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Plastics — Thermoplastic semi-finished products for machining — Requirements and test methods

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National foreword

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Plastiques - Produits semi-finis thermoplastiques pour usinage - Exigences et méthodes d'essai

Kunststoffe - Thermoplastische Halbzeuge für die spanende Verarbeitung - Anforderungen und Prüfmethoden

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Contents

Page

Foreword

This document (EN 15860:2010) has been prepared by Technical Committee CEN/TC 249 “Plastics”, the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2010, and conflicting national standards shall be withdrawn at the latest by December 2010.

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1 Scope

This European Standard specifies the requirements and associated test methods that apply to semi-finished products such as rods, hollow bars and plates made from thermoplastic materials. These semi-finished products are used predominantly for the manufacture of finished parts by means of machining.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 291:2008, *Plastics — Standard atmospheres for conditioning and testing (ISO 291:2008)*

EN ISO 306, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST) (ISO 306:2004)*

EN ISO 307, *Plastics — Polyamides — Determination of viscosity number (ISO 307:2007)*

EN ISO 527-1, *Plastics — Determination of tensile properties — Part 1: General principles (ISO 527-1:1993 including Corr. 1:1994)*

EN ISO 527-2:1996, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2:1993 including Corr.1:1994)*

EN ISO 1043-1:2001, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics (ISO 1043-1:2001)*

EN ISO 1133, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics (ISO 1133:2005)*

EN ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method (ISO 1183-1: 2004)*

EN ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method (ISO 1183-2:2004)*

EN ISO 2818, *Plastics — Preparation of test specimens by machining (ISO 2818:1994)*

EN ISO 10350-1, *Plastics — Acquisition and presentation of comparable single-point data — Part 1: Moulding materials (ISO 10350-1:2007)*

EN ISO 11357-1, *Plastics — Differential scanning calorimetry (DSC) — Part 1: General principles (ISO 11357-1:2009)*

ISO 1628-5, *Plastics — Determination of the viscosity of polymers in dilute solution using capillary viscometers — Part 5: Thermoplastic polyester (TP) homopolymers and copolymers*

ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature*

ISO 11357-3, *Plastics — Differential scanning calorimetry (DSC) — Part 3: Determination of temperature and enthalpy of melting and crystallization*

ISO 15527:2007, *Plastics — Compression-moulded sheets of polyethylene (PE-UHMW, PE-HD) — Requirements and test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
semi-finished products
rods, hollow bars and panels/plates from which finished parts are manufactured by means of machining

3.2
rods
long, straight and solid products manufactured by means of extrusion, casting or compression moulding and having a uniform circular cross-section over their entire length

3.3
hollow bars
long, straight and hollow products manufactured by means of extrusion, casting or compression moulding and having a uniform circular cross-section, with concentric inside and outside diameter, over their entire length

3.4
panels
plates
flat, rectangular, solid products manufactured by means of extrusion, extrusion, calendering, casting or compression moulding and having a thickness of at least 0,2 mm which is uniform over their full cross-section

4 Materials

The semi-finished products shall be made of thermoplastic materials (see Table 1). These materials may contain additives such as processing aids, reinforcing agents, fillers, stabilizers or colorants, in which case, they are further referred to in this standard as "modified materials".

The nature and the quantity of these additives can influence the mechanical, thermal and electrical properties of the semi-finished products. The choice and the quantities of additives used are left to the discretion of the manufacturer of the semi-finished products.

Table 1 — List of the thermoplastic materials most commonly used for the manufacture of semi-finished products

Abbreviated terms (according to EN ISO 1043-1:2001)	Materials
ABS	Acrylonitrile-butadiene-styrene
ECTFE	Ethylene-chlorotrifluoroethylene copolymer
PA 6	Polyamide 6
PA 6 C[a]	Polyamide 6, cast
PA 66	Polyamide 66
PA 12	Polyamide 12
PA 12 C[a]	Polyamide 12, cast
PA 46	Polyamide 46
PA 6/12 C[ab]	Polyamide 6/12, cast
PBT	Polybutylene terephthalate
PC	Polycarbonate
PEEK	Polyetheretherketone
PE-HD	Polyethylene, high density (Group 2.1 or 3.1 of ISO 15527:2007)
PE-LD	Polyethylene, low density
PE-UHMW	Polyethylene, ultra high molecular weight (Group 1.1 or 1.2 of ISO 15527:2007)
PEI	Polyetherimide
PESU	Polyethersulfone
PET	Polyethylene terephthalate
POM-C	Polyoxymethylene, copolymer
POM-H	Polyoxymethylene, homopolymer
PP-B	Polypropylene, block copolymer
PP-H	Polypropylene, homopolymer
PP-R	Polypropylene, random copolymer
PPE+PS	Polystyrene modified polyphenylene ether
PPS	Polyphenylene sulfide
PPSU	Polyphenylene sulfone
PSU	Polysulfone
PVC-C	Polyvinyl chloride, chlorinated
PVC-HI	Polyvinyl chloride, high-impact modified
PVC-U	Polyvinyl chloride, unplasticized
PVDF	Polyvinylidene fluoride

[a] "C" means "cast "

[b] PA 6/12 with max. 15 % laurinlactam

5 Requirements

5.1 As-delivered condition

Semi-finished products shall be free of blisters, voids, cracks, foreign matter and other defects which make the product unfit for the intended use. Specific requirements in this respect shall be agreed upon between supplier and customer.

The semi-finished products shall be manufactured in such a way that their internal stress level is minimal (see 5.6.2).

Natural coloured materials: slight variations in hue originating from raw materials and/or manufacturing process are allowed.

Natural colour means that no additives (colorants) are added to the raw materials during their manufacture and processing into semi-finished products for the purpose of obtaining another colour.

Coloration: this shall be uniform and shall be agreed upon between supplier and customer. Slight variations in hue originating from raw materials and/or manufacturing process are allowed.

The testing of the as-delivered condition shall be performed according to 6.4.

NOTE Semi-finished products made from PA are dry after manufacture, but absorb moisture during storage. The moisture content in the as-delivered condition is a function of the type of moulding material, the cross-section (plate thickness, rod diameter or hollow bar wall thickness) of the semi-finished product concerned, as well as the type and period of storage.

Semi-finished products made from POM, PEEK and PP are permitted to have light patches in the centre of the cross-section.

Microporosity in the centre of the cross-section may occur in semi-finished products made from POM-H and PP. The largest diameter or the widest part of the microporosity line(s) shall, however, not exceed 4 %. The procedure for the determination and measurement of microporosity is described in Annex A.

When semi-finished products made from POM and PP are subject to specific requirements, e. g. pressure tightness and/or dielectric strength, they shall be agreed upon between supplier and customer.

5.2 Surface appearance

Semi-finished products shall essentially have smooth surfaces. Shallow marks, grooves and irregularities resulting from the manufacturing process are allowed provided that the product meets the dimensional requirements according to 5.3, 5.4 and 5.5.

Testing of the surface appearance shall be performed according to 6.5.

Specific requirements with respect to the surface appearance are to be agreed upon between supplier and customer.

5.3 Dimensions and tolerances for rods

5.3.1 Diameter

The diameters commonly available are given in the delivery programmes of the suppliers.

The tolerances on the diameters are given in Table 2 for different diameter ranges.

Table 2 — Tolerances on diameters for rods

Dimensions in millimetres

Diameter ranges	Column 1 ECTFE PEEK PA 6 PET PA 66 POM PA 12 PPS PA 46 PVDF PBT	Column 2 PA 6 C PA 6/12 C PA 12 C	Column 3 ABS PC PEI PESU PPE+PS PPSU PSU	Column 4 PE-LD PE-HD PE-UHMW PP-B PP-H PP-R	Column 5 PVC-C PVC-HI PVC-U
up to 4	+ 0,6 + 0,1	—	+ 0,7 + 0,1	+ 0,3 + 0,1	
over 4 up to 6		—		+ 0,4 + 0,1	
over 6 up to 8	+ 0,7 + 0,1	—	+ 0,8 + 0,1	+ 0,5 + 0,1	
over 8 up to 10				+ 0,6 + 0,1	
over 10 up to 12	+ 0,8 + 0,2	—	+ 0,9 + 0,2	+ 0,7 + 0,2	
over 12 up to 16				+ 0,8 + 0,2	
over 16 up to 18				+ 0,9 + 0,2	
over 18 up to 20				+ 1,2 + 0,2	
over 20 up to 25	+ 1,0 + 0,2	—	+ 1,2 + 0,2		
over 25 up to 30					
over 30 up to 32	+ 1,2 + 0,2	+ 1,4 + 0,2	+ 1,2 + 0,2	+ 1,3 + 0,2	
over 32 up to 36			+ 1,6 + 0,2		
over 36 up to 40				+ 1,5 + 0,2	
over 40 up to 45	+ 1,3 + 0,3	+ 1,9 + 0,3	+ 2 + 0,3	+ 2 + 0,3	
over 45 up to 56					
over 56 up to 63	+ 1,6 + 0,3	+ 2,5 + 0,3	+ 2,5 + 0,3	+ 2,3 + 0,3	
over 63 up to 70				+ 2,5 + 0,3	
over 70 up to 80	+ 2,0 + 0,4	+ 2,8 + 0,4	+ 3,0 + 0,4	+ 3,0 + 0,4	
over 80 up to 90	+ 2,2 + 0,5	+ 3,2 + 0,5	+ 3,4 + 0,5	+ 3,4 + 0,5	+ 3,0 + 0,5
over 90 up to 100	+ 2,5 + 0,6	+ 3,5 + 0,6	+ 3,8 + 0,6	+ 3,8 + 0,6	+ 3,5 + 0,6
over 100 up to 110	+ 3,0 + 0,7	+ 3,9 + 0,7	+ 4,2 + 0,7	+ 4,2 + 0,7	+ 4,0 + 0,7
over 110 up to 125	+ 3,5 + 0,8	+ 4,3 + 0,8	+ 4,6 + 0,8	+ 4,6 + 0,8	+ 5,0 + 0,8
over 125 up to 140	+ 3,8 + 0,9	+ 5,0 + 0,8	+ 5,4 + 0,9	+ 5,4 + 0,9	+ 6,0 + 0,9
over 140 up to 150	+ 4,2 + 1,0	+ 5,3 + 0,8	+ 5,8 + 1,0	+ 5,8 + 1,0	+ 7,0 + 1,0
over 150 up to 160	+ 4,5 + 1,1	+ 6,0 + 0,8	+ 6,3 + 1,1	+ 6,3 + 1,1	+ 8,0 + 1,1
over 160 up to 180	+ 5,0 + 1,2	+ 6,5 + 1,0	+ 7,4 + 1,2	+ 7,4 + 1,2	+ 9,0 + 1,2

Table 2 (*continued*)

Dimensions in millimetres

Diameter ranges	Column 1	Column 2	Column 3	Column 4	Column 5
	ECTFE PEEK PA 6 PET PA 66 POM PA 12 PPS PA 46 PVDF PBT	PA 6 C PA 6/12 C PA 12 C	ABS PC PEI PESU PPE+PS PPSU PSU	PE-LD PE-HD PE-UHMW PP-B PP-H PP-R	PVC-C PVC-HI PVC-U
over 180 up to 200	+ 5,5 + 1,3	+ 7,5 + 1,0	+ 8,5 + 1,3	+ 8,5 + 1,3	+ 10,0 + 1,3
over 200 up to 220	+ 5,8 + 1,3	+ 8,5 + 1,0	+ 9,0 + 1,3	+ 9,0 + 1,3	+ 11,0 + 1,3
over 220 up to 250	+ 6,2 + 1,5	+ 9,5 + 1,0	+ 9,5 + 1,5	+ 9,5 + 1,5	+ 11,0 + 1,5
over 250 up to 280	+ 6,6 + 1,5	+ 11,0 + 1,0		+10,0 + 1,5	+ 12,0 + 1,5
over 280 up to 320	+ 7,5 + 1,5	+ 12,0 + 1,5	—	+ 10,5 + 1,5	—
over 320 up to 360	+ 8,5 + 1,5	+ 13,5 + 1,5		+ 12 + 1,5	
over 360 up to 400	+ 9,5 + 1,5	+ 15,0 + 1,5			
over 400 up to 450	+ 10,5 + 1,5	+ 16,5 + 1,5		+ 12 + 1,5	
over 450 up to 500	+ 11,5 + 1,5	+ 18,0 + 1,5	—		—
over 500 up to 600	—	+ 21 + 3		—	
over 600 up to 700	—	+ 25 + 3			

Rods made from reinforced materials do not, however, have to meet the tolerances given in their respective column but those in Column 3.

