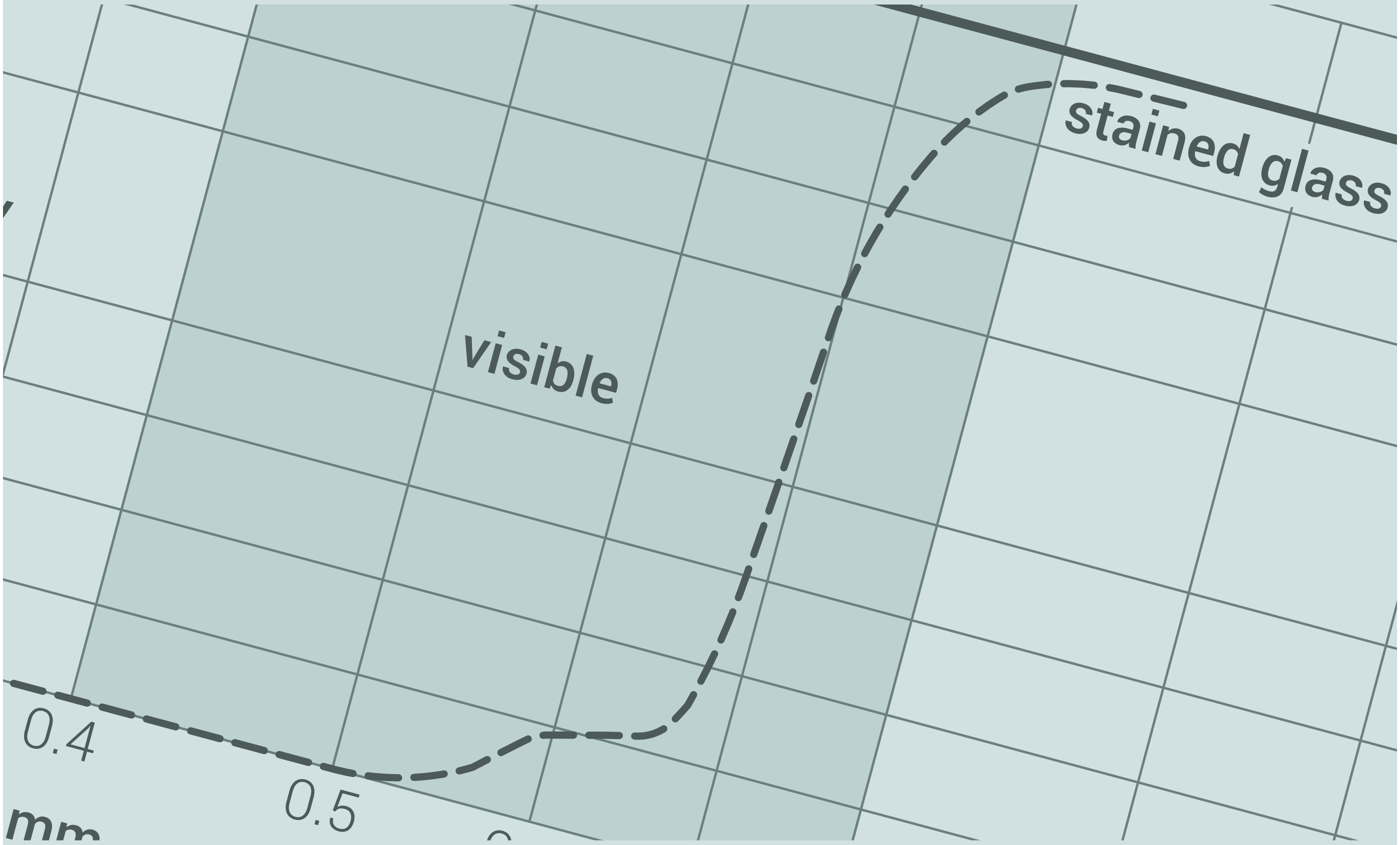
TECHNICAL INFORMATION



Technical Information

Introduction

All glass reactors, plants, pipelines and components are manufactured from **Borosilicate Glass 3.3**. This particular name derives from the main chemical components, i.e. silicon and boron, and from the figures of the mean linear thermal expansion coefficient, i.e. 3.3 10^{-6} K^{-1}, one of its most important characteristics.

