mm
	15–19 mm	0.3 mm
Edge straightness deviation** according to aspect ratio – t ₄	< 1:5	0.2 mm/m
	< 1:10	0.3 mm/m

* measured at least 25 mm from the edge

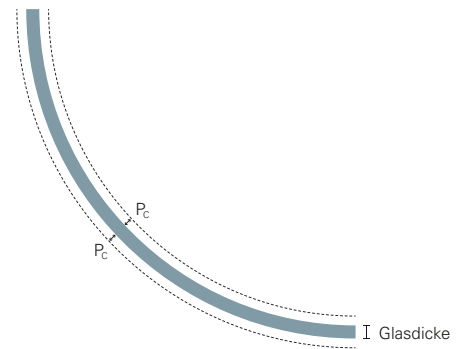
** For printed glass, separate values must be arranged.



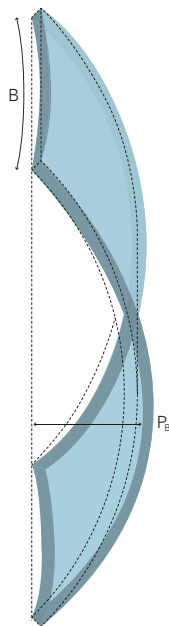
top view

3.5 Tolerances of bent glass (in addition to 3.4)

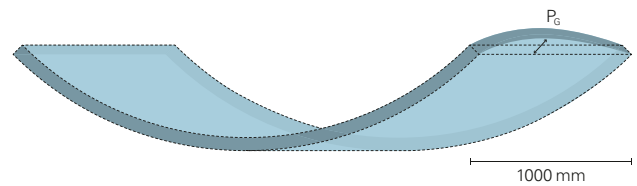
Characteristics	Tolerance length
Deviation from the target shape, contour accuracy (main area) – P_c	± 4 mm
General warp or deflection – P_B	4 mm/m
Straightness of the edge per 1m (no bent edges) – P_G	± 3 mm/m
Torsion per 1m (no bent edges) – P_V	± 3 mm/m



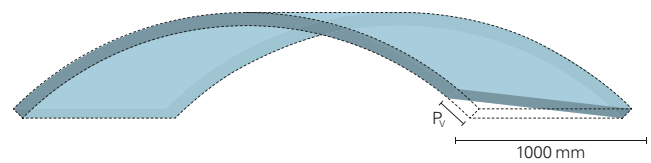
Representation of the target shape



Representation of warp



Representation of the straightness of the edge



Representation of torsion

4 laminated glass

Laminated glass: DIN EN 12543, DIN EN 14449
GlasCobond®: ABZ Z-70.3-153, Z-70.3-175

This chapter refers to the products sedak VSG, sedak secusun®, sedak secusound®, sedak secuprotect®, sedak secucolor®, sedak secudecor®, sedak clear-edge, GlasCobond®, GLY-MarineCobond® and all further laminates being manufactured with

usual lamination sheets (SentryGlas®, PVB, EVA, etc.). This chapter does not apply to units laminated with e.g. casting resin or being UV-bonded.

4.1 Dimensions

(total dimensions of the laminated element)

Edge length	Tolerance length (tL)	Tolerance diag. (td)
≤ 1000mm	± 2.5mm	± 3mm
≤ 2000mm	± 3mm	± 5mm
≤ 3000mm	± 4mm	± 7mm
≤ 6000mm	± 6mm	± 8mm
≤ 9000mm	± 6mm	± 9mm
≤ 12000mm	± 8mm	± 11mm
≤ 16000mm	± 9mm	± 13mm
≤ 20000mm	± 10mm	± 15mm

4.3 Thickness tolerance

The maximum permissible thickness of a laminated glass unit is the result of the tolerance for single glass panes (see chapter 1.1) plus 0.1 mm per millimeter of the lamination interlayer.

4.4 Bent glass

For bent laminates, the same specifications for single glass panes of bent glass with the below mentioned additions are valid. This chapter only refers to cold-bent glass. For laminates out of warm-bent glass, separate agreements must be arranged.

