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Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes

Tubes en polyoléfines pour le transport des fluides — Détermination de la résistance à la propagation de la fissure — Méthode d'essai de la propagation lente de la fissure d'un tube entaillé (essai d'entaille)

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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 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,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 155, *Plastics piping systems and ducting systems,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 13479:2009), which has been technically revised.

The main changes are as follows:

— warnings have been added to follow the method of test piece preparation and the test procedure because of the influence on the result;

— a maximum notch radius has been specified;

— in case of premature failure, alternative test pressures and times for PE 80 and PE 100 have been added to allow retesting at a lower pressure for a longer time;

— an accelerated method by testing with an external detergent has been added.

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.

Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes

1 Scope

This document specifies a test method for determining the resistance to slow crack growth of polyolefin pipes, expressed in terms of time to failure in a hydrostatic pressure test on a pipe with machined longitudinal notches in the outside surface. The test is applicable to pipes of wall thickness greater than 5 mm.

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 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

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

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 11922-1, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 15510, *Stainless steels — Chemical composition*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 161-1 and ISO 11922-1 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms related to geometrical dimensions

3.1.1
nominal outside diameter
d_n
specified outside diameter assigned to a nominal size DN/OD

Note 1 to entry: Nominal outside diameter is expressed in millimetres.

3.1.2
mean outside diameter
d_{em}
value of the measurement of the outer circumference of the pipe or spigot end of a fitting in any cross-section divided by π (= 3,142), rounded to the next greater 0,1 mm

3.1.3
minimum wall thickness
e_{min}
minimum value for the wall thickness at any point around the circumference of a component, as specified

3.1.4
standard dimension ratio
SDR
numerical designation of a pipe series, which is a convenient round number, approximately equal to the dimension ratio of the nominal outside diameter, d_n, and the nominal wall thickness, e_n

3.1.5
pipe series
number for pipe designation

Note 1 to entry: Pipe series values are defined according to ISO 4065.

Note 2 to entry: The relationship between the pipe series, S, and the standard dimension ratio, SDR, is given in ISO 4065 as follows.

$$S = \frac{SDR - 1}{2}$$

3.1.6
ligament thickness

δ_{lg}
value of the measurement or calculation of the remaining ligament after machining of the notch

3.1.7
notch depth
h
value of the depth of the notch after machining, measured or calculated

3.1.8
notch length
l_n
value of the length of the notch

3.1.9
width of machined surface of notch
b_s
value of the width of the machined surface of the notch

3.2 Terms related to machining of notches

3.2.1
climb milling
milling in which the cutting motion of the tool is in the same direction as the feeding direction of the component being milled

Note 1 to entry: This is also referred to as 'down milling'.

3.2.2
revolution of the cutter
r
value used as a basis for the cutting rate

4 Symbols and abbreviation

4.1 Symbols

For the purposes of this document, the following symbols apply.

b_s width of machined surface of the notch

d_{em} mean outside diameter

d_n nominal outside diameter

e wall thickness (at any point) of a pipe

e_m mean wall thickness

e_{max} maximum wall thickness (at any point) of a pipe

e_{min} minimum wall thickness (at any point) of a pipe

h notch depth

l_n notch length

p test pressure

r revolution of the cutter

δ_{lg} ligament thickness

σ hydrostatic stress, in megapascals

4.2 Abbreviated terms

ANPT accelerated notch pipe test

PE polyethylene

RC raised crack resistance

S pipe series

SDR standard dimension ratio

5 Principle

A length of pipe with four machined longitudinal external notches is subject to a hydrostatic pressure test whilst immersed in a water tank at 80 °C in accordance with ISO 1167-1 and ISO 1167-2. The time to failure or test period is recorded.

NOTE 1 It is assumed that the following test parameters are set by the standard or specification making reference to this test method:

a) the number of test pieces, if applicable (see 7.5);

b) the test pressure (see 9.1);

c) the test period (see 9.1).

