BRAND

APPLICATION KNOWLEDGE

Laboratory Glass

Chemical and mechanical resistance

Introduction

Glass has very good chemical resistance against water, saline solutions, acids, alkalis and organic solvents and in this respect surpasses the majority of plastics. It is only attacked by hydrofluoric acid, and – at elevated temperatures – by strong alkalis and concentrated phosphoric acid. Further advantages of glass are its dimensional stability, even at elevated temperatures, and its high transparency.

Working with glass

When working with glass, it is essential to consider its limitations regarding resistance to thermal shock and to mechanical stress. Strict safety measures must be observed:

+ Do not heat volumetric instruments, measuring cylinders and flasks on hot plates.
+ Exothermic reactions such as diluting sulfuric acid or dissolving solid alkaline hydroxides must always be carried out while stirring and cooling the reagents, and in suitable vessels such as Erlenmeyer flasks – never in graduated cylinders or volumetric flasks!
+ Glass instruments must never be exposed to sudden temperature changes. When taking them out of a drying cabinet while hot, never place on a cold or wet lab bench.
+ For compressive loads, only glass instruments intended for this purpose may be used. For example, filtering flasks and desiccators may be evacuated only after confirming that they are in perfect condition. BRAND does not offer instruments for pressure applications.

Specific properties of individual glasses

Soda-lime glass (e.g., AR-GLAS®) has good chemical and physical properties. It is suitable for products which are usually subjected to short-term chemical exposure, and to limited thermal stress (e.g., pipettes, culture tubes).

Borosilicate glass (Boro 3.3, Boro 5.4) has very good chemical and physical properties. The abbreviation Boro 3.3 stands for a borosilicate glass type 3.3 as specified in international standard DIN ISO 3585, for applications requiring very good chemical and thermal resistance (including resistance to thermal shock), and high mechanical stability. Typical applications are components for chemical apparatus, round-bottom flasks, and beakers.

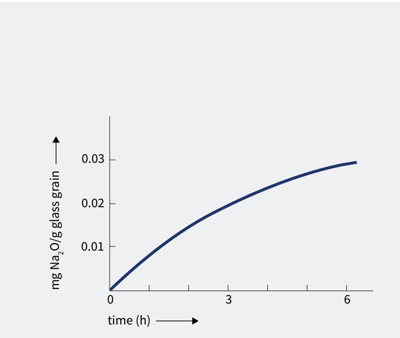
Chemical Resistance

Chemical interaction of glass with water and acids

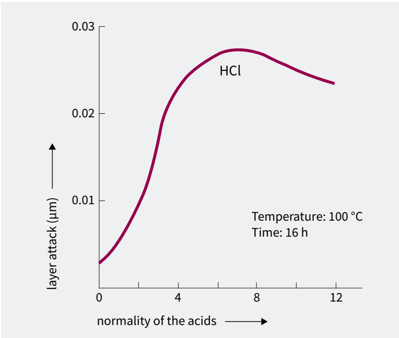
The chemical interaction of water and acids with glass surfaces is negligibly small; only very small amounts, primarily monovalent ions, are dissolved from the glass. This forms a very thin, almost non-porous layer of silica gel on the glass surface, inhibiting further attack. Exceptions are hydrofluoric acid and hot phosphoric acid which prevent the formation of the inert layer.

Chemical interaction of glass with alkalis

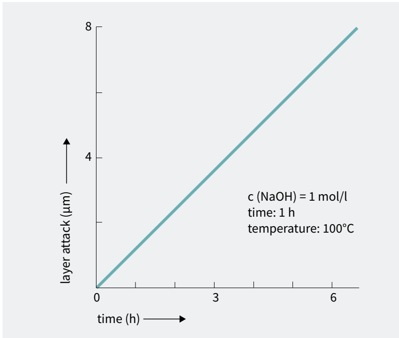
Alkalis attack glass surfaces as concentration and temperatures increase. Borosilicate glass 3.3 (Boro 3.3) limits surface erosion to the µm range; however, after prolonged exposure, volume changes and/or graduation destruction may occur.



Hydrolytic attack on Boro 3.3
as a function of time



Acid attack on Boro 3.3
as a function of acid concentration



Alkali attack on Boro 3.3
as a function of time

Hydrolytic resistance of glass grains

Borosilicate glass 3.3 meets hydrolytic resistance class 1 of DIN ISO 719 (98 °C), which is divided into 5 hydrolytical resistance classes. This means that when glass grain with a granulation rate of 300-500 µm is exposed to water at 98 °C for 1 hour, less than 31 µg Na_2O per gram of glass grain will be removed.
In addition, Borosilicate glass 3.3 also meets class 1 of DIN ISO 720 (121 °C), which is divided into 3 hydrolytical resistance classes. This means that when glass grain is exposed to water at 121 °C for 1 hour, less than 62 µg Na_2O per gram of glass grain will be removed.

Acid resistance

Borosilicate glass 3.3 meets class 1 of DIN 12 116, which is divided into 4 acid resistance classes. Borosilicate glass is also called acid-resistant borosilicate glass, as the surface erosion after 6 hours of boiling in 6 N HCl is less than 0.7 mg/100 cm^2. Removal of alkali oxide according to DIN ISO 1776 is less than 100 µg Na_2O/100 cm^2.

