
**Thermoplastics pipes —
Determination of tensile properties —
Part 1:
General test method**

*Tubes en matières thermoplastiques — Détermination des
caractéristiques en traction —*

Partie 1: Méthode générale d'essai





COPYRIGHT PROTECTED DOCUMENT

© ISO 2015

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative reference	1
3 Terms and definitions	1
3.1 Geometric definitions.....	1
3.2 Definitions related to material characteristics.....	3
4 Principle	3
5 Apparatus	3
6 Test Pieces	4
6.1 Type of the test piece.....	4
6.2 Preparation of test pieces.....	4
6.2.1 Sampling from the pipe.....	4
6.2.2 Selection of test pieces.....	5
6.3 Checking test pieces.....	6
7 Conditioning	6
8 Test speed	6
9 Procedure	6
10 Expression of results	7
10.1 Stress at yield.....	7
10.2 Elongation at break.....	7
10.3 Statistical parameters.....	7
10.4 Retests.....	7
11 Test report	8
Bibliography	9

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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 138, *Plastics pipes, fittings, and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings, and valves of plastic materials and their accessories — Test methods and basic specifications*.

This second edition cancels and replaces the first edition (ISO 6259-1:1997), which has been technically revised.

ISO 6259 consists of the following parts, under the general title *Thermoplastics pipes — Determination of tensile properties*:

- *Part 1: General test method*
- *Part 2: Pipes made of unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly (vinyl chloride) (PVC-C), and high-impact poly (vinyl chloride) (PVC-HI)*
- *Part 3: Polyolefin pipes*

Introduction

This part of ISO 6259 specifies a short-term tensile test method for determining the tensile properties of thermoplastics pipes.

It can provide data for further testing for the purpose of research and development.

It cannot be regarded as significant for applications in which the conditions of application of the force differ considerably with those in this test method, such as applications requiring the appropriate impact, creep, and fatigue tests.

The tests of tensile properties are intended to be principally regarded as tests of material in the form of pipe. The results can be useful as a material process control test but are not a quantitative assessment of long-term pipe performance.

ISO 6259 has been drawn up on the basis of ISO 527.^{[1][2]}

For ease of use, it has been thought preferable to draw up a complete document that can be used for determining the tensile properties of thermoplastics pipes. For greater detail, reference can be made to ISO 527.^{[1][2]}

However, let it be noted that ISO 527^{[1][2]} is applicable to materials in sheet form, whereas ISO 6259 is applicable to materials in pipe form.

As it was considered essential to test the pipes as supplied, i.e. without reduction in thickness, difficulties are those in the choice of test piece.

ISO 527^{[1][2]} specifies test pieces a few millimetres thick, whereas the thickness of a pipe can be in excess of 50 mm. This is why certain changes have been made on this point.

For thin-walled pipes, the test piece can be obtained by die cutting, while for thick pipes, it can be obtained only by machining.

At present, ISO 6259 comprises three parts. The first part gives the general conditions under which the tensile properties of thermoplastics pipes are to be determined. The other two parts provide, respectively, particular information on the execution of tests on pipe made from different materials (see the Foreword).

The basic specifications for the various materials are given in informative annexes in the relevant parts.

.....

Thermoplastics pipes — Determination of tensile properties —

Part 1: General test method

1 Scope

The ISO 6259 series specifies a method of determining the tensile properties of thermoplastics pipes, including the following properties:

- stress at yield;
- elongation at break.

This part of ISO 6259 is applicable to all types of thermoplastics pipe, regardless of their intended use.

2 Normative reference

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

ISO 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 6259-2:1997, *Thermoplastics pipes — Determination of tensile properties — Part 2: Pipes made of unplasticized poly(vinyl chloride) (PVC-U), chlorinated poly(vinyl chloride) (PVC-C) and high-impact poly(vinyl chloride) (PVC-HI)*

ISO 6259-3:2015, *Thermoplastics pipes — Determination of tensile properties — Part 3: Polyolefin pipes*

3 Terms and definitions

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

3.1 Geometric definitions

3.1.1

gauge length at break

L

distance between the gauge marks on the central part of the test specimen at break

Note 1 to entry: It is expressed in millimetres (mm).

3.1.2
initial cross-section

A

product of initial width and thickness of a test specimen (i.e. $A = bh$)

Note 1 to entry: It is expressed in square millimetres (mm²).