To accelerate the test, the pipe with external machined notches is immersed in a tank containing a detergent, for example Arkopal® N100[1)], in accordance with Annex D.

6 Apparatus

6.1 Pipe pressure-testing equipment, as specified in ISO 1167-1.

NOTE Ideally when testing notched pipes, it is recommended to use a single test station. Furthermore, it is recommended to use automated shut off equipment for each individual pipe when testing multiple pipes on a manifold. Otherwise, when a pipe fails, the other pipes are disturbed, and re-pressurizing can accelerate any crack growth present in the notches.

6.2 Notch machining equipment, for example a milling machine with a horizontal mandrel rigidly fixed to the bed to enable the pipe to be securely clamped to give a straight test piece.

Alternatively, the pipe to be notched can also be fixed from the outside with suitable clamps to keep it in a stable position to avoid vibrations during the notching process.

The milling cutter mounted on a horizontal arbor shall be a 60° double equal angle V-cutter with a pointed tip, having a calculated cutting rate of (0,010 ± 0,002) (mm/r)/tooth (see example).

It is important that the cutting rate is within the specified range, otherwise the results will not be valid.

EXAMPLE A cutter with 20 teeth rotating at 700 r/min, traversed at a speed of 150 mm/min, has a calculated cutting rate of 150/(20 × 700) = 0,011 (mm/r)/tooth.

Vibration of the cutter or the machine bed can affect the radius formed at the bottom of the notch and shall be minimized.

The milling cutter shall be carefully protected against damage. The cutter shall be subject to a running-in treatment amounting to 10 m of notching at the specified cutting rate, prior to its first use for the preparation of test pieces. It shall not be used for any other material or purpose and shall be replaced after 500 m of notching.

The cutter shall be checked for damage or wear after not more than 100 m of cutting. The cutter teeth shall be compared with a new cutter by examination with a microscope using a magnification of 10 to 20 times. If there is any evidence of damage or wear it shall be replaced.

The quality of the cutter and machining process can be checked by carrying out notching of a sample and visually checking the notch tip radius after cutting the cross-section of the pipe. This shall be done after installation of a new cutter.

6.3 End caps, type A in accordance with ISO 1167-1.

7 Test piece preparation

7.1 General

Prior to any measurements the test piece shall be conditioned at (23 ± 2) °C for at least 4 h.

1) Arkopal® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO. See Clause D.3, NOTE 2 concerning ongoing research to find alternative stress cracking media to replace nonylphenol ethoxylate types providing accepted correlation has been developed.

7.2 Test pieces

Each test piece shall comprise a length of pipe sufficient to give a minimum free length of pipe of ($3d_n$ ± 5) mm between the end caps, when fitted for pressure testing in accordance with ISO 1167-2, where d_n is the nominal outside diameter of the pipe. For pipes with a nominal outside diameter d_n > 315 mm, a minimum free length of (3 d_n ± 5) mm shall be used where practical; otherwise a minimum free length of ≥ 1 000 mm shall be used.

NOTE It is possible that the use of pipes less than 3 d_n and notch lengths less than or greater than the nominal outside diameter will affect the results.

7.3 Notch location and measurement of dimensions

Positions shall be marked for machining four notches equally spaced around the pipe circumference (see Figure 1). Measure the mean outside diameter, d_{em}, of the test pipe and the wall thickness of the pipe in the centre of the pipe at each notch position in accordance with ISO 3126.

7.4 Machining the notches

7.4.1 If the wall thickness of the test piece is greater than 50 mm, the material shall be machined with a slot drill of 15 mm to 20 mm diameter to leave approximately 10 mm to be removed by the V-cutter, used in accordance with 7.4.2. Machining of notches shall not take place within 24 h of production of the pipe.

7.4.2 Each notch shall be machined by climb milling (see Figure 2), to such a depth as to produce a pipe wall ligament thickness of between 0,78 and 0,82 times the minimum wall thickness, e_{min}, as specified in ISO 11922-1, for the diameter and pressure series of the pipe as shown in Table A.1. The ends of each notch shall be aligned circumferentially as shown in Figure 1 and Figure 2. It is important that the climb milling technique is used, otherwise the results will not be valid.

