

<b>Specification</b> <b>Technical Properties</b>	<b>TE - AF 45</b>
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<b>Description:</b>	AF 45 is an alkaline-free and colorless borosilicate glass with high content of BaO and Al <sub>2</sub> O <sub>3</sub> . Contents of alkali oxide up to 0.2 weight percentage are possible by contamination of the raw materials and refractory materials. The special composition of this substrate glass with fire-polished surface makes it suitable for a variety of applications.
<b>Applications (e.g.):</b>	CCD/CMOS-Sensors LCD-Substrates MEMS (Micro-Electro-Mechanical Systems) Wafer leveled chip size packaging Printed circuits board High-temperature applications up to approx. 600 °C
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This specification defines product properties for different processing levels. According to customer demands different processing levels (defined by inquiries or orders) refer to different specifications which have to be used. Following processing levels are defined within this specification:

- raw material inspected
- cut to size and inspected (rectangular or round shape)
- cut to size, ground edges, washed and inspected (only rectangular shape for thickness 0.3-0.5 mm)

SCHOTT Spezialglas GmbH retains the right to adjust the data in according to the latest technical standards. Non tolerated numerical values are reference values of an average production quality.

Requirements deviating from these specifications have to be defined in writing by a **Customer Agreement**.

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**1. Dimensions**

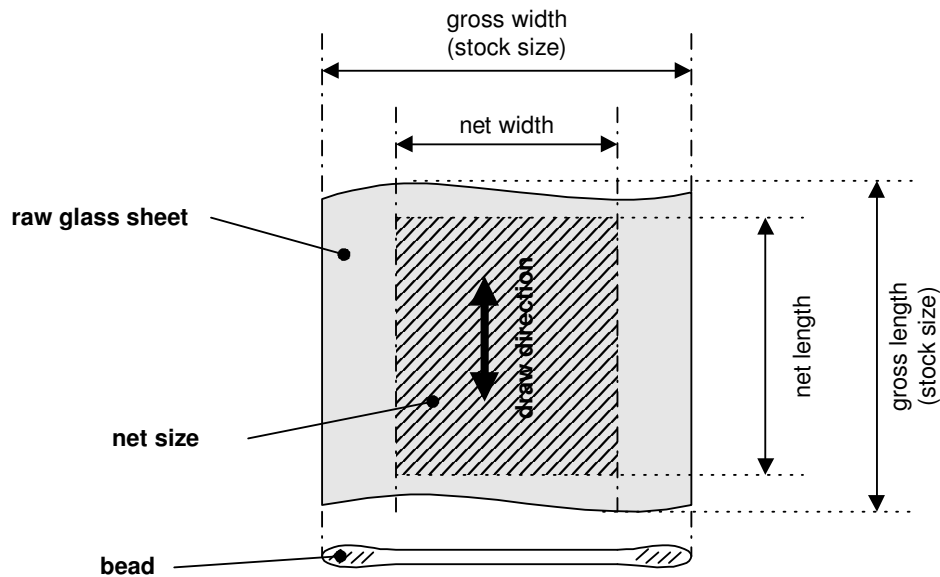
**1.0 General definitions**

AF 45 thin glass is produced by down-draw technology. Drawn as a continuous ribbon the glass is separated into sheets by cutting. The size of the raw glass sheet is limited parallel to draw direction by beads and perpendicular to draw direction by cut edges (see drawing).

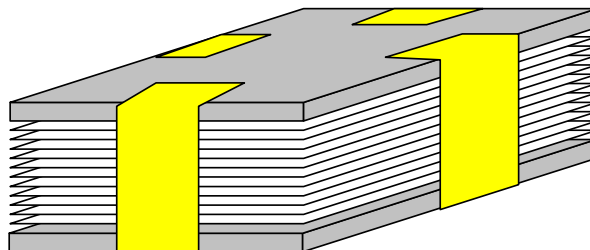
Raw glass sheets are produced including beads. The size is defined by gross length and gross width. Within this standard area a net size is defined centered to the beads in which subsequent properties and quality items are guaranteed. The net size is defined by net length and net width.

“Cut to size” glass sheets are cut out of the net size according to customer requirements in rectangular or round shapes. Sheet glass is available with cut edges or with edge work by flat bevel (seamed) or radiused edges (C-shape) for rectangular shapes only.

In general, the sheet glass size is defined by length in draw direction and width across draw direction. The quality area is defined within the net size area as shown in the figure below.



Glass sheets are delivered in stacks with paper interleaves supported by a cardboard sheet on top and bottom. In order to stabilize the stacks cardboard sheets are fixed by special tapes.