No other well-known material can offer a better combination of properties for a large number of chemical or biochemical applications.
The most important chemical and physical properties of borosilicate glass 3.3 are defined by international standard ISO 3585.

Properties

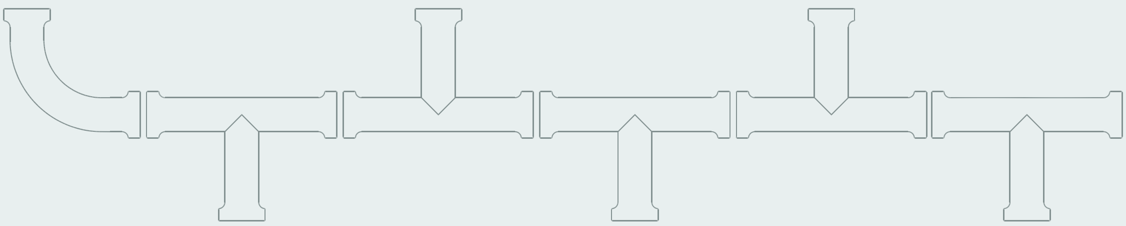
- Smooth, non-porous surface, easy to clean and sterilize;
- excellent and wide chemical compatibility, including high resistance to water, saline solution, organic substances, halogens and also many acids;
- no catalytic effect on chemical processes;
- no adverse physiological properties on biochemical processes;
- transparency;
- non flammability;
- good thermal resistance and stability;
- low thermal expansion.

Soffieria Sestese timeline

1984 – Founding of Soffieria Sestese, glass manufacturer specialized in borosilicate glass 3.3 industrial components.

1999 – Development of Engineering Department and national sales network consolidation.

2011 – Moving to new headquarters and manufacturing plant in Seregno (MB).



1992 – Production of the first industrial plants.
Starting of direct management of Italian clients.

2003 – Leader in the Italian market, Soffieria Sestese starts building its worldwide presence.

2015 – New corporate identity and “Flat connections catalog”, in line with ongoing company development...

Soffieria Sestese may alter detail specifications at its discretion and without notice, in line with its policy of continuous development.

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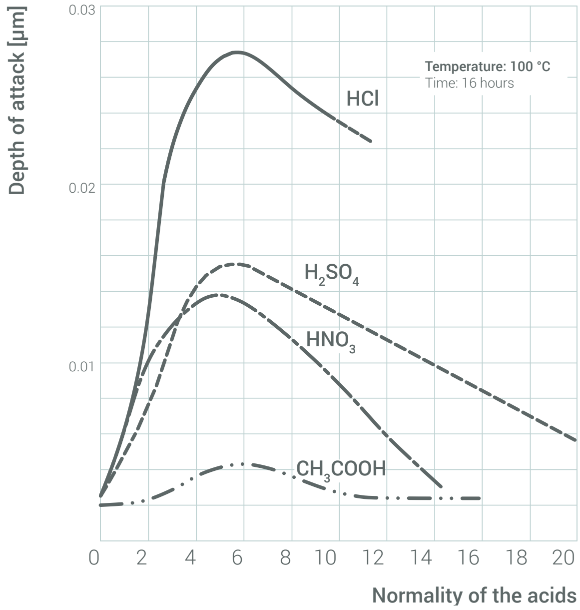
Chemical composition of borosilicate glass 3.3

Table 1 summarizes the chemical composition of borosilicate glass 3.3:

COMPONENT	% BY WEIGHT
SiO_2	80.6
B_2O_3	12.5
Na_2O	4.2
Al_2O_3	2.2
Trace elements	0.5

Table 1
Borosilicate glass 3.3 chemical composition



Graph 1
Corrosion of borosilicate glass 3.3 as a functions of acid concentration

Chemical resistance

The most important chemical and physical properties of borosilicate glass 3.3 are defined by international standard ISO 3585:1998; EN1595).

