Nissink | Business Glass B.V.

Amazing glass creation

LEADING GLASS

A guide to manufacturing tolerances and visual assessment standards for glass products

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1 FOREWORD

This handbook serves as a basis for the assessment of products manufactured and sold by Nissink Business Glass b.v. 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 replacesd 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 indidated cated 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 - (Soda-lime sillicate glass) for normal float and low-iron glass. For different glass types, the values must be arranged.

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

Nissink Business Glass b.v. is aligned according to ISO 9001: 2015.

Our delevery and payment terms can be downloaded at www.nissinkglass.com/algemene-voorwaarden

2 BASIC GLASS

Basic glass: EN 572

2.1 GLASS THICKNESS

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

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 |< 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 installment. In order to reduce the risk, a heat soak test according to EN 14179 is recommended. This 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 Nissink Business Glass b.v., not for e.g. framesystems 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 insulatingglass: type of coating and gas), the results will be according to to those specifications and cannot be influenced considerably by Nissink Business Glass b.v.. 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.

CHEMICAL STRENGTH

By putting glass under certain conditions in a salt bath, it gets a thin surface layer of high pressure tension. This tension gives the glass the mechanic specifications that help improve the strength of the glass to its best.
The chemical toughneness is especially used voor the clot of 3mm thin glass. Voor a chemical treatment it is neccessary for the surface to stay flat. This gives producers the possiblity to use toughened glas in solutions like: copying machines, sun panels, microwaves, meters, lightning, cars, boats and many other.

3.1 DEFINITION EDGE TYPES

Arrised edge

Arrised edge.

Cut edge with broken edges;

Flakes possible.

No dimensional tolerance according to 3.2

Flat edge mat

Ground edge.

Ground to the required dimensions;

Mat appearance.

Flat edge polished

Polished edge.

Shining appearance

Using FEM and FEP, flakes with a length of max. 15 % 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 trough light reflections.

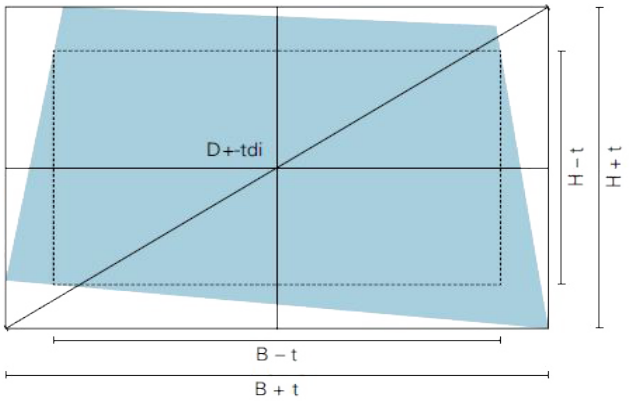
Without any further definition, the edge is executed with a 1.5 x 1.5 mm 45° arris on both sides. The dimensional tolerance for the arris width is ± 0.5 mm.

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	± 3mm	± 5 mm
|< 6000 mm	± 4mm	± 6 mm
|< 9000 mm	± 4mm	± 7 mm
|< 12000 mm	± 5 mm	± 8 mm
|< 16000 mm	± 6 mm	± 9 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. egde 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.



top view

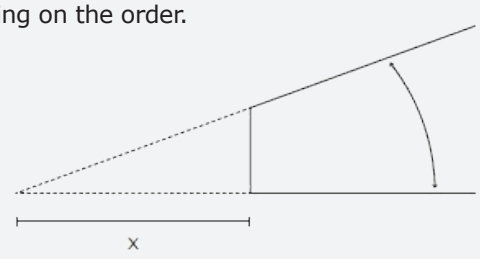
3.3 DRILL – HOLES – RADIUS - AND CUT OUTS

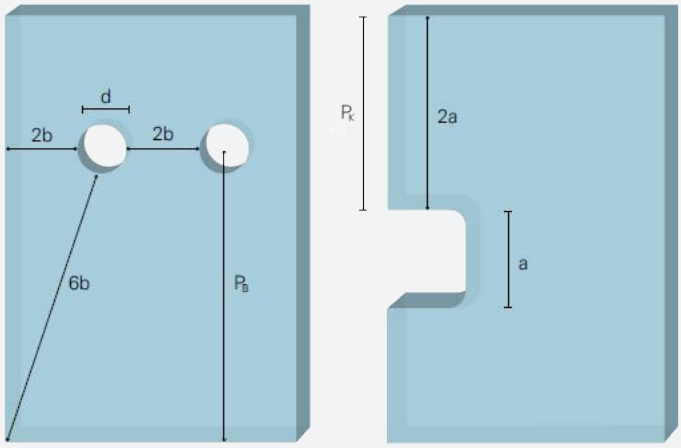
An inner radius finishing has 2 points of attention.