Vibration of the cutter or machine bed can affect the radius formed at the bottom of the notch and shall be minimized.

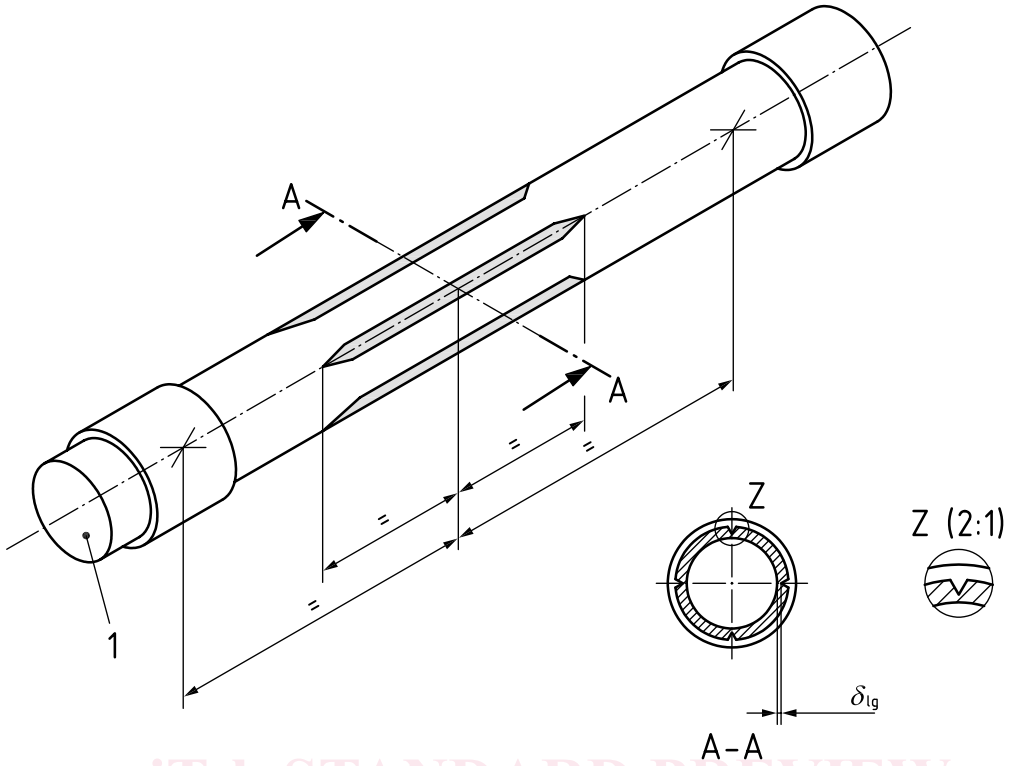
The notch radius shall not be greater than 100 µm when measured in accordance with the method described in Annex E and shall be checked at regular intervals of not more than 100 m of cutting.

The length of each notch, at full depth, shall be equal to the pipe nominal outside diameter ±1 mm. For pipes greater than 315 mm in diameter with a free length of pipe of less than (3 d_n ± 5) mm, the length of each notch, at full depth, shall be equal to the free length minus (500 ± 1) mm, in accordance with 7.2.

NOTE To achieve a remaining ligament within the required tolerance range, it is advisable to aim for a remaining ligament at the maximum of the tolerance range. This is because the pipe wall can move due to the release of residual stresses, resulting in a deeper than anticipated notch.

7.4.3 Measure and record the depth of each notch and the ligament thickness, $\delta_{lg,}$ by contact mechanical measurement or non-contact means.

NOTE An example of a non-contact method is given in Reference [4] of the Bibliography.