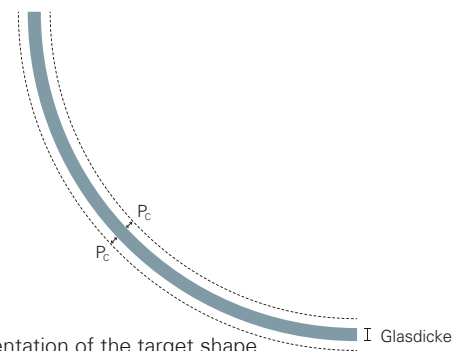
4.2 Edge offset

Characteristics	Tolerance offset (v)
	$L \leq 6m$ 2mm
Maximum edge offset from glass pane to glass pane (adjacent glass panes) in the laminate	$L \leq 12m$ 2.5mm
	$L \leq 16m$ 3mm
Maximum edge offset reference edge from glass pane to glass pane (adjacent glass panes), max. 1 edge per laminate	1mm

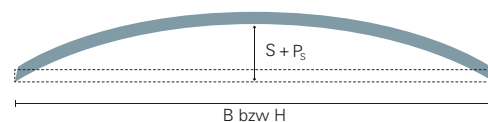
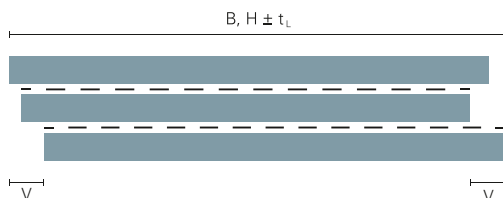
If no reference edge is defined, the offset of the single glass panes will be located as best as possible. When using bent glass, the permissible tolerance from 4.1 and 4.2 rises by 50 %.

Characteristics	Tolerance radius
Deviation from the target shape, contour accuracy – Pc	± 4mm
Permissible deviation circle segment height (s)* – Ps	± 5%

* If necessary, the circle segment height must be measured in the related fittings etc. if measuring it at the freestanding pane does not deliver adequate results.



Representation of the target shape



Representation of the circle segment height

5 insulating glass

Insulating glass: DIN EN 1279, Hadamar Guideline (BF-Bulletin 006-2009)

This chapter refers to the products sedak isotherm®, sedak isosun®, sedak isosound®, sedak isosecure®, sedak isocolor®, sedak isodecor®, sedak isopure® and those insulating glass products that are manufactured with a gas-proof spacer.

The minimal size of insulating glass is 680 mm x 400 mm.

5.1 Thickness tolerance of insulating glass

The permissible total thickness is the result of the single tolerances (see chapters 1.1 and 3.3) plus ± 0.1 mm per 1 mm thickness of the edge seal.

5.4 Spacer

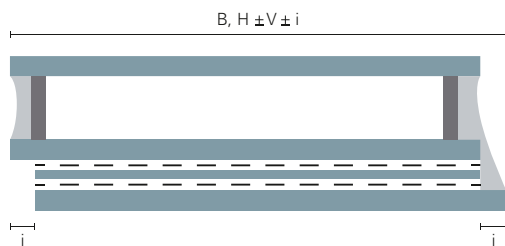
If not specified distinctively, the spacer is executed as a warm edge out of a black foam matrix with spacer labeling. The joint of the profiles is usually executed and bonded in the corners. When required, gas can be filled by puncturing the spacer with a cannula. Finally, the hole is closed before the silicone edge seal is applied.

5.2 Offset of the edge seal

The permissible offset of a laminate is defined in chapter 3.2. In addition, an offset of the components of insulating glass can arise.

Characteristics		Tolerance offset
	$L \leq 6$ m	5 mm
	$L \leq 12$ m	7 mm
Maximum offset (i)	$L \leq 16$ m	9 mm

The permissible offset of stepped insulating glass must be arranged separately.

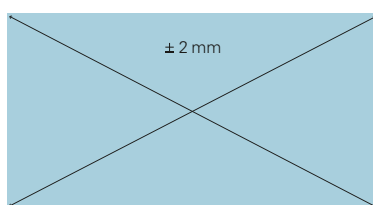


5.5 Glass spacer

Glass spacers are applied by hand. This can lead to air inclusions. A bubble with a diameter of up to 3mm per linear meters or a linear air inclusion with a maximum width of 0.5 to 1mm over a length of up to 15mm is within the tolerance. In the area of the corners applies the following: 5 bubbles smaller than 1mm plus two bubbles up to 3mm. The insulating glass is tested from a distance of 1m perpendicular to the glass surface.

