


TECHNICAL SPECIFICATION		
	Name: TUBES FROM BOROSILICATE GLASS	Number : TP 13/70/06

1 Subject

This technical specification applies to manufacturing and delivery of tubes from borosilicate glass 3,3 (hereinafter tubes) used in production of laboratory apparatuses and their parts.

2 Dimensions

2.1 Basic dimensions of tubes and their permitted deviations should correspond to data given in table 1.

Table 1 - Outer diameter and thickness of tube wall
Dimensions in mm

Outer diameter d with permitted deviations	Wall thickness t with permitted deviations		
	thin	medium	thick
4.0 ±0.15 5.0 ±0.15	0.8 ±0.04	---	---
6.0 ±0.15 7.0 ±0.15 8.0 ±0.15 9.0 ±0.15	1.0 ±0.04	1.5 ±0.1	---
10.0 ±0.15	1.0 ±0.04	1.5 ±0.1	2.2 ±0.15
11.0 ±0.20 12.0 ±0.20 13.0 ±0.20 14.0 ±0.20	1.0 ±0.04	1.5 ±0.1	2.2 ±0.15
15.0 ±0.20 16.0 ±0.20 17.0 ±0.20 18.0 ±0.20 19.0 ±0.20	1.2 ±0.05	1.8 ± 0.1	2.5 ±0.15
20.0 ± 0.25 22.0 ± 0.25 24.0 ±0.25	1.2 ±0.05	1.8 ±0.1	2.5 ±0.15

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26.0 ±0.25 28.0 ±0.25	1.4 ±0.05	2.0 ±0.1	2.8 ±0.15
30.0 ±0.40 32.0 ±0.40	1.4 ±0.1	2.0 ±0.15	2.8 ±0.2
33.0 ±0.40		2.0 ±0.15	
34.0 ±0.40	1.4 ±0.1	2.0 ±0.15	2.8 ±0.2
36.0 ±0.45 38.0 ±0.45	1.4 ±0.1	2.0 ±0.15	2.8 ±0.2
40.0 ±0.60	1.6 ±0.1	2.3 ±0.2	3.2 ±0.3 5.0 ±0.4
42.0 ±0.60 44.0 ±0.60	1.6 ±0.1	2.3 ±0.2	3.2 ±0.3
45.0 ±0.70			5.0 ±0.4
46.0 ±0.70 48.0 ±0.70	1.6 ±0.1	2.3 ±0.2	3.2 ±0.3
50.0 ±0.70	1.8 ±0.15	2.5 ±0.2	3.5 ±0.3 5.0 ±0.4 7.0 ±0.6
52.0 ±0.80 54.0 ±0.80	1.8 ±0.15	2.5 ±0.2	3.5 ±0.3 5.0 ±0.4
55 ±0.80			5.0 ±0.4
56.0 ±0.80 58.0 ±0.80	1.8 ±0.15	2.5 ±0.2	3.5 ±0.3 5.0 ±0.4
60.0 ±0.90	2.2 ±0.2	3.2 ±0.25	4.2 ±0.4 5.0 ±0.4 7.0 ±0.6 9.0 ±0.7
65.0 ±0.90	2.2 ±0.2	3.2 ±0.25	4.2 ±0.4 5.0 ±0.4
70.0 ±1.0	2.2 ±0.2	3.2 ±0.25	4.2 ±0.4 5.0 ±0.4 7.0 ±0.6 9.0 ±0.7
75.0 ±1.0	2.2 ±0.2	3.2 ±0.25	4.2 ±0.4 5.0 ±0.4
80.0 ±1.3	2.5 ±0.2	3.5 ±0.3	5.0 ±0.5

