1. Basic features of SIMAX glass

All glass parts are made of borosilicate glass 3.3 – SIMAX.
This type of borosilicate glass is characterized by high chemical resistance, low coefficient of linear thermal expansivity and thus high resistance against temperature changes. Properties of the SIMAX glass are under a permanent supervision and are certified in accordance with ISO 3585.

Chemical composition

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

1.1. Chemical resistance

Products from SIMAX glass feature high resistance against the effects of water, steam, acids, salt solutions, and relatively good resistance against alkalis. For these reasons, SIMAX glass is used in cases where high chemical resistance and neutrality against stored or working substances are required for the products, i.e. in chemistry, laboratories, health care, pharmaceutics, food industry, etc. Chemical resistance is assessed by standard international methods defined by ISO standards.

Method according to standard ISO	Acceptable value		Max. value attained for SIMAX glass	
	Class	Value	Class	Value
Resistance against water at 98 °C according to ISO 719, loss of alkalis μg/g	HGB1	31	HGB1	25
Resistance against water at 121 °C according to ISO 720, loss of alkalis μg/g	HGA1	62	HGA1	28
Resistance against acids according to ISO 1776, loss of weight μg/dm^2	1	100	1	11
Resistance against alkalis according to ISO 695, loss of weight mg/dm^2	A2	175	A2	120

1.1.1. Resistance against water at 98°C

The test is carried out according to ČSN ISO 719. Data of the extract from 2 g of crushed glass, grain size between 300 and 500 μm, with water of degree of purity 2, for 60 min at 98 °C, are used for practical purposes.

1.1.2. Resistance against water at 121°C

The test is carried out according to ČSN ISO 720. Data of the extract from 10 g of crushed glass, grain size between 300 and 425 μm, with water of degree of purity 2, for 30 min at 121 °C, are used for practical purposes.

1.1.3. Resistance against acids

SIMAX glass, same as all internationally approved borosilicate glasses, is practically resistant against all aggressive agents except for hydrofluoric, fluorosilicic, phosphoric acids and hot concentrated lyes which markedly attack glass contact surfaces.
Glass surface is attacked by hydrofluoric acid even at low concentrations. Phosphoric acid and lyes only slightly attack glass at low temperatures and concentrations. At high concentrations and temperatures, glass resistance significantly decreases. Permanent alternation of acidic and alkaline environment increases corrosion.
The test is carried out according to ISO 1776. Sample pieces, size 30–40 cm^2, are subject to the effect of an aqueous solution of hydrochloric acid at 100 °C for 3 hours.

1.1.4. Resistance against alkalis

The test is carried out according to ČSN ISO 695. Sample pieces, size 10–15 cm^2, are submerged in boiling solution of same volumes of sodium carbonate and sodium hydroxide for 3 hours.

1.2. Physical properties

The mean coefficient of linear thermal expansivity ανδ (20 °C; 300 °C)	$3.3 \cdot 10^{-6}$ K^{-1}
Transformational temperature T_g	525 °C
The glass temperature at viscosity of η in dPa.s 10^{13} (the upper temperature of cooling)	560°C
The glass temperature at viscosity of η in dPa.s $10^{7.6}$ (the temperature of softening)	825°C
The glass temperature at viscosity of η in dPa.s 10^{4} (operation range)	1,260°C
The highest short-term allowed operation range	500°C
Density ρ at 20°C	$2.23\, g \cdot cm^{-3}$
Elastic modulus E (Young's modulus)	$64 \cdot 10^{3}$
Poisson's constant μ	0.20
Heat-carrying capacity λ (20 to 100°C)	$1.2\, W \cdot m^{-1} \cdot K^{-1}$

1.2.1. Thermal properties

High resistance of products made of Simax glass against sudden changes in temperature - thermal stability - depends on the low coefficient of linear thermal expansivity, relatively low module tensile elasticity and relatively high thermal conductivity which result in a lower thermal gradient in the product wall. When cooling and heating the glass product, no undesirable inner tension is created. If a glass product is broken down as a result of changing the temperature, it is caused by tensile stress on the product surface by linear expansivity of the glass at the time of quick cooling from the product surface.
Permissible thermal stress depends on the temperature gradient in the glass part wall.
Provided that there is no temperature shock, the glass can be used up to temperatures of about 300°C. Generally and with respect to packing and jointing material, it is recommended to use the glass piping and apparatus up to temperatures of about 200°C.
The boundary of possibility of quickly changing temperatures depends on thermal stress evoked by process conditions, connection and fixing of parts, and is also influenced by the different wall thickness of these parts. For these reasons, limiting value cannot be specified for all encountered technological and process conditions.
A substantial condition of good resistance against temperature shock is the absence of mechanical working and scratching of the uniform glass surface with coarse scratches or dull stains. Temperature shock is a quick temperature change between the glass part and the environment. It depends on the wall thickness of glass parts and the form of heating. Resistance of glass parts against sudden changes in temperature in relation to the maximum part wall thickness according to PN 13 8900.

