Technical Data

• PYREX Borosilicate Glass

IWAKI manufactures PYREX® borosilicate glass under licence of Corning Glass Works, U.S.A..

• Most dependable Glass

PYREX® borosilicate glass is a low alkali borosilicate heat resistant glass. It is virtually free of magnesialime-zinc group and heavy metals.

• Superior chemical durability

Compared with other glasses, corrosion of PYREX® borosilicate glass by acids and distilled water is extremely low. PYREX® borosilicate glass is the best and the most suitable glass available for laboratory use.

• Thermal Resistance

Coefficient of expansion is one-third in comparison with other commercial glass, meaning high resistance to thermal shock. For example, the size of 150mm×150mm×3mm PYREX® borosilicate glass can withstand sudden temperature change of up to 180°C (Sudden cooling down)

PYREX® borosilicate glass manufactured under superior melting technique, strict inspection on appearance and severe quality control is the best for testing and analysis which require high precision.

❶ Glass composition

Chemical composition is given below. PYREX® borosilicate glass is characteristic of low coefficient of linear thermal expansion and high thermal shock resistance, because it abounds with silica as major composition and though a lot of B_2O_3 is contained. Na_2O and K_2O contents are low.
Abrasion as well as scratch and squeeze hardnesse is also excellent. Thanks to superior melting method, PYREX® borosilicate glass does not require putting fluxing agents and, therefore, offers neither bubble nor coloring even in fabrication by gas.

• Table 1 Composition

Content	SiO_2	Al_2O_3	Fe_2O_3	B_2O_3	Na_2O	K_2O
%	80.9	2.3	0.03	12.7	4.0	0.04

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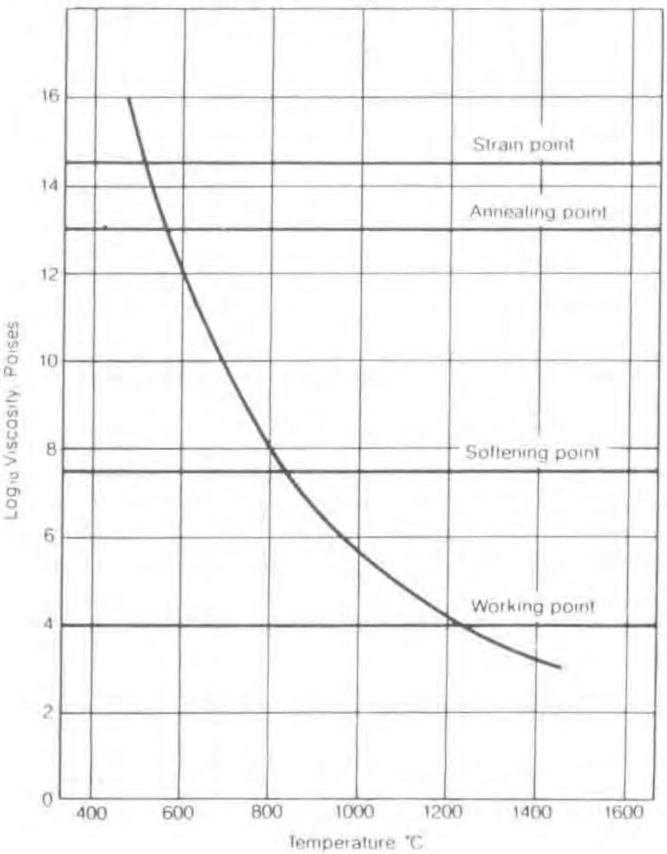
❷ Viscosity

Glass has an infinite viscosity in normal temperature and will deform only at temperature which approaches its strain points. Its viscosity range is normally between $10^{15} \sim 10^{2}$ poises. Viscosity is one of characteristic properties of glass, by which glass is measured.
Table 2 shows Viscosity of PYREX® borosilicate glass and Figure 1 shows Viscosity temperature curve.

● Table 2 Viscosity

	Working point	Softening point	Annealing point	Strain point
Viscosity	10^{4} poises	$10^{7.6}$ poises	$10^{13.0}$ poises	$10^{14.5}$ poises
Temperature	1,252℃	821℃	560℃	510℃

● Figure 1. Viscosity/Temperature Curve



❸ Physical Properties

Remarkable point of PYREX® borosilicate glass is low coefficient of linear thermal expansion, as shown Table 3. It is also one of characteristic properties that density is low compared with that of metal and soda-lime glass.

