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Polyethylene pipes — Resistance to slow crack growth — Cone test method

*Tubes en polyéthylène — Résistance à la propagation lente des
fissures — Méthode d'essai avec le cône*

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13480 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*.

Annex A of this International Standard is for information only.

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
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Polyethylene pipes — Resistance to slow crack growth — Cone test method

1 Scope

This International Standard specifies a method of test for determining the resistance to slow crack growth of polyethylene pipe expressed in terms of the rate of crack growth in a notched pipe ring subject to a constant hoop strain and immersed in a surface active solution held at an elevated temperature.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3126:1974, *Plastics pipes — Measurement of dimensions*.

ISO 13479:1997, *Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes (notch test)*.

3 Principle

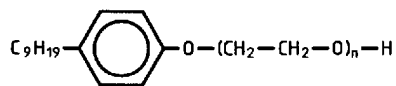
Rings cut from pipe to a specified length are held at a constant strain by insertion of a mandrel and a single notch is made at one end of the pipe ring. The assembly is immersed in a specified surface-active solution held at a temperature of $80\text{ °C} \pm 1\text{ °C}$. The rate of growth of the crack propagating from the notch is measured. The test is applicable to pipe of wall thickness up to and including 5 mm.

NOTE 1 For wall thickness greater than 5 mm, ISO 13479 is applicable.

4 Materials

4.1 Surface active solution

A nonyl-phenoxy(ethyleneoxy)ethanol neutral type detergent shall be used with 11 ethyleneoxide molecules as shown below:



where n is 11.

Prepare a sufficient quantity of a solution of a concentration equivalent to 5 % by weight of the detergent with deionised water to ensure complete immersion of the range of sizes to be tested.

This solution will age with time at 80 °C. Therefore the solution shall be used for no more than 100 days.

5 Apparatus

5.1 Thermostatically controlled tank

Thermostatically controlled tank to contain the surface active solution of dimensions to ensure full immersion of the range of specimen sizes to be tested. The tank shall be constructed from materials which shall not affect the surface active solution. It shall have a lid or cover to prevent evaporation and a means of stirring the solution,

NOTE 2 The object of stirring is to prevent separation or layering of the solution.

5.2 Cone

A mandrel of dimensions specified below with a conical end is required for insertion into the pipe ring to maintain a constant strain, see figure 1. At the end of the mandrel is a longitudinal groove of dimensions 20 mm \pm 1 mm by 1 mm \pm 0,2 mm and depth (e) 2 mm \pm 0,2 mm. The material used for manufacture of the mandrel shall not affect the surface active solution, brass for example.

$D = 1,12 \times$ the nominal internal diameter of the pipe ($\pm 0,1$ mm).

$H = D$ for nominal outer diameters not exceeding 40 mm, and $D/2$ for nominal diameters above 40 mm (± 1 mm).

$R = 4 \times$ the specified internal diameter of the pipe of nominal size of less than or equal to 40 mm, and equal to the nominal internal diameter of pipe of nominal size above 40 mm (± 2 mm).

The nominal diameter is equal to the nominal pipe size less twice the specified minimum wall thickness.

5.3 Press or vice

A press to drive the mandrel into the pipe ring at a rate which will not cause damage or distort the end or edges of the ring. Alternatively a vice with retaining and guiding jaws can be used.

5.4 Notching device

A notching device is required which is capable of inserting a razor blade into the end of the pipe to create a notch, as shown in figure 2. Alternatively a mechanised means of performing this operation, such as using a specialised jig or a machine with a moving table, is acceptable.

Dimensions in millimetres

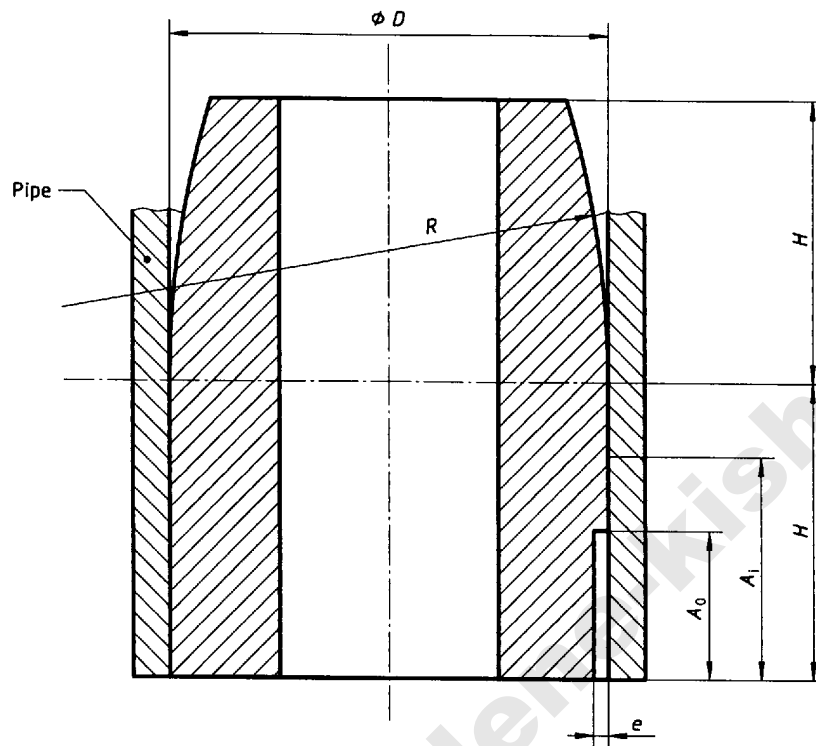


Figure 1 — Virole or cone

A commercial razor blade shall be used for this operation which shall be changed after no more than 20 notching operations.

