

**SCHOTT**  
glass made of ideas

## TTS DURAN®

Technical Terms of Supply for  
DURAN® standard applications



# Technical Terms of Supply

For special glass tubing for DURAN® standard applications

## A 1 – Introduction and Scope

The Tubing Business Unit (BU) in the SCHOTT Group handles activities related to the manufacturing of tubes, capillaries, rods and profiles made of special glass.

The BU Tubing division consists of the companies

- SCHOTT AG, Mitterteich and Mainz sites, Germany, as the lead company in BU Tubing
- SCHOTT BRASIL LTDA., DIVISION VITROFARMA, Rio de Janeiro, Brazil
- SCHOTT Glass India Pvt. Ltd., Tubing Division, Baroda, India

These Technical Terms of Supply (TTS) are only valid for special glass tubes for DURAN® standard applications.

TTS's for other applications are available, or can be supplemented if necessary.

Since each application has its own specific technical requirements, the specifications in the TTS's are based on the respective field of application. Different types of glass may be used for a range of applications.

We would like to advise you on selecting the appropriate type of glass for the intended use.

The TTS's are revised and adapted to current market demands and the current state of technology at appropriate intervals.

Quality-determining material changes to technical glasses by the processors are generally indicated with adequate advance notice prior to the intended introduction.

With the publication of these TTS's, existing customer-related specifications or TTS's shall cease to be valid if the corresponding application is included in the present TTS's and if individual contractual provisions do not preclude such.

Requirements that are not covered by our TTS have to be agreed upon and must be explicitly confirmed by us to become valid. An order should normally always include the application that the tube is intended for.

By means of the presented specifications in these TTS including defined AQL values, the property of the products which are subject to these TTS will be finally defined. Further guaranties for the condition of our products will not be given, as long as no agreements on individual contract basis are reached.

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# Glass and Dimensional Quality

## B 1 – Criteria for Glass and Dimensional Quality

The decisive point when assessing the quality of glass tubing is its suitability for processing in accordance with present standards. Nonconformities may be reported if the quality criteria of the tubing supplied are not adhered to, as indicated in these TTS.

All dimensional nonconformities are summarized in one class and assigned to one aggregated AQL value.

Visual nonconformities have an AQL value for each feature. If the decisive AQL value is not exceeded within the concerned lot, the total lot is considered in accordance with the TTS.

### Note:

AQL-value = Acceptable Quality Level  
In the style of DIN ISO 2859 Part 1

Simple random sample test, level II, normal test

| Testing Units<br>per Lot | AQL<br>0.025<br>n / c | AQL<br>0.10<br>n / c | AQL<br>0.25<br>n / c | AQL<br>0.40<br>n / c | AQL<br>0.65<br>n / c | AQL<br>1.0<br>n / c | AQL<br>1.5<br>n / c | AQL<br>2.5<br>n / c | AQL<br>4.0<br>n / c | AQL<br>6.5<br>n / c |
|--------------------------|-----------------------|----------------------|----------------------|----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 151 – 280                | 500/0                 | 125/0                | 50/0                 | 32/0                 | 20/0                 | 50/1                | 32/1                | 32/2                | 32/3                | 32/5                |
| 281 – 500                | 500/0                 | 125/0                | 50/0                 | 32/1                 | 80/0                 | 50/1                | 50/1                | 50/3                | 50/5                | 50/7                |
| 501 – 1,200              | 500/0                 | 125/0                | 50/0                 | 125/1                | 80/1                 | 80/2                | 80/3                | 80/5                | 80/7                | 80/10               |
| 1,201 – 3,200            | 500/0                 | 125/0                | 200/1                | 125/1                | 125/2                | 125/3               | 125/5               | 125/7               | 125/10              | 125/14              |
| 3,201 – 10,000           | 500/0                 | 125/0                | 200/1                | 200/2                | 200/3                | 200/5               | 200/7               | 200/10              | 200/14              | 200/21              |
| 10,001 – 35,000          | 500/0                 | 500/1                | 315/2                | 315/3                | 315/5                | 315/7               | 315/10              | 315/14              | 315/21              | 200/21              |
| 35,001 – 150,000         | 500/0                 | 500/1                | 500/3                | 500/5                | 500/7                | 500/10              | 500/14              | 500/21              | 315/21              | 200/21              |
| 150,001 – 500,000        | 500/0                 | 800/2                | 800/5                | 800/7                | 800/10               | 800/14              | 800/21              | 500/21              | 315/21              | 200/21              |
| > 500,000                | 2000/1                | 1250/3               | 1250/7               | 1250/10              | 1250/14              | 1250/21             | 800/21              | 500/21              | 315/21              | 200/21              |

Lot = 1 Pallet or Delivery Lot

n = Random sample size (number of testing units [PE]) Lot.: Lot < n are tested 100

c = Acceptance Figure

(The lot is accepted if the number of nonconformities in the random sample is small than or equals the Acceptance Figure).

### Note:

Complaints outside the given quality stipulations can only be settled by mutual agreement between customer and supplier.

# Glass and Dimensional Quality

## B 2 – Outside Diameter

**Definition:**

Maximum distance between 2 points on the outside surface of the tubing in a plane perpendicular to the tubing axis.

**Testing Method**

See chapter D 1

**Testing Unit:**

1 tubing length

**Nonconformity Definition:**

There is a nonconformity if a total piece of 60 mm is out of tolerance over the whole length of the tube.

**Limit Values and AQL:**

Included in the aggregate AQL for dimensional nonconformities, see chapter C 1.1 – C 1.3

**API-Definition:**

API means: ALLPOINTS IN

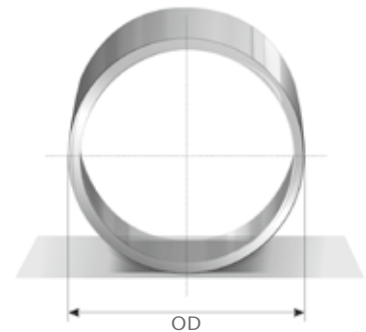
Each OD on all points of the tube is within the tolerance. Ovality and taper do not lead to the tubing OD being out of tolerance.

If tolerances are exceeded due to permissible glass nonconformities (stones/knots), this is not considered a nonconformity. 15 mm from the end of the tube are not included in API due to the end execution.

Tubing supplies according to API upon request.

**Notes on the Production Process:**

- The outside diameter can only be produced in conjunction with the inside diameter or the wall thickness.
- The on-line measuring and sorting device not only checks the ends of the tubing, but also gauges the outside diameter over the entire tubing length. Tubes with an outside diameter out of tolerance as per nonconformity definition are rejected.



## Glass and Dimensional Quality

### B 3 – Inside Diameter

**Definition:**

Maximum distance between 2 points on the inside surface of the tubing in a plane perpendicular to the tubing axis.

**Testing Method:**

See chapter D 2

**Testing Unit:**

1 tubing length

**Nonconformity Definition:**

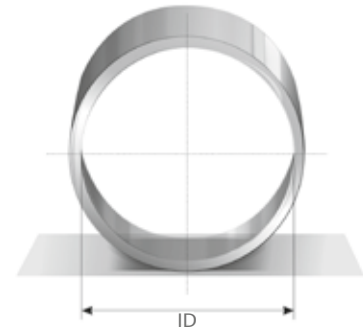
There is a nonconformity if a total piece of 60 mm is out of tolerance over the whole length of the tube.

**Limit Values and AQL:**

Included in the aggregate AQL for dimensional nonconformities, see chapter C 1.1 – C 1.3

**Note on the Production Process:**

The inside diameter can only be produced in conjunction with the outside diameter or the wall thickness.