● Table 3 Physical Properties

Description	Value
Specific heat (25℃) Average (25～400℃)	0.17cal/g·℃ 0.233cal/g·℃
Thermal Conductivity (25℃) (100℃)	0.0026cal/cm·sec·℃ 0.0030cal/cm·sec·℃
Linear coefficient of expansion (0～300℃)	32.5×10^{-7}/℃
Density	2.23g/cm³

● Expression of thermal stress

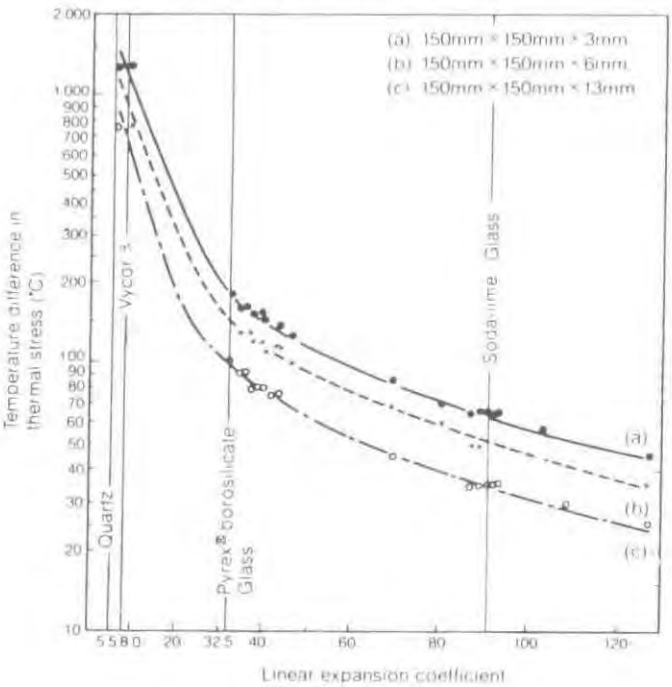
$$\sigma th = \frac{\alpha E \Delta T}{2(1-\varepsilon)} \quad \cdots\cdots (1)$$

σth:	Thermal stress	kg/cm²
E:	Young's module	kg/cm²
α:	Linear expansion coefficient	1/℃
ΔT:	Temperature difference	℃
ε:	Poisson's ratio	

❹ Thermal prosperties

Glass will be failed resulting from sudden cooling down or heating up.
Surface of glass causes tensile stress by cooling down and compression stress by heating.
Failure always results from tensile component of stress, even when the load is applied in compression. Glass is much stronger under compressive loads than under tensile loads. The reason is that tensile stress to occur in the surface of glass becomes stronger than maximum strength of glass. As formula (1) shows, the lower coefficient of thermal expansion is, the higher thermal resistance becomes. Therefore, PYREX® borosilicate glass is strong against thermal shock.
In general, thermal endurance of glass depends on form, condition of finishing etc. Figure 2 shows rates of linear expansion coefficient and temperature difference in thermal stress for 3 kinds of wall thickness of glass plate.

● Figure 2 Thermal shock resistance



❺ Mechanical properties

Fracture occurs at the maximum point of tension. Theoretical strength of glass is 200,000 kgs/cm².
However, breaking strength is commonly found to occur at tensile strength of about 500 kg/cm², because of surface scratch and thermal stress caused when designing glass components, fabrication, transportation and etc. It depends on following conditions.

a) Method of production
b) Method of fabrication
c) Method of heat treatment
d) Actual use and care

Design of glass components should be made by taking several times of safety measure.
PYREX® borosilicate glass is stronger than commercial glass, because of mechanical strength which prevents surface scratch.
Table 4 shows mechnical properies of PYREX® borosilicate glass.