3.1.3
initial gauge length

L₀

initial distance between the gauge marks on the central part of the test specimen

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: The values of the gauge length that are indicated for the specimen types in the different parts of ISO 527[1][2] represent the relevant maximum gauge length.

3.1.4
nominal outside diameter

d_n

specified outside diameter, assigned to a nominal size DN/OD

Note 1 to entry: It is expressed in millimetres (mm).

3.1.5
nominal size
DN/OD

numerical designation of the size of a component, other than a component designated by thread size, which is a convenient round number, approximately equal to the manufacturing dimension, related to the outside diameter

Note 1 to entry: It is expressed in millimetres (mm).

3.1.6
nominal wall thickness

e_n

numerical designation of the wall thickness of a component, which is a convenient round number, approximately equal to the manufacturing dimension

Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: For thermoplastics components, the value of the nominal wall thickness, e_n , is identical to the specified minimum wall thickness at any point, e_{min} .

3.1.7
thickness

h

smaller initial dimension of the rectangular cross section in the central part of a test specimen

Note 1 to entry: It is expressed in millimetres (mm).

3.1.8
width

b

larger initial dimension of the rectangular cross section in the central part of a test specimen

Note 1 to entry: It is expressed in millimetres (mm).

3.2 Definitions related to material characteristics

3.2.1

elongation at break

ε_b

calculated from the gauge length at break

Note 1 to entry: It is expressed as a percentage (%).

3.2.2

force at yield

F

force measured at yield

Note 1 to entry: It is expressed in Newtons (N).

3.2.3

stress at yield

σ_y

stress measured at the yield strain

Note 1 to entry: It is expressed in megapascals (MPa).

3.2.4

yield

transition from elastic to plastic deformation usually characterised by a decrease or shoulder in the stress-strain curve

4 Principle

Test pieces of given shape and dimensions are obtained from a thermoplastics pipe, in the longitudinal direction, by cutting or machining.

The tensile properties are measured using a test machine under specified conditions.

5 Apparatus

5.1 Tensile-testing machine, complying with ISO 5893 and meeting the specifications given in [5.2](#), [5.3](#), and [5.4](#).

NOTE The use of computer-controlled machines in accordance with ISO 527-1:2012^[1] is an option.

5.2 Grips, for holding the test piece and attached to the machine so that the major axis of the test piece coincides with the direction of pull through the centreline of the assembly. This can be achieved, for example, by using pins in the grips to centre.

The test piece shall be held such that slip relative to the grips is prevented as far as possible and this shall be carried out with the type of grip that maintains or increases pressure on the test piece as the force applied to the test piece increases.

The clamping system shall not cause premature fracture of the test piece at the grips.

It might be necessary to pre-stress the test specimen to obtain correct alignment and specimen seating and to avoid any irregularity at the start of the stress/strain diagram.

5.3 Load indicator, incorporating a mechanism capable of showing the total tensile load carried by the test piece when held by the grips. The mechanism shall be essentially free from inertia lag at the specified rate of testing and shall indicate the load with an accuracy of within 1 % of the actual value. Attention is drawn to ISO 5893 and to ISO 7500-1^[4].

5.4 Extensometer, suitable for determining the gauge length of the test piece at any moment during the test.

The instrument shall be essentially free from inertia lag at the specified test speeds and shall be capable of measuring deformation to an accuracy of within 1 %. When a mechanical extensometer is used, this shall be fixed to the test piece in such a way that the test piece does not undergo any damage and distortion and no slip occurs between it and the extensometer.

The measurement of elongation of the test piece on the basis of the movement of the grips lacks accuracy and shall be avoided whenever possible.

NOTE It is desirable, but not essential, for this instrument to record this length, or any variation in it, automatically as a function of the stress in the test piece.

5.5 Micrometer or equivalent, capable of reading to 0,01 mm or less and suitable for measuring the thickness and width of the test piece.

5.6 Cutting die, conforming to the relevant profile in ISO 6259-2:1997 or ISO 6259-3:2015, as applicable.

5.7 Milling machine and cutter, capable of producing the test piece specified in ISO 6259-2:1997 or ISO 6259-3:2015, as applicable.

6 Test Pieces

6.1 Type of the test piece

The test pieces shall conform to the relevant type specified in ISO 6259-2:1997 or ISO 6259-3:2015 or the relevant product standard, as applicable.

