

---

---

**Plastics — Determination of  
environmental stress cracking (ESC)  
of polyethylene — Full-notch creep  
test (FNCT)**

*Plastiques — Détermination de la fissuration sous contrainte dans un  
environnement donné (ESC) du polyéthylène — Essai sur éprouvette  
entièrement entaillée (FNCT)*





**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, 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  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

	Page
<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Principle</b> .....	<b>3</b>
<b>5 Apparatus</b> .....	<b>3</b>
<b>6 Test specimens</b> .....	<b>6</b>
6.1 General.....	6
6.2 Test specimens geometry.....	6
6.3 Test specimen preparation.....	8
6.3.1 General.....	8
6.3.2 Test specimens machined from compression moulded sheets.....	8
6.3.3 Test specimens machined from injection-moulded type 1A multipurpose test specimen.....	8
6.3.4 Test specimens machined from finished products.....	8
6.4 Test specimen notching.....	8
6.5 Conditioning of the test specimens.....	9
<b>7 Test environment</b> .....	<b>9</b>
7.1 General.....	9
7.2 Recommended test environment.....	9
7.2.1 Test environment No. 1.....	9
7.2.2 Test environment No. 2.....	10
7.3 Other test environments.....	11
<b>8 Test procedure</b> .....	<b>11</b>
8.1 Selection of detergent, reference tensile stress and test temperature.....	11
8.2 Number of test specimens to be tested.....	11
8.3 Calculation of the test load.....	13
8.4 Application of the load to the test specimen.....	13
8.5 Removing individual specimens from a chamber.....	13
8.6 Measurement of the ligament area after failure.....	13
<b>9 Expression of results</b> .....	<b>14</b>
9.1 Calculation of the actual tensile stress.....	14
9.2 Calculation of time to failure at the reference tensile stress.....	14
<b>10 Precision</b> .....	<b>15</b>
<b>11 Test report</b> .....	<b>15</b>
<b>Annex A (informative) Precision statement</b> .....	<b>17</b>
<b>Annex B (informative) Example of a recommended test report for FNCT determination</b> .....	<b>20</b>
<b>Annex C (informative) Practical examples of fracture surfaces and corresponding definition of failure mode</b> .....	<b>22</b>
<b>Bibliography</b> .....	<b>25</b>

## 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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 9, *Thermoplastics*.

This second edition cancels and replaces the first edition (ISO 16770:2004), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the test conditions for bimodal PE materials with substantially increased crack-resistance have been extended on an alternative more aggressive detergent;
- the compression moulding conditions for 10 mm × 10 mm test specimen (Type A) have been modified;
- the specimen types have been updated, with injection moulded test specimens being included;
- precision data (repeatability) from interlaboratory testing have been included for Type A test specimen.

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](http://www.iso.org/members.html).

## Introduction

Since mid-2000, the full-notch creep test (FNCT) has been widely used as one of the tests characterizing the environmental stress cracking (ESC) of polyethylene (PE) materials used in demanding applications. Among current ESC tests, the FNCT is relatively simple, easy to perform and still a sensitive laboratory scale test method to characterize ESC resistance of PE materials. The advantage of FNCT is that it enables the evaluation of the whole PE product range by variation of test conditions (test specimen geometry, temperature, medium and load conditions).

The FNCT method was standardized in 2004 as a PE material property, with partial precision statement based on the repeatability for a 6 mm × 6 mm-cross-sectional test specimen (Type B). Since then, several interlaboratory tests have been performed, resulting in a repeatability statement for 10 mm × 10 mm-cross-sectional test specimen (Type A). Type A specimen is prepared by using modified compression moulding conditions, which give more consistent test results compared to the original moulding conditions.

In addition, due to recent development of new PE pipe materials, known as PE 100 RC, which exhibit substantially improved crack resistance, it became necessary to define test conditions for these materials. Testing of these materials using the conditions specified in the previous edition of this document (i.e. ISO 16770:2004) resulted in failure times of one year or longer. As a consequence, this document includes extended test conditions to cover PE materials with substantially increased crack resistance. This accelerated test procedure using extended test conditions allows failure times to be reduced substantially compared to conventional test conditions given in ISO 16770:2004. In addition, a good correlation between accelerated and conventional test methods was derived; see References [4], [7] and [9].

The FNCT is a material characterization and production monitoring test, which, by strictly maintaining the test conditions defined, enables relevant and reliable comparison among similar PE materials or group of PE materials.



# Plastics — Determination of environmental stress cracking (ESC) of polyethylene — Full-notch creep test (FNCT)

## 1 Scope

This document specifies a method for determining the environmental stress cracking (ESC) resistance of polyethylene (PE) materials in a defined test environment. The test is carried out on notched test specimens machined from moulded sheets/specimens or from finished products. The test specimen is subjected to a static tensile load when immersed into an environment such as a surfactant solution held at a specified temperature. The time to failure is measured.

The method has been specifically developed for polyethylene materials but can be used to evaluate PE products, such as pipes, fusion welds/fittings and blow-moulded PE containers to study the effect of aggressive environments, i.e. dangerous goods and chemicals.

The method is suitable for use with test specimens moulded to chosen dimensions or machined from compression moulded sheets or injection moulded specimens, or from finished products, such as mouldings and pipes. When the test specimens are machined from extruded or moulded parts, the results can be affected not only by properties of the material, but also by stresses or orientation introduced during processing.

## 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 294-1, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*

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

ISO 7500-2, *Metallic materials — Verification of static uniaxial testing machines — Part 2: Tension creep testing machines — Verification of the applied force*

ISO 17855-2, *Plastics — Polyethylene (PE) moulding and extrusion materials — Part 2: Preparation of test specimens and determination of properties*

ISO 20753, *Plastics — Test specimens*

## 3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 3.1

#### **failure**

complete separation of the two halves of the test specimen