Tubing, Capillary, Rod and Float of Borosilicate Glass 3.3

Tubing

mm	±mm	mm	±mm
3	0.15	0.7	0.04
4	0.15	0.8	0.04
5	0.15	0.8	0.04
6	0.15	1.0	0.04
		1.5	0.10
7	0.15	1.0	0.04
		1.5	0.10
8	0.15	1.0	0.04
		1.5	0.10
9	0.15	1.0	0.04
		1.5	0.10
10	0.15	1.0	0.04
		1.5	0.10
		2.2	0.15
11	0.20	1.0	0.04
		1.5	0.10
		2.2	0.15
12	0.20	1.0	0.04
		1.5	0.10
		2.2	0.15
13	0.20	1.0	0.04
		1.5	0.10
		2.2	0.15
14	0.20	1.0	0.04
		1.5	0.10
		2.2	0.15
15	0.20	1.2	0.05
		1.8	0.10
		2.5	0.15
16	0.20	1.2	0.05
		1.8	0.10
		2.5	0.15
17	0.20	1.2	0.05
		1.8	0.10
		2.5	0.15
18	0.20	1.2	0.05
		1.8	0.10
		2.5	0.15
19	0.20	1.2	0.05
		1.8	0.10
		2.5	0.15
20	0.25	1.2	0.05
		1.8	0.10
		2.5	0.15
22	0.25	1.2	0.05
		1.8	0.10
		2.5	0.15
24	0.25	1.2	0.05
		1.8	0.10
		2.5	0.15
26	0.25	1.4	0.05
		2.0	0.10
		2.8	0.15
28	0.25	1.4	0.05
		2.0	0.10
		2.8	0.15
30	0.40	1.4	0.10
		2.0	0.15
		2.8	0.20
32	0.40	1.4	0.10
		2.0	0.15
		2.8	0.20
33	0.40	2.0	0.15
34	0.40	1.4	0.10
		2.0	0.15
		2.8	0.20
36	0.45	1.4	0.10
		2.0	0.15
		2.8	0.20
38	0.45	1.4	0.10
		2.0	0.15
		2.8	0.20
40	0.60	1.6	0.10
		2.3	0.20
		3.2	0.30
		5.0	0.40
42	0.60	1.6	0.10
		2.3	0.20
		3.2	0.30
44	0.60	1.6	0.10
		2.3	0.20
		3.2	0.30
45	0.70	5.0	0.40
46	0.70	1.6	0.10
		2.3	0.20
		3.2	0.30
48	0.80	1.6	0.10
		2.3	0.20
		3.2	0.30
50	0.70	1.8	0.15
		2.5	0.20
		3.5	0.30
		5.0	0.40
		7.0	0.60
		9.0	0.70
52	0.80	1.8	0.15
		2.5	0.20
		3.5	0.30
54	0.80	1.8	0.15
		2.5	0.20
		3.5	0.30
55	0.80	5.0	0.40
56	0.80	1.8	0.15
		2.5	0.20
		3.5	0.30
58	0.80	1.8	0.15
		2.5	0.20
		3.5	0.30
60	0.90	2.2	0.20
		3.2	0.25
		4.2	0.40
		5.0	0.40
		7.0	0.60
		9.0	0.70
65	0.90	2.2	0.20
		3.2	0.25
		4.2	0.40
		5.0	0.40
70	1.00	2.2	0.20
		3.2	0.25
		4.2	0.40
		5.0	0.40
		7.0	0.60
		9.0	0.70
75	1.00	2.2	0.20
		3.2	0.25
		4.2	0.40
		5.0	0.40
80	1.30	2.5	0.20
		3.5	0.30
		5.0	0.50
		9.0	0.80
85	1.30	2.5	0.20
		3.5	0.30
		5.0	0.50
90	1.30	2.5	0.20
		3.5	0.30
		5.0	0.50
		7.0	0.70
		9.0	0.80
95	1.50	2.5	0.20
		3.5	0.30
		5.0	0.50
100	1.50	2.5	0.20
		3.0	0.20
		3.5	0.30
		5.0	0.50
		7.0	0.70
		9.0	0.80
105	1.70	3.0	0.40
		5.0	0.70
110	1.70	3.0	0.50
		5.0	0.70
		7.0	0.80
115	1.70	3.0	0.50
		5.0	0.70
		7.0	0.80
120	1.70	3.0	0.50
		5.0	0.70
		7.0	0.80
		9.0	0.90
125	1.70	5.0	0.70
		9.0	0.90
130	1.80	3.0	0.60
		5.0	0.70
		7.0	0.90
		9.0	0.90
135	1.80	5.0	0.70
		7.0	0.90
140	1.90	3.0	0.60
		5.0	0.70
		7.0	0.90
145	1.90	5.0	0.70
150	2.00	3.0	0.60
		5.0	0.70
		7.0	0.90
		9.0	1.00
155	2.00	5.0	0.70
160	2.00	5.0	0.70
		7.0	1.00
165	2.00	5.0	0.70
		7.0	1.00
170	2.00	5.0	0.70
		7.0	1.00
		9.0	1.10
180	2.20	5.0	0.70
		7.0	1.00
		9.0	1.20
190	2.30	5.0	0.80
		7.0	1.00
200	2.40	5.0	0.80
		7.0	1.00
		9.0	1.20
215	2.50	7.0	1.10
		9.0	1.20
225	2.70	7.0	1.10
		9.0	1.30
240	2.90	9.0	1.30
250	3.00	5.0	0.80
		7.0	1.10
		9.0	1.30
270	3.00	5.0	0.80
		7.0	1.10
		9.0	1.30
300	3.80	5.0	0.80
		7.0	1.20
		9.0	1.40
315	3.90	7.0	1.20
		9.0	1.40
325	4.00	9.0	1.40
		10.0	1.40
		9.0	1.40
		10.0	1.40
350	4.00	5.0	0.80
365	4.50	7.0	1.40
400	5.00	6.0	1.50
415	5.00	7.0	1.50
420	5.00	9.5	1.50
430	5.00	6.0	1.00
440	5.00	7.0	1.00
450	5.00	7.0	1.00
		8.0	1.00
460	5.50	8.5	1.20
465	6.00	7.0	1.00