Tolerances on other diameters or deviating tolerances shall be agreed upon between supplier and customer.

NOTE The tolerances in Table 2 apply to rods made from modified and non-modified materials.

5.3.2 Length

The tolerance on length is 0/+ 3 %.

The rods shall have neatly trimmed end faces – perpendicular to their longitudinal axis – so that the nominal length can always be obtained.

Deviating tolerances on the length shall be agreed upon between supplier and customer.

5.3.3 Roundness

The roundness deviation – the difference between the largest and the smallest diameter measured within the same cross-section – shall not be larger than half the tolerance width given in Table 2 for the respective diameter.

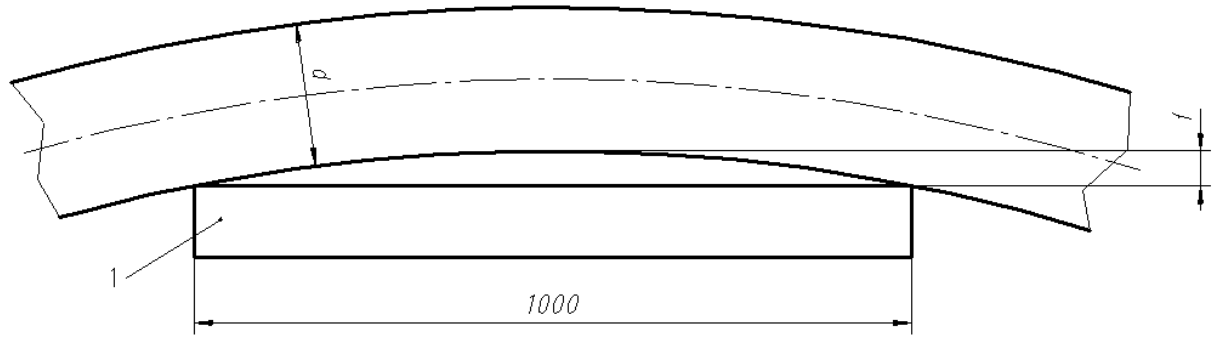
5.3.4 Straightness

The deviations of the rods from the straight line extended from edge to edge over the measuring length shall not exceed the values given in Table 3 for different diameter ranges. These limit values refer to a reference length of 1 000 mm (see Figure 1). To allow proper measuring, the rod is laid unconstrained on its side on a flat surface so that the weight of the product does not influence the results. The measured value f is the greatest distance between the straight 1 000 mm measuring ruler and the maximum concave point on the rod.

See Annex B for the conversion of the deflection as a function of the length.

NOTE An example is given in Annex B

Dimensions in millimetres



Key
1 measuring ruler
d diameter
f deviation from straight line

Figure 1 — Principle of the straightness measurement for rods

Table 3 — Straightness requirements for rods

Dimensions in millimetres

Diameter ranges	Max. allowable deviations from straight line ($f_{max.\ all.}$)					
	Column 1		Column 2	Column 3	Column 4	Column 5
	ABS, PA 12, PA 12 C, PA 46, PA 6, PA 6 C, PA 6/12 C, PA 66, PBT, PC, PEEK, PEI, PESU, PET, POM, PPE+PS, PPS, PPSU, PSU		ECTFE, PE-LD, PE-HD, PVDF	PE-UHMW	PP-H, PP-B, PP-R	PVC-C, PVC-HI, PVC-U
	non-fibre-reinforced[a]	fibre-reinforced				
up to 20	8,0	10,0	15,0	20,0	10,0	10,0
over 20 up to 32	5,0	6,5	12,0	17,5	8,0	8,0
over 32 up to 50	4,0	5,0	10,0	17,5	8,0	8,0
over 50 up to 100	4,0	5,0	8,0	15,0	6,5	6,5
over 100 up to 150	3,5	4,0	6,0	10,0	5,0	5,0
over 150	3,5	4,0	6,0	10,0	5,0	5,0
Special straightness requirements shall be agreed upon between supplier and customer.						
NOTE The limit values given in Columns 2 to 5 apply to rods made from modified and non-modified materials.						
[a] Additives other than fibres can be included in the materials.						

5.4 Dimensions and tolerances for hollow bars

5.4.1 Diameters

The diameters commonly available are given in the delivery programmes of the suppliers.

The tolerances on the outside and inside diameters are given in Table 4 for different diameter ranges.

Table 4 — Tolerances on diameters for hollow bars

Dimensions in millimetres

Outside diameter ranges	**Tolerances on outside diameter**	**Tolerances on outside diameter**	**Tolerances on inside diameter**	**Tolerances on inside diameter**
	ABS, ECTFE, PA 6, PA 66, PA 12, PA 46, PBT, PC, PEEK, PET, PEI, PESU, POM, PPE+PS, PPS, PPSU, PSU, PVDF	PA6 C, PA12 C, PA 6/12 C	ABS, ECTFE, PA 6, PA 66, PA 12, PA 46, PBT, PC, PEEK, PET, PEI, PESU, POM, PPE+PS, PPS, PPSU, PSU, PVDF	PA6 C, PA12 C, PA 6/12 C
from 20 up to 30	+ 1,1 + 0,4	+ 3,0 + 0,8	- 0,4 - 1,1	- 0,8 - 4,0
over 30 up to 50	+ 2,0 + 0,6		- 0,6 - 2,0	
over 50 up to 60	+ 2,5 + 0,8		- 0,8 - 2,5	
over 60 up to 80	+ 3,0 + 0,8	+ 4,0 + 0,8	- 0,8 - 3,0	- 0,8 - 4,0
over 80 up to 110	+ 3,6 + 1,2	+ 5,0 + 1,0	- 1,6 - 5,0	- 1,0 - 6,0
over 110 up to 150	+ 4,5 + 1,5	+ 7,5 + 1,5	- 2,0 - 6,5	- 1,5 - 7,5
over 150 up to 180	+ 5,4 + 1,8	+ 9,0 + 1,8	- 2,2 - 7,5	- 1,8 - 9,0
over 180 up to 220	+ 6,0 + 2,0	+ 11,0 + 2,0	- 2,5 - 8,5	- 2,0 - 11,0
over 220 up to 250	+ 9,0 + 3,0	+ 12,5 + 2,5	- 3,0 - 12,0	- 2,5 - 12,5
over 250 up to 300	+ 10,0 + 3,0	+ 15,0 + 3,0	- 3,5 - 13,0	- 3,0 - 15,0
over 300 up to 400	+ 11,0 + 3,0	+ 17,5 + 3,0	- 3,5 - 14,0	- 3,0 - 17,5
over 400 up to 500	+ 13,0 + 3,0	+ 20,0 + 3,0	- 3,5 - 16,0	- 3,0 - 20,0
over 500 up to 600	+ 15,0 + 3,0	+ 25,0 + 3,0	- 3,5 - 18,0	- 3,0 - 25,0

Tolerances for other diameters or deviating tolerances shall be agreed upon between supplier and customer.

NOTE 1 The tolerances in Table 4 apply to hollow bars made from modified and non-modified materials.

NOTE 2 The tolerances in Table 4 can also be used for hollow bars made from PE and PP provided that there are no other specific standards for these materials.

5.4.2 Length

The tolerance on length is 0/+ 3 %.

The hollow bars shall have neatly trimmed end-faces – perpendicular to their longitudinal axis – so that the nominal length can always be obtained.

Deviating tolerances on the length shall be agreed upon between supplier and customer.

5.4.3 Roundness

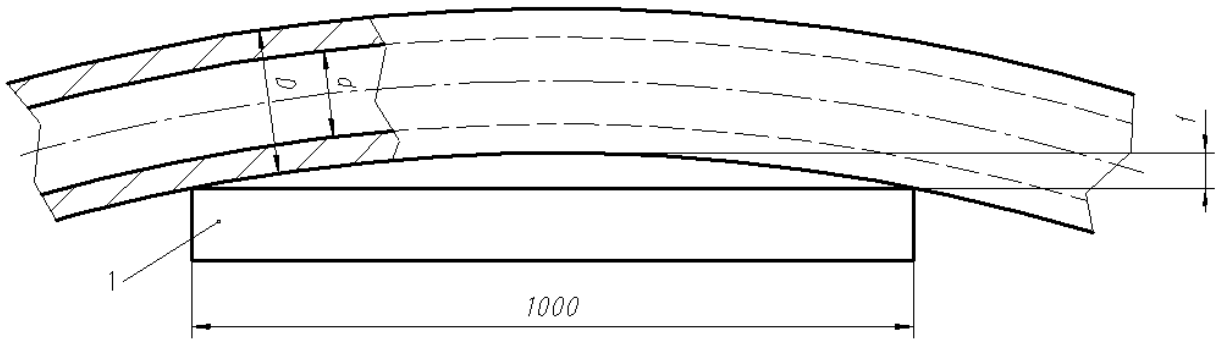
The roundness deviation on the inside and outside diameter – the difference between the largest and the smallest diameter measured within the same cross-section – shall not be larger than half the tolerance range given in Table 4 for the respective diameters.

5.4.4 Straightness

The deviations of the hollow bars from the straight line extended from edge to edge over the measuring length shall not exceed the values given in Table 5 for different outside diameter ranges. These limit values refer to a reference length of 1 000 mm (see Figure 2). To allow proper measuring, the hollow bar is laid unconstrained on its side on a flat surface so that the weight of the product does not influence the results. The measured value f is the greatest distance between the straight, 1 000 mm long, measuring ruler and the concave point of the hollow bar.

See Annex B for the conversion of the deflection as a function of the length.

Dimensions in millimetres



Key
1 measuring ruler
d inside diameter
D outside diameter
f deviation from straight line

Figure 2 — Principle of the straightness measurement for hollow bars

Table 5 — Straightness requirements for hollow bars

Dimensions in millimetres

Outside diameter ranges	Maximal allowable deviations from the straight line ($f_{max.\ all.}$)
up to 20	10
from 20 up to 45	6
over 45 up to 100	5
over 100	4
Special straightness requirements shall be agreed upon between supplier and customer. NOTE The limit values given in Table 5 apply to hollow bars made from modified and non-modified materials.	

5.4.5 Concentricity

In order to allow machining of the nominal outside and nominal inside diameter from the hollow bar when clamping both on the outside or the inside diameter, the eccentricity – the deviation between the centres of inside and outside diameter (ΔE/2) – shall be such that the difference in wall thickness ΔE is less than or equal to $0{,}8 \cdot (d_{nom} - d_{max})$ and less than or equal to $0{,}8 \cdot (D_{min} - D_{nom})$.

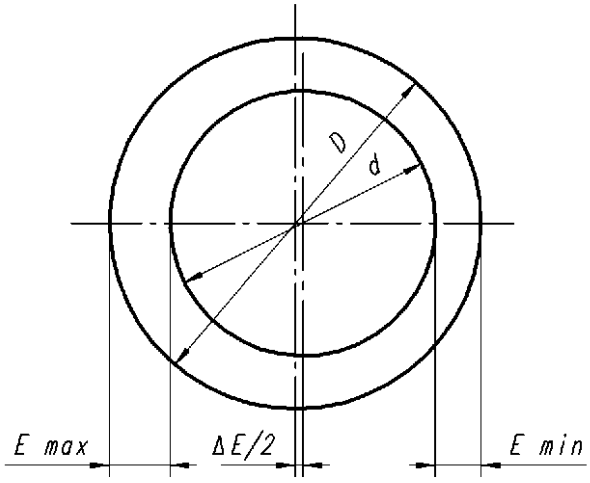
$$\Delta E = E_{max} - E_{min} \leq 0{,}8 \cdot (d_{nenn} - d_{max})$$

and

$$\Delta E = E_{max} - E_{min} \leq 0{,}8 \cdot (D_{min} - D_{nenn})$$

where

E_{max} is the maximum wall thickness in cross-section;
E_{min} is the minimum wall thickness in cross-section;
d_{nom} is the nominal inside diameter;
d_{max} is the measured maximum inside diameter;
D_{nom} is the nominal outside diameter;
D_{min} is the measured minimum outside diameter.



Key
D outside diameter
d inside diameter
E_{max} maximum wall thickness in cross-section
E_{min} minimum wall thickness in cross-section
$\Delta E/2$ concentricity deviation

Figure 3 — Principle of the concentricity measurement

5.5 Dimensions and tolerances for panels/plates

5.5.1 Thickness

The thicknesses generally available are given in the delivery programmes of the suppliers.

The tolerances on thicknesses are given in Tables 6 and 7 for different thickness ranges.