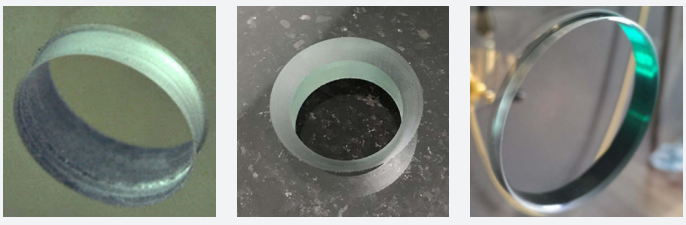
- A mat finish radius must be minimum R=6mm
- A polished radius must be minimum R=15mm

Characteristics		Tolerance legth
Position drill-hole (view of the center, deviation of target position) – PB		± 3 mm
Diameter of the drill-hole - d	12 |< Ø |< 20	± 1 mm
	20 < Ø |< 100	± 2 mm
Position edge cut-out - Pk		± 2 mm
Size of cut-out - a		± 2 mm

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 edge 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 < 13 mm cannot be executed with polished edges. The minimal radius for drill-holes is 6 mm. Small radii can perhaps only be arrissed by hand. The drill-hole diameter should not fall below the glass thickness. 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. 30 mm at an angle of 20°. Smaller angles have to be clarified depending on the order.







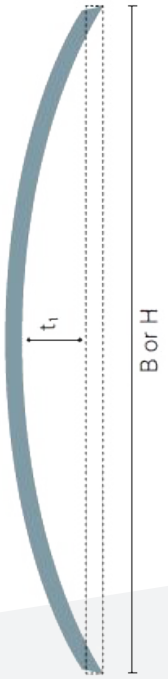
3.4 TOLERANCES FOR THERMALLY TREATED GLASS (HEAT-STRENGTHENED, FULLY TEMPERED, HEAT-SOAKED FULLY TEMPERED AND OTHERS)

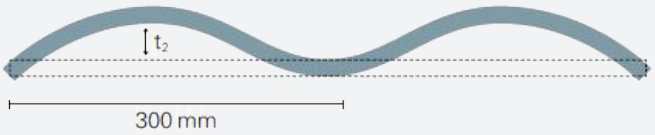
Considered are the products manufactured with Nissink Business Glass b.v. According to DIN EN 1863 for half tempered/heatstrengthened glass, according to DIN EN 12150 for fully tempered glass and according to DIN EN 14179 for heat-soaked fully tempered glass, those three glass types require a permanent and visible marking (stamp) normaly. If not defined differently, the stamp marks the rightcorner of the bottom edge with a distance of 20 mm from the respective edges, or will be not add when this is agreed.

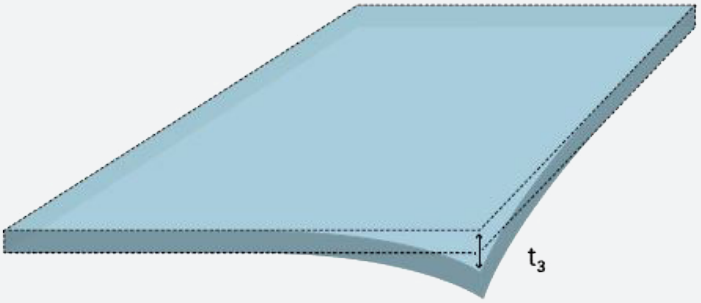
Characteristics		**Tolerance legth**
General warp or deflection - t1		3 mm/m
Local warp or roller waves per 300 mm* - t2	Fully tempered	0.5 mm
	Heatstrength	0.3 mm
Edge deviation (per glass thickness) - t3	6 - 12 mm	0.3 mm
	15 - 19 mm	0.3 mm
Edge straightness deviation** according to aspect ratio - t4	< 1:5	0.2 mm/m
	< 1:10	0.3 mm/m

