Application: This standard is applicable to direct drawn tubes produced with ilmasil® PN base material

1 Optical Properties

1.1 Transmission

1.1.1 Guaranteed values

<table>
<thead>
<tr>
<th>Wavelength λ [nm]</th>
<th>200</th>
<th>250</th>
<th>254</th>
<th>360</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>wallthickness 1 mm</td>
<td>70 %</td>
<td>85 %</td>
<td>87 %</td>
<td>90 %</td>
<td>91 %</td>
</tr>
<tr>
<td>wallthickness 1,5 mm</td>
<td>65 %</td>
<td>84 %</td>
<td>85 %</td>
<td>90 %</td>
<td>91 %</td>
</tr>
<tr>
<td>wallthickness 2 mm</td>
<td>55 %</td>
<td>82 %</td>
<td>84 %</td>
<td>90 %</td>
<td>91 %</td>
</tr>
</tbody>
</table>

1.1.2 Typical Transmission for UV–range
1.1.3 Typical Transmission for IR – range

![Graph showing transmission vs wavelength for different diameters (1 mm, 1.5 mm, 2 mm).]

- **Transmission in %**
- **Wavelength in nm**

**Remarking:** All values are valid for measurement on a flat surface. Measurements on tube surface may vary depending on the tube diameter.

2 Hydroxyl Content (OH-content)

**Definition:** degree of hydroxyl groups in the tube wall (excluding outer surface)

- The typical content in ilmasil PN fused quartz tubes is 30 ppm

**Limit:** max. 45 ppm

**Remark:** After thermal treatment, a decrease of maximum 3 ppm is obtainable by tempering the material at 1000°C under vacuum for a period of 30 hours.
3 **Visual Characteristics**

The term "visual" is used for the inspection method where the tubing to be inspected at a distance of 0.3 – 0.6 m from the inspector, with a white/black background under general inspection illumination.

### 3.1 Bubbles

**Enclosed Bubbles**

Definition: a spherical void, wholly within the tube wall

Limit:

<table>
<thead>
<tr>
<th>Tube size</th>
<th>Length [mm]</th>
<th>Width [mm]</th>
<th>Max. Number per 100 mm tube length [pieces]</th>
<th>Total length of all detected bubbles per 100 mm tube length [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD ≤ 40 mm; Wt ≤ 1 mm</td>
<td>&gt; 10</td>
<td></td>
<td>0</td>
<td>20 mm</td>
</tr>
<tr>
<td></td>
<td>&gt; 5 – 10</td>
<td>max. 0.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 4 – 5</td>
<td>max. 0.2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2 – 4</td>
<td>max. 0.2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 1 – 2</td>
<td>max. 0.2</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 0.5 – 1</td>
<td>max. 0.2</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>OD ≤ 40 mm; Wt &gt; 1 – 2 mm</td>
<td>&gt; 10</td>
<td></td>
<td>0</td>
<td>20 mm</td>
</tr>
<tr>
<td></td>
<td>&gt; 5 – 10</td>
<td>max. 0.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 4 – 5</td>
<td>max. 0.2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2 – 4</td>
<td>max. 0.2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 1 – 2</td>
<td>max. 0.2</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 0.5 – 1</td>
<td>max. 0.2</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>OD ≤ 40 mm; Wt &gt;2 -4 mm</td>
<td>&gt; 10</td>
<td></td>
<td>0</td>
<td>40 mm</td>
</tr>
<tr>
<td></td>
<td>&gt; 5 – 10</td>
<td>max. 0.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 4 – 5</td>
<td>max. 0.2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2 – 4</td>
<td>max. 0.2</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 1 – 2</td>
<td>max. 0.2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 0.5 – 1</td>
<td>max. 0.2</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>
### 2. Tube outer diameter (OD) < 40 and wall thickness (Wt) > 4 mm

#### Tube outer diameter (OD) > 40 mm

<table>
<thead>
<tr>
<th>Tube size</th>
<th>Length [mm]</th>
<th>Width [mm]</th>
<th>Max. Number per 100 mm tube length [pieces]</th>
<th>Total length of all detected bubbles per 100 mm tube length [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>- OD &gt; 40 mm - OD &lt; 40 mm with wt &gt;4 mm</td>
<td>&gt; 10</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 5 – 10</td>
<td>max. 0.2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 4 – 5</td>
<td>max. 0.2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 2 – 4</td>
<td>max. 0.2</td>
<td>10</td>
<td>30 mm</td>
</tr>
</tbody>
</table>

Bubbles in width and length < 0.3 mm are not counted

Bubbles in width and length > 0.3 to 2 mm: Total bubble cross section: max. 50 mm² per 100 cm³ (as per DIN 58927)

Bubble clusters: judge the whole cluster to the limits of a single bubble

**Inspection:** visual, scale magnifier

**Open Bubbles**

**Definition:** A void, open to the outer or inner surface

**Limit:** max. number: 5 per meter tube length with max. length 3 mm and max. depth 0.2 mm

**Inspection:** visual, scale magnifier

### 3.2 Inclusions

**Definition:** included foreign particles (spots), visible by color difference

**Limit:** inclusions > 0.1 mm are not permitted

**Inspection:** visual, scale magnifier

For detection of white spots use a black background

For detection of black spots use a white background
3.3 Striation

Definition: transparent inclusions, causing apparent optical distortion

Limit: scattered colorless striations are permitted
       Colored striations are not permitted

Inspection: visual on a crosswalk-background

3.4 Surface defects

3.4.1 Scratches

Definition: a fine line abrasion on outer surface (line wider as 0.1 mm) visible by unaided eye with a black background

Limit: permitted if not perceptible with gloved fingers
       if perceptible with gloved fingers these limits are to apply:
       in axial direction: scattered scratches with length of max. 50 mm length;
                        Total length of all scratches: max. 10% of tube length
       in peripheral direction: max. total length: OD * \( \pi \)
                        not permitted if completely circumferential

Inspection: visual, caliper, scale magnifier

3.4.2 Scuff

Definition: broad surface abrasion (groups of lines wider as 0.1 mm).

Limits: No individual OD scuff wider than 10 mm or longer than 5 mm
        Total area of all scuffs on the outer surface, added together, are to be no more than 0.25% of tube outer surface area.

Inspection: visual, caliper
3.4.3 Waterspots, Fingerprints, Cutter dust

Definition: removable surface deposits left by washing residue or finger touch

Limit: permitted to a minor degree

Inspection: visual

3.4.4 Vapor

Definition: a broad area or band of white haze on the inner or outer surface visible to the unaided eye on a black background

Limits: not permitted

Inspection: visual

3.4.5 Structure

Definition: Optical distortion caused by marginal variations in the wall thickness

Limit: permitted if not perceptible with gloved fingers
 permitted if low-contrast appearance (comparison with limit sample)

Inspection: visual

3.4.6 Bubble Scars

Definition: Depressions on the surface caused by healed or collapsed bubbles

Limit: permitted if not perceptible with gloved fingers

Inspection: visual (inspection to be performed in axial direction)

3.4.7 Surface adhesions

Definition: non-colored quartz particles fused into the surface causing a protrusion

Limit: not permitted if any sharp edges

Inspection: visual, manually

4 Further applicable documents

S-101-05 Specification and Inspection Criteria for Tubes: Dimensional Characteristics
S-101-01-PN Material Standard: Clear Fused Quartz ilmasil® PN