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### 1.1 Size

#### 1.1.1 Stock size (raw glass size)

Nominal thickness [mm]	Gross length [mm]	Gross width [mm]	Net width (quality width) [mm]	Parallelism <sup>1)</sup> [%]	Squareness <sup>1)</sup> [%]
0.05	440 ± 10	approx. 420	360 +10 / -0	-	-
0.10 - 0.50	440 ± 10		360 +10 / -0	≤ 0.5	≤ 1.0

1) in % of measured edge length

#### 1.1.2 Cut to size

Maximum size is limited to net width and net length of raw glass sheet. Minimum size is limited by technical limitations of cutting and/or edge working capabilities. In general, the processing capability of a specific substrate size will be checked in advance of order acceptance.

#### Rectangular Shape

Nominal thickness [mm]	Max. size		Min. size <sup>2)</sup>	Parallelism <sup>1)</sup> [%]	Squareness <sup>1)</sup> [%]
	length [mm]	width [mm]	length x width [mm]		
0.05	≤ 410.0 ± 0.8	≤ 360.0 ± 0.8	25.0 x 25.0 ± 0.8	≤ 0.2	≤ 0.3
0.10 - 0.20	≤ 410.0 ± 0.5	≤ 360.0 ± 0.5	25.0 x 25.0 ± 0.5	≤ 0.1	≤ 0.2
0.30 - 0.50				≤ 0.1	≤ 0.2

2) smaller size on request

1) in % of measured edge length

#### Round Shape

Nominal thickness [mm]	Diameter	
	Max. size [mm]	Min. size <sup>1)</sup> [mm]
0.05	≤ 360.0 ± 1.0	≤ 40.0 ± 1.0
0.10 - 0.20	≤ 360.0 ± 0.5	≤ 40.0 ± 0.5
0.30 - 0.50		

1) smaller size on request

#### 1.1.3 Substrates with edge work (rectangular shape only)

Nominal thickness [mm]	Max. size		Min. size	Parallelism <sup>1)</sup> [%]	Squareness <sup>1)</sup> [%]
	length [mm]	width [mm]	length x width [mm]		
0.30 - 0.50	≤ 410.0 ± 0.3	≤ 360.0 ± 0.3	≥ 235.0 x 150.0 ± 0.3	≤ 0.1	≤ 0.2

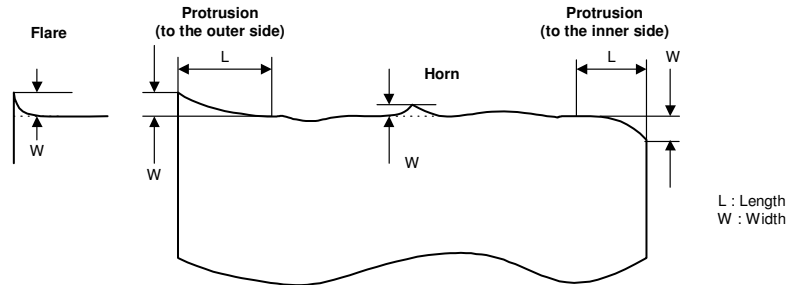
1) in % of measured edge

length

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**1.2 Edge work**

- Remarks :
- 1.) Edge shape according to DIN 1249, part 11
  - 2.) Deviation of edge see sketch
  - 3.) Edge defects see item 2. Edge defects

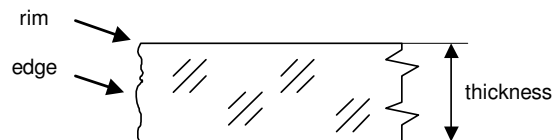


**1.2.1 Cut straight edge**

Nominal thickness	Protrusion L/W ≈ 10 ... 100	Flare, Horn (L/W ≈ 1 ... 5)
0.05 mm	width ≤ 0.25 mm length ≤ 10 mm	width ≤ 0.15 mm
0.10 – 0.20 mm	width ≤ 0.2 mm length ≤ 10 mm	width ≤ 0.1 mm
0.30 – 0.50 mm	width ≤ 0.2 mm length ≤ 10 mm	width ≤ 0.1 mm

**1.2.2 Cut round edge**

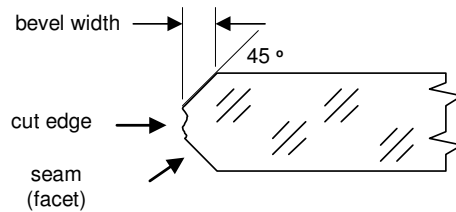
Nominal thickness	Flare, Horn (L/W ≈ 1 ... 5)
0.05 mm	width ≤ 0.25 mm
0.10 – 0.20 mm	width ≤ 0.2 mm
0.30 – 0.50 mm	width ≤ 0.2 mm