5.3 Flatness of the glass panes

After the insulating glass unit has been manufactured, the flatness of the air or gas filled pane (deflection at the point of intersection of its diagonals) must, in addition to the global warps, not deviate by more than ± 2 mm (length of the pane < 6 m) from the edge thickness.



top view

5.6 Butyl sealing

The primary sealant is a butyl sealing tape. It must be executed consistently with a minimum width of 3 mm. In the corners where the butyl joints are, more butyl may be applied.

physical characteristics

5.7 Edge seal

The width of the secondary sealant (silicone edge sealant) is usually 8 mm. If a distinctive width of the silicone edge sealant is required, the client is obliged to specify that.

The client is also responsible for the dimensioning of the insulating glass pane (static load, climatic load, etc.). Provided that no other agreement has been arranged, the edge seal is executed with black 2K silicone (DC 993 or equivalent). The client is obliged to verify the compatibility with adjacent materials that are not part of the order with sedak GmbH & Co. KG.

Variations and deviations regarding the spacer or the edge seal must be arranged before an order is placed.

5.8 Glass coatings

Coatings (e.g. low-e or solar control coatings) are executed according to the regulations of DIN EN 1096. The permissible sizes and types of defects are also defined according to that standard. The permissible defects of the coating are to be seen additionally to the permissible defects of the single glass pane or the laminate.

6 assessment of the visual quality of single glass panes and glass laminates

6.1 Sphere of validity

This chapter refers to for the assessment of the visual quality of the exposed surface of a glass pane after the installment. It is valid for clear glass, coated glass, and glass colored throughout the mass, for both single glass panes (including heat-strengthened glass and fully tempered glass) and laminates. Restrictions are valid for glass with inserts, patterned or cast glass, and attack-resistant and fire protective glazings. When using those products, the materials required must be considered.

The quality is assessed according to the future use and the installation situation. If the client does not specify any future use, the glass is considered to be used as a vertical façade glass without any special approval requirements and with covered edges. The view and assessment direction is always the direction of the exterior view.

6.2 Inspection

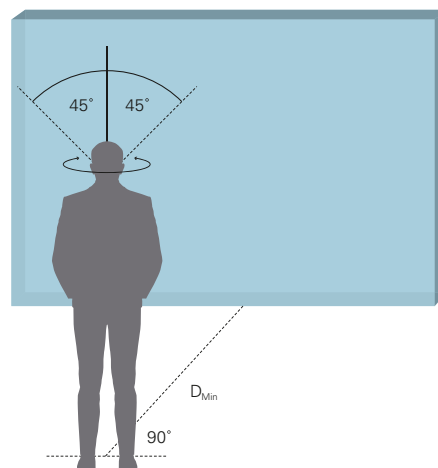
Generally when inspecting, the looking through the glazing, i.e. looking at the background, not focusing the glass surface, is decisive. The defects must not be marked during the inspection.

The glazing is inspected with a distance of 1 meter vertical from the glass surface. The permissible angle of view corresponds to the usual room use. However, the maximum are 45° to the surface. The inspection is carried out by diffuse daylight (e.g. overcast sky) without direct sunshine or artificial lighting. For interior glazings, the normal, diffuse lighting of the interior is decisive. Exterior glazings must be viewed from the normal (freely accessible) distance D_{Min} to the installed glazing (however, always at least 1 m). Only defects that are not marked and recognizable from said distance are not assessed.

Inspection conditions and distances required by the product standards for the glazings are not valid for this regulation.

Only defects and effects that are recognizable by diffuse light without reflections are considered.

The inspection conditions by diffuse light in the production of sedak GmbH & Co. KG are decisive.