A blade penetration speed of around 10 mm/min has been found to be satisfactory.

6 Test pieces

Prepare three ring test pieces of $\left(100 \begin{smallmatrix} +5 \\ 0 \end{smallmatrix}\right)$ mm length from a sample of pipe of nominal outer diameter ≤ 40 mm, or of $\left(150 \begin{smallmatrix} +5 \\ 0 \end{smallmatrix}\right)$ mm in length for pipe or nominal diameter > 40 mm, ensuring that the ends of the ring are cut square.

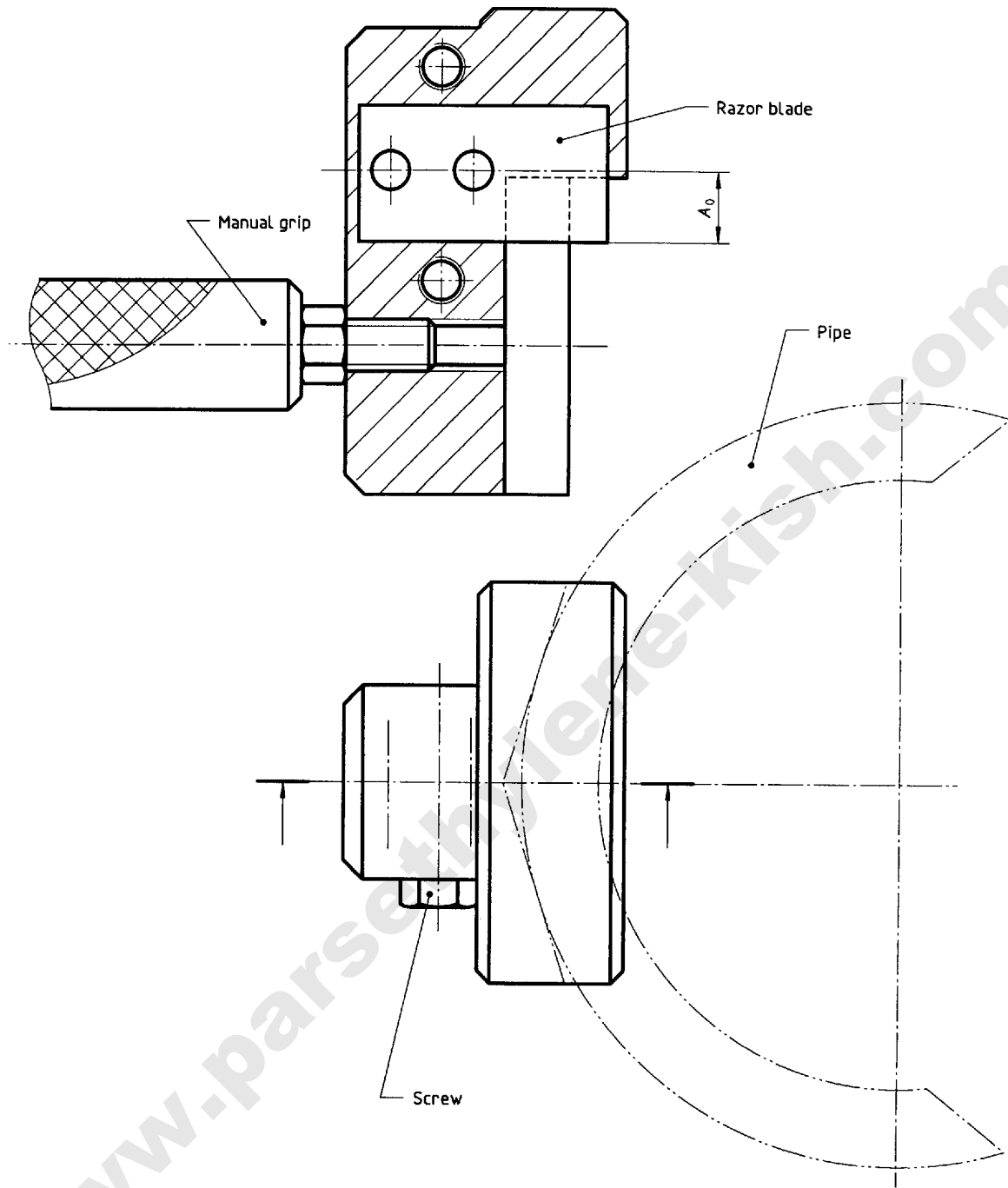


Figure 2 — Notching device

Measure the outer diameter (D_1) of the specimen 30 mm from the end of the pipe ring into which the mandrel will be inserted.

