

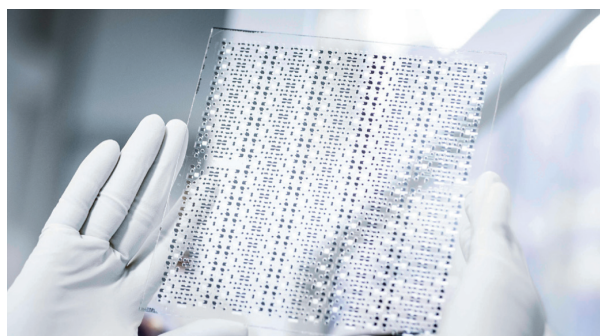
DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Chemical Properties

The sum of its properties is what makes it unique.

BOROFLOAT® 33 from Germany is the world's first floated borosilicate flat glass. Its superior quality and excellent flatness combine with outstanding thermal, optical, chemical and mechanical features. The chemical composition and physical values of BOROFLOAT® 33 are in accordance with DIN ISO 3585 and DIN EN 1748 T1. Rediscover BOROFLOAT® 33 and experience the infinite potential of our most versatile material platform. BOROFLOAT® – Inspiration through Quality.



Microreaction systems made of BOROFLOAT® 33 are characterized by high chemical resistance.

Chemical durability

Hydrolytic resistance	(according to ISO 719 / DIN 12 111) (according to ISO 720)	HGB 1 HGA 1
Acid resistance	(according to DIN 12 116) (according to ISO 1776) $\leq 100 \mu\text{g Na}_2\text{O per } 100 \text{ cm}^2$	1
Alkali resistance	(according to ISO 695 / DIN 52 322)	A 2

Resistance to selected chemicals

Reagent	Abrasion [mg/cm^2]	Visual observations
24 h at 95 °C		
H ₂ O	< 0,01	Unchanged
5 Vol.% HCl	< 0,01	Unchanged
0,02 n H ₂ SO ₄	< 0,01	Unchanged
6 h at 95 °C		
5 % NaOH	1,1	White stains
0,02 n NaOH	0,16	White haze
0,02 n Na ₂ CO ₃	0,16	Unchanged
20 min. at 23 °C		
10 % HF	1,1	Stained white haze
10 % NH ₄ F x HF	0,14	Unchanged

Chemical resistance of BOROFLOAT® 33 to selected reagents as a function of time and temperature.

Further data and information available on request.

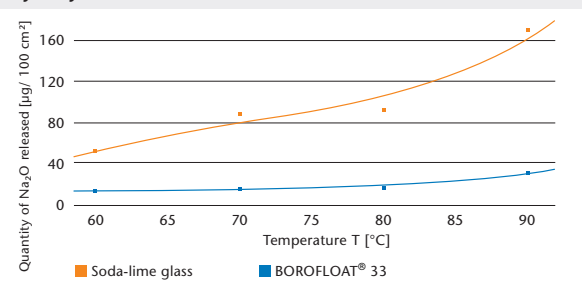
All values listed on the data sheet are not guaranteed reference values.

Key benefits

High chemical durability

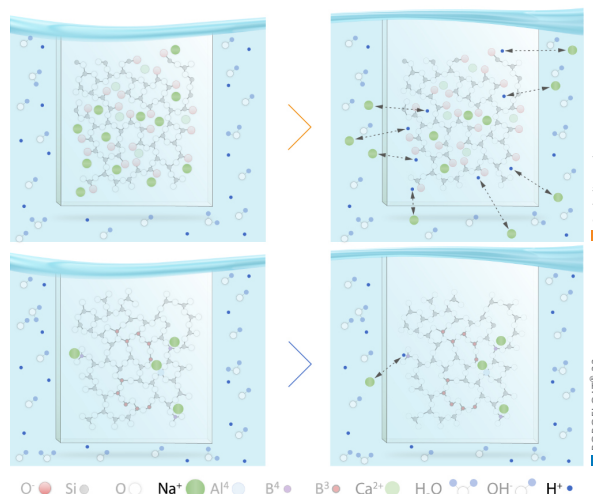
- High hydrolytic resistance
- Excellent resistance to acids
- High resistance to alkalis
- Low alkali diffusion

Hydrolytic resistance



Quantity of Na₂O released from BOROFLOAT® 33 compared to soda-lime glass depending on the temperature after 16 hours.

Ion exchange during a hydrolytic attack



Compared to soda-lime glass, BOROFLOAT® 33 has a significantly higher hydrolytic resistance, because the number of sodium ions in the glass network is significantly lower with BOROFLOAT® 33. The few sodium ions are also more strongly bound.

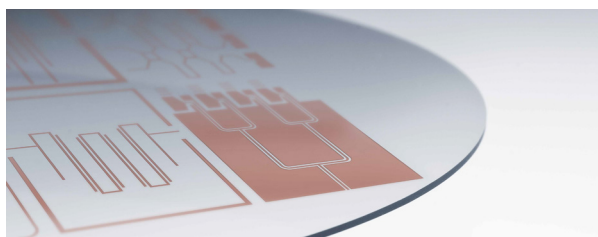
DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Electrical Properties

The sum of its properties is what makes it unique.

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Can be easily processed by using all state-of-the-art semiconductor structuring technologies

Key benefits:

Unique combination of electrical properties

- Low dielectric constant in combination with low loss tangent
- High electrical volume resistivity
- Anodically bondable
- Homogeneous material based on amorphous structure
- Available in broad range of sizes and thicknesses

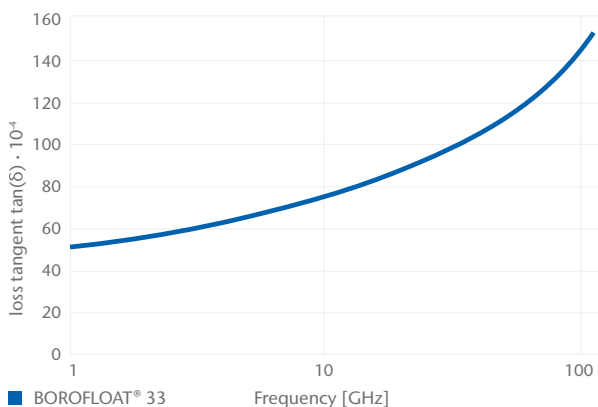
Dielectrical properties

Dielectric constant (permittivity) ϵ_r	1 MHz, 25°C	4.6
loss tangent $\tan(\delta)^* [10^{-4}]$	1 MHz, 25°C	48

Frequency [GHz]	1	2	2.45	5	10	15	24	77	110
Dielectric constant (permittivity) ϵ_r	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
loss tangent $\tan(\delta)^* [10^{-4}]$	51	56	58	66	75	82	91	127	152

Dependence of dielectric constant and loss tangent on frequency

Frequency dependent loss tangent $\tan(\delta)$



* The data ranging from 1 GHz to 15 GHz are measured using a split-post-dielectric resonator method (SPDR) and have an accuracy for the loss tangent of approx. 10^{-3} . The data ranging from 20 GHz to 110 GHz are obtained by using a Fabry-Perot Open Resonator (FPOR). The measurements have been done at room temperature (25°C $\pm$ 3°C)

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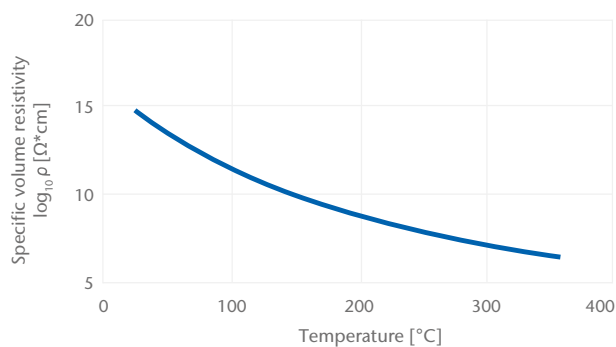
SCHOTT BOROFLOAT® 33

Temperature dependent loss tangent $\tan(\delta)$ at 10 GHz frequency

Temperature [K]	234	254	275	293	313	323	332
Dielectric constant (permittivity) ϵ_r	4.4	4.5	4.5	4.5	4.5	4.5	4.5
loss tangent $\tan(\delta) \cdot [10^{-4}]$	68	70	72	75	78	79	80

Electrical resistivity

Specific volume resistivity	
Temperature [°C]	$\log_{10} \rho [\Omega \cdot \text{cm}]$
25	14.8
250	8.0
350	6.5
Temperature of the specific electrical resistivity at $10^8 \Omega \cdot \text{cm}$	
T_{k100} [°C]	250



■ BOROFLOAT® 33

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DATA SHEET

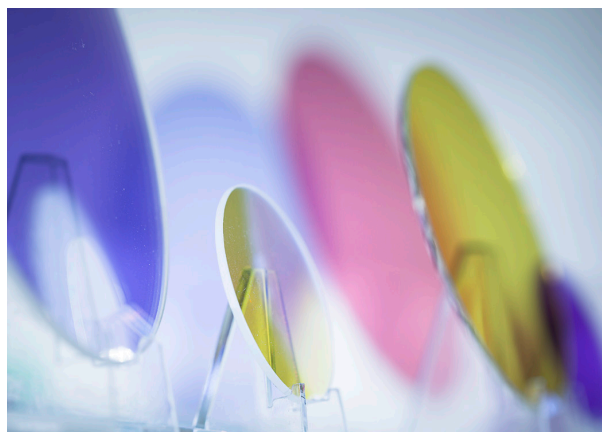
SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 & Functional Coatings: A Union of Inspiration & Quality

The sum of its properties is what makes it unique.