			9.0 ±0.8
85.0 ±1.3	2.5 ±0.2	3.5 ±0.3	5.0 ±0.5
90.0 ±1.3	2.5 ±0.2	3.5 ±0.3	5.0 ±0.5 7.0 ±0.7 9.0 ±0.8
95.0 ±1.5	2.5 ±0.2	3.5 ±0.3	5.0 ±0.5
100.0 ±1.5	2.5 ±0.2	3.0 ±0.2 3.5 ±0.3	5.0 ±0.5 7.0 ±0.7 9.0 ±0.8
105.0 ±1.7	3.0 ±0.3	5.0 ±0.5	
110.0 ±1.7 115.0 ±1.7	3.0 ±0.3	5.0 ±0.5	7.0 ±0.8
120.0 ±1.7	3.0 ±0.4	5.0 ±0.6	7.0 ±0.8 9.0 ±0.9
125.0 ±1.7	3.0 ±0.4	5.0 ±0.6	9.0 ±0.9
130.0 ±1.8	3.0 ±0.5	5.0 ±0.6	7.0 ±0.9 9.0 ±0.9
135.0 ±1.8	3.0 ±0.5	5.0 ±0.6	7.0 ±0.9
140.0 ±1.9	3.0 ±0.5	5.0 ±0.6	7.0 ±0.9
145.0 ±1.9	3.0 ±0.5	5.0 ±0.6	
150.0 ±2.0	3.0 ±0.5	5.0 ±0.6	7.0 ±0.9 9.0 ±1.0
155.0 ±2.0		5.0 ±0.7	
160.0 ±2.0 165.0 ±2.0		5.0 ±0.7	7.0 ±1.0
170.0 ±2.0		5.0 ±0.7	7.0 ±1.0 9.0 ±1.1
180.0 ±2.2		5.0 ±0.7	7.0 ±1.0 9.0 ±1.2

2.2 The tubes are delivered in lengths and endings according to table 2, unless otherwise agreed upon.

Table 2

Dimensions in mm

Outer diameter of tube	Length of tube	Tube ends	Deviation of perpendicularity of faces
$4 \leq \varnothing \leq 5$	1500 +10 - 0	non-fire-polished	-
$5 < \varnothing \leq 100$		fire-polished	2.5
$100 < \varnothing \leq 180$		fire-polished	4

2.3 Bow of tubes must not exceed the value given in table 3.

Table 3 – Permitted values of bow Dimensions in mm

Outer diameter	Maximum permitted deviation t
$4 \leq \varnothing < 6$	4/1500
$6 \leq \varnothing < 30$	1,5/1000
$30 \leq \varnothing < 100$	2.0/1400
$100 \leq \varnothing \leq 180$	2.5/1400

2.4 Non-roundness

Non-roundness depends on outer diameter of the tube. In the whole manufacturing range, maximum value 0.7 % of outer diameter must not be exceeded - see 4.4.

2.5 Difference between maximum and minimum thickness of wall at any place of the tube must not exceed 12 % of nominal wall thickness.

3 Technical requirements

3.1 The tubes are manufactured from the borosilicate glass 3,3 meeting requirements of ČSN ISO 3585.

3.2 Strain in tubes must not exceed the values given in table 4.

Table 4 - Limits of strain

Outer diameter in mm	$\varnothing < 40$	$40 \leq \varnothing \leq 60$	$\varnothing > 60$
Internal strain in tube length	3 MPa 102.9 nm/cm	3.5 MPa 120.05 nm/cm	2.5 MPa 85.75 nm/cm
Internal strain at margin	4 MPa 137.2 nm/cm	3.5 MPa 120.05 nm/cm	2.5 MPa 85.75 nm/cm

3.3 The following defects are not permitted on surface and in thickness of the tube glass: +)

- a) streaks (1), showing dangerous internal stress,
- b) devitrification (8),
- c) cracks (16),
- d) scale (11),
- e) scratches (18), gross,
- f) bubbles (9), open which can be pressed through,
- g) non-washable impurities (24),
- h) stones (7) of size greater than 2 mm,
- i) knots (5), abscesses (6) of size greater than 3 mm.

3.4 The following defects are permitted on surface and in thickness of the tube glass: +)
stones (7):

- 1 mm $\leq \varnothing \leq$ 2 mm: max. 1 piece/1 kg of glass
- 0.3 mm $\leq \varnothing <$ 1 mm: max. 2 pieces/1 kg of glass
- $\varnothing <$ 0.3 mm: permitted

knots (5), abscesses (6)

- 1 mm $\leq \varnothing \leq$ 3 mm: max. 2 pieces/1 kg of glass
- 0.3 mm $\leq \varnothing <$ 1 mm: max. 4 pieces/1 kg of glass
- $\varnothing <$ 0.3 mm: permitted

capillary cells (10): up to length $<$ 20 mm permitted 20 pieces/1 kg of glass
up to length \geq 20 mm permitted 0.8 m/10 m length of tube

- width of capillary cell is permitted:
- max. 1 mm for tubes of $\varnothing \leq$ 100 mm,
- max. 2 mm for tubes of $\varnothing >$ 100 mm.

