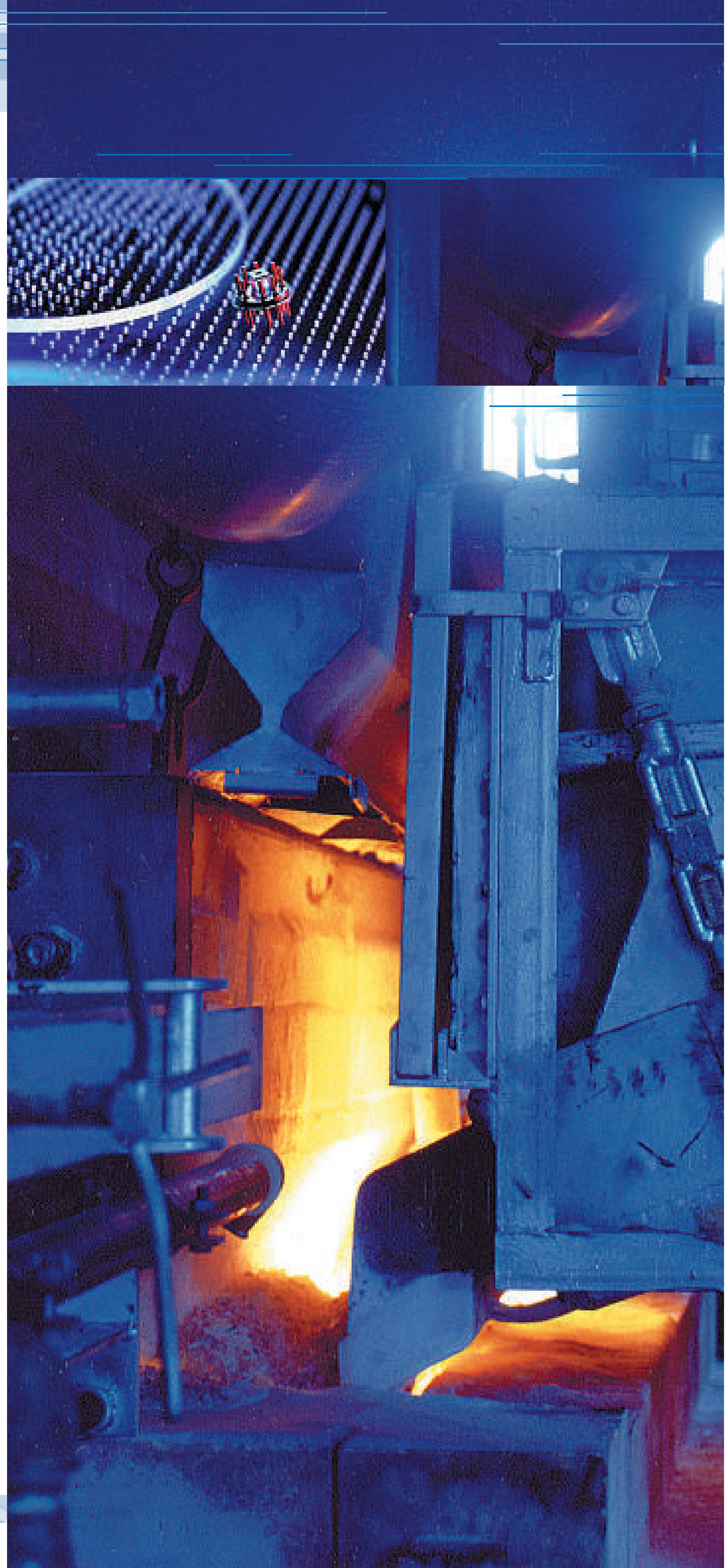
SCHOTT BOROFLOAT® 33

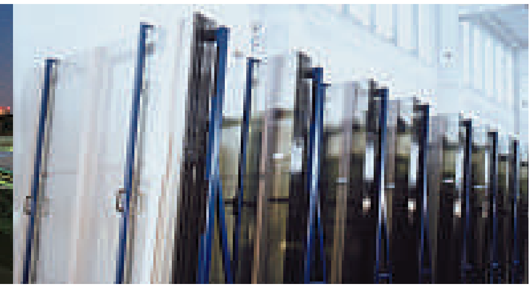
The versatile floated borosilicate glass - with an infinite number of applications

SCHOTT
glass made of ideas

▶ Summary







SCHOTT BOROFLOAT® 33

Floated Borosilicate Glass from SCHOTT

BOROFLOAT® 33 is a high quality borosilicate glass with outstanding properties for a wide-range of applications.

This unique special float glass is manufactured by SCHOTT Technical Glass Solutions GmbH using the Microfloat process and the latest technology. This technology also results in a homogeneous material that has an excellent mirror-like surface, a high degree of flatness and an outstanding optical quality.

BOROFLOAT® 33 is a clear and transparent colourless glass. Its excellent transmission and its very weak fluorescence intensities over the entire light spectrum make BOROFLOAT® 33 ideal for a wide range of applications in optics, optoelectronics, photonics and analytical equipment.

Its low thermal expansion, its high thermal shock resistance and its ability to withstand temperatures up to 450°C for long periods make BOROFLOAT® 33 a good choice for applications which call for good temperature stability (e.g. internal panels in pyrolytic self-cleaning ovens and over plates for high-power floodlights).

BOROFLOAT® 33 is highly resistant to attack by water, strong acids, alkalis as well as organic substances. Therefore it is particularly suitable for applications in the chemical industry such as sight glasses for reaction vessels and fittings.

Another interesting field of application is in medical and analytical technology. Measurements are hardly influenced by the glass receptacle because the exposure to water and acids results only in the leaching out of small amounts of ions from the glass.

BOROFLOAT® 33 has a lower density than soda lime float glass. It makes it possible to construct lightweight laminated glass systems (e.g. bulletproof glass).

BOROFLOAT® 33 has proven itself in many traditional applications and, today, there is an increasing area of usage in new and technically sophisticated special glass applications such as biotechnology, microelectronics and photovoltaics.

Fields of Application of BOROFLOAT® 33

Its special physical and chemical properties make BOROFLOAT® 33 a truly versatile performer with a broad range of uses:

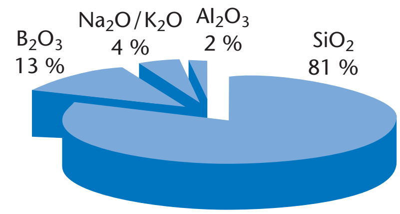
- Home Appliances (interior oven doors, fittings in microwave appliances, window panels for fireplaces)
- Environmental engineering, chemical industry (resistant linings and sight glasses for reaction vessels, microfluidic systems)
- Lighting (protective panels for spotlights and high-power floodlights)
- Photovoltaics (glass for solar collectors)
- Precision engineering, optics (optical filters and mirrors etc.)
- Medical technology, biotechnology (slides, biochips, titration plates, DNA sequencers, microfluidic systems)
- Semiconductor engineering, electronics, sensors (wafers, display glass)
- Safety (bulletproof glazing)

The quality of BOROFLOAT® 33 is ensured by our quality assurance system according to the requirements of the DIN ISO 9001.

Product Description

Chemical Composition

BOROFLOAT® 33 is a borosilicate glass type 3.3 as specified in the international standard ISO 3585 and EN 1748 T1. BOROFLOAT® 33 products meet most international standards, for example the German, British, American and French standards.



The structural characteristics and the material's purity grade (low content of polyvalent ions) of BOROFLOAT® 33 results in an overall high transmission of ultraviolet, visible and infrared wavelengths.

Thanks to its low alkali content, BOROFLOAT® 33 works as a good electric insulator.

Due to its high boron content, BOROFLOAT® 33 can be used as a neutron absorber glass in nuclear energy applications.

Environmental Safety/ Ecological Reliability

BOROFLOAT® 33 is environmentally friendly and made of natural raw materials. The glass can be recycled several times and disposed of without difficulties.

Forms Supplied

▶ ***Panel Thickness***

BOROFLOAT® 33 is offered in the following thicknesses and tolerances, in mm (in.):

Thickness		Tolerance	
0.70	(0.027)	± 0.07	(0.003)
1.10	(0.043)	± 0.1	(0.004)
1.75	(0.069)	± 0.1	(0.004)
2.00	(0.079)	± 0.2	(0.008)
2.25	(0.089)	± 0.2	(0.008)
2.75	(0.108)	± 0.2	(0.008)
3.30	(0.130)	± 0.2	(0.008)
3.80	(0.150)	± 0.2	(0.008)
5.00	(0.197)	± 0.2	(0.008)
5.50	(0.216)	± 0.2	(0.008)
6.50	(0.256)	± 0.2	(0.008)
7.50	(0.295)	± 0.3	(0.012)
8.00	(0.315)	± 0.3	(0.012)
9.00	(0.354)	± 0.3	(0.012)
11.00	(0.433)	± 0.3	(0.012)
13.00	(0.512)	± 0.5	(0.020)
15.00	(0.590)	± 0.5	(0.020)
16.00	(0.630)	± 0.5	(0.020)
18.00	(0.708)	± 0.5	(0.020)
19.00	(0.748)	± 0.5	(0.020)
20.00	(0.787)	± 0.7	(0.027)
21.00	(0.827)	± 0.7	(0.027)
25.40	(1.000)	± 1.0	(0.040)

Panel thickness is continuously measured during production using laser thickness measuring equipment. Other nominal thicknesses and tolerances are supplied on request.

