SIMAX: PHYSICAL AND CHEMICAL PROPERTIES

In 1837 The Kavalier Glassworks was established, and it has been making glass ever since, in fact it is the oldest technical glass factory in Europe. Over the years many changes have taken place, and today it is considered an important producer world-wide. The glass made is borosilicate and is marketed under its own registered brand name SIMAX.

SIMAX glass, by its chemical composition and properties, ranges in the group of clear, hard, borosilicate 3.3, characterised with high heat and chemical stability, specified by international standard ISO 3585, resp. CSN ISO 3585, and, ASTM E 438 Type I, Class A. It entirely meets the demands as set out in the said standards. From SIMAX glass a wide spectrum of technical as well as laboratory glass products, industrial apparatus, household boiling and oven-ware as well as decorative glassware are manufactured.

Owing to its properties, SIMAX glass is used in such areas where the highest demands are made on products froma viewpoint of heat and chemical stability as well as neutrality to substances or preparations contacting them, e.g. in chemistry, petro-chemistry, food, power supply, metallurgy, health service, microbiology, pharmaceuticals, mechanical engineering and laboratories.

SIMAX tubing, rods, profiles and capillary tubes are used, in the production of laboratory glassware, industrial apparatus, pilot plant, pipe lines, drainage, decorative glass, solar collectors, light fittings, to name but a few. Products made from SIMAX glass are smooth and nonporous, transparent, catalytically indifferent, corrosion-resistant even in exacting operations, sufficiently homogenous and without presence of heterogenous particles.

Simax glass matches the demanding environmental requirements and it is absolutely unexceptionable from an ecological viewpoint.

SIMAX tubing, rod, profiles and capillary tubes are produced under very tight control, the tolerances are governed by the most up to date computer technology.

The company´s entire production is produced under a quality system and is certified under EN ISO 9001:2000 TUV CERT.

Physical data

Mean linear and thermal coefficient of expansion		
α (20 °C; 300 °C) according to ISO 7991	3,3 .10^{-6} K^{-1}	
Transformation temperature Tg	525 °C	
Glass temperature at	10^{13} (upper chilling temperature)	560 °C
Viscosity η in dPa . s:	$10^{7,6}$ (softening temperature)	825 °C
	10^{4} (working range)	1,260 °C
Highest short-term admissible working range		500 °C
Density ρ at 20 °C		2.23g. cm^{-3}
Modulus of elasticity E (Young's modulus)		64.103 MPa
Poisson's ratio μ		0.20
Thermal conductivity λ (20 to 100 °C)	1.2 $W.m^{-1}.K^{-1}$	
Temperature for specific electric resistance		
108 Ω.cm (DIN 52326) t_{k100}		250 °C
Logarithm of electric	at 250 °C	8
bulk resistivity (Ω . cm)	at 350 °C	6.5
Dielectric properties (1 MHz, 25 °C)		
Permitivity ε		4.6
Loss factor tan δ		37.10^{-4}
Refractive index (λ = 587.6 nm) nd		1.473
Photoelastic constant (DIN 52314) K		$4.0.10^{-6}$ $mm^2.N^{-1}$

SIMAX tubes and capillaries pressure resistance

Pressure resistance (p) calculation with a known wall thickness (Wt) and a given outside diameter (OD):

$$p = \frac{Wt \cdot 20 \cdot \frac{K}{S}}{OD\text{-}Wt}$$

Wall thickness (Wt) calculation with a given pressure resistance (p) and outside diameter (OD):

$$Wt = \frac{OD \cdot p}{20 \cdot \frac{K}{S} + p}$$

OD = outside diameter in mm — *Wt = wall thickness in mm*

p = pressure resistance in bar — *K/S = admissible stress in N . mm^{-2}*

SIMAX borosilicate glass 3.3 admissible stress: K/S = 7 N . mm^{-2} according to ČSN EN 1595 Standard:
Pressure Vessels Made of Borosilicate Glass 3.3; General Principles for Construction, Manufacturing and Testing.

Pressure resistance (p) affects, among others, the following:

- thermal difference between the inside and outside walls
- surface quality
- working the ends
- compliance with assembling conditions in accordance with pressure vessels regulations
- tube length

The manufacturer may perform an exact calculation, where necessary.

In addition, the following should be taken into consideration:

- ČSN EN 1595:1998 Pressure Vessels Made of Borosilicate Glass 3.3 General Principles for Construction, Manufacturing and Testing
- ČSN EN 12585:1999 Glass Equipment, Pipes and Pipe Fittings. Piping and Pipe Fittings with a Nominal Diameter of DN 15 to 1000. Compatibility and Interchangeability

Resistance to Temperature Variations

Resistance to temperature variations corresponds according to ISO 718 to the thermal difference between the hot test piece and the cold water bath (room temperature), where the first cracks appear on 50 per cent of samples, when these will have been quickly dipped into the water bath. Resistance to temperature variations of tubes, capillaries and rods depends on the wall thickness, shape and size of the cooled surface, surface condition, tension and final working. Uneven, flash heating or fast cooling may easily lead to cracking due to the resulting tension. It is recommended not to exceed the thermal difference of 120 °C. At thicker walls, this thermal difference is limited to lower values. As for examples of resistance to temperature variations of tubes and rods made of SIMAX borosilicate glass 3.3 some values measured have been specified hereinafter. These values may be considered indicators, because considerable differences may exist among parts of the same sizes:

Wall thickness in mm	Resistance to temperature variations in K
1	303
3	175
5	136
7	115

The manufacturer may perform an exact calculation, where necessary.

