Specification and inspection criteria for tubes

Dimensional characteristics

Application

This specification and inspection criteria is applicable for direct drawn Ilmasil™ fused quartz tubes

Outer diameter (OD)

Definition: all outside diameter in all cross-sectional planes along the tube length, measured rectangular to the tube axis.

Tolerance: enclosure 1 or as specified

Tested by: caliper gauge

Inner diameter (ID)

Definition: inside diameter the cross-sectional planes of both tube ends; to measure rectangular to the tube axis

Tolerance: no criteria unless specified in drawing and/or order

Tested by: caliper gauge, plug gauge

Wall thickness (WT)

Definition: wall thickness to measure rectangular to the tube axis on all positions of cross section on both ends

Tolerance: wall thickness ≤ 2 mm: ± 0.2 mm
wall thickness > 2 mm: ± 10 % of nominal wall thickness

Tested by: caliper gauge, micrometer, ultrasonic wall thickness gauge

Comment: due to technological reasons only combinations of two sizes can be accepted.
The size range of the third size results from the nominal sizes/tolerances.

Possible combinations:

Tolerances for OD/wt	→	ID without tolerance (preferred combination)
Tolerances for ID/wt	→	AD without tolerance
Tolerances for OD/ID	→	WT without tolerance

Siding (SD)

Definition: difference between largest and smallest wall thickness of cross sections, measured on both ends rectangular to the tube axis

Tolerance: max. 50 % of tolerance for wall thickness

Tested by: caliper gauge, micrometer, ultrasonic wall thickness gauge

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Ovality (OVA)

Definition: difference between largest and smallest outside diameter at any cross section, anywhere along or around the tube

Tolerance:

OD in mm	Maximum ovality in mm
> 0.4 – 3	0.1
> 3 – 5	0.2

$$\frac{\text{max. OD} - \text{min. OD}}{\text{nominal OD}} \times 100\,\%$$

OD in mm	Maximum ovality in %		
	OD : ID < 1.7	OD : ID = 1.7 ... 2.5	OD : ID > 2.5
> 5 – 10	2.0	3.0	5
> 10 – 16	1.5	2.5	5
> 16 – 35	1.0	2.0	5
> 35 – 65	1.0	1.5	–

Tested by: caliper gauge

Length (L)

Ends furnace cut (fc)

Definition: usable length, if tube is to cut to rectangular ends

Tolerance: + 20 mm/– 0 mm related to the nominal length

Tested by: ruler or measuring tape

Comment: tube to be scratched and broken. Ends may have non-rectangular sharp ends, splinters and tips.

Ends trim cut (tc)

Definition: length between both ends

Tolerance:

Tube length (mm)	Tolerance (mm)
30 – 299	± 1
300 – 599	± 1.5
600 – 999	± 3.0

Tested by: ruler, measuring tape, caliper gauge

Comment: tube to be scratched and broken. Ends may have splinters and tips.

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Ends saw cut (sc)

Definition: length between both ends

Tolerance:

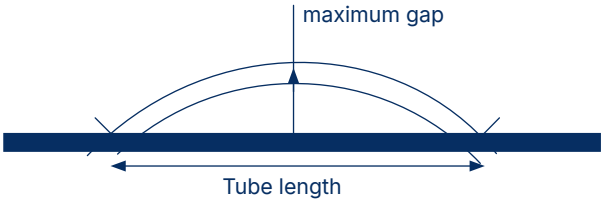
Tube length (mm)	OD ≤ 30 mm	OD > 30 mm
30 –299	± 0.5	±1.0
300 – 599	± 1.0	±1.5
600 – 999	± 2.0	±3.0
1000 – 2499	± 3.0	±4.0
2500 – 4000	± 4.0	±5.0

Tested by: ruler, measuring tape, caliper gauge

Comment: tube to be cut by cutting disk

Bow

Definition: maximum deviation from the ideal centre line between both ends.



Tolerance: 1.5 mm/m

Tested by: tube is placed on a straight plate, bow is tested by measuring the distance between plate and tube surface by feeler gauge. The maximum gap between plate and tube surface to be calculated:

$$x = [r - \sqrt{\left(r^2 - \frac{l^2}{4}\right)}] * 1000$$

x – max. gap in mm
r – radius of curvature in m
l – tube length in m

Maximum gap in mm related to the tube length:

Tube length (m)	Max. gap (mm)	Tube length (m)	Max. gap (mm)	Tube length (m)	Max. gap (mm)
0.5	0.3	1.2	2.1	1.9	5.4
0.6	0.5	1.3	2.5	2.0	6.0
0.7	0.7	1.4	2.9	2.1	6.6
0.8	0.9	1.5	3.3	2.2	7.2
0.9	1.2	1.6	3.8	2.3	7.9
1.0	1.5	1.7	4.3	2.4	8.6
1.1	1.8	1.8	4.8	2.5	9.3

Comment: not valid for tubes with bowing under dead load

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Taper

Definition: difference between the largest and smallest outer diameters. measured anywhere along or around the tube

Tolerance: max. 50 % of tolerance for outer diameter (OD)

Tested by: caliper gauge

Cutting irregularities

Angularity of tube ends

Definition: angel between cross section and axial outer surface shell

	Tolerance	Inspection by
Furnace cut end (fc)	not specified	–
Trim cut ends (tc)	not specified	–
Saw cut ends (sc)	max. 1°	angle meter

Chipping

	Tolerance	Inspection by
Furnace cut end (fc)	not specified	–
Trim cut ends (tc)	not specified	–
Saw cut ends (sc)	max. 1/4 of wall thickness max. 1.5 mm along tube	visual/caliper gauge

Roughness of cross sections

	Tolerance	Inspection by
Furnace cut end (fc)	not specified	–
Trim cut ends (tc)	not specified	–
Saw cut ends (sc)	max. Ra 2.5 µm	roughness measuring device

Flatness

	Tolerance	Inspection by
Furnace cut end (fc)	not specified	–
Trim cut ends (tc)	not specified	–
Saw cut ends (sc)	max. 0.5 mm	feeler gauge

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Attachment

Outer diameter tolerances

Outer diameter (OD) (mm)	Tolerance (mm)	Outer diameter (OD) (mm)	Tolerance (mm)
0.5	± 0.1	18	± 0.5
1	± 0.1	20	± 0.5
2	± 0.1	22	± 0.6
3	± 0.2	23	± 0.6
4	± 0.2	24	± 0.6
5	± 0.2	25	± 0.6
6	± 0.2	26	± 0.7
7	± 0.3	28	± 0.8
8	± 0.3	30	± 0.8
9	± 0.3	35	± 0.9
10	± 0.3	40	± 1.2
11	± 0.3	45	± 1.5
12	± 0.4	50	± 2.0
13	± 0.4	55	± 2.0
14	± 0.4	60	± 2.0
15	± 0.4	65	± 2.0
16	± 0.5	70	± 2.5
18	± 0.5	75	± 2.5
20	± 0.5	80	± 3.0

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