### B 4 – Wall Thickness

**Definition:**

The wall thickness is the shortest distance between the inner and outer surface.

**Testing Method:**

See chapter D 3

**Testing Unit:**

1 tubing length

**Nonconformity Definition:**

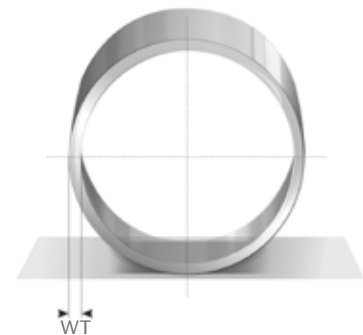
There is a nonconformity if the wall thickness is out of tolerance.

**Limit Values and AQL:**

Included in the aggregate AQL for dimensional nonconformities, see chapter C 1.1 – C 1.3

**Note on the Production Process:**

The wall thickness can only be produced in conjunction with the outside diameter or the inside diameter.



# Glass and Dimensional Quality

## B 5 – Length

**Definition:**

The distance between the furthest points in an axial direction.



The standard tubing length is 1500 mm.  
Special length and tolerances upon request.

**Test Unit:**

1 tubing length

**Nonconformity Definition:**

There is a nonconformity if the length is out of tolerance.

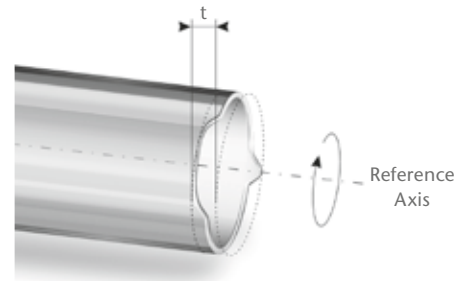
**Limit Values and AQL:**

Included in the aggregate AQL for dimensional nonconformities, see chapter C 2

## B 6 – Square Cut

**Definition:**

The tolerance zone is limited by two parallel planes from distance  $t$ , which are vertical to the reference axis.



**Testing method:**

See chapter D 4

**Nonconformity Definition:**

There is a nonconformity if the limit value for square cut is exceeded.

**Limit Values and AQL:**

See chapter C 2

# Glass and Dimensional Quality

## B 7 – Circularity

### Definition:

The peripheral line of each cross-section of a sample must be situated between two concentric circles in the same plane which are at a distance  $t$  from each other. According to ISO 1101, the tolerance zone  $t$  is termed the circularity tolerance.

### Schematical Diagram:

Circularity according to ISO 1101

### Testing Method:

See chapter D 1

### Testing Unit:

1 tubing length

### Limit Values and AQL:

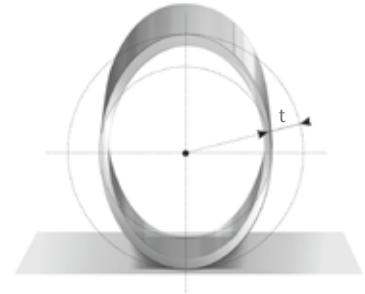
Included in the aggregate AQL for dimensional nonconformities, see chapter C 1.1 – C 1.3

### Nonconformity Definition:

There is a nonconformity if the limit value for circularity is exceeded.

### Note:

The term „Out of Round“ or „Ovality“ used in practice means: the difference between the maximum and minimum OD in a measuring plane vertical to the tubing length axis. This value is twice as high as the circularity value.



## B 8 – Siding

### Definition:

Siding is the difference between the largest and smallest wall thickness within one measuring plane.

### Testing method:

See chapter D 3

### Testing Unit:

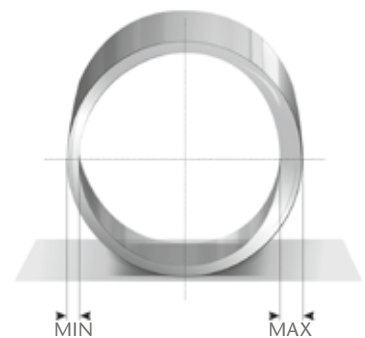
1 tubing length

### Nonconformity Definition:

There is a nonconformity if the limit value for siding is exceeded.

### Limit Values and AQL:

Included in the aggregate for dimensional nonconformities, see chapter C 1.1 – C 1.3



# Glass and Dimensional Quality

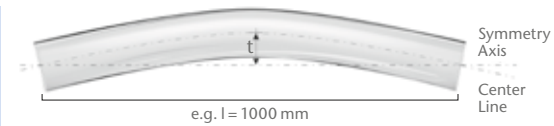
## B 9 – Straightness

### Definition:

Straightness according to ISO 1101 is the greatest distance between any point on the surface of a sample to an adjacent line with a geometrically ideal form. When projected onto a plane, this is the tolerance zone  $t$ , which is limited by two parallel straight lines.

In the measuring stipulations described, “the adjacent line with a geometrically ideal form” is the connecting line between the ends of the tubing (OD:  $3 - < 6$  mm) or the rotation axis around which the tube (OD:  $\geq 6$  mm), resting on two supports at a distance of 1000 mm, is turned.

From OD  $\geq 30$  mm the support distance is 1400 mm.



### Schematical Diagram:

Straightness according to ISO 1101

### Testing Method:

See chapter D 5

### Testing Unit:

1 tubing length

### Limit Values and AQL:

Included in aggregate AQL for dimensional nonconformities, see chapter C 1.1 – C 1.3

### Nonconformity Definition:

There is a nonconformity if the limit value for straightness is exceeded.

# Glass and Dimensional Quality

## B 10 – Stones and Knots

### Definition:

- Stones are opaque inclusions, Knots are transparent inclusions.
- These nonconformities are dependent on the glass mass.

### Schematical Diagram:

Core as measuring basis

### Testing Method:

See Chapter D 6

### Testing Unit:

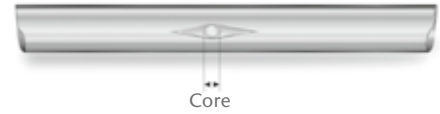
1 kg glass

### Nonconformity Definition:

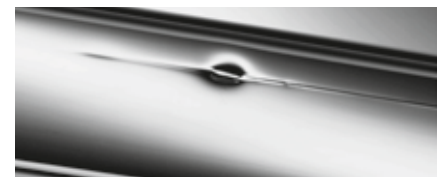
There is a nonconformity if the limit value for stones and knots is exceeded.

### Limit Values and AQL:

See chapter C 3



Stones



Knots

## B 11 – Airlines

### Definition:

- Closed airlines are elongated, gaseous inclusions in the tubing. The aggregate closed airline length is the sum of all airlines > 15 mm length (or, in the case of two or more overlapping airlines, the distance between the extremities of the airlines concerned).
- An open airline is a gaseous inclusion drawn out by the drawing process, from which the gas trapped can escape due to its proximity to the wall surface forming a cavity between the inner and outer surface. An open airline does not show a capillary effect.
- Seeds are airlines 2 – 15 mm length.

### Testing Method:

See chapter D 6

### Testing Unit:

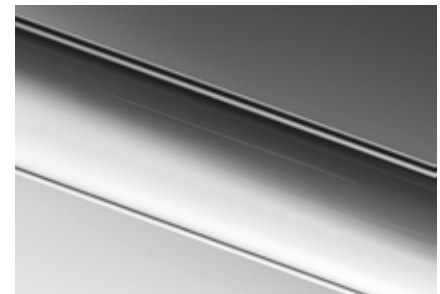
Airlines: Min. 100 m tubing per palette or at least 10 m tubing for carton single delivery  
Seeds: 1 kg tubing

### Nonconformity Definition:

There is a nonconformity if the limit value is exceeded.