Table 6 — Tolerances on the thicknesses for calendered panels/plates

Dimensions in millimetres

Thickness	Tolerances ABS, ECTFE, PA 6, PA 66, PA 12, PA 46, PBT, PEEK, PEI, PESU, PET, POM, PPE+PS, PPS, PPSU, PSU
0,2 to 0,5	± 0,05
over 0,5 to 1,2	± 0,10
over 1,2 to 2,5	± 0,15
over 2,5 to 4	± 0,20
over 4 to 6	± 0,25
NOTE ISO 15014 and EN ISO 11963 are applicable for tolerances on PVDF and PC respectively.	

Table 7 — Tolerances on thicknesses for extruded, cast and compression-moulded panels/plates

Dimensions in millimetres

Thickness	Tolerances ABS, ECTFE, PA 6, PA 66, PA 12, PA 46, PBT, PC, PEEK, PEI, PESU, PET, POM, PPE+PS, PPS, PPSU, PSU, PVDF	Tolerances PA 6 C, PA 12 C, PA 6/12 C
from 5 to 6	+ 0,7 + 0,2	+ 1,5 + 0,2
over 6 to 10	+ 1,1 + 0,2	
over 10 to 25	+ 1,5 + 0,3	+ 2,5 + 0,3
over 25 to 50	+ 2,5 + 0,5	+ 3,5 + 0,5
over 50 to 70	+ 3,5 + 0,5	+ 5,0 + 0,5
over 70 to 100	+ 5,0 + 0,5	+ 7,0 + 0,5
over 100 to 130	+ 6,0 + 0,5	+ 9,0 + 0,5
over 130 to 160	+ 7,0 + 0,5	+ 10,0 + 0,5

Tolerances for other thicknesses or deviating tolerances shall be agreed upon between supplier and customer.

NOTE 1 The tolerances in Table 7 apply to panels/plates made from modified and non-modified materials.

NOTE 2 The tolerances in Table 7 can also be used for panels/plates made from PE and PP provided that there are no other specific standards for these materials.

NOTE 3 Tolerances for PVDF and PC apply only to the thickness ranges not given in ISO 15014 or EN ISO 11953 respectively.

5.5.2 Length and width

- Tolerance on width: + 0,5 %/+ 4 %
- Tolerance on length: + 0 %/+ 3 %

Deviating tolerances on width and/or length shall be agreed upon between supplier and customer.

The plates shall have neatly trimmed end faces perpendicular to the axes of symmetry so that the nominal length and/or nominal width can always be obtained.

5.5.3 Straightness

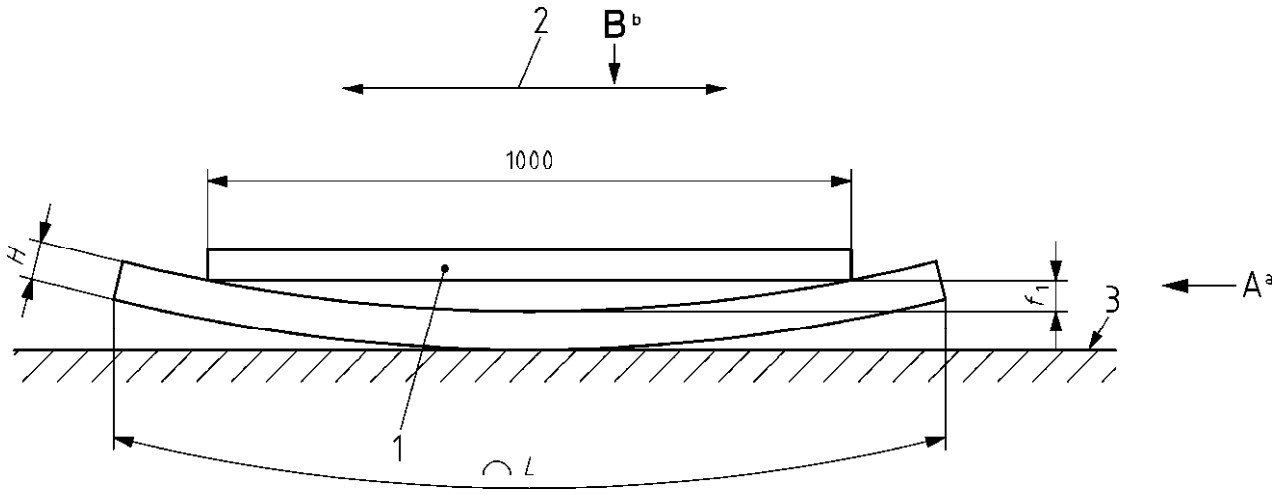
The deviations of the panels/plates from the straight line extended from edge to edge over the measuring length shall not exceed the values given in Table 8 for different thickness ranges. These limit values refer to a reference length of 1 000 mm (see Figures 4a), 4b) and 4c)). To allow proper measuring, the panel/plate is laid unconstrained on a flat surface so that the concave side is uppermost.

The measured value f is the maximum distance between the straight, 1 000 mm long, measuring ruler and the concave side of the panel/plate l, measured over the longest length or width.

See Annex B for the conversion of the deflection as a function of the length.

NOTE An example is given in Annex B.

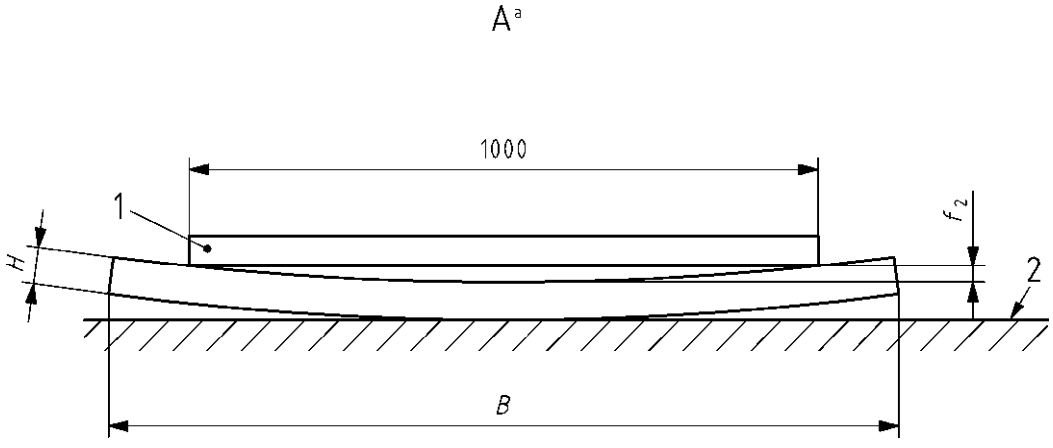
Dimensions in millimetres



Key
1 measuring ruler
2 direction of extrusion (if applicable)
3 flat surface
H thickness
L length
f_1 deviation from straight line
A [a] side view
B [b] top view

a) Principle of straightness measurement on panels/plates over the length (L)

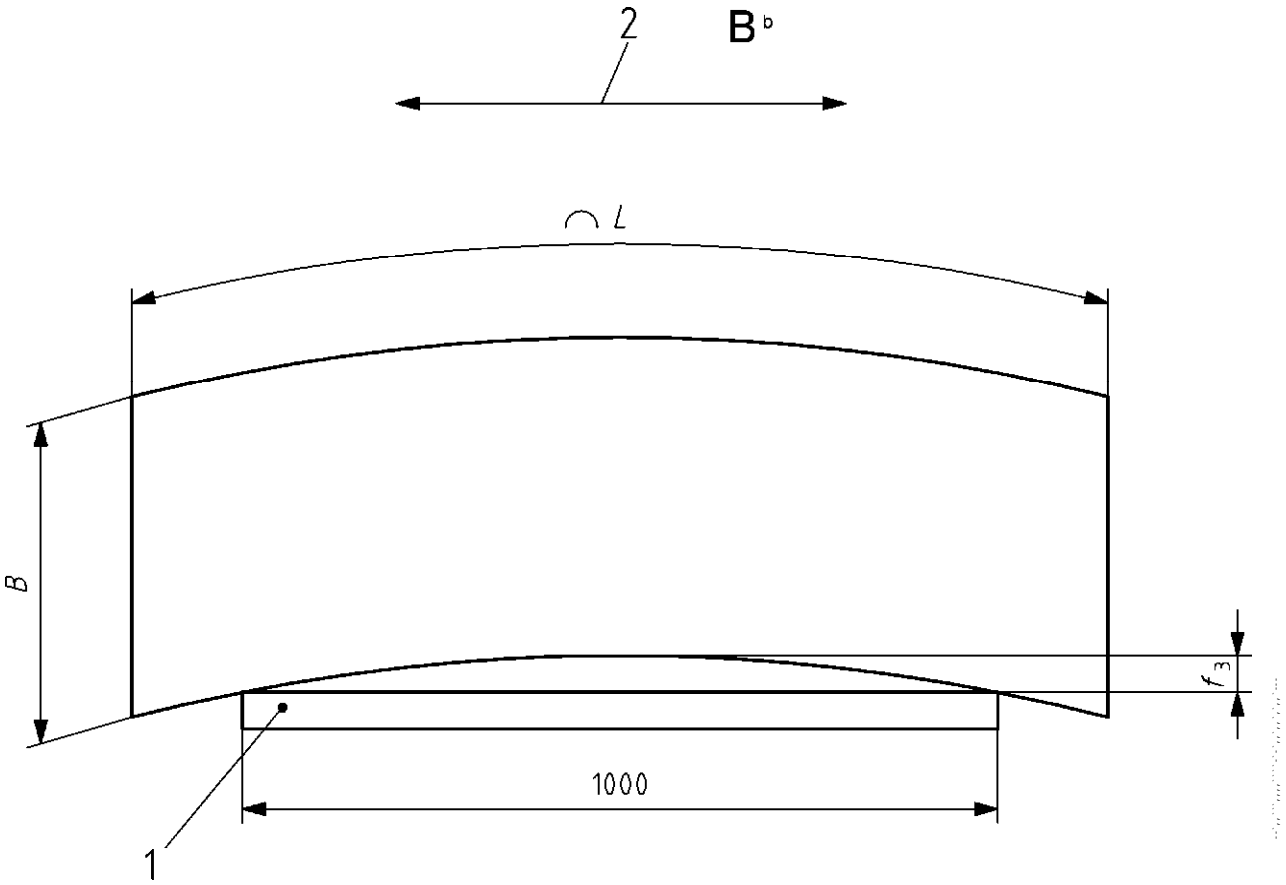
Dimensions in millimetres



Key
1 measuring ruler
2 flat surface
H thickness
B width
f_2 deviation from straight line

b) Principle of the straightness measurement on panels/plates over the width (B)

Dimensions in millimetres



Key
1 measuring ruler
2 direction of extrusion (if applicable)
3 flat surface
L length
B width
f_3 deviation from straight line

c) Principle of the straightness measurement on panels/plates along the edges

Figure 4 — Principle of the straightness measurement on panels/plates

Table 8 — Straightness requirements for panels/plates

Dimensions in millimetres

Thickness ranges	Maximal allowable deviations from the straight line ($f_{max.\ all.}$)		
	ABS, ECTFE, PA 6, PA 6 C, PA 66, PA 12, PA 12 C, PA 6/12 C, PA 46, PBT, PC, PEEK, PEI, PESU, PET, POM, PPE+PS, PPS, PPSU, PSU, PVDF		
	f_1 (see Figure 4a))	f_2 (see Figure 4b))	f_3 (see Figure 4c))
up to 6	6,0	7,0	4,0
over 6 up to 16	4,0	5,0	
over 16 up to 25	2,5	3,5	
over 25 up to 50	2,0		
over 50	1,5		
Deviating straightness requirements shall be agreed upon between supplier and customer.			
NOTE The limit values in Table 8 apply to unmachined panels/plates made from modified and non-modified materials.			

5.6 Properties

5.6.1 Physical properties

The property values below apply only to semi-finished products made from non-modified materials in natural colour (measured on test specimens machined from the semi-finished products). The property values or special requirements for modified materials are to be agreed upon between supplier and customer.

The property values of semi-finished products made from thermoplastic materials depend mainly on their thermal history and morphology, and, therefore, on the respective shape (rod, hollow bar, panel/plate) and dimension (diameter or thickness). This makes it very difficult to give limit values that apply to all shapes and dimensions. As a consequence, the values given in the Tables 9 and 10 for density, tensile stress at yield, elongation at break, tensile modulus of elasticity, melting temperature/glass transition temperature and Vicat softening temperature VST/B/50 are not minimum values but guideline values (in italics). They are typical average values from tests on rods of diameter 40 mm to 60 mm, mainly to be used for comparative purposes when selecting a material for a given application. Although these values fall within the normal range of product properties, they are, however, not assured and should not be used to establish material specification limits.