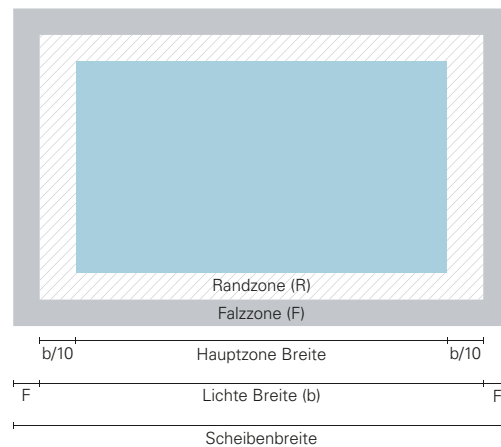


The inspection of the glass pane is carried out in several inspection zones. The pane is thereby considered to be used as a regular façade glass with all 4 edges installed. Different inspection zones must be arranged before an order is placed.

visual characteristics

Rebate Zone (F):	width: at least 18mm circumferential width rebate zone insulating glass: width spacer incl. insulating glass edge seal or the area covered by a spacer
Edge zone:	10 per cent of the respective exposed dimensions in width and height
Main zone:	remaining exposed area

The glass' inherent color influences the entire appearance of the glass. Especially when using coatings or laminates of several layers, the effects can be recognized increasingly. When not using a low-iron glass, after a relatively short time, the glass' color recognizably turns green. Furthermore, there are always slight variations of the raw glass material even among the same glass type by the same supplier. For an order, sedak GmbH & Co. KG uses the best glass types and suppliers available at that moment if not specified distinctively. It must be arranged when placing an order should a specific product be used.



Drawing: inspection zones on a glass pane (not to scale)

6.2.1 Assessment of the visual quality

Table: Permissibilities for the visual quality of glass

Type of defect	Main zone (H)	Edge zone (R)	Rebate zone (F)
Inclusions, bubbles, spots, stains, ... $\leq 0.5 \text{ mm } \varnothing$ ⁽³⁾	no restriction (with ODF ⁽⁵⁾ max. 3 mm)	no restriction (with ODF ⁽⁵⁾ max. 3 mm)	no restriction
Inclusions, bubbles, spots, stains, ... $> 0.5 - 1 \text{ mm } \varnothing$ ⁽³⁾	no restriction (with ODF ⁽⁵⁾ max. 3 mm) no high density ⁽²⁾	no restriction (with ODF ⁽⁵⁾ max. 3 mm) no high density ⁽²⁾	no restriction
Inclusions, bubbles, spots, stains, ... $> 1 \text{ mm } \varnothing$ ^{(3), (4)}	average max. 2 defects $\hat{a} \leq 2 \text{ mm } \varnothing$ pro qm no high density ⁽²⁾	average max. 3 defects $\hat{a} \leq 3 \text{ mm } \varnothing$ pro qm no high density ⁽²⁾	no restriction
Scratches ⁽³⁾	individual length max. 15 mm, max. 3 per 2 qm	individual length max. 30 mm, max. 3 per 2 qm	no restriction
Hairline scratches ⁽¹⁾	not permitted in high density ⁽²⁾	not permitted in high density ⁽²⁾ punctual: max. 1 defect $\leq 3 \text{ mm } \varnothing$ per 1m edge length flat: max. 1 defect $\leq 3 \text{ qcm}$ per 5 qm (color whitish, grey, translucent, transparent, ...)	no restriction
Residues in the cavity (insulating glass)	not permitted	(color whitish, grey, translucent, transparent, ...)	not applicable

⁽¹⁾ hairline scratches = not palpable damage of the surface

⁽²⁾ high density: more than 4 defects in a circle $\varnothing 20 \text{ cm}$

⁽³⁾ laminates and laminated safety glass: when using structures with more than 2 glass layers, the number of permissibilities in the zones R and H increases by 50 % per further layer (rounded off to full defects)

⁽⁴⁾ maximum size of defects with ODF ⁽⁵⁾ 5 mm with core defect $\leq 2 \text{ mm}$, ODF ⁽⁵⁾ 6 mm with core defect $\leq 3 \text{ mm}$

⁽⁵⁾ ODF = optically distorted fields

6.2.2 Assessment of tempered glass

The surface of tempered glass is further influenced. The assessment according to the list in chapter 6.2.1 remains valid. Additionally, the criteria mentioned below are considered. This is valid for all types of thermally treated glass, especially for heat-strengthened glass (TVG) as well as fully tempered glass (ESG) and heat-soaked fully tempered glass (ESG-H).