● **Table 4 Mechanical properties**

Young's module	6.4×10^5kg/cm²
Poisson's ratio	0.20
Shear modules	2.7×10^5kg/cm²
Knoop Hardness (100g)	418KHN
Bending strength	$4\sim7\times10^2$kg/cm²
Design stress (Safety factor)	67kg/cm²

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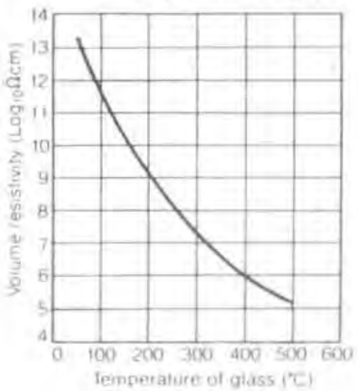
❻ Electrical Properties

Glass is widely used in the electrical industris as insulaters, lamps and parts of electron tube. Properties of PYREX® borosilicate glass has a large dielectric power, high volume resistance, high surface resistance and smooth solid -surface and also has a charactristic of low dielectric loss without carbonizing by action of arc and conductivity.
Figures 3, 4 and 5 show the charactristic of electrical properties.

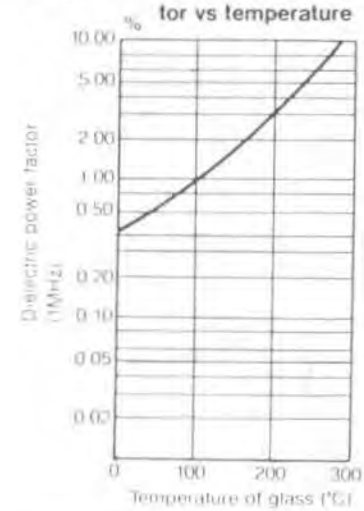
● Table 5 Electrical properties

Dielectric strength (thickness 0.1mm)	4,800kV/cm
Volume resistivity (Log_{10}) (25°C)	15Ω·cm
(250°C)	8.1Ω·cm
(350°C)	6.6Ω·cm
Dielectric power factor (1M Hz 20°C)	0.39%
Dielectric constant (1M Hz 20°C)	4.6%
Dielectric loss (1M Hz 20°C)	2.6%

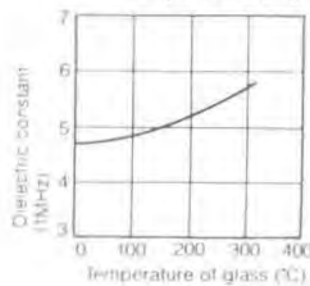
● Figure 3 Volume resistivity vs temperature of glass



● Figure 4 Dielectric power factor vs temperature



● Figure 5 Dielectric constant vs temperature of glass



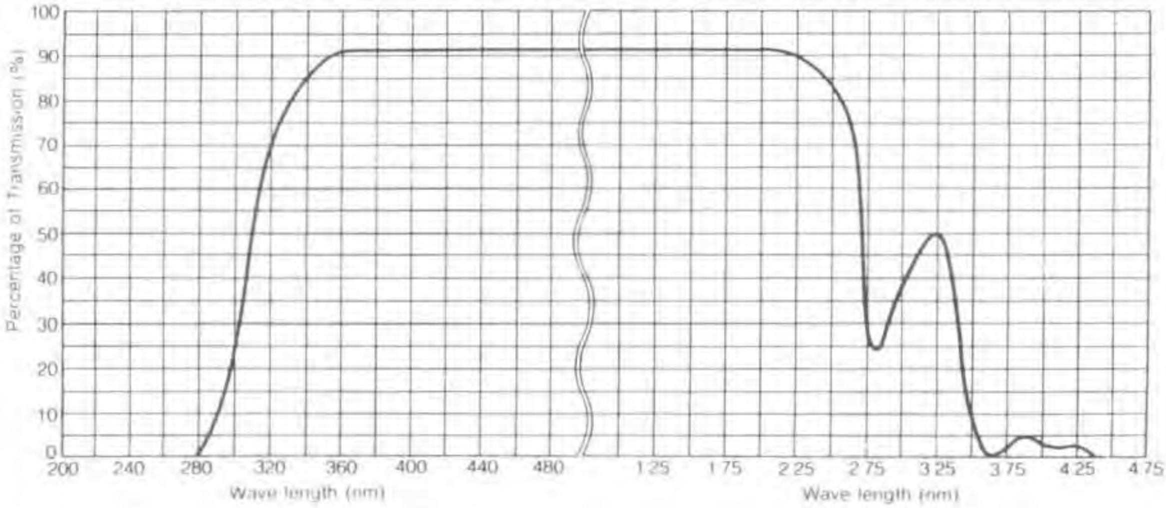
❼ Optical properties

PYREX® borosilicate glass has high ability to transmit light, due to use of refined materials containing a low percentage of iron. Refractive index nD is 1.474.

