

1 Scope

These guidelines apply when assessing the visual quality of completely or partially enamelled and screen-printed glasses that are produced by applying and burning in inorganic colours as tempered safety glass or heat-strengthened glass.

These guidelines also apply when assessing the visual quality of structure-coated glasses.

For quality assurance and correct assessment of products, it is necessary to notify the manufacturer of the **specific area of application** with the order.

It pertains in particular to the following information:

- inside or outside application
- requirements for soaking printed or enamelled tempered safety glass (application in the façade)
- use for the inspection area (viewing of both sides, e.g., separation walls, curtain-type façades, etc.)
- use with direct backlighting
- edge quality and any freestanding visible edges (for freestanding edges, the type of edge must be ground or polished)
- further processing of single panes into insulation glass or laminated safety glass (only for released colours)
- reference point with screen-printed glass

2 Explanations / directions / terms

2.1 Completely enamelled glass

The glass surface is completely enamelled in various types of applications. Viewing is always done through the non-enamelled glass pane onto the colour so that the inherent colour of the glass influences the colouring.

The enamelled side must **always** be the side turned away from the weathering (level 2 or higher).

Exceptions are permissible only with inside application after prior consultation with the manufacturer.

Applications in the inspection area (viewing of both sides) must **always** be coordinated with the manufacturer, since enamelled glass is generally **not** suitable for backlit applications.

Depending on the manufacturing process, differences and special features result that are mentioned in what follows.

2.1.1 Rolling process

The flat glass pane is passed under a grooved rubber roller that transfers the enamel onto the glass surface without the addition of solvents and thus in an environmentally friendly manner. A uniform, homogeneous colour distribution is thus ensured (prerequisite: absolutely flat glass surface) which, however, is adjustable only to a limited extent regarding colour application (colour density, covering power).

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Typically, the grooved structure of the roller can be seen close up (colour side). However, you normally hardly ever see these “grooves” from the front (viewed through the glass).

It must be taken into consideration that a medium (sealant, panel adhesive, insulation, support, etc.) applied directly to the back (colour side) can show through with bright colours.

As a rule, rolled enamelled glass is **not** suitable for the inspection area, so that such applications are **absolutely** to be coordinated in advance with the manufacturer (starry sky).

A light “colour flashover” on all edges that can be slightly wavy, particularly on the longitudinal edges (seen in the running direction of the rolling machine), is dependent on the process. However, as a rule the edge surface remains clean.

2.1.2 Casting process

The glass plate runs horizontally through a so-called “casting mist” (colour blended with solvent, i.e., not environmentally friendly and obsolete) and covers the surface with colour.

By adjusting the density of the casting mist and the throughput speed, the thickness of the colour application can be controlled over a relatively large area. However, due to slight unevenness of the casting lip, there is a danger that in the longitudinal direction unequally thick streaks can be caused.

Analogously to the rolling process, it holds for the inspection area that these applications are **absolutely** to be coordinated in advance with the manufacturer.

The colour “flashover” on the edges is substantially greater than with the rolling process and can only be eliminated with much manual effort. If visible edges are desired, the panes have to be ordered with “polished” edge quality for that reason.

2.1.3 Serigraphy process

On a horizontal serigraphy table, the colour is imprinted without a solvent onto the glass surface through a close-meshed screen with a doctor; in doing so, the thickness of the colour application can only be slightly influenced by the mesh width of the screen.

The colour application is generally thinner than with the rolling or casting process and, depending on the colour chosen, appears opaque or translucent.

Media applied directly to the rear (colour side) show through (sealants, panel adhesives, insulation, supports, etc.).

Here, too, the application for the inspection area is **absolutely** to be coordinated in advance with the manufacturer.

Depending on the colour, streaks both in the printing direction and also at a right angle to it as well as individually occurring “mist spots” due to selective screen cleaning in production are typical for the manufacturing process and thus permissible.

