Application: This specification and inspection criteria is applicable for direct drawn ilmasil® fused quartz tubes

1 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

2 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

3 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

Remark**:** 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

4 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

5 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

6 Length (L)

6.1. 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

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

6.2. 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

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

6.3 Ends saw cut (sc)

Definition: Length between both ends

Tolerance:

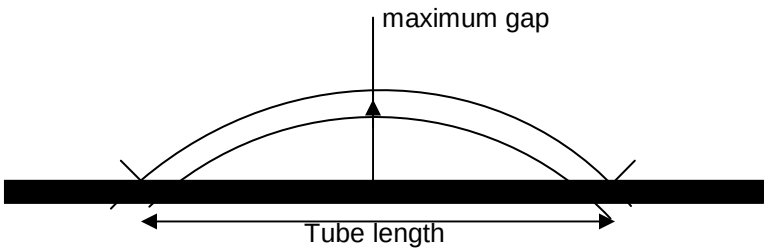
Tube length [mm]	OD ≤ 30 mm	OD > 30 mm
30 - 299	± 0.5	±1.0
300 - 599	± 1.0	±1.5
600 - 999	± 2.0	±3.0
1000- 2499	± 3.0	±4.0
2500 - 4000	± 4.0	±5.0

Tested by: Ruler, measuring tape, caliper gauge

Remark: tube to be cut by cutting disk

7 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:

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

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

Remark: not valid for tubes with bowing under dead load

8 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

9 Cutting Irregularities

9.1 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

9.2 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

9.3 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

9.4 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

10 Other applicable documents

S-101-01 Specification of base materials

11 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