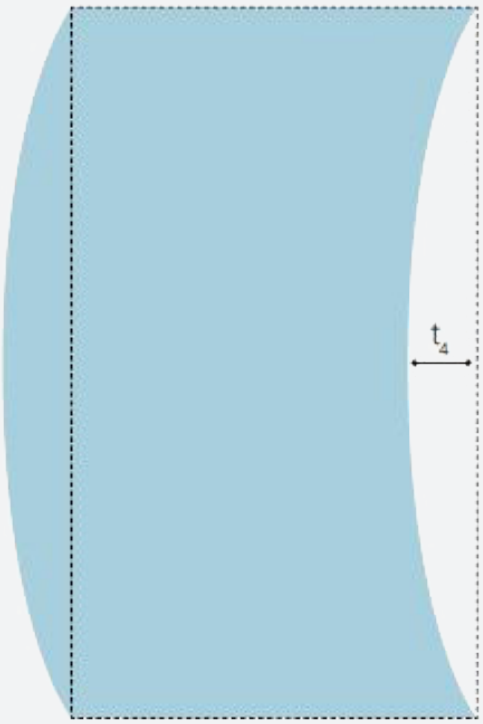
* measured at least 25 mm from the edge

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





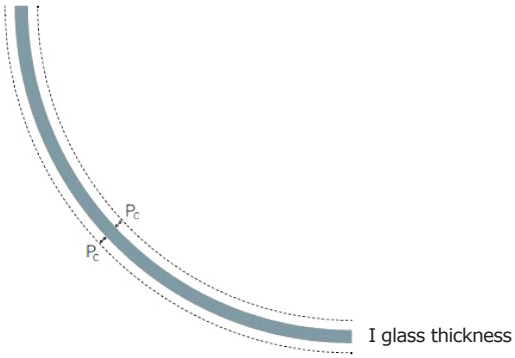




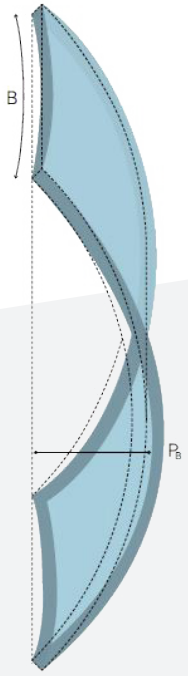
top view

3.5 TOLERANCES OF THERMICAL OR HEATHSTRENGTH TEMPERED BENT GLASS (IN ADDITION TO 3.4)

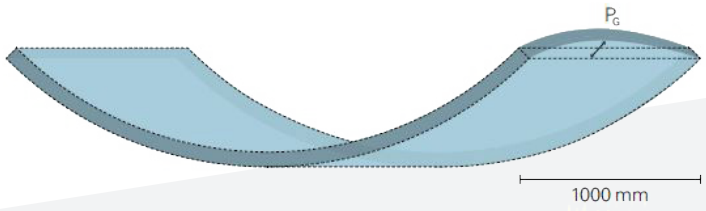
Characteristics	**Tolerance**
Deviation from the target shape, contour accuracy (main area) - Pc	± 4 mm
General warp or deflection - Pb	± 4 mm/m
Straightness of the edge per Im (no bent edges) - Pg	± 3 mm/m
Torsion per Im (no bent edges) - Pv	± 3 mm/m



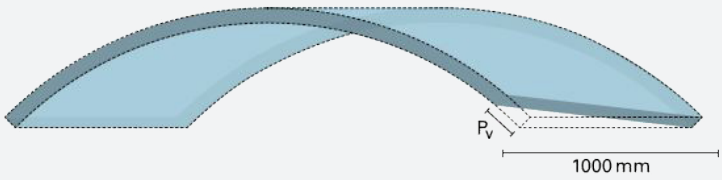
Representation of the target shape



Representation of warp



Representation of the straightness of the edge



Representation of the straightness of the edge

3.6 ANNEALED BENT GLASS CURVED

Characteristics	**Tolerance**
Deviation from the target shape, contour accuracy (main area) - Pc	± 2 mm
General warp or deflection - Pb	± 2 mm/m
Straightness of the edge per Im (no bent edges) - Pg	± 1,5 mm/m
Torsion per Im (no bent edges) - Pv	± 5 mm/m

Laminated glass: DIN EN 12543, DIN EN 14449

This chapter refers to the products of Nissink Business Glass b.v. and all further laminates being manufactured with usual lamination sheets (SentryGlas®) PVB, EVA, TPV) This chapter does not apply to units laminated with e.g. casting resin or being UVbonded.