Capillary Kapillaren

mm	±mm	mm	±mm
4	0.2	0.8	0.08
		0.4	0.08
		0.5	0.08
		0.6	0.08
5	0.2	0.8	0.08
		1.0	0.08
		1.2	0.08
		1.5	0.10
		0.4	0.08
		0.8	0.08
		1.0	0.08
		1.2	0.08
		1.5	0.10
6	0.2	1.7	0.10
		2.0	0.10
		2.2	0.10
		2.5	0.10
		2.7	0.10
		0.8	0.08
		1.2	0.08
		1.5	0.10
		1.7	0.10
7	0.25	2.0	0.10
		2.2	0.10
		2.5	0.10
		2.7	0.10
		3.0	0.10
		0.8	0.08
		1.0	0.08
		1.2	0.08
		1.5	0.10
		1.7	0.10
8	0.25	2.0	0.10
		2.2	0.10
		2.5	0.10
		2.7	0.10
		3.0	0.10
		3.5	0.10
		0.8	0.08
		1.2	0.08
		1.5	0.10
		1.7	0.10
		2.0	0.10
9	0.25	2.2	0.10
		2.5	0.10
		2.7	0.10
		3.0	0.10
		3.5	0.10
		1.5	0.10
		2.0	0.10
10	0.25	2.5	0.08
		3.0	0.08
		3.5	0.10

Triangle capillary Dreieckka-pillaren

mm	±mm
7x7x7	0.4
8x8x8	0.4
9x9x9	0.4
10x10x10	0.4
11x11x11	0.5

Rod Stäbe

mm	±mm
3	0.15
4	0.15
5	0.15
6	0.15
7	0.15
8	0.25
9	0.25
10	0.25
11	0.25
12	0.25
13	0.35
14	0.35
15	0.35
16	0.35
18	0.45
20	0.45
22	0.50
24	0.50
26	0.60
28	0.90
30	0.90

Inside profile tubing Innen Profilröhren

mm	±mm	mm	±mm
11.0	0.4	1.0	0.15
14.0	0.4	1.0	0.15
15.0	0.4	1.0	0.15
22.0	0.5	1.0	0.15
26.0	0.5	1.5	0.15
28.0	0.5	2.0	0.20
30.0	0.8	2.0	0.20
34.0	0.8	2.0	0.30
36.0	0.8	2.0	0.25
38.0	0.8	2.0	0.25
40.0	1.5	2.0	0.30
50.0	1.5	2.5	0.30
60.0	0.5	2.3	0.30
70.0	0.5	2.8	0.30
80.0	1.8	3.2	0.40
100.0	1.8	3.0	0.40