Due to slight fluctuations in layer thickness, the overall colour impression can be varied over the surface, depending on the colour. The occurrence of slight fluctuations in layer thickness is typical for the serigraphy process. Colour differences resulting from this are permissible.

As a rule, the edges remain clean with serigraphy, but can have a light colour beading in the fringe area, so that the reference to freestanding edges is required for application-compatible manufacturing.

Printing of lightly structured glass is possible, but is always to be clarified with the manufacturer.

2.2 Partially enamelled glass

The glass surfaces are partially enamelled by various types of application. This also applies to border-enamelled glass. Analogously to 2.1, the same special features apply.

2.3 Screen-printed glass

On the basis of specific decor patterns and serigraphy stencils, the glass surfaces are mechanically printed with solvent-free enamel colours and conveyed to the oven process (tempered safety glass or heat-strengthened glass) for burning in, analogously to enamelled glass.

The same prerequisites always apply as in the case of completely enamelled glass (see 2.1).

Due to tolerances in the glass and screen, there may be unprinted borders.

2.4 Structure-coated glass

Using the serigraphy process, printing on glass surfaces (fully tempered glass, heat strengthened glass or float glass) with a water-soluble marking based on specific patterns is possible. Subsequently, a thin-film coating (produced with the magnetron process) is applied to the masked panes. After removal of the masking a structured thin-film coating remains on the glass surface.

Generally, the same conditions apply as for screen-printed glass (cf. section 2.3).

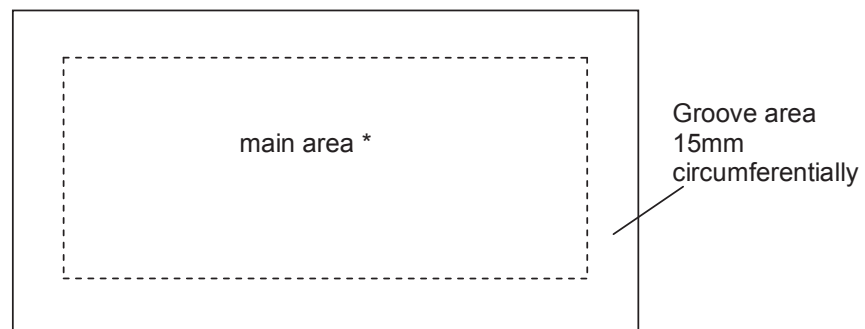
3 Tests

Assessing the visual quality of enamelled, screen-printed and structure-coated glass is done at a distance of at least 3 meters and viewed vertically, or viewed at max. 30° to the vertical, in normal daylight, without the sun shining directly on the glass or back-lighting from the front or back, and in front of an opaque background. Viewing is always done through the untreated glass side onto the enamelled, screen-printed or structure-coated pane. If the assessment is to be done from both sides in the case of glass that is ordered for the inspection area, then this is to be explicitly coordinated in advance with the manufacturer.

The complaints must not be especially marked in the test. Flaws which are not visible from this distance are not assessed.

For flaws specific to annealed glass, the guideline for tempered safety glass applies. In assessing the flaws, a differentiation between groove area and main area is made corresponding to the following diagram.

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- * If visible edges are required when the order is placed, the groove area is omitted and the main area extends to the edge of the pane.

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The requirements as to visual quality are given in the following tables 1 and 2:

Table 1: Types of flaws / tolerances for completely or partially enamelled glass

Type of flaw	Main area	Groove area
Defects in the enamel*	Surface: max. 25 mm ² Number: max. 3, none ≥ 25 mm ²	Width: max. 3 mm, sporadically 5 mm Length: no limit
Light scratches (only visible with changing incidence of light)	permissible up to 10 mm in length	permissible / no limitation
Clouds	impermissible	permissible / no limitation
Water spots	impermissible	permissible / no limitation
Colour flashover on the edges	omitted	<ul style="list-style-type: none"> • permissible with framed panes • impermissible with visible edges (prerequisite: ground or polished edge)
Dimensional tolerance with partial enamel ** Enamel width:	Depending on width of enamel	
<ul style="list-style-type: none"> ≤ 100 mm ≤ 500 mm ≤ 1000 mm ≤ 2000 mm ≤ 3000 mm ≤ 4000 mm 	<ul style="list-style-type: none"> ± 1.5 mm ± 2.0 mm ± 2.5 mm ± 3.0 mm ± 4.0 mm ± 5.0 mm 	
Enamel position tolerance ** (only with partial enamelling)	Print size ≤ 200 cm: ± 2.0 mm Print size > 200 cm: ± 4.0 mm	
Colour deviations	See section 4.	