### Limit Values and AQL:

See chapter C 3



Airline

# Glass and Dimensional Quality

## B 12 – Surface Cracks

**Definition:**

A surface crack is an extensive break running deep into or completely permeating the glass wall.

**Testing Method:**

See chapter D 6

**Testing Unit:**

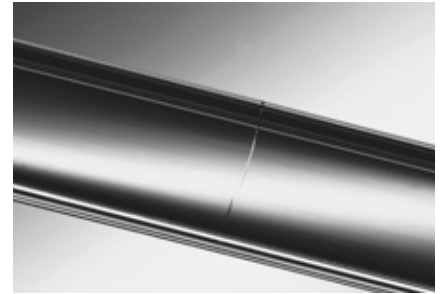
1 tubing length

**Nonconformity Definition:**

Surface cracks of any kind are nonconformities.

**Limit Values and AQL:**

See chapter C 3



Radial crack

## B 13 – Fissures

**Definition:**

Fissures are cracks which occur at the tubing end during the production process and are normally fused to the fire polishing of the tubing ends. Due to the differences in the probability of occurrence, one distinguishes between cracks and fissures.

**Testing Method:**

See chapter D 6

**Testing Unit:**

1 tubing length

**Nonconformity Definition:**

There is a nonconformity if the limit value is exceeded.

**Limit Values and AQL:**

See chapter C 3



Fissure



Fused fissure

## Glass and Dimensional Quality

### B 14 – Scratches

**Definition:**

Scratches constitute slight damage to the outer surface of the glass tubing. Unlike cracks, scratches do not penetrate the glass wall.

**Testing Method:**

See chapter D 6

**Testing Unit:**

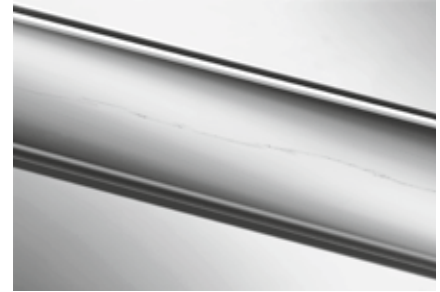
10 m tubing

**Nonconformity Definition:**

There is a nonconformity if the limit value is exceeded.

**Limit Values and AQL:**

See chapter C 3



Scratch

### B 15 – End Executions

Standard end execution versions for tubing

| OD (mm) | End Execution Treatments                                   |
|---------|--|
| ≥ 6.00  | Fused  |
| < 6.00  | Untreated (without end execution treatments) and/or sealed |

Other end execution treatments possible on request.

**Testing Unit:**

1 tubing length

**Nonconformity Definition:**

There is a nonconformity if limit values according to chapter C 2 are exceeded.

**Limit Values and AQL:**

See chapter C 2

### B 16 – Traceability and Labeling

**Traceability is guaranteed as follows:**

1. through the code number, which gives access to the processing data,
2. through the package number, which makes traceability possible to one hour with reference to the code number.

**Note:**

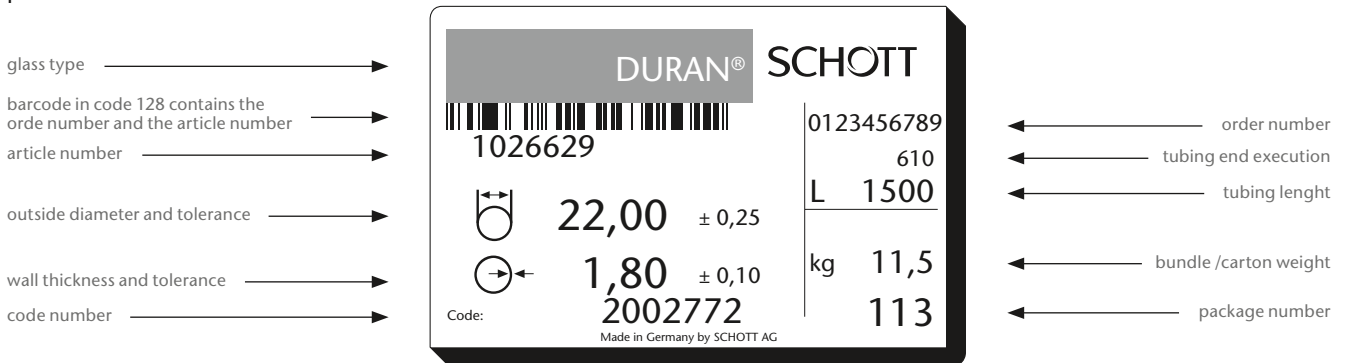
For speedy treatment of complaints the code and package number should be indicated.

# Glass and Dimensional Quality

## B 16 – Traceability and Labeling

### 1. Carton labels (example)

Missing pallet labels or nonconformity or illegible texts on the labels are not permissible.



**Material:**

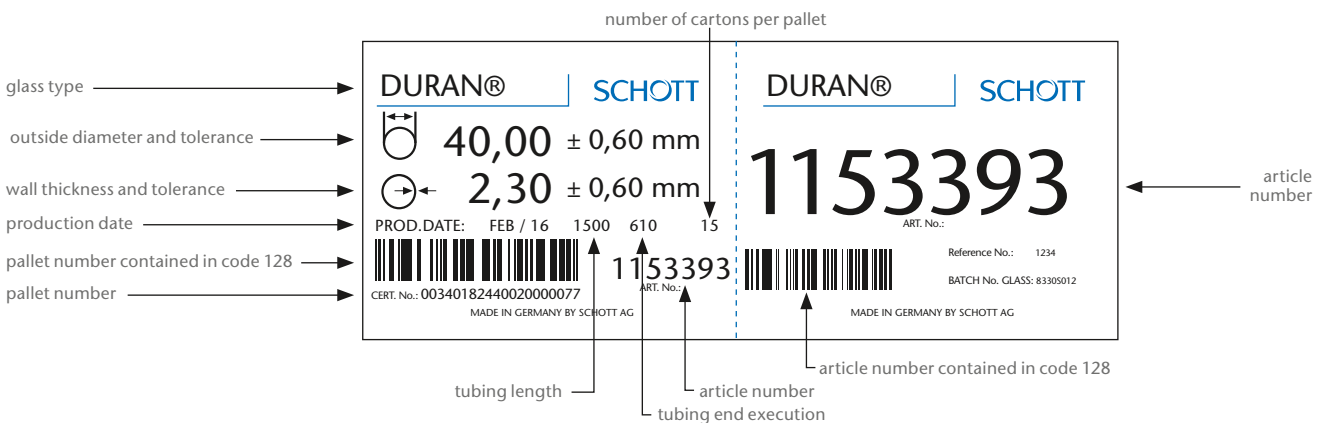
Paper

**Recycling:**

The label can be disposed of together with the cartons.

### 2. Pallet labels (example)

Missing pallet labels or nonconformity or illegible texts on the labels are not permissible.



**Material:**

Paper

**Recycling:**

The label can be disposed of together with the cartons.