More than 20 years ago, SCHOTT set up the first micro-float production line for what would soon become one of the most influential specialty glass materials. The result was BOROFLOAT® – the world's first floated borosilicate glass. With high-quality German engineering at its core, BOROFLOAT® quickly became an outstanding example of what seamless interaction between advanced know-how, innovative technology and professional curiosity – all in combination with the developmental drive of our team of experts – can deliver.

The performance requirements for optical filters and mirrors are highly dependent on the material's ability to reflect, absorb, enhance or modify incoming light. This can be accomplished with bulk optical glass materials or through coatings that are applied to a pristine glass substrate. Coatings usually allow significantly more freedom for customized light management design options which can be developed even further when a flat glass material with outstanding optical, thermal, mechanical and chemical properties is used. BOROFLOAT® borosilicate glass is such a unique substrate and has hence become the material of choice for robust high-temperature resistant dichroic filters, hot and cold mirrors.



Specialized coating companies have discovered BOROFLOAT® glass as a substrate for advanced coatings capable of performing under the most challenging conditions.

BOROFLOAT® – The sum of its properties is what makes it unique for functional coatings

- Exceptionally high transparency
- Outstanding thermal resistance
- Excellent mechanical strength
- Broad range of sizes and thicknesses

BOROFLOAT® glass with functional coatings offers exceptionally high transparency

BOROFLOAT® glass - the industrial float glass with the lowest level of iron and other absorbing impurities in the market - offers exceptional light transmission. High UV transparency down to 300 nm, greater than 92 % light transmittance in the visible and near IR wavelength range, outstanding clarity, low auto-fluorescence and low solarization are specific characteristics of BOROFLOAT® glass substrates used in many optical fields.

DATA SHEET

SCHOTT BOROFLOAT® 33

Optical data

Abbe number ($v_e = (n_e - 1) / (n_F - n_C)$)	65.41
Refraction index ($n_d(\lambda_{587.6 \text{ nm}})$)	1.47140
Dispersion ($n_F - n_C$)	71.4×10^{-4}
Stress-optical coefficient (κ)	$4.0 \times 10^{-6} \text{ mm}^2 \text{ N}^{-1}$

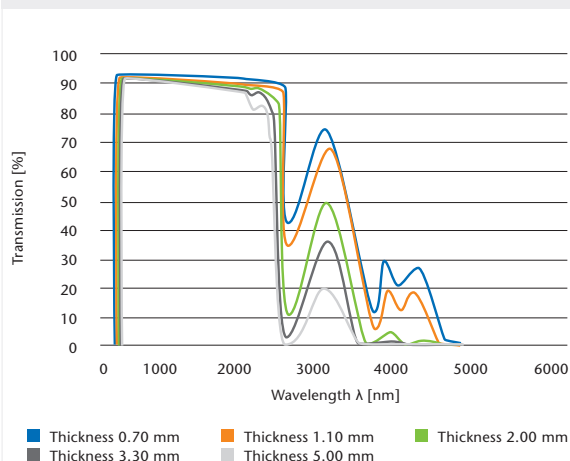
Average reference values, not guaranteed values.

Optical index of refraction

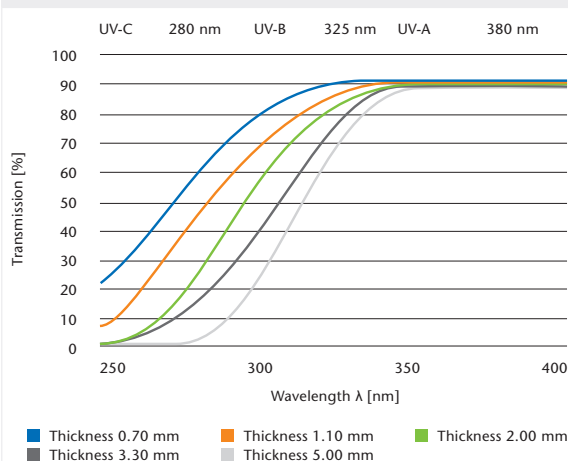
Wavelength λ (nm)	Refraction index n
435.8	1.48015
479.9	1.47676 (n_F)
546.1	1.47311 (n_e)
589.3	1.47133
643.8	1.46953 (n_C)
656.3	1.46916

Mean reference values, not guaranteed values.

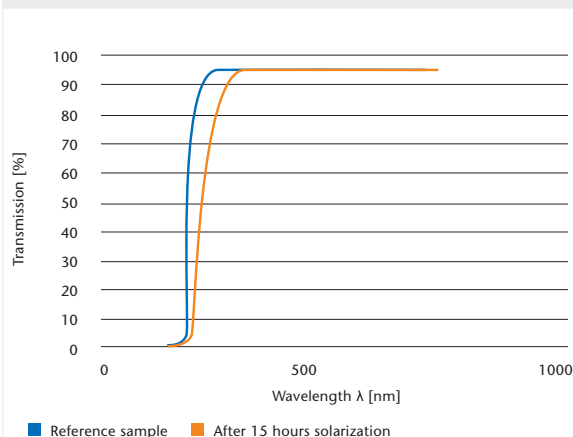
Transmission



Transmission in UV range

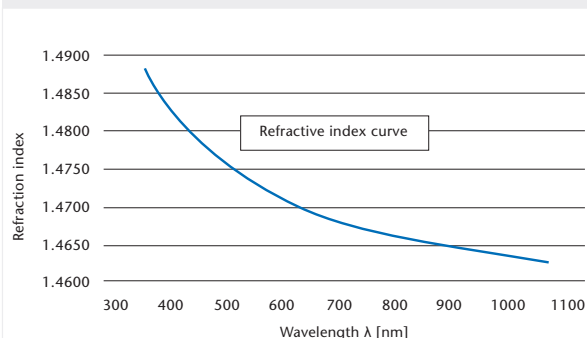


Solarization



The glass sample of a size $30 \times 15 \times 1 \text{ mm}^3$ is radiation-exposed by using the high-pressure mercury vapor lamp HOK 4/120. This lamp works with a radiation intensity of 850 W/cm^2 and with a main wavelength of 365 nm.

Dispersion



DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® glass - ideal for hot and cold mirrors due to its outstanding thermal resistance

Hot and cold mirrors either reflect or transmit infrared light and hence require high thermal resistance. The high boron content in BOROFLOAT® glass lowers the thermal expansion coefficient to $3.25 \cdot 10^{-6} \text{K}^{-1}$ resulting in excellent resistance to thermal shock and temperature gradients.

The thermal properties of BOROFLOAT® glass (uncoated substrate) are shown below. Maximum thermal resistance of coated filters and mirrors varies depending on the filter supplier.

Maximum operating temperatures	
Maximum Operating Temperature	
For short-term usage (< 10 h)	500 °C
For long-term usage (≥ 10 h)	450 °C

Resistance to Thermal Gradients (RTG) and Resistance to Thermal Shock (RTS) must be considered when determining max. operation temperatures.

Thermal properties	
Coefficient of	
Linear Thermal Expansion (C.T.E.) α (20 - 300 °C)	$3.25 \times 10^{-6} \text{ K}^{-1} *$
Specific heat capacity c_p (20 - 100 °C)	0.83 kJ / (kg · K)
Thermal conductivity λ (90 °C)	1.2 W / (m · K)

* According to ISO 7991.

Resistance to Thermal Shock (RTS)	
Glass Thickness	RTS (5 %-Fraktil)
≤ 3.8 mm	175 K
5.0 – 5.5 mm	160 K
6.5 mm	155 K
11 mm	142 K
18 mm	144 K
25 mm	128 K

Panels measuring 20 x 20 cm² (8 x 8 inches) are heated in an oven with circulating air and afterwards doused in the center with 50 ml of cold water (68 °F). The temperature is controlled via pyrometer. The RTS value is the difference in temperature between the hot panel and the cold water, at which breakage occurs in less than or equal to 5 % of the samples. In order to simulate damage that can occur in practical use, the samples are abraded with 220 grid sandpaper before testing.

Resistance to Thermal Gradients (RTG)			
Glass Thickness	Tempering	RTG	
		T _{change} *	T _{heat-up} *
3.8 mm	No	123 K	136 K
6.5 mm	No	119 K	132 K
11 mm	No	52 K	173 K
18 mm	No	31 K	188 K
6 mm	Thermal	> 300 K	

Edges ground or polished

*T_{change}: sudden temperature change
T_{heat up}: continuous heat-up

Panels measuring 25 x 25 cm² (10 x 10 inches²) are heated in the center of the panel to a defined temperature; the edges are maintained at room temperature. The temperature is increased within one minute to a level that initiates breakage of the test panel. The temperature is controlled via pyrometer. The RTG value is the difference in temperature between the hot center of the panel and the cool panel edge, at which breakage occurs in less than or equal to 5 % of the samples. In order to simulate damage that can occur in practical use, the samples are abraded with 220 grid sandpaper before testing.

DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® glass - process robustness guaranteed

Mechanical strength and robustness during manufacturing are essential for high quality substrates for functional coatings. BOROFLOAT® glass has a very strong microstructure with a relatively low amount of non-bridging oxygen resulting in better scratch resistance, excellent abrasion resistance and lower darkening behavior during high intensity radiation exposure than other flat glass types.

Mechanical properties

Density ρ (25 °C)	2.23 g/cm ³
Young's Modulus E (according to DIN 13316)	64 kN/mm ²
Poisson's Ratio μ (according to DIN 13316)	0.2
Knoop Hardness $H_{0.1/20}$ (according to ISO 9385)	480
Bending Strength σ (according to DIN 5292 T 1)	25 MPa

Impact resistance

The impact resistance of BOROFLOAT® 33 depends on the way it is fitted, the size and thickness of the panel, the type of impact involved, presence of drill holes and their arrangement as well as other parameters.

Reference values, not guaranteed values.

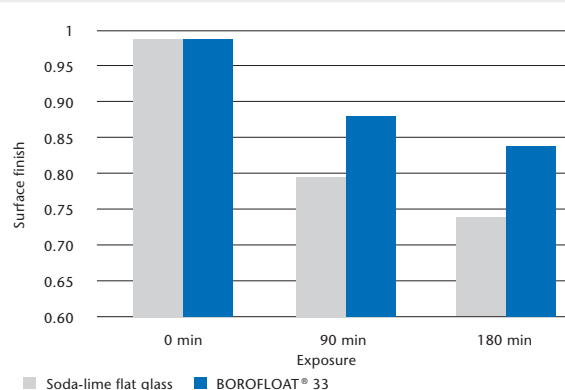
Critical forces

Material	Mean value F_c [mN]	Stdev.* [mN]
BOROFLOAT® 33	363.8	4.3
Other borosilicate glass	271.2	1.9
Soda-lime flat glass	214.4	4.6

Summary of critical forces in Scanning-Scratch-Test.

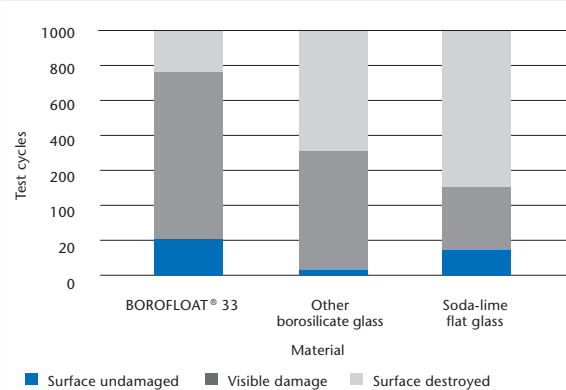
*Standard deviation

Comparison of sand abrasion BOROFLOAT® 33 & soda-lime flat glass



According to a study conducted by the Fraunhofer Institute for Applied Optics and Precision Engineering, BOROFLOAT® 33 displayed the highest resistance to mechanical forces in comparison to other Materials.

Resistance to abrasion



DATA SHEET

SCHOTT BOROFLOAT® 33

The right size and thickness for any application

Forms supplied

BOROFLOAT® 33 is available in the following standard thicknesses and tolerances:

Standard thicknesses	
Thickness mm	Tolerance mm
0.70	± 0.05
1.10	± 0.05
1.75	± 0.05
2.00	± 0.05
2.25	± 0.05
2.75	± 0.10
3.30	± 0.20
3.80	± 0.20
5.00	± 0.20
5.50	± 0.20
6.50	± 0.20
7.50	± 0.30
9.00	± 0.30
11.00	± 0.30
13.00	± 0.30
15.00	± 0.40
16.00	± 0.50
19.00	± 0.50
21.00	± 0.70
25.40	± 1.00

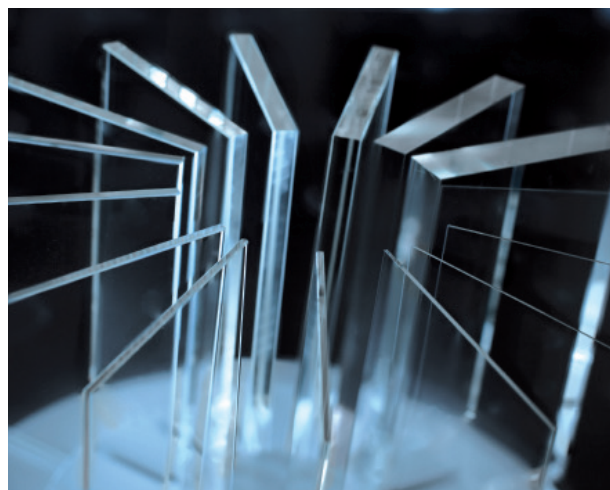
Panel thickness is continuously measured during production using laser thickness measuring equipment. Further thicknesses and tolerances are available on request.

Sizes

BOROFLOAT® 33 is available in the following standard sizes:

Standard sizes	
Size	Thickness
1,150 x 850 mm	0.7 – 25.4 mm
1,700 x 1,300 mm	16.0 – 21.0 mm
2,300 x 1,700 mm	0.7 – 15.0 mm

Standard sizes of BOROFLOAT® 33.



BOROFLOAT® 33 is available in a broad range of thicknesses.

DATA SHEET

SCHOTT BOROFLOAT® 33

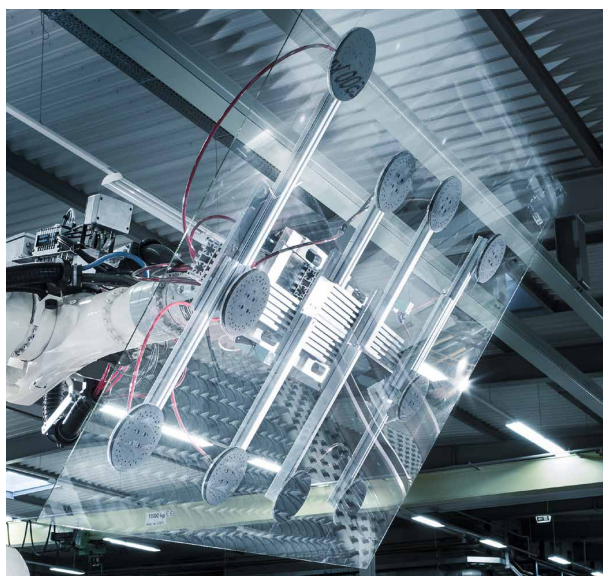
BOROFLOAT® 33 – General Information

The sum of its properties is what makes it unique.

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Rediscover BOROFLOAT® 33 and experience the infinite potential of our most versatile material platform.

BOROFLOAT® 33 – Inspiration through Quality.

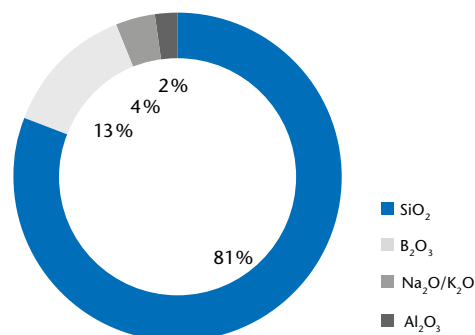


The world's first floated Borosilicate Glass – Made in Germany with IQ.

Key benefits:

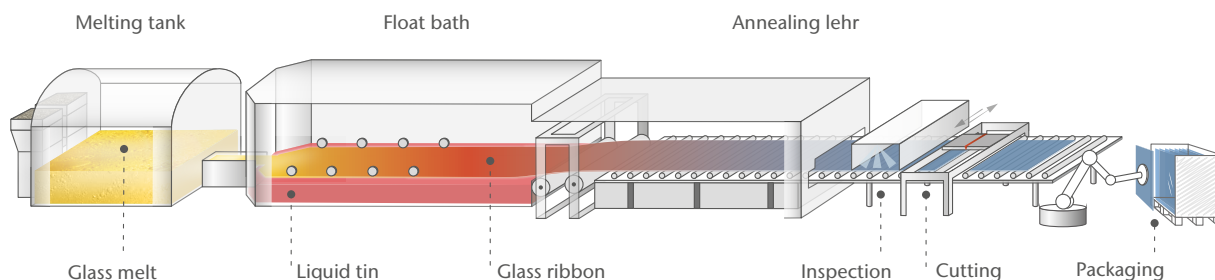
- Excellent mechanical strength
- Outstanding thermal resistance
- Exceptionally high transparency
- High chemical durability

Chemical composition of BOROFLOAT® 33



Production in the Microfloat Process

SCHOTT manufactures BOROFLOAT® 33 using proprietary, state-of-the-art Microfloat technology. The Microfloat process delivers highly homogeneous glass quality with a mirror-like surface, excellent flatness and outstanding optical properties.