Tempered glass is subject to several physical characteristics that do not represent any reason for complaints. The most important characteristics are listed below:

Roller waves (local warps): Due to the transport of the glass on the rolls of the furnace, the glass surface may become wavy (roller waves). Besides the warps, this can also lead to marginal visual damages.

Anisotropies: They are caused by the internal stress distribution that occurs during the tempering process. Under polarized light, the birefringence (tiger pattern) becomes visual. The amount of polarized light varies depending on the time of day and the season. The effect increases with a higher glass thickness. However, the effect cannot be avoided basically.

Wettability of the surface: Due to marks caused by rolls, labels, suction cups, etc., the wettability of the surface can vary. This only becomes visual when the surface is exposed to humidity. The appearance of the dry glass pane is decisive.

During the production of tempered glass, marks, so called "heat marks" or "orange peel," on the glass surface might be caused. These defects are assessed according to the table in chapter 6.2.1.

6.2.3 Assessment of glass edges

sedak GmbH & Co. KG offers several high quality edges. When exposed or visual edges are required, a consultancy regarding the accurate edge quality should take place before an order is placed. If the client does not define any edge quality, the edges are polished. Tempered glass requires at least a ground edge (KGN) to avoid any damages of the edge during the tempering process.

Depending on the edge quality and the production process, tool traces might be more or less visual on the edge. These traces may be periodically repetitive. They do not represent any reason for complaints. For a reliable clarification, a sample is recommended.

Edges must be free of open flakes or breaks. From the edge type KG on, the edges may not be sharp.

7 assessment of the visual quality of printed glass

7.1 Sphere of validity

This chapter refers to the assessment of the visual quality of full-surface and partial-surface enameled and screen-printed (e.g. sedak secudecor®, sedak secucolor®, sedak isodecor®, sedak isocolor®) glass units which are manufactured as fully tempered or heat-strengthened glass by the applying and the subsequent burning in of ceramic inks. It is also valid for full-surface and partial-surface varnished plane glass units (with shining or matt surface). The visual quality of the colorcoated surface is assessed according to the tables of this chapter when a viewing from one side of the non-coated or non-varnished surface is carried out.

This regulation cannot be consulted for the visual assessment of glass defects of the respectively used glass type.

For the used glass types and products, separate product-specific, visual assessment regulations are valid. The assessment is carried out according to the following described inspection principles by means of the permissibilities stated in the tables. The exposed glass surface remaining after the installment is assessed by viewing the non-coated or non-varnished glass surface (through the glass). This regulation is not valid for custom-made glass like attack-resistant glazings, fire protective glazings and sandblasted surfaces.

The quality is assessed according to the future use and the installation situation. If the client does not specify any future use, the glass is considered to be used as a vertical façade glass without any special approval requirements with installed edges. The view and assessment direction is always the direction of the non-printed glass side.

7.2 Installation areas

Enameled glass can be manufactured both as monolithic panes and laminates. However, it must be borne in mind that the static values of a printed glass must be recognized lower than those of non-printed glass.

If printed glass is used in laminates, it is recommendable to clarify the future use in order to determine whether the print should be within the laminate or on the exterior side. It must be taken into account that environmental conditions (particularly the exposure to SO₂, NO₂, flue dust and further aggressive substances) can affect an exterior print and its visual appearance noticeably.

7.3 Inspection of printed glass

The inspection is carried out with the view of the glazing's non-coated or non-varnished surface. Defects must not be marked. The measuring of the homogeneity of color is carried out on the printed side of the glass.

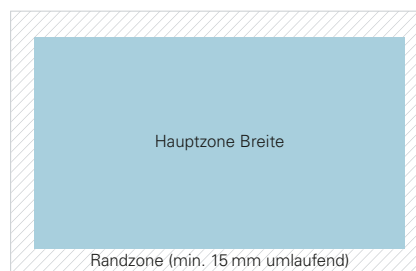
The visual quality of colorcoated glass is assessed from a distance of at least 3m and vertically to the surface (deviation max. 30°).

The viewing level for bent glass is the tangent to the viewing point. The assessment is carried out by diffuse daylight (e.g. overcast sky), without direct sunshine or artificial lighting, without a lit background or a covering of the printed layer.

