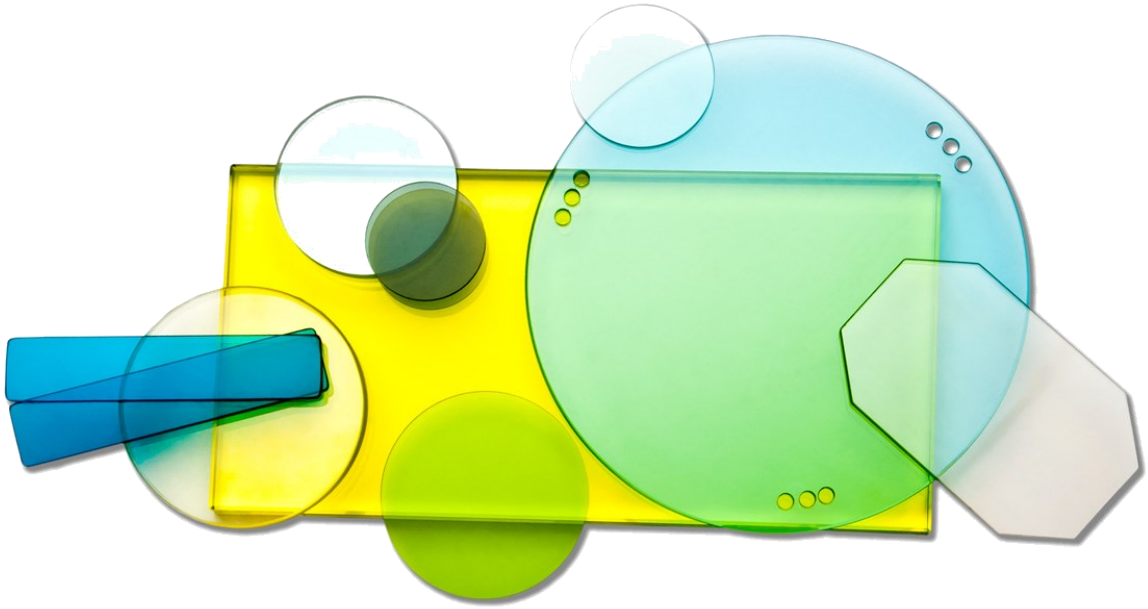
Specialty Glass Materials Products & Specifications

04/14



Specialty Glass Materials
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It all starts with the basic element, the glass. Each substrate has unique and specific qualities which are matched to the application and specifications that your unique project requires.

High Ion-Exchange (HIE™) Thin Glass

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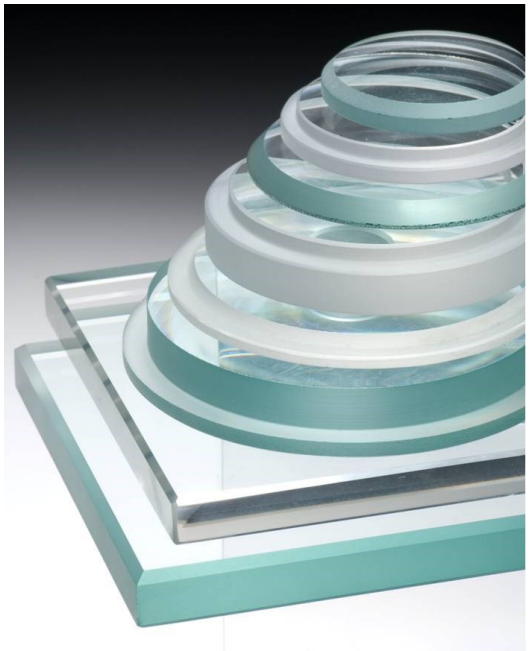

Quartz/Fused Silica

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Specialty Glass

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High Ion-Exchange (HIE™) Chemically Strengthened Aluminosilicate Thin Glass

High Ion-Exchange (HIE™) thin glass is strong, lightweight and flexible. It is a high quality aluminosilicate glass that is chemically strengthened to achieve incredible scratch, break/impact, and shock resistance. HIE™ glass is significantly stronger than similar thickness soda lime glass.

Specially designed material and unique salt bath processes combine to achieve a very high depth of layer during the chemical strengthening process, the end result of which is increased strength making HIE™ glass the ideal solution for cover glass and touch screen applications.

Features:

- Thin, lightweight
- Superior strength, scratch and shock resistant
- Excellent optical transmission
- High compression layer

Applications:

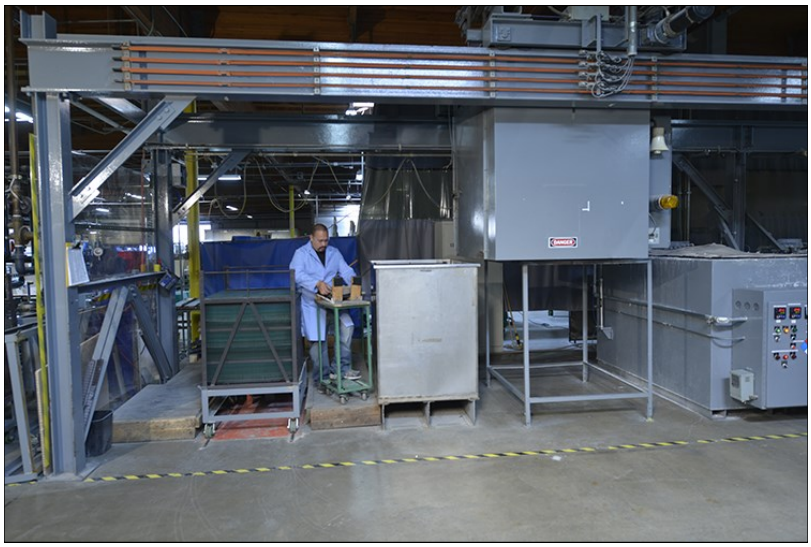
- Display & Touch Screen Cover & Back Plate Glass
  - Projected Capacitive (PCAP) Touch
  - Surface Acoustic Wave (SAW)
  - Acoustic Pulse Recognition (APR)
  - Multi-touch
  - Optical Touch
  - Micro-displays
- Optical Components

Abrisa Technologies can supply the following HIE™ glass substrates to meet your application-specific requirements.

- Asahi (AGC) Dragontrail™
- Corning® Gorilla® Glass
- SCHOTT Xensation™

Dimensions:

- Thicknesses: 0.55mm - 2mm stocked
- Sizes: Up to 32” x 24” (812.8 x 609.6mm)
- Non-standard sizes may also be available upon request.



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Asahi Glass Corporation (AGC) Dragontrail™

Glass produced using a High Ion Exchange (HIE™) process is stronger and more durable than non HIE™ glass substrates. Abrisa Technologies distributes, fabricates and can apply coatings to three major manufactured HIE brands of glass; Asahi Dragontrail™, Corning® Gorilla® Glass, and Schott Xensation™.

(AGC) Dragontrail™ - Ideal glass for use as cover glass for portable equipment such as smart phones, tablet PCs, and handheld displays and instrumentation.

Characteristics in Comparison to Soda-lime Glass:

- Scratch resistant
- Scratches are less noticeable
- Crack resistant should scratches occur
  (Chemically strengthened Dragontrail™ is much stronger than conventional soda-lime glass)
- Dragontrail™ is manufactured using the float process, ideal for mass-production insuring stable supply

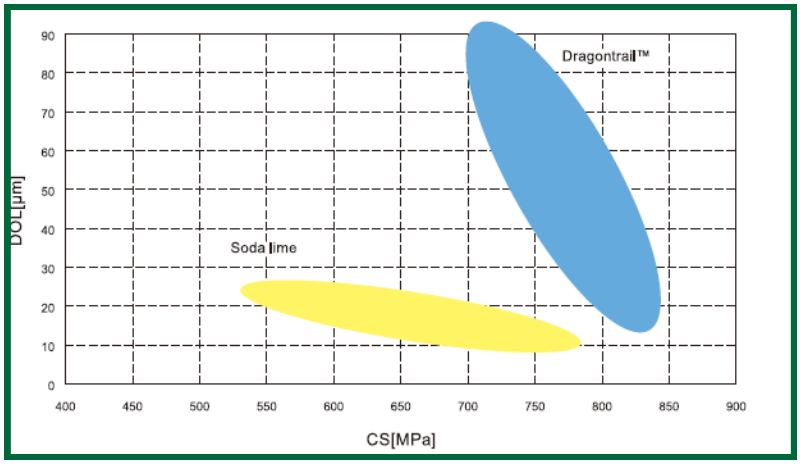
Dimensional Availability:

- Thicknesses - ranging from 0.55 to over 5.0 mm. Stock thicknesses include 0.8mm and 1.1mm.
- Sheet size - 48” x 29” (1219.2 x 736.6mm) standard and 60” x 48” (1524 x 736.6mm) available in 1.1mm. custom sizes may be available upon request.

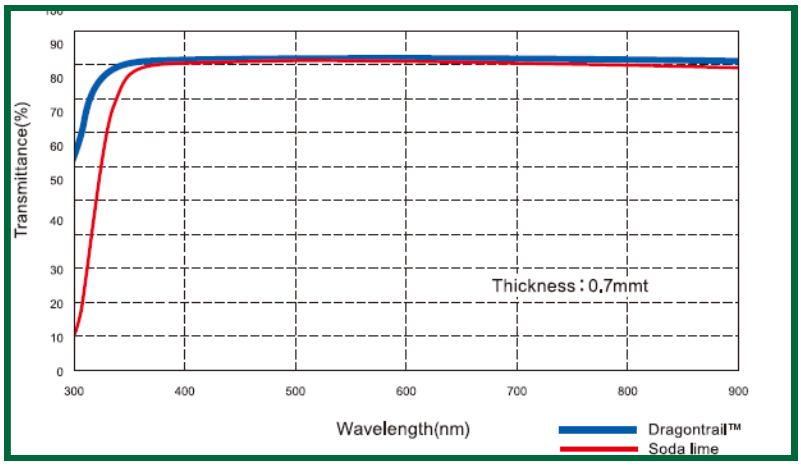
Physical Properties:

Property		Dragontrail™	Soda lime
Mechanical property	Density(g/cm^3)	2.48	2.50
	Young's Modulus(GPa)	74	73
	Shear Modulus(GPa)	30	30
	Poisson's Ratio	0.23	0.21
	Vickers hardness(before CT)	595	533
	Vickers hardness(after CT)	673	580
Thermal property	CTE(50-350°C×10^{-7}/°C)	98	85
	Tg(°C)	604	550
	Softening Point(°C)	831	733
	Annealing Point(°C)	606	554
	Strain Point(°C)	556	511
Optical property	Refraction Index(Nd)	1.51	1.52
	Photoelastic constant(nm/cm Mpa)	28.3	25.6
Electrical property	Volume Resistivity(log(Ω·cm))	8.4	8.5

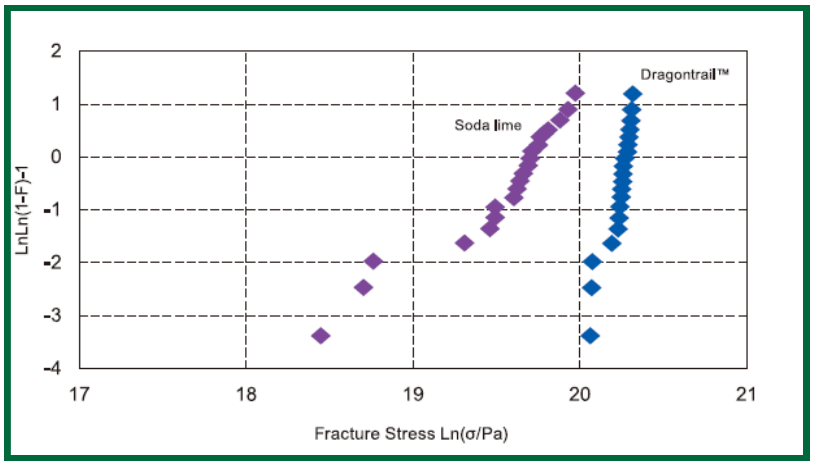
Asahi Glass Corporation (AGC) Dragontrail™ *(cont.)*



C/S Characteristics



Optical Transmittance



Three-Point Bending Result

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Corning® Gorilla® Glass

Is an environmentally friendly alkali-aluminosilcate thin sheet glass. Its superior composition allows a deeper layer of chemical strengthening than is possible with most other chemically strengthened glasses, making it durable and damage resistant.