4.1 DIMENSIONS

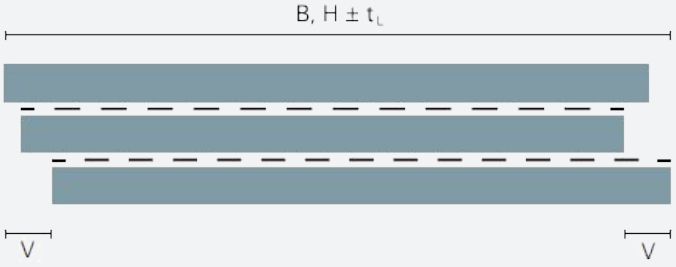
(total dimensions of the laminated element)

Edge length	**Tolerance legth (t_L)**	**Tolerance diag. (t_D)**
< 1000 mm	± 2.5 mm	± 3 mm
< 2000 mm	± 3 mm	±5 mm
< 3000 mm	± 4 mm	± 7 mm
< 6000 mm	± 6 mm	± 8 mm

4.2 EDGE OFFSET

Characteristics	**Tolerance legth**	
Maximum edge offset from glass pane to glass pane (adjacent glass panes) in the laminate	L < 6 m	2 mm
Maximum edge offset reference edge from glass pane to glass pane (adjacent glas panes) max. 1 edge per laminate		1 mm

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 %.



4.3 THICKNESS TOLERANCE

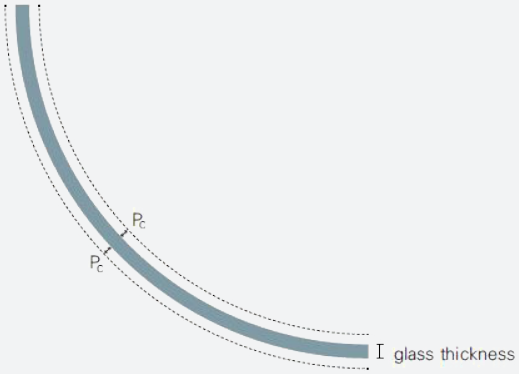
The maximum permissible thickness of a laminated glass unit is the result of the tolerance for single glass panes (see chapter 1.1) plus 0.1 mm per millimeter of the lamination interlayer.

4.4 BENT GLASS

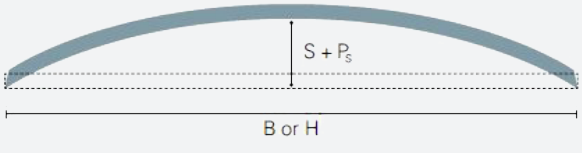
For bent laminates, the same specifications for single glass panes of bent glass with the below mentioned additions are valid. This chapter only refers to cold-bent glass. For laminates out of warm-bent glass, sepa-rate agreements must be arranged.

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

* If necessary, the circle segment heigh 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 Guidline (BF-Bulletin 006-2009)

This chapter refers to the products of Nissink Business Glass b.v. and those insulating glass products that are manufactured with a gas-proof spacer. The minimal size of insulating glass is100 mm x 100 mm.

5.1 THICKNESS TOLERANCE OF INSULATING GLASS

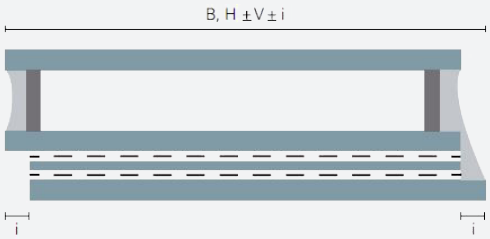
The permissible total thickness is the result of the single tolerances (see chapters 1.1 and 3.3) plus ± 0.1 mm per 1 mm thickness of the edge seal.

5.2 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.

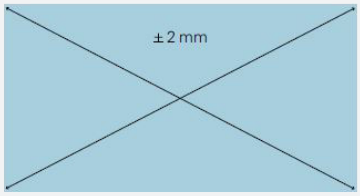
Characteristics	**Tolerance legth**	
	L < 6 m	5 mm
Maximum offset (i)		

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



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 < 6m) from the edge thicknes



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 edge seal is applied.

