
**Plastics — Polytetrafluoroethylene
(PTFE) semi-finished products —**

**Part 2:
Preparation of test specimens and
determination of properties**

Plastiques — Semi-produits en polytétrafluoroéthylène (PTFE) —

Partie 2: Préparation des éprouvettes et détermination des propriétés

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 9, *Thermoplastic materials*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 13000-2:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

- in [Clause 2](#), normative references have been updated;
- the former Figure 2 has been split into two figures ([Figures 2](#) and [3](#)) and subsequent figures have been renumbered;
- in [Figures 2](#) and [3](#), new dimensions (thickness $1,5 \pm 0,25$ and $1,0 \pm 0,20$) have been added;
- in [Clause 6](#):
 - [Table 1](#) has been edited to compliment [Figures 2](#) and [3](#);
 - a new [Table 2](#) has been added to compliment [Figure 4](#);
- former Annex A has been changed to Bibliography, and titles for standards have been corrected.

A list of all parts in the ISO 13000 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Plastics — Polytetrafluoroethylene (PTFE) semi-finished products —

Part 2:

Preparation of test specimens and determination of properties

WARNING — Persons using this document should be familiar with normal laboratory practice, if applicable. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory requirements prior to use.

1 Scope

This document specifies the preparation of test specimens and gives the test methods applicable to semi-finished products of polytetrafluoroethylene (PTFE).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 472, *Plastics — Vocabulary*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 527-3, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*

ISO 1923, *Cellular plastics and rubbers — Determination of linear dimensions*

ISO 2039-1, *Plastics — Determination of hardness — Part 1: Ball indentation method*

ISO 3611, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

ISO 22088-3, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 3: Bent strip method*

ISO 22088-4, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 4: Ball or pin impression method*

ISO 13000-1, *Plastics — Polytetrafluoroethylene (PTFE) semi-finished products — Part 1: Requirements and designation*

IEC 60243-1:2013, *Electrical strength of insulating materials — Test methods — Part 1: Tests at power frequencies*

IEC 60243-2, *Electric strength of insulating materials — Test methods — Part 2: Additional requirements for tests using direct voltage*

CIE 1931 *standard colorimetric system*

CIE 1964 *standard colorimetric system*

CIE PUBLICATION No 15, *Colorimetry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and ISO 13000-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Sampling

Details of procedures for sampling semi-finished products depend to a large extent on the physical shape of the particular material. Whenever feasible, the materials shall be sampled. Sampling shall be statistically adequate to satisfy the requirements of the test method concerned.

5 Preparation of test specimens

The specimens used for testing shall be taken directly from or shall be machined from the semi-finished product without other treatment. Thus, conversion of a semi-finished product into a test specimen by any moulding procedure is not permitted. In some instances, special procedures are required that are described either in the general discussion or in the method.

6 Testing of semi-finished PTFE products

6.1 General

Properties required for specification purposes shall be determined in accordance with the procedures given in this document. For the determination of density, tensile properties, hardness and electrical properties, condition the test specimens at $23\text{ °C} \pm 2\text{ °C}$ for a period of at least 4 h prior to test. The other tests require no conditioning.

6.2 Linear dimensions

These shall be determined by the procedures provided in ISO 1923 for cellular plastics.

6.3 Tensile properties

6.3.1 Tensile specimens

6.3.1.1 General

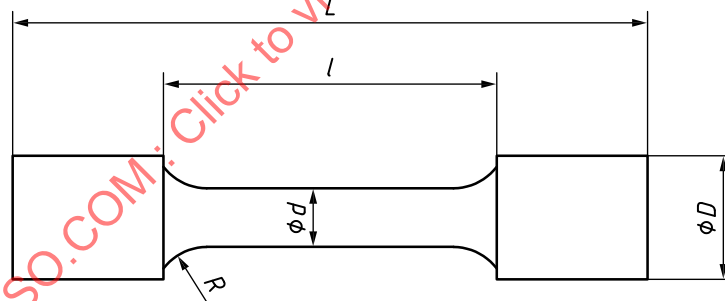
The appropriate type of test specimen shall be chosen from those given in 6.3.1.2 to 6.3.1.5. At least three test specimens shall be prepared from the sample and three specimens shall be tested.