Figure 6 below given shows spectral transmittancy.

● Figure 6 Spectral Transmittancy of PYREX® borosilicate glass

(Thickness: 1.9 ~ 2.1mm) (Ultra-violet ray: under 380nm Visible ray: 380 ~ 770nm, Infrared ray: over 770nm)



❻ Chemical properties

Chemical durability of glass means chemical resistance. The surface of glass will be somewhat damaged by moisture, carbonic acid gas and so on in the air.
Durability is judged from the rate of resistance of glass to chemical corrosion. Corrosive amount of PYREX® borosilicate glass against acid materials and distilled water is extremely low compared with other glasses. Following figure shows loss of weight value of PYREX® borosilicate glass.

a) Distilled water

Solubility of Alkali 0.01mg
(100°C, 1HR, 300 ~ 500 particle test)
Weight loss of surface 0.001mg/cm² (100°C 6HRS)

b) Moisture (Weight loss of surface mg/cm²)

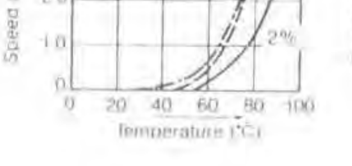
Exposing time	HR 1/2	HR 1	HR 2	HR 3	HR 4	HR 6	HR 8	HR 12
121°C (1.05kg/cm²G)	—	0.0075	—	0.0135	—	—	0.019	0.022
224°C (24.5kg/cm²G)	0.043	0.076	0.124	—	0.176	0.202	—	—

c) Acid, Alkali (Weight loss mg/cm²)

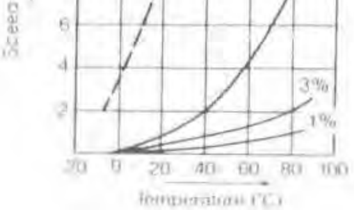
5% HCL 24Hrs 100°C	5% NaOH 6Hrs 99°C	N/50 Na_2CO_3 6Hrs 100°C
0.0045	1.4	0.12

PYREX® borosilicate glass is inert to almost all materials with the exception of hydrofluoric acid, phosphoric acid and hot strong caustic solutions.
Hydrofluoric acid has the most serious effect. However, the rate of attack of alkaline solution is not excessive, if not highly concentrated and at the room temperature. The rate of attack increases at the temperature over 40°C. Figures 7, 8, 9 and 10 show rates for both speed of corrosion by NaOH and fluoric acid, and weight loss against alkali.

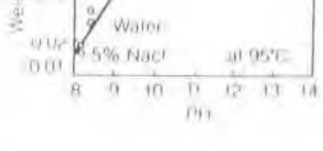
● Figure 7 Corrosion by NaOH Solution



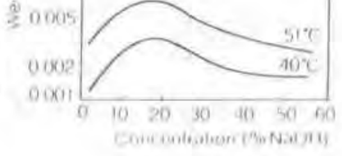
● Figure 8 Corrosion by Fluoric acid



● Figure 9 Durability vs Alkali



● Figure 10 Durability vs Alkali



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❾ Mechanical strength of internal pressure of PYREX® borosilicate glass tubes

The graph shows the mechanical strength for PYREX® borosilicate glass tubes of various diameter and thicknesses at 25°C calculated from the following formula.