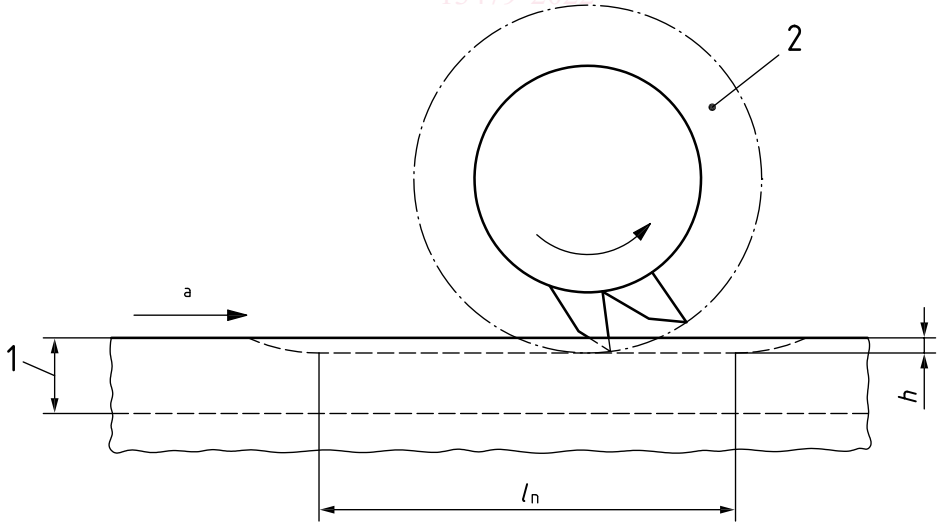


Key

1 end cap

δ_{lg} ligament thickness: 0,78 to 0,82 times minimum thickness specified by the product standard for the pipe being tested, in millimetres

Figure 1 — Pipe test piece



Key

1 pipe wall

2 60° double equal angle V-cutter

h notch depth, in millimetres

l_n notch length ($1 \times d_n$) centred on test piece

a Direction.

Figure 2 — Notching method

7.5 Number of test pieces

Prepare a minimum of three test pieces, unless specified otherwise in the referring standard or specification.

8 Conditioning

The test pieces shall be filled with water, immersed in a water tank at 80 °C and allowed to condition for 24 h ± 1 h for wall thickness up to 25 mm and 48 h ± 1 h for greater wall thickness.

9 Procedure

9.1 Hydrostatic-pressure testing

9.1.1 An internal pressure test in accordance with ISO 1167-1 at a test temperature of 80 °C shall be carried out on the prepared test piece by applying and maintaining the pressure specified by the referring standard.

9.1.2 Connect the test piece(s) to the pressurizing equipment and bleed off the air. After conditioning in accordance with Clause 8, progressively and smoothly apply the test pressure, in the shortest time practicable between 30 s and 1 h, depending upon the size of the test piece and the capability of the pressurizing equipment.

NOTE Shock loading by rapid increase of pressure can create crack tip blunting that will affect the test result.

9.1.3 Maintain the pressure until either the test piece ruptures or the time specified by the referring standard has elapsed, whichever occurs first. Record the time under pressure to the nearest hour. In the case of failure, record the location of the failure for each test piece.

Table B.1 gives recommended applicable pressure levels for polyethylene pipes, dependent on material type and pipe series.

9.1.4 If the sample fails prematurely before the specified requirement, a retest can be performed at a selected lower pressure for a longer time, if permitted by the referring standard. Annex C gives this information for polyethylene.

9.2 Ligament thickness measurement after testing

Measurement after testing shall be carried out if premature failure has occurred, or for the purpose of verifying notch depth measurement according to 7.4.3, using the following method. If the remaining ligament is found to be outside the tolerance range, the test result shall be discarded. A retest shall be performed using the same conditions and requirements.

On completion of the pressure test, remove the test piece from the water tank and allow to cool to ambient temperature. Cut a section of pipe out from around the position of each notch. Open up the notch to give clear access to one of the machined surfaces of the notch. Measure the width of the machined surface of the notch, b_s, to an accuracy of ±0,1 mm with a microscope or equivalent means, as shown in Figure 3. If required by the referring standard, measure the depth of penetration of the crack.