Defects that are not recognizable from this distance are not assessed.

The glazing in rooms (interior glazings) is to be inspected by normal (diffuse) lighting being planned for the room use.

Further visual criteria like e.g. degree of shine, degree of reflection, tempering defects, anisotropies, ... are to be assessed in addition according to chapter 6. The effects can be added together.



The edge zone is the result of the total length of the printed glass. It is 0.5 per cent of the glass length, however, at least 15mm circumferential.

The accuracy of a print when printing no pattern is the result of the distance between the print edge and the reference edge. The positional tolerance (l_d) for digital printing is also the result of the distance between the reference edge and the edge of the pattern. The elements among each other are defined with the table below. There is both a tolerance for the size of the printed elements and the distance between the elements. These tolerances can be added. The distance between two elements must be at least 0.5mm to avoid any blurring of the elements.

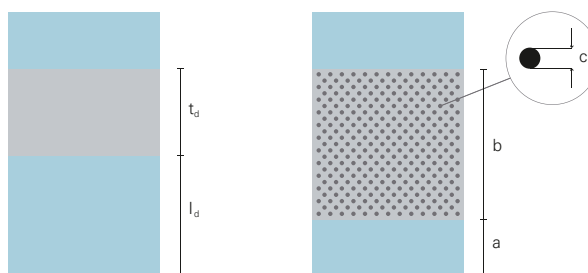


Table: Classification of defects for printed glass

Type of defect	Main zone	Edge zone	
Defective areas in the printing per defined area ⁽¹⁾	Ø max. 5 defects per 15 qm of the the pane (individual area max. 10 qmm) Total area max. 15 qmm per 15 qm of the pane	Ø max. 3 defects (individual size ≤ 25 qmm) per 1m of edge zone	
Scratches	permitted up to 10 mm long, max. 3 defects and max. total length 30 mm per 10 qm	permitted up to 70 mm long, max. 3 defects und max. total length 70 mm per 1m of edge zone	
Waviness (variation of the color within the same color shade)	section width of a color variation max. 15 mm	see Main zone	
Clouding/misty areas/shadowing	dependent on the coating technology (see below)	permitted/no restriction	
Water stains	not permitted	permitted/no restriction	
Color over-run at edges	not relevant	permitted at installed edges	
Dimensional tolerance of partially printed surfaces (in dependence of the enameling) t _d	width of enameling	tolerance	
	≤ 100 mm	± 1.5 mm	
	≤ 500 mm	± 2 mm	
	≤ 1000 mm	± 2.5 mm	
	≤ 2000 mm	± 3 mm	
	≤ 3000 mm	± 4 mm	
Positional tolerance for enamel (from the reference edge) ⁽²⁾ for partial non-pattern enameling l _d	print size ≤ 2000 mm: ± 2 mm print size > 2000 mm: ± 4 mm	see Main zone	
Accuracy resolution ⁽³⁾ for printed patterns and ornaments (c)	element size	tolerance	
	≤ 10 mm	± 0.5 mm	
	≤ 50 mm	± 1 mm	
	≤ 100 mm	± 1.5 mm	
for printed patterns and ornaments (c)	≤ 200 mm	± 2 mm	see Main zone
Deviating superposition with prints of several paint-layers	25 % of the diameter or the width of the print, min. 0.4 mm	see Main zone	

⁽¹⁾ Defects of a diameter ≤ 0.5 mm are generally permitted.

The repair of defects using an appropriate color or varnish is permitted provided that the defects are not recognizable from a distance of 3 m.

⁽²⁾ The positional tolerance is also valid for individual elements (points, circles, lines, squares, ...) within a larger print pattern.

⁽³⁾ Refers to the dimensions of all individual elements of a print. Also defines the accuracy of the distances between the elements of print patterns (e.g. dot grids). Larger elements or distances must be arranged.