Water level indicators

mm	±mm	mm	±mm
9.5	0.18	1.50	0.10
11.5	0.18	1.50	0.10
12.5	0.18	1.50	0.10
13.5	0.18	1.75	0.10
14.5	0.18	2.25	0.15
15.5	0.18	2.25	0.15
18.5	0.18	2.25	0.15
19.5	0.18	2.25	0.15
20.5	0.25	2.50	0.15
25.5	0.25	2.50	0.15
29.5	0.30	2.75	0.20
34.5	0.45	2.75	0.20
39.5	0.45	3.00	0.20

Flat capillary Ovalkapillaren

mm	±mm	mm	±mm
15	0.6	4.0	0.4
16	0.6	4.2	0.4
17	0.6	4.5	0.4
18	0.6	4.8	0.4
19	0.6	5.0	0.4
20	0.6	5.3	0.4
21	0.6	5.5	0.4

Flat rod Ovalstäbe

mm	±mm	mm	±mm
5	0.5	2.6	0.5
6	0.5	3.2	0.5
7	0.5	3.7	0.5
8	0.5	4.2	0.5
9	0.5	4.8	0.5
10	0.5	4.5	0.5
11	0.5	5.0	0.5
12	0.5	5.4	0.5
13	0.5	5.8	0.5
14	0.5	5.2	0.5
	0.5	6.3	0.5
15	0.5	6.7	0.5
16	0.5	7.1	0.5
18	0.5	8.0	0.5
20	0.6	8.0	0.5

Profile rod Profilstäbe

mm	±mm
8	0.3
9	0.3
10	0.4
11	0.4
12	0.4
13	0.4
14	0.4
15	0.4
16	0.4

mm	±mm
6x6x6	0.4
7x7x7	0.4
8x8x8	0.4
9x9x9	0.4
10x10x10	0.4
11x11x11	0.5

mm	±mm	±mm
4	0.5x5.4	0.5
5	0.5x6.7	0.5
6	0.5x8.0	0.5
7	0.5x9.4	0.5
8	0.5x10.8	0.5
9	0.5x12.0	0.5
10	0.5x13.2	0.5
11	0.5x14.6	0.5
12	0.5x16.0	0.5

Resistance to thermal shock

Legend **Dates**

According to DIN ISO 718, the resistance to thermal shock is the difference in temperature between the hot test sample and the cold water bath (room temperature9 at which 50 % of all test samples show a tendency to crack when quickly immersed. Resistance to thermal shock of tubing, capillary and rod is dependent on the wall thickness, the shape and size of the quenched area, the state of the surface, the stress which may be present and the end finish. Fast, uneven heating or cooling can easily lead to breakage as a result of tensile strenght. It is recommended not to exceed a temperature difference of 120 °C. For large wall thicknesses, this temperature is limited to lower values. Listed below are some measured values to illustrate the resistance to thermal shock of Borosilicate Glass 3.3 tubing and rod. These should be used only as reference values as considerable differences between tubing/rod of the same dimensions are possible.

Tubing	**OD 50.5/ WT 5.00 mm: 220 °C**
	OD 133.0/ WT 7.00 mm: 180 °C
	OD 120.0/ WT 8.00 mm: 180 °C
Rod	**Diameter 24.0 mm: 140 °C**

Capillary

mm	±mm	mm	±mm
4	0.20	0.8	0.08
5	0.20	0.4	0.08
		0.6	0.08
		0.8	0.08
		1.2	0.08
6	0.20	0.4	0.08
		0.8	0.08
		1.2	0.08
		1.7	0.10
		2.2	0.10
		2.7	0.10
7	0.25	0.8	0.08
		1.2	0.08
		1.7	0.10
		2.2	0.10
		2.7	0.10
		3.0	0.10
8	0.25	0.8	0.08
		1.2	0.08
		1.7	0.10
		2.2	0.10
		2.7	0.10
		3.0	0.10
9	0.25	0.8	0.08
		1.2	0.08
		1.7	0.10
		2.2	0.10
		2.7	0.10
		3.0	0.10