Property values to be used for establishing material specification limits shall be agreed upon between supplier and customer as a function of the shape and dimension(s) concerned.

In the case of melt volume flow rate and viscosity number, these are minimum values.

Table 9 — Property values for semi-finished products made from ABS, ECTFE, PA, PBT, PC, PEEK, PEI, PESU, PET, POM, PPE+PS, PPS, PPSU, PSU and PVDF

Properties	Unit	Materials											Testing according to subclause
		ABS	ECTFE	PA 6	PA 6 C	PA 66 [a]	PA 12	PA 12 C	PA 46	PA 6/12 C	PBT	PC	
Density	g/cm^3	*1,04*	*1,70*	*1,14*	*1,15*	*1,14*	*1,01*	*1,02*	*1,19*	*1,13*	*1,32*	*1,20*	6.7
Tensile stress at yield	MPa	*40*	*30*	*80*	*80*	*90*	*50*	*60*	*100*	*75*	*65*	*70*	6.8
Elongation at break	%	*50*	*> 50*	*> 50*	*40*	*40*	*> 50*	*> 50*	*30*	*> 50*	*15*	*> 50*	6.8
Tensile modulus of elasticity	MPa	*2 000*	*1 600*	*3 200*	*3 300*	*3 400*	*1 800*	*1 900*	*3 250*	*2 800*	*2 800*	*2 300*	6.9
Melt volume-flow rate MVR	cm^3/10 min	≤ 6	≤ 5	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	≤ 8	6.11
Melting temperature (*) or glass transition temperature (**)	°C	*109* (**)	*225* (*)	*220* (*)	*217* (*)	*260* (*)	*180* (*)	*175* (*)	*290* (*)	*212* (*)	*225* (*)	*150* (**)	6.12
Viscosity number	ml/g	NA [c]	NA [c]	≥ 220 [b]	NM [d]	≥ 220	≥ 190	NM [d]	≥ 120 [b]	NM [d]	≥ 130	NA [c]	6.13

a For processing reasons, PA 6 can be added for semi-finished products made from PA 66.

b Based on the use of sulfuric acid as solvent.

c "NA" means "not applicable".

d "NM" means "not measurable".

Table 9 *(continued)*

Properties	Unit	Materials											Testing according to subclause
		PEEK	PEI	PESU	PET	POM-C	POM-H	PPE + PS	PPS	PPSU	PSU	PVDF	
Density	g/cm^3	*1,31*	*1,28*	*1,37*	*1,38*	*1,41*	*1,42*	*1,06*	*1,35*	*1,29*	*1,24*	*1,78*	6.7
Tensile stress at yield	MPa	*110*	*120*	*90*	*90*	*65*	*75*	*50*	*95*	*80*	*85*	*58*	6.8
Elongation at break	%	*15*	*10*	*20*	*15*	*40*	*50*	*25*	*5*	*> 50*	*10*	*25*	6.8
Tensile modulus of elasticity	MPa	*4 100*	*3 300*	*2 600*	*3 350*	*2 800*	*3 300*	*2 100*	*3 400*	*2 400*	*2 700*	*2 000*	6.9
Melt volume-flow rate MVR	cm^3/10 min	≤ 12	≤ 16	NV [e]	NA [c]	≤ 3,5	≤ 3,5	≤ 12	NV [e]	≤ 18	≤ 8	≤ 6	6.11
Melting temperature (*) or glass transition temperature (**)	°C	*343 (*)*	*218 (**)*	*230 (**)*	*250 (*)*	*165 (*)*	*175 (*)*	*140 (**)*	*280 (*)*	*225 (**)*	*190 (**)*	*176 (*)*	6.12
Viscosity number	ml/g	NA [c]	NA [c]	NA [c]	≥ 100	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	NA [c]	6.13

[c] "NA" means "not applicable".

[e] "NV" means "no values available".

Table 10 — Property values for semi-finished products made from PE, PP und PVC

Properties	Unit	Materials										Testing according to subclause
		PE-LD	PE-HD Group 3.1	PE-HD Group 2.1	PE-UHMW	PP-H	PP-B	PP-R	PVC-C	PVC-HI	PVC-U	
Density	g/cm^3	*0,92*	*0,95*	*0,96*	*0,93*	*0,90*	*0,90*	*0,90*	*1,60*	*1,40*	*1,44*	6.7
Tensile stress at yield	MPa	*10*	*23*	*29*	*19*	*32*	*26*	*25*	*60*	*52*	*54*	6.8
Elongation at break	%	*> 50*	*> 50*	*> 50*	*> 50*	*> 50*	*> 50*	*> 50*	*15*	*22*	*15*	6.8
Tensile modulus of elasticity	MPa	*250*	*900*	*1 200*	*600*	*1 400*	*1 200*	*1 000*	*2 900*	*2 700*	*3 100*	6.9
Vicat softening temperature VST/B/50	°C	*50*	*70*	*80*	*80*	*90*	*60*	*60*	*103*	*74*	*78*	6.10
Melt volume-flow rate MVR	cm^3/10 min	≤ 0,5	≤ 2,0 [f] ≤ 30,0 [g]	≤ 0,15 [f] ≤ 5,0 [g]	NM [d]	≤ 0,6	≤ 0,6	≤ 0,4	≤ 121	NV [e]	≤ 83	6.11
Melting temperature (*) or glass transition temperature (**)	°C	115 (*)	136 (*)	138 (*)	135 (*)	167 (*)	167 (*)	150 (*)	121 (**)	NV [e]	NV [e]	6.12

[d] "NM" means "not measurable".

[e] "NV" means "no values available".

[f] "Values for 190°C/5kg".

[g] "Values for 190°C/21,6kg".

5.6.2 Dimensional stability after heat treatment

The dimensional stability after heat treatment is determined by means of the test described in 6.14.

The relative changes in length, thickness and diameter of semi-finished products made from non-modified materials such as polyamide (PA), polybutylene terephthalate (PBT), polycarbonate (PC), polyetheretherketone (PEEK), polyethylene terephthalate (PET), polyoxymethylene (POM), polystyrene modified polyphenylene ether (PPE+PS) and polyvinylidenfluoride (PVDF) shall not exceed the guideline values given in Table 11 derived from measurements from panels 20 mm high and rods with a diameter of 50 mm to 60 mm..

NOTE There are no values available yet for the other materials listed in Table 1.

Table 11 — Guideline values for the relative dimensional changes

Type of semi-finished product	Dimensions mm	Guideline values for the relative dimensional changes													
		PA 6	PA 6,C	PA 66	PA 12	PA 12,C	PA 46	PA 6/12 C	PBT	PC	PEEK	PET	PPE+ PS	POM	PVDF
Rods	$d \geq 12$ to ≤ 200	1,75%	1,5%	1,5%	1,5%	1,0%	1,5%	1,5%	1,25%	0,25%	1,0%	1,0%	0,25%	0,75%	1,0%
Hollow bars	$D \leq 300$ and $E \leq 40$														
Panels/plates	$H \geq 5$ to ≤ 100	0,75%	0,5%	0,75%	1,0%	0,5%	1,0%	0,5%	0,75%	0,25%	1,0%	0,75%	0,25%	0,5%	0,75%
NOTE These figures apply to semi-finished products with a moisture content of ≤ 0,2%															

5.6.3 Physiological behaviour

The requirements specified by the different applicable regulations shall be met when the semi-finished products are further used for the manufacture of articles intended to come into contact with foodstuffs and confectionery.

Specific requirements with respect to their suitability for contact with foodstuffs and/or drinking water or for use in medical devices shall be agreed upon between supplier and customer.

6 Test methods

6.1 Test conditions

Unless otherwise stated in 6.7 to 6.15 or otherwise agreed between supplier and customer, the tests are carried out in a standard atmosphere at (23 ± 2) °C according to EN ISO 291:2008 on dry test specimens.

In the case of polyamides, the test specimens shall be dried prior to testing in a vacuum oven at 80 °C until constant weight is achieved followed by storage of at least 16 hours in a desiccator at (23 ± 2) °C. After removal from the desiccator, the tests shall be carried out immediately.

6.2 Sampling size

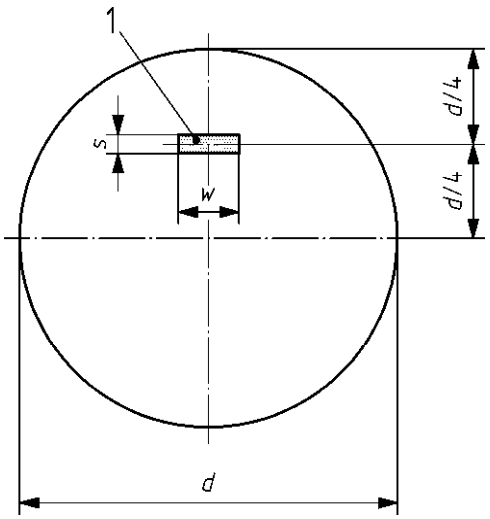
The type and number of semi-finished products belonging to a delivery that have to be tested shall be derived from the respective standards or be agreed between supplier and customer.

6.3 Test specimen preparation

6.3.1 Mechanical properties

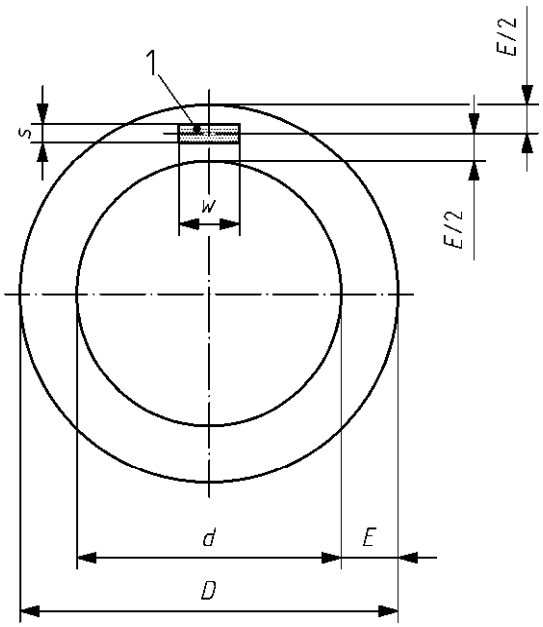
The test specimens shall be taken as shown in Figures 5, 6 and 7 by means of machining from the semi-finished product in the extrusion direction/longitudinal direction according to the requirements of EN ISO 2818.

Deviating procedures, e. g. taking the test specimens perpendicular to instead of parallel with the extrusion direction, shall be agreed between supplier and customer.



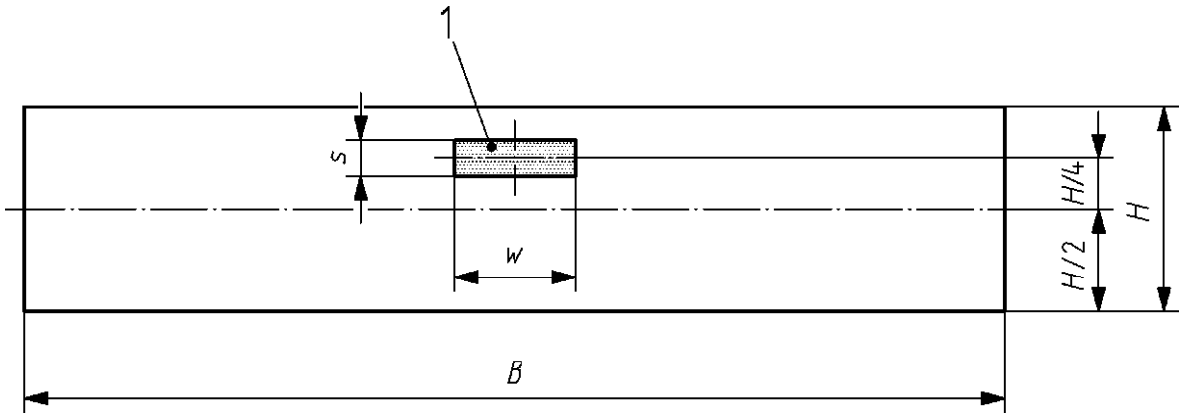
Key
1 test specimen
s thickness
w width
d diameter

Figure 5 — Taking test specimens from rods



Key
1 test specimen
s thickness
w width
d inside dameter
D outside diameter
E wall thickness

Figure 6 — Taking test specimens from hollow bars



Key
1 test specimen
s thickness
w width
H panel thickness
B panel width

Figure 7 — Taking test specimens from panels/plates

The test specimen shall be free from surface defects which may give rise to notch effects. Burrs created during machining shall be removed without, however, damaging the surfaces, e.g. creating notches. If

necessary, the test specimen surfaces shall be finished with abrasive paper – grain size 240 or finer – or other suitable means. This finishing operation shall be carried out parallel to the long side of the test specimens.

