A Comprehensive Guide to Borosilicate Glass: Understanding Types, Composition, and Properties

We are surrounded by different types of glass around us in our daily lives. Although all glasses appear the same visually, it is interesting to know how they differ in terms of properties and applications.

Glass by definition is an inorganic product of fusion, which is cooled to a rigid condition without crystallizing. Borosilicate glass, also known as Type 1 glass, was first developed by German glassmaker Otto Schott in the late 19th century. In the year 1939, the Late Dr. Sridhar Raghunath Lele, a world-renowned Glass Technologist, indigenously produced borosilicate glass for the first time in India. He started a company that was reformed under the name of 'M/s. Borosil Glass Works Ltd' to produce 'Corning' brand 32 expansion pyrex type Borosilicate glass under the Chairmanship of Dr. S R Lele.

Borosilicate glass is a mixture of Silica, Boron, Sodium, and Aluminum. It is particularly valued for its excellent thermal and chemical resistance and, hence, most widely used in all scientific laboratories and household cooking applications due to its unique properties. As a result, glassware made of Type 1 borosilicate glass forms an integral part of laboratories.

Composition of borosilicate glass

Borosilicate glass is a special type of glass that contains Boron trioxide (B_2O_3) as one of the important & major components.

The raw materials of Borosilicate glass may be classified into:-

i) Glass formers (such as SiO_2, P_2O_5, B_2O_3)

ii) Modifiers, fluxes etc.(such as Al_2O_3, CaO, Na_2O, Li_2O etc.)

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Chemical	3.3 Expansion Borosilicate Glass	4.9 Expansion Borosilicate Glass (Clear)	5.4 Expansion Borosilicate Glass (Amber)
SiO_2	80.60%	75.00%	70.00%
B_2O_3	13.00%	10.50%	7.50%
Na_2O	4.00%	5.00%	6.50%
Al_2O_3	2.30%	7.00%	6.00%
CaO	–	1.50%	<1.0%
Fe_2O_3	–	–	1.00%
TiO_2	–	–	5.00%
K_2O	–	–	1.00%
BaO	–	–	2.00%
MnO_2	–	–	–
MgO	–	–	–

Properties of borosilicate glass

	3.3 Expansion Borosilicate Glass	4.9 Expansion Borosilicate Glass (Clear)	5.4 Expansion Borosilicate Glass (Amber)
Coefficient of Thermal Expansion (20-300°C) $x10^{-6} K^{-1}$	3.3	4.9	5.4
Annealing Point ℃	565	565	560
Softening Point ℃	820	785	770
Density at 25°C g/cm^3	2.23	2.34	2.42

Borosilicate glass is known for its low coefficient of expansion and high chemical durability. Thermal expansion refers to the ability of a material to respond to heat. Glass with lower thermal expansion withstands the changes in temperature without breaking. 3.3 borosilicate glass has the lowest coefficient of thermal expansion which is $3.3 \times 10^{-6} K^{-1}$. It is highly resistant to most chemicals, except for hydrofluoric acid (HF), phosphoric acid (H_3PO_4), and hot strong caustic solutions. These properties of 3.3 borosilicate glass makes it the ideal choice of glass to be used for laboratory applications involving high heat and temperature fluctuations.

Classification of Borosilicate Glass as per standards

Standard	3.3 Expansion Borosilicate Glass	4.9 Expansion Borosilicate Glass (Clear)	5.4 Expansion Borosilicate Glass (Amber)
ASTM E-438	Type 1 Class A	Type 1 Class B	Type 1 Class B
US Pharmacopoeia (USP)	Type 1	Type 1	Type 1
European Pharmacopoeia (EP)	Type 1	Type 1	Type 1

Additionally, there is another International Standard ISO 3585 which was prepared by Technical Committee ISO/TC 48 for Laboratory glassware and related apparatus. The purpose of this International Standard is to define and facilitate the identification of a type of glass appropriate for laboratory glassware.
Note: Borosil represents India on the ISO/TC 48 Technical Committee for Laboratory glassware and related apparatus

Types of Laboratory Glassware

Due to its high thermal and chemical resistance, 3.3 borosilicate glass is the preferred choice of glass for laboratory applications. At Borosil Scientific we manufacture over 2500 products made from this glass. Laboratory glassware can be broadly classified into **Calibrated glassware** – such as Volumetric Flasks, Pipettes, Measuring Cylinder, Burettes and **General laboratory glassware** – such as Bottles, Beakers, Conical Flasks, Test Tubes, etc.

All of our glassware are made from 3.3 low expansion borosilicate glass that complies with USP Type 1, ASTM E438 Type 1 Class A and ISO 3585 standards. However, there are other standards as well, which specifies the tolerances and dimensions for different types of glassware articles. *For example: ISO 3819 specifies requirements for an internationally acceptable series of glass beakers for laboratory use, where as ISO 4796, in its 3 parts, specifies the requirements for screw neck, conical neck and aspirator bottles.*

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