Forms Supplied

Sizes

Standard Sizes		Thickness	
1150 x 850 mm²	(45.3 x 33.5 in.²)	0.7–25.4 mm	(0.027 to 1.000 in.)
1700 x 1300 mm²	(66.9 x 51.2 in.²)	16.0–21.0 mm	(0.630 to 0.827 in.)
2300 x 1700 mm²	(90.5 x 66.9 in.²)	3.3–15.0 mm	(0.130 to 0.590 in.)

Min. size for stock sizes	700 x 575 mm²	(28 x 23 in.²)
Max. size for stock sizes	3000 x 2300 mm²	(120 x 92 in.²)
	[for 5.5 to 9 mm (0.216–0.354 in.) thickness]	

We will be happy to provide other sizes upon request.

Processing and Finishing

Our BOROFLOAT® 33 product range is complemented by a wide variety of processing and finishing possibilities:

Processing:

1.1 Cutting (including water jet and laser)

1.2 Edge finish (arrissed, bevelled, ground or polished edges) and corner finish (dubbed or rounded corners)

1.3 Drilling (including ultrasonic)

Finishing:

2.1 Coating

2.2 Thermal semi-toughening

2.3 Printing, sandblasting/matte finishing

2.4 Surface polishing

2.5 Bending

2.6 Subsurface laser engraving

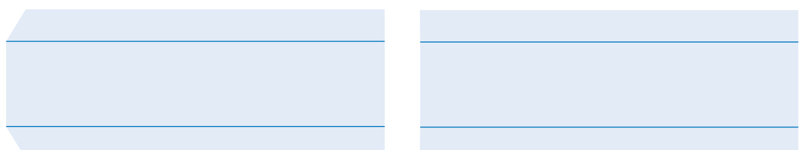
Forms Supplied

► *Processing*

1.1 **Cutting:** BOROFLOAT® 33 can be cut to size within the standard sizes. The minimum dimensions of cut-to-size sheets will be supplied on request.

1.2 **Edge and corner finish:** The standard edge finish for cut-to-size panels is RK2 following DIN 1249 T 11, see sketch 1.2.a and prEN 13024 – 1, see sketch 1.2.b.
Other edge forms (ground and polished) on request.

1.2.a: Rounded edge, flat-arrissed (RK2)



1.2.b: Ground edge

The standard corner working is dubbed. Sheet can also be supplied on request with corner radii.

1.3 **Drilling:** BOROFLOAT® 33 can be supplied with boreholes as agreed. *Processing*

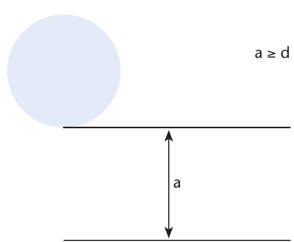
Diameter of boreholes
BOROFLOAT® 33 can be supplied with boreholes of Ø 2 mm and larger.
BOROFLOAT® 33 with cut-outs on request.

Limitations on the position of boreholes
Limitations on the position of boreholes in relation to the edges and corners of the sheet and also to each other are generally dependent on:

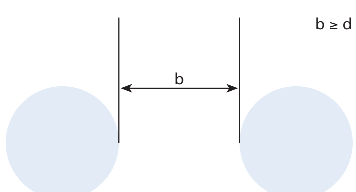
- the nominal thickness of the glass (*d*),
- the sheet dimensions (B, H),
- the diameter of the hole (Ø)
- the shape of sheet.

The following limitations on the position of holes apply to sheets with a maximum of four holes. If the sheet has a different hole configuration, other limitations may apply. Details on request.

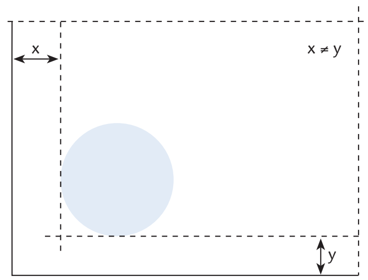
1. The distance *a* between the edge of the hole and the edge of the glass should not be less than the thickness of the glass *d*.



2. The distance *b* between the edges of the various holes should also not be less than *d*.



3. Depending on the position of the holes in relation to the corner of the glass it is possible for the distance to the two sides edges to be different. Details on request.



4. Permitted borehole position deviation:
   Deviation of borehole center: ± 1.5 mm.

2.1 **Coating**

Coating with composite materials can be used to vary the specific properties of BOROFLOAT® to match the requirements of a particular application. This increases its functionality:

BOROFLOAT® M with reflective coating

The application of appropriate interference layers (e.g. metal oxides) results in the part of the radiation of visible light responsible for the reflection being semireflected particularly well (reflection wanted). Due to the reflection effect e.g. appliance components located behind the glass can be concealed. Typical applications of this nature are to be found in the lighting industry.

BOROFLOAT® AR with anti-reflective coating

The application of appropriate interference layers results in the part of the radiation responsible for the reflection being reduced (reflection and mirror effect largely prevented). There are applications for BOROFLOAT® AR everywhere where a glass is required without any irritating reflections.

Coated BOROFLOAT® 33 is supplied in the 3.3 mm thickness and 1150 x 850 mm sheet size. We will be happy to provide information about other thickness and sizes plus information about other coatings upon request.

2.2 **Thermal semi-toughening:**

The resistance of BOROFLOAT® 33 to thermal and mechanical loads is improved by thermal semi-toughening.

Thermal semi-toughening is possible in the thicknesses from 3.3 to 15 mm. The maximum sheet size is 3000 x 1800 mm and the minimum edge length is 300 mm. We will be happy to provide information about thickness and sizes at any time on request.

2.3–2.6 We will be happy to provide detailed information on request.

Technical Properties

The values below are generally applicable basic data for BOROFLOAT® 33. Unless stated different these are guide figures according to DIN 55 350 T12. However, they also apply to the coated versions (BOROFLOAT® AR and BOROFLOAT® M) except for the transmission data (see Optical Properties, pages 19 ff).

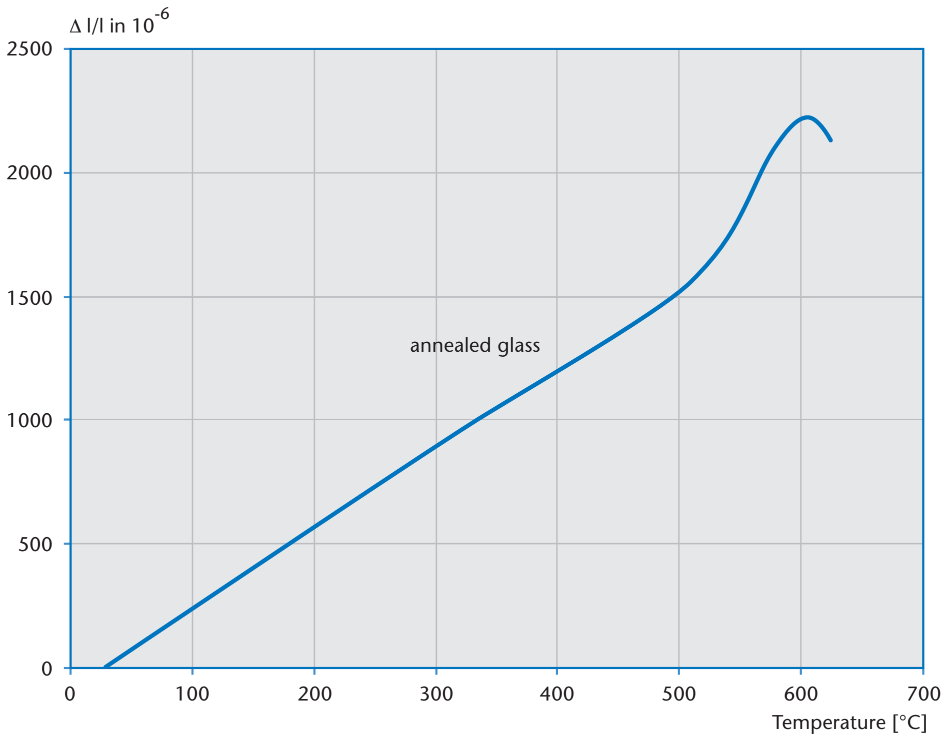
Mechanical Properties

Density (25°C)	ρ	2.2 g/cm³	
Young's Modulus	E	64 kN/mm²	(to DIN 13 316)
Poisson's Ratio	μ	0.2	(to DIN 13 316)
Knoop Hardness	$HK_{0.1/20}$	480	(to ISO 9385)
Bending strength	σ	25 MPa	(to DIN 52 292 T1)
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 involed, presence of drill holes and their arrangement as well as other parameters.		