BOROFLOAT® 33 is produced using SCHOTT's unique Microfloat process.

DATA SHEET

SCHOTT BOROFLOAT® 33

Forms supplied

BOROFLOAT® 33 is available in the following standard thicknesses and tolerances:

Standard thicknesses	
Thickness (mm)	Tolerance (mm)
0.70	± 0.05
1.10	± 0.05
1.75	± 0.05
2.00	± 0.05
2.25	± 0.05
2.75	± 0.10
3.30	± 0.20
3.80	± 0.20
5.00	± 0.20
5.50	± 0.20
6.50	± 0.20
7.50	± 0.30
9.00	± 0.30
11.00	± 0.30
13.00	± 0.30
15.00	± 0.40
19.00	± 0.50
20.00	± 0.70
21.00	± 0.70
25.40	± 1.00

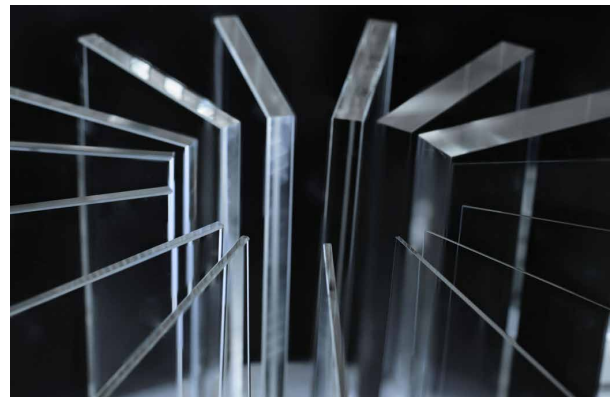
Panel thickness is continuously measured during production using laser thickness measuring equipment. Further thicknesses and tolerances are available on request.

Sizes

BOROFLOAT® 33 is available in the following standard sizes:

Standard sizes	
Size	Thickness
1,150 x 850 mm	0.7 – 25.4 mm
1,700 x 1,300 mm	19.0 – 21.0 mm
2,300 x 1,700 mm	3.3 – 15.0 mm

BOROFLOAT® 33 is supplied in wooden boxes in accordance with the regulation ISPM15 for wooden packaging material in international trade (ISPM15 under the international plant protection convention IPPC).



BOROFLOAT® 33 is available in broad range of thicknesses.

Processing options

BOROFLOAT® is also available in other formats. On request, further processing services can be offered, e.g. customer-specific cuts from BOROFLOAT® 33 standard sheet sizes and individual edge processing, with the quantities ranging from individual prototypes to series production.

Cleaning

BOROFLOAT® 33 panes can be cleaned with warm water. Insoluble contaminants on the glass surfaces may require the use of a cleaning agent. Cleaning agents and their quantities must be adapted to the respective cleaning processes according to the manufacturer's instructions.

Note: Under no circumstances should abrasive sponges, scouring powders or other corrosive or abrasive cleaners be used, as these can cause damage to the surface of the borosilicate glass.

Recommended storage

BOROFLOAT® 33 should be stored in the original packaging protected from moisture and other environmental influences.

DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Mechanical Properties

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Sight glasses and transparent, lightweight cover glasses require a maximum mechanical strength.

Key benefits:

Excellent mechanical strength

- Low weight
- Strong resistance to abrasion and scratches
- High elasticity

Mechanical properties

Density ρ (25° C)	2.23 g/cm ³
Young's Modulus E (according to DIN 13316)	64 kN/mm ²
Poisson's Ratio μ (according to DIN 13316)	0.2
Knoop Hardness HK _{0.1/20} (according to DIN ISO 9385)	480

Mechanical strength

The **bending strength** σ_b of BOROFLOAT® 33 with a

- typical float glass surface is normally 150 MPa*.
Higher values are possible.
- surface pre-damaged to simulate used condition, is ~ 25 MPa**.

The strength of glass is not a material constant, but is subject to a statistical distribution according to the type and distribution of surface defects and depends, among other things, on the following criteria:

- Conditions during glass processing (including edge processing, drilled holes, etc.)
- Used condition of the glass surface
- Force, type and duration of the effective load
- Environmental conditions (e.g.: corrosive chemicals)
- The geometry of the glass pane and accompanying installation factors

* typical value determined in accordance with DIN EN ISO 1288-5; glass thickness 2.75 mm

** Pre-damaged with 220 sandpaper; based on the former DIN 52292 Part 1

When specifying data for the mechanical strength of glass, the special properties of this brittle material must be taken into account. When glass comes into contact with materials that are just as hard or harder, surface defects in the form of indentations and cracks occur. When glass is subjected to a mechanical load, the build-up of critical stress at the points of these indentations and cracks cannot be relieved by plastic flow, as is possible with ductile materials such as metals. Glass breaks without warning, whereby the material failure can occur over a relatively wide load area.

When using glass as a construction material (e.g. in mechanical and plant engineering), the respective country- and industry-specific requirements and standards must be observed for any material suitability test as well as the basis for any construction calculations.

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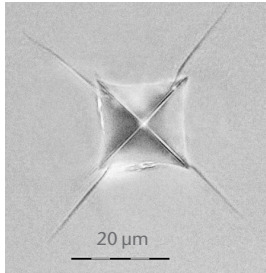
SCHOTT BOROFLOAT® 33

Behaviour when glass surface is exposed to typical mechanical loads

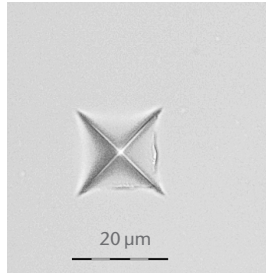
Vickers-Test

Mechanical resistance to penetration by a pointed object –

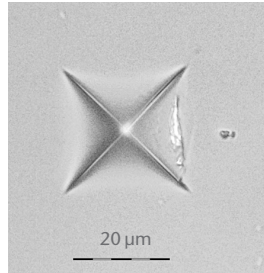
BOROFLOAT® 33 is particularly resistant due to its glass structure.



Soda-lime glass – 2 N



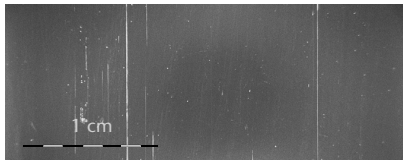
BOROFLOAT® 33 – 2 N



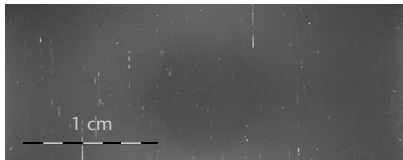
BOROFLOAT® 33 – 4 N

Scotch-Brite® – Abrasion Test:

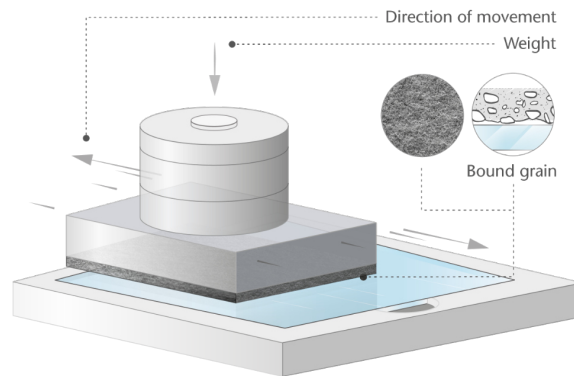
Sliding abrasion (bound grain) – **BOROFLOAT® 33 much lower abrasion.**



Soda-lime glass

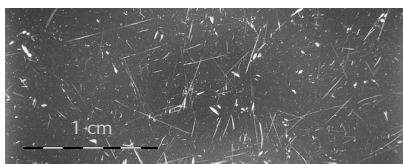


BOROFLOAT® 33

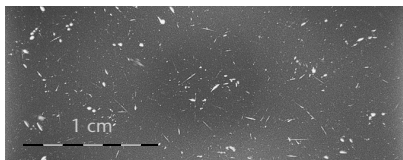


PEI Abrasion Test

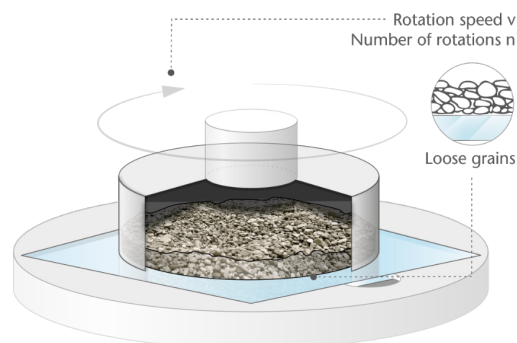
Transition from sliding abrasion to erosion (grain fill, loose grains) – **BOROFLOAT® 33 is particularly abrasion resistant.**



Soda-lime glass



BOROFLOAT® 33



DATA SHEET

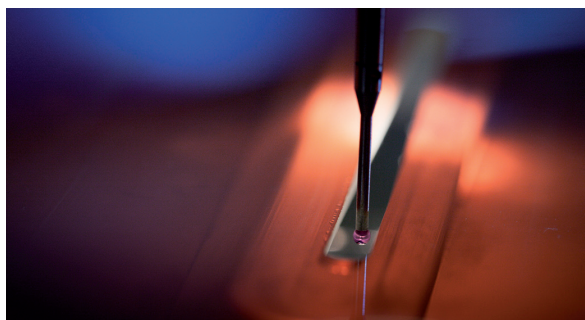
SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 & Optical Mirrors: A Union of Inspiration & Quality

The sum of its properties is what makes it unique.