7 Procedure

7.1 Insertion of the cone

Carefully insert the cone into the pipe ring to ensure that the axes of both are aligned. Using the press or vice drive the mandrel fully into the pipe ring at a rate which shall not damage or distort the end or edges of the ring. A rate of 100 mm/min \pm 50 mm/min is suitable. Re-measure the diameter (D_2) of the pipe in the same position 30 mm from the end.

Following insertion of the cone, the test piece shall be notched and immersed in the surface active solution within 10 minutes.

7.2 Calculation of strain

Calculate the strain level in the specimen after insertion of the mandrel, using the following formula, expressing the result as a percentage:

$$\text{Strain} = \frac{D_2 - D_1}{D_1} \times 100$$

7.3 Cutting of the notch

A radial notch of axial length 10 mm \pm 1 mm shall be cut through the pipe wall at the end of the pipe ring which has been fully strained by the mandrel. The circumferential position of the notch relative to the pipe marking shall be noted.

The notch shall be cut using the device shown in figure 2.

To ensure that the notch is extended through the full wall thickness of the pipe ring specimen a press or vice shall be used to push the notching device into the ring.

Measure the axial length of the notch from the end of the pipe, $A_0 \pm 0,5$ mm.

NOTE 3 A mechanised means of cutting the notch is acceptable. For instance the test assembly may be held in a tensile test machine or a special jig allowing the blade to form the notch in a controlled way. A cutting speed of around 10 mm/min is recommended.

7.4 Immersion of test piece

Introduce the test piece with inserted mandrel, after notching, into the tank containing the surface active solution, maintained at a constant temperature of 80 °C \pm 1 °C.

The test pieces shall be positioned vertically in the tank, fully immersed, with the end of the mandrel sitting on the bottom of the tank, ie with the conical end facing upwards.

The lid or cover shall be placed on the tank and sealed.

7.5 Measurement of crack growth

The test piece shall be removed from the tank every 24 hours and the axial notch shall be examined. The appearance shall be noted and the length of the notch from the end of the pipe ($A_i \pm 0,5$ mm) shall be measured at each 24 hour period with a precision of $\pm 0,5$ mm. At least 3 successive increases in the notch length shall be obtained. If the notch growth curves away from an axial path significantly, the test shall be stopped and a new sample prepared.

NOTE 4 If no crack growth occurs after one week in the three test pieces, the test can be halted. The specimen of pipe is deemed to be resistant to slow crack growth.

8 Expression of results

Plot a graph of increase in crack length ($A_i - A_0$) versus time, as shown in the example in figure 3.

Carry out linear regression for the data set.

Determine the rate of crack growth (v mm/24 h) from the slope of this line for each test specimen.

Unless otherwise specified in the referring standard the highest measured rate of crack growth is taken as the result.

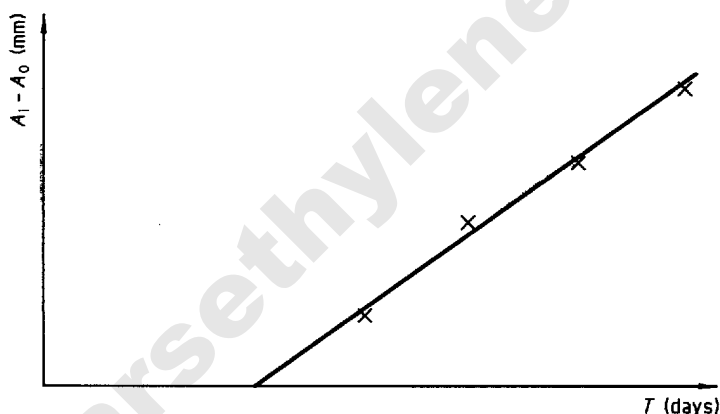


Figure 3 — Increase in crack length versus time

9 Test report

A report of this test shall include the following:

- A complete identification of the pipe (manufacturer, type of pipe, production date);
- Date of commencement of the test;
- The original diameter (D_1), wall thickness, and length of the test piece.
- The diameter (D_2) and strain level of the test piece after insertion of the mandrel;
- The initial notch length (A_0) and the notch lengths (A_i) after each 24 hour period;

- f) The appearance of the test piece with a diagram showing the path of crack growth;
- g) Any incidents likely to have affected the test, for example a reduction of temperature of the surface active solution;
- h) The rate of crack growth (v mm/24 h), determined from the graph, see figure 3, for each test piece;
- i) The highest rate of crack growth of the three test pieces.

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Annexe A (informative)

Recommended requirement

This test is independent of pipe diameter, pipe series and tolerances within the specified ranges. However it has been found to be dependent on the type of detergent used. A maximum allowable crack growth rate of 10 mm/day is recommended for pipe manufactured in any class of polyethylene tested with the detergent type detailed in 4.1, ie ethoxylated nonylphenol type detergent.

This type of detergent has been specified because of manufacture to a technical specification and availability world wide. (An example of such a product is Arkopal N110). The use of an alternative type of detergent will require the requirement to be established.

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