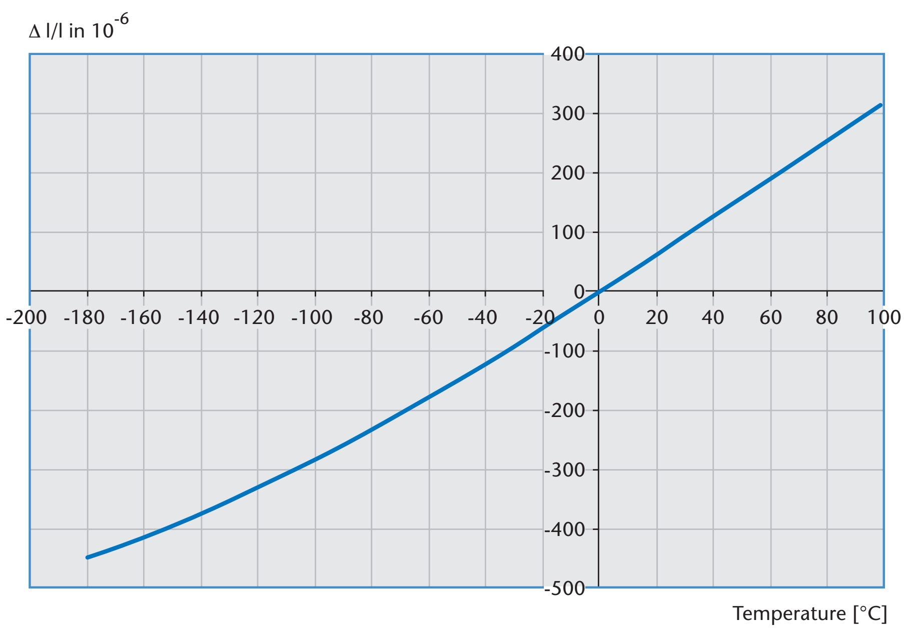
Thermal Properties

Coefficient of Linear Thermal Expansion (C.T.E.)	$\alpha_{(20–300\ °C)}$	3.25×10^{-6} K^{-1} (to ISO 7991)
Specific Heat Capacity	$c_{p\ (20–100\ °C)}$	0.83 KJ x (kg x K)$^{-1}$
Thermal Conductivity	$\lambda_{(90\ °C)}$	1.2 W x (m x K)$^{-1}$

Thermal Properties



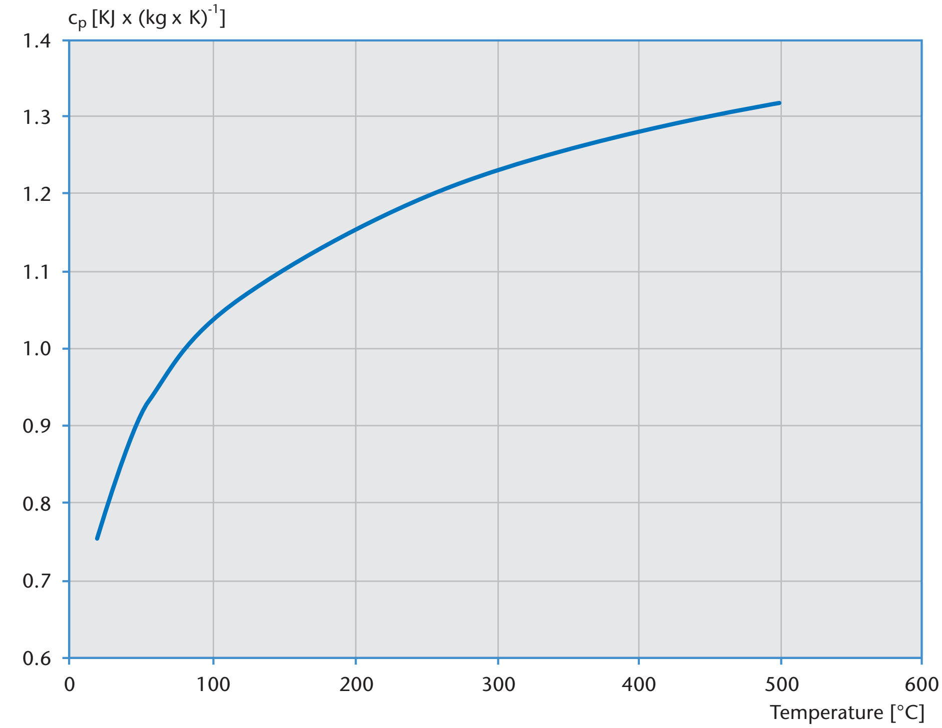
BOROFLOAT® 33 – Thermal Expansion



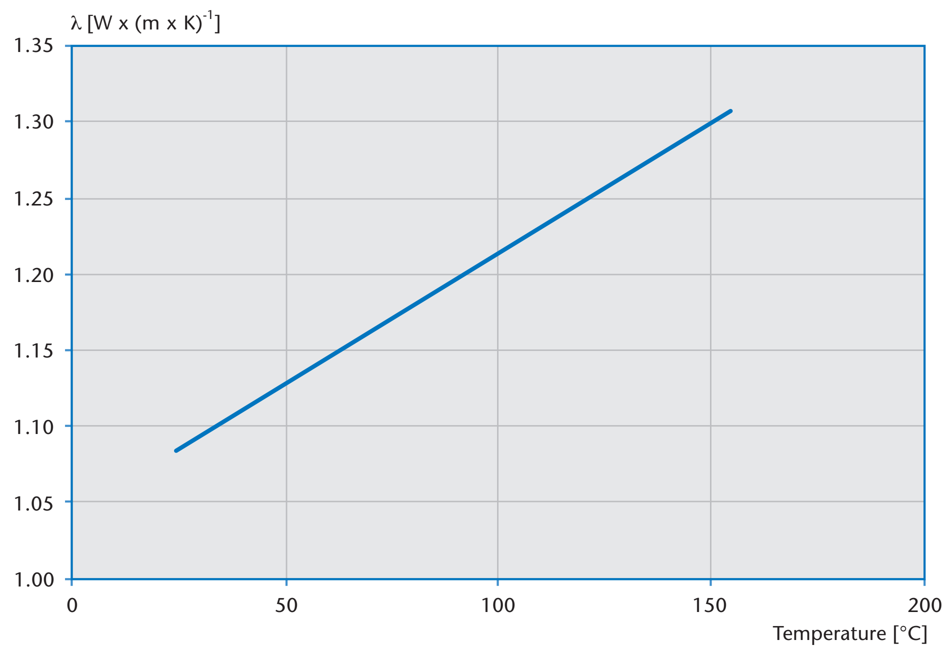
BOROFLOAT® 33 – Behavior in the Cryogenic Temperature Range

Thermal Properties

▶ ***BOROFLOAT® 33 – Specific Heat Capacity (c_p)***



▶ ***BOROFLOAT® 33 – Thermal Conductivity (λ)***



Thermal Properties

Maximum Operating Temperature

		T_{max}
For short-term usage	< 10 h	500 °C
For long-term usage	≥ 10 h	450 °C

The maximum temperatures in use indicated apply only if the following RTG and RTS values are observed at the same time.

Resistance to Thermal Gradients (RTG)

The RTG value characterizes the ability of a glass type to withstand a specific temperature difference between the hot center and the cold edges of a panel.

	RTG
< 1 hour	110 K
1–100 hours	90 K
> 100 hours	80 K

Test method: Plates of approximately 25 x 25 cm^2 (10 x 10 $in.^2$) are heated in the center to a defined temperature, and the edge of the plate is kept at room temperature, at which ≤ 5 % of the samples suffer breakage.
The plates are abraded with 40 grit sandpaper prior to the test. This simulates extreme surface damage which may occur in operation.

Resistance to Thermal Shock (RTS)

The RTS value characterizes the ability of a glass panel to withstand a sudden temperature decrease.

Glass Thickness	RTS
≤ 3.8 mm	175 K
5.0 – 5.5 mm	160 K
6.5 – 15.0 mm	150 K
> 15.0 mm	125 K

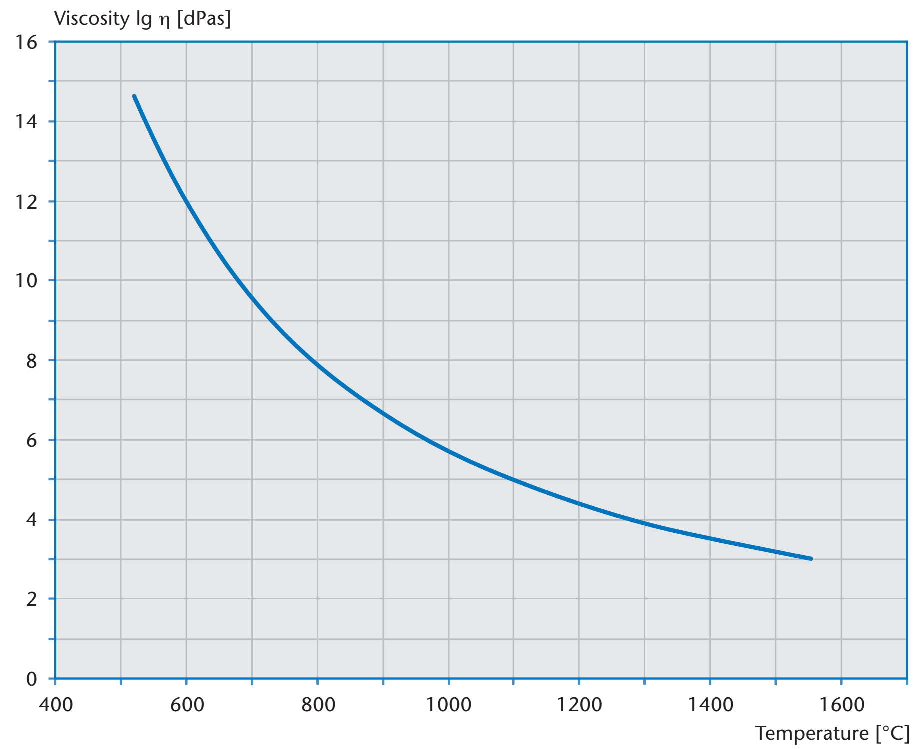
Test method: Plates of approximately 20 x 20 cm^2 (8 x 8 $in.^2$) are heated in an oven with recirculated air and then doused in the center with 50 ml (3.3 oz.) of room temperature water, at which ≤ 5 % of the samples suffer breakage.
The plates are abraded before heating with 220 grit sandpaper to simulate typical surface condition during practical use.