Part size	Wall thickness, mm	Temperature difference, °C
DN 15–25	4	120
DN 40–100	5	100
DN 150–400	7	90
DN600	10	80

1.2.2. Heat transfer

Orientation values of total coefficient of heat transfer through SIMAX glass walls:
When used as a condenser (steam condensation around tubes, cooling water through tubes)
k = 290–580 W/m^2K (250–500 $kcal/m^2h$ °C)
When used as an evaporator (water evaporation around tubes, steam condensation in tubes)
k = 465–814 W/m^2K (400–700 $kcal/m^2h$ °C)
When used as a heat exchanger (heated liquid around tubes, heating liquid through tubes)
k = 250–400 W/m^2K (200–350 $kcal/m^2h$ °C)

1.2.3. Change in length depending on temperature

The SIMAX glass features a very low coefficient of thermal expansivity.
Change in length of a piping line, length 100 m, in relation to temperature is given in the following table:

Temperature (°C)	50	100	150
Length change ∇ (mm)	17	33	50

In case of longer lines, the change in length of the piping due to change in temperature should be taken into consideration and the piping should be fixed in a way that allows for the change in length. This is usually achieved by using various expansion joints.

1.2.4. Mechanical properties

The mechanical properties and lifespan of products made of Simax glass depend partly on the level of their finishing, especially as a whole, i.e. deep damage on the surface by handling and subsequent thermal load deteriorates the lifespan.

Abrasion hardness of the glass matter 6° on the Mohs scale	
Allowed tensile stress	3.5 MPa

Cooling Simax glass

Cooling is a thermal process with the purpose of preventing the generation of undesirable and inadmissible high thermal stress in glass that would decrease the product resistance and/or remove any existing stress.
The cooling cycle involves three stages:
Temperature growth (heating of the product) with the heating rate from feeding temperature to the upper cooling temperature.
Persistence for a certain period (lag, temper, stabilization) of products on the upper cooling temperature, with the temperature differences in the product need to be balanced out, including a decrease in the stress to a permissible limit.
Temperature decrease (cooling and after-cooling) with the cooling rate from the upper to the lower cooling temperature (this stage is important because permanent stress might be generated) and from the lower cooling temperature to the final temperature or ambient temperature (important for subsequent practical manipulation with the product).

1.2.5. Permissible stress with inner overpressure

Permissible inner overpressure in glass piping and equipment depends on nominal inner diameter, shape, operating temperature, material of connecting parts, and type of gasket used.
In case of an apparatus assembled from parts of different inner diameters and shapes, the permissible stress by inner overpressure is always given by the part of the lowest permissible stress.

The operating values of liquid overpressure at a temperature difference between the inner and outer wall
t = 5 °C (and temperatures up to 120°C) are:

DN	15	25	40	50	80	100	150	200	300	400	600
MPa	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.07	0.07

value in MPa = overpressure

Table of permissible overpressures for "T" pieces and crosses

DN	80	100	150	200	300	400	600
25	0.3	0.2	0.2	0.1	0.1	0.07	0.07
40	0.3	0.2	0.2	0.1	0.1	0.07	0.07
50	0.3	0.2	0.2	0.1	0.1	0.07	0.07
80	0.2*	0.2	0.2	0.1	0.1	0.07	0.07
100		0.15*	0.15*	0.1	0.1	0.07	0.07
150			0.1*	0.07*	0.05*	0.05*	0.05*
200				0.07*	0.05*	0.05*	0.03*
300					0.03*		

