TECHNICAL SPECIFICATION

ISO/TS 16479

First edition
2012-10-01

Thermoplastics pipes for the conveyance of fluids — Determination of the slow cracking resistance of pipes and fittings using the Notched Ring Test (NRT)

Tubes en matières thermoplastiques pour le transport des fluides — Détermination de la résistance des tubes et raccords à la propagation lente de la fissure au moyen d'essais sur sections fendues

Reference number
ISO/TS 16479:2012(E)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

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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.

ISO/TS 16479 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*.

Introduction

At the present time ISO/TC 138 provides several test methods for determining the resistance to slow cracking which are essential for assessing properties and durability of thermoplastics pipes and fittings. In fact, they constitute a basis for determining the long term performance characteristics of these parts. In line with the development of better slow crack resistant materials, new accelerated test methods for evaluating slow crack resistance of thermoplastic piping parts are frequently under investigation [1-3]. In consideration of this, the Notched Ring Test (NRT) method has been developed and applied to determine its applicability as the standard test method and has demonstrated its effectiveness in generating slow cracking within the time frame of interest [4-7]. This Technical Specification provides details of the NRT method in terms of test implementation, its SCG performance evaluation, and the application of the method utilizing the stress intensity factor approach.

Thermoplastics pipes for the conveyance of fluids — Determination of the slow cracking resistance of pipes and fittings using the Notched Ring Test (NRT)

1 Scope

This Technical Specification determines the slow cracking resistance of pipes and fittings using the Notched Ring Test (NRT) which is a method for determining the slow crack resistance of thermoplastics resins and compounds in pipe form and/or finished products (e.g. pipes and fittings) from which a ring specimen can be cut and notched. The test is performed under sustained constant loading in a test medium at a specified temperature and the time to the on-set of slow cracking is measured. This method applies to the rings from pipes or fittings having a wall thickness greater than 5 mm. This Technical Specification specifies the method of testing using notched ring specimens directly obtained from pipes or fittings.

2 Normative references

The following referenced documents are indispensable for the application 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 6108, *Double equal angle cutters with plain bore and key drive*

ISO 13479, *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 Terms and definitions

3.1
slow crack growth
SCG
crack growth that occurs below the critical stress intensity factor at which the unstable rapid crack propagation takes place

NOTE The crack growth is stable and hence can grow to a substantial length before causing material to fail either by rapid fracture or ligament yielding. In some polyolefin materials, distinct fracture surface features characteristic of slow crack growth are apparent and are often used as an indicator of slow crack growth

3.2
ring deflection curve
time dependent deflection curve obtained from the sustained constant flexure loading of the ring specimen

NOTE 1 See Annex A.

NOTE 2 The curve may have similar features of a creep curve, normally consisting of primary, steady state secondary and tertiary regions. Deflection is normally taken at the notch position and directly above the line of load application.

3.3
on-set slow cracking time
t_i (h)
time for first noticeable abnormal change to appear on the recorded ring deflection curve

NOTE 1 See Annex A.

NOTE 2 For this definition to be complete, the fracture surface must show features of slow cracking in any degree or features defined otherwise.

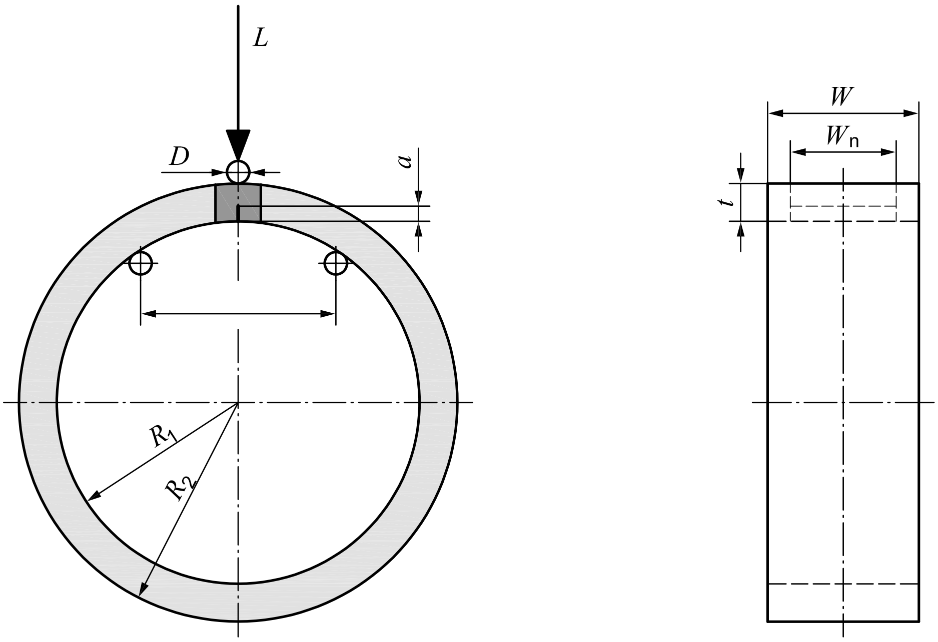
EXAMPLE Examples of abnormal change are discontinuity, slope change etc.