Note: Capillary cell is a cell elongated in the direction of length of the product in the form of capillaries of length greater than 2 mm.

3.5 Resistance of tubes against internal pressure and effects decreasing this resistance are given in the informative supplement.

4 Testing

4.1 The following properties are checked and tested on the tubes:

- a) outer appearance and workmanship,
- b) dimensions,
- c) internal stress.

4.2 Outer appearance is checked visually under day scattered or similar artificial light at a distance of 0.5 m. Dimensions of defects are determined by appropriate gauges, e.g. magnifying glass with scale.

+) Terms and definitions of defects - see ČSN 70 0020

4.3 Dimensions of tubes are checked by appropriate gauges.

4.4 Non-roundness (s) defined in fig. 1 is checked by rotating the tube 360° around its longitudinal axis and determining the difference between the maximum and minimum values on the gauge (track scanner) placed perpendicularly to the longitudinal axis of the tube. The measured value is divided by two.

Fig. 1 Determination of non-roundness

4.5 Measurement of tube bow

a) Measurement of bow of tubes of outer diameter 4 mm to 9 mm (see fig. 2):

The tube is laid on a flat, smooth surface so that its ends are apposed to a flat stop. The distance t is measured at the tube centre as a distance of the tube from this stop. Surface of the bearing plane is tilted at about 10° against horizontal plane, which provides both for good contact of the tube with the stop and for excluding change in the determined bow due to weight of the tube itself.

Fig. 2 Determination of bow of tubes of outer diameter 4 mm to 9 mm

b) Measurement of bow of tubes of outer diameter higher than 10 mm (see fig. 3):

The tube is laid on two supports. Distance of the supports is chosen according to table 3. The tube is rotated 360° around its longitudinal axis and pull-up in the tube centre is measured. The value of bow t is determined as a half of the measured value $2t$.

Fig. 3 Determination of bow of tubes of outer diameter higher than 10 mm

4.6 Internal stress is checked according to ČSN 70 0534 (ASTM E 671-94).

5 Acceptance

5.1 Acceptance is accomplished according to ČSN ISO 2859-1 by a single choice at AQL = 4.0 and checking level II.

6 Packing and labelling

6.1 The tubes should be delivered in bulk packing, sufficiently secured against damage during transport and storage.

On a well visible place the bulk packing should contain:

- dimensions,
- name or trademark of the manufacturer.

S U P P L E M E N T

Standards cited

ČSN ISO 2859-1 (01 0261) Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

ČSN 70 0020 Defects in glassware. Terms and definitions

ČSN 70 0534 Glass. Method for testing of internal stress in glass products.

ČSN ISO 3585 (71 4016) Borosilicate glass 3,3 - Properties.

Similar foreign standards

DIN 12 217:2002 Laborgeräte aus Glas. Rohre aus Borosilicatglas 3,3 (Laboratory glassware. Tubes from borosilicate glass 3,3.

Informative supplement

Resistance of tubes (SIMAX) against internal pressure.

Calculation of internal pressure (p) for given wall thickness (t) and given outer diameter (D):

$$p = \frac{t \cdot 20 \cdot \frac{K}{S}}{D - t}$$

Calculation of wall thickness (t) for given internal pressure (p) and outer diameter (D):

$$t = \frac{D \cdot p}{20 \cdot \frac{K}{S} + p}$$

D = outer diameter in mm

t = wall thickness in mm

p = internal pressure in bars

K = strength characteristics in N/mm²

S = coefficient of safety

Strength characteristics for SIMAX – borosilicate glass 3,3:

K/S = 7 N/mm² corresponds to the standard ČSN EN 1595 Pressure vessels from borosilicate glass 3,3 – General principles for design, manufacturing and testing.

Resistance against internal pressure (p) can be reduced by the following effects:

- temperature difference between inner and outer wall,
- quality of surface,
- finishing of ends,
- meeting the conditions for layout of pressure vessels during assembly.

Moreover, it is necessary to follow:

- ČSN EN 1595:1998 Pressure vessels from borosilicate glass 3,3 General principles for design, manufacturing and testing.
- ČSN EN 12585:1999 Glass apparatuses, piping and fittings. Piping and fittings DN 15 to 1000. Compatibility and interchangeability.

Note: Strength parameters of the tubes were verified in the State Testing Laboratory no. 2240 of the Engineering and Testing Institute, Jablonec nad Nisou. Protocol on the test issued by ETI on October 15, 1999.