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The performance requirements for optical mirrors are extremely rigorous as slight deviations can have significant impacts on the outcome of specific performance. Thermal stability is a must if mirrors are used in environments subjected to temperature changes. Excellent surface quality combined with exceptionally high transmission and reasonable cost are other attributes that engineers consider when specifying their material of choice. BOROFLOAT® glass meets such demanding requirements and has been used for sophisticated optics around the globe.



BOROFLOAT® - The sum of its properties is what makes it unique for optical mirrors

- Exceptionally high transparency
- Outstanding thermal resistance
- High chemical durability
- Broad range of sizes and thicknesses

BOROFLOAT®'s exceptionally high transparency makes it a key material of choice for optical applications in research and industry.

Optical mirrors made of BOROFLOAT® glass offer outstanding transmission

BOROFLOAT®'s exceptionally high transparency, outstanding visual quality and optical clarity make it the material of choice for many optical applications in research and industry. **High transparency in visible and near IR & UV range of wavelengths** offers customers a vast wealth of new possibilities. Specific light transmittance values are thickness dependent and significantly influenced by Fe_2O_3 impurity levels. BOROFLOAT® specialty glass uses only the purest raw materials resulting in extremely low (~90 ppm) iron impurity levels and hence exceptionally high transmission values. In fact BOROFLOAT® is the industrial glass with the lowest level of iron impurity of all float glass materials in the market.

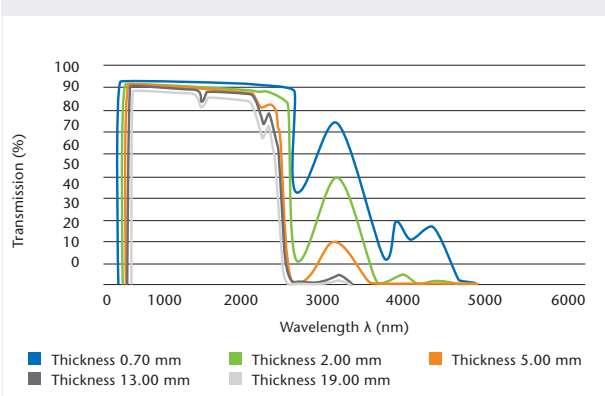
Optical data	
Abbe number ($v_e = (n_e - 1) / (n_f - n_c)$)	65.41
Refraction index ($n_d (\lambda_{587.6 \text{ nm}})$)	1.47140
Dispersion ($n_f - n_c$)	71.4×10^{-4}
Stress-optical coefficient (K)	$4.0 \times 10^{-6} \text{ mm}^2 \text{ N}^{-1}$

Reference values, not guaranteed values.

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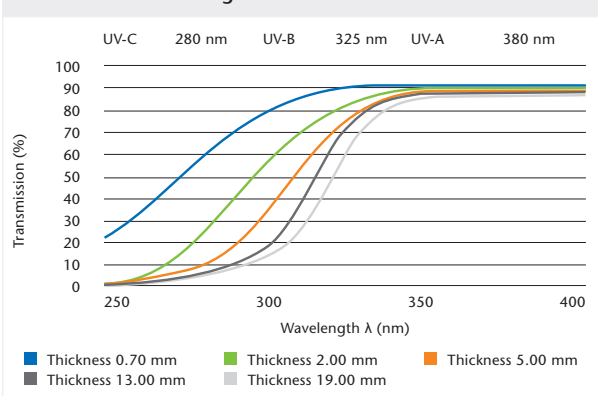
SCHOTT BOROFLOAT® 33

Transmission



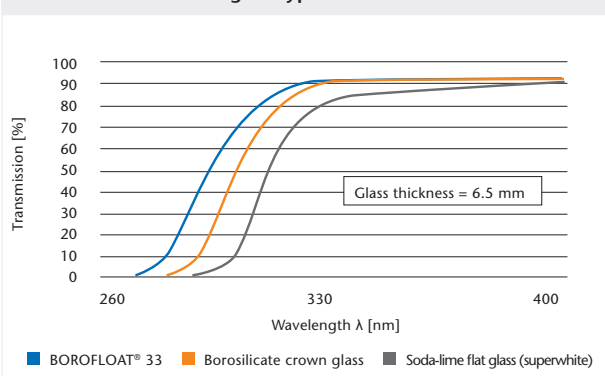
Transmission values for other thicknesses are available on request.

Transmission in UV range



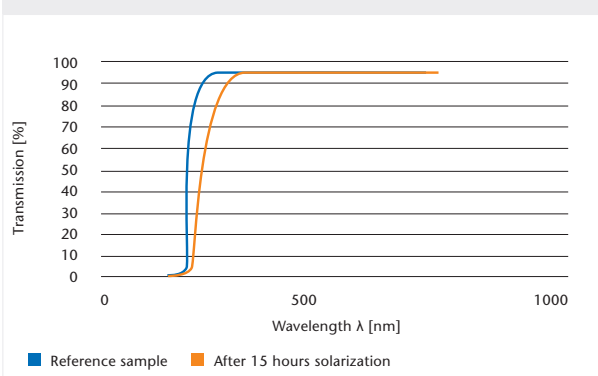
Transmission values for other thicknesses are available on request.

Transmission of various glass types



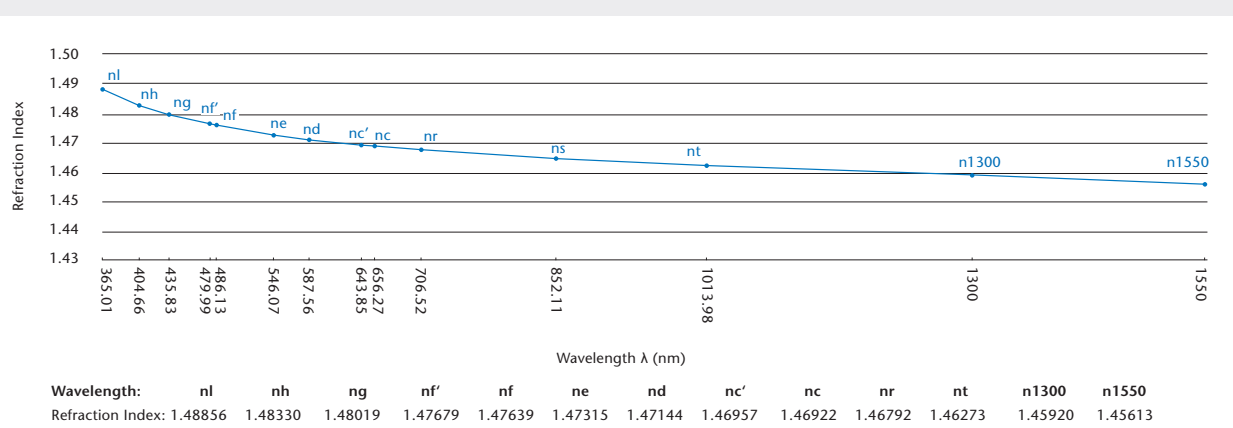
Transmission of BOROFLOAT® 33 in comparison to borosilicate crown glass and soda-lime flat glass.

Solarization



The glass sample of a size 30 x 15 x 1 mm³ is radiation-exposed by using the high-pressure mercury vapor lamp HOK 4/120. This lamp works with a radiation intensity of 850 W/cm² and with a main wavelength of 365 nm.

Refraction Index

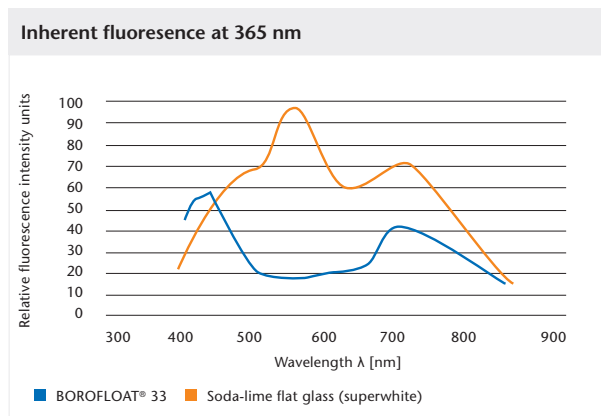


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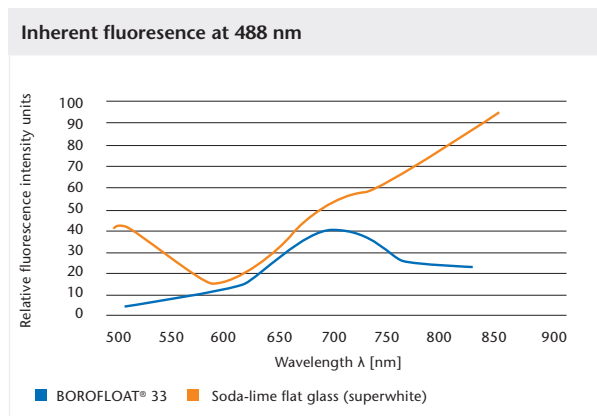
SCHOTT BOROFLOAT® 33

BOROFLOAT® glass - the ideal substrate for applications that require low inherent fluorescence

Some materials have the ability to emit electromagnetic radiation after being activated by high energy radiation. This property is referred to as fluorescence. It depends on the material's purity and structural characteristics as well as the radiation's excitation energy and excitation wavelength. BOROFLOAT® 33 is a highly transparent glass with a much **lower inherent fluorescence** than soda-lime flat glass.