Thermal Properties

▶ ***Viscosity of Borosilicate Glasses***

Viscosity η			
Working Point	10^4	dPas	1270 °C
Softening Point	$10^{7.6}$	dPas	820 °C
Annealing Point	10^{13}	dPas	560 °C
Strain Point	$10^{14.5}$	dPas	518 °C
Transformation Temperature (T_g)			525 °C

▶ ***BOROFLOAT® 33 – Temperature Dependence of the Viscosity (η)***



Chemical Properties

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

Chemical Resistance of BOROFLOAT® 33 to Selected Reagents

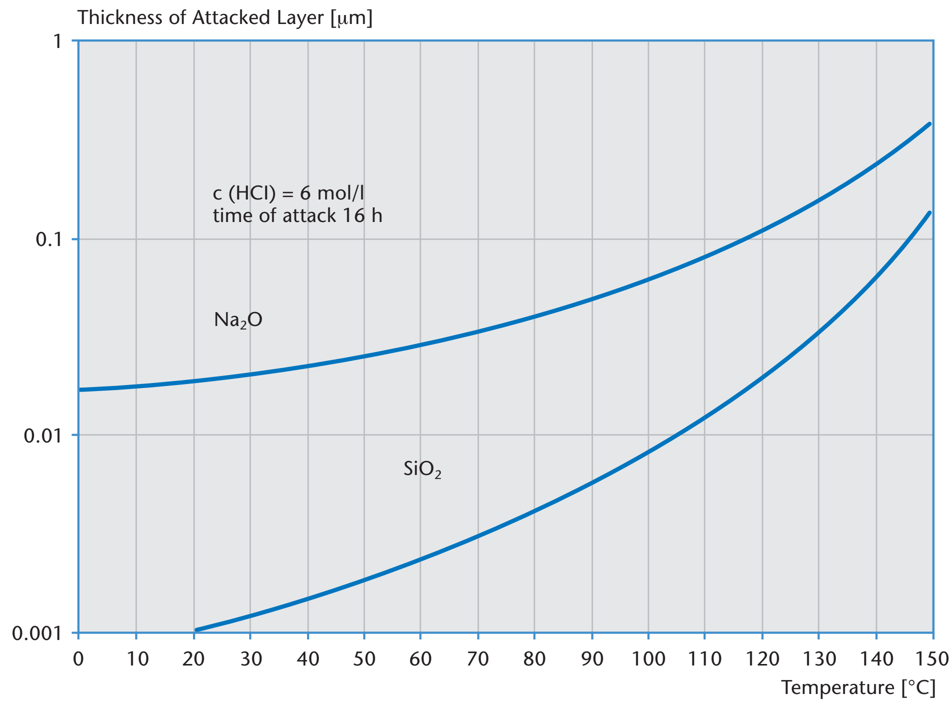
Reagent	Weight Loss [mg/cm²]	Visual Inspection Results/ Appearance
24 h at 95 °C		
5 Vol.% HCl	< 0.01	unchanged
0.02 n H_2S0_4	< 0.01	unchanged
H_20	< 0.01	unchanged
6 h at 95 °C		
5% NaOH	1.1	white stains
0.02 n NaOH	0.16	white haze
0.02 n Na_2CO_3	0.16	unchanged
20 min at 23 °C		
10% HF	1.1	stained white haze
10% NH_4F x HF	0.14	unchanged

Tin Residues

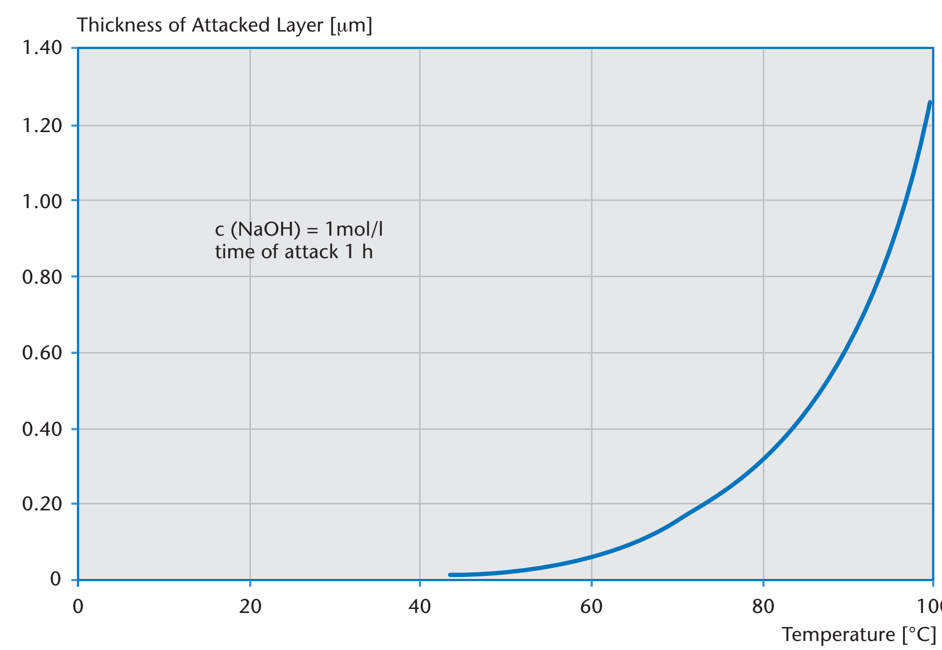
The phenomenon of tin traces on the surface is commonly known from the manufacture of soda-lime float glass. It is caused by an evaporation effect in the float bath atmosphere. These values are considerably lower for BOROFLOAT® 33 than for soda-lime float glass on both the side in contact with the tin and on the other side which is exposed to the atmosphere. The reciprocal effect with coating is thus markedly less. It is recommended that the top side (labeled by the manufacturer) is used for coatings.

Chemical Properties

Attack of Acid on BOROFLOAT® 33 Surface – Related to Temperature, Calculated from Weight Loss



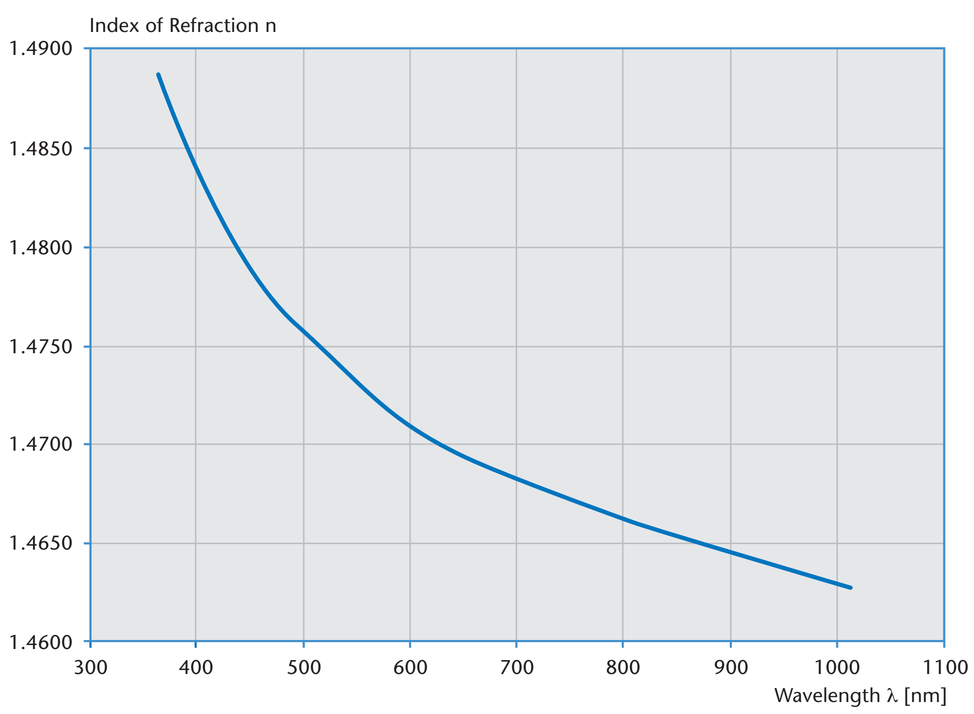
Attack of Alkali on BOROFLOAT® 33 Surface – Related to Temperature, Calculated from Weight Loss



Optical Properties

Wavelength λ (nm)	435.8	479.9	546.1	589.3	643.8	656.3
Index of Refraction n	1.48015	1.47676 ($n_{F'}$)	1.47311 (n_e)	1.47133	1.46953 ($n_{C'}$)	1.46916