# Glass and Dimensional Quality

## B 17 – Technical Information Data Sheet for Safety

The Technical Information Data Sheet for safety can be sent to you upon request.

|   |                    |  |                    |                  |
|---|--------------------|--|--------------------|------------------|
| <b>Technical Information<br/>Data Sheet (Safety)</b>  |                    | Status: 01.03.12   | <b>SCHOTT</b>      |                  |
| Product: DURAN®   |                    | Version: 2   |                    |                  |
|   |                    | Printing date: 29.03.12<br>Page: 1/5   |                    |                  |
| <b>1. Material / Preparation and Company Designation</b>  |                    |  |                    |                  |
| <b>Product Data</b>   |                    |  |                    |                  |
| Trade Name:   |                    | DURAN®   |                    |                  |
| <b>Manufacturer Data</b>  |                    |  |                    |                  |
| Company:  |                    | SCHOTT AG<br>Erich-Schott-Str. 14<br>D-95666 Mitterteich<br>Phone: +49 (0)9633/ 80-0 |                    |                  |
| <b>Information:</b>   |                    |  |                    |                  |
|   |                    | Safety Department<br>Phone: +49 (0)9633/ 80-454                                      |                    |                  |
| <b>2. Composition / Component Data</b>  |                    |  |                    |                  |
| <b>Chemical Characterization</b>  |                    |  |                    |                  |
| Glass Product CAS- No. 65997-17-3   |                    |  |                    |                  |
| <b>EINECS-No.:</b>  |                    |  |                    |                  |
| <b>Hazardous Contents</b>   |                    |  |                    |                  |
| <b>CAS No.</b>  | <b>Designation</b> | <b>Contents</b>  | <b>Code Letter</b> | <b>R-phrases</b> |
| not applicable  |                    |  |                    |                  |
| <b>3. Possible Hazards</b>  |                    |  |                    |                  |
| Injury hazard from glass fragments.<br>In case of high/long-term exposure to dust (e.g. caused by mechanical processing), silicosis hazard. |                    |  |                    |                  |
| <b>4. First-Aid Measures</b>  |                    |  |                    |                  |
| <b>General Hints</b>  |                    |  |                    |                  |
| <b>after skin contact</b><br>wash thoroughly with soap and water  |                    |  |                    |                  |
| <b>after eye contact</b><br>wash out dust and splinters under running water; see ophthalmic surgeon   |                    |  |                    |                  |
| <b>after swallowing</b><br>see a doctor   |                    |  |                    |                  |
| <b>after breathing-in</b><br>dust - remove to fresh air; see a doctor   |                    |  |                    |                  |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 3.00       | ± 0.13                    | 0.70       | ± 0.03                    | 0.02                        | 0.07                   | 4.0/1500                     |
| 4.00       | ± 0.13                    | 0.80       | ± 0.03                    | 0.03                        | 0.08                   |                              |
| 5.00       | ± 0.13                    | 0.80       | ± 0.03                    | 0.03                        | 0.08                   |                              |
| 6.00       | ± 0.13                    | 1.00       | ± 0.04                    | 0.04                        | 0.10                   | 1.0/1000                     |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
| 7.00       | ± 0.13                    | 1.00       | ± 0.04                    | 0.04                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
| 8.00       | ± 0.13                    | 1.00       | ± 0.04                    | 0.05                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
| 9.00       | ± 0.13                    | 1.00       | ± 0.04                    | 0.05                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
| 10.00      | ± 0.13                    | 1.00       | ± 0.04                    | 0.06                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
|            |                           | 2.20       | ± 0.11                    |                             | 0.22                   |                              |
| 11.00      | ± 0.16                    | 1.00       | ± 0.04                    | 0.07                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
|            |                           | 2.20       | ± 0.11                    |                             | 0.22                   |                              |
| 12.00      | ± 0.16                    | 1.00       | ± 0.04                    | 0.07                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
|            |                           | 2.20       | ± 0.11                    |                             | 0.22                   |                              |
| 13.00      | ± 0.16                    | 1.00       | ± 0.04                    | 0.08                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
|            |                           | 2.20       | ± 0.11                    |                             | 0.22                   |                              |
| 14.00      | ± 0.16                    | 1.00       | ± 0.04                    | 0.08                        | 0.10                   |                              |
|            |                           | 1.50       | ± 0.07                    |                             | 0.15                   |                              |
|            |                           | 2.20       | ± 0.11                    |                             | 0.22                   |                              |
| 15.00      | ± 0.16                    | 1.20       | ± 0.05                    | 0.09                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 16.00      | ± 0.16                    | 1.20       | ± 0.05                    | 0.10                        | 0.12                   | 1.0/1000                     |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 17.00      | ± 0.16                    | 1.20       | ± 0.05                    | 0.10                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 18.00      | ± 0.16                    | 1.20       | ± 0.05                    | 0.11                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 19.00      | ± 0.16                    | 1.20       | ± 0.05                    | 0.11                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 20.00      | ± 0.23                    | 1.20       | ± 0.05                    | 0.12                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 22.00      | ± 0.23                    | 1.20       | ± 0.05                    | 0.13                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 24.00      | ± 0.23                    | 1.20       | ± 0.05                    | 0.14                        | 0.12                   |                              |
|            |                           | 1.80       | ± 0.08                    |                             | 0.18                   |                              |
|            |                           | 2.50       | ± 0.12                    |                             | 0.25                   |                              |
| 26.00      | ± 0.24                    | 1.40       | ± 0.05                    | 0.16                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 28.00      | ± 0.24                    | 1.40       | ± 0.05                    | 0.17                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 30.00      | ± 0.30                    | 1.40       | ± 0.07                    | 0.18                        | 0.14                   | 1.7/1400                     |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 32.00      | ± 0.30                    | 1.40       | ± 0.07                    | 0.19                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 33.00      | ± 0.30                    | 2.00       | ± 0.09                    | 0.20                        | 0.20                   |                              |
| 34.00      | ± 0.30                    | 1.40       | ± 0.07                    | 0.20                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 36.00      | ± 0.35                    | 1.40       | ± 0.07                    | 0.22                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 38.00      | ± 0.35                    | 1.40       | ± 0.07                    | 0.23                        | 0.14                   |                              |
|            |                           | 2.00       | ± 0.09                    |                             | 0.20                   |                              |
|            |                           | 2.80       | ± 0.14                    |                             | 0.28                   |                              |
| 40.00      | ± 0.50                    | 1.60       | ± 0.08                    | 0.24                        | 0.16                   |                              |
|            |                           | 2.30       | ± 0.11                    |                             | 0.23                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |
| 42.00      | ± 0.50                    | 1.60       | ± 0.08                    | 0.25                        | 0.16                   |                              |
|            |                           | 2.30       | ± 0.11                    |                             | 0.23                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.35                   |                              |
|            |                           |            |                           |                             |                        |                              |
| 44.00      | ± 0.50                    | 1.60       | ± 0.08                    | 0.28                        | 0.16                   |                              |
|            |                           | 2.30       | ± 0.11                    |                             | 0.23                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           |            |                           |                             |                        |                              |
| 45.00      | ± 0.60                    | 5.00       | ± 0.30                    | 0.28                        | 0.50                   |                              |
| 46.00      | ± 0.60                    | 1.60       | ± 0.08                    | 0.28                        | 0.16                   |                              |
|            |                           | 2.30       | ± 0.11                    |                             | 0.23                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
| 48.00      | ± 0.60                    | 1.60       | ± 0.08                    | 0.29                        | 0.16                   |                              |
|            |                           | 2.30       | ± 0.11                    |                             | 0.23                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 50.00      | ± 0.65                    | 1.80       | ± 0.11                    | 0.35                        | 0.18                   | 1.7/1400                     |
|            |                           | 2.50       | ± 0.14                    |                             | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.45                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.60                    |                             | 0.90                   |                              |
| 52.00      | ± 0.65                    | 1.80       | ± 0.11                    | 0.36                        | 0.18                   |                              |
|            |                           | 2.50       | ± 0.14                    |                             | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
| 54.00      | ± 0.65                    | 1.80       | ± 0.11                    | 0.38                        | 0.18                   |                              |
|            |                           | 2.50       | ± 0.14                    |                             | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
| 55.00      | ± 0.65                    | 5.00       | ± 0.30                    | 0.39                        | 0.50                   |                              |
| 56.00      | ± 0.65                    | 1.80       | ± 0.11                    | 0.39                        | 0.18                   |                              |
|            |                           | 2.50       | ± 0.14                    |                             | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
| 58.00      | ± 0.65                    | 1.80       | ± 0.11                    | 0.41                        | 0.18                   |                              |
|            |                           | 2.50       | ± 0.14                    |                             | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
| 60.00      | ± 0.75                    | 2.20       | ± 0.16                    | 0.42                        | 0.22                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           | 4.20       | ± 0.25                    |                             | 0.42                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.45                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.60                    |                             | 0.90                   |                              |
| 65.00      | ± 0.75                    | 2.20       | ± 0.16                    | 0.46                        | 0.22                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           | 4.20       | ± 0.25                    |                             | 0.42                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 70.00      | ± 0.85                    | 2.20       | ± 0.16                    | 0.49                        | 0.22                   | 1.7/1400                     |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           | 4.20       | ± 0.25                    |                             | 0.42                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.45                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.60                    |                             | 0.90                   |                              |
| 75.00      | ± 0.85                    | 2.20       | ± 0.16                    | 0.53                        | 0.22                   |                              |
|            |                           | 3.20       | ± 0.18                    |                             | 0.32                   |                              |
|            |                           | 4.20       | ± 0.25                    |                             | 0.42                   |                              |
|            |                           | 5.00       | ± 0.30                    |                             | 0.50                   |                              |
| 80.00      | ± 1.10                    | 2.50       | ± 0.16                    | 0.56                        | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.35                    |                             | 0.50                   |                              |
|            |                           | 9.00       | ± 0.65                    |                             | 0.90                   |                              |
| 85.00      | ± 1.10                    | 2.50       | ± 0.16                    | 0.60                        | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.35                    |                             | 0.50                   |                              |
| 90.00      | ± 1.10                    | 2.50       | ± 0.16                    | 0.63                        | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.35                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.45                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.65                    |                             | 0.90                   |                              |
| 95.00      | ± 1.30                    | 2.50       | ± 0.16                    | 0.67                        | 0.25                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.35                    |                             | 0.55                   |                              |
| 100.00     | ± 1.30                    | 2.50       | ± 0.16                    | 0.70                        | 0.25                   | 2.2/1400                     |
|            |                           | 3.00       | ± 0.18                    |                             | 0.30                   |                              |
|            |                           | 3.50       | ± 0.22                    |                             | 0.35                   |                              |
|            |                           | 5.00       | ± 0.35                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.45                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.65                    |                             | 0.90                   |                              |
| 105.00     | ± 1.40                    | 3.00       | ± 0.18                    | 0.74                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.40                    |                             | 0.50                   |                              |
| 110.00     | ± 1.40                    | 3.00       | ± 0.25                    | 0.77                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 115.00     | ± 1.40                    | 3.00       | ± 0.25                    | 0.81                        | 0.30                   | 2.2/1400                     |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
| 120.00     | ± 1.40                    | 3.00       | ± 0.25                    | 0.84                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.80                    |                             | 0.90                   |                              |
| 125.00     | ± 1.40                    | 5.00       | ± 0.45                    | 0.88                        | 0.50                   |                              |
|            |                           | 9.00       | ± 0.80                    |                             | 0.90                   |                              |
| 130.00     | ± 1.50                    | 3.00       | ± 0.25                    | 0.91                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.80                    |                             | 0.90                   |                              |
| 135.00     | ± 1.50                    | 5.00       | ± 0.45                    | 0.95                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
| 140.00     | ± 1.60                    | 3.00       | ± 0.25                    | 0.98                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
| 145.00     | ± 1.60                    | 5.00       | ± 0.45                    | 1.02                        | 0.50                   |                              |
| 150.00     | ± 1.70                    | 3.00       | ± 0.25                    | 1.05                        | 0.30                   |                              |
|            |                           | 5.00       | ± 0.45                    |                             | 0.50                   |                              |
|            |                           | 7.00       | ± 0.60                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.80                    |                             | 0.90                   |                              |
| 155.00     | ± 1.75                    | 5.00       | ± 0.45                    | 1.09                        | 0.50                   |                              |
| 160.00     | ± 1.75                    | 5.00       | ± 0.45                    | 1.12                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.70                    |                             | 0.70                   |                              |
| 165.00     | ± 1.75                    | 5.00       | ± 0.45                    | 1.16                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.70                    |                             | 0.70                   |                              |
| 170.00     | ± 1.75                    | 5.00       | ± 0.45                    | 1.19                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.70                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.90                    |                             | 0.90                   |                              |
| 180.00     | ± 1.95                    | 5.00       | ± 0.45                    | 1.26                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.70                    |                             | 0.70                   |                              |
|            |                           | 9.00       | ± 0.90                    |                             | 0.90                   |                              |
| 190.00     | ± 2.05                    | 5.00       | ± 0.45                    | 1.33                        | 0.50                   |                              |
|            |                           | 7.00       | ± 0.70                    |                             | 0.70                   |                              |