3.4
applied load
***L* (N)**
load applied in three point flexure mode

3.5
applied stress intensity factor
K_0 (N/m$^{3/2}$)
crack-tip stress intensity factor calculated based on the initial notch dimension

4 Principle

A suitable NRT specimen is an undisturbed full ring of certain width directly removed from the pipes or fittings (see Figure 1), having features that include an inner wall notch along the sample width between the tips of two coplanar sidewall notches (see Figure 5). The inner wall and sidewall notches are all in the same plane and the notch and specimen dimensions are such that conditions for the plane-strain slow crack growth are met at the notch tip. Coplanar sidewall notches are introduced to further maintain the plane strain condition as well as to act to guide the loading rod accurately along the line of the crack tip. NRT specimens are subjected to sustained and constant flexure load in a temperature controlled medium and the time to on-set cracking as defined in 3.3 is determined from the measured ring deflection curve (see 3.2 and Annex A). In the NRT specimen, the slow cracking can be initiated in a relatively shorter time due to the possibility of constrained crack tip deformation induced by the sample and the loading geometry, hence allowing higher stress intensity to develop at the crack tip without gross yielding.



Key

W width of the ring
W_n width between sidewall notches
R_1 inside radius
R_2 outside radius
t wall thickness
S span length
a razor notch depth
L applied load
D diameter of loading and supporting rods

Figure 1 — The diagram and loading configuration of NRT specimen

5 Apparatus

5.1 Loading apparatus

A suitable device for loading the ring specimen in a sustained and constant manner under flexure mode shall be used. The device may utilize dead weights, pneumatically actuated loading or any other means for producing a sustained constant load with accuracy better than ±1,0 % of the applied load. The loading, supporting and guiding rods (see Figure 1) are made from a 316 stainless steel having the same ground surface and they are positioned parallel to each other. The guiding rod guides the loading rod right on top of the inner wall notch by means of adapting the sidewall notches (see Figures 1 and 5). An impression of a typical loading jig is shown in Figure 2.

5.2 Ring deflection measuring device

Ring deflection of the mid-span containing the plane of the crack front (see Figure 1) shall be measured by means of a suitable device that will not influence the specimen in any way. Particular caution should be practiced to ensure the stability of the measuring device with time, temperature and humidity. The device shall be capable of deflection measurement with accuracy better than ±1,0 % and a resolution of 0,01 mm. Since it is important to continuously monitor the deflection, it is recommended to use an automatic deflection measuring system. An example of an electronic displacement gauge and its assembly to an overall loading-measuring device is shown in Annex A. The measurement shall not be influenced by any mechanical and/or electric disturbances that may end up in the deflection curve being obtained.

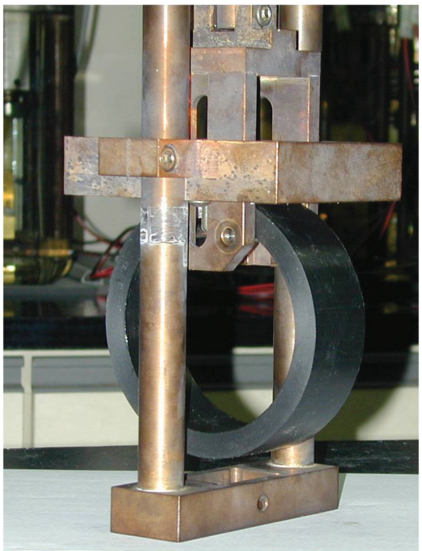


Figure 2 — Flexure apparatus for loading notched ring specimen

5.3 Temperature chamber

A suitable chamber should contain the environment needed for this test and ensure complete immersion of the specimen. The construction material of this chamber shall not affect the environment or vice versa. The chamber can usually be closed with a lid to prevent medium evaporation as well as to protect the loading-measuring apparatus. The temperature of the environment is controlled to maintain the specimens within ±1,0 °C of the specified test temperature. Replenishment of the lost medium due to evaporation is achieved best through the use of an auxiliary container using gravity feeding to minimize temperature variation during feeding.

5.4 Test medium

The tests are usually performed in water, unless stated otherwise.

5.5 Timing device

A suitable timing device that can monitor time accumulation shall be used. The accuracy of the measurement is recommended to be better than ±1 % of the elapsed time.

5.6 Microscope

A travelling microscope or an equivalent device is used to measure the initial razor notch length accurately after the slow crack test. The recommended resolution for this method is ±100 µm.

NOTE A combination of digital camera and image processing software is considered a readily available solution. This method can provide a razor notch depth measurement with required accuracy and convenience.

5.7 Notching apparatus

5.7.1 Inner wall notching device

The device shall be capable of producing a sharp notch at the inner wall of the ring specimen at a cutting speed of less than 300µm per minute.

NOTE Such cutting speeds are generally available in a typical universal testing machine and the load-displacement curve can be readily obtained simultaneously by installing the notching device on such machines [see Figure 3b)]. Higher notching speed is known to create abnormality at the notch tip which can affect the slow crack initiation.

It is recommended that the device utilized is also able to produce load-razor blade displacement curve during notching for the purpose of checking consistency and uniformity of notching. The notch tip radius produced depends on the type of razor blade (blade thickness not exceeding 0,2 mm) and shall be less than 10 µm. A broaching device is also acceptable provided that the notch tip radius is also less than 10 µm.

Figure 3 shows an inner wall notching device. It consists of a removable arm for accommodating the razor blade holder, depth adjusting parts and the ring specimen, a base to hold the arm perpendicular to the compression load and a mechanism for firmly holding the base to the universal testing machine.

5.7.2 Sidewall notching device

A suitable device capable of machining a 90° angle "V"-notch at each sidewall of the ring specimen opposite each other and the notch tips in the same plane (see Figure 1) shall be used. The device should provide a notching rate of 0,010 ± 0,002 (mm/rev)/tooth (see ISO 13479 for details) and the cutter subject to a pre-treatment amounting to 10 m of notching prior to its first use. It is strongly recommended to use the cutter solely for this purpose and only on this material, to be replaced after 100 m of notching. The 90°-included-angle "V"-cutter employed shall conform to ISO 6108.