7.3.1 Assessment of color transitions and color deviations

- When printing patterns with narrow grids (partial areas or distances of partial areas < 5 mm) a so called “Moiré Pattern” may occur. This is no deviation and due to the ornament’s nature.
- The human eye reacts very critically when it is confronted with figures, shapes and distances < 3 mm, or color transitions. Even the slightest tolerances are already perceived as a gross deviation. If this effect is to be avoided, the details must be settled before the beginning of the fabrication.
- Furthermore, the subjective perception of a color differs depending on the color shade. Color differences of blue tones e.g. are observed more clearly than green tones. This factor must be considered when assessing such color differences. Color deviations can also occur within the same production unit due to diverse factors. That might be caused by variations of the basic glass’ inherent color, of inorganic basic substances of the color, of the exact burning temperature during the burning process, of the color mixing (particularly with order-specific mixed colors), and mechanic influences during the application of the enamel color. The pane’s size and thickness also have an influence to the final product. If color deviations occur, they are verified by comparing the manufactured pane to a determined reference sample. As an indicator for a comparative measurement for standard colors, a reflection measurement at five measuring points with $\Delta E < 4$ can be considered permissible (exception: blue tones and acid-etch tones). This corresponds to the classification of a color difference that is visible to the naked eye by the same light conditions (decisive are the conditions of the production hall). It must also be borne in mind that differences between a small sample and a large finished pane may occur and that not all surfaces and colors are suitable for a measurement of the ΔE value. This is especially the case with metallic colors and coatings.
- For digital prints and printed patterns, a color difference can only be assessed with the naked eye for technical reasons. Such a technical measurement is carried out with a Konica Minolta colorimeter.
- When using acid-etch tones (regardless of whether it is a color print or the surface is treated with caustic agents), color variations may occur, particularly under backlight conditions. Such color variations may appear as a formation of stains. These are caused by variations of the glass mass and in the surface, and cannot always be excluded.
- The light transmission and therefore the opaqueness decisively depend on the used printing technology and the chosen color. Light colors and thin paint-layers (e.g. digital print of one layer) naturally have higher light transmission values and provide therefore a lower opaqueness. If that value is important for the future use, it is essential to settle the details before an order is placed. The higher the opaqueness the more changes the appearance of the print on the non-printed glass side. A 100 per cent opaqueness can only be offered after the technical details have been clarified and a sample has been produced.
- The light conditions during the viewing of the glass vary depending on the daytime and the season. Every layer of the surface absorbs and reflects a part of the light. The light that meets the color or its pigments is absorbed or reflected by this color. Therefore, the color appears differently depending on the light source.
- Only a print on glass can be compared with a print on glass. Comparing it to a print on paper is not possible.

7.4 Production technology of printing glass

7.4.1 Roller application technology

When using the roller application technology, the glass pane is printed by a rubber-covered printing roller. The roller has grooves that allow an even application. After the printing, these grooves are still visible on the color side of the print. The layer is thicker with the roller application technology than with the digital printing technology. The layer thickness can only be changed under certain circumstances. A color over-run is possible especially with non-rectangular shaped panes. At the pane's edges perpendicular to the direction in which the roller is applying, color over-runs can occur. The roller application technology is particularly suitable when the glass surface is largely and monochromatically printed.

7.4.2 Digital printing technology

When using the digital printing technology, a mobile print head moves over the pane. During the printing process, the print head can mix colors or apply previously mixed colors. Shapes and pictures almost of all kinds are possible. The paint-layer is usually not as thick as when using the roller application technology. At the edges of a print, a fine spray mist may occur. The available colors base on a special color system. Therefore, the details about whether the required color can be shown within the system must be arranged. The digital printing technology is especially suitable for glass panes that are to be printed with patterns, pictures, or different colors. For the printing, the client must make an appropriate printing template.

7.4.3 Thermal treatment

Enameled and printed glass can only be produced as fully tempered glass (ESG), heat-soaked fully tempered glass (ESG-H) or heat-strengthened glass (TVG). Only the side of the glass that is averted from the rolls of the tempering furnace can be printed. During the tempering process, the glass may change due to the production (see chapter 3). It must be considered that the static values (e.g. bending tensile strength, mechanic values, etc) of printed enameled glass and non-printed glass cannot be compared.

7.4.4 Laminated glass

When using printed glass to the lamination side, the use and the appearance must be arranged. Particularly with acid-etch tones, the color shape may be "swallowed" as a result of reducing the optical density of the printing.

For further information and details please contact our sales department.

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