Chemical Composition

(main components in percentage by weight)

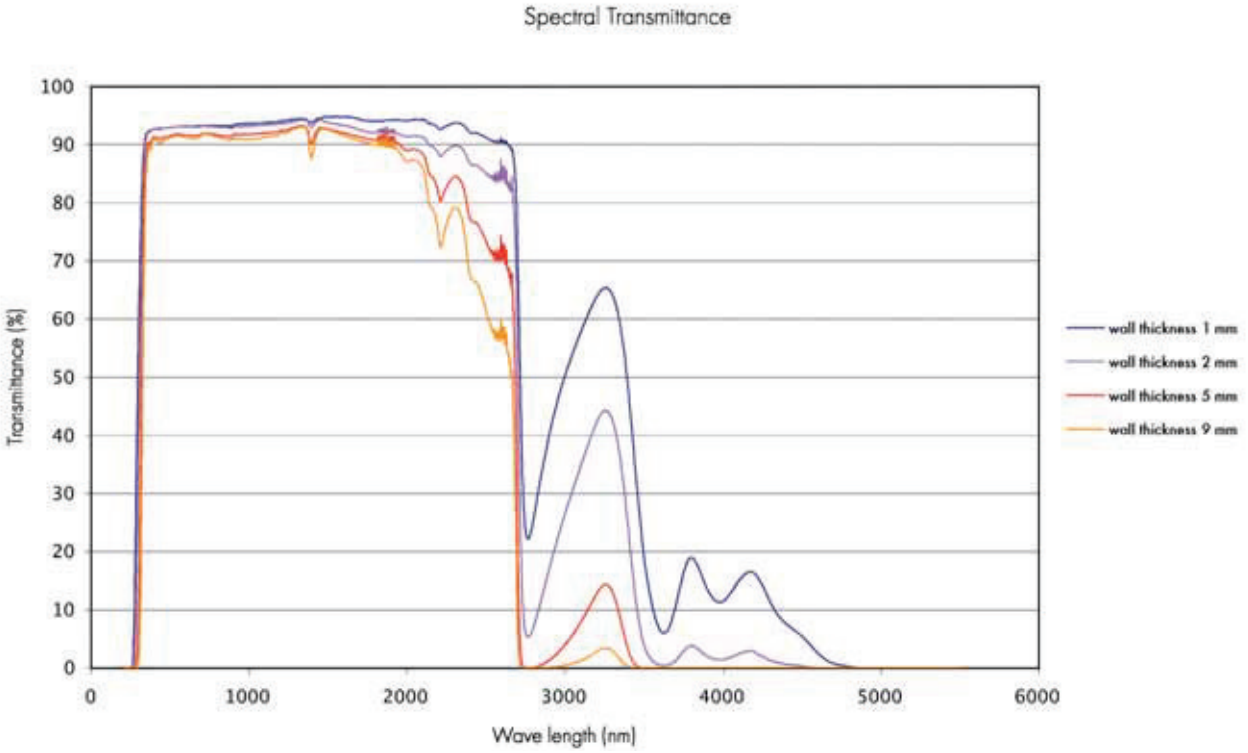
SiO_2	B_2O_3	$Na_2O + K_2O$	Al_2O_3
80.6	13	4	2.4

Chemical Durability

Class of Resistance to Water Effects (ISO 719)	HGB 1
Class of Resistance to Acid Effects (ISO 1776 a DIN 12116)	Class S1
Class of Resistance to Various Kinds of Lye (ISO 695)	Class A2

SIMAX borosilicate glass 3.3 is highly resistant to water effects, neutral and acid solutions, heavy acids and their mixtures, to chlorine, bromine, iodine and organic compounds. Even in long-term effects and at temperatures above 100 °C, this glass outstrips with its chemical durability most metals and other raw materials. Due to water and acid effects the glass releases small amounts only, mostly those of monovalent ions. At the same time, on the glass surface, there is formed a very thin, permeable siliceous gel layer, which ensures resistance to further effects. Hydrogen fluoride, hot phosphoric acid and alkaline solutions have an affect on the glass surface, depending on concentration and temperature.