Benefits:

- Glass designed for a high degree of chemical strengthening
  - High compression
  - Deep compression layer
- High retained strength after use
- High resistance to scratch damage
- Pristine surface quality

Applications:

- Ideal protective cover for electronic displays in:
  - Handheld devices and instrumentation
  - Laptops and tablet computer screens
  - Mobile devices including smart phones
- Touchscreen devices
- Optical components
- High strength glass articles

Dimensions:

- Available thicknesses 0.55 mm - 2.0 mm
- Non-standard sizes may also be available upon request
- Available in Gen 5 - 49.21 x 35.43" (1250 x 900mm) sheets

Viscosity:

Softening Point (107.6 poises)	852˚C
Annealing Point (1013.2poises)	613˚C
Strain Point (1014.7 poises)	563˚C

Properties:

Density 2	0.44 g/cm^3
Young's Modulus	71.7 GPa
Poisson's Ratio	0.21
Shear Modulus	29.7 GPa
Vickers Hardness (200 g load)	
Un-strengthened	625 kgf/mm^2
Strengthened	674 kgf/mm^2
Fracture Toughness	0.7 MPa m0.5
Coefficient of Expansion (0˚C - 300˚C)	84.5 x 10-7/˚C

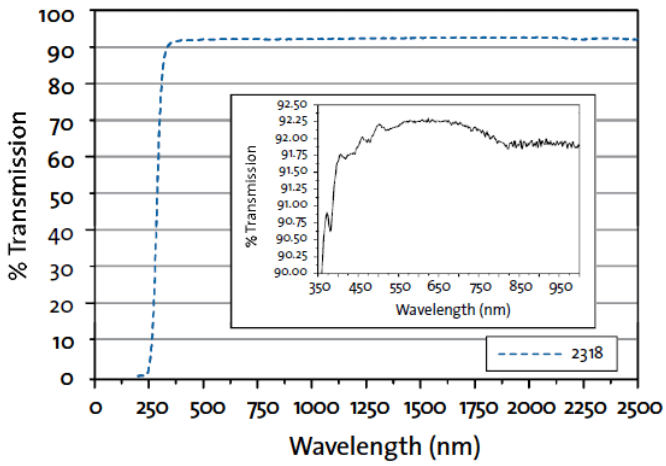
Chemical Strengthening:

Compressive Stress	Capable ≥800 MPa
Depth of Layer	Capable ≥40µm

Optical:

- Refractive Index (633nm)

Core Glass	1.5094
Compression layer	1.5116



Chemical Durability:

Durability is measured via weight loss per surface area after immersion. Values are highly dependent upon actual testing conditions. Data is reported for Code 2318 glass. Unless otherwise noted, concentrations refer to weight percent.

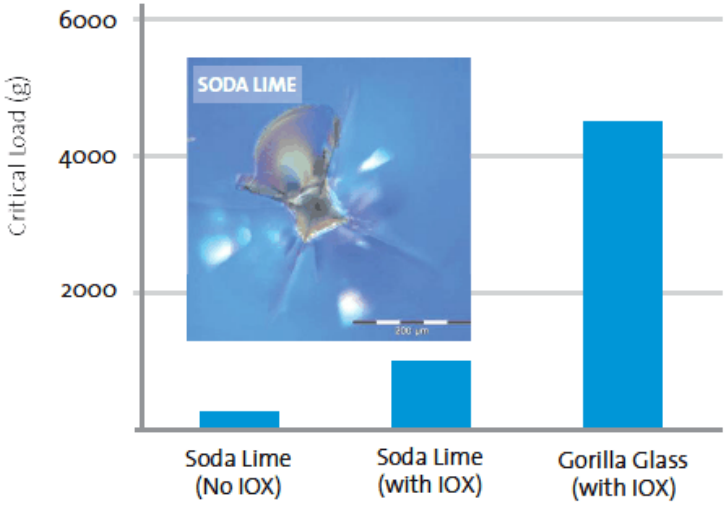
Reagent	Time	Temperature (C)	Weight Loss (mg/cm2)
HCl - 5%	24 hrs	95	0.04
NH4F:HF - 10%	20 min	20	3.14
HF - 10%	20 min	20	11.96
NaOH - 5%	6 hrs	95	1.10

Corning Gorilla Glass *(cont.)*

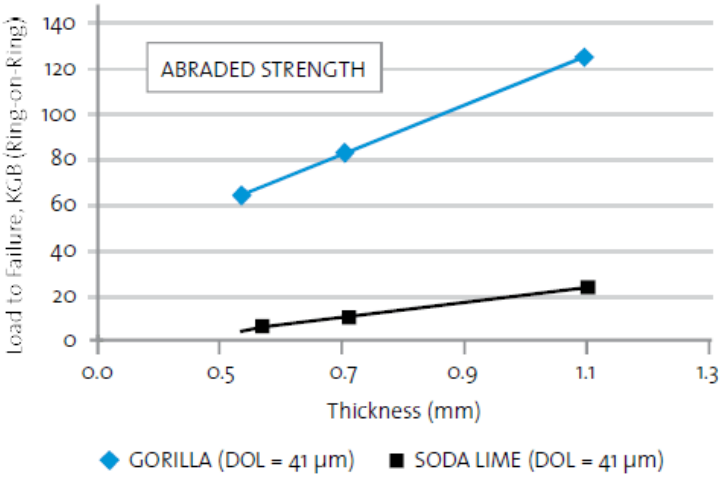
Electrical: Characteristics:

Frequency (MHz)	Dielectric Constant	Loss Tangent
54	7.38	0.013
490	7.26	0.013
912	7.30	0.014
1977	7.22	0.015
2986	7.19	0.016

Has Greater Damage Resistance:

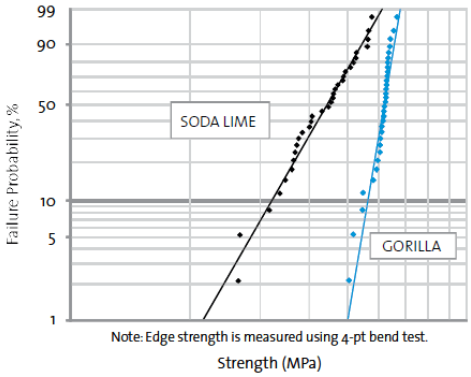


Enables Use of Thinner Glass:



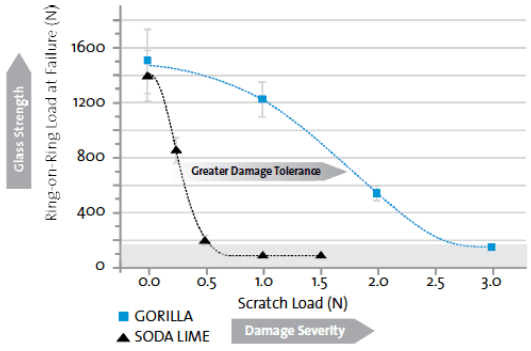
Devices benefit from a greater retained strength.

Has Greater Design Strength:



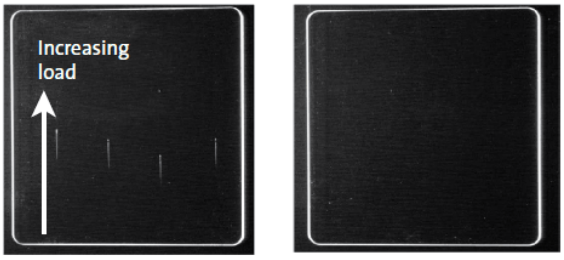
Corning Gorilla Glass exhibits tighter strength distribution.

Greater Retained Strength:



There is less strength degradation after scratching.

Scratches are Less Visible:



Ion-Exchanged Soda Lime Silicate
8 mm scratches made with load ramped from 20 g to 100 g

Ion-Exchanged Corning Gorilla Glass
Scratches on Corning Gorilla Glass are visible only under a microscope

Corning Gorilla Glass suppresses damage zone and lateral cracking that make scratches less visible.

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SCHOTT Xensation™

SCHOTT Xensation™ is a high-quality alumino-silicate glass with outstanding resistance to breakage and scratches for all cover and touch applications, including capacitive, resistive, optical, and acoustic touch technologies.

Key-Benefits of Xensation™ Cover:

- SCHOTT's unique micro-float manufacturing process gives the Xensation™ Cover alumino-silicate glass its excellent sheet quality.
- Impressively high and very stable Compressive Stress (CS) and Depth of Layer (DoL), ensure that Xensation™ Cover offers outstanding strength.

Thermal Properties:

Thermal Conductivity λ (25 °C)	0.96 W/(m•K)
Specific Heat Capacity C_p (20 °C; 100 °C)	0.84 KJ/(Kg•K)
Coefficient of Mean Linear Thermal Expansion α (20 °C; 300 °C)	$8.8 \cdot 10^{-6}\ K^{-1}$*
Transformation Point Tg	615 °C*
Annealing Point (10^{13} dPas)	635 °C
Softening Point ($10^{7.6}$ dPas)	880 °C
Working Point (10^{4} dPas)	1265 °C

*cooled according to DIN

Chemical Properties:
Optical Properties:

Hydrolytic Resistance	DIN ISO 719	Class HGB 1
Acid Resistance	DIN 12116	Class S 4
Alkali Resistance	DIN ISO 695	Class A 1

Refractive Index at	588 nm (n_d)	633 nm	780 nm
Core Glass	1.508	1.506	1.502
Compression Layer KNO_3 pure	1.516	1.514	1.510
Transmittance τ (Glass Thickness 0.7mm)			
840 nm			> 91.5 %
560 nm			> 91.5 %
380 nm			> 90 %
Photoelastic Constant			29.2 nm/cm/MPa

Sheet Dimensions:

- Sheet Size: 475 x 575mm (18.7 x 22.64")
  1150 x 950mm (45.27 x 37.4")
- Thickness Range: 0.55 to 2mm stocked other requirements available on request

Electrical Properties:

Frequency MHz	Dielectric Constant ε′	Loss Tangent tanδ
1	7.74	0.011
54	7.49	0.008
480	7.40	0.009
825	7.38	0.010
912	7.38	0.010
1977	7.35	0.012
2170	7.35	0.012
2986	7.34	0.012
Electric Volume Resistivity ρ_D for A.C. at 50Hz		
ν = 250 °C		$1.5 \cdot 10^{6}\ \Omega \cdot cm$
ν = 350 °C		$8.9 \cdot 10^{4}\ \Omega \cdot cm$

*These values are no guaranteed data - for customer orientation only.