# Specification

## C 1.1 – Tolerances of OD, WT, Circularity, Siding, Straightness

### Tubes

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | WT<br>[mm] | WT-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm]  |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|---|
| 200.00     | ± 2.30                    | 5.00       | ± 0.70                    | 2.00                        | 0.50                   | up to OD<br>270.00:<br>2.8/1400<br><br>from OD<br>300.00:<br>3.0/1400 |
|            |                           | 7.00       | ± 0.80                    |                             | 0.70                   |   |
|            |                           | 9.00       | ± 1.00                    |                             | 0.90                   |   |
| 215.00     | ± 2.40                    | 5.00       | ± 0.70                    | 2.15                        | 0.50                   |   |
|            |                           | 7.00       | ± 0.80                    |                             | 0.70                   |   |
|            |                           | 9.00       | ± 1.00                    |                             | 0.90                   |   |
| 225.00     | ± 2.60                    | 7.00       | ± 0.80                    | 2.25                        | 0.70                   |   |
|            |                           | 9.00       | ± 1.10                    |                             | 0.90                   |   |
| 240.00     | ± 2.80                    | 9.00       | ± 1.10                    | 2.40                        | 0.90                   |   |
| 250.00     | ± 2.90                    | 5.00       | ± 0.70                    | 2.50                        | 0.50                   |   |
|            |                           | 7.00       | ± 0.90                    |                             | 0.70                   |   |
|            |                           | 9.00       | ± 1.10                    |                             | 0.90                   |   |
| 270.00     | ± 2.90                    | 5.00       | ± 0.70                    | 2.70                        | 0.50                   |   |
|            |                           | 7.00       | ± 0.90                    |                             | 0.70                   |   |
|            |                           | 9.00       | ± 1.10                    |                             | 0.90                   |   |
| 300.00     | ± 3.70                    | 5.00       | ± 0.70                    | 3.00                        | 0.50                   |   |
|            |                           | 7.00       | ± 1.10                    |                             | 0.70                   |   |
|            |                           | 9.00       | ± 1.40                    |                             | 0.90                   |   |
| 315.00     | ± 3.80                    | 7.00       | ± 1.10                    | 3.15                        | 0.70                   |   |
|            |                           | 9.00       | ± 1.40                    |                             | 0.90                   |   |
| 325.00     | ± 4.00                    | 9.00       | ± 1.40                    | 3.25                        | 0.90                   |   |
|            |                           | 10.00      | ± 1.40                    |                             | 1.00                   |   |
| 350.00     | ± 4.00                    | 5.00       | ± 0.80                    | 5.25                        | 0.55                   |   |
| 365.00     | ± 4.50                    | 7.00       | ± 1.40                    | 5.48                        | 0.77                   |   |
| 400.00     | ± 5.00                    | 6.00       | ± 1.50                    | 6.00                        | 0.66                   | 3.5/1400  |
| 415.00     | ± 5.00                    | 7.00       | ± 1.50                    | 6.23                        | 0.77                   |   |
| 420.00     | ± 5.00                    | 9.50       | ± 1.50                    | 6.30                        | 1.10                   |   |
| 430.00     | ± 5.00                    | 6.00       | ± 1.00                    | 6.45                        | 0.66                   |   |
| 440.00     | ± 5.00                    | 7.00       | ± 1.00                    | 6.60                        | 0.77                   |   |
| 450.00     | ± 5.00                    | 7.00       | ± 1.00                    | 6.75                        | 0.77                   | 4.0/1400  |
|            |                           | 8.00       | ± 1.00                    |                             | 0.88                   |   |
| 460.00     | ± 5.50                    | 8.50       | ± 1.20                    | 6.90                        | 0.94                   |   |
| 465.00     | ± 6.00                    | 7.00       | ± 1.00                    | 7.00                        | 0.77                   |   |