* decreased value of permissible overpressure

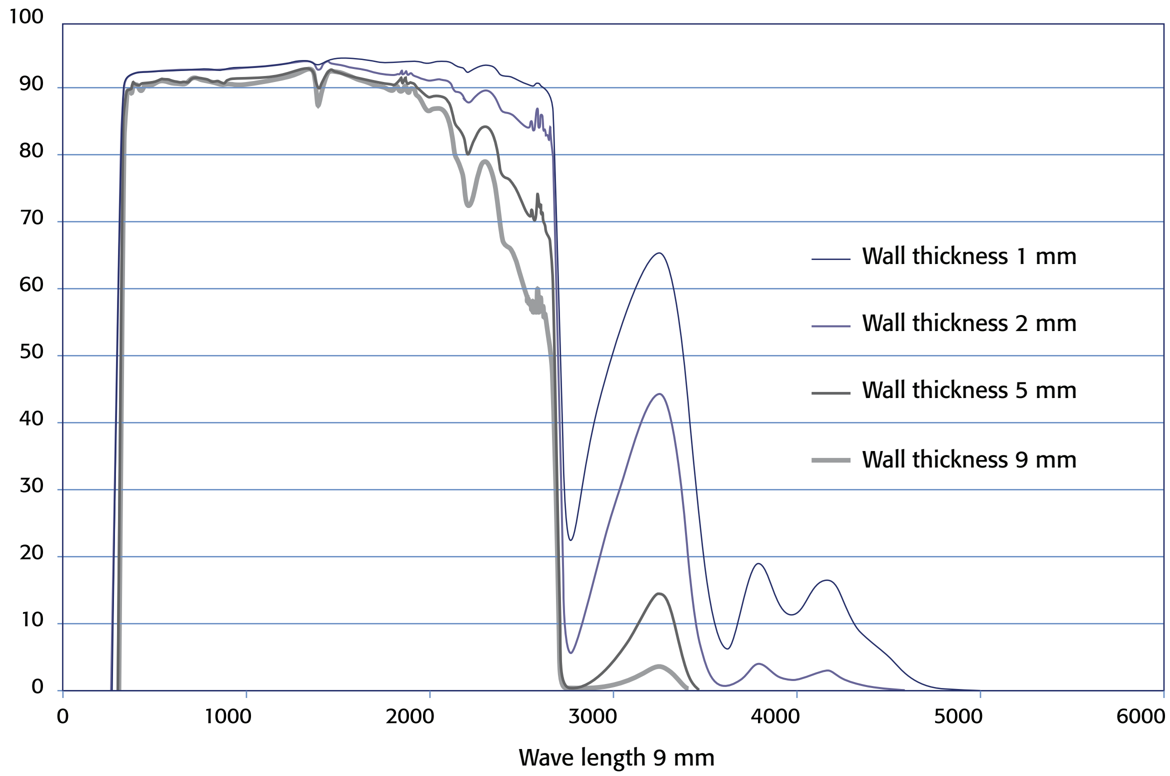
The pressure shocks caused by running pumps or fittings should not exceed the maximum operating pressure of the piping, the piping must be protected (safety valves, receivers, etc.).

1.2.6. Permissible stress by inner underpressure

Permissible stress of the apparatus by vacuum depends on shape stability of large glass parts, operating temperature, material of connecting parts and type of gasket used.
Long-term process experience has proven that an apparatus can be safely operated with the underpressure corresponding to the absolute pressure of 0.0015–0.0020 MPa.

1.2.7. Optical properties

The SIMAX glass does not show any significant absorption in the visible spectrum and it is clear and colourless. The permeability of ultraviolet rays is limited to middle-wave-length spectrum and it is higher than for normal table glass, which allows the glass apparatus to be used for photochemical reactions, e.g. sulfonation and halogenation processes.



1.2.8. Electrical properties

Under normal temperatures, Simax glass is a non-conductive material – it is insulant. Specific resistance in the environment resistant against humidity (20°C) above 10^{13} – 10^{15} $\Omega \cdot$ cm. Permitivity ε (20°C, 1 MHz) 4.6. Loss angle tg ε (20 °C, 1 MHz) $4.9 \cdot 10^{-3}$. Electrical losses rapidly increase with increasing temperature and change with the frequency.

2. Layout and design of glass apparatus

The documentation of all steps of design preparation should contain the following items:
- flow sheet
- assembly diagram
- building layout
- requirements for building works
- list of materials
- technical report
- safety regulations

3. Assembly of glass apparatus

Guarantees for correct and safe operation are only granted in the case that the assembly and commissioning have been carried out professionally in accordance with the accompanying technical documentation and by technicians who have been authorised to work with glass equipment (assembly men of the Kavalierglass or individuals tested and approved by the Kavalierglass).

Assembly is to be carried out exclusively according to the contract documents approved by the customer. In case the apparatus assembly is to be carried out in a way different from that specified by the documentation, each such change should be approved in advance by the designer or the customer should write a record in the assembly log book and make a change in the documentation.

Inspection of the building site before the assembly includes inspection of building preparedness of the space intended for installing the apparatus and the space for assembly preparation. At the same time, realization of the construction is inspected with respect to safety during assembly. Taking-over connecting points applies particularly to technological piping to which the apparatus is to be connected and on which the assembly depends.

Glass as well as non-glass parts are wrapped in disposable packing. Only non-damaged parts of equipment can be assembled. Immediately before assembly, the glass parts should be cleaned to remove all impurities. Fittings should be checked for conditions of seats, cones and all parts should be cleaned.

The assembly of supporting structures, fastening stirrups, supporting beds and frames is carried out according to drawings and approved drawing documentation.

