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Polyethylene (PE) materials for piping systems — Determination of resistance to slow crack growth under cyclic loading — Cracked Round Bar test method

Matériaux polyéthylène (PE) pour systèmes de tuyauterie — Détermination de la résistance à la propagation lente de fissures sous un chargement cyclique — Méthode d'essai de la barre ronde fissurée

Reference number
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Foreword

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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 corrected version of ISO 18489:2015 incorporates the following corrections.

Formula (2) has been revised.

Formulae (A.1), (A.2) and (A.3) have been revised, as well as the corresponding explanation of symbols.

Introduction

Knowledge about the resistance to long-term failure mechanisms as a result of crack initiation and slow crack growth (SCG) is important for the ranking and pre-selection of thermoplastic materials, especially for long-term applications such as pipes and fittings made of polyethylene. Several tests to determine the relevant failure mechanisms are available today where elevated temperatures and also the combination with stress cracking liquids are used to decrease the time frame for testing.

However, developments in modern raw materials have led to a significant increase of resistance of polyethylene to crack initiation and SCG so that testing with available methods exceeds practical time frames. Therefore, new acceleration methods, preferably at application relevant temperatures and without additional time reducing liquids, are required.

This test method achieves a significant decrease of testing time even at ambient temperatures of 23 °C. This is more relevant to the temperature range of many applications and testing at this temperature does not change the structural status of the polymer. Acceleration of material testing is achieved by the specimen geometry and the cyclic loading regime to result in completion of testing in a relatively short time.[2],[3],[4]

Polyethylene (PE) materials for piping systems — Determination of resistance to slow crack growth under cyclic loading — Cracked Round Bar test method

1 Scope

This International Standard specifies a method to determine the resistance to slow crack growth (SCG) of polyethylene materials, pipes, and fittings. The test is applicable to samples taken from compression moulded sheet or extruded pipes and injection moulded fittings of suitable thickness.

This International Standard provides a method that is suitable for an accelerated fracture-mechanics characterization at ambient temperatures of 23 °C of different polyethylene grades, especially for PE 80 and PE 100 types for pipe applications.

NOTE This test method could be adapted for other thermoplastics materials by developing the procedure using different test parameters.

2 Normative references

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 2818, *Plastics — Preparation of test specimens by machining*

3 Terms and definitions

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

3.1
crack length
a
depth of the crack at any time during a test measured from the specimen surface to the crack tip

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

3.2
cycle
N
smallest segment of a load-time or stress-time function which is repeated periodically

3.3
failure cycle number
N_f
total number of *cycles* (3.2) from the beginning until failure of the test specimen

3.4
frequency
f
number of *cycles* (3.2) within one second

Note 1 to entry: It is expressed in hertz (Hz).

3.5
initial crack length
a_{ini}
measured depth of the crack from the specimen surface through the crack tip at the beginning of the test

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

3.6
initial ligament diameter
D_{ini}
inner diameter of the cylindrical specimen after notching

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

Note 2 to entry: It is calculated by

$$D_{ini} = D - 2 \cdot a_{ini}$$

3.7
load ratio
R
ratio of the minimum to the *maximum load* (3.9) in one *cycle* (3.2)

Note 1 to entry: It is calculated by

$$R = \frac{F_{min}}{F_{max}}$$

3.8
load range
ΔF
difference between the maximum and *minimum load* (3.10), in Newtons (N), in one *cycle* (3.2)

3.9
maximum load
F_{max}
highest value of the applied load, in Newtons (N), in one *cycle* (3.2)

3.10
minimum load
F_{min}
lowest value of the applied load, in Newtons (N), in one *cycle* (3.2)

3.11
notch distance
L_{min}
minimum distance from notch to clamping system

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

3.12
target initial crack length
a_{ini}^*
target depth of the crack from the specimen surface through the crack tip after notching

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

3.13
target initial ligament diameter
D_{ini}*
target inner diameter of the cylindrical specimen after notching

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

3.14
target stress range
$\Delta\sigma_0$*
target difference between the maximum and minimum stress at the beginning of the test

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

3.15
specimen diameter
D
diameter of the cylindrical specimen

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

3.16
specimen length
L
total length of the test specimen

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

3.17
stress range
$\Delta\sigma_0$
applied difference between the maximum and minimum stress after notching at the beginning of the test

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

3.18
waveform
shape of the load-time curve within a single *cycle* (3.2)

4 Principle

A cyclic tensile test with constant load range is imposed on a cylindrical specimen under suitable test conditions within the stress range where SCG is achieved. A circumferential notch is machined in the centre of the test specimen to enable crack initiation and SCG to final failure of the specimen. The number of cycles until final failure, N_f, is recorded as a function of the stress range, $\Delta\sigma_0$, at the initial crack length, a_{ini}. The specimen geometry ensures quick crack initiation and short testing times due to the high constraint and low plastics deformations along the crack tip.

NOTE Crack initiation can be monitored by the use of extensometers if required.[2]

5 Apparatus

5.1 Test machine

5.1.1 Loading system

The loading system shall be capable of imposing and recording a cyclic load varied by time between accurately defined limits (load control mode) with a specific waveform. Servo-hydraulically driven test