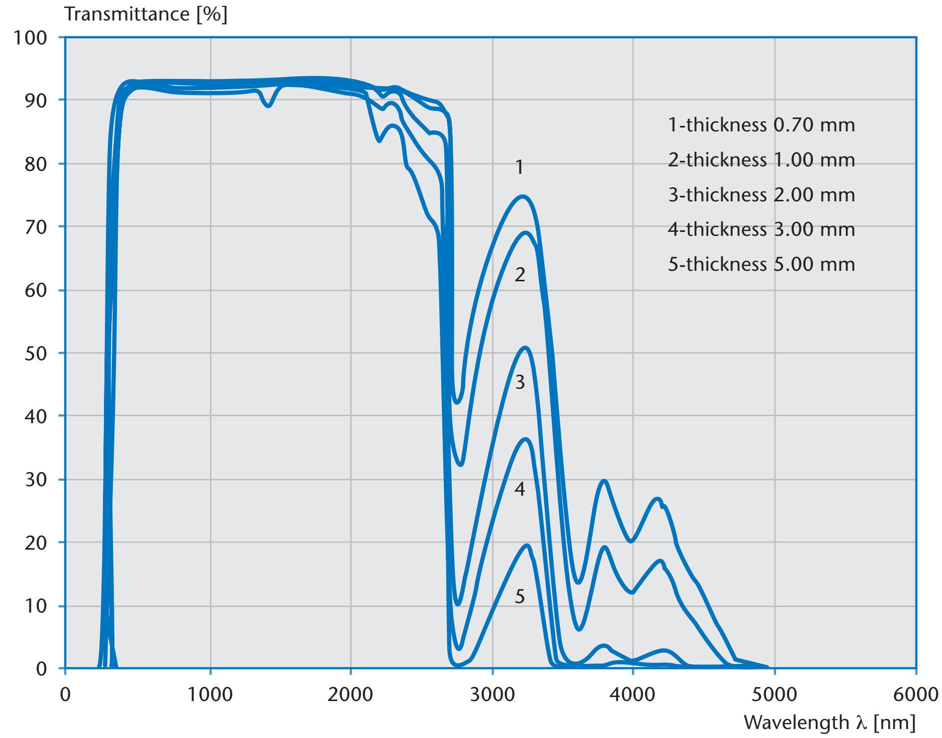
Abbe Constant	$v_e = (n_e - 1) / (n_{F'} - n_{C'})$	65.41
Refractive Index	n_d ($\lambda_{587.6\ nm}$)	1.47140
Dispersion	$n_F - n_C$	71.4×10^{-4}
Stress-optical Coefficent	K	4.0×10^{-6} $mm^2 N^{-1}$



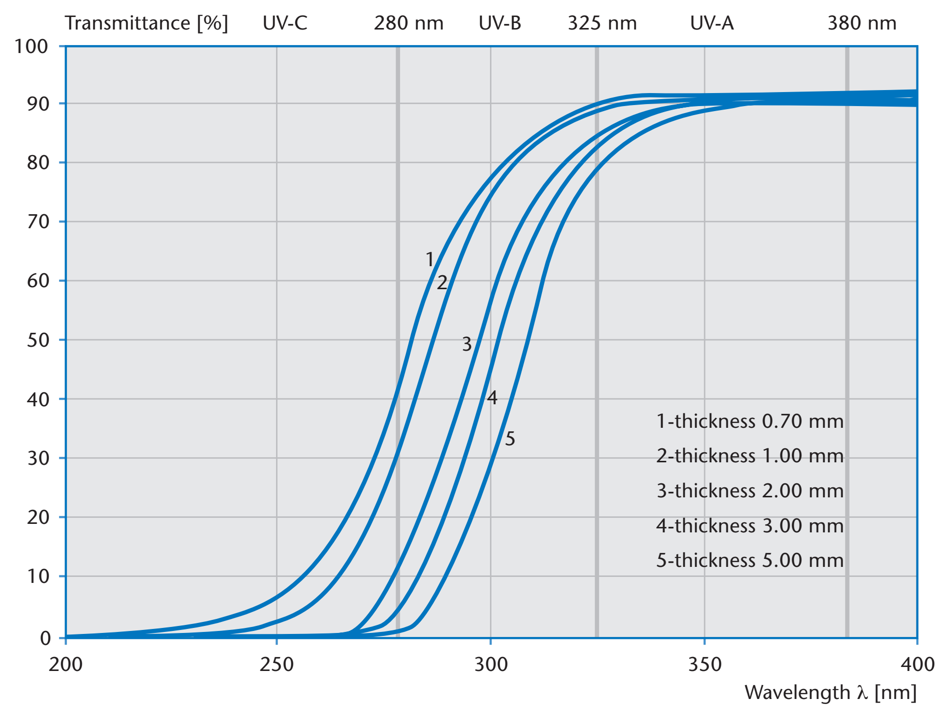
Dispersion of BOROFLOAT® 33 – Index of Refraction (n) vs. Wavelength (λ)