5.5 BUTYL SEALING

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

5.6 EDGE SEAL

The width of the secondary sealant (silicone or hybride edge sealant) is usually 8 mm. If a distinctive width of the 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. The clientis obliged to verify the compatibility with adjacent materials that are not part of the order with Nissink Business Glass b.v. Variations and deviations regarding the spacer or the edge seal must be arranged before an order is placed.

5.7 GLASS COATINGS

Coating (e.g. low-e or solar control coatings) are executed according to the regulations of DIN EN 1096. The permissible sizes ans 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.

5.8 PREMIUM EDGE

Nissink Business Glass b.v. develep a special edge finisch called “Premium edge”. This is the best optical finish which is posible to make in laminaded glass.

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 heatstrengthened 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 mist be considered.

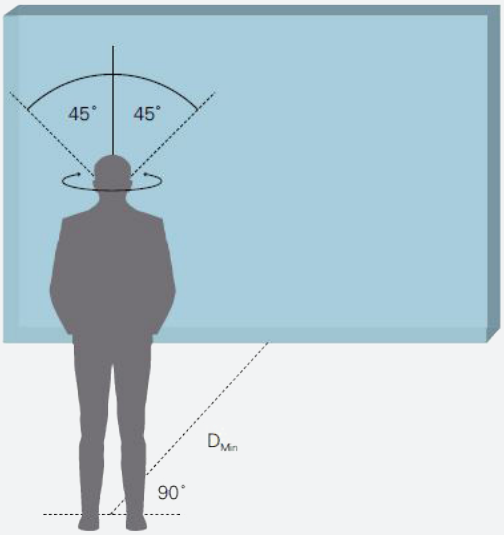
The quality is assessed according to the future use and the installation situation. If the client does not specify any future use, the glass is considered to be used as a vertical façade glass without any special approval requirements and with covered edges. The view and assessment direction is always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

6.2 INSPECTION

Generally when inspecting, the looking trough 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} tot 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 distance required by the product standerds 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 Nissink Business Glass b.v. are decisive.

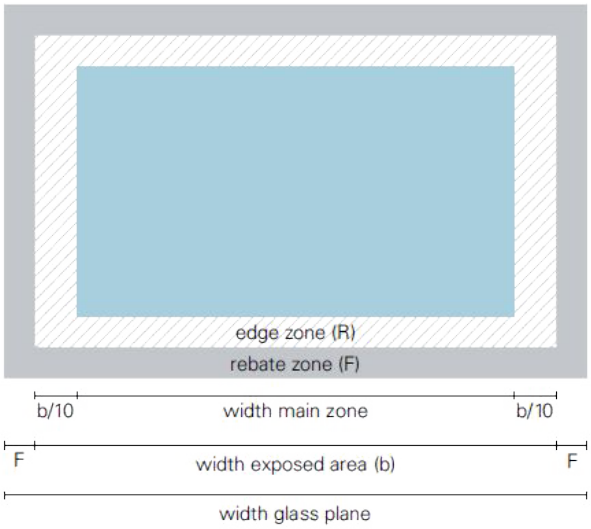


The inspection of the glass pane is carried out in several inspection zones. The pane is thereny considered to be used as a regular façade glass with all 4 edges installed. Different inspection zones must be arranged before an order is placed.

Rebate Zone (F): width: at least 18 mm circumferential width rebate zone insulating glass: width spacer incl. insulating glass edge seal or the area covered by a spacer

Edge zone: 10 % of the respective exposed dimensions in width and height

Main zone: remaining exposed erea



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, Nissink Business glass b.v. 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.

6.2.1 ASSESSMENT OF THE VISUAL QUALITY

Type of defect	**Main zone (H)**	**Edge zone (R)**	**Rebate zone (F)**
Inclusions bubbles, spots, stains, ... < 0,5 mm Ø (3)	no restriction (with ODF(5) max. 3mm)	no restriction (with ODF (5) max. 3 mm)	no restriction
Inclusions, bubbles, spots, stains, ... > 0.5 - 1 mm Ø (3)	no restriction (with ODF(5) max. 3mm) no high density	no restriction (with ODF (5) max. 3mm) no high density	no restriction
Inclusions, bubbles, spots, stains, ... > 1 mm Ø (3) (4)	average max. 2 defects a < 2mm Ø pro qm no high density	average max. 3 defects a < 3mm Ø pro qm no high density	no restriction
Scratches (3)	Inividual length max. 15 mm, max 3 oer 2qm	individual length max. 30 mm, max. 3 per qm	no restriction
Hairline scratches (1)	Not permitted in high density (2)	Not permitted in high density (2)	no restriction
Residues in the cavity (insulating glass)	Not permitted	Punctual: max 1 defect < 3 mm Ø per Im edge length flat: max. 1 defect < 3qcm per 5 qm (color whitish, grey translucent, transp..)	not applicable