Mechanical Properties:

Density	2.477 g/cm³*
Young's Modulus E	74 kN/mm²
Poisson's Ratio	0.215
Shear Modulus	30 kN/mm²
Knoop Hardness HK 0.1/20	
Non-strengthened	534
Strengthened	639
Vickers Hardness HV 0.2/20	
Non-strengthened	617
Strengthened	681

*cooled according to DIN

Chemical Strengthening:

Compressive Stress	capable > 900 MPa
Depth of Layer	capable > 50 µm
4-Point Bending Strength	cap. > 800 MPa

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Soda-Lime
Soda Lime Float Glass (Clear & Tinted)

Description:
Soda lime glass is the most prevalent type of glass and is prepared by melting the raw materials, such as soda, lime, silica, alumina, and small quantities of fining agents in a glass furnace at temperatures up to 1675°C. Soda lime sheet glass is made by floating molten glass on a bed of molten tin. This method gives the sheet uniform thickness and very flat surfaces. Soda lime glass is the base material for most clear, colored and patterned glass types.

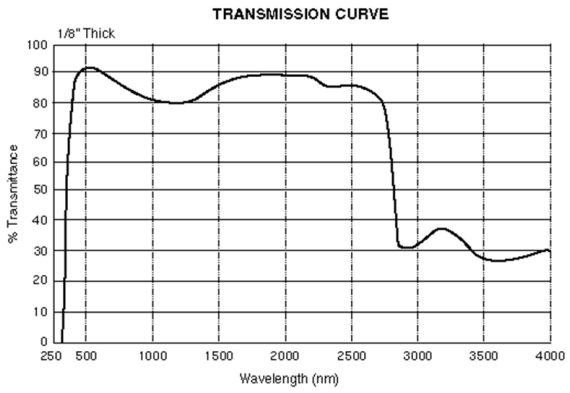
Features:
- Can be chemically strengthened to increase mechanical strength*
- Can be heat strengthened or heat tempered to increase thermal shock resistance and mechanical strength
- Can be machined, optically coated, chemically etched, sandblasted, colored, or laminated
- Good flatness and surface quality due to float process
- The lowest cost solution for sheet fabricating glass components

Physical Properties:

Modulus of Elasticity (Young's)	7.2 x 10^{10} Pa	(10.4 x 10^{6} psi)
Modulus of Rigidity (Shear)	3.0 x 10^{10} Pa	(4.3 x 10^{6} psi)
Bulk Modulus	4.3 x 10^{10} Pa	(6.18 x 10^{6} psi)
Poisson's Ration	0.23	
Specific Gravity	2.53	
Density	2530 kg/m^3	(158 lb/ft^3)
Coefficient of Thermal Stress	0.62 mPa/°C	(50 psi/°F)
Thermal Conductivity	0.937 W.m/m^2°C	(6.5 btu.in/hr.°F.ft^2)
Specific Heat	0.21	
Coefficient of Linear Expansion	8.9 x 10^{-6} strain/°C	(4.9 x 10^{-6} strain/°F)
Hardness (Moh's Scale)	5 to 6	
Refractive Index (Sodium D line)	1.523	
(1 µm)	1.511	
(2 µm)	1.499	
Softening Point	340°F	(726°C)
Annealing Point	1015°F	(546°C)
Strain Point	957°F	(514°C)
Emissivity (Hemispherical) at 75°F	0.84	

Dimensions of Standard Products:
- Thicknesses: 0.02" - 1" (0.55mm - 25.4mm)
- Sizes: Up to 96" x 72" (2440mm x 1830mm)
- Other sizes may be available upon request

*Mechanical strength is the general ability of a material to withstand stress and strain. The mechanical strength of tempered or chemically strengthened glass can be 4 times as much as ordinary glass.



Specialty Glass Materials
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Soda-Lime
Low Iron

Description:
Low iron soda lime is created by using high quality grades of silica sand that are virtually free of iron oxides. This results in a transparent, water white" glass that has higher transmission characteristics compared to normal soda lime. The difference is usually 2-3% at thicknesses 10mm and up to 8% greater transmission for thicker low iron glass. Even higher transmission (up to 98-99% total transmission) can be achieved by specifying an anti-reflective thin film coating. (Refer to our Thin Film Coating Brochure)

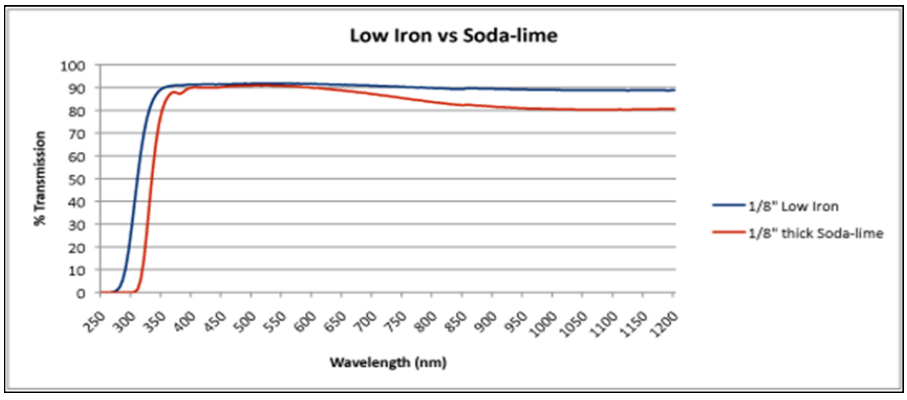
Features:
- Higher light transmission
- Can be chemically strengthened
- Good flatness
- No green tint

Applications:
Port projection
Display
Lighting
Optical

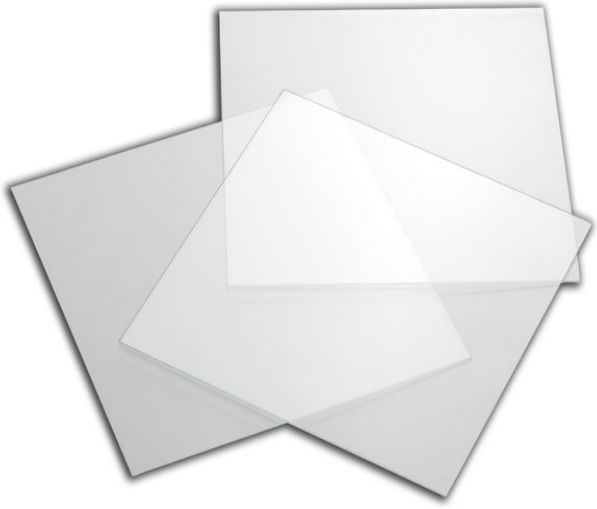
Physical Properties:

Density	2530 kg/m^3	(158 lb/ft^3)
Modulus of Elasticity (Young's)	7.2 x 10^{10} Pa	(10.4 x 10^6 psi)
Modulus of Rigidity (Shear)	3.0 x 10^{10} Pa	(4.3 x 10^6 psi)
Bulk Modulus	4.3 x 10^{10} Pa	(6.18 x 10^6 psi)
Poisson's Ration	0.23	
Specific Gravity	2.53	
Coefficient of Thermal Stress	0.62 mPa/°C	(50 psi/°F)
Thermal Conductivity	0.937 W.m/m^2°C	(6.5 btu.in/hr.°F.ft^2)
Specific Heat	0.21	
Coefficient of Linear Expansion	8.9 x 10^{-6} strain/°C	(4.9 x 10^{-6} strain/°F)
Hardness (Moh's Scale)	5 to 6	
Refractive Index (Sodium D line)	1.523	
(1 µm)	1.511	
(2 µm)	1.499	
Softening Point	726°C	1340°F
Annealing Point	546°C	1015°F
Strain Point	514°C	957°F
Emissivity (Hemispherical) at 75°F	0.84	

Dimensions:
- Thicknesses: 1mm - 12mm thick
- Sizes: Up to 130" x 96" (3302 x 2438.4mm)



Soda-Lime
Anti-Glare Etched Glass



Anti-glare glass breaks up incident light reflected images, allowing the user to focus on the display image versus the reflected images. Unlike anti-reflection coated or untreated surfaces, anti-glare etched glass does not become highly reflective as a result of oily finger prints.

Abrisa Technologies anti-glare glass is manufactured by a controlled acid etch process yielding uniform diffused surfaces for anti-glare, high resolution, anti-Newton ring applications.

Varying levels of diffusion specified as gloss yield different levels of reduced glare. A lower gloss reading denotes a more diffuse panel. The more diffuse the panel surface, the more glare reduction it provides. However, an inverse relationship exists between the degree of diffusion and the panel's resolution.

Anti-glare glass can be laminated, tempered or chemically strengthened. Sizes, thicknesses and gloss levels as listed are typically in stock and can be readily shaped to your specifications.

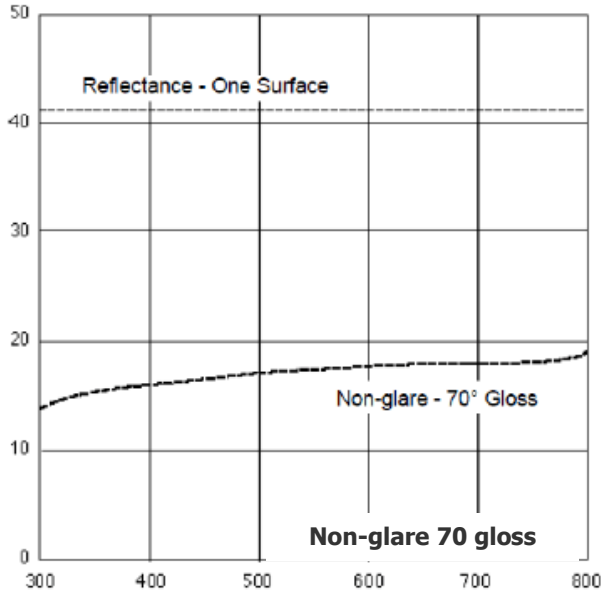
Custom thickness, sizes and gloss ranges from 50° to 120° are available upon request.

Features:

- Glare Reduction
- High Resolution
- Superior Durability
- Anti-Newton Ring

Typical Applications :

- Monitor Face Plates
- Electronic Displays
- Medical Instruments
- Video Game Screens
- Touch Panels
- LED Displays
- Outdoor Electronic Monitors & Systems



- Gloss: 60 - 130 (US Gloss, measured at 60° by a BYK Gardner Glossmeter, model 4501)
- Thickness: 0.7mm - 4.75mm
- Sheet Size: Up to 62" x 39" (1574.8 x 990.6")

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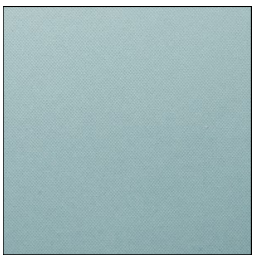
Soda-Lime
Patterned Glass for Diffusion & Light Control

Abrisa Technologies offers a number of patterned glass products and hexagon louvers for diffusion and light control. These products can be fabricated onto virtually any shape, and can be drilled, sandblasted, screen printed, polished, UV coated, dichroic coated, heat tempered (to increase thermal shock resistance and mechanical strength), to meet your application-specific criteria.



Solite® (Softening)

Maximum Size: 48” x 102” (1219 x 2590mm)
Thickness: 1/8”, 3/16” and 5/32” or 4mm and 5mm
Features: Stipple effect provides obscurity while retaining high transmission values.
Low iron optically clear glass offering maximum transmission and minimal absorption.
Does not yellow over time, retains optical clarity

Industrex® (Diffusion)

Maximum Size: 60” x 132” (524 x 3352.8mm)
Thickness: 5/32” and 3/16” (4mm and 5mm)
Features: Provides obscurity while retaining a high level of transmission.
Low iron optically clear glass offering maximum transmission and minimal absorption.
Does not yellow over time, retains optical clarity.