Optical Properties

▶ ***BOROFLOAT® 33 – Total Optical Transmittance***

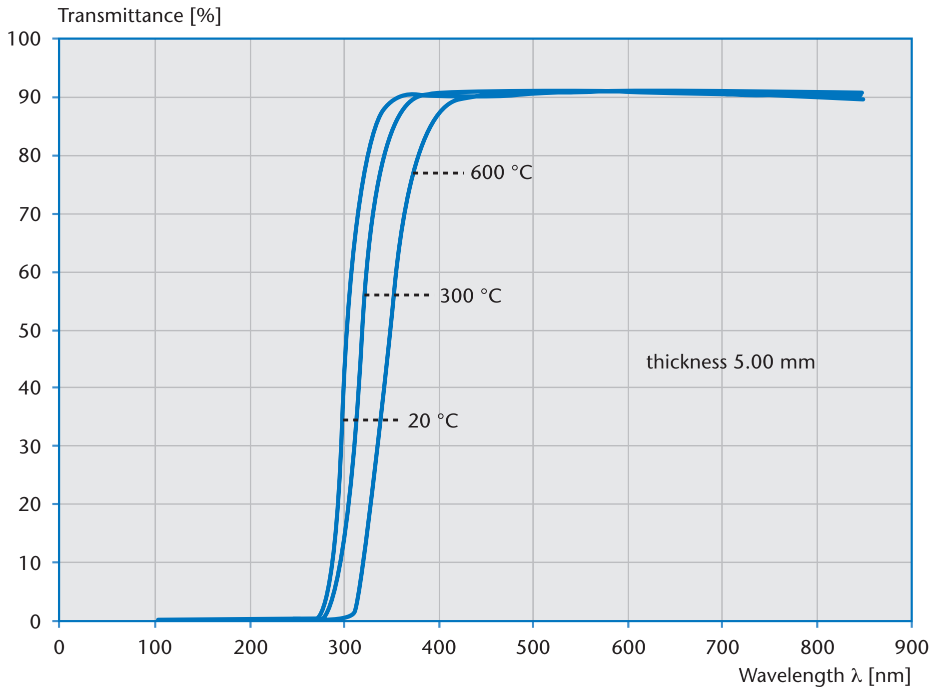


▶ ***BOROFLOAT® 33 – Transmittance in the UV Range***

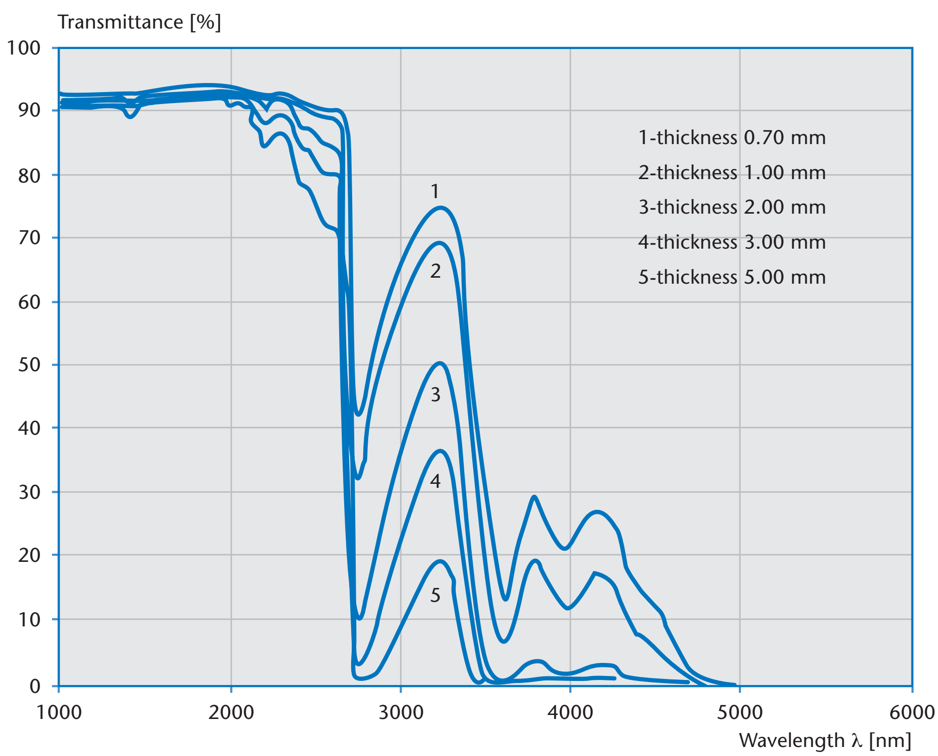


Optical Properties

BOROFLOAT® 33 – Transmittance in the UV Range Dependence on Temperature

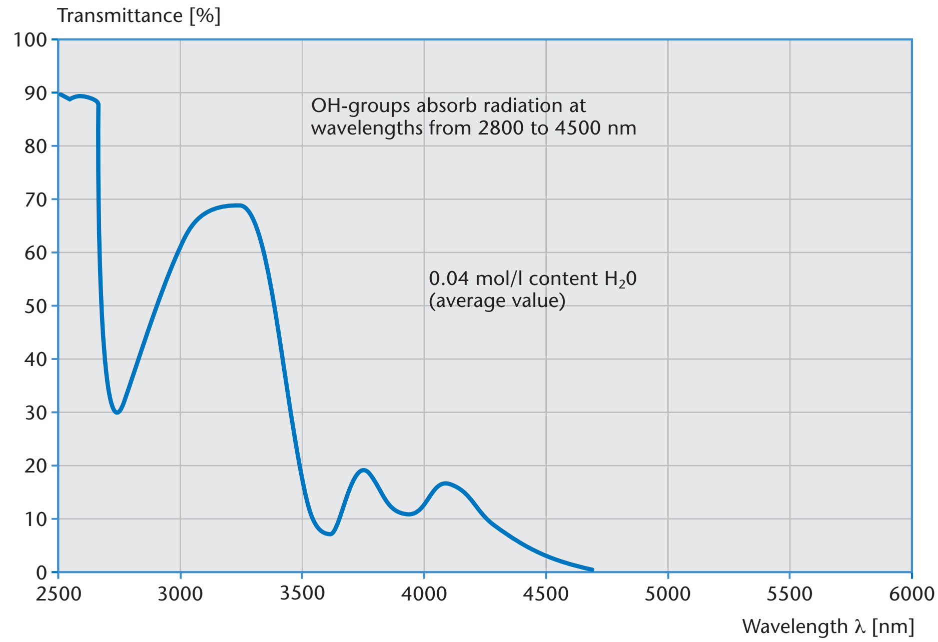


BOROFLOAT® 33 – Transmittance in the IR Range

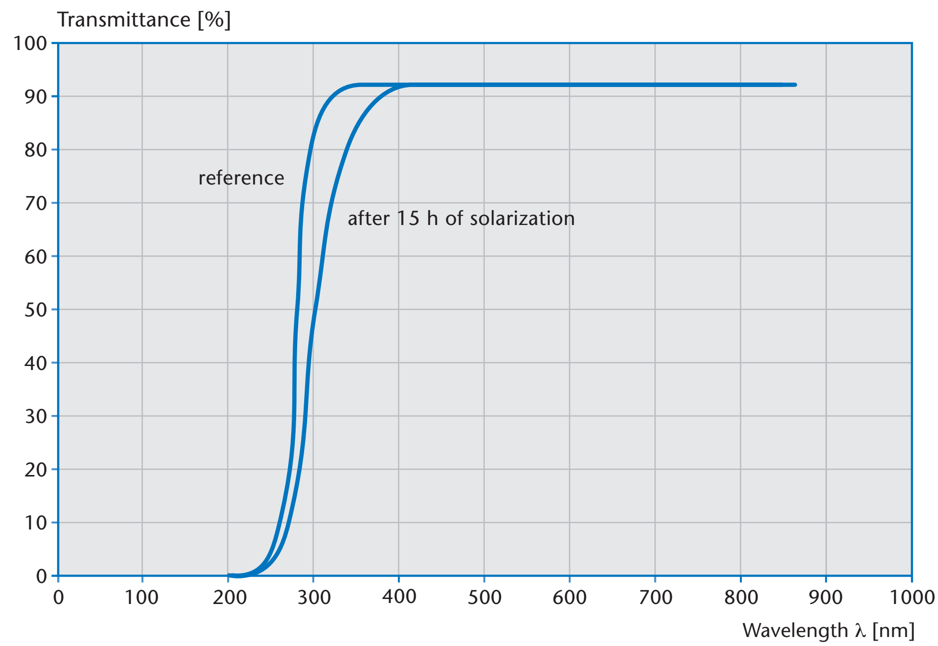


Optical Properties

BOROFLOAT® 33 – Influence of Water Content on the Transmittance



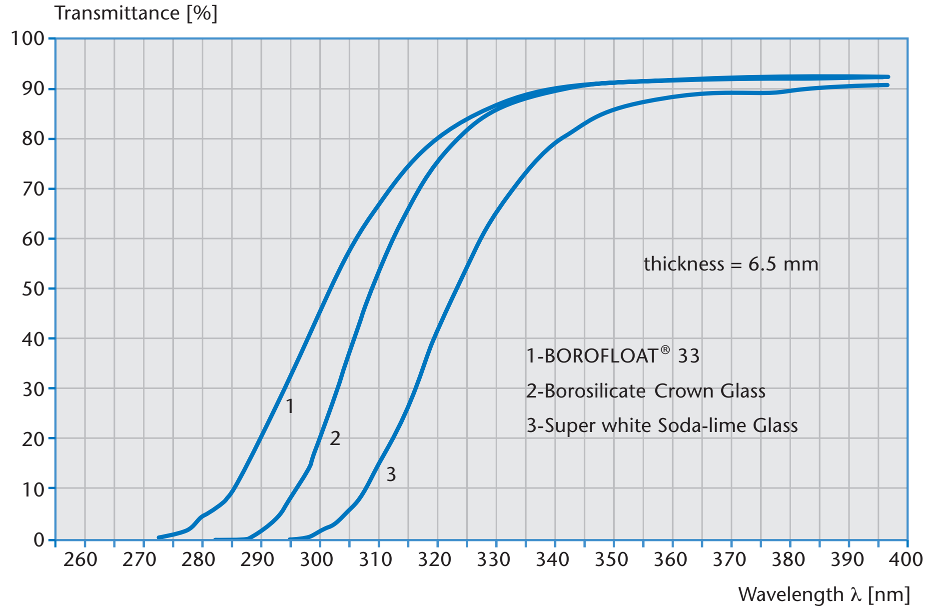
BOROFLOAT® 33 – Resistance towards Radiation Degradation



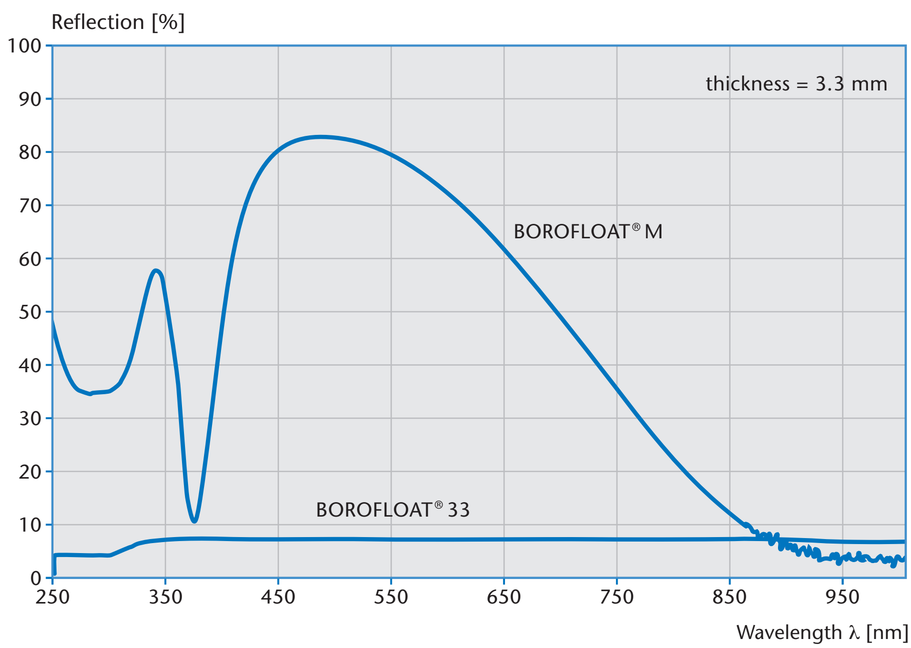
The influence of radiation on the transmittance of BOROFLOAT® 33 is measured according to the SCHOTT test conditions:

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.

Optical Properties



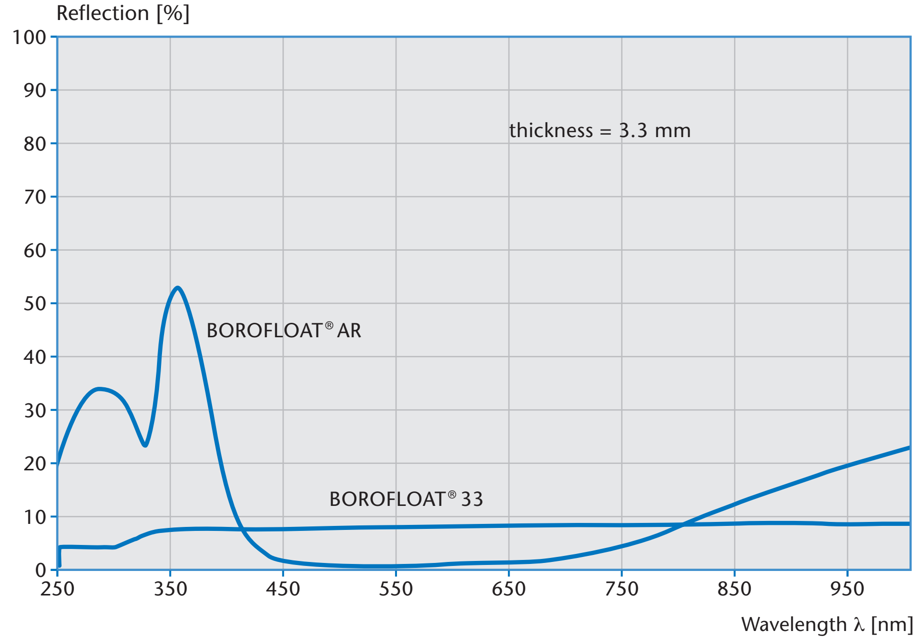
Transmittance of BOROFLOAT® 33 in Comparison with Borosilicate Crown Glass and Soda-lime Glass (superwhite)



Reflection of BOROFLOAT® 33 in Comparison with BOROFLOAT® M (with reflective coating)

Optical Properties

► ***Reflection of BOROFLOAT® 33 in Comparison with BOROFLOAT® AR (with anti-reflective coating)***



Optical Properties

Fluorescence Behavior of BOROFLOAT® 33

Some materials have the ability to emit electromagnetic radiation after being activated by high frequency short-wave radiation of high energy intensity. This behavior of the materials is called fluorescence and it depends on the material's purity and structural characteristics, as well as the energy per pulse, pulse rate and excitation wavelength of the radiation.