6.3.2 Density

The test specimens shall be taken from the semi-finished products at the positions shown in Figures 5, 6 and 7. During this operation, the material shall not be deformed, overheated or melted.

6.3.3 Melt volume-flow rate, viscosity number, melting temperature/glass transition temperature

The test specimens, in the form of granules or chips, shall be taken from the semi-finished products at the positions shown in Figures 5, 6 and 7. Care shall be taken that the material is not overheated or melted during this operation. If moisture-sensitive materials are not tested directly after sampling, the test specimens shall be stored in a desiccator with a drying agent. The testing itself shall be carried out on dry test specimens.

6.3.4 Dimensional stability after heat treatment

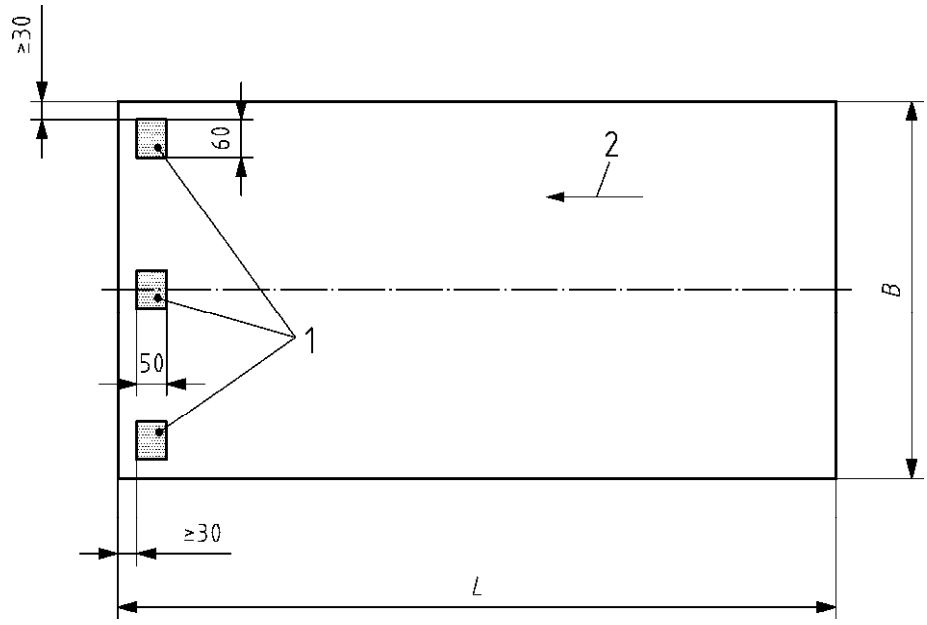
6.3.4.1 Rods/hollow bars

Three test specimens having a length (l) of (25 ± 0,1) mm shall be taken at least 30 mm from the end faces of the rod or hollow bar. The test specimen diameter shall be the same as in the “as-delivered” condition so that the diameter of the test specimen is equal to the diameter of the rod or hollow bar. The end faces of the test specimens shall machined (turned/milled) to be plane-parallel and smooth; see Figures 9 and 10.

6.3.4.2 Panels/plates

Three test specimens of rectangular shape (50 ± 0,2) mm (milled/planed) x (60 ± 1) mm (saw-cut) (rectangular blocks) shall be machined from the panels/plates. The test specimens are taken uniformly over the width of the plate as shown in Figure 8. The thickness shall be the same as in the “as-delivered” condition so that the test specimen thickness is equal to the plate thickness.

Dimensions in millimetres



Key
1 test specimens
2 direction of extrusion (if applicable)
L length of panel
B width of panel

Figure 8 — Taking test specimens from panels/plates

6.4 As-delivered condition

The surfaces shall be assessed visually and without the use of optical instruments for blisters, gouges, voids, cracks or other defects. Testing for internal defects may be carried out by means of ultrasound or alternatively by means of optical checking of the trimmed edges.

6.5 Surface appearance

The surface appearance shall be assessed visually and without the use of optical instruments. Possible marks and irregularities shall be evaluated by machining to nominal size.

6.6 Accuracy of the dimension measuring instruments

The accuracy of measurement of the instruments used for the determination of the diameter, thickness and straightness of the semi-finished products should be 0,1 mm. The accuracy of measurement for the determination of width and length of the semi-finished products should be 1 mm.

6.7 Density

The density shall be determined according to EN ISO 1183-1 or EN ISO 1183-2 on at least 3 test specimens each having a minimum mass of 1 g.

6.8 Tensile stress at yield and elongation at break

The tensile stress at yield and the elongation at break shall be determined according to EN ISO 527-1 and EN ISO 527-2:1996 on at least 5 test specimens of type 1B.

The testing speed shall be 5 mm/min or 50 mm/min, to be chosen as a function of the ductile behaviour of the material (tough or brittle) according to EN ISO 10350-1.

6.9 Tensile modulus of elasticity

The tensile modulus of elasticity shall be determined according to EN ISO 527-1 and EN ISO 527-2:1996 on at least 5 test specimens of type 1B. The testing speed shall be 1 mm/min with a permissible deviation of ± 20 %.

6.10 Vicat softening temperature

The Vicat softening temperature VST/B/50 shall be determined according to EN ISO 306 on at least 2 test specimens.

6.11 Melt volume-flow rate (MVR)

The melt volume-flow rate MVR shall be determined according to EN ISO 1133 on at least 1 test specimen, using the temperature/load-combination given in Table 12 for the respective material.

Table 12 — Test conditions for determination of the melt volume-flow rate (MVR)

Material	Temperature °C	Load kg
ECTFE	275	5
ABS	220	10
PC	300	1,2
PEEK	380	5
PE-HD [b]	190	5
PE-HD [b]	190	21,6
PE-LD	190	2,16
PE-UHMW [a]	190	21,6
PEI	360	5
PESU	380	2,16
POM	190	2,16
PP	230	2,16
PPE+PS	280	5
PPS	315	5
PPSU	365	5
PSU	343	2,16
PVDF	230	5

[a] Not measurable

[b] Both methods applicable

6.12 Melting temperature/glass transition temperature

The melting temperature (peak melting temperature T_{pm}) shall be determined according to EN ISO 11357-1 and ISO 11357-3 from the second heat scan, using a heating rate of 10 °C/min.

The glass transition temperature shall be determined according to EN ISO 11357-1 and ISO 11357-2 from the second heat scan, using a heating rate of 20 °C/min.

6.13 Viscosity number

The viscosity number shall be determined for the materials listed in Table 13 on at least 2 test specimens. The solvent and the test method shall also be selected from Table 13.

Table 13 — Test methods and solvents to be used for determination of the viscosity number

Material	Solvents	Test methods
PA 6 PA 6 C PA 66 PA 46 PA 6/12 C	Sulfuric acid (96 ± 0,15) % m/m Formic acid (90 ± 0,15) % m/m	EN ISO 307
PA 12 PA 12 C	m-cresol 99 % m/m minimum	EN ISO 307
PBT PET	Solution of 50 parts by mass of phenol and 50 parts by mass of 1,2-dichlorobenzene	ISO 1628-5

6.14 Dimensional stability after heat treatment

The dimensional stability after heat treatment shall be determined on dry test specimens and after adequate temperature equilibrium has been reached:

The test specimen length (l) of rods and hollow bars or thickness (h) of panels/plates is measured to the nearest of 0,01 mm in the standard atmosphere at (23 ± 2) °C. This is done in the centre of the cylindrical test specimen (in the case of rods) and in the centre of the rectangular test specimen (in the case of panels/plates) or at two marked positions offset by 180° in the middle of the wall thickness (in the case of hollow bars); see Figures 9, 10 and 11.

The diameter of each test specimen (d in the case of rods and D in the case of hollow bars) is measured to the nearest 0,01 mm in the standard atmosphere at (23 ± 2) °C. This is done at two marked positions offset by 90° and at mid-length (see Figures 9 and 10).

For panels/plates, the width (nominal size 50 mm) of each rectangular test specimen is measured to the nearest 0,01 mm in the standard atmosphere at (23 ± 2) °C. This is done in the middle of the test specimen thickness and length (see Figure 11).

The test specimens are put in an air oven with forced air circulation which is then to be heated to the temperature indicated in Table 14 for the material concerned, using a heating rate of 10 °C/h to 20 °C/h. Once the test temperature is reached, it is maintained for 6 h. In the next step, the test specimens are cooled down in the oven to room temperature at a cooling rate of 10 °C/h to 20 °C/h. They are then left in standard air atmosphere at (23 ± 2) °C for at least 12 h (temperature equilibrium) before they are measured again as described above to the nearest 0,01 mm, at the same positions as during the first measurements.

The relative dimensional changes in length, thickness, width, thickness or diameter are determined as average values and calculated as follows:

$$\Delta l = \frac{l_S - l_E}{l_S} \times 100$$

and/or

$$\Delta h = \frac{h_S - h_E}{h_S} \times 100$$

and/or

$$\Delta b = \frac{b_S - b_E}{b_S} \times 100$$

and/or

$$\Delta d = \frac{d_S - d_E}{d_S} \times 100$$

and/or

$$\Delta D = \frac{D_S - D_E}{D_S} \times 100 .$$

where

Δl, Δh, Δb, Δd, ΔD is the relative dimensional change, in %;

l_S, h_S, b_S is the test specimen length, thickness and width, before the heat treatment, in mm;

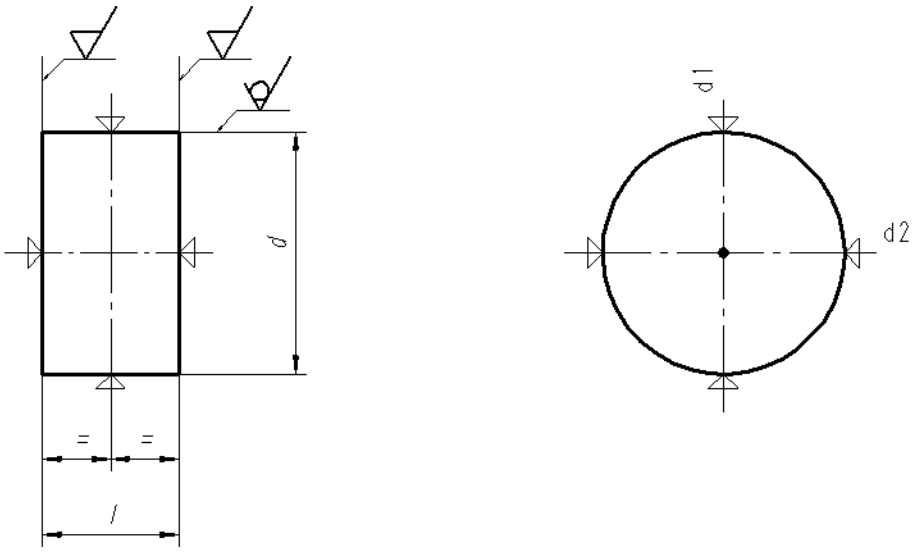
l_E, h_E, b_E is the test specimen length, thickness and width, after the heat treatment, in mm;

d_S, D_S is the test specimen diameter before the heat treatment, in mm;

d_E, D_E is the test specimen diameter after the heat treatment, in mm.