The assembly of parts is carried out by means of suitable mechanization tools in compliance with safety regulations. When mounting vertical sections of glass apparatus, it is necessary to meet the condition of a single firm support to prevent creating stress in glass parts. In case the whole weight of the apparatus cannot be fixed to a single support it is necessary to use one fixed support and other sliding supports. The main (fixed) support is to be fastened to a strength-appropriate glass part so that as much of the weight of the apparatus as possible is fixed completely. None of movable parts of the seating may be seized or twisted. Care should be taken to ensure that the assembly setting of movable parts of seating allows for the range of dilatation movement during operation.

The apparatus should be sufficiently secured in stability by assembly elements so that forced assembly cannot cause stress in glass parts. PTFE expansion joints are mounted so that they not only compensate dilatations in the direction of the piping line axis but also prevent transferring vibrations.

4. TESTING GLASS APPARATUS

After construction, reconstruction or repair and before commissioning, the assembled apparatus should be tested. Individual types of tests are specified in the contract documents, namely:
- check of assembled apparatus (constructional test) – it is used for ascertaining that overall realization and material used correspond to the submitted contract documents and agreed-upon requirements of the customer, and preparedness for pressure test is checked
- pressure tests – they serve for verifying pressure resistance of the piping
- test of temperature change – it verifies behaviour of the piping during temperature fluctuations
- tightness test – it checks the glass piping for tightness.

A protocol is to be elaborated about the tests carried out.

5. OPERATION AND MAINTENANCE OF GLASS APPARATUS

5.1. Technical requirements

The operating conditions of each glass apparatus should be specified in the design. In case the process has been designed by the customer using glass parts specified in design plans, leaflets and documentation of the supplier, the limits of operating conditions cannot exceed the conditions specified for respective parts by the manufacturer. Written operating instructions which describe in details the process sections, including start-up, operation and termination of equipment operation, should be at disposal. Critical factors should be specified which would result in stopping the operation. If this applies to working procedures in which operating pressure limits can be exceeded, the glass apparatus should be protected at appropriate places with pressure safety valves, piercing shutter fuses, alarm devices, etc. In chemical processes where a risk of fire or explosion due to static electricity exists, the safety measures, particularly in processing and transport of liquids in glass piping, should include earthing of a point on the external surface of each glass part. The glass apparatus in which processing is carried out of chemical substances, the escape of which could result in detriment to the operator's health, should be protected by a suitably fitted shield or by installing the whole apparatus into a separate room which can be locked during operation.

5.2. Commissioning

Before putting the apparatus into operation, it is necessary to carry out a general inspection of all glass parts for the possibility of occurrence of mechanical damage (impacts and cracks) incurred during the assembly. These impacts and cracks could make performing glass apparatus testing impossible or could cause material damages. During filling, heating-up and putting the apparatus into operation, the glass stress cannot exceed the values considered by the designer according to valid regulations and standards.

5.3. Maintenance of glass apparatus

5.3.1. Cleaning of glass

For cleaning the surfaces of glass parts and preserving all required properties of the glass, it is necessary to clean parts immediately after shutting down the apparatus. No cleaning agent of abrasive character may be used and chemical dissolving of impurities should be preferred. Because of a danger of gradual loss in glass lustre and transparency of glass parts, cleaning agents of neutral reaction should be preferred to strongly alkaline ones.

5.3.2. Labour safety

During maintenance of the apparatus it is forbidden:

- to work on an apparatus and equipment in operation and under pressure
- to use glass parts of the apparatus as load-bearing parts
- to hang auxiliary assembly tools on glass parts
- to carry out a pressure test with a defective manometer or under pressure which is higher than the prescribed value
- dismantled parts should be cleaned and checked for possible damage
- after repair it is necessary to inspect flange joints and the whole apparatus in operation for the period of 24 hours
- a record should be made in the revision book on each repair of the apparatus and test performed.

6. Guarantee

The manufacturer of the glass apparatus, the Kavalierglass, confirms that the product has been made from SIMAX borosilicate glass 3.3 SIMAX, and that it meets the requirements of ČSN ISO 3585. The dimensions and quality of workmanship of glass parts complies with the standards ČSN EN 1595, ČSN EN 12 585 and the internal company standards. The manufacturer warrants for the period of one year that no spontaneous failure of glass parts shall occur. Correct and safe operation is only covered by the guarantee of the manufacturer if assembly and commissioning have been carried out professionally in compliance with the technical documentation and by technicians who were trained for working with the glass apparatus supplied by the joint-stock company Kavalierglass (assembly men of the Kavalierglass or persons tested and authorized by the experts of the joint-stock company Kavalierglass). The manufacturer does not provide a guarantee in the case of mechanical damage and other failures caused by improper storage, transport, non-professional assembly and cleaning, or by running the apparatus beyond the parameters specified in the technical documentation. The products listed in the documentation do not represent a binding production programme; the manufacturer reserves the right to implementing technical modifications.