NOTE Test specimens prepared from moulded basic shapes, rods or tubes conforming to 6.3.1.2 are likely to give results similar to those obtained with test specimens prepared from the same product but conforming to 6.3.1.3.

When testing extruded products, the test specimens shall be cut parallel to the axis of extrusion so that, as far as possible, each test specimen represents a different section along the axis and a different area of the cross-section. When testing skived tape, skived sheet or skived film, the test specimens shall be cut perpendicular to the direction in which the pressure was applied when moulding the billet from which the product was skived. If this direction is not known, two sets of test specimens shall be prepared and tested, the test specimens in one set being cut at 90° to those in the other set and the mean result shall be calculated from the higher set of values (indicating, typically, the direction perpendicular to the axis of applied pressure). This procedure ensures a uniform way of reporting test results. The micro-tensile test specimen (see 6.3.1.3) is used most commonly for PTFE products.

6.3.1.2 Turned dumb-bell test specimens

The test specimens shall be turned so that their dimensions are in the ratios given in Figure 1, and so that the shape is as shown in Figure 1. The value of the larger diameter (D) shall be 7 mm ± 0,5 mm, 10 mm ± 0,5 mm or 20 mm ± 0,5 mm.



Key

Ratios of dimensions of turned dumb-bell specimens:

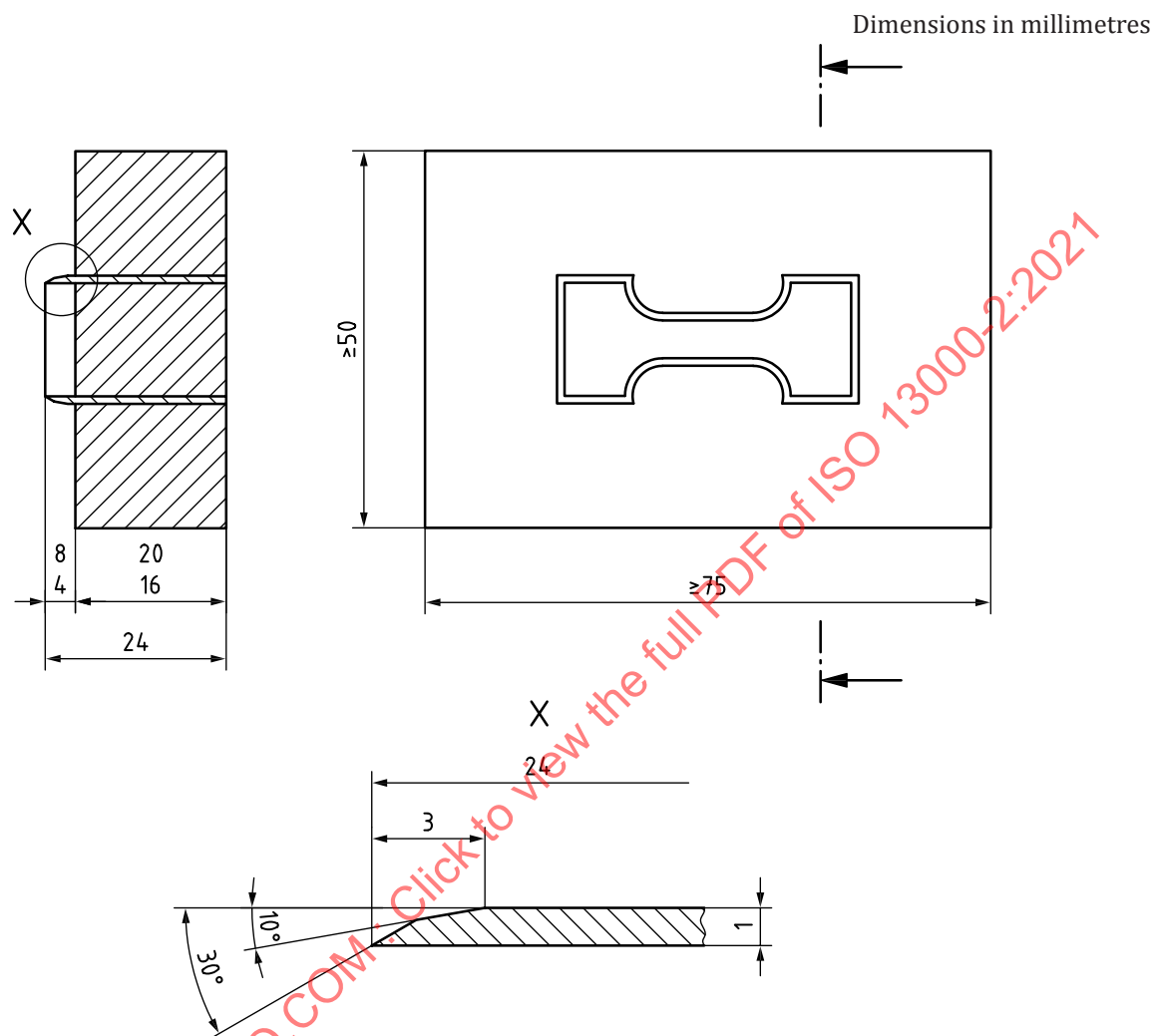
d	0,45 D to 0,55 D
L	5 D to 6 D
l	3 D to 3,5 D
R	0,2 D to 0,3 D