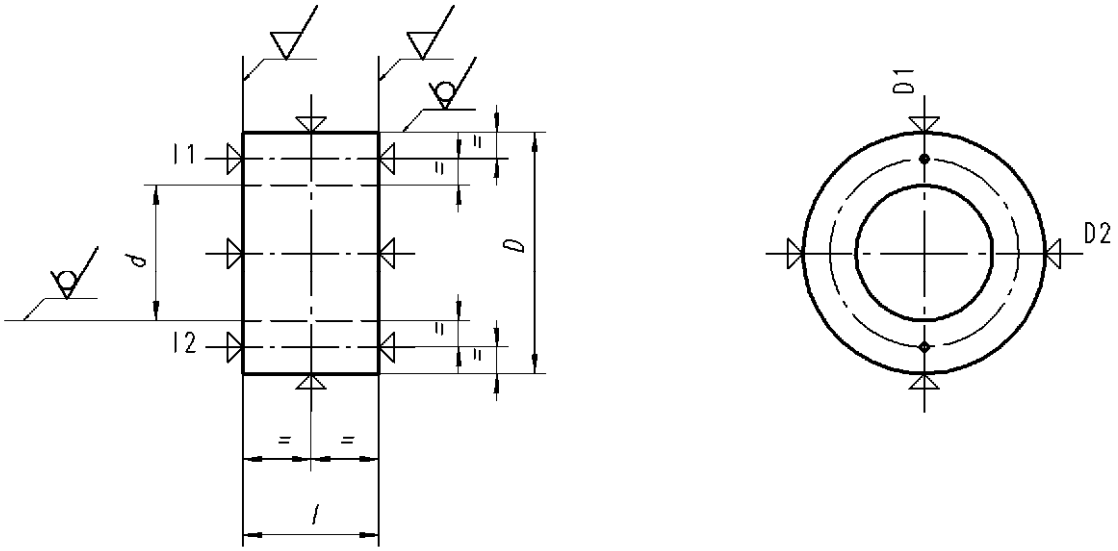
Table 14 — Test temperatures for determination of dimensional stability after heat treatment

Material	Test temperatures (°C)
PA 6	160
PA 6 C	160
PA 66	180
PA 12	140
PA 12 C	140
PA 46	200
PA 6/12 C	160
PBT	150
PC	130
PEEK	300
PET	160
POM	140
PPE + PS	110
PVDF	150



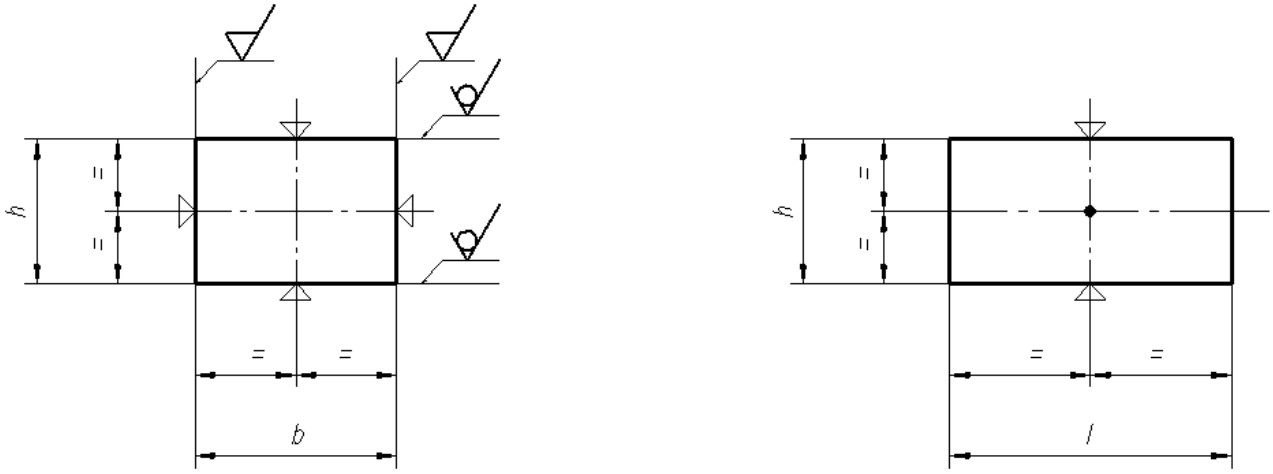
Key
d diameter of test specimens
l length of test specimens
⏚ measuring points

Figure 9 — Measuring points on test specimens taken from rods



Key
D outside diameter of test specimens
d inside diameter of test specimens
l length of test specimens
⏚ measuring points

Figure 10 — Measuring points on test specimens taken from hollow bars



Key
b width of test specimens (50 mm)
l length of test specimens (60 mm)
h thickness of test specimens
⏚ measuring points

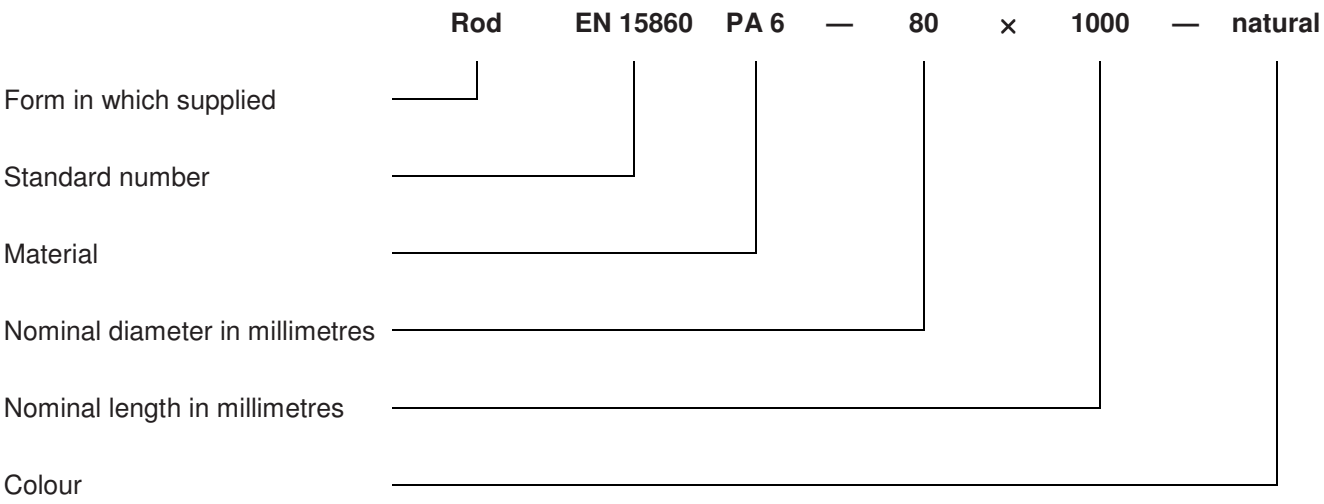
Figure 11 — Measuring points on test specimens taken from panels/plates

6.15 Preparation of test results

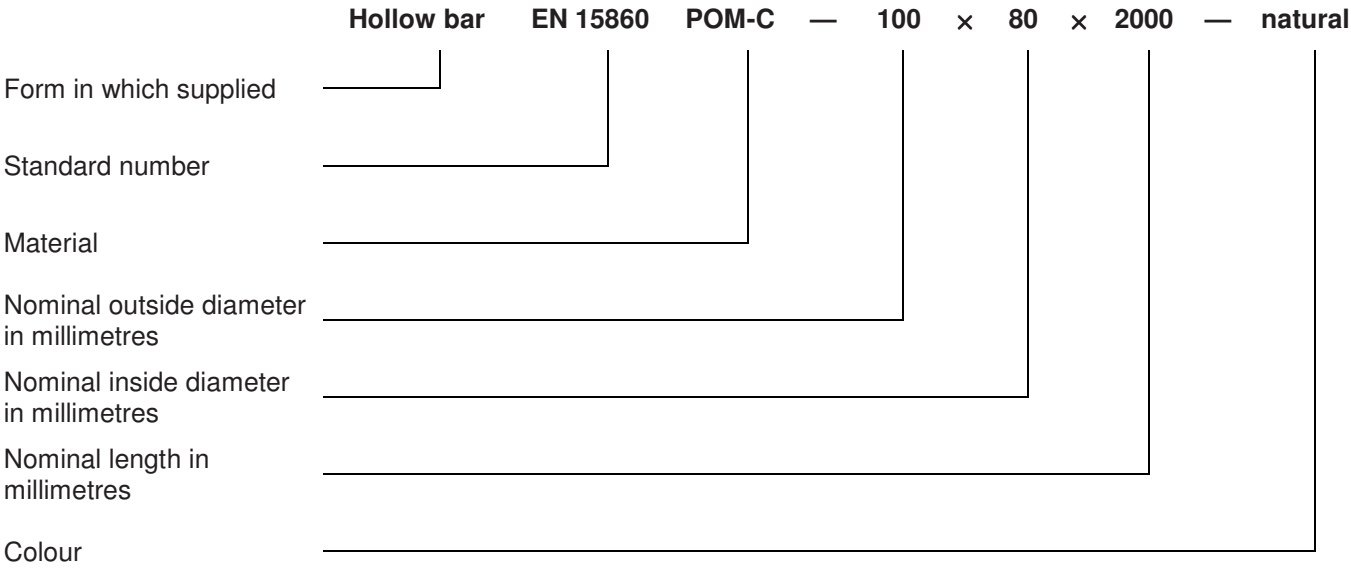
Unless otherwise stated in the test for the specific property, the average value of the individual test results shall be calculated and rated as a representative value for the property measured on the tested semi-finished product.

7 Designation

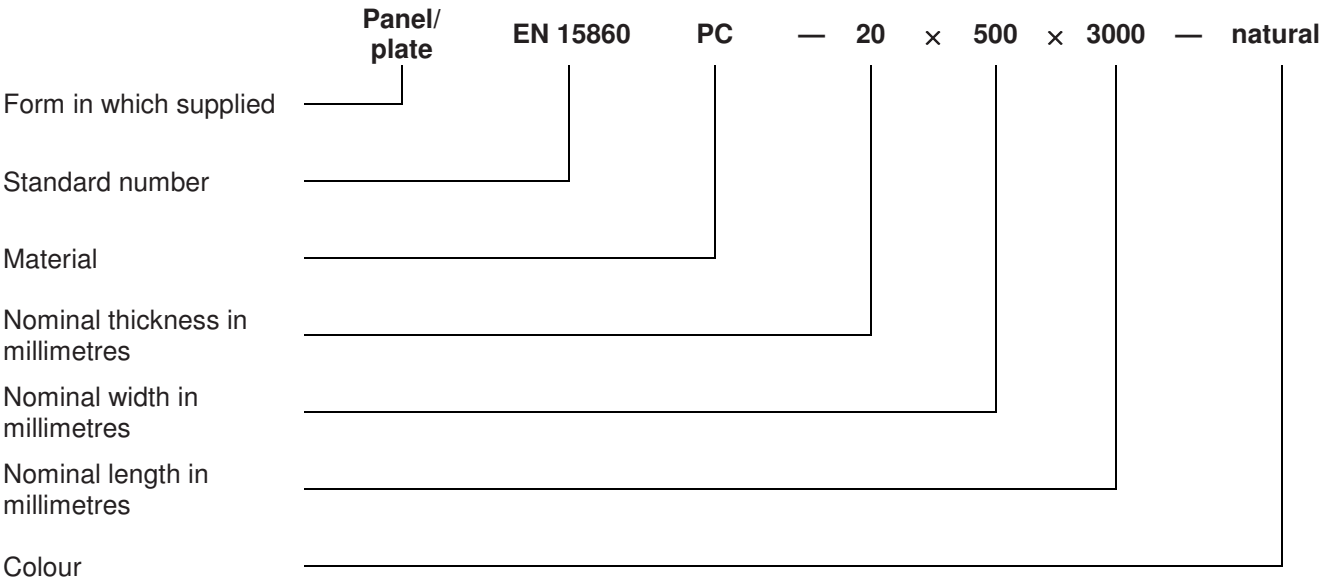
7.1 Rods



7.2 Hollow bars



7.3 Panels/plates



8 Marking

Semi-finished products that meet the requirements of this standard can be marked as follows:

a) manufacturer's mark;

b) number of this European Standard (EN 15860);

c) material designation;

d) date of manufacture/production number.

Annex A
(normative)

Procedure for the determination of microporosity in semi-finished products

Microporosity means microvoids which are visible to the naked eye when applying the dye penetration method described below.

For rods or hollow bars, a 100 mm long piece is cut in half lengthwise, approximately 2 mm off centre, and is then machined down to the centre so that a clean and smooth surface is obtained (surface roughness: 1,5 µm ≤ *R*a ≤ 2,5 µm) (see Figures A.1 and A.2).