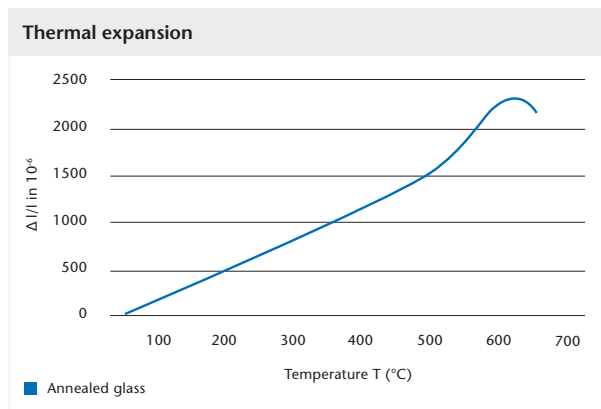
Inherent fluorescence of BOROFLOAT® 33 and soda-lime flat glass with an excitation wavelength of 365 nm.



Inherent fluorescence of BOROFLOAT® 33 and soda-lime flat glass with an excitation wavelength of 488 nm.

Optics made of BOROFLOAT® glass are resistant to thermal loads and chemical attacks

The glass composition of BOROFLOAT® specialty glass is not only tailored towards excellent optical properties. It is also designed to provide very low thermal expansion and high chemical durability. The element boron plays a significant role in delivering such special properties as it determines how strong the bonds are within the glass network. BOROFLOAT® glass is used whenever **very good temperature stability** and **excellent resistance to thermal shock** are required. It can be **thermally toughened** and **thermally shaped (3D)**. BOROFLOAT® is also **highly resistant to hydrolytics, acids and alkalis** and is known for its **low alkali diffusion**.



Thermal properties

Coefficient of	
Linear Thermal Expansion (C.T.E.) α (20 - 300 °C)	$3.25 \times 10^{-6} \text{ K}^{-1} *$
Specific heat capacity c_p (20 - 100 °C)	0.83 kJ/(kg·K)
Thermal conductivity λ (90 °C)	1.2 W/(m·K)

* According to ISO 7991.

Chemical durability

Hydrolytic resistance	(according to ISO 719 / DIN 12 111)	HGB 1
	(according to ISO 720)	HGA 1
Acid resistance	(according to ISO 1776 / DIN 12 116)	1
Alkali resistance	(according to ISO 695 / DIN 52 322)	A 2

DATA SHEET

SCHOTT BOROFLOAT® 33

The right size and thickness for any application

Forms supplied

BOROFLOAT® 33 is available in the following standard thicknesses and tolerances:

Standard thicknesses	
Thickness mm	Tolerance mm
0.70	± 0.05
1.10	± 0.05
1.75	± 0.05
2.00	± 0.05
2.25	± 0.05
2.75	± 0.10
3.30	± 0.20
3.80	± 0.20
5.00	± 0.20
5.50	± 0.20
6.50	± 0.20
7.50	± 0.30
9.00	± 0.30
11.00	± 0.30
13.00	± 0.30
15.00	± 0.40
16.00	± 0.50
19.00	± 0.50
21.00	± 0.70
25.40	± 1.00

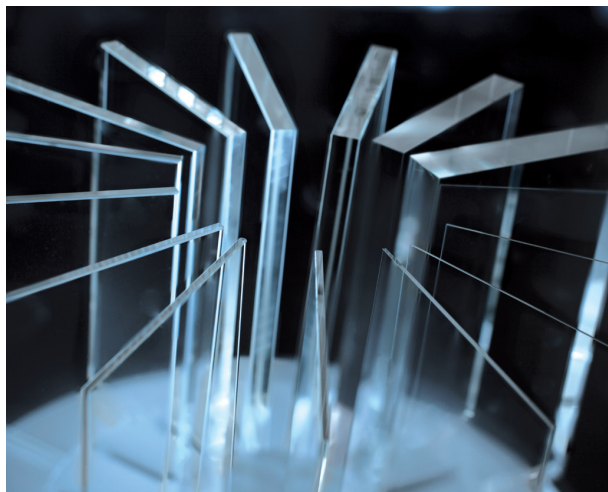
Panel thickness is continuously measured during production using laser thickness measuring equipment. Further thicknesses and tolerances are available on request.

Sizes

BOROFLOAT® 33 is available in the following standard sizes:

Standard sizes	
Size	Thickness
1,150 x 850 mm	0.7 – 25.4 mm
1,700 x 1,300 mm	16.0 – 21.0 mm
2,300 x 1,700 mm	0.7 – 15.0 mm

Standard sizes of BOROFLOAT® 33.



BOROFLOAT® 33 is available in a broad range of thicknesses.

DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Optical Properties

The sum of its properties is what makes it unique.

BOROFLOAT® 33 from Germany is the world's first floated borosilicate flat glass. It combines superior quality and excellent flatness with outstanding thermal, optical, chemical and mechanical features. The chemical composition and physical properties of BOROFLOAT® 33 are in accordance with DIN ISO 3585 and DIN EN 1748 T1. Rediscover BOROFLOAT® 33 and experience the infinite potential of our most versatile material platform. BOROFLOAT® – Inspiration through Quality.



Optical wheel made of BOROFLOAT® 33.

Optical data

Abbe number ($v_e = (n_e - 1) / (n_f - n_c)$)	65.41
Refractive index (n_d)	1.471
Dispersion ($n_f - n_c$)	71.4×10^{-4}
Stress-optical coefficient (K)	$4.0 \times 10^{-6} \text{ mm}^2 \text{ N}^{-1}$

Reference values, not guaranteed values.

Key benefits:

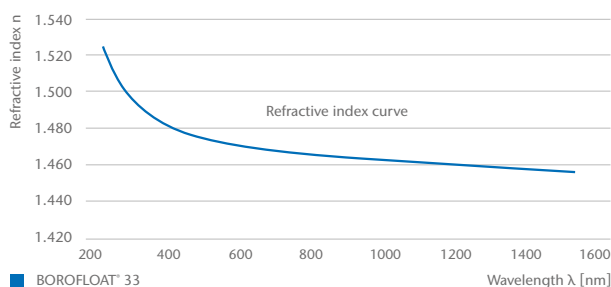
Exceptionally high transparency

- High transparency in visible and near IR & UV range of wavelengths
- Outstanding visual quality and optical clarity
- Low inherent fluorescence and solarisation tendency

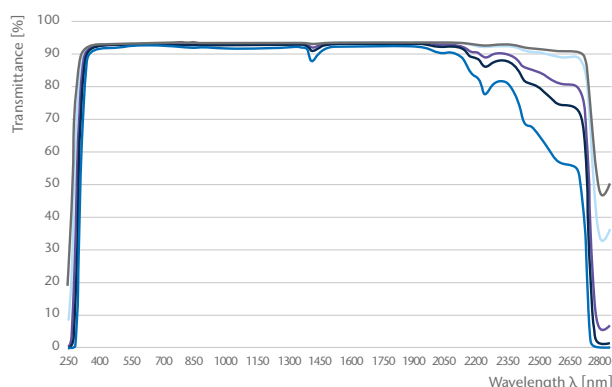
Dispersion

	$n_{248.3}^*$	$n_{296.7}$	n_i	n_g	n_f	n_e	n_d	$n_{632.8}$	n_c	n_s	n_l	$n_{1529.6}$
λ	248.3	296.7	365.0	435.8	480.0	546.1	587.6	632.8	643.8	852.1	1014.0	1529.6
n	1.525	1.504	1.489	1.480	1.477	1.473	1.471	1.470	1.470	1.465	1.463	1.456

* calculated value done by extrapolation of the dispersion curve

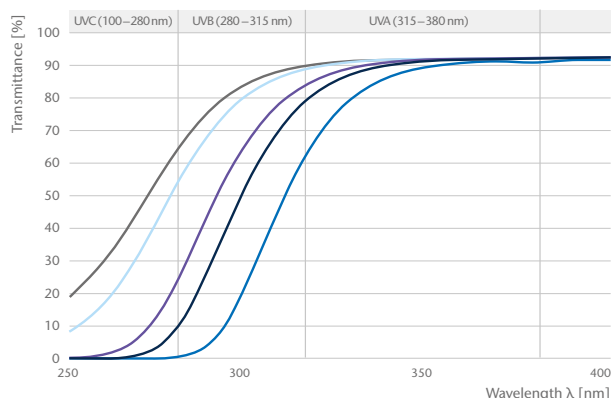


Transmittance at 250 – 2800 nm



■ thickness 0.7 mm ■ thickness 1.1 mm ■ thickness 3.3 mm ■ thickness 5.0 mm ■ thickness 11.0 mm