Pattern 62™ (Obscures)

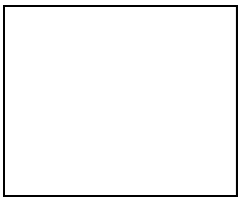
Maximum Size: 60” x 132” (524 x 3352.8mm)
Thickness: 1/8, 5/32” and 3/16” (4mm and 5mm)
Features: Acts as a diffuser and can be used to project an obscure or uneven pattern.
Can be backlit to diffuse light.

Skytex (Linear)

Maximum Size: 85” x 65” (2159 x 1652mm)
Thickness: 5/32” (4mm)
Features: Ribbed linear diffusion glass used to spread light horizontally or vertically.
Ideal for diffusing and elongating a beam of light to structures such as columns.
Has a 1/8” wide linear fluted pattern on one surface with a 55 degree spread either horizontally
or vertically.

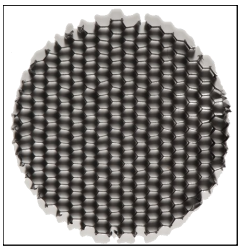
Blue color of glass is for viewing purposes only — glass is actually clear

Soda-Lime
Patterned Glass for Diffusion & Light Control (cont.)



Frosted Glass (Sandblasted)

Maximum Size: 60” x 132” (1524 x 3352.8mm)
Thickness: 3.3 mm Std.
Features: Used to soften a beam of light.
Available in soda lime or low iron soda lime, and sandblasted in any shape, size, or thickness.

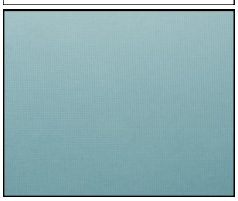


Hexagon Louver

Maximum Size: 12” x 12” (304.8mm)
Thickness: 1/8” (3 mm)
Features: Used in conjunction with a standard diffusion, colored and dichroic products to reduce glare brightness from a variety of light sources.
Made from low density, high strength material originally used for structural use in the aircraft industry.
Available in aluminum color or black and can withstand temperatures up to 350°F.

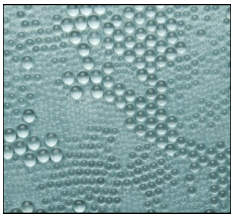
White Flashed Opal

Maximum Size: 32.5” x 27.875” (825.5 x 708mm)
Thickness: 3 mm and 6 mm
Features: Colorless base soda lime glass which is fused to a thin white flashed layer.
Creates an ambience in diffused lighting similar to daylight with very little shadow. (skylight effect)
Average transmission of approx. 35%. Scratch-resistant, non-deforming, and non-combustible.



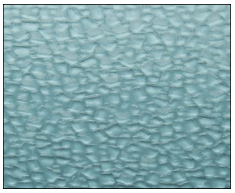
Mislite

Maximum Size: 72” x 42” (1828.8 x 1066.8mm)
Thickness: 1/8” (3mm)
Features: Figured glass that is translucent yet provided obscurity for decorative purposes.



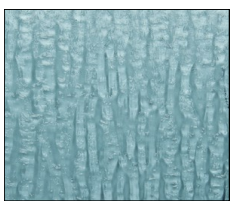
Croco Droplet

Maximum Size: 85” x 65” (2159 x 1651mm)
Thickness: 1/4” (6mm)
Features: Decorative Glass — see image



Ice Block

Maximum Size: 89” x 52” (2260.6 x 1330.8mm)
Thickness: 5/32” (4mm)
Features: Decorative glass. Can be heat strengthened



Rain

Maximum Size: 84” x 60” (2133.6 x 1524mm)
Thickness: 3/16” (5mm)
Features: Decorative glass. Can be heat strengthened.

Blue color of glass is for viewing purposes only — glass is actually clear

Soda-Lime
Low Emissivity (Low-E) Glass

Description:
Low Emissivity (Low-E) glass provides excellent performance in situations where temperature separation is desired. Low-E is used to help meet energy efficiency requirements by blocking UV light and providing heat insulation. This is done with a special thin-film metallic or oxide coating which prevents the passage of short-wave solar energy and also prevents long-wave energy produced by heating systems and lighting from escaping.

Features:
- Higher window U-value
- Increased insulation performance
- Energy savings
- Decreases color fade on interior furniture by blocking UV light

Applications:
- Architecture
- Grocery store refrigerators
- Deli food windows

Physical Properties:
• Visible Light Transmission	76%
• SHGC (Solar Heat Gain Coefficient)	0.71
• LSG (Laminated Safety Glass)	1.07
• U-Factor (Btu/hr/ft^2/°F)	
◦ Air	0.35
◦ Argon	0.31
• Indoor glass temp (°F)	
◦ Winter	52
◦ Summer	99
• UV Transmission	49%

Dimensions:
- Thicknesses: 3.2 mm, 5.0mm
- Sizes: Up to 96” x 60” (2438.4 x 1524”)
  Up to 130” x 72” (3302 x 1828.8”)

Specialty Glass Materials
Products & Specifications 01/14

Soda-Lime
Heat Absorbing Float Glass

Product Description
Heat Absorbing Float Glass (HAFG) provides superior performance in reducing solar heat gain while maintaining desirable high visible light transmission. The light blue/green color subdues brightness while providing the highest visible light transmittance (77% for 6.0 mm thickness) of all tinted glass substrates currently available.

Features:
- Absorbs IR

Applications:
• Short pass (SP) filter

Physical Properties:

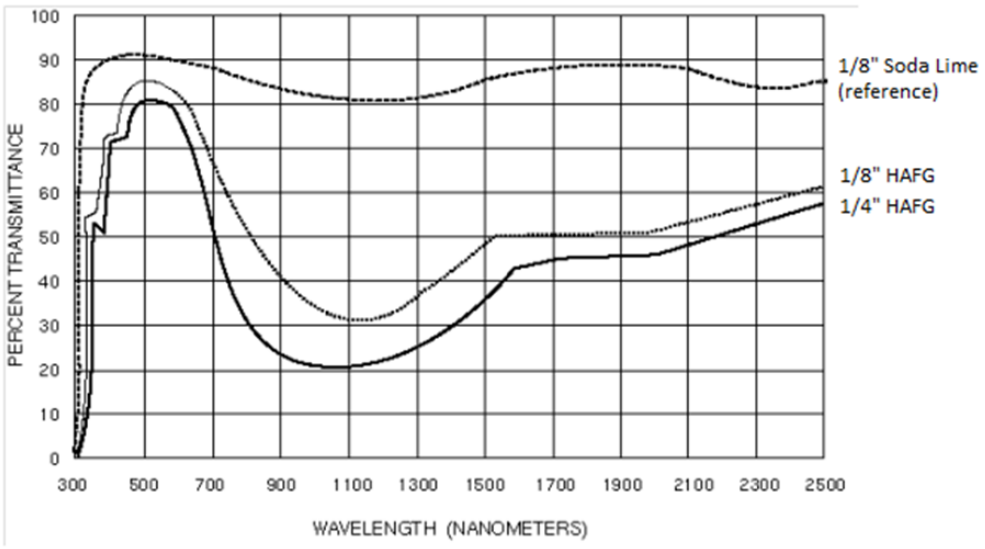
Optical Properties:

• Refractive index at sodium D Line (ND)	1.5184
• CIE Illuminate “C” data chromaticity coordinates	x=0.301, y=0.323
• Dominant wavelength	501 nm
• Excitation purity	2.9%

Thermal Properties:

• Expansion coefficient (25°C to 300°C)	8.6 x 10^{-6}/°C	4.8 x 10^{-6}/°F
• Specific Heat at 0° - 100°C (32° - 212°F)	0.205	
• Softening point	719°C	1327°F
• Annealing point	540°C	1004°F
• Strain point	503°C	937°F

Dimensions:
- Thicknesses: 1/8” & 1/4” (3.175mm & 6.35mm)
- Sizes: Up to 60” x 84” (1524 x 2133.6”)



Specialty Glass Materials
Products & Specifications 01/14

Borosilicate
SCHOTT Borofloat® 33 - Multi-Functional Float Glass

Description:
SCHOTT Borofloat® 33 is a versatile borosilicate glass with excellent light transmission, thermal properties, and chemical resistance. Its unique properties make it desirable in many different applications, from high temperature lighting windows, view ports in extreme conditions, to the medical and semiconductor industry. Borofloat wafers are an excellent substrate for MEMS (micro-electro-mechanical systems), as its coefficient of thermal expansion is very similar to silicon and allows for anodic bonding between the two. The low density of Borofloat also makes it an excellent choice for lighter weight laminated glass systems such as (bulletproof glass).

Features:
- Excellent flatness and surface quality
- Very good optical properties
- Low thermal expansion
- High chemical durability
- Low density

Applications:
- High temperature windows for lighting
- Optical windows, filters, and mirrors
- MEMS devices
- Chemically resistant view ports
- Bulletproof glass systems

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.2 g/cm^3	137.3 lb/ft^3
• Young's Modulus E	64 kN/mm2	9.28 Mpsi
• Poisson's Ratio μ	0.2	
• Knoop Hardness $HK_{0.1/20}$	480	
• Bending strength σ	25 MPa	3.63 x 10^3 psi

Viscosity:

• Working Point (10^4 poises)	1270°C	2318°F
• Softening Point (10$^{7.6}$ poises)	820°C	1508°F
• Annealing Point (10^{13} poises)	560°C	1040°F
• Strain Point (10$^{14.5}$ poises)	518°C	964°F

Thermal Expansion:

• 0 – 300°C (32 – 572°F)	3.25 x 10^{-6}/K

Optical:

• Index of Refraction @	435.8nm	1.4802
	479.9nm	1.4768
	546.1nm	1.4731
	589.3nm	1.4713
	643.8nm	1.4695
	656.3.nm	1.4692

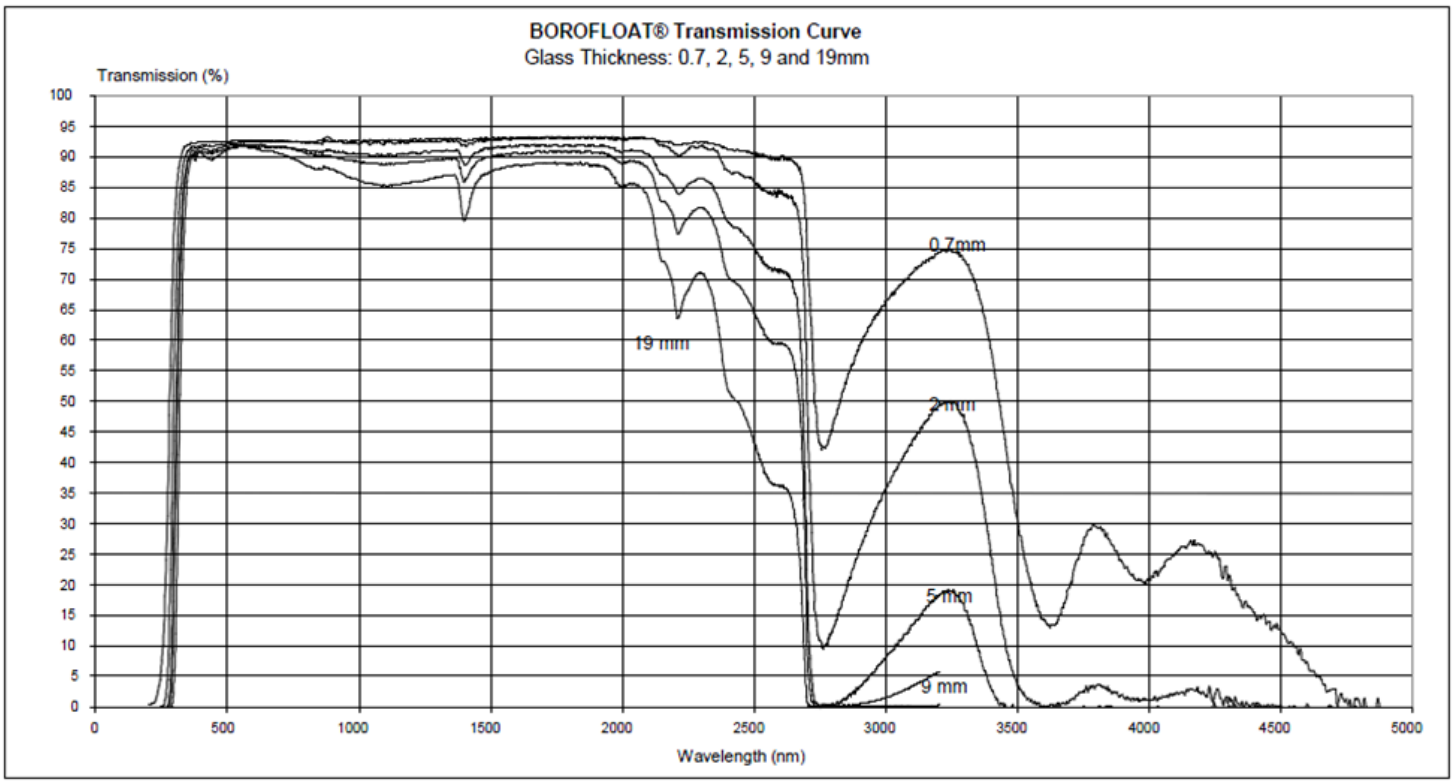
Electrical:

• Log10 Volume Resistivity:	(250°C, 482°F)	8.0
	(350°C, 932°F)	6.5

Dimensions:
- Thicknesses: 0.7mm – 25.4mm
- Sizes: Up to 90" x 67" (2286 x 1701.8mm)

Borosilicate

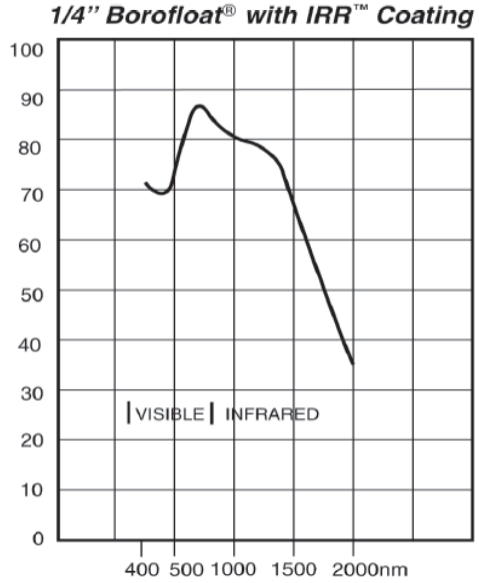
SCHOTT Borofloat® 33 - Multi-Functional Float Glass (*cont.)*



Borosilicate
SCHOTT Borofloat® Infrared Reflective (IRR)

Description:
Heat reflective glass is specifically designed to be placed where high radiant heat conditions exist, such as in the steel industry. This special glass will effectively reflect long wave length infrared radiation while providing a high grade of transparency. That percentage which is absorbed by the glass will seldom create a problem due to the thermal shock quality of the glass. The small percentage of radiant heat that is permitted to pass through the heat reflective glass is illustrated in the chart below. Other types of glass such as heat absorbing float glass reflect only 4% infrared, while heat absorbing (IRR) glass reflects both radiant and convected heat. This reflective property is a metallic film bonded permanently to the glass surface.

	Tempered Heat Reflective Borosilicate	Tempered Heat Reflective Safety Glass
Type of Glass	Borosilicate	
Coeff. of Thermal Expansion/° C. x 10-7	33	64-80
Transmission % of Infrared Radiation From 2000° F. Source	8	8
Thermal Shock	very good	fair-good
Protection-Molten Metal Splash	good	poor
Haze-Free	yes	yes
Mechanical Strength Flex Resistance and Impact Strength	good	excellent



Applications:
- Crane service: ladle, slab handling, furnace charging, soaking pit, teeming, mixing and other hot metal handling
- Control stations & pulpits: located physically near furnaces, red hot or molten metal
- Foundries: can use heat shields to protect hot metal carriers, pouring operators and sand movers
- Furnaces: viewing windows to reduce heat loss and protect the instruments of operating personnel that are looking inside.

Radiation Control:
Radiant heat is transmitted through space by wave motion, the intensity and wave length distribution depending on the nature and temperature of the surface. This heat can only be controlled by insulator screening and not by general ventilation, according to Mr. GF Haines, Jr., Mellon Institute. Regular glass can not properly insulate direct radiation. Reflective glass makes the most efficient transparent screen. This screening of radiation can reduce fatigue and protect against eye injury of personnel and improve work conditions in “hot Spots”

- The coated side is installed toward the heat source.

Radiation Control:
When building structures cooling requirement scan be reduced by using heat reflective glass for window areas.

Electrical Conductivity:
For applications such as static shielding and refrigeration units to prevent fogging Ohm/square typically 20 ohms or better.

Specialty Glass Materials
Products & Specifications 01/14

Borosilicate
SCHOTT Supremax® Rolled Borosilicate

Description:
SCHOTT Supremax®Rolled Borosilicate is almost identical in its properties to Borofloat® 33, it has slightly lower surface quality due to the rolled process. It is a versatile borosilicate glass with excellent thermal properties, chemical resistance, and good light transmission material for its thickness. Supremax® Rolled Borosilicate also maintains a low density and therefore higher transmissivity compared to that of soda lime glass.

Features:
- Large thickness range
- Very good optical properties
- Low thermal expansion
- High chemical durability
- Low density

Applications:
- High temperature windows for lighting
- Optical windows, filters, and mirrors
- Chemically resistant view ports
- Bulletproof glass systems

Physical Properties:

Mechanical:

Density (25°C) ρ	2.2 g/cm^3	137.3 lb/ft^3
Young's Modulus E	64 kN/mm2	9.28 Mpsi
Poisson's Ratio μ	0.2	
Knoop Hardness $HK_{0.1/20}$	480	
Bending strength σ	25 MPa	3.63 x 10^3 psi

Viscosity:

Working Point (10^4 poises)	1270°C	2318°F
Softening Point (10$^{7.6}$ poises)	820°C	1508°F
Annealing Point (10^{13} poises)	560°C	1040°F
Strain Point (10$^{14.5}$ poises)	518°C	964°F

Thermal Expansion:

0 – 300°C (32 – 572°F)	3.25 x 10^{-6}/K

Optical:

Index of Refraction @	435.8nm	1.4802
	479.9nm	1.4768
	546.1nm	1.4731
	589.3nm	1.4713
	643.8nm	1.4695
	656.3.3nm	1.4692

Electrical:

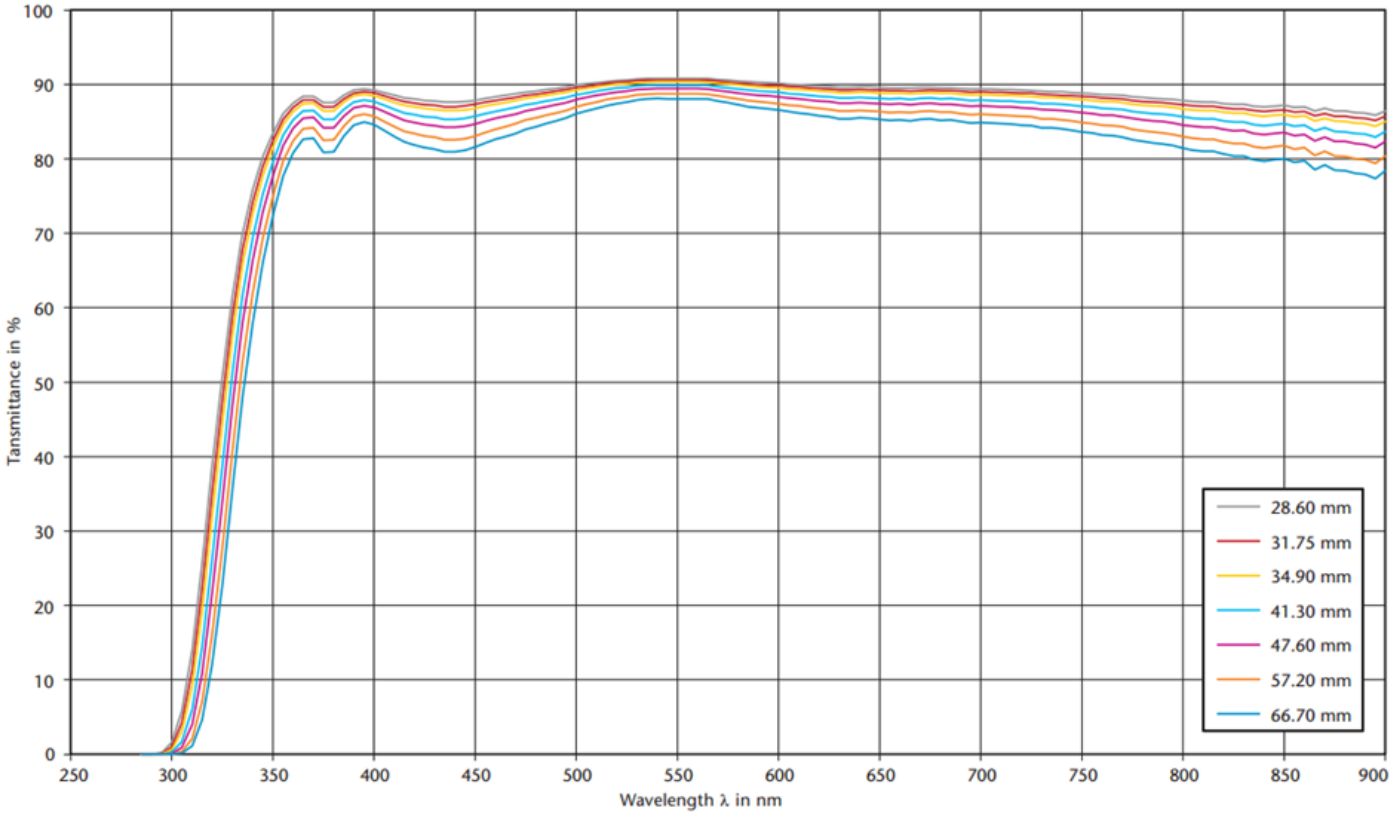
Log10 Volume Resistivity:	(250°C, 482°F)	8.0
	(350°C, 932°F)	6.5

Dimensions:

Thicknesses:	28.6mm – 66.7mm (1 ⅛" – 2 ⅝")
Sizes:	Up to 90" x 67" (2286 x 1701.8")

Borosilicate

SCHOTT Supremax® Rolled Borosilicate *(cont.)*



Spectral Transmittance

Specialty Glass Materials
Products & Specifications 01/14

Borosilicate
SCHOTT D263® Colorless Thin Glass

Description:
SCHOTT D263® is a thin borosilicate glass with low alkali content produced with extremely pure raw materials making it highly chemical resistant. It is produced in a special draw process that results in excellent surface quality that can be coated without any post-process surface work. The combination of these traits makes D263® highly versatile.