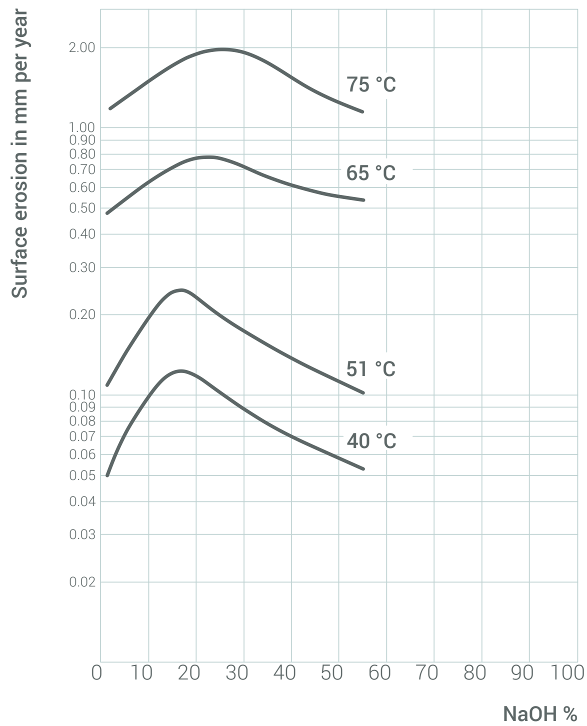
PROPERTY	ISO 3585
Hydrolytic resistance at 98 °C (ISO 719)	HGB 1
Hydrolytic resistance at 121 °C (ISO 720)	HGA 1
Acid resistance (ISO 1776)	Na_2O <100 mg/dm²
Alkali resistance (ISO 695)	A_2

Table 2
Chemical property

On a practical point of view, the most important chemical properties for manufacturing of reactors or chemical plants are those related to glass behavior about attacks from acid and alkaline solutions.
Detailed information on these subjects is available in technical or scientific literature but, in short, the only serious corrosion effects of the glass surfaces arise from:

- Hydrofluoric acid;
- Concentrated solution of phosphoric acid;
- Combination of caustic solutions (high alkaline pH) and high temperatures.

As a rule of thumb, pH values higher than 10 at more than 100 °C can lead to serious corrosion effects on borosilicate glass.



Graph 2
Corrosion of borosilicate glass 3.3 as a function of NaOH concentration and temperature

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Physical properties

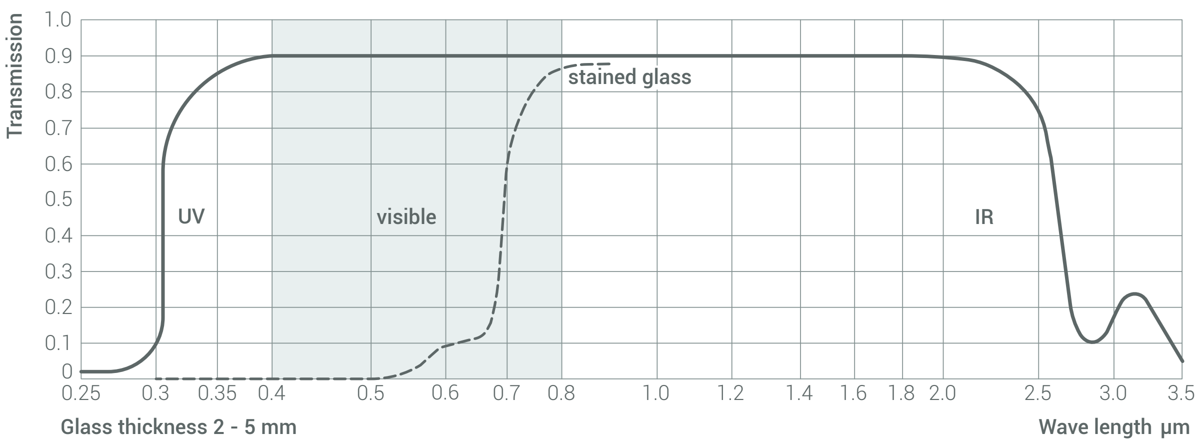
Physical properties of borosilicate glass 3.3 are defined by international standard (ISO 3585:1998; EN 1595).