Transmittance at 250 – 400 nm

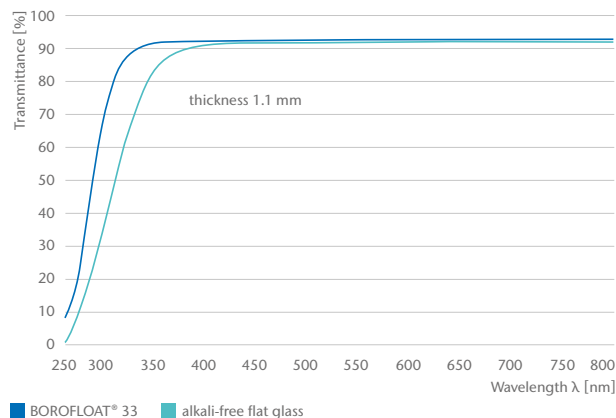


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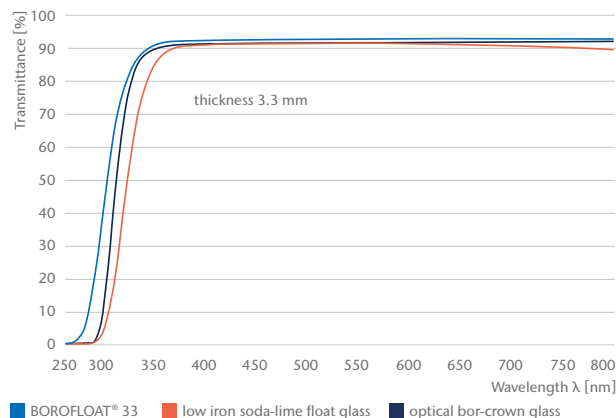
SCHOTT BOROFLOAT® 33

Transmittance at 250 – 800 nm – Comparison BOROFLOAT® 33 vs. different glass materials

For applications requiring thin glass substrates



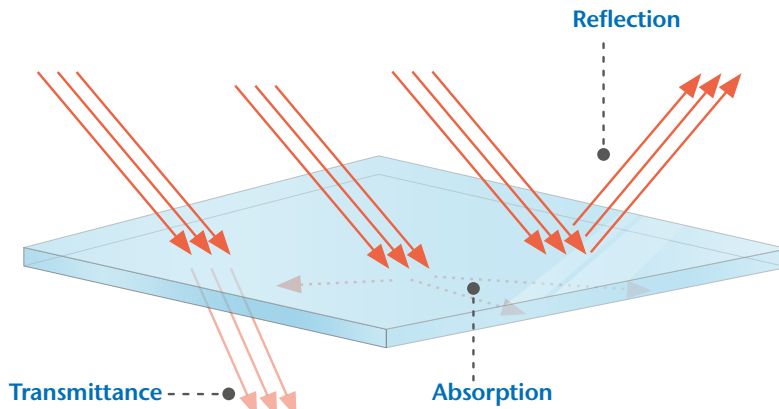
For applications requiring thicker glass substrates



Radiation of Light

Glasses transmit a certain amount of radiation energy. The incident radiation energy is reduced by absorption and reflection (up to 8 %)*. The sum of reflection, transmittance and absorption is 100 %. The glass composition, the network structure and the glass thickness as well as the wavelength of the radiation have a direct influence on the transmitted intensity of radiation energy.

* Floated glass surfaces show typically around 8 % reflection losses.



Ultraviolet transmittance τ_{UV} and light transmittance τ_V

The ultraviolet transmittance τ_{UV} and light transmittance τ_V are calculated values according to the methods described in DIN EN 410:2011-04. This European Standard describes methods of determining the luminous and solar characteristics of glazing in buildings.

		BOROFLOAT® 33							low iron soda-lime float glass		alkali- free flat glass *
Glass thickness	mm	0.7	1.1	3.3	3.8	5.0	9.0	11.0	3.3	5	1.1
τ_{UV} (280–380 nm)	%	91.8	91.6	90.5	89.9	89.3	85.9	84.9	83.7	80.0	84.1
τ_V (380–780 nm)	%	92.8	92.7	92.6	92.5	92.5	92.0	91.9	91.5	91.0	92.3

* drawn TFT-LCD glass

All values listed on the data sheet are not guaranteed reference values.

DATA SHEET

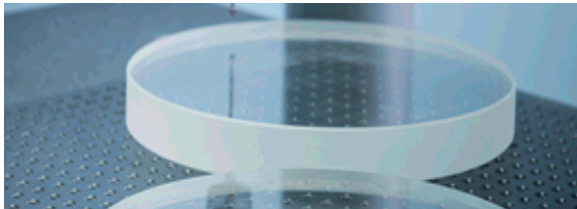
SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 & Sight Glass: A Union of Inspiration & Quality

The sum of its properties is what makes it unique.

More than 20 years ago, SCHOTT set up the first micro-float production line for what would soon become one of the most influential specialty glass materials. The result was BOROFLOAT® – the world's first floated borosilicate glass. With high-quality German engineering at its core, BOROFLOAT® quickly became an outstanding example of what seamless interaction between advanced know-how, innovative technology and professional curiosity – all in combination with the developmental drive of our team of experts – can deliver.

The performance requirements for sight glasses, used to verify process conditions in piping, vessels, chemical reactors or other industrial equipment, are extremely high. Subjected to elevated temperatures, chemical attack and high pressure - specifying the right material is critical in order to ensure safety in even the harshest environments. While many materials fail to address such challenging conditions, this is where BOROFLOAT® feels right at home.



The performance requirements for sight glasses are extremely high.

BOROFLOAT® - The sum of its properties is what makes it unique for sight glass applications!

- Outstanding thermal resistance
- High chemical durability
- Excellent mechanical strength
- Exceptionally high transparency

BOROFLOAT® 33 sight glasses stand up to high thermal loads

A particularly low coefficient of thermal expansion makes BOROFLOAT® remarkably resistant to high temperature levels. Our borosilicate glass is proven to stand up to not only high, but also fluctuating temperatures which are typical for sight

glass windows used in chemical, pharmaceutical, food & beverage and many other industries. Even with applications where rapid cooling from higher temperatures is the requirement, BOROFLOAT® easily passes the test.

Maximum operating temperatures

Maximum Operating Temperature	
For short-term usage (< 10 h)	500 °C
For long-term usage (≥ 10 h)	450 °C

The maximum operation temperatures for BOROFLOAT® should be seen in conjunction with RTG (Resistance to Temperature Gradients) and RTS (Resistance to Thermal Shock) values. Such values and test methods are available on request.

Thermal properties

Coefficient of	
Linear Thermal Expansion (C.T.E.) $\alpha_{(20-300\text{ °C})}$	$3.25 \times 10^{-6} \text{ K}^{-1} *$
Specific heat capacity $c_p_{(20-100\text{ °C})}$	0.83 kJ/(kg·K)
Thermal conductivity $\lambda_{(90\text{ °C})}$	1.2 W/(m·K)

* According to ISO 7991.

BOROFLOAT® 33 sight glasses are extremely resistant to chemical attack

Chemical durability

Hydrolytic resistance	(according to ISO 719 / DIN 12 111)	HGB 1
	(according to ISO 720)	HGA 1
Acid resistance	(according to ISO 1776 / DIN 12 116)	1
Alkali resistance	(according to ISO 695 / DIN 52 322)	A 2

Acids, alkalis and organic substances have virtually no negative impact on BOROFLOAT® glass. Its high resistance to water is another important performance benefit for many industrial applications. Such exceptional chemical resistance is the reason why this type of borosilicate glass has been successfully used in the chemical, pharmaceutical and food industry for over 130 years as annual edge sight glasses, laboratory glassware, chemical reactors, vials, ampules and even cookware.

DATA SHEET

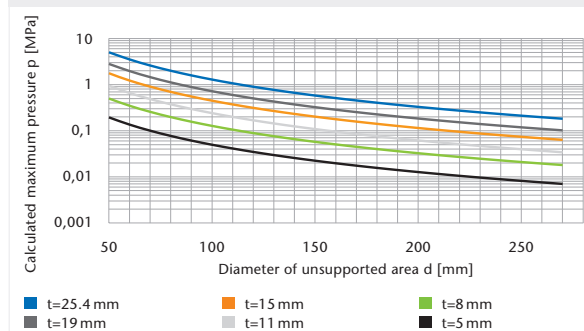
SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 sight glasses stand up to high mechanical loads

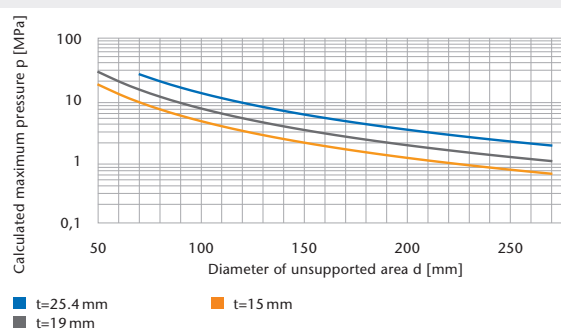
Mechanical properties	
Density ρ (25 °C)	2.23 g/cm ³
Young's Modulus E (according to DIN 13316)	64 kN/mm ²
Poisson's Ratio μ (according to DIN 13316)	0.2
Knoop Hardness $H_{0,1/20}$ (according to ISO 9385)	480

Thermally toughened BOROFLOAT® glass is characterized by high bending strength, in combination with outstanding abrasion and scratch resistance. These properties are particularly crucial when high pressure and mechanical loads play an important role. The material's low inherent weight makes it ideal for lightweight glazings and applications in modern high-tech facilities. BOROFLOAT® delivers lightweight resistance! To further increase strength, BOROFLOAT® glass can be thermally toughened to allow it to withstand even higher pressure loads.