Further dimensions are possible for special production upon request.

Aggregate AQL for dimensional nonconformities: 2.5

# Specification

## C 1.2 – Tolerances of OD, ID, Circularity, Siding, Straightness

### Capillaries

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | ID<br>[mm] | ID-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Siding<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|------------|---------------------------|-----------------------------|------------------------|------------------------------|
| 4.00       | ± 0.16                    | 0.80       | ± 0.08                    | 0.04                        | 0.16                   | 4.5/1500                     |
| 5.00       | ± 0.16                    | 0.40       | ± 0.08                    | 0.05                        | 0.24                   |                              |
|            |                           | 0.60       | ± 0.08                    |                             | 0.22                   |                              |
|            |                           | 0.80       | ± 0.08                    |                             | 0.21                   |                              |
|            |                           | 1.20       | ± 0.08                    |                             | 0.19                   |                              |
| 6.00       | ± 0.16                    | 0.40       | ± 0.08                    | 0.06                        | 0.28                   | 1.0/1000                     |
|            |                           | 0.80       | ± 0.08                    |                             | 0.26                   |                              |
|            |                           | 1.20       | ± 0.08                    |                             | 0.24                   |                              |
|            |                           | 1.70       | ± 0.10                    |                             | 0.22                   |                              |
|            |                           | 2.20       | ± 0.10                    |                             | 0.19                   |                              |
|            |                           | 2.70       | ± 0.10                    |                             | 0.17                   |                              |
| 7.00       | ± 0.18                    | 0.80       | ± 0.08                    | 0.07                        | 0.32                   |                              |
|            |                           | 1.20       | ± 0.08                    |                             | 0.29                   |                              |
|            |                           | 1.70       | ± 0.10                    |                             | 0.27                   |                              |
|            |                           | 2.20       | ± 0.10                    |                             | 0.24                   |                              |
|            |                           | 2.70       | ± 0.10                    |                             | 0.22                   |                              |
|            |                           | 3.00       | ± 0.10                    |                             | 0.20                   |                              |
| 8.00       | ± 0.18                    | 0.80       | ± 0.08                    | 0.08                        | 0.36                   |                              |
|            |                           | 1.20       | ± 0.08                    |                             | 0.34                   |                              |
|            |                           | 1.70       | ± 0.10                    |                             | 0.32                   |                              |
|            |                           | 2.20       | ± 0.10                    |                             | 0.29                   |                              |
|            |                           | 2.70       | ± 0.10                    |                             | 0.27                   |                              |
|            |                           | 3.00       | ± 0.10                    |                             | 0.25                   |                              |
| 9.00       | ± 0.18                    | 0.80       | ± 0.08                    | 0.09                        | 0.41                   |                              |
|            |                           | 1.20       | ± 0.08                    |                             | 0.39                   |                              |
|            |                           | 1.70       | ± 0.10                    |                             | 0.37                   |                              |
|            |                           | 2.20       | ± 0.10                    |                             | 0.34                   |                              |
|            |                           | 2.70       | ± 0.10                    |                             | 0.32                   |                              |
|            |                           | 3.00       | ± 0.10                    |                             | 0.30                   |                              |

Further dimensions are possible for special production upon request.

Aggregate AQL for dimensional nonconformities: 2.5

# Specification

## C 1.3 – Tolerances of OD, Circularity, Straightness

### Rods

| OD<br>[mm] | OD-<br>Tolerances<br>[mm] | max.<br>Circularity<br>[mm] | max.<br>Straightness<br>[mm] |
|------------|---------------------------|-----------------------------|------------------------------|
| 3.00       | ± 0.13                    | 0.03                        | 5.0/1500                     |
| 4.00       | ± 0.13                    | 0.04                        |                              |
| 5.00       | ± 0.13                    | 0.05                        |                              |
| 6.00       | ± 0.13                    | 0.06                        |                              |
| 7.00       | ± 0.13                    | 0.07                        | 2.3/1000                     |
| 8.00       | ± 0.18                    | 0.08                        |                              |
| 9.00       | ± 0.18                    | 0.09                        |                              |
| 10.00      | ± 0.18                    | 0.10                        |                              |
| 12.00      | ± 0.18                    | 0.12                        |                              |
| 14.00      | ± 0.26                    | 0.14                        |                              |
| 16.00      | ± 0.26                    | 0.16                        |                              |
| 18.00      | ± 0.36                    | 0.18                        |                              |
| 20.00      | ± 0.36                    | 0.30                        |                              |
| 22.00      | ± 0.40                    | 0.33                        |                              |
| 24.00      | ± 0.40                    | 0.36                        |                              |
| 26.00      | ± 0.50                    | 0.39                        |                              |
| 28.00      | ± 0.70                    | 0.42                        |                              |
| 30.00      | ± 0.70                    | 0.45                        |                              |

Further dimensions are possible for special production upon request.

Aggregate AQL for dimensional nonconformities: 2.5

# Specification

## C 2 – End Execution Treatments and Square Cut

### Tubes

#### Length Tolerances

| OD [mm]         | End Execution Treatments | Length Tolerances [mm] | AQL |
|-----------------|--------------------------|------------------------|-----|
| 3.00 – 5.00     | Untreated and/or Sealed  | + 30 / - 30            |     |
| 6.00 – 199.00   | Fused                    | + 10 / - 0             | 2.5 |
| 200.00 – 420.00 | Fused                    | + 15 / - 0             |     |

#### Square Cut

| Characteristic | Nonconformity Criteria |                    | AQL       |
|----------------|------------------------|--------------------|-----------|
|                | OD-Range [mm]          | Limited Value [mm] |           |
| Square Cut (*) | < 6                    | not rated          | not rated |
|                | 6 – 59                 | 2.5                |           |
|                | 60 – 99                | 3.0                |           |
|                | 100 – 199              | 4.0                | 2.5       |
|                | 200 – 325              | 6.0                |           |
|                | > 325                  | 9.0                |           |

(\*) Valid only for open, treated and not drawn in tube ends.