PROPERTY	ISO 3585
Mean linear thermal expansion (ISO 7991)	$\alpha_{20/300} = (3.30 \pm 0.1)\ 10^{-6}\ K^{-1}$
Mean thermal conductivity (20 ÷ 200 °C)	$\lambda_{20/200} = 1.2$ W/m·K
Mean specific heat capacity (20 ÷ 100 °C)	$C_{p\ 20/100} = 800$ J/kg·K
Mean specific heat capacity (20 ÷ 200 °C)	$C_{p\ 20/200} = 900$ J/kg·K
Density at 20 °C	$\rho = 2.23$ g/cm³
Transformation temperature	525 ± 15 °C
Working temperature	≤ 300 °C
Modulus of elasticity	E = 64 kN/mm²
Poisson's ratio	v = 0.2

Table 3
Physical properties

Optical properties

Borosilicate glass 3.3 shows no appreciable light absorption in the visible part of the EM spectrum and it is therefore clear and colorless.
On the other hand, brown or opaque coating can be easily applied to glass components, if necessary.
This allows borosilicate glass equipment to be suitable both for photochemical reactions, where UV light is needed to run the process, and for reactions or storage involving photosensitive chemicals.



Graph 3
EM radiation transmission through borosilicate 3.3 glass

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Mechanical properties

The mechanical behavior of borosilicate glass 3.3 is that of a relatively hard-surfaced, fragile (non-ductile) material.

PROPERTY	
Max permissible tensile and bending strength (ground polished, worked)	K/S = 7.0 N/mm²
Max permissible tensile and bending strength (flame polished, undamaged)	K/S = 10 N/mm²
Max permissible compressive strength (all conditions)	K/S = 100 N/mm²
Modulus of elasticity	E = 64 kN/mm²
Poisson's ratio	v = 0.2

Table 4
Strength parameters according to EN 1595

Permissible operating temperature

It is well known that in borosilicate glass 3.3 deformation only occurs at temperatures approaching the glass transformation temperature, i.e. about 525 °C. Until very close to that temperature, the glass retains all its mechanical properties.
Due to requirement imposed by design and safety standards, maximum permissible temperature for glass-manufactured components is however much lower. In case of borosilicate glass 3.3 the maximum operating temperature is normally at 200 °C, if no other constrains arise (see later at section 1.6)
Under exceptional circumstances and with special precautions borosilicate glass components may work up to 300 °C. Such components must be clearly marked and must be installed according to special instructions provided by the manufacturer.
On the other hand, low temperatures are normally not a serious issue for glass-manufactured components, since glass tensile strengths actually increase at sub-zero temperatures.
As before, anyway, safety standards normally limit the use of borosilicate 3.3 glass at not less than −80 °C.

For part of **jacketed components**, taking into account a sufficiently high safety factor, the permissible operating temperature for the inner component is −80 °C to +200 °C and for the jacket it is −50 °C to +180 °C.

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Thermal shock

A serious threat to glass made components comes from thermal shocks, i.e. sudden change in temperature, rather than temperature value itself. As a matter of fact a quick temperature change can easily lead to additional thermal stress inside the glass resulting in breaking even at temperatures well according to the above-mentioned limits. For a well-manufactured glass component the thermal shock limit is usually set at 120 °C.
This means the equipment can withstand a sudden (less than 5 seconds) change in temperature of a maximum of 120 °C.