Circular sight glass at room temperature
annealed BOROFLOAT® 33 (design strength 6 MPa)



Circular sight glass at room temperature
BOROFLOAT® 33 high pressure heat strengthened 54 MPa (design strength 60 MPa)



BOROFLOAT® 33 sight glasses guarantee clear views

Essential for view ports and sight glasses are outstanding visual quality along with high clarity and excellent transmission. BOROFLOAT® glass outperforms many soda-lime glasses due to its low iron content which results in exceptional UV and light transmission and has made BOROFLOAT® glass the material of choice for many optical applications.

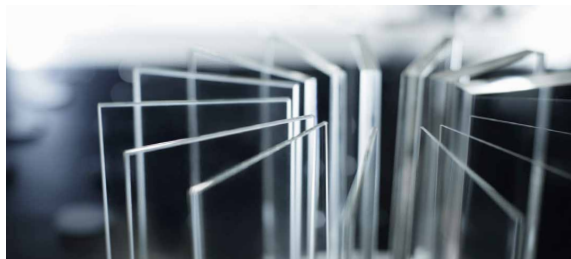
BOROFLOAT® 33 sight glasses – your choice for any harsh environment

Elevated temperatures, chemical attack and high pressure – alone or in combination – need to be considered when specifying a material that can safely resist such environments. The thickness and diameter of a sight glass must be determined in order to be able to satisfactorily meet the expected pressure and thermal loads. SCHOTT has years of experience and supports sight glass fabricators in designing safe and lightweight products. Please request our technical paper „BOROFLOAT® & Sight Glass: A Union of Inspiration & Quality“ to learn more about sight glass calculations. It contains calculation examples and pressure charts allowing you to easily determine which glass thickness and diameter to use for your specific application.

DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Technical Data



The world's first floated Borosilicate Glass.

Key benefits:

- Outstanding thermal resistance
- Exceptionally high transparency
- High chemical durability
- Excellent mechanical strength

Thermal properties

Coefficient of Linear Thermal Expansion (C.T.E.) $\alpha_{(20-300\text{ }^{\circ}\text{C})}$	$3.25 \times 10^{-6} \text{ K}^{-1} *$
Transformation temperature T_g	525 °C
Annealing Point (10^{13} dPas)	560 °C
LITTLETON temperature/Softening point ($10^{7.6}$ dPas)	820 °C
Thermal conductivity λ (90 °C)	1.2 W/(m·K)
Specific heat capacity c_p (20–100 °C)	0.83 kJ/(kg·K)
Maximum Operating Temperature	
For short-term usage (< 10 h)	500 °C
For long-term usage (≥ 10 h)	450 °C

* According to ISO 7991.

Optical Properties

Refraction index ($n_d(\lambda_{587.6 \text{ nm}})$)	1.471
Dispersion ($n_f - n_c$)	71.4×10^{-4}
Low inherent fluorescence and solarisation tendency	

Chemical durability

Hydrolytic resistance	(according to ISO 719 / DIN 12 111)	HGB 1
	(according to ISO 720)	HGA 1
Acid resistance	(according to ISO 1776 / DIN 12 116)	1
Alkali resistance	(according to ISO 695 / DIN 52 322)	A 2

Mechanical properties

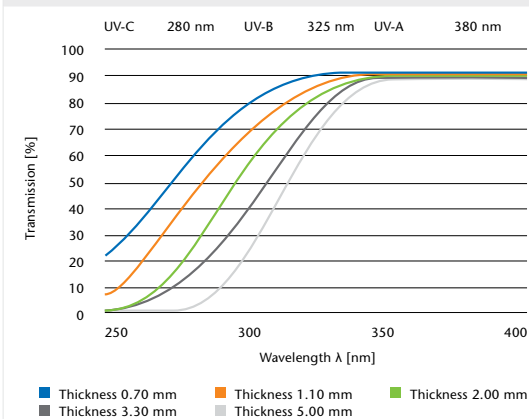
Density ρ (25 °C)	2.23 g/cm ³
Young's Modulus E (according to DIN 13316)	64 kN/mm ²
Poisson's Ratio μ (according to DIN 13316)	0.2
Knoop Hardness $H_{0.1/20}$ (according to ISO 9385)	480
Bending Strength σ (according to DIN 52292 T 1)	25 MPa
Impact resistance	

The impact resistance of BOROFLOAT® 33 depends on the way it is fitted, the size and thickness of the panel, the type of impact involved, presence of drill holes and their arrangement as well as other parameters.

Electrical Properties

Dielectric Constant ϵ_r (1 MHz & 25 °C)	4.6
Loss Tangent $\tan \delta$ (1 MHz & 25 °C)	37×10^{-4}
Specific Volume Resistance in $\Omega \text{ cm}$	
$\log \rho$ 250 °C	8.0
$\log \rho$ 350 °C	6.5

Transmission in UV range



DATA SHEET

SCHOTT BOROFLOAT® 33

BOROFLOAT® 33 – Thermal Properties

The sum of its properties is what makes it unique.

BOROFLOAT® 33 from Germany is the world's first floated borosilicate flat glass. It combines superior quality and excellent flatness with outstanding thermal, optical, chemical and mechanical features. The chemical composition and physical values of BOROFLOAT® 33 are in accordance with DIN ISO 3585 and DIN EN 1748 T1. Rediscover BOROFLOAT® 33 and experience the infinite potential of our most versatile material platform. BOROFLOAT® – Inspiration through Quality.



Thermally resistant oven door made with BOROFLOAT® 33.

Key benefits:

Outstanding thermal resistance

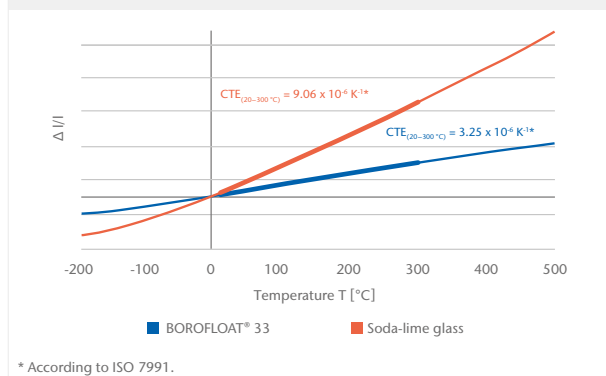
- Very good temperature stability
- Excellent resistance to thermal shock
- Can be thermally toughened
- Can be thermally shaped (3D)

Thermal properties

Specific heat capacity c_p (20–100 °C)	0.83 kJ/(kg·K)
Thermal conductivity λ (90 °C)	1.2 W/(m·K)
Transformation temperature T_g^* (according to ISO 7884)	525 °C

* Equivalent term: glass transition temperature.

Coefficient of Linear Thermal Expansion (CTE)

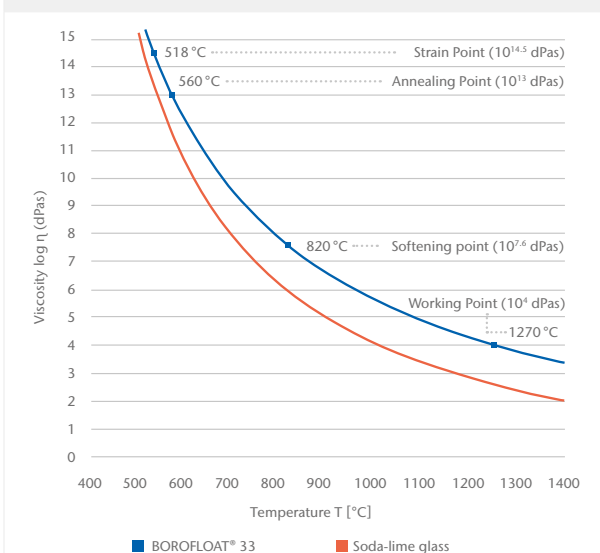


The CTE of BOROFLOAT® 33 is 3 times lower than the CTE of Soda-lime glass.

Maximum Operating Temperature

For short-term usage (< 10 h)	500 °C
For long-term usage (≥ 10 h)	450 °C

Viscosity of BOROFLOAT® 33



Further data and information available on request.

All values listed on the data sheet are not guaranteed reference values.