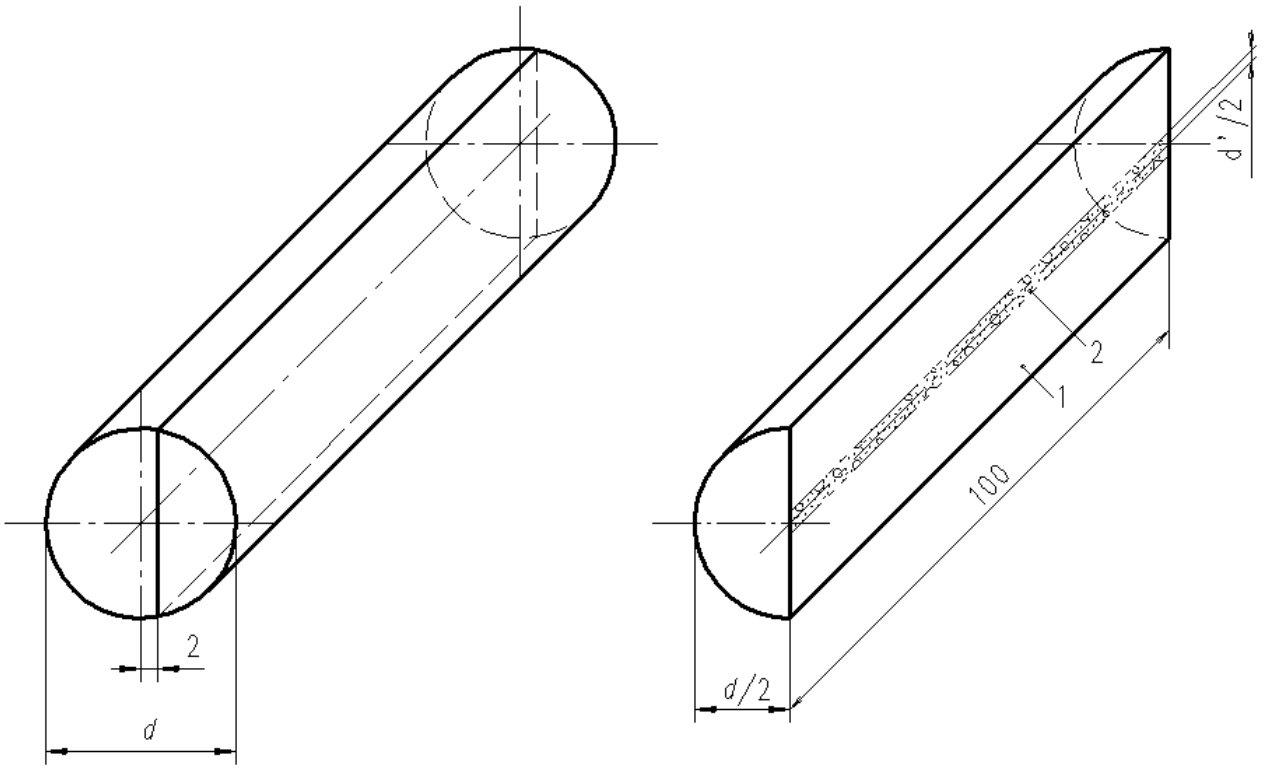
For panels/plates, a 20 mm to 40 mm wide strip is cut over the full width of the panel/plate. Then, one face is machined over a depth of about 2 mm so that a clean and smooth surface is obtained (surface roughness: 1,5 µm ≤ *R*a ≤ 2,5 µm) (see Figure A.3).

After cleaning the machined surface, e. g. with isopropyl alcohol, the surface is coloured by means of a fluorescent permanent magic marker. Through capillary effect, the ink penetrates the pores, if present. After about one minute drying time, the coloured area is cleaned off with isopropyl alcohol. The ink or dye will not be washed from inside the pores and will show up as coloured particles (to be examined preferably using a UV-light sensor). If no coloured particles are visible, then the material does not have microporosity.

If coloured particles are visible, a measurement is made of the largest diameter (d' in case of rods) or the widest part (b' in case of hollow bars or panels) of the porosity line(s) over the 100 mm long piece (for rods or hollow bars) or over the full panel/plate width (B).

The value of the largest diameter or the widest part of the porosity line is then divided by the diameter of the rod or the wall thickness of the hollow bar or the thickness of the panel, and multiplied by 100 to obtain the percentage centreline porosity value. As indicated in 5.1, this value shall not exceed 4 %.

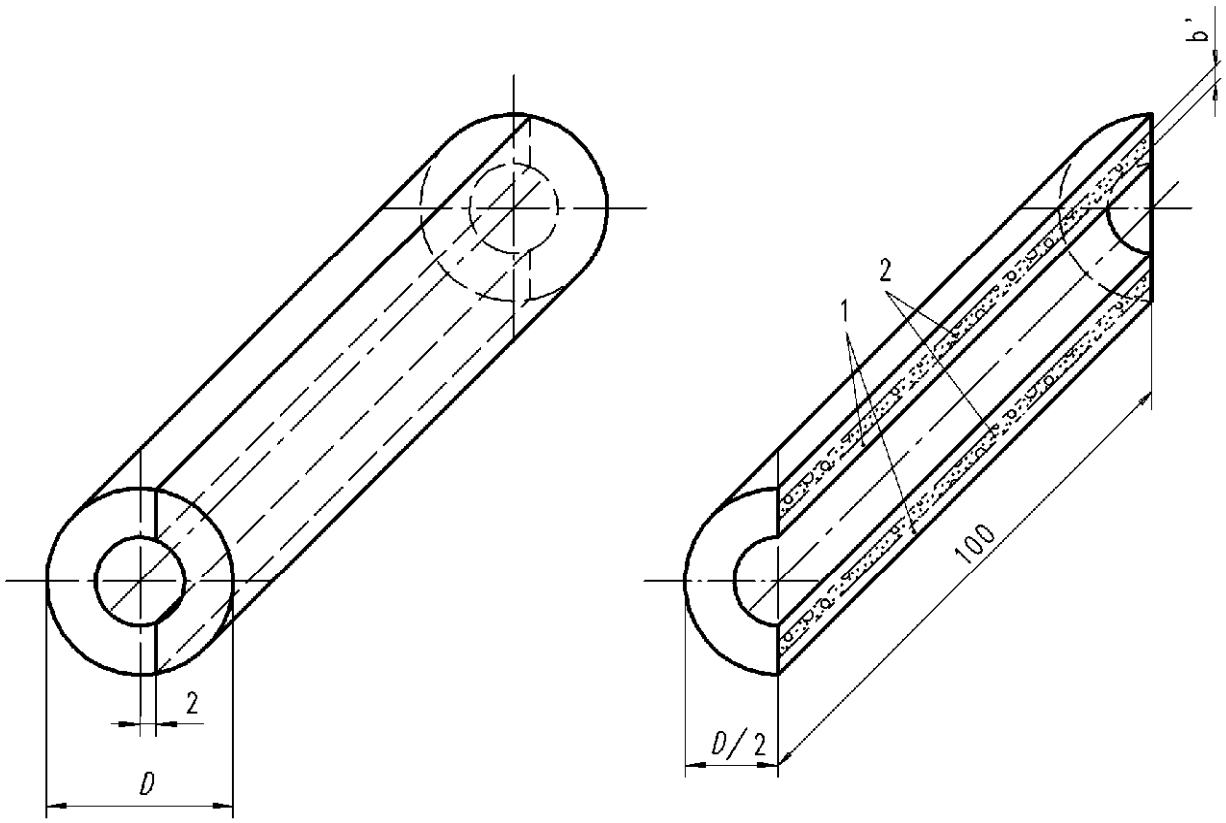
Dimensions in millimetres



Key
1 machined surface
2 microporosity line
d diameter
d' maximum diameter of porosity line

Figure A.1 — Procedure for rods

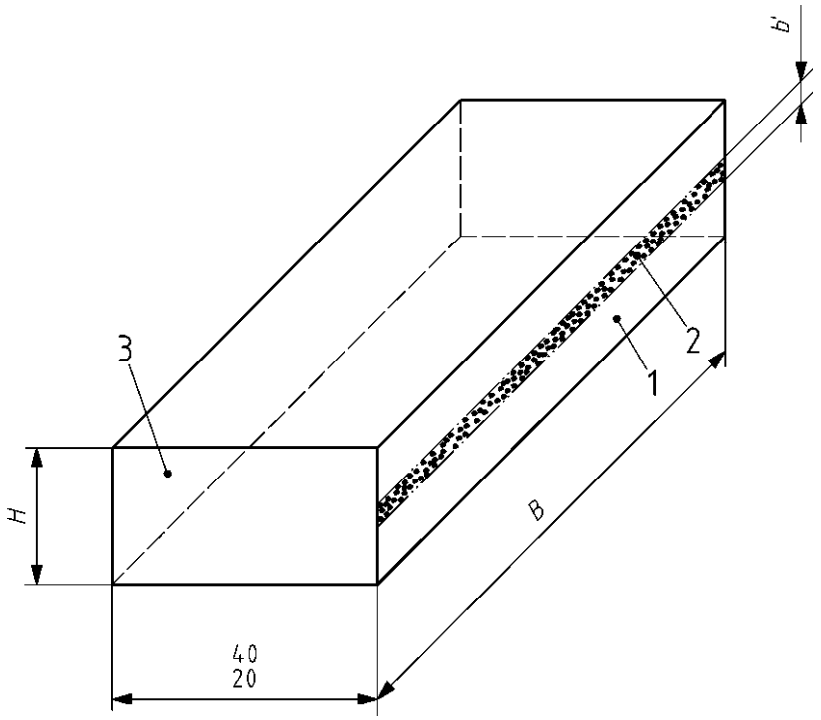
Dimensions in millimetres



Key
1 machined surface
2 microporosity line
D outside diameter
b' maximum width of porosity line

Figure A.2 — Procedure for hollow bars

Dimensions in millimetres



Key
1 machined surface
2 microporosity line
3 saw-cut surface
H thickness of panel
B width of panel
b' maximum width of porosity line

Figure A.3 — Procedure for panels/plates

Annex B
(normative)

Tables for the conversion of deflection values (straightness)

Table B.1 — Conversion of the deflection *f* measured on a reference length of 1 000 mm to lengths of 300 mm to 3 000 mm

Dimensions in millimetres

Deflection *f* measured on a reference length of 1 000 mm	Deflection converted to lengths of 300 mm to 3 000 mm											
	300	400	500	600	700	800	900	1 000	1 250	1 500	2 000	3 000
1,50	0,13	0,24	0,37	0,54	0,73	0,96	1,21	1,50	2,34	3,38	6,00	13,50
2,50	0,22	0,40	0,62	0,90	1,22	1,60	2,02	2,50	3,91	5,63	10,00	22,50
3,00	0,27	0,48	0,75	1,08	1,47	1,92	2,43	3,00	4,69	6,75	12,00	27,01
3,50	0,31	0,56	0,87	1,26	1,71	2,24	2,83	3,50	5,47	7,88	14,00	31,51
4,00	0,36	0,64	1,00	1,44	1,96	2,56	3,24	4,00	6,25	9,00	16,00	36,02
5,00	0,45	0,80	1,25	1,80	2,45	3,20	4,05	5,00	7,81	11,25	20,01	45,04
6,50	0,58	1,04	1,62	2,34	3,18	4,16	5,26	6,50	10,16	14,63	26,01	58,58
7,50	0,67	1,20	1,87	2,70	3,67	4,80	6,07	7,50	11,72	16,88	30,02	67,62
8,00	0,72	1,28	2,00	2,88	3,92	5,12	6,48	8,00	12,50	18,01	32,02	72,15
10,00	0,90	1,60	2,50	3,60	4,90	6,40	8,10	10,00	15,63	22,51	40,05	90,29
12,50	1,12	2,00	3,12	4,50	6,12	8,00	10,12	12,50	19,54	28,15	50,09	113,07
15,00	1,35	2,40	3,75	5,40	7,35	9,60	12,15	15,00	23,45	33,79	60,16	135,99
17,50	1,57	2,80	4,37	6,30	8,57	11,20	14,17	17,50	27,36	39,44	70,26	159,08
20,00	1,80	3,20	4,99	7,19	9,79	12,79	16,20	20,00	31,28	45,09	80,39	182,37

NOTE 1 The deflection *f* is the maximum distance between the straight 1 000 mm long measuring ruler and the concave side of the semi-finished product

NOTE 2 Conversion calculation is based on the assumption that the deflection line is a circular function ($R^2 = X^2 + Y^2$).