For part of **jacketed components**, the maximum permissible temperature difference ($\Delta\Theta$) between the inner and outer areas is 180 K for heat transfer coefficients up to α_i = 1200 W/m²·K (inner component) and α_a = 11.6 W/m²·K (Jacket).

Permissible operating pressure

Permissible max operating pressure for glass-manufactured standard components are described in the following tables. For full reaction units, plants or more complex pieces of equipment please refer to equipment technical specifications. Generally speaking all glass equipment manufactured by Soffieria Sestese can be used with full vacuum, i.e. −1 bar g.

For **jacketed components**, the maximum permissible operating pressure in the jacket is +0.5 bar g up to an overall heat transfer coefficient of U = 70 W/m²·K.
This average value can be expected during a heating process with thermal oil in the jacket and stirred liquid inside the vessel.

Max permissible pressure for glass components:

DN	PS (bar g)
15	4
25	4
40	4
50	4
80	3
100	2
150	2
200	1
300	1
400	0.6
450	0.6
600	0.6

For spherical components:

CAPACITY (L) / DIAMETER (mm)	PS (bar g)
10 / 280	1
20 / 350	1
50 / 490	0.6
100 / 610	0.6
200 / 750	0.6

For valves:

DN	PS (bar g)
15	3
25	3
40	3
50	3
80	1.5

Technical Information

Design and manufacturing procedures for equipment in borosilicate glass 3.3

Our specialized technical office provides to analyze the inputs issued by the specific demands of the client and if is necessary to elaborate technical specifications and relative Manuals or Instructions of use and Maintenance according to Safety Essential Requirements of the specific Directives.
The equipment in borosilicate glass 3.3 are designed considering the factors to assure the duration. The design is based on the followings points:

1. Analysis of the risks through FMEA, according to UNI EN ISO 14121-1

Standard equipment in borosilicate glass 3.3, present in the Soffieria Sestese catalog, have been object of a risk analysis according to Directive 97/23/CE. The method adopted by Soffieria Sestese according to UNI EN ISO 14121-1, is the Failure Mode and Effects Analysis (FMEA). FMEA is a systematic method of analyzing and ranking the risks associated with various product failure mode (both existing and potential), prioritizing them for remedial action, acting on the highest ranked items, re-evaluating those items and returning to the prioritization step in a continuous loop until marginal returns set in.

2. Basic and detail engineering

Our technical office is able to develop basic and detail engineering of borosilicate glass 3.3 equipment, according to Essential Safety Requirements of Directive 97/23/CE.
The codes of calculation used in the evaluations of the maximum allowable loads for equipment in borosilicate glass 3.3 are collected in AD 2000-Merkblatt (N4;B;S) and ISPESL (VSR;M;S). Besides Soffieria Sestese is able to elaborate:

- P&ID
- Isometric drawings
- Constructive sketches

Design of equipment in borosilicate glass 3.3 asks a specific knowledge of materials and standards. Moreover, due care should be exercised in particular in selecting materials in order to prevent brittle-type fracture where necessary; where for specific reasons brittle material has to be used appropriate measures must be taken physical and chemical properties in different process conditions, ageing effects, applications during the scheduled lifetime, be selected in order to avoid significant undesirable effects when the various materials are put together.
To such purpose, according to the Directive 97/23/CE are used:

- Specific material traceability procedures;
- Particular Material Approvals (PMA) for all materials not covered by European Approval of the Materials.

3. Manufacturing

Soffieria Sestese manufacturing procedures ensure the competent execution of the provisions set out at the design stage by applying the appropriate techniques and relevant procedures.
For pressure equipment, permanent joining of components which contribute to the pressure resistance of equipment and components which are directly attached to them must be carried out by suitably qualified personnel according to suitable operating procedures. For pressure equipment in categories II, III and IV, operating procedures and personnel must be approved by a Notified Body (DNV).