Features:
- Extremely flat surfaces
- Wide range of thicknesses (0.030mm – 1.1mm)
- Very good substrate for optical coatings
- Excellent transmission over a large spectrum
- Low level mobility of alkali ions
- Coefficient of thermal expansion close to ceramic
- High chemical resistance
- Smooth fire polished surface

Applications:
- Liquid crystal displays (LCD's)
- Touch screens
- Optoelectronics (opto-caps in laser diodes)
- Solar cells

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.51 g/cm^3	156.7 lb/ft^3
• Young's Modulus E	72.9 kN/mm2	10.6 Mpsi
• Poisson's Ratio μ	0.208	
• Knoop Hardness $HK_{0.1/20}$	590	
• Bending strength σ	30.1 kN/mm^2	4.4 Mpsi

Viscosity:

• Softening Point ($10^{7.6}$ poises)	736°C	1357°F
• Annealing Point (10^{13} poises)	557°C	1035°F
• Strain Point ($10^{14.5}$ poises)	529°C	984°F

Thermal Expansion:

• 0 – 300°C (32 – 572°F)	7.2 x 10^{-6}/K

Optical:

• Index of Refraction @	n_e 546nm	1.5255
	n_d 588nm	1.5231

Electrical:

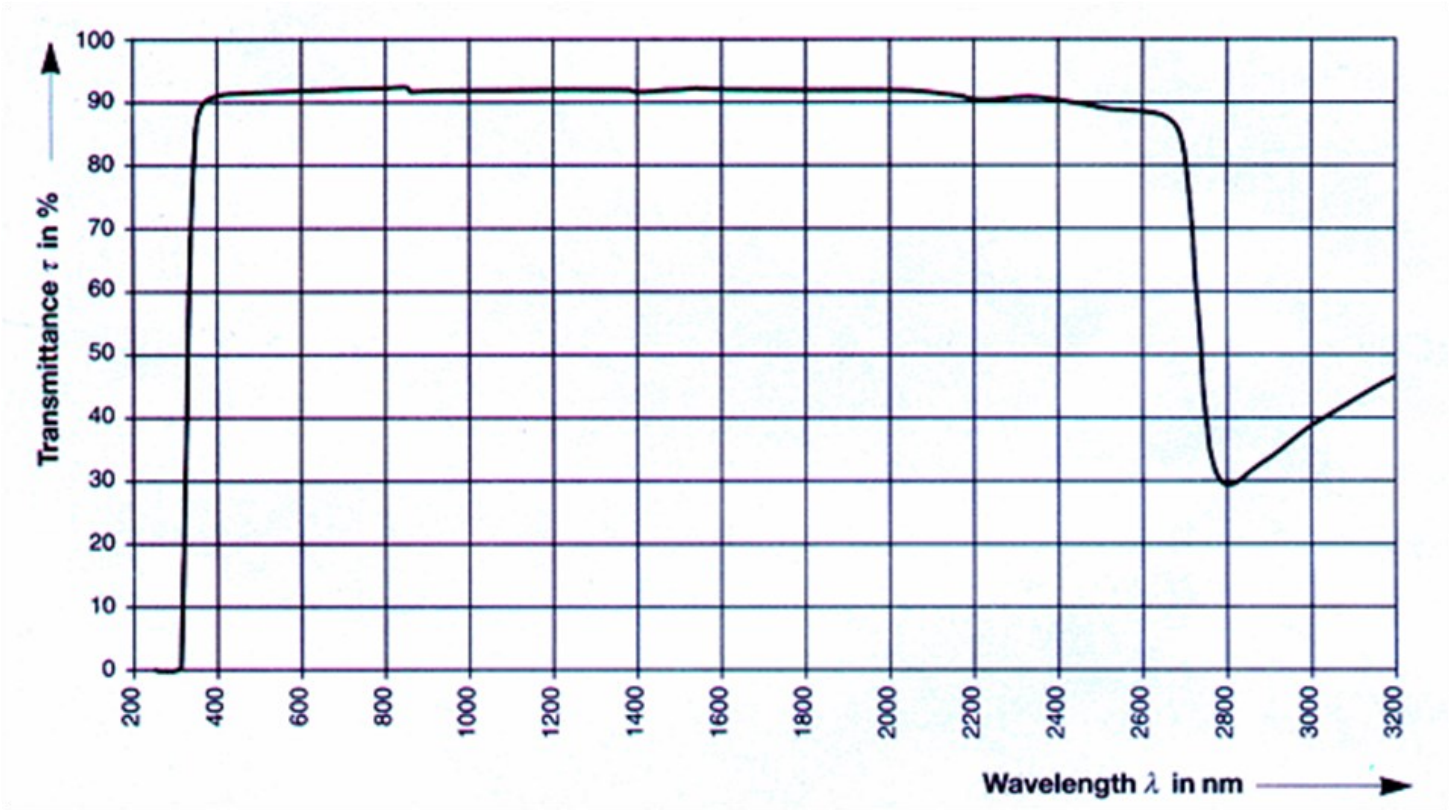
• Log10 Volume Resistivity:	(250°C, 482°F)	1.6 x 10^8
	(350°C, 932°F)	3.5 x 10^6

Dimensions:

• Thicknesses:	0.030mm – 1.1m
• Sizes:	Up to 17" x 14" (431.8 x 355.6mm)

Borosilicate

SCHOTT D263® Colorless Thin Glass *(cont.)*



Specialty Glass Materials
Products & Specifications 01/14

Borosilicate
SCHOTT Duran® Lab Glass (Tubed)

Description:
SCHOTT Duran® is general-purpose borosilicate glass tubing. Duran® has identical chemical and thermal properties as Schott's Borofloat® 33, as it is made from the same material. Duran's high resistance to chemicals and heat makes it ideal for laboratory glassware.

Features:
- Excellent thermal properties
- Highly resistant to chemicals
- Very good transmission properties

Applications:
- Lab glassware
- Pipelines
- Chemical industry
- Flameproof tubes
- Flowmeters

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.2 g/cm^3	137.3 lb/ft^3
• Young's Modulus E	64 kN/mm^2	9.28 Mpsi
• Poisson's Ratio μ	0.2	0.2
• Knoop Hardness $HK_{0.1/20}$	480	480
• Bending strength σ	25 MPa	3.63 x 10^3 psi

Viscosity:

• Working Point (10^4 poises)	1260°C	2300°F
• Softening Point (10$^{7.6}$ poises)	825°C	1517°F
• Annealing Point (10^{13} poises)	560°C	1040°F
• Strain Point (10$^{14.5}$ poises)	518°C	964°F

Thermal Expansion:

• 0 – 300°C (32 – 572°F)	3.25 x 10^{-6}/K

Optical:

• Index of Refraction @	435.8nm	1.4802
	479.9nm	1.4768
	546.1nm	1.4731
	589.3nm	1.4713
	643.8nm	1.4695
	656.3.3nm	1.4692

Electrical:

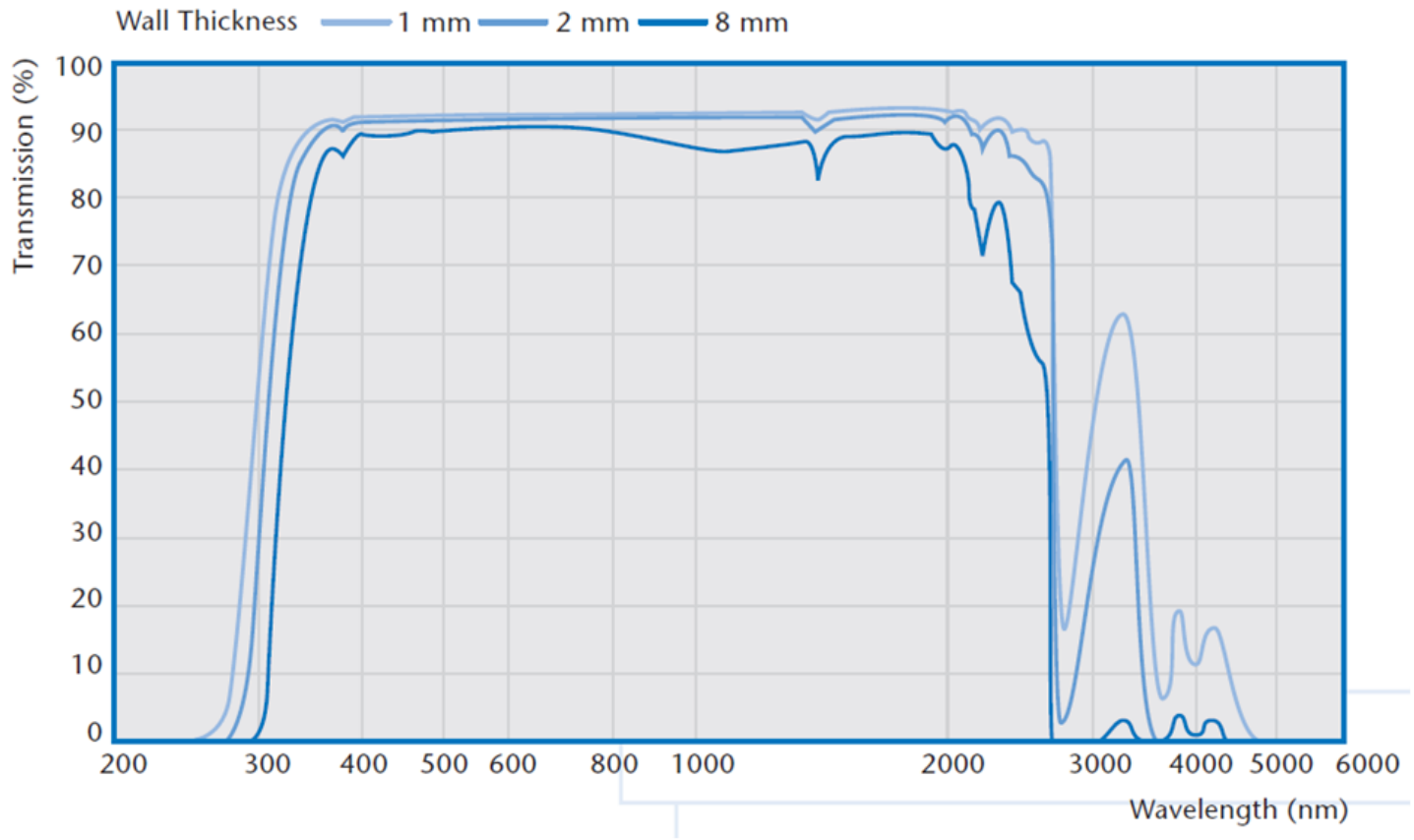
• Log10 Volume Resistivity:	(250°C, 482°F)	8.0
	(350°C, 932°F)	6.5

Dimensions:

	Outer Diameter:	Wall Thickness:	Length:
• Smallest size:	3mm (0.118")	0.7mm (0.028")	17mm (0.669")
• Largest size:	325mm (12.795")	10mm (0.394")	150mm (5.9")

Borosilicate
SCHOTT Duran® Lab Glass -Tubed *(cont.)*

Transmission



Specialty Glass Materials
Products & Specifications 01/14

Ceramic/Glass
SCHOTT Robax® Transparent Ceramic

Description:
SCHOTT Robax® is a transparent ceramic glass that is extremely heat resistant. The combination of good optical transmission (including infrared, which we perceive as heat) and low thermal expansion make Robax® an excellent choice for windows in heating devices. Robax® also has good UV blocking characteristics. The most common uses are fireplaces, stoves, and other types of heating systems.