* Flaws ≤ 0.5 mm (“starry sky” or “pin holes” = the smallest defects in the enamel) are permissible and are generally not taken into consideration. Correction of defects in enamel colour **before** the tempering process or with organic enamel varnish **after** the tempering process is permissible; in doing so, however, organic enamel varnish may **not** be used if the glass is further processed into insulation glass and the defect is in the area of the insulation glass sealing edge. The corrected defects must not be visible from a distance of 3 meters.

** The enamel tolerance is measured from a reference point.

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Table 2: Types of flaws / tolerances for screen-printed and structure-coated glass

Type of flaw	Main area	Groove area
Defects in the enamel*	Surface: max. 25 mm ² Number: max. 3, none ≥ 25 mm ²	Width: max. 3 mm, sporadically 5 mm Length: no limit
defects in the structured coating ****	Surface: max. 25 mm ² /m ² Number: no restriction, but total ≤ 25 mm ² /m ²	Width: max. 3 mm, sporadically 5 mm Length: no limit
Light scratches only visible with changing incidence of light)	permissible up to 10 mm in length	permissible / no limitation
Clouds**	impermissible	permissible / no limitation
Water spots	impermissible	permissible / no limitation
Colour flashover on the edges	omitted	<ul style="list-style-type: none"> • permissible with framed panes • impermissible with visible edges (prerequisite: ground or polished edge)
Geometry of the figure (resolution precision) Printing surface:	Depending on size of printing surface:	no limitations
<ul style="list-style-type: none"> ≤ 30 mm ≤ 100 mm ≤ 500 mm ≤ 1000 mm ≤ 2000 mm ≤ 3000 mm ≤ 4000 mm 	<ul style="list-style-type: none"> ± 0.8 mm ± 1.0 mm ± 1.2 mm ± 2.0 mm ± 2.5 mm ± 3.0 mm ± 4.0 mm 	
Design position tolerance ***	Print size ≤ 200 cm: ± 2 mm Print size > 200 cm: ± 4 mm	
Colour deviations	See section 4.	

* Flaws ≤ 0.5 mm (“starry sky” or “pin holes” = the smallest defects in the enamel) are permissible and are generally not taken into consideration.

** With fine decors (screening with partial areas smaller than 5 mm), a so-called moiré effect can occur. For this reason, coordination with the manufacturer is required.

*** The design tolerance is measured from a reference point.

**** Flaws ≤ 1 mm (“starry sky” or “pin holes” or spot coating on the previously masked glass pane areas) are permissible and are generally not taken into consideration.

For geometrical figures or so-called dot masks less than 3 mm in size or progressions from 0 – 100%, the following remarks apply:

- If points, lines or figures of this size are strung together with little distance between them, then the human eye reacts very “critically.”
- Tolerances of geometry or distance in the tenth of a millimetre range stand out as gross deviations.
- These applications must in each case be checked with the manufacturer as to feasibility.

4 Assessing the colour impression

Colour deviations cannot in principle be excluded, since they can occur due to several unavoidable influences.

Due to the influences mentioned in what follows, under certain light and viewing conditions a discernable colour difference between two enamelled glass plates can predominate that can be classified very subjectively by the observer as “bothersome” or “not bothersome.”

4.1 Type of basic glass and influence of the colour

As a rule, the basic glass used is a float glass, i.e., the surface is very flat and it has a high light reflection.