4. Non destructive tests

Soffieria Sestese has created a laboratory to test and control quality of the manufactured glass equipment. Specific tests for borosilicate glass equipment are:

- Dimensional by means different certify measure instruments periodically calibrated for example caliper, thickness digital gauge, surface plate.
- Visual according to AD 2000 Merkblatt N4.
- Polarized light test.
- Measurements of temperature according to EN 13463-1.
- Tests of thermal shock according to CEI EN 50014.
- Hydraulic pressure tests according to EN 1595.

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Tightness problem and environment leakage

A critical point in the borosilicate glass 3.3 plant is the low value permissible torque (N/m) in flanged system. The problem of tightness in borosilicate glass 3.3 equipment and relative leakages in environment, is always dealt during the stage of the design process with:

- Choice of torque wrench setting value vs. borosilicate glass flange DN value.
- Choice of seal type material (example, virgin PTFE, TFM, VITON)
- Seal type (example GMP).

Besides static tightness tests in agreement with TA-Luft VDI 2440 flanged system have been positive feedback.
During maintenance operation of the flanges coupling, remind:

- alternate tightening of the bolts using a “X” pattern;
- tightening by means calibrated dynamometric wrench (N/m) versus nominal diameter (DN), see table below.

NOMINAL DIAMETER (DN)	TORQUE N/m PLASTIC FLANGES	TORQUE N/m ALUMINIUM FLANGES
15	1.0	1.0
25	1.5	2.5
40	1.5	3.0
50	1.5	3.0
80	2	3.0
100	2	4.5
150	2	4.5
200	3.5	4.5
300	3.5	5.0
400	-	6.5
450	-	6.5
600	-	11

Covering of equipment in borosilicate glass 3.3

Soffieria Sestese propose three typologies of coating for glass equipment.

1. Coating TrasparentSafe

TrasparentSafe is a desiccation covering UV, soluble in water, that forms a protective layer fragment retention and drain off protection on surfaces of equipments in borosilicate glass 3.3
TrasparentSafe is a transparent coating with a thickness of over 500 µm applied to spray. The maximum temperatures admissible for long periods is of 140 °C, with a peak temperature of 180 °C for short periods. To the than above of the 140 °C the covering becomes amber-coloured, also maintaining unchanged the transparency and the mechanical properties.

TrasparentSafe principal specification:

- autoclavable at 134 °C;
- resisting in dishwashing machine with thermal disinfection at 53 °C.

Resisting at following chemicals product:

- water;
- hydrocloridric acid at 20% ambient temperature;
- nitric acid at 20% ambient temperature;
- sulphuric acid at 20% ambient temperature;
- acetone ambient temperature;
- 2 – propanol ambient temperature;
- Carbon tetrachloride ambient temperature.

Resistance to specific stress to be verified

2. Coating ConductiveSafe

When glass components have to operate in areas classified to risk of explosion according to the directive ATEX 99/92/CE, it is essential to consider the risk to the electrostatic discharge.
According to Standard CLC/TR 50404:2003, the borosilicate glass 3.3 is considered a material with smaller values of surface resistivity less than 1010 Ω.
The Soffieria Sestese proposes, to improve the characteristics of conductibility of the borosilicate glass 3.3, a conductive polymeric covering:

Coating ConductiveSafe characteristics:

- superficial resistance = 10^6 Ω (in acc. IEC standard 93; VDE 0303; ASTM D 257);
- transmission to 550 nm>95% for thickness of covering between 4 ÷ 12 mm;
- thickness covering between 4 ÷ 6 µm;
- viscosity: 25 mPa·s;
- pH value: 8;
- max permissible temperature: 140 °C.

The ConductiveSafe is spray applied and usually composite action with Hydrolux
(splinterproof and antispillage coating) in order to increase borosilicate glass 3.3 mechanical specifications.

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ATEX application

As safety not depend only by equipment, components and protective system, but also by material used and its utilization, is needed to avoid static charge accumulation and reduce inherent hazard. The risk evaluation therefore includes the static charge accumulation associated with liquids of low conductivity (< 10^{-9} S/m) and for this purpose are applied different security devices such as:

- employed of dissipative materials in PTFE;
- grounding for electrostatic discharge;
- employed mechanical seals for agitation unit standard Soffieria Sestese dal DN25 al DN50.