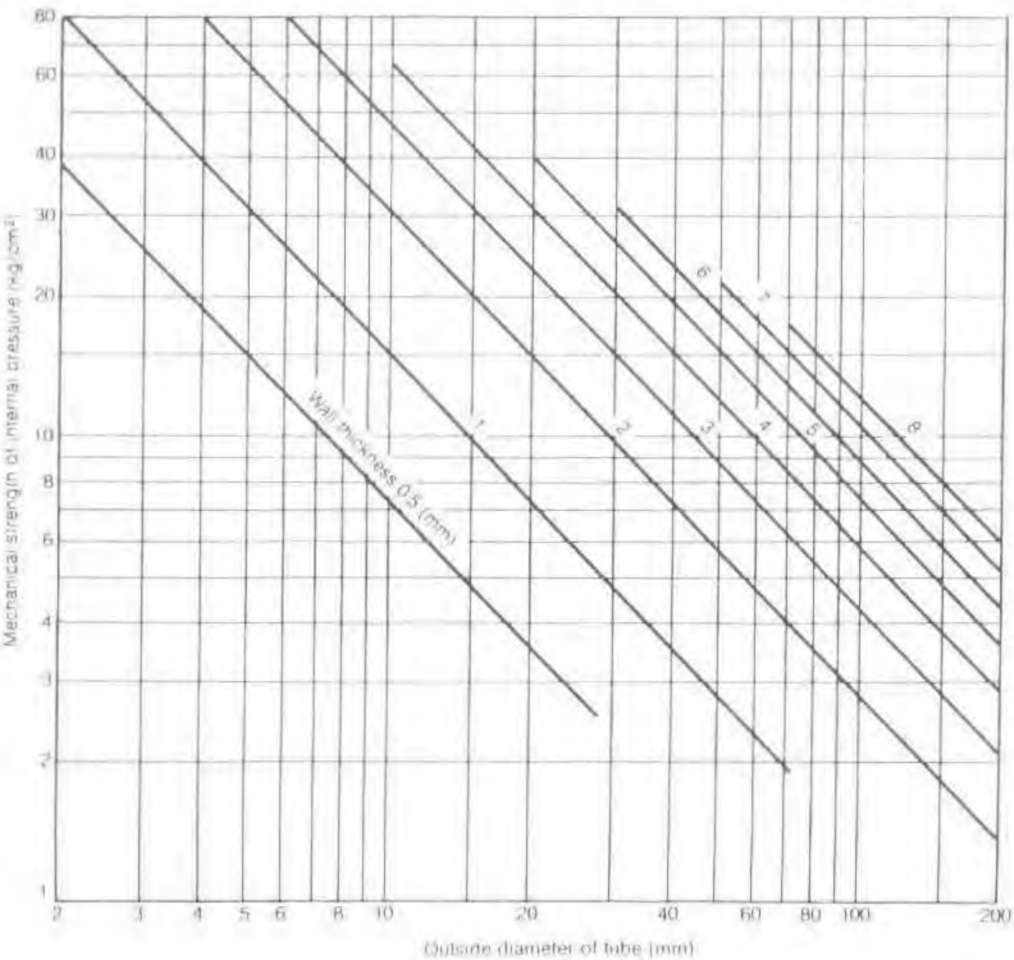
- $$P = \frac{1-\left(\frac{d}{D}\right)^2}{1+\left(\frac{d}{D}\right)^2} \cdot \sigma$$

P: Mechanical strength of internal pressure (kg/cm²)
σ: Design stress (67kg/cm²)
(The factor of average stress of cutting direction against inwall of glass tube is considered to be twice.)
d: Inside diameter
D: Outside dimeter

Note 1
The mechanical strength obtained from the graph is made for reference only and does not mean guaranteed internal pressure of PYREX® glass tubes.

Note: 2
The graph is not applicable to glass tubes under the following influences.
1. Pressure due to bend by fastening.
2. Hot pressure caused by difference of temperature.
3. Chip in glass tube.
4. Mechanical scratch.
5. Fast change of pressure.
6. Miscellaneous.

● **Figure 11 Mechanical strength of internal pressure of PYREX® borosilicate glass tubes**



⑩ Nomogram for computing relative centrifugal forces(RCF)

To calculate RCF value at any point along the tube or flask measure the radius in mm from the centre of the centrifuge spindle to the particular point. Draw a line from this radius value on the right-hand column to the appropriate centrifuge speed on the left-hand column. The RCF value is the point where the line crosses the centre column.

The nomogram is based on the formula:

$RCF = 11.18 \times 10^{-7} \times RN^2$

R = Radius in mm from centrifuge spindle to point in tube.

N = Speed of spindle in rpm.