Figure 1 — Turned dumb-bell specimen

6.3.1.3 Micro-tensile (small punched dumb-bell) test specimens

The sample shall be machined to produce a sheet or disc of thickness 1,5 mm to 2,5 mm, or turned to produce a rectangular-section ring which can be cut and flattened to give such a sheet. Test specimens conforming to the shape shown in Figures 2 and 3 and the dimensions given in Table 1 for micro-tensile specimens shall be punched from a sheet or disc using a single-stroke press and the appropriate knife-edged die. In any one test specimen, the thickness of the narrow, parallel-sided portion shall nowhere deviate by more than 2 % from the mean. The sheet shall be supported, while the test specimens are

punched from it, on a slightly yielding material having a smooth surface (e.g. leather, rubber or high-quality cardboard) on a flat, rigid base. The cutting edge of the die shall be sharp and free from notches or other visual defects. In the case of thin sheet or skived tape of thickness from 0,125 mm to 3,0 mm, the test specimens shall be punched from the material “as-received”.



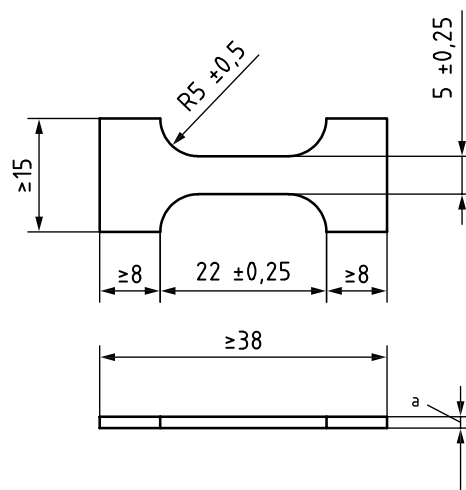
Inside dimensions of die are same as those of test specimen.

Rockwell C hardness of die: 45 to 50.

Die to be sharpened on outside of knife-edge only.

Figure 2 — Knife-edged die for micro-tensile (type A) specimens, and punched-out specimen — Steel-rule die

Dimensions in millimetres

**Key**

a Possible thicknesses:

- 1,5 ± 0,25
- 1,0 ± 0,20
- 0,8 ± 0,15
- 0,5 ± 0,1
- 0,125 ± 0,03

Figure 3 — Knife-edged die for micro-tensile (type A) specimens, and punched-out specimen — Micro-tensile specimen

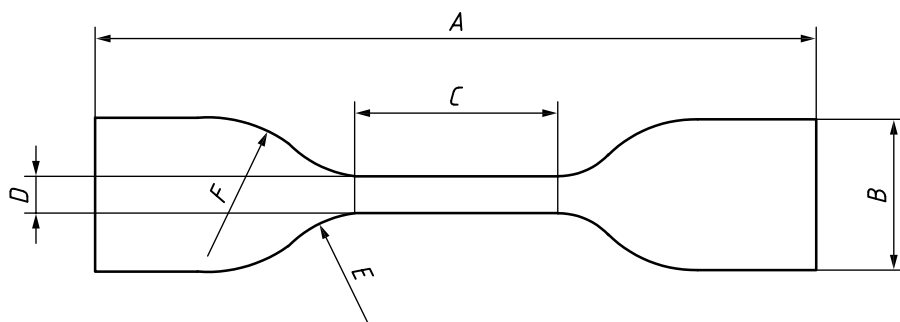
Table 1 — Dimensions of micro-tensile specimen

	Micro-tensile specimen (see Figures 2 and 3)
	mm
A Overall length, minimum	38
B Width at ends, minimum	15
C Length of narrow, parallel-sided portion	12 ± 0,5
D Width of narrow, parallel-sided portion	5 ± 0,25
E Small radius	5 ± 0,5
F Large radius	n.a.