Table B.2 — Conversion of the deflection f measured on lengths of 300 mm to 3 000 mm to a reference length of 1000 mm

Dimensions in millimetres

300 ⇒ 1 000	400 ⇒ 1 000	500 ⇒ 1 000	600 ⇒ 1 000	700 ⇒ 1 000	800 ⇒ 1 000
0,15 ⇒ 1,67	0,25 ⇒ 1,56	0,40 ⇒ 1,60	0,55 ⇒ 1,53	0,75 ⇒ 1,53	1,00 ⇒ 1,56
0,25 ⇒ 2,78	0,40 ⇒ 2,50	0,60 ⇒ 2,40	0,90 ⇒ 2,50	1,20 ⇒ 2,45	1,60 ⇒ 2,50
0,35 ⇒ 3,89	0,55 ⇒ 3,44	0,85 ⇒ 3,40	1,20 ⇒ 3,33	1,60 ⇒ 3,27	2,20 ⇒ 3,44
0,45 ⇒ 5,00	0,70 ⇒ 4,38	1,10 ⇒ 4,40	1,60 ⇒ 4,44	2,25 ⇒ 4,59	3,00 ⇒ 4,69
0,55 ⇒ 6,11	0,90 ⇒ 5,63	1,40 ⇒ 5,60	2,00 ⇒ 5,56	2,80 ⇒ 5,71	3,75 ⇒ 5,86
0,65 ⇒ 7,22	1,10 ⇒ 6,88	1,75 ⇒ 7,00	2,50 ⇒ 6,95	3,50 ⇒ 7,14	4,50 ⇒ 7,03
0,75 ⇒ 8,34	1,30 ⇒ 8,13	2,00 ⇒ 8,00	3,00 ⇒ 8,33	4,00 ⇒ 8,16	5,25 ⇒ 8,20
0,85 ⇒ 9,45	1,50 ⇒ 9,38	2,30 ⇒ 9,20	3,50 ⇒ 9,72	4,50 ⇒ 9,19	6,00 ⇒ 9,38
1,00 ⇒ 11,12	1,75 ⇒ 10,94	2,75 ⇒ 11,00	4,00 ⇒ 11,11	5,50 ⇒ 11,23	7,00 ⇒ 10,94
1,20 ⇒ 13,34	2,10 ⇒ 13,13	3,25 ⇒ 13,01	4,75 ⇒ 13,20	6,50 ⇒ 13,27	8,50 ⇒ 13,28
1,40 ⇒ 15,57	2,50 ⇒ 15,64	3,75 ⇒ 15,01	5,50 ⇒ 15,29	7,50 ⇒ 15,31	10,00 ⇒ 15,63
1,60 ⇒ 17,80	2,90 ⇒ 18,15	4,50 ⇒ 18,02	6,50 ⇒ 18,07	9,00 ⇒ 18,38	11,50 ⇒ 17,98
1,90 ⇒ 21,15	3,40 ⇒ 21,28	5,25 ⇒ 21,03	7,50 ⇒ 20,86	10,50 ⇒ 21,45	13,50 ⇒ 21,11
2,20 ⇒ 24,50	3,80 ⇒ 23,80	6,00 ⇒ 24,04	8,50 ⇒ 23,64	11,50 ⇒ 23,50	15,00 ⇒ 23,46

Table B.2 *(continued)*

Dimensions in millimetres

900 ⇒ 1 000	1250 ⇒ 1 000	1500 ⇒ 1 000	2000 ⇒ 1 000	2500 ⇒ 1 000	3000 ⇒ 1 000
1,25 ⇒ 1,54	2,40 ⇒ 1,54	3,50 ⇒ 1,56	6,00 ⇒ 1,50	9,50 ⇒ 1,52	14,00 ⇒ 1,56
2,00 ⇒ 2,47	4,00 ⇒ 2,56	5,50 ⇒ 2,44	10,00 ⇒ 2,50	16,00 ⇒ 2,56	23,00 ⇒ 2,56
2,75 ⇒ 3,40	5,50 ⇒ 3,52	8,00 ⇒ 3,56	14,00 ⇒ 3,50	22,00 ⇒ 3,52	32,00 ⇒ 3,55
3,50 ⇒ 4,32	7,25 ⇒ 4,64	10,50 ⇒ 4,67	18,00 ⇒ 4,50	29,00 ⇒ 4,64	42,00 ⇒ 4,66
4,25 ⇒ 5,25	9,00 ⇒ 5,76	13,00 ⇒ 5,78	23,00 ⇒ 5,75	36,00 ⇒ 5,76	52,00 ⇒ 5,77
5,50 ⇒ 6,79	10,50 ⇒ 6,72	15,50 ⇒ 6,89	27,50 ⇒ 6,87	43,00 ⇒ 6,87	62,00 ⇒ 6,88
6,50 ⇒ 8,03	12,50 ⇒ 8,00	18,00 ⇒ 8,00	32,50 ⇒ 8,12	50,00 ⇒ 7,99	72,00 ⇒ 7,98
8,00 ⇒ 9,88	15,00 ⇒ 9,60	22,00 ⇒ 9,77	38,50 ⇒ 9,61	61,00 ⇒ 9,74	88,00 ⇒ 9,75
9,50 ⇒ 11,73	18,00 ⇒ 11,52	26,00 ⇒ 11,55	46,00 ⇒ 11,48	72,00 ⇒ 11,49	105,00 ⇒ 11,62
11,00 ⇒ 13,58	21,50 ⇒ 13,75	31,00 ⇒ 13,76	54,00 ⇒ 13,47	84,00 ⇒ 13,39	120,00 ⇒ 13,26
12,50 ⇒ 15,43	25,00 ⇒ 15,99	36,00 ⇒ 15,98	63,00 ⇒ 15,70	99,00 ⇒ 15,76	145,00 ⇒ 15,98
14,50 ⇒ 17,91	28,50 ⇒ 18,23	41,00 ⇒ 18,19	73,00 ⇒ 18,18	115,00 ⇒ 18,27	165,00 ⇒ 18,14
17,00 ⇒ 20,99	32,50 ⇒ 20,78	47,00 ⇒ 20,84	84,00 ⇒ 20,89	135,00 ⇒ 21,39	195,00 ⇒ 21,35
19,00 ⇒ 23,47	37,00 ⇒ 23,65	54,00 ⇒ 23,93	96,00 ⇒ 23,83	150,00 ⇒ 23,71	220,00 ⇒ 23,98

NOTE 1 The deflection f is the maximum distance between the straight 1 000 mm long measuring ruler and the concave side of the semi-finished product

NOTE 2 Conversion calculation is based on the assumption that the deflection line is a circular function ($R^2 = X^2 + Y^2$).

– **example 1:**

A rod (∅ 60 mm × 3 000 mm) made from fibre-reinforced PEEK is laid unconstrained on its side on a flat surface. By means of a straight, 1 000 mm long measuring ruler, the maximum deviation from the straight line over the full 3 000 mm rod length is measured: f = 3 mm. According to Column 1 of Table 3, this deviation is acceptable (≤ 5,0 mm).

If the maximum deviation from the straight line is measured on the same rod using a 500 mm or 2 000 mm long measuring ruler, then a deflection f of 0,75 mm or 12 mm would be found, as can be derived from Table B.1.

– example 2:

A panel (30 mm × 600 mm × 3 000 mm) made from PET is laid unconstrained on a flat surface with its crown side down. By means of a straight, 1 000 mm long measuring ruler, the maximum deviations from the straight line along different directions are measured (see Figures 4a), 4b) and 4c)).

The maximum deviation from the straight line over the full 3 000 mm panel length is: f_1 = 2 mm. According to Table 8, this deviation is acceptable (≤ 2,0 mm).

The maximum deviation from the straight line over the 600 mm panel width (measured at different positions over the 3 000 mm panel length) is f_2 = 2 mm. Using Table B.2, this value corresponds to a deflection of 5,56 mm over a reference length of 1 000 mm. According to Table 8, this deviation is not acceptable (> 3,5 mm)

Measured along the lengthwise edges of the panel, the maximum deviation from the straight line over the full 3 000 mm panel length is f_3 = 2 mm. According to Table 8, this deviation is acceptable (≤ 4,0 mm).

Annex C
(informative)

Examples of calculation of dimensional stability after heat treatment

C.1 Rods

Three test specimens of length (25 ± 0,1) mm are fabricated from a PET rod (Ø 120 mm) as described in 6.3.4.1. After being machined and having reached adequate temperature equilibrium in the standard atmosphere at (23 ± 2) °C, the length (l) and diameter (d) of each test specimen are measured to the nearest 0,01 mm – as described in 6.14.

The test specimens are then subjected to the heat treatment described in 6.14 in an oven with forced air circulation, using a test temperature of 160 °C (see Table 14).

Then, after temperature equilibrium has been reached for 12 h in the standard atmosphere at (23 ± 2) °C, the length (l) and diameter (d) of the test specimens are measured again to the nearest 0,01 mm and at the same positions as during the first measurements

Table C.1 — Calculation of dimensional stability for rods after heat treatment

Dimensions	Measured values of the different dimensions before and after heat treatment									Relative changes as average values of the three test specimens [a]
	Test specimen 1			Test specimen 2			Test specimen 3			
	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	%
$d1$	122,15	121,95	– 0,16	122,22	122,04	– 0,15	122,24	122,01	– 0,19	– 0,18
$d2$	122,35	122,10	– 0,20	122,01	121,78	– 0,19	121,95	121,74	– 0,17	
		$d_{average} \Rightarrow$	– 0,18		$d_{average} \Rightarrow$	– 0,17		$d_{average} \Rightarrow$	– 0,18	
l	25,05	24,80	– 1,00	25,10	24,82	– 1,12	24,94	24,67	– 0,18	1,07
			A			**B**			**C**	**D = (A+B+C)/3**

[a] These values shall be evaluated compared with the guideline values given in Table 11

C.2 Hollow bars

Three test specimens of length (25 ± 0,1 mm) are fabricated from a (∅ 180 mm × ∅ 140 mm) POM-C hollow bar as described in 6.3.4.1. After being machined and having reached adequate temperature equilibrium in the standard atmosphere at (23 ± 2) °C, the length (l) and outside diameter (D) of each test specimen are measured to the nearest 0,01 mm – as described in 6.14.

The test specimens are then subjected to the heat treatment described in 6.14 in an oven with forced air circulation, using a test temperature of 140 °C (see Table 14).

Then after temperature equilibrium has been reached for 12 h in the standard atmosphere at (23 ± 2) °C, the length (l) and outside diameter (D) of the three test specimens are measured again to the nearest 0,01 mm and at the same positions as during the first measurements

Table C.2 — Calculation of dimensional stability for hollow bars after heat treatment

Dimensions	Measured values of the different dimensions before and after heat treatment									Relative changes as average values of the three test specimens[a] %
	Test specimen 1			Test specimen 2			Test specimen 3			
	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	
D_1	183,80	183,69	– 0,06	183,75	183,62	– 0,07	183,68	183,60	– 0,04	– 0,05
D_2	183,35	183,27	– 0,04	183,40	183,30	– 0,05	183,28	183,21	– 0,04	
	$D_{average} \Rightarrow$		– 0,05	$D_{average} \Rightarrow$		– 0,06	$D_{average} \Rightarrow$		– 0,04	
l_1	25,10	25,02	– 0,32	24,94	24,85	– 0,36	25,05	24,98	– 0,28	– 0,31
l_2	25,08	25,01	– 0,28	24,96	24,88	– 0,32	25,03	24,95	– 0,32	
	$l_{average} \Rightarrow$		– 0,30	$l_{average} \Rightarrow$		– 0,34	$l_{average} \Rightarrow$		– 0,30	
			A			**B**			**C**	**D = (A+B+C)/3**

[a] These values shall be evaluated compared with the guideline values given in Table 11.

C.3 Panels/plates

Three rectangular test specimens (50 ± 0,2) mm × (60 ± 1) mm are fabricated – as described in 6.3.4.2 and shown in Figure 8 – from a 40 mm thick and 600 mm wide PA 66 panel. After being machined and having reached adequate temperature equilibrium in the standard atmosphere (23 ± 2) °C, width (b) and thickness (h) of each test specimen are measured to the nearest 0,01 mm – as described in 6.14.

The test specimens are then subjected to the heat treatment described in 6.14 in an oven with forced air circulation, using a test temperature of 180 °C (see Table 14).

Then, after temperature equilibrium has been reached for 12 h in the standard atmosphere at (23 ± 2) °C, the width (b) and thickness (h) of the three test specimens are measured again to the nearest 0,01 mm and at the same positions as during the first measurements

Table C.3 — Calculation of dimensional stability for panels/plates after heat treatment

Dimensions	Measured values of the different dimensions before and after heat treatment									Relative changes as average values of the three test specimens [a] %
	Test specimen 1			Test specimen 2			Test specimen 3			
	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	Before mm	After mm	Relative change %	
b	50,16	49,75	– 0,82	49,96	49,58	– 0,76	50,06	49,66	– 0,80	– 0,79
h	41,40	41,66	0,63	41,50	41,74	0,58	41,36	41,64	0,68	0,63
			A			**B**			**C**	**D = (A+B+C)/3**

[a] These values shall be evaluated compared with the guideline values given in Table 11.

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