6.2 Preparation of test pieces

6.2.1 Sampling from the pipe

Take sections of pipe of the appropriate length according to the type of test piece to be used.

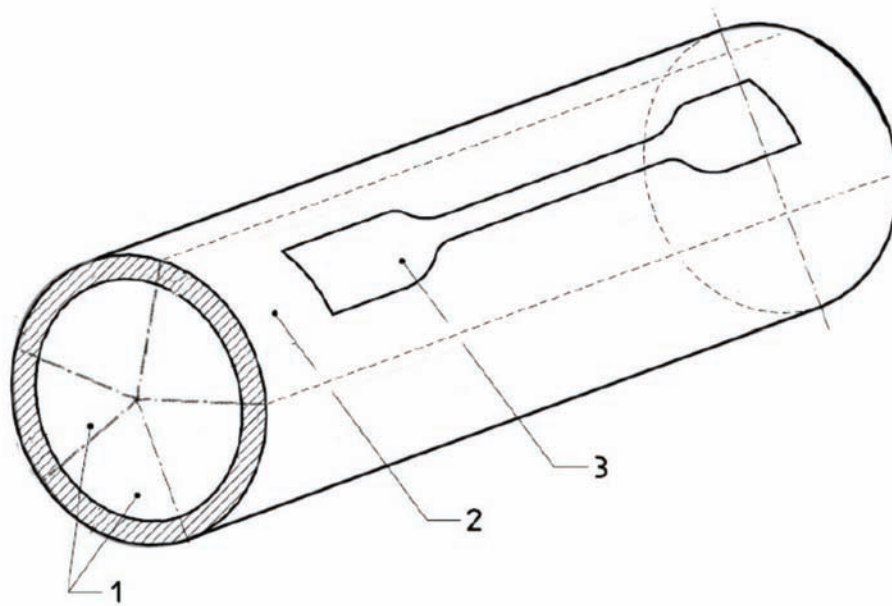
Cut strips from the pipe section as supplied, i.e. which has not been heated or flattened, so that their axes are parallel to the axis of the pipe. Small diameter pipes might need to be cut and opened to allow the strips to be cut.

Cut strips from the pipe section in such a way that they are equally distributed around the circumference of the pipe as shown in [Figure 1](#), starting from a reference line drawn along the pipe. Cut out one test piece per strip.

The minimum number of test pieces is given in [Table 1](#). When it is not possible to obtain the required number of strips from around the circumference of one pipe section, additional strips shall be taken from another section of the pipe.

Table 1 — Minimum number of test pieces

Nominal outside diameter, d_n mm	$15 < d_n \leq 32$	$32 < d_n \leq 63$	>63
Number of strips	2	3	5



Key

- 1 sectors
- 2 strip
- 3 test piece

Figure 1 — Preparation of test pieces

6.2.2 Selection of test pieces

6.2.2.1 Selection

Select the test pieces from the centre of the strips taken from the length of pipe either by die cutting or machining, in accordance with ISO 6259-2:1997 or ISO 6259-3:2015 or relevant product standard, or in accordance with the appropriate product standard for the pipe material.

6.2.2.2 Cutting method

Use the cutting die (5.6) with clean cutting edges, free from notches, with the profile shown in ISO 6259-2:1997 or ISO 6259-3:2015, as applicable.

Cut the test piece from the strip (see 6.2.1).

Care should be taken when using die cutting to avoid damaging the test piece or producing non-parallel sides.

6.2.2.3 Machining method

Produce the specimen by milling, where necessary, using a milling jig.

The shape of the milling cutter and the machining conditions (speed of rotation and advance) are at the discretion of the operator. They shall, however, be chosen so as to avoid excessive heating of the test piece and deterioration of its surface such as cracks, scratches, or other visible flaws.

For the machining procedure, it is recommended that the user consult ISO 2818[3].

6.2.2.4 Gauge marks

These shall be approximately equidistant from the mid-point, and the distance between the marks shall be measured to an accuracy of 1 % or better.

Gauge marks shall not be scratched, punched, or impressed upon the test piece in any way that can damage the material being tested. It shall be ensured that the marking medium has no detrimental effect on the material being tested and that, in the case of parallel lines, they are as narrow as possible.

6.2.2.5 Number of test pieces

Carry out the test on the number of test pieces as shown in [Table 1](#) according to diameter unless specified otherwise by the referring standard.

6.3 Checking test pieces

The surfaces and edges should be free of scratches or pits, checked by visual observation before testing.