6.3.1.4 Test specimens prepared from thin or narrow tape and from small-diameter tubing of less than 7,0 mm ID

When testing tape of less than 0,1 mm in thickness that has a width W 25 mm, the test specimens shall be parallel-sided strips 25 mm wide and of an appropriate length to suit the test machine grips. Alternatively, test specimens conforming to the shape shown in [Figure 4](#) and the dimensions given in [Table 2](#) for large dumb-bells shall be punched from the tape by the method described in [6.3.1.3](#). In any one test specimen, the thickness of the narrow, parallel-sided portion shall nowhere deviate by more than 2 % from the mean.

In the case of tape of less than 25 mm in width, the full width shall be tested. Tubing of less than 7 mm OD shall be tested as manufactured, unmachined, without slitting the tube and then flattening it.

**Key**

<i>A</i>	overall length, minimum:	115 mm
<i>B</i>	width at ends, minimum:	25 mm ± 1 mm
<i>C</i>	length of narrow, parallel-sided portion:	33 mm ± 2 mm
<i>D</i>	width of narrow, parallel-sided portion:	6 mm ± 0,4 mm
<i>E</i>	small radius:	14 mm ± 1 mm
<i>F</i>	large radius:	25 mm ± 2 mm

Figure 4 — Punched large dumb-bell (type B) specimen**Table 2 — Dimensions of large dumb-bell test specimen**

	Large dumb-bell specimen (see Figure 4) mm
<i>A</i> Overall length, minimum	115
<i>B</i> Width at ends, minimum	25 ± 1
<i>C</i> Length of narrow, parallel-sided portion	33 ± 2
<i>D</i> Width of narrow, parallel-sided portion	6 ± 0,4
<i>E</i> Small radius	14 ± 1
<i>F</i> Large radius	25 ± 2

6.3.1.5 Test specimens prepared from small-diameter rod

When testing rod of not more than 7 mm in diameter, the test specimens shall consist of 100 mm lengths cut from the rod either “as received” or with a reduction in diameter of up to 15 % over a test length of 25 mm to 30 mm. This reduction in diameter will facilitate gripping the specimen in the test machine without breakage occurring within the grips.

6.3.1.6 Marking of test specimens

Before marking test specimens of the types specified in [6.3.1.2](#), [6.3.1.3](#) or [6.3.1.5](#), any machining or punch marks can be removed by sanding lightly with fine abrasive paper.

Mark each test specimen with two reference marks 10 mm to 25 mm apart (15 mm to 20 mm for small dumb-bell test specimens) and approximately equidistant from the midpoint, taking care to avoid damaging the specimen. Ensure that the marking medium has no detrimental effect on the material being tested and that the marks are as narrow as possible. Do not scratch, punch or impress the lines upon the specimen.

6.3.2 Procedure

Determine the tensile properties in accordance with the procedures described in ISO 527-2 and ISO 527-3 except that the specimens used shall be as detailed in 6.3.1. The initial jaw separation for the types described in 6.3.1.4 and 6.3.1.5 shall be at least twice the gauge length of 10 mm to 25 mm, and the speed of testing shall be 50 mm/min $\pm$ 5 mm/min.

Clamp the specimens with an essentially equal length in each jaw. If using a chart recorder, measure the elongation at break from the chart by drawing a perpendicular line from the break point to the time axis and measuring the distance along the time axis from the foot of this perpendicular line to the beginning of the load-time curve. Alternatively, the elongation at break can be measured by visual means, holding a ruler against the reference marks and noting the elongation at the break point. Optionally, an extensometer can be used to determine the elongation.

Calculate the elongation at break for each specimen by dividing the maximum elongation of the gauge length recorded during the test by the original gauge length. If the cross-head rate and the chart rate are not the same, provide the correct magnification ratio for calculations involving the time axis.