Alkali resistance

Borosilicate glass 3.3 meets class 2 of DIN ISO 695, which is divided in 3 alkali resistance classes. Surface erosion after 3 hours of boiling in a mixture with equal volumes of sodium hydroxide solution (1 mol/l) and sodium carbonate solution (0.5 mol/l) is approximately 134 mg/100 cm^2.

Chemical resistance to	Water DIN ISO 719 (HGB Class 1-5)	Acids DIN 12 116 (Class 1-4)	Alkalis DIN ISO 695 (Class 1-3)
Soda-lime glass (AR-GLAS®)	3	1	2
Borosilicate glass 3.3 (Boro 3.3)	1	1	2

Mechanical Resistance

Thermal stresses

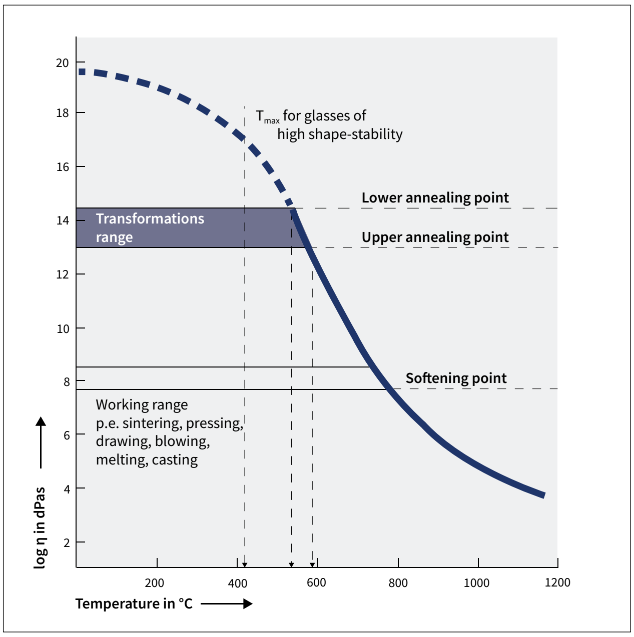
During the production and processing of glass, hazardous thermal stresses may be introduced. During the cooling of molten glass, the transition from the plastic state to the brittle state takes place in the range between the upper and lower annealing points. At this stage, existing thermal stress must be eliminated through a carefully controlled annealing process. Once the lower annealing point is reached, the glass may be cooled more rapidly, without introducing any major new stress.
Glass responds in a similar way when heated, e.g., through direct exposure to a Bunsen flame, to a temperature higher than the lower annealing point. Uncontrolled cooling may result in the "freezing in" of thermal stress which would considerably reduce resistance to breakage and mechanical stability.
To eliminate inherent stress, glass must be heated up to a temperature between the upper and lower annealing point, be kept at this temperature for approx. 30 minutes and be cooled by observing the prescribed cooling rates.

Resistance to temperature changes

When glass is heated to a temperature below the lower annealing point, thermal expansion and the poor thermal conductivity result in tensile and compressive stress. If, due to improper heating or cooling rates, the permissible mechanical strength is exceeded, breakage occurs. Apart from the coefficient of expansion α, which varies with each kind of glass, the wall thickness, the geometry of the glass body, and any existing scratches must be taken into account. Therefore, it is difficult to state specific nu- merical values for thermal shock resistance. However, a comparison of the α values shows that Boro 3.3 is much more resistant to thermal changes than, e.g., AR-GLAS®.

Mechanical stresses

From a technical viewpoint, glasses behave in an ideally elastic way. This means that, after exceeding the limits of elasticity, tensile and compressive stress does not result in plastic deformation, but breakage occurs. The tensile strength is relatively low and may be further diminished by scratches or cracks. For safety reasons, the tensile strength of Boro 3.3 in apparatus and plant design is calculated at 6 N/mm². The compressive strength, however, is approximately ten times as high.



Glass viscosity curve
Typical viscosity temperature curve using a borosilicate glass as an example.

	Upper annealing point (viscosity 10^{13} dPas)	Lower annealing point (viscosity $10^{14.5}$ dPas)	Linear expansion coefficient $\alpha_{20/300}$ 10^{-6} K^{-1}	Density g/cm³
Soda-lime glass (AR-GLAS®)	530	495	9.1	2.52
Borosilicate glass 3.3 (Boro 3.3)	560	510	3.3	2.23

BRAND®, BRAND. For lab. For life.® as well as the BRAND figurative mark are registered trademarks or trademarks of BRAND GMBH + CO KG, Germany. All other trademarks mentioned or depicted here are the property of the respective owners.

Our technical literature is intended to inform and advise our customers. However, the validity of general empirical values, and of results obtained under test conditions, for specific applications depends on many factors beyond our control. Please appreciate, therefore, that no claims can be derived from our advice. The user is responsible for checking the appropriateness of the product for any particular application. California Residents: For more information concerning California Proposition 65, please refer to www.brand.de/calprop65.

Subject to technical modification without notice. Errors excepted.

Find all information about our products at **shop.brand.de**

Further information on products and applications can be found on our YouTube channel **mylabBRAND**

BRAND GMBH + CO KG
Postfach 1155 | 97861 Wertheim | Germany
T +49 9342 808 0 | F +49 9342 808 98000 | info@brand.de | www.brand.de

BRAND®