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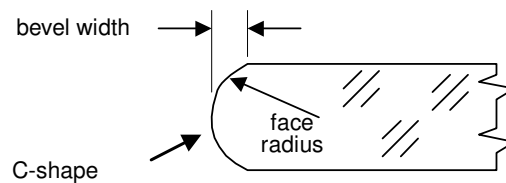
**1.2.3 Straight edge, Chamfered edge (flat bevel, facet )**

Nominal thickness	Bevel width	Protrusion L/W ≈ 10 ... 100	Flare, Horn (L/W ≈ 1 ... 5)
0.05 - 0.20 mm	not available		
0.30 - 0.50 mm	0.05 – 0.35 mm	width ≤ 0.2 mm length ≤ 10 mm	width ≤ 0.1 mm



**1.2.4 Straight edge, Radiussed edge ( C-shape )**

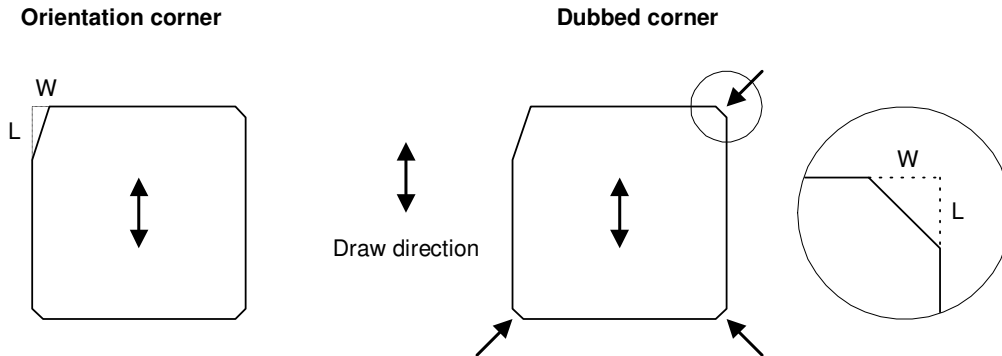
Nominal thickness	Bevel width	Face radius	Protrusion L/W ≈ 10 ... 100	Flare, Horn (L/W ≈ 1 ... 5)
0.05 - 0.20 mm	not available			
0.30 - 0.50 mm	0.05 - 1.20 mm	0.25 - 0.50 mm	width ≤ 0.2 mm length ≤ 10 mm	none



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### 1.3 Corner cut

Standard corner cut is done by one orientation corner and 3 dubbed corner. All corner cut with C-shape profile. Size, location and orientation is adaptable to customer need.



	Length (L)	Width (W)
Orientation corner	5.0 ± 1.5 mm	2.0 ± 1.0 mm
Dubbed corner	1.0 ± 0.5 mm	1.0 ± 0.5 mm

### 1.4 Thickness, thickness deviation, warp

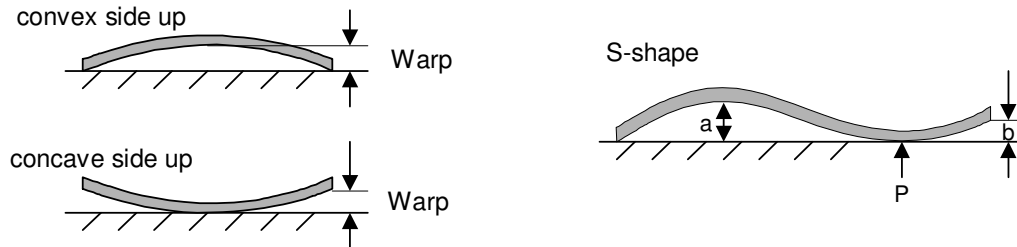
Nominal thickness	Thickness tolerance	Thickness variation $\Delta D$ (deltaD)	Flatness deviation Warp <sup>1)</sup>
	Variation in lot	Within sheet, across draw direction	Referenced to max. cut to size dimension (1.1.2)
[mm]	[mm]	[ $\mu\text{m}$ ]	[mm]
0.050	± 0.010	≤ 10	2)
0.100	± 0.015	≤ 20	
0.200	± 0.020	≤ 20	
0.300	± 0.020	≤ 20	≤ 0.6
0.400	± 0.020	≤ 20	≤ 0.6
0.500	± 0.050	≤ 30	≤ 0.6

1) and 2) see next page

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Remarks:

- 1) Warp measured on a flat table in a mechanical unconstrained state.