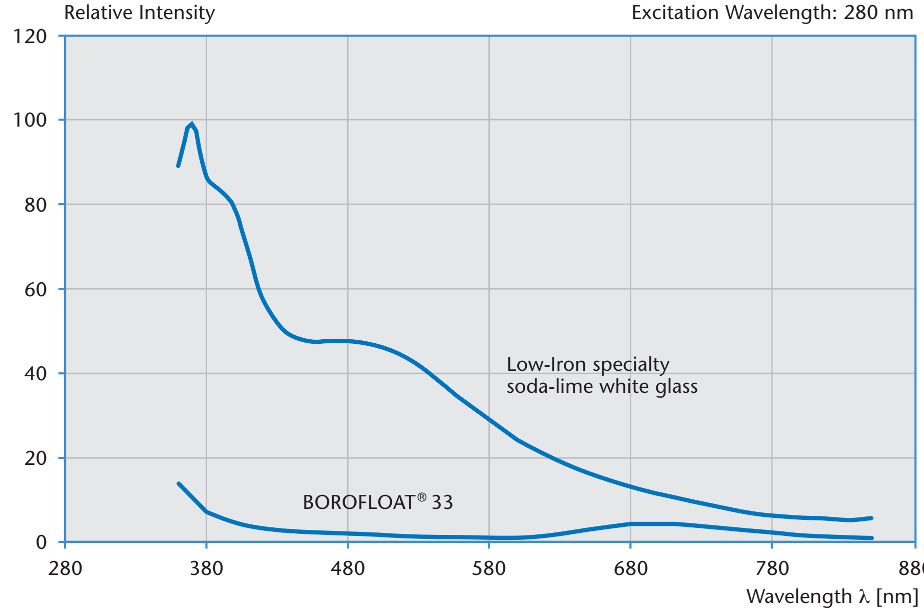
BOROFLOAT® 33 is a material with high transmission showing very weak fluorescence intensities over the whole spectrum of light.

Selected Standard Laser Wavelength and Lasing Media

Wavelength (nm)	Lasing Medium	Wavelength (nm)	Lasing Medium	Wavelength (nm)	Lasing Medium
308	XeCl	488	Ar	1047	Nd:YLF
325	HeCd	514.5	Ar	1053	Nd:YLF
337	N_2	532	Nd:YAG	1064	Nd:YAG
350	XeF	632.8	HeNe	1153	HeNe
351.1	Ar	694.3	Ruby	1319	Nd:YAG
363.8	Ar	730-780	Alexandrite	1730	Er:YLF
427	N_2	850	Er:YLF	2060	Ho:YLF
441.6	HeCd	905	GaAs	10640	CO_2

Optical Properties

Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation



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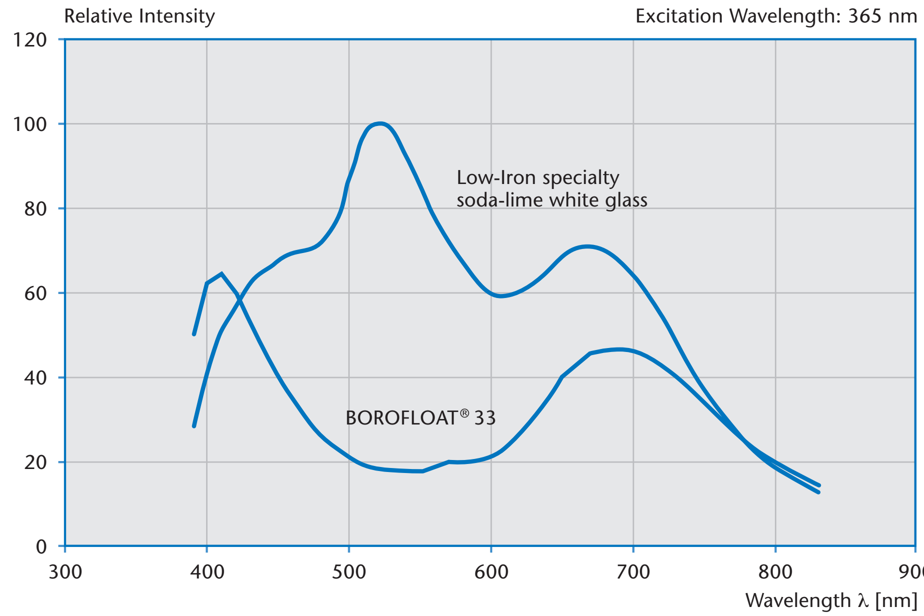
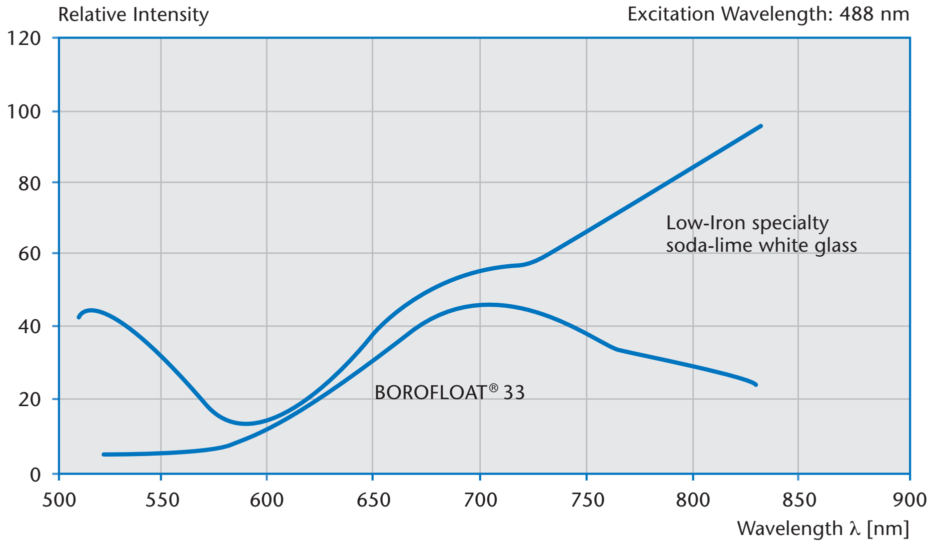
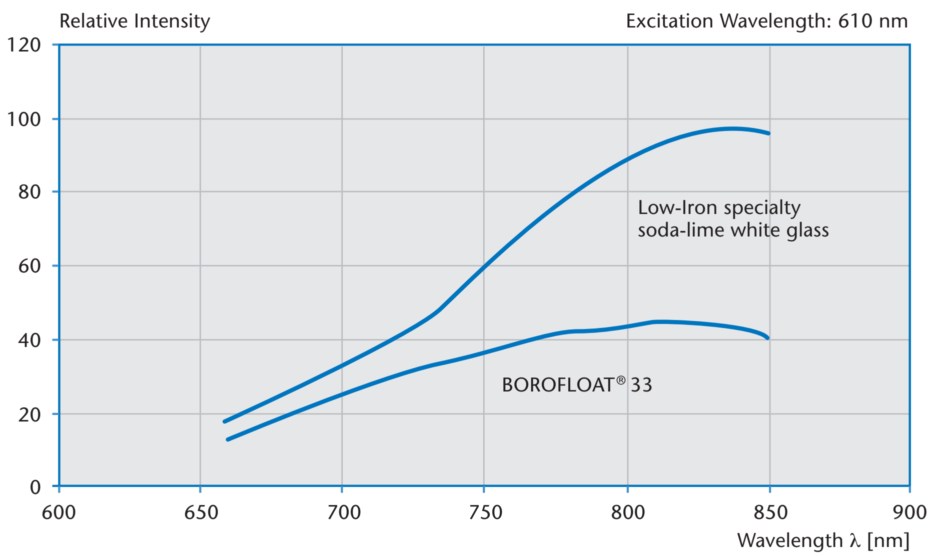