Light Transmittance



Instructions for processing

SIMAX tubes, capillaries and rod material properties guarantee a very good workability in glass forming and dividing, which is usual with technical glass. To remove temporary stress, which originates in processing, it is appropriate to warm the glass through well up to a temperature of 550 °C, and, to leave it at this temperature over a period of time of at maximum 30 minutes; as a rule, in thin-walled products a fraction of this time would suffice. With regard to glass chemical durability the stabilization time should be as short as possible. For subsequent cooling down, the cooling speeds have been recommended as per the below table:

Cooling speed

Wall thickness in mm	Range of temperature		
	560 to 490 °C	490 to 440 °C	440 to 20 °C
3	14 °C /min	28 °C /mm	up to 447 °C /min
6	3°C /min	6 °C /min	up to 111 °C /min
12	0.6 °C /min	1.6 °C /min	up to 28 °C /min

In the event that it is necessary to cool the product down several times, the sum of all the stabilization times at 550 °C should not exceed two hours. SIMAX glass may be melted and joined with other brands of borosilicate glass of the same type, without stress, and processed and stabilized at the same temperatures. SIMAX tubes, capillaries and rods may be printed using silver- and copper-based diffusion colours and silk-screenprinting colours.

KAVALIER SIMAX: TECHNICAL CONDITIONS

Length

Standard lengths:

Tubing		1,500 +10mm −0mm
Capillary		1,500 ±10mm
Rod:	diameter 3 to 6mm	1,500 ±20mm
	diameter 7 to 16mm	1,500 ±10mm
	diameter 18 to 30mm	1,500 ±30mm
Non-circular assortment		1,500 ±20mm

Non Standard Lengths:
Both shorter and longer lengths can be produced to suit special requirements. For example; depending on outside diameter and wall thickness, we can produce tubing up to 12 metres in length. Inquiries are most welcome.

Out-Of-Roundness

Tubing

∅ <18mm	s_{max} 0.7% of the outside diameter

Capillary

∅ <10mm	s_{max} 1.0% of the outside diameter

Rod

∅ <20mm	s_{max} 1.0% of the outside diameter
20mm ≤ ∅ ≤30	s_{max} 1.5% of the outside diameter

Wall Thickness Variance

The difference between the maximum and minimum wall thickness at arbitrary point of a tube may not exceed 12% of the wall nominal thickness.

Deflection

Tubes deflection according to ISO 1101 may be as follows:

Outside diameter 4–<6mm	maximum 4.0 mm/1,500mm
Outside diameter ≥6–<30mm	maximum 1.5 mm/1,000mm
Outside diameter ≥30–<100mm	maximum 2.0 mm/1,400mm
Outside diameter ≥100–≤180mm	maximum 2.5 mm/1,400mm

Rods and capillaries are supplied with deflection of maximum 4mm over 1,500mm of the product length.

Non-circular assortment is supplied as follows :
- tubes with deflection of maximum 0.4% of nominal length
- capillaries and rods with deflection of maximum 0.6% of nominal length

Stress

Tubes

Outside diameter in mm	∅ < 40	40 ≤ ∅ ≤ 60	∅ > 60
Internal stress over the tube length	3.0 MPa 102.9 nm/cm	3.5 MPa 120.05 nm/cm	2.5 MPa 85.75 nm/cm
Internal stress at the edge	4.0 MPa 137.2 nm/cm	3.5 MPa 120.05 nm/cm	2.5 MPa 85.75 nm/cm

Rods are not normally annealed, however, rods 18 to 30mm diameter can be delivered annealed, if requested by the customer.

Profiles, and capillary tubes are not annealed.

Stones and tails

Stones	**Stones/ 1kg of glass**
Size <0.3mm	permitted
Size ≥0.3–<1.0mm	max. 2
Size ≥1.0–≤2.0mm	max. 1
Size >2.0mm	prohibited

Tails	**Tails/ 1kg of glass**
Size <0.3mm	permitted
Size ≥0.3–<1.0mm	max. 4
Size ≥ .0–≤3.0mm	max. 2
Size >3.0mm	prohibited

The grain size is considered as corresponding to stones or tail size.

Bubbles

Length

Bubbles length corresponds to the length of all bubbles ≥20mm.
Permitted length of bubbles is 0.8 m/10m of a tube.
Bubbles <20mm: 20 pcs/1kg of glass.

Width

Bubbles wider than 1mm are prohibited in tubes with a diameter of ∅ ≤100mm.
Bubbles wider than 2mm are prohibited in tubes with a diameter of ∅ >100mm.

Note:
capillary bubble is a bubble drawn in the direction of the length of a product in the form of a capillary with a length greater than 2mm.

End Finish and Front Surfaces Perpendic ularity Deviation

Tubing

Tubes	**Tube Ends**	**Front surfaces perpendicularity deviation**
4 ≤ ∅ ≤ 5	not flame polished	–
5 < ∅ ≤ 100	flame polished	2.5
100 < ∅ ≤ 180	flame polished	4.0

In flame polishing the ends, wall thickness may get enlarged by 0.1mm.

Capillaries and rods are not flame polished.

Profiles are not flame polished at the ends, with the exception of tubes fluted inside, which are flame polished at the ends.

Packing

Products are supplied in conveniently sized cartons, with sufficient protection against damage in transportation and storage.