S-shape is not allowed if warp > 0.3 mm :

A not admissible S-shape is given, when the sheet is laying on an ideal flat surface with contact in two points (e.g. point P and one point at the edge), so that two points "a" and "b" exists which both have a greater distance to the flat surface than the half of the warp tolerance.

- 2) Because of low stiffness of very thin (0.050 to 0.20 mm) and big sized glass sheets the gravity force influences flatness shape significantly. Therefore flatness deviation (warp) can not be specified for this thickness range.

### 1.5 Waviness

A stylus tip surface roughness tester (Mitutoyo SurfTest SV 3000-8) is used for waviness measurements. Typical actual values of waviness for this fire polished glass surfaces are  $\leq 400$  nm. Waviness is measured perpendicular to the draw direction with an evaluation length of 20 mm, a phase correct 75% filter and edge wavelengths of 0.8 mm and 8.0 mm. Actual values are available for glass thickness >0.20 mm. Today, the reproducibility of waviness measurements for thickness  $\leq 0.2$  mm is not yet given by the state of the art roughness measurement methods.

### 1.7 Roughness

The roughness of fire polished surface shows typical values below 1 nm (RMS).

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## 2. Glass defects

The subsequent glass defects are applied to final size defined by customer demands. Conditions for visual inspection regarding glass defects: 1.5 klux, light in reflection, dark background, 15 sec. inspection time.

### 2.1 Bulk defects

Type of defect: Inclusions (e.g.: bubbles, stones, knots)

Nominal thickness	Defect size <sup>1)</sup>	Admissible count	Conditions
0.05 mm	visibility	none visible	
0.10 to 0.20 mm	< 50 µm	ignore	
	50 to 100 µm	≤ 3	distance > 25 mm
	> 100 µm	0	
0.30 to 0.50 mm	< 100 µm	ignore	
	100 to 200 µm	≤ 3	distance > 25 mm
	> 200 µm	0	

1) Defect size is defined by the max. dimension of defect.

### 2.2 Surface defects

Type of defect	Defect size	Admissible count
<b>Elongated defects:</b> e.g.: scratches, rubs, sleek	width < 20 µm and length < 25 mm	ignore
	width 20 to 50 µm and length < 25 mm	≤ 3
	width > 50 µm and length > 25 mm	none
<b>Spot type defects <sup>2)</sup> :</b> e.g.: pits, digs, devitrifications, not removable particles <sup>3)</sup> , open bubbles	< 100 µm	ignore
	100 to 200 µm	≤ 3
	> 200 µm	none

2) Defect size is defined by the max. dimension of defect.

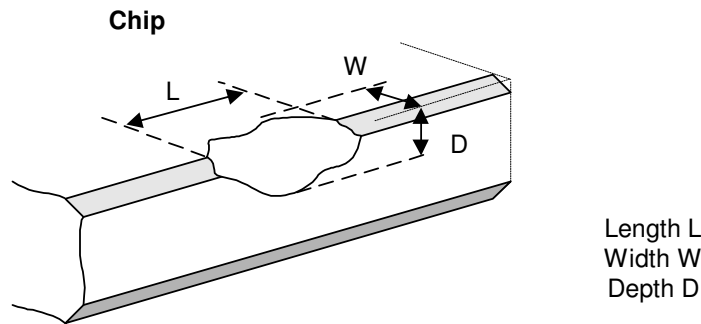
3) not removable by standard cleaning process at customer (as specified in 2.4)



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**2.3 Edge defects**

Type of defect	Defect size	Admissible count
<b>Edge chips</b>	$\leq 0.2$ mm	ignore
	length $\leq 1$ mm, width $\leq 1$ mm, depth $\leq 50\%$ of thickness	$\leq 2$ pcs / edge, $\leq 5$ pcs / sheet
<b>Shiners</b> (partial not ground portion of the edge after edge work)	length $\leq 10$ mm, depth $\leq 50\%$ of thickness	$\leq 1$ pcs / edge
<b>Cracks</b>	visible	none



dimension indication for a chip at seamed edge

**2.4 Contamination**

Contaminations e.g. finger prints, conveyor marks, paper marks, haze, cullets, dust, foreign particles are permissible if they are soluble/cleanable by standard washing processes at customer side for thin glass (depending on thickness e.g. brush roller, ultra sonic, DI-water and alkaline detergent, e.g. DECONEX). Cleanable defects will be ignored and are permissible without any size restriction.

**2.5 Quality level**

<b>inspection of dimensional properties</b> (e.g. thickness, size, waviness, ...)	inspection level „S3“; single sampling; normal inspection; AQL 2.5
<b>inspection of visual properties</b> (e.g. bulk defects, surface defects, ...)	inspection level „II“; single sampling; normal inspection; AQL 4.0