#### Fused End Execution Treatments

| Fusing       | Guide value for Bead Thickness [mm] |
|--------------|-------------------------------------|
| Light fusing | 0.05                                |
| Fusing (*)   | 0.10                                |
| Vial fusing  | 0.15                                |
| Heavy fusing | 0.20                                |

(\*) Standard fusing

There is a nonconformity, if by fused end execution treatments is an unfused tube end. Limit Values and AQL: 0.65

### Capillaries

| OD [mm]     | End Execution Treatments | Length Tolerances [mm] | AQL |
|-------------|--------------------------|------------------------|-----|
| 4.00 – 9.00 | Sealed                   | + 30 / -30             | 2.5 |

### Rods

| OD [mm]      | End Execution Treatments | Length Tolerances [mm] | AQL |
|--------------|--------------------------|------------------------|-----|
| 3.00 – 30.00 | Untreated                | + 30 / - 30            | 2.5 |

Standard length = 1500 mm

Further end execution treatments, length and length tolerances are possible upon request.

# Specification

## C 3 – Glass Quality

| Characteristic         | Nonconformity Criteria  |                        | AQL |     |
|------------------------|---|------------------------|-----|-----|
|                        | Size  | Max. acceptable Number |     |     |
| Stones<br>per kg Glass | < 0.3 mm  | not rated              | --- |     |
|                        | ≥ 0.3 mm – < 1.0 mm   | 2                      |     |     |
|                        | ≥ 1.0 mm – ≤ 2.0 mm   | 1                      |     |     |
|                        | > 2.0 mm  | not allowed            |     |     |
| Knots<br>per kg Glass  | < 0.3 mm  | not rated              | --- |     |
|                        | ≥ 0.3 mm – < 1.0 mm   | 4                      |     |     |
|                        | ≥ 1.0 mm – ≤ 3.0 mm   | 2                      |     |     |
|                        | > 3.0 mm  | not allowed            |     |     |
| Airlines               | <ul style="list-style-type: none"> <li>Aggregate airline length consists of open and closed airlines &gt; 15 mm and can be max. 5 % of the tested tubing length.</li> </ul>   |                        | --- |     |
|                        | <ul style="list-style-type: none"> <li>Airline width</li> </ul>   |                        |     |     |
|                        | OD-Range [mm]   | Max. Width [mm]        |     | 2.5 |
|                        | > 300   | 4.0                    |     |     |
|                        | > 100 – ≤ 300   | 2.0                    |     |     |
| ≤ 100                  | 1.0   |                        |     |     |
| Seeds                  | Limit value: 15 piece/kg tubing<br>(Seeds = Airlines from 2 – 15 mm length)   | 2.5                    |     |     |
| Scratches              | Limit value (aggregate nonconformity length)<br>Tubes/Capillaries/Rods: <ul style="list-style-type: none"> <li>Not separately packed (Glass/Glass-Contact is given): 250 mm/1500 mm</li> <li>Separately packed: 100 mm/1500 mm</li> </ul> <hr/> All scratches wider than 0.2 mm are included in the aggregate nonconformity length. | 2.5                    |     |     |
| Surface Cracks         | Nonconformity in any degree   | 0.025                  |     |     |
| Fissures               | <ul style="list-style-type: none"> <li>End execution treatment: Fused<br/>Nonconformity in any degree</li> <li>End execution treatment: Untreated and/or sealed<br/>Nonconformity, if longer than 20 mm</li> </ul>  | 2.5                    |     |     |


# Specification

## C 4 – Packing

|        | OD [mm]     | WD [mm] | Packing                              |
|--------|-------------|---------|--------------------------------------|
| Tubing | ≤ 10        | ---     | not separately packed                |
|        | > 10 – < 30 | ≤ 1.50  |                                      |
|        | > 10 – < 30 | > 1.50  | separately packed with carton layers |
|        | 30 – < 100  | ---     | special carton layers                |
|        | ≥ 100       | ---     |                                      |

Special Packing upon requested (DENSOPACK® is possible up to OD 50 mm).

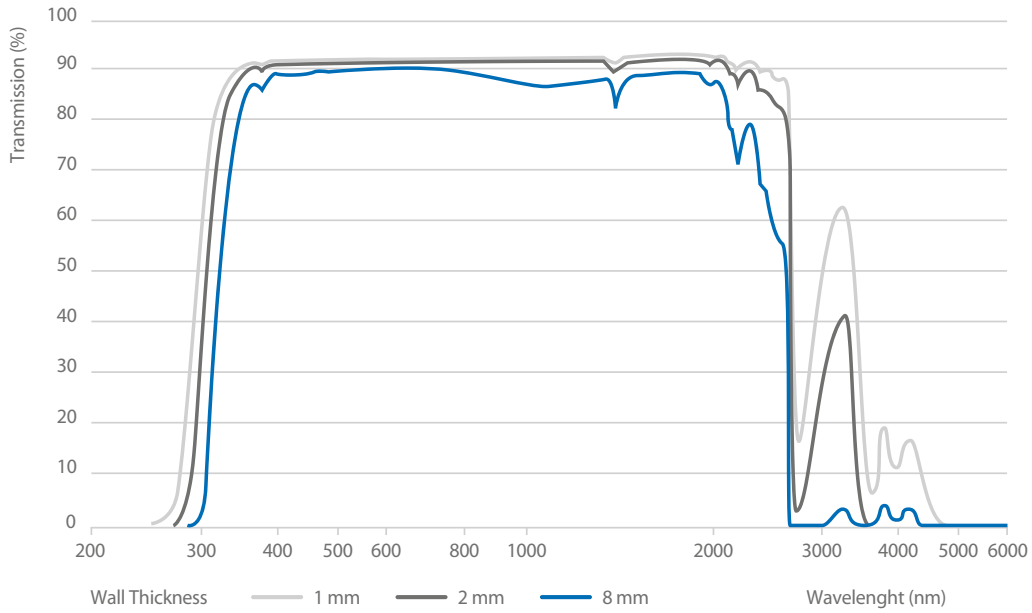
## C 5 – Technical Data

| DURAN®  |   | Technical Data |  |
|---|---|----------------|--|
| GlassType/Application   | Borosilicate glass 3.3 acc. to ISO 3585, chemically and thermally highly resistant<br>General-purpose glass for apparatus for the chemical industry, for pipelines and lab glassware  |                |  |
| Physical Data   | Coefficient of mean linear thermal expansion<br>$\alpha(20^{\circ}\text{C}; 300^{\circ}\text{C})$ (ISO 7991) ..... 3.3 $10^{-6}\text{K}^{-1}$<br>Transformation temperature $T_g$ (ISO 7884-8)..... 525 $^{\circ}\text{C}$<br>Glass temperature at viscosity $\eta$ in dPa·s<br>$10^{13}$ (annealing point) (ISO 7884-4)..... 560 $^{\circ}\text{C}$<br>$10^{7.6}$ (softening point) (ISO 7884-3)..... 825 $^{\circ}\text{C}$<br>$10^4$ (working point) (ISO 7884-2)..... 1260 $^{\circ}\text{C}$<br>Stress-optical coefficient K (DIN 52314)..... 4.0 $10^{-6}\text{mm}^2 \cdot \text{N}^{-1}$<br>Density $\rho$ at 25°C ..... 2.23 $\text{g} \cdot \text{cm}^{-3}$<br>Modulus of elasticity E (Young's modulus) ..... 63 $10^9 \text{N} \cdot \text{mm}^{-2}$<br>Poisson's ratio $\mu$ ..... 0.2<br>Thermal conductivity $\lambda_w$ at 90°C ..... 1.2 $\text{W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$<br>Log of the electric volume resistivity ( $\Omega \cdot \text{cm}$ )<br>at 250°C ..... 8.0<br>at 350°C ..... 6.5<br>$t_{k100}$ ..... 250 $^{\circ}\text{C}$<br>Dielectric constant $\epsilon$ for 1 MHz at 25°C ..... 4.6<br>Dielectric loss factor $\tan \delta$ for 1 MHz at 25°C ..... 37 $10^{-4}$<br>Refractive index $n_d$ ( $\lambda = 587.6 \text{ nm}$ ) ..... 1.473 |                |  |
| Chemical Resistance   | Hydrolytic resistance (ISO 719) ..... Class   | HGB 1          |  |
|   | Acid resistance (DIN 12116) ..... Class   | S 1            |  |
|   | Alkali resistance (ISO 695) ..... Class   | A 2            |  |
|   | The heavy metal content for the elements lead, cadmium, mercury and hexavalent chromium is below 100 ppm  |                |  |
| DURAN® is a registered trade mark for DURAN Group<br>Business Segment Tubing / 1/2013 |   |                |  |
|    |   |                |  |