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Marking

Marking procedures for equipments in borosilicate glass 3.3 is tightly connected to Quality System.

The European Directives for CE marking are:

1. Directive Machinery 2006/42/CE

2. Directive 97/23/CE (PED)

Module D1 (Guarantee Quality of Production) Annex III for equipments of Category II according to Safety Essential Requirements approved by N.B. DNV module 1

3. Directive 94/9/CE (ATEX)

According to Safety Essential Requirements approved by ICEPI (0066) Annex VIII for equipments installed in the zone 1/21; 2/22

In addition, equipment not covered by a specific directive, Soffieria Sestese may issue, in accordance with standard EN 10204:2004:

- Declaration of compliance with the order 2.1.
- Test report 2.2.
- Inspection certificate 3.1.
- Inspection certificate 3.2.

On the right the different types of marking for equipment in borosilicate glass 3.3.

Art. 3.3 – no CE marking

Category I = A Module

Category II = D1 Module

CE marking according to PED directive

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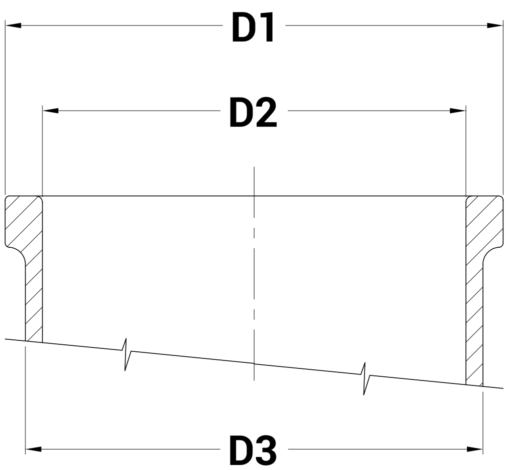
Borosilicate glass flanges dimensions

In practice the buttress end areas of borosilicate glass components have to withstand not only the tensile and compressive stresses resulting from being operated under pressure or vacuum, and the thermal stresses caused by the operating temperature, but also the stresses set up by the bolting forces in the coupling. Engineering a safe buttress end therefore involves ensuring that the sum of these stresses is minimised. The design of the flange coupling and the fire polished sealing surface both make significant contributions to this end.



NOMINAL DIAMETER	D1 (mm)	D2 (mm)	D3 (mm)
15	30 (+0.0 / −1.0)	15	22
25	44 (+0.0 / −1.0)	25	32
40	62 (+0.0 / −1.0)	40	50
50	76 (+0.0 / −1.0)	50	60
80	110 (+0.0 / −1.5)	80	90
100	131 (+0.0 / −1.5)	100	110
150	185 (+0.0 / −1.5)	151	165
200	234 (+0.0 / −1.5)	201	215
300	338 (+0.0 / −1.5)	301	315
400	465 (+0.0 / −1.5)	401	415
450	528 (+0.0 / −1.5)	457	465
600	684 (+0.0 / −4.0)	612	620

NOMINAL SIZE	FLANGE FORM	PIPE END	BACKING FLANGE	INSERT	DRILLING	NO. OF DRILLINGS
15	Flat	Fire-polished and grinded	Plastic / Metal	Plastic Metal Spring	M6	3
25					M8	4
40						
50						
80						8
100						
150						
200						
300						12
400			Metal	PTFE		16
450						
600					M12	20

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Quality

Soffieria Sestese is compliant with the highest quality standards, thanks to a well-documented managing system that is able to integrate and co-ordinate every activity.

Our system introduces a quality control certified with UNI EN ISO 9001:2008. The quality procedures are constantly applied to every phase of the production line and controlled by the dedicated Quality department.

Our test laboratory allows us to certify the compliance of every product, both in borosilicate glass 3.3 and other materials.

Notes