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

(2) High densite: more than 4 defects in a circle Ø 20 cm

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

(4) Maximum size of defects with ODF (5) 5mm with core defect < 2 mm, ODF (5) 6 mm with core defect < 3 mm

(5) ODF = optically distorted fields

6.2.2 ASSESMENT OF THERMICAL TEMPERED GLASS

The surface of thermical 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 as well as fully tempered glass and heat-soaked fully tempered glass. 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: Thery 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

Nissink Business Glass b.v. 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 dous not define any edge quality, the edges are polished. Tempered glass requires at least a ground edge 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 arrised edge on, the edges may not be sharp.

6.2.4 “PREMIUM EDGE” OF MONOLITIC GLASS

Nissink Business Glass has developt a special edge called “Premium edge”. This is an additional edge especialy for chemicaly strength glass. When a special test is required according EN 1288 this edge most be ordered seperatly to reach the maximum bending strength.

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 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 fullsurface 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 nonvarnished

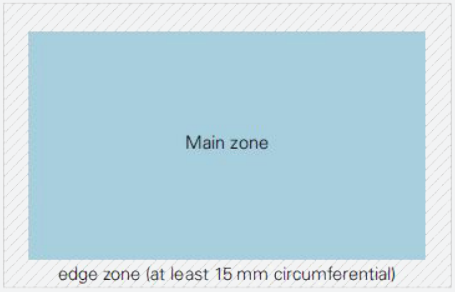
surface is carried out. This regulation cannot be consulted for the visual assessment of glass defects of the respectively used glass type. For the used glass types and products, separate product specific, visual assessment regulations are valid. The assessment is carried out according to the following 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 custummade glass like attack-ressistant glazings, dire 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 SO_2, NO_2, flue dust and furthur 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 vieuw of the glazing's noncoated 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 3 m 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 % of the glass length, however, at least 15 mm 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 (ld) 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. Ther 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 0.5 mm to avoid any blurring of the elements.

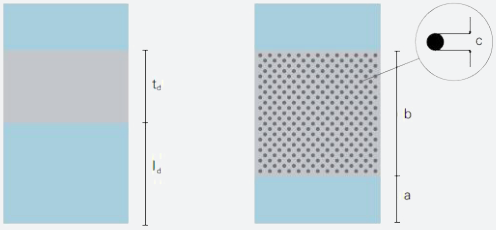


Table: Classification of defects for printed glass

Type of defect	**Main zone (H)**		**Edge zone (R)**
Defective areas in the printing per defined area [1]	Ø max. 5 defects per 15qm of the the pane (individual area max. 10 qmm) Total area max. 15 qmm per 15qm of the pane		Ø max. 3 defects (individual size < 25 qmm) per Im of edge zone
Scratches	permitted up to 10 mm long, max. 3 defects and max. total length 30 mm per 10qm		permitted up to 70 mm long, max. 3 defects und max. total length 70 mm per Im 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 eareas / 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	
	> 3000 mm	± 5 mm	see Main zone
Positional tolerance for enamel (from the reference edge) (2) for partial non-pattern enameling ld	print size < 2000 mm: ± 2mm 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	
	< 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 approriate 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 distance 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 distance <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 measurements at five measuring points with Ø $\Delta E < 4$ 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 born in mind that differences between a small sample and a large finished pane may occur and may 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 detail before an order is placed. The higher rhe opaqueness the more changes the appearance of the print on the non-printed glass side. A 100 % apqueness 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 detail 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.

Shapes and pictures can be freely selected.

7.4.3 THERMAL TREATMENT

Enameled and printed glass can only be produced as fully tempered glass, heat-soaked fully tempered glass or heat-strengthened glass. 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 CHEMICAL TREATMENT

7.4.5 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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