

~~ISO/FDIS 6603-2:2023(E)~~

~~2022(E)-02-13~~

~~2022-09-21~~

~~ISO TC 61/SC 2/WG 3~~

Secretariat: SAC

Plastics — Determination of puncture impact behaviour of rigid plastics —Part 2: Instrumented impact testing

~~*Plastiques — Détermination du comportement des plastiques rigides perforés sous l'effet d'un choc — Partie 2: Essais de choc instrumentés*~~

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Published in Switzerland

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Contents

Foreword	iv
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Principle	6
5 Apparatus	6
5.1 Testing instrument, consisting of the following essential components.....	6
5.2 Instruments for measuring force and deflection.....	9
5.3 Thickness gauge, as specified ISO 16012.....	10
6 Test specimens	10
6.1 Shape and dimensions.....	10
6.2 Preparation of test specimens.....	10
6.3 Non-homogeneous test specimens.....	11
6.4 Checking the test specimens.....	11
6.5 Number of test specimens.....	11
6.6 Conditioning of test specimens.....	11
7 Procedure	11
7.1 Test atmosphere.....	11
7.1.1 General.....	11
7.1.2 Ambient temperature testing.....	11
7.1.3 Low temperature testing.....	12
7.2 Measurement of thickness.....	12
7.3 Clamping the test specimen.....	12
7.4 Lubrication.....	12
7.5 Puncture test procedure.....	12
8 Calculations	12
8.1 Expression of results.....	12
8.2 Calculation of deflection.....	13
8.3 Calculation of energy.....	13
8.4 Statistical parameters.....	1
8.5 Significant figures.....	1
9 Precision	1
10 Test report	2
Annex A (informative) Interpretation of complex force-deflection curves	3
Annex B (informative) Friction between striker and specimen	5
Annex C (informative) Clamping of specimens	7
Annex D (informative) Tough/brittle transitions	8
Annex E (informative) Influence of specimen thickness	9
Annex F (informative) Guidance for the classification of the type of failure	11
Annex G (informative) Precision Data	14

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Bibliography	17
Foreword	iv
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Principle	6
5 Apparatus	6
5.1 Testing instrument, consisting of the following essential components.....	6
5.2 Instruments for measuring force and deflection.....	9
5.3 Thickness gauge, as specified ISO 16012.....	10
6 Test specimens	10
6.1 Shape and dimensions.....	10
6.2 Preparation of test specimens.....	10
6.3 Non-homogeneous test specimens.....	11
6.4 Checking the test specimens.....	11
6.5 Number of test specimens.....	11
6.6 Conditioning of test specimens.....	11
7 Procedure	11
7.1 Test atmosphere.....	11
7.1.1 General.....	11
7.1.2 Ambient temperature testing.....	11
7.1.3 Low temperature testing.....	12
7.2 Measurement of thickness.....	12
7.3 Clamping the test specimen.....	12
7.4 Lubrication.....	12
7.5 Puncture test procedure.....	12
8 Calculations	12
8.1 Expression of results.....	12
8.2 Calculation of deflection.....	13
8.3 Calculation of energy.....	13
8.4 Statistical parameters.....	1
8.5 Significant figures.....	1
9 Precision	1
10 Test report	2
Annex A (informative) Interpretation of complex force-deflection curves	3
Annex B (informative) Friction between striker and specimen	5
Annex C (informative) Clamping of specimens	7
Annex D (informative) Tough/brittle transitions	8
Annex E (informative) Influence of specimen thickness	9
Annex F (informative) Guidance for the classification of the type of failure	11
Annex G (informative) Precision Data	14
Bibliography	17

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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 61, *Plastics*, Subcommittee SC 2, *Mechanical behavior*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 6603-2:2000), which has been technically revised.

The main changes are as follows:

- ~~References~~ references to ISO 6603-1 ~~were have been~~ replaced by the corresponding text;
- ~~Normative~~ normative references and bibliography ~~were have been~~ updated and completed;
- ~~Requirements~~ requirements for force measurement accuracy ~~were have been~~ revised;
- ~~Definitions~~ definitions for conditioning and test climate ~~were have been~~ updated;
- ~~Testing~~ testing in a clamped situation ~~was have been~~ defined as the preferred method;
- ~~Precision Data was~~ — precision data has been added to annex F.

A list of all parts in the ISO 6603 series can be found on the ISO website.

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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.

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Plastics — Determination of puncture impact behaviour of rigid plastics —

Part 2: Instrumented impact testing

1 Scope

This document specifies a test method for the determination of puncture impact properties of rigid plastics, in the form of flat specimens, using instruments for measuring force and deflection. It is applicable if a force-deflection or force-time diagram, recorded at nominal constant striker velocity, is necessary for detailed characterization of the impact behaviour.

The test method is applicable to specimens with a thickness between 1 mm and 4 mm.