7 Conditioning

The test pieces shall not be tested within a period of 15 h after the production of the pipes, except for manufacturing checks.

Unless specified otherwise in the relevant product standard, conditioning shall be carried out as specified below.

Prior to testing, condition the test pieces in air at a temperature of (23 ± 2) °C for a period of not less than the time specified in Table 1 of ISO 1167-1:2006, according to the thickness of the test piece.

Polymers sensitive to humidity, for example, polyamide, shall be conditioned at a humidity of (50 ± 10) %.

NOTE For polymers sensitive to humidity, reaching equilibrium can take a long time for thicker samples.

8 Test speed

The test speed depends on the constituent material and wall thickness of the pipe and shall be as specified in the applicable product standard or in ISO 6259-2:1997 or ISO 6259-3:2015.

9 Procedure

9.1 Carry out the following procedure at a temperature of (23 ± 2) °C.

9.2 Measure, to within 0,01 mm, the width and minimum thickness of the central part of the test piece between the gauge marks. Calculate the minimum cross-sectional area.

9.3 Place the test piece in the tensile-testing machine ([5.1](#)) in such a way that the axis of the test piece coincides more or less with the direction of the tensile force. Clamp the grips ([5.2](#)) uniformly and tightly to avoid any slippage of the test piece.

9.4 When using an extensometer ([5.4](#)), monitor the gauge length (the part between the gauge marks) of the test piece.

9.5 Apply a pre-stress when necessary. Start the test at the specified test speed.

9.6 Record the stress/strain curve up to the rupture of the test piece and record on this curve the force at the yield point and the gauge length at rupture, or note directly the value of the force at yield and the gauge length after rupture.

Discard any test pieces which slip in the grips, those which break at one of the shoulders and those which deform, thus changing the width of the shoulders, and retest an identical number of test pieces.

10 Expression of results

10.1 Stress at yield

Calculate, for each test piece, the tensile stress at yield on the basis of the initial cross-sectional area of the test piece, using Formula (1):

$$\sigma_y = \frac{F}{A} \quad (1)$$

where

σ_y is the tensile stress at yield, expressed in megapascals (MPa) (1 MPa = 1 N/mm²);

F is the force at yield, expressed in Newtons (N);

A is the initial cross-sectional area of the test piece, expressed in square millimetres (mm²).

Express the result to three significant figures.

The yield stress should, in fact, be calculated using the cross-sectional area of the test piece at yield, but for reasons of convenience, the initial cross-sectional area is used.

10.2 Elongation at break

Calculate, for each test piece, the elongation at break, using Formula (2):

$$\varepsilon_b = \frac{L - L_0}{L_0} \times 100 \quad (2)$$

where

ε_b is the elongation at break, expressed as a percentage (%);

L is the gauge length at break, expressed in millimetres (mm);

L_0 is the initial gauge length of the test piece, expressed in millimetres (mm).

Express the result to three significant figures.

10.3 Statistical parameters

The standard deviations and the 95 % confidence intervals of the mean values can be calculated by the procedure given in ISO 2602, if required.

10.4 Retests

If a significant deviation in result is obtained for one or more test pieces, the result(s) may be discarded provided that the tests are repeated on twice that number of test pieces.

11 Test report

The test report shall include the following information:

- a) a reference to the relevant part of ISO 6259 (i.e. ISO 6259-1);
- b) all details necessary for complete identification of the pipe tested, including the constituent material, type, origin, nominal dimensions, etc.;
- c) the type of test piece used and the method by which it was prepared;
- d) the climatic conditions in the laboratory, the method of conditioning of the test pieces, and the conditioning time;
- e) the number of test pieces tested;
- f) the test speed;
- g) the stress at yield (individual values, arithmetic mean, and standard deviation);
- h) the elongation at break (individual values, arithmetic mean, and standard deviation);
- i) details of any operation not specified in this part of ISO 6259, as well as any incident likely to have had an effect on the results, and in particular, any special features (such as foreign bodies) observed on the test pieces or in the cross-section of rupture;
- j) the date of the test.

Bibliography

- [1] ISO 527-1:2012, *Plastics — Determination of tensile properties — Part 1: General principles*
- [2] ISO 527-2:2012, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*
- [3] ISO 2818:1994, *Plastics — Preparation of test specimens by machining*
- [4] ISO 7500-1:2004, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