Features:
- High resistance to heat (up to 700°C)
- Good transmission
- Excellent resistance to thermal shock
- Blocks UV

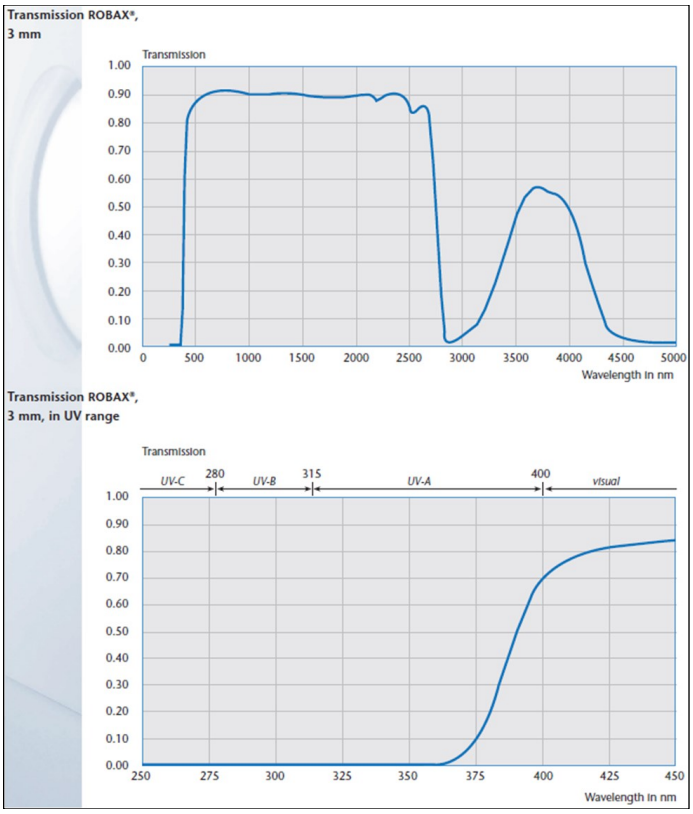
Applications:
- Windows in room heaters and stoves
- Cover panels for heating radiators
- UV blocking shields
- Cover panels for high powered flood lights
- Cover panels for IR drying appliances

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.58 g/cm3	161.1 lb/ft^3
• Young's Modulus E	92 Gpa	13 Mpsi
• Poisson's Ratio μ	0.25	0.25

Thermal Expansion:
- 20 – 700°C (68 – 1292°F) (0 +/- 0.5) x 10^{-6}/K



Maximum Operating Temperatures:

Usage Temp:	Usage Time:
560°C	5000 hours
610°C	1000 hours
660°C	100 hours
710°C	10 hours
760°C	5 hours

Dimensions:
- Thicknesses: 3mm – 5mm
- Sizes: Up to 62" x 33" (1574.8 x 838.2")

Ceramic/Glass
SCHOTT Pyran® Fire Rated Ceramic

Description:
SCHOTT Pyran® is a transparent glass ceramic that is fire-protection rated. It works with fire rated frames of the same rating. Pyran® fits applications with non-impact, safety rated requirements of up to 90 minutes.

Features:
- Fire rated up to 90 minutes
- Environmentally friendly
- Transparent and wireless

Applications
• Safety rated windows
• Insulated glazing units

Rating in minutes	Location	Max. exposed area of glazing (in^2)	Max. width of exposed glazing (in)	Max. height of exposed glazing (in)	Min. depth of groove (in)
Up to 90 min	Other than Doors	3,422 (23.7 ft^2)	76	76	5/8

Transmission Properties:
Visible spectrum: ~80% transmission

Dimensions:
- Thicknesses: 5mm (3/16”)
- Sizes: Up to 77” x 43” (1955.8 x 1092.2mm)

Specialty Glass Materials
Products & Specifications 01/14

Quartz/Fused Silica
Corning® 7980 Fused Silica

Description:
Corning® 7980 is a very pure, non-crystalline silica glass. It features very low thermal expansion and excellent optical qualities, including very high transmission in the UV spectrum.

Features:
- Excellent optical properties
- Low thermal expansion
- High UV transmission

Applications:
• Optical windows
• High temperature view ports

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.201 g/cm^3	137.4 lb/ft^3
• Young's Modulus E	72.7 GPa	10.5 Mpsi
• Poisson's Ratio μ	0.16	0.16
• Knoop Hardness HK0.1/20	522 kg/mm^2	
• Shear Modulus	31.4 GPa	4.55 Mpsi

Viscosity:

• Softening Point ($10^{7.6}$ poises)	1585°C	2885°F
• Annealing Point (10^{13} poises)	1042°C	1908°F
• Strain Point ($10^{14.5}$ poises)	893°C	1639°F

Thermal Expansion:

• 0 – 200°C (32 – 392°F)	5.7 x 10^{-7}/°C

Optical:

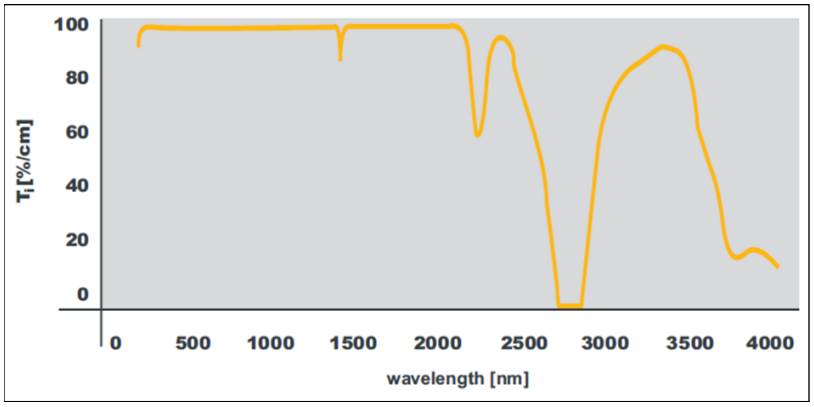
• Index of Refraction @ 589.3nm	1.45840

Electrical:

• Log10 Volume Resistivity: (250°C, 482°F)	11.8 ohm*cm

Dimensions:

• Thicknesses:	1.6mm
• Sizes:	Up to 6.5" x 6.5" (165.1 x 165.1")



Specialty Glass Materials
Products & Specifications 01/14

Quartz/Fused Silica
GE 124 Fused Silica

Description:
GE 124 is a very pure fused quartz, made from crystalline silica. GE 124 is very similar to fused silica, with the exception of less transmission in the UV spectrum and much lower OH content. Other features besides its purity include excellent thermal properties and high resistance to chemicals.

Features:
- Excellent Thermal Properties
- Stain (chemical) Resistant
- Very Good Optical Transmission

Applications:
- Water Carriers
- Flanges
- Optical Plates
- Test Plates
- Pressure Windows

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.21 g/cm^3	38.0 lb/ft^3
• Young's Modulus E	70 kN/mm2	10.5 Mpsi
• Poisson's Ratio μ	0.17	0.17
• Knoop Hardness $HK_{0.1/20}$	600 kg/mm^2	600 kg/mm^2

Viscosity:

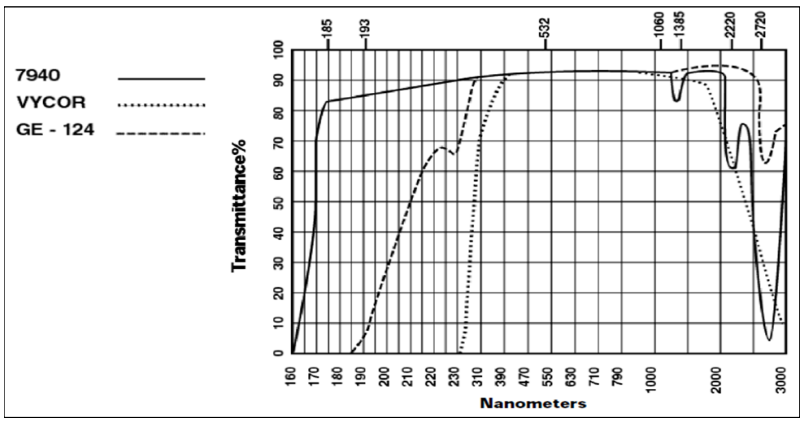
• Softening Point ($10^{7.6}$ poises)	1683°C	3061°F
• Annealing Point (10^{13} poises)	1214°C	2217°F
• Strain Point ($10^{14.5}$ poises)	1122°C	2052°F

Thermal Expansion:
- 0 – 300°C (32 – 572°F) 5.5 x 10^{-7}/°C

Optical:
- Index of Refraction 1.4585

Electrical:
- Log10 Volume Resistivity:
  - (250°C, 482°F)
  - (350°C, 662°F) 7 x 10^7

Dimensions:
- Thicknesses: Up to 4" thick (101.6mm)
- Sizes: Up to 36" (914.4mm) diameter



Specialty Glass Materials
Products & Specifications 04/14

Specialty Glass
Corning® Willow® Glass

Corning® Willow® alkali-free borosilicate Glass is thin, light and cost-efficient. The thinness, strength and flexibility of the glass has the potential to enable display screen to be "wrapped" around a device or structure. Additionally, Corning® Willow® Glass can be processed at temperatures up to 500°C. High temperature processing capability is essential for today's high end displays, and is a processing condition that cannot be supported with polymer films.

Features:
- Provides a thin, flexible, transparent barrier to moisture and oxygen for use in multiple applications
- Available in sheet or roll-to-roll processes while adding minimal weight and maintaining its inherent flexibility characteristics
- Provides high-performance, cost-effective alternative to polymer barrier films or thicker glass

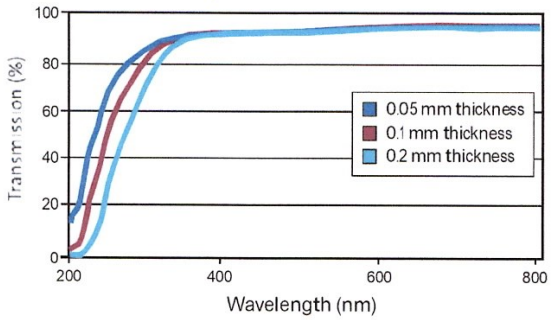
Applications:
- OLED and LCD Displays
- Curved (conformable) displays
- Touch sensors

Dimensions:
- **Sheets** - 100µm and 200µm (≤ 500 x ≤ 500) and (≤ 1250 x ≤ 1000)
- **Rolls** - 100µm (≤ 1m wide, ≤ 300m long) and (≤500mm wide, ≤300m long)

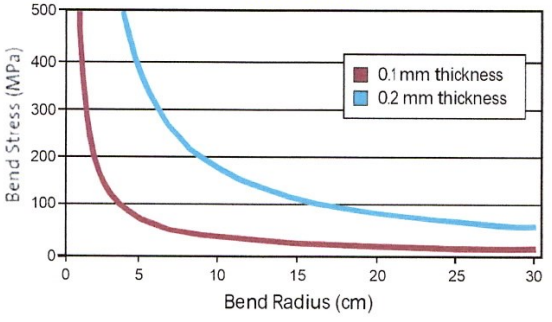
Sample Characteristics

Bulk Properties	Metric Unit	Nominal Values
Density	g / cc	2.3 - 2.5
CTE (0° to 300° C)	ppm / °C	3 - 5
Young's Modulus	GPa	70 - 80
Poisson Ratio	—	0.20 - 0.25
Strain Point	°C	650 - 700
Annealing Point	°C	700 - 750
Dielectric Constant ($k=E_o/E$)	—	5 - 6
Surface Roughness	Ra (nm)	< 0.5
	Rpv (nm)	< 20

Optical Transmission



Bend Stress



Specialty Glass Materials
Products & Specifications 01/14

Borosilicate
Corning® Eagle XG® LCD Glass

Description:
Corning® Eagle XG® is a borosilicate glass specifically designed for high performance LCD's. It is considered environmentally friendly as it contains no heavy metals (arsenic, antimony, barium, or halides). The glass also features high surface quality, excellent thermal properties, low density, and high resistance to chemicals.