In addition, this glass can be furnished with the most varied coatings, such as sun protection layers (increase in light reflection of the surface), reflection-lessening coatings or can also be lightly calendered, such as in the case of textured glass.

There is also the so-called inherent colour of the glass that substantially depends on the thickness and type of glass (e.g., imbued glass, decoloured glass, etc.).

The enamel colour consists of inorganic materials that are responsible for the colouring and are subject to slight fluctuations. These materials are blended with “paste.”

During the tempering process, the “paste” surrounds the coloured pigments and bonds with the glass surface. Only after this “burning process” can the final colouring be seen.

The colours are “set” so that they “melt” into the surface at a glass surface temperature of ca. 600 - 620°C within 2 - 4 minutes. This “temperature window” is very tight and cannot not always be repeatably complied with, in particular with panes of varying sizes.

In addition, the type of application is also decisive for the colour impression. Due to the thin colour application, a screen print (see 2.1.3) delivers less covering power of the colour than a product manufactured in the rolling process with thicker and thus denser colour application.

4.2 Type of light in which the object is viewed

The light conditions are constantly different depending on the season, time of day and the prevailing weather. This means that the spectral colours of the light which impinge

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on the colour through the various media (air, 1st surface, glass body) are present in varying degrees in the range of the visible spectrum (400 - 700 nm). The first surface already reflects a part of the occurring light more or less according to the angle of incidence. The “spectral colours” impinging on the colour are partially reflected or absorbed by the colour (colour pigments). The colour thus appears different according to the light source.

4.3 Viewers or type of viewing

The human eye reacts very differently to different colours. While a very slight colour difference seriously stands out with blue tones, colour differences with green colours are noticed less.

Other factors are the viewing angle, the size of the object and above all how closely two objects to be compared are placed to one another.

An objective visual estimation and evaluation of colour differences is not possible for the reasons mentioned above. Introduction of an objective standard of evaluation thus requires measurement of the colour difference under conditions exactly defined beforehand (type of glass, colour, light).

For those cases in which the customer desires an objective standard of evaluation for the colour location, the procedure is to be coordinated **beforehand** with the supplier. The basic procedure is defined as follows:

- Sampling of one or more colours
- Selection of one or more colours
- Determination of tolerances per colour by the customer (e.g., allowed colour deviation)
- Checking feasibility by the supplier regarding adherence to the specified tolerance (extent of application, availability of raw material, etc.)
- Production of a 1:1 production sample and sign-off by the customer
- Manufacture of the application within the established tolerances

5 Other information

The other characteristics of the products are to be gathered from the respective European standards or their drafts. They are:

- DIN EN 12150 for tempered safety glass
- DIN EN 1863-1 for heat-strengthened glass

However, the manufacturer reserves the right to production-related deviations and changes in best available technology.

- Applications with enamel or partial enamel and serigraphy or partial serigraphy **for film with laminated safety glass** must be checked with the manufacturer as to feasibility. That applies in particular to use of etching tone for the film,

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since the optical density of the etching tone can be severely reduced and the effect of the etching tone is preserved only with use on level 1 or 4.

- Special colours, e.g., metallic effect, slip-resistant coatings or combinations of several colours can be produced on request. The respective special characteristics or the appearance of the product are to be clarified with the manufacturer.
- Enamelled and screen-printed glass can only be manufactured as tempered safety glass or heat-strengthened glass.
- Subsequent processing of the glass, regardless of what type, influences the characteristics of the product, substantially under some circumstances, and is **not** permissible.
- Enamelled glass can be used as monolithic pane or in connection with laminated safety glass or insulation glass. In this case, the respective provisions, standards and guidelines are to be taken into consideration by the user.
- Enamelled glass can be heat-soak tested as **tempered safety glass**. The respective necessity of the heat-soak test is to be checked by the user and disclosed to the manufacturer.
- The static values of enamelled glass are **not** to be equated with non-printed or non-enamelled glass.