Optical Properties



Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation

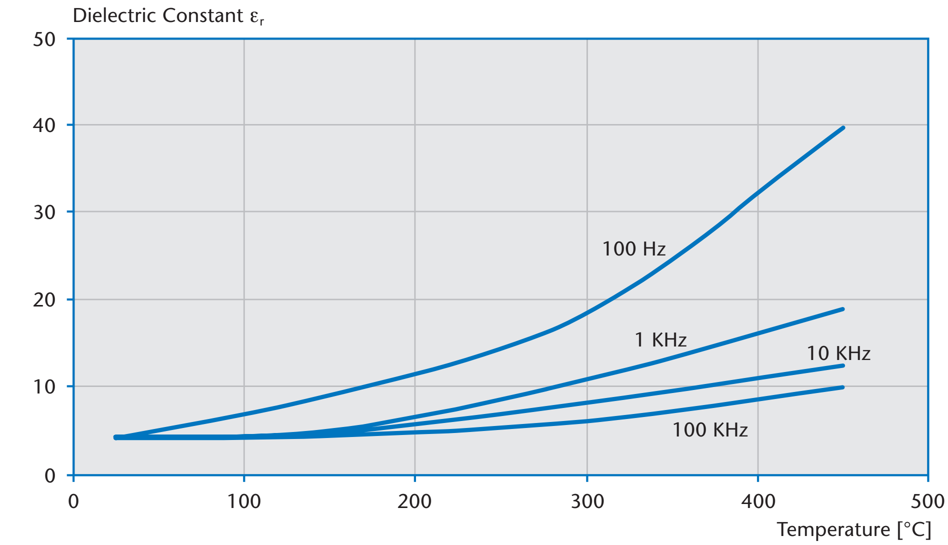


Fluorescence Behavior of BOROFLOAT® 33 and Soda-Lime Glass Type for Different Wavelength Excitation

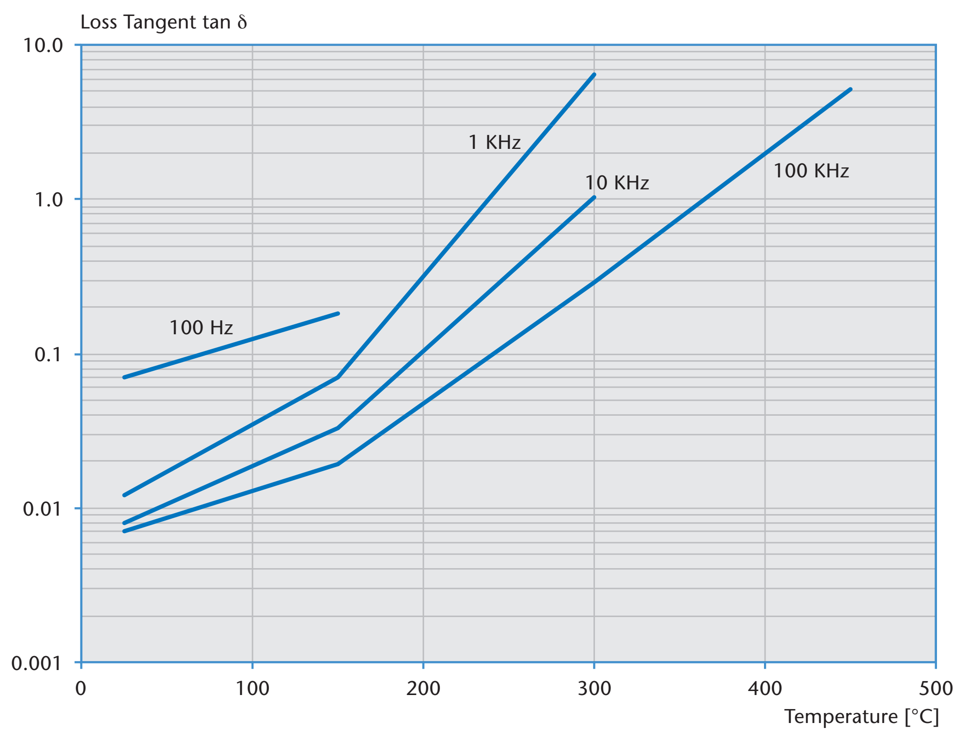
Electrical Properties

Dielectric Constant	ε_r	(25 °C, 1 MHz)	4.6
Loss Tangent	tan δ	(25 °C, 1 MHz)	37 x 10^{-4}

BOROFLOAT® 33 – Dielectric Constant as a Function of Temperature

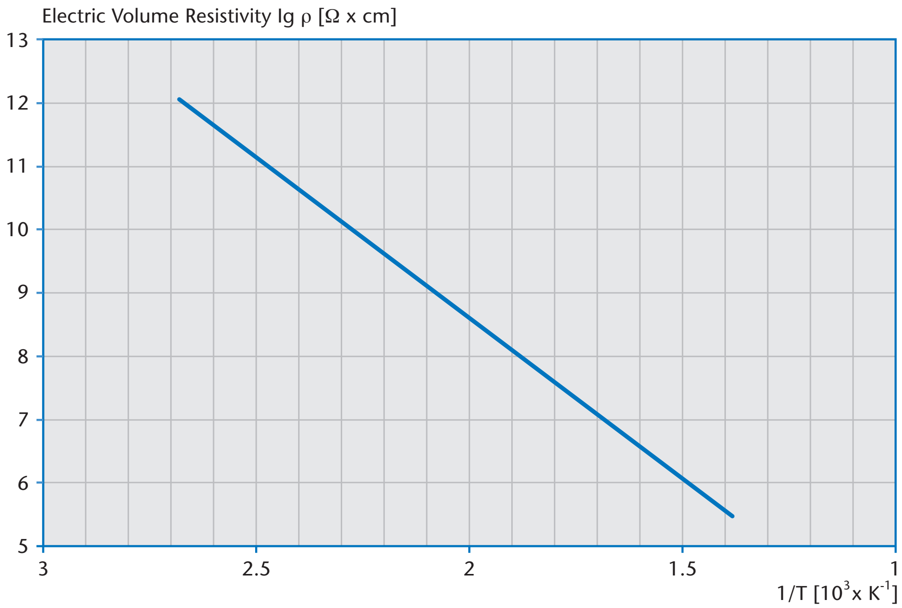


BOROFLOAT® 33 – Loss Tangent as a Function of Temperature

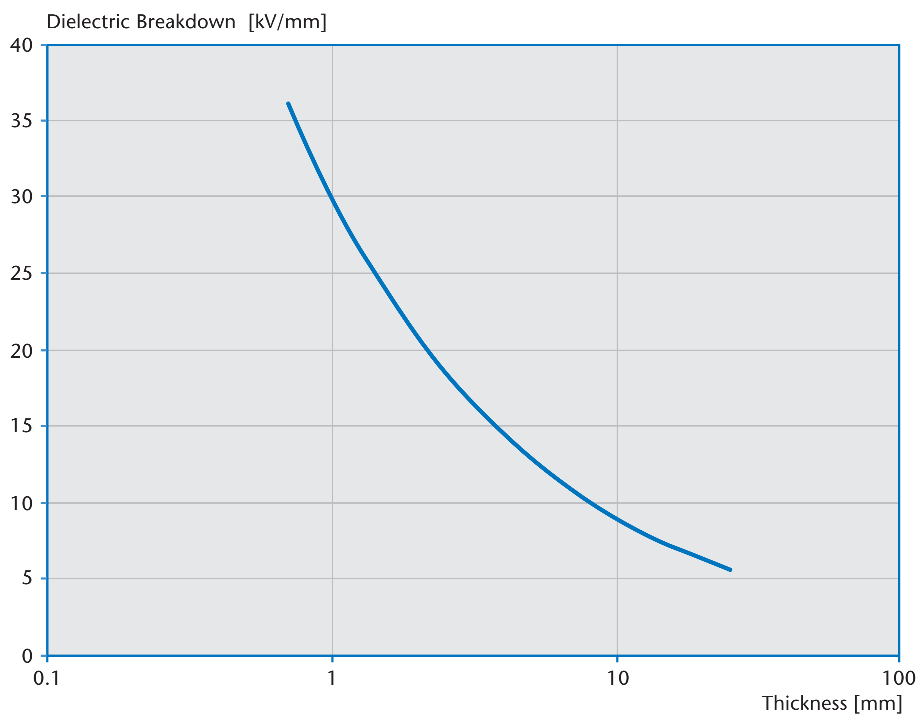


Electrical Properties

Logarithm of the Electric Volume Resistivity: lg ρ	250 °C	8.0 Ω x cm
	350 °C	6.5 Ω x cm



BOROFLOAT® 33 –
Electric Volume Resistivity as a Function of Temperature



BOROFLOAT® 33 –
Dielectric Breakdown as a Function of Glass Thickness (in air)

Fitting

The basic guidelines for the fitting and handling of glass and glass-ceramics also apply to BOROFLOAT® 33.

1. When sizing frames and panels, the different thermal expansions of BOROFLOAT® 33 and the various frame materials plus any possible manufacturing tolerances must be taken into account.

2. If it is necessary for design considerations to use compression fixing of the glass in the frame, this pressure must be applied uniformly all around the edge of the panel (no uneven pressure).

3. The glass must be fitted in non-distorting frames. If it is not possible to avoid a small amount of torsion, a suitable permanently elastic gasket must be used to prevent the torsion in the frame being transferred to the glass.

4. There must be no direct contact between glass and metal (or any other hard element of construction). Permanently elastic, heat-resistant materials (e.g. mineral fiber materials) are recommended as an intermediate layer between glass and metal.

Source: Zumtobel

Cleaning

BOROFLOAT® 33 glass can be cleaned with any commercially available glass cleaner.

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 glass.

Source: Miele