Features:
- Environmentally friendly (free of heavy metals)
- Excellent surface quality
- Good thermal properties
- Low density
- Chemical durability

Applications:
- Liquid crystal displays (LCDs)
- Lightweight optical windows

Physical Properties:

Mechanical:

• Density (20°C, 68 °F)	2.38 g/cm^3	148.5 lb/ft^3
• Young's Modulus	73.6 GPa	10.7Mpsi
• Poisson's Ratio	0.23	0.23
• Shear Modulus	0.1 GPa	4.4 Mpsi
• Vickers Hardness (200 gm load, 25 sec dwell)	640	

Viscosity:

• Working Point (10^4 poises)	1293°C	2359°F
• Softening Point ($10^{7.6}$ poises)	971°C	1780°F
• Annealing Point (10^{13} poises)	722°C	1332°F
• Strain Point ($10^{14.5}$ poises)	669°C	1236°F

Thermal Expansion:

• 0 – 300°C (32 – 572°F)	31.7 x 10^{-7}/°C	17.7 x 10^{-7}/°F
• Room Temperature to Setting Point 25 – 675°C (77 – 1247°F)	35.5 x 10^{-7}/°C	19.7 x 10^{-7}/°F

Optical:

• Index of Refraction @	435.8nm	1.5198
	467.8nm	1.5169
	480.0nm	1.5160
	508.6nm	1.5141
	546.1nm	1.5119
	589.3nm	1.5099
	643.8nm	1.5078
• Birefringence Constant:	(331 nm/cm)/(kg/mm^2)	

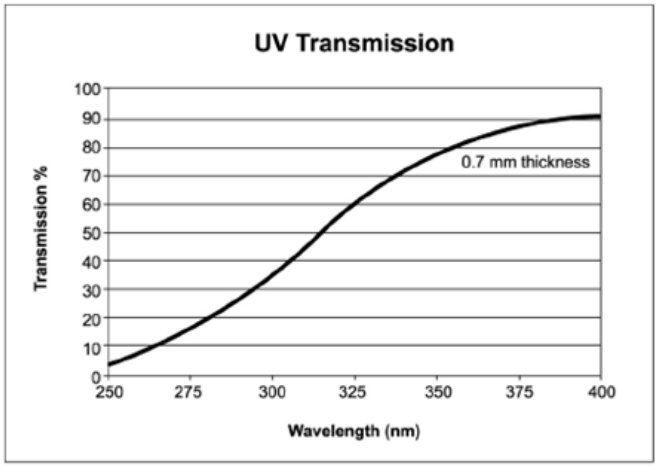
Electrical:

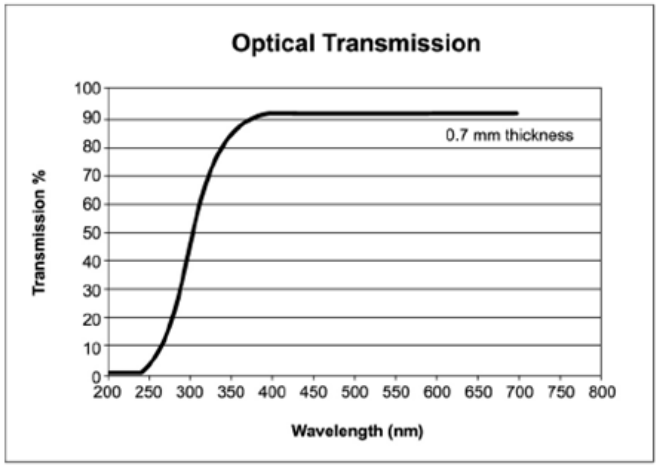
• Log10 Volume Resistivity:	(250°C, 482°F)	12.9
	(500°C, 932°F)	8.8

Dimensions:
- Thicknesses: 0.0433", 0.0275" (0.7mm, 1.1mm)
- Sizes: Up to 61" x 52" (1549.4 x 1320.8mm)

Borosilicate
Corning® Eagle XG® LCD Glass *(cont.)*

Transmittance





Specialty Glass
Laminated Glass — Safety Glass

Description:
Laminated glass is created by layering two or more pieces of glass together with a transpassive interlayer, such as PVB (polyvinyl butyral). When broken the interlayer holds the glass together, providing increased strength and safety. Laminated glass is used in automobiles, architecture, and bulletproofing. Abrisa can fabricate the laminated glass to custom sizes for a wide variety of applications including automobile and vehicular displays where passenger safety is as critical as the optical performance of the cover glass.

For more information about this product please contact us at:

- info@abrisatechnologies.com
- (877) 622-7472

Specialty Glass Materials
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Specialty Glass
SCHOTT Superwhite B 270® Flat Glass

Description:
SCHOTT B 270® Superwhite is an ultra clear crown glass*. It is produced by melting high purity raw materials and then made using the continuous draw process. This results in excellent transmission in the ultraviolet, visible, and infrared spectrums, and high surface quality without the need for post processing.

Features:
- High transmission
- Excellent surface quality
- Can be thermally or chemically strengthened

Applications:
- Large area LCD covers
- Cover panes for copying machines
- Front covers for oscillograph tubes
- Optical elements for light sensors
- Signal optics

Physical Properties:

Mechanical:

• Density (25°C) ρ	2.55 g/cm^3	159.2 lb/ft^3
• Young's Modulus E	71.5 kN/mm2	10.4 Mpsi
• Poisson's Ratio μ	0.219	0.219
• Knoop Hardness $HK_{0.1/20}$	542	542
• Bending strength σ	29.3 kN/mm^2	4.2 Mpsi

Viscosity:

• Softening Point ($10^{7.6}$ poises)	724°C	1335°F
• Annealing Point (10^{13} poises)	541°C	1006°F
• Strain Point ($10^{14.5}$ poises)	511°C	991°F

Thermal Expansion:

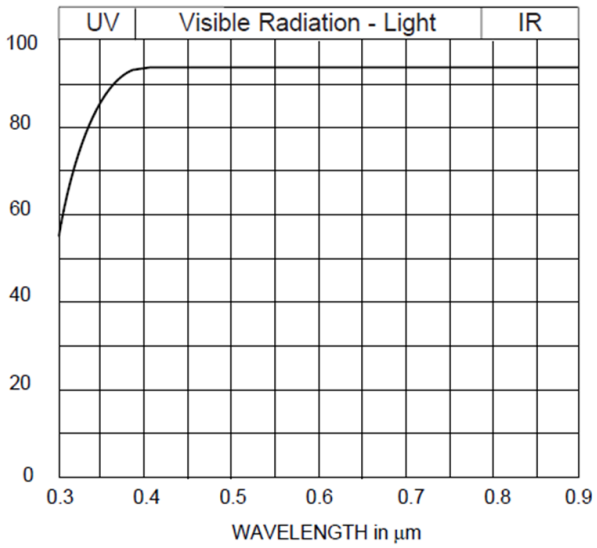
• 0 – 300°C (32 – 572°F)	9.4 x 10^{-6}/K

Optical:

• Index of Refraction @	546nm	1.5252
	588nm	1.5231

Electrical:
- Log10 Volume Resistivity:
  - (250°C, 482°F) 1 x 10^9 ohm*cm
  - (350°C, 662°F) 1.6 x 10^7 ohm*cm

Dimensions:
- Thicknesses: 0.9mm – 10mm
- Sizes: Up to 66" x 28" (1676.4 x 711.2mm)



* **Crown glass** is a type of optical glass used in lenses and other optical components. It has relatively low refractive index (≈1.52) and low dispersion (with Abbe numbers around 60). Crown glass is produced from alkali-lime (RCH) silicates containing approximately 10% potassium oxide and is one of the earliest low dispersion glasses.

Specialty Glass
Weld Shield

Description:
Weld shield is a leaded glass specifically designed for welding masks and other eye protection equipment. The glass blocks out harmful ultraviolet light and can cause “arc eye”. It is available in different shades for varying degrees of protection, and can be cut to size as ordered.

For more information about this product please contact us at:

- info@abrisatechnologies.com
- (877) 622-7472

Specialty Glass
White Flashed Opal

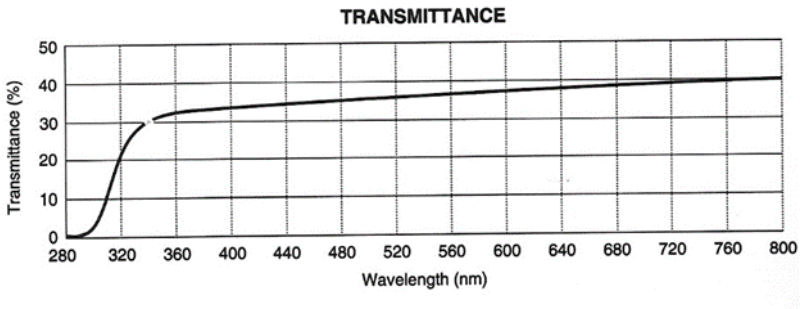
Description:
White Flashed Opal consists of a colorless base soda-lime glass which is fused to a thin white flashed layer. Using white flashed opal one can create an ambiance in diffused lighting similar to daylight with very little shadow. Flashed opal is perfect for creating a pleasant atmosphere in professional or residential areas.

Features:
- Average transmission of approximately 35%
- Can be heat strengthened or tempered
- Helps create a similar effect as a skylight
- Scratch resistant, non-deforming, and non-combustible
- Readily available off the shelf in (MR11) - 1.370” diameter and (MR16) - 1.965” diameter sizes

Dimensions:
- Thicknesses: 2.7mm to 3.3mm & 4.0mm to 6.0mm
- Sizes: 55” x 67” Max (1397 x 1701.8mm)

Transmission:
The transmission properties of White Flashed Opal glass are for the most part dependent solely upon the white layer, the thickness of which varies over the manufacturing width and is generally in the order of 0.45 ± 0.2mm. The visual light transmission in the case of standard illuminant A is on average τ vA = 35 % (± 10 %).

Light Diffusion:
In the visible spectrum of the DESAG, White Flashed Opal glass provides almost ideal diffusion. In the near infrared range a directed component is superimposed which appears on the diffusion indicatrix as a small “nose”. From λ = 800nm, the proportion of the directed transmission increases relatively sharply and where λ = 2000 nm, values of 50 % may be reached.



Chemical Properties:
White Flashed Opal glass is largely insensitive to the action of water acids, alkalis, and salt solutions (with the exception of hydrofluoric acid).

Electrical Properties:
Specific electrical resistivity > 10_{10} Ω·cm

Thermal Properties:
Thermal conductivity at 90°C = 1.06 W/(m • K)
Transformation temperature Tg = 521°C
Mean linear thermal coefficient of expansion α (20-300°C): 9.5 • 10_{-6} K_{-1}

Mechanical Properties:
Compressive strength 800-930 N/mm_2

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Specialty Glass
X-Ray Glass or Radiation Shielding Glass

Description:
X-Ray leaded glass is a radiation shielding glass that contains a high content of heavy metallic oxides. Most notably the lead oxide (PbO) provides the protective qualities against X-rays and Y-rays for use in the medical and technical fields. Despite the high metallic oxide content, Radiation Shielding Glass features high optical transmission, making it a perfect fit for view windows for X-ray rooms.

Features:
- Protection from X-rays and Y-rays
- Good optical transmission

Applications:
- Control windows for X-ray rooms
- Protection windows in materials testing houses, baggage control units, and laboratories

Physical Properties:
- Optical Transmission in Visible Spectrum: 86-88%

Dimensions:
- Thicknesses: 8 mm
- Sizes: Up to 31” x 29” (787.4 x 736.6mm)