# Specification

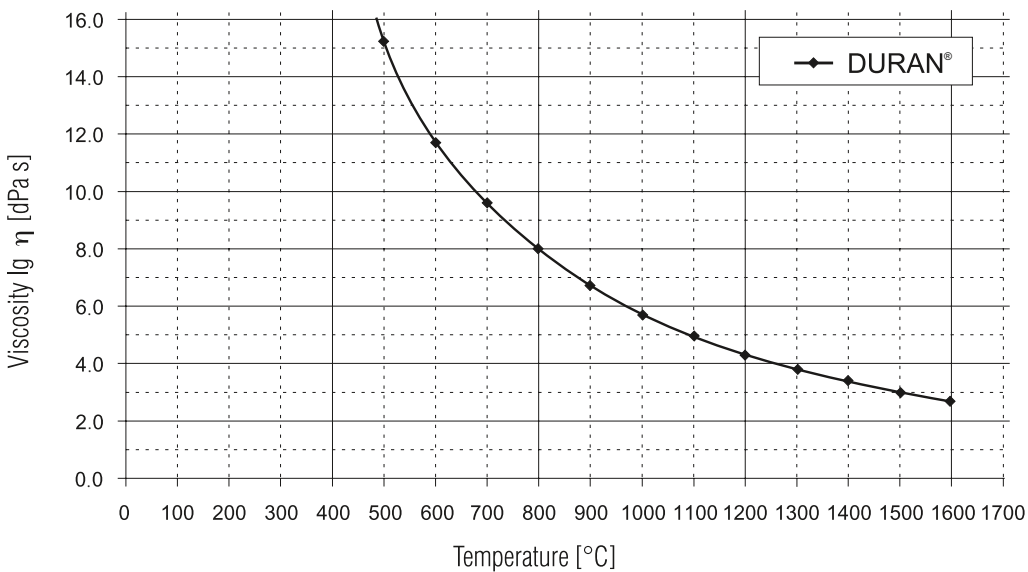
## C 6 – Transmission

### Transmission DURAN®



## C 7 – Viscosity

### Viscosity



## Testing Method

Comparable test results can only be reached on the basis of identical test methods.

### D 1 – Outside Diameter, Circularity

#### Testing Method:

The min. and max. outside diameter (OD) is determined between two parallel edges perpendicular to the tubing axis. Circularity is calculated by taking half the maximum OD difference in a measuring plane. Ovality is the whole OD difference in a measuring plane.

The deviation from the nominal value is measured.  
Zero adjustment is made using a gauge rod.

#### Note:

For thin-walled tubing, devices with a gauge pressure of > 1.5 N (such as micrometer screws) may not be used.

### D 2 – Inside Diameter

#### Testing Method:

The ID is measured using a double-point snap gauge.  
The deviation from the nominal value is measured.  
Zero adjustment is made using adjusting rings.

#### Note:

When making manual measurement, the axial centering of the caliper is obtained by a pendular movement within the bore. The arrest point of the pointer then shows the correct value (see schematic diagram).



#### Schematic diagram ID snap gauge:

The nose of the moving pointer (1) transmits to the dial indicator the expansion movement produced by spring force of the semi-circular measuring jaws (2) – which centre automatically on the test specimen.

# Testing Method

## D 3 – Wall Thickness and Siding

### Testing Method:

Wall thickness can be most accurately measured between a hemi-spherical point on the inner surface and a small flat area on the outer surface.

The deviation from the nominal value is measured.  
Zero adjustment is made using a parallel slip gauge.

### Note:

Suitable instruments: Special WT measuring devices, or micrometer screws with a hemi-spherical anvil.

## D 4 – Square Cut

### Testing Method:

Two prismatic supports (prisms or rolls) are fixed to a flat base onto which the tube to be tested is placed and is unilaterally led towards a stop plate which is positioned at right angles to the support axis.

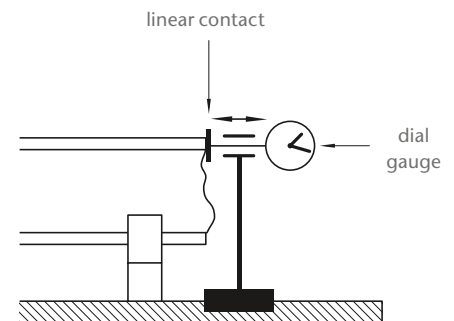
When rotating the tube round its longitudinal axis, at the opposite end of the tube to the plate, a length difference is registered by a dial gauge provided with a linear contact. During the whole measuring process, the tube is pressed onto the stop plate either manually or by a suitable construction of the support.

The measurement is repeated at the other tubing end in a second step.

The greatest length difference from both measurements is considered the square cut deviation.

### Note:

The steel plate must be larger than the outside diameter of the tube.  
The contact surface must be hardened and polished.



## Testing Method

### D 5 – Straightness

#### Testing Method:

Tubing with OD 3 – < 6 mm:

The tube rests on a smooth level surface; Straightness is the distance  $t$  from the base surface at the centre of the tube. Measurement is made according to the following diagram:

#### Note:

Suitable measuring instruments are, for example, special bow measuring devices. In the case of thin tubes, straightness must be determined gauge pressure free. Tubing with OD between 3 – < 6 mm would bend under its own weight if measured resting on two supports!

#### Testing Method:

Tubing with OD  $\geq 6$  – < 30 mm:

The tube rests on supports (distance between supports 1000 mm) and is rotated. The bend  $t$  at the centre of the tube is the straightness (i.e. half the indicated value  $2 \cdot t$ ).

Tubing with OD  $\geq 30$ mm:

The tube rests on supports (distance between supports 1400 mm) and is rotated. The bend  $t$  at the centre of the tube is the straightness (i.e. half the indicated value  $2 \cdot t$ ).

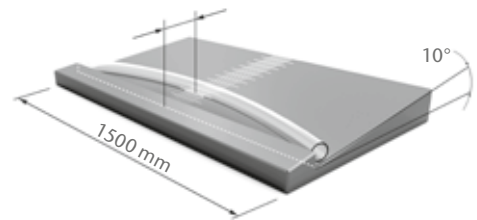
### D 6 – Visual Nonconformities

#### Testing Method:

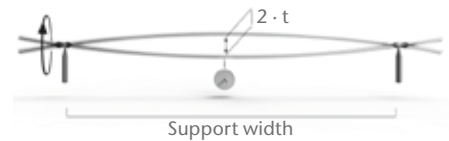
Assessment to be made with the naked emmetropic eye. The size of the particular feature can be determined by a measuring magnifier (with a scale of 0.1 mm) and a comparative parallel gauge.

#### Note:

A bank of light is suitable for assessing these features (fluorescent lamp and flashed glass).



Schematic sketch: Determination of straightness in tubing OD 3 to < 6 mm



Schematic sketch: Determination of straightness in tubing OD  $\geq 6$  mm

## E 1 – Imprint

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Status: 01.05.2016 / 3. Edition

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