Other profile tubing

mm	mm
86 x 58	2.75

mm	mm
44.5 x 44.5	1.4
67.8 x 67.8	2.75

mm	mm
140 x 68	3.8
80 x 40	3.0
40 x 30	2.5

mm	mm
140 x 68	3.8

Borofloat

mm	mm	tollerance +mm
1150 x 850	3.3	0.2
1150 x 850	1.1	0.2
1150 x 850	1.8	0.2
1150 x 850	2.0	0.2
1150 x 850	2.3	0.2
1150 x 850	2.8	0.2
1150 x 850	3.8	0.2
1150 x 850	5.0	0.2
1150 x 850	5.5	0.2
1150 x 850	6.5	0.2
1150 x 850	7.5	0.3
1150 x 850	9.0	0.3
1150 x 850	11.0	0.3
1150 x 850	13.0	0.3
1150 x 850	15.0	0.3

Notes

Diameters and thickness as required for orders more than 500 kg.

Chemical data

Legend	Dates
Hydrolityc Class (ISO 719)	1
Acid Class (ISO 1776)	1
Alkali Class (ISO 695)	2

Borosilicate Glass 3.3 is highly resistance water, neutral and acid solutions, concentrated acids and acid mixtures, and to chlorine, bromine, iodine and organic substances. The chemical resistance of this glass is superior to that of most metals nd other materials, even when exposed to long processing periods and temperatures above 100 °C.
A slight release of mainly monovalent ions takes place after exposure of the glass to water or acids. A very thin layer of impervious silica gel is subsequently formed on the surface of the glass wich in turn slows down futher attack. At higher temperatures and in more concentrated forms the glass surface is subject to increased attack by hydrofluoric acid, hot phosphoric acid and alkaline solutions.

Pressure resistance of Tubing and Capillary

Legend
Dates

Calculation of pressure resistance (p) for a given Wall Thickness (WT) and a given Outside Diameter (OD)

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

Calculation of the Wall Thickness (WT) at a given pressure resistance (p) and Outside Diameter (OD)

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

Resistance parameter for Borosilicate Glass 3.3: $K/S = 7\ N \cdot mm^{-2}$ as per DIN EN ISO 1595 Standard: Pressure equipment made from Borosilicate glass 3.3: General rules for design, manufacture and testing.

Pressure resistance (p) is also influenced by the following:
Difference in temperature between inside and outside wall
Surface quality
End finish
Observance of conditions of installation as per pressure vessel regulations
Tubing length

Exact calculations are available on request

Other points to be considered:
AD leaflet N4, edition 9.83: pressure vessels made of glass, with encl.1, edition 6.85: evaluation of faults in walls of glass pressure containers
AD leaflet B1, edition 6.86: cylingrical and spherical shells under internal pressure overload

OD : Outside Diameter in mm
WT : Wall Thickness in mm
p : Pressure Resistance un bar
$\frac{K}{S}$: Resistance Parameter in $N \cdot mm^{-2}$

Phycal data

Legend	Dates
Mean coefficient of linear expansion $\alpha_{20/300}$ acc. to ISO 7991	$3.3 \cdot 10^{-6}\ K^{-1}$
Transformation temperature T_g	525 °C
Temperature fixed points at viscosity η in dpa . s:	
10^{13} upper anealing point	560 °C
$10^{7.6}$ softening point	825 °C
10^4 working point	1260 °C
Maximum short-time working temperature	500 °C
Densityρ	$2.3\ g \cdot cm^{-3}$
Modulus of elasticity E, Young's modulus	$63 \cdot 10^3\ N \cdot mm^{-2}$
Poisson's ratioμ	0.20
Thermal conductivityλ_w at 90 °C	$1.2\ W \cdot m^{-1} \cdot K^{-1}$
Temperature for the specific electrical resistance of $10^8\ \Omega \cdot cm$ (DIN 52326) $t_{k\ 100}$	250 °C
Logarithm of the electric volume resistance ($\Omega \cdot cm$)	
at 250°C	8
at 350°C	6.5
Dielectric properties (1 MHz, 25 °C)	
Dielectric figureε	4.6
Dielectric loss factor tanδ	$37 \cdot 10^{-4}$
Refractive index (λ = 587.6 nm) n_d	1.473
Stress-optical constant (DIN 52314) K	$4.0 \cdot 10^{-6}\ mm^2 \cdot N^{-1}$

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