Calculate the tensile strength of each test specimen by dividing the maximum force (in newtons) recorded during the test by the original mean cross-sectional area (in square millimetres) of the test specimens. Report the tensile strength in megapascals.

6.4 Density

Cut two specimens from the semi-finished product and determine the density in accordance with the appropriate part of ISO 1183. If ISO 1183-2 is used, the liquid system used shall have a density gradient appropriate for the fluoropolymer being tested (see ISO 1183-2:2019, Table A.1). It is acceptable to use newly available equipment that uses special balances with a specific programme that gives the value of the density directly (taking into account the density of water, its temperature and the temperature of the test specimen).

NOTE Problems caused by the effect of temperature on the density of PTFE can be minimized when the measurement is made using the immersion procedure (ISO 1183-1:2019, method A) if a sensitive thermometer (e.g. one reading to $\pm 0,1$ °C) is used in the liquid, the temperature is adjusted to at least 22 °C but not over 25 °C, and the density is corrected to 23 °C using the relationship shown as [Formula \(1\)](#):

$$\rho_c = \rho_m + (T_m - 23) \times 0,000\,52 \quad (1)$$

where

ρ_c is the density corrected to 23 °C;

ρ_m is the measured density;

T_m is the temperature at which the measurement was made.

6.5 Loss in mass at 300 °C

Weigh, to the nearest 1 mg, 10 g of the semi-finished product. Heat the weighed test sample for 6 h in an air oven at a temperature of 300 °C $\pm$ 5 °C. Cool the test sample in a desiccator and reweigh.

Report any loss in mass as a percentage of the original mass. Examine the test sample after heating and report any sign of melting.

6.6 Dimensional stability — General method

6.6.1 Apparatus

6.6.1.1 Micrometer, in conformance with ISO 3611 except that the measuring faces shall be hemispherical.

6.6.1.2 Oven, capable of being maintained at $285\text{ °C} \pm 5\text{ °C}$.

6.6.2 Test specimen

From the sample, machine a test specimen which is, as much as possible, within the range 25 mm to 100 mm and which has a thickness and width or diameter, as appropriate, within the range 5 mm to 25 mm. The faces at each end of the test specimen shall be parallel to within 0,25 mm. Whenever possible, the test specimen shall be cut so the length is parallel to the direction of the moulding pressure or to the axis of extrusion.

If it is not possible to prepare a test specimen of at least 25 mm length, the test can be carried out using a shorter test specimen, but a commensurate adjustment shall apply to the requirements for precision of measurement.

For rods less than 5 mm in diameter, cut a test specimen 50 mm to 100 mm in length and machine the faces at each end so that they are flat and at right angles to the axis.

6.6.3 Procedure

Condition the test specimen at $23\text{ °C} \pm 2\text{ °C}$ for at least 4 h and, while it is maintained at that temperature, measure its length to $\pm 0,025\text{ mm}$ using a micrometer.

Place the test specimen in an oven, maintained at $285\text{ °C} \pm 5\text{ °C}$, for a period of at least 4 h. At the end of this period allow the test specimen to cool at a rate not exceeding 30 °C/h . When cooled, recondition the test specimen at $23\text{ °C} \pm 2\text{ °C}$ for at least 4 h and measure its length at several points to $\pm 0,025\text{ mm}$.

NOTE If the test specimen is thin in proportion to its length, for example if it is a rod less than 5 mm in diameter, it is probable for some degree of bending to occur both before and during the stress-relieving process. If bending occurs, the test specimen can be straightened while carrying out the measurement.

6.6.4 Expression of results

Report the maximum change in length as a percentage of the original length.

6.7 Dimensional stability — Special method for the determination of the dimensional and the geometrical stability of thick-walled tubes

6.7.1 Apparatus

6.7.1.1 Micrometer, in conformance with ISO 3611.

6.7.1.2 Oven, capable of being maintained at $285\text{ °C} \pm 5\text{ °C}$.

6.7.2 Test specimen

Machine the outside surface of an approximately 30 mm length of the tube, taking care to remove only the minimum material necessary to “clean up” the specimen and produce a circular cross-section accurate to $\pm 0,025\text{ mm}$.