The method is suitable for use with the following types of material:

- rigid thermoplastic moulding and extrusion materials, including filled, unfilled and reinforced compounds and sheets;
- rigid thermosetting moulding and extrusion materials, including filled and reinforced compounds, sheets and laminates;
- fibre-reinforced thermoset and thermoplastic composites incorporating unidirectional or multi-directional reinforcements such as mats, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings, milled fibres and sheets made from pre-impregnated materials (prepregs).

The method is also applicable to specimens which are either moulded or machined from finished products, laminates and extruded or cast sheet.

The test results are comparable only if the conditions of preparation of the specimens, their dimensions and surfaces as well as the test conditions are the same. In particular, results determined on specimens of different thickness cannot be compared with one another (see [annex Annex E](#)). Comprehensive evaluation of the reaction to impact stress can be obtained by determinations made as a function of impact velocity and temperature for different material variables, such as crystallinity and moisture content.

The impact behaviour of finished products cannot be predicted directly from this test, but specimens may be taken from finished products (see above) for tests by this method.

Test data developed by this method is not intended to be used for design calculations. However, information on the typical behaviour of the material can be obtained by testing at different temperatures and impact velocities (see [annex Annex D](#)) by varying the thickness (see [annex Annex E](#)) and by testing specimens prepared under different conditions.

It is not the purpose of this document to give an interpretation of the mechanism occurring on every particular point of the force-deflection diagram. These interpretations are a task for scientific research.

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

ISO 293, *Plastics — Compression moulding of test specimens of thermoplastic materials*

~~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 294-3, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 3: Small plates*

ISO 295, *Plastics — Compression moulding of test specimens of thermosetting materials*

ISO 1268-1, *Fibre-reinforced plastics — Methods of producing test plates — Part 1: General conditions*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

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

ISO 16012, *Plastics — Determination of linear dimensions of test specimens*

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 <https://www.electropedia.org/>

3.1 impact velocity

v_0
velocity of the striker relative to the support at the moment of impact

Note 1 to entry: Impact velocity is expressed in metres per second (m/s).

3.2 force

F
force exerted by the striker on the test specimen in the direction of impact

Note 1 to entry: Force is expressed in newtons (N).

3.3 deflection

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l
relative displacement between the striker and the specimen support, starting from the first contact between the striker and the test specimen

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

3.4 energy

E
energy expended in deforming and penetrating the test specimen up to a deflection l

Note 1 to entry: Energy is expressed in joules (J).

Note 2 to entry: Energy is measured as the integral of the force-deflection curve starting from the point of impact up to a deflection l .

3.5 maximum force

F_M
maximum force which occurs during the test

Note 1 to entry: See Figures 1 to 4.

Note 2 to entry: Maximum force is expressed in newtons (N).

3.6 deflection at maximum force

l_M
deflection that occurs at maximum force F_M

Note 1 to entry: See Figures 1 to 4.

Note 2 to entry: Deflection at maximum force is expressed in millimetres (mm).

3.7 energy to maximum force

E_M
energy expended up to the deflection l_M at maximum force

Note 1 to entry: See Figures 1 to 4.

Note 2 to entry: Energy to maximum force is expressed in joules (J).

3.8 puncture deflection

l_p
deflection at which the force has dropped to half the maximum force F_M

Note 1 to entry: See Figures 1 to 4 and note 3 to entry of 3.9.

Note 2 to entry: Puncture deflection is expressed in millimetres (mm).

3.9 puncture energy

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E_p
energy expended up to the puncture deflection l_p

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Note 1 to entry: See Figures 1 to 4 and note 3.

Note 2 to entry: Puncture energy is expressed in joules (J).

Note 3 to entry: When testing tough materials, a transducer mounted at some distance from the impacting tip may record frictional force acting between the cylindrical part of the striker and the punctured material. The corresponding frictional energy shall not be included in the puncture energy, which, therefore, is restricted to that deflection, at which the force drops to half the maximum force F_M .

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3.10 impact failure

mechanical behaviour of the material under test which may be either one of the following types:

- a) YD yielding followed by deep drawing, see [figureFigure 1](#)
- b) YS yielding followed by an at least partially stable cracking, see [figureFigure 2](#)
- c) YU yielding followed by unstable cracking, see [figureFigure 3](#)
- d) NY no yielding, see [figureFigure 4](#)

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Note 1 to entry: The classification of the type of failure shall take into account the shape of the curve as well as the assessment of the broken specimen.

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Note 2 to entry: Yielding is characterised by a zero slope at maximum force in the force deflection diagram, or by whitening of the material in the area of puncture, or by a significant reduction of the material thickness in the area where the break appears.

Note 13 to entry: Comparison of Figures 2 and 3 shows puncture deflection l_p and puncture energy E_p are identical for the failure types YS and YU. As shown in Figure 4, identical values at maximum and at puncture are found for the deflection as well as the energy in the case of failure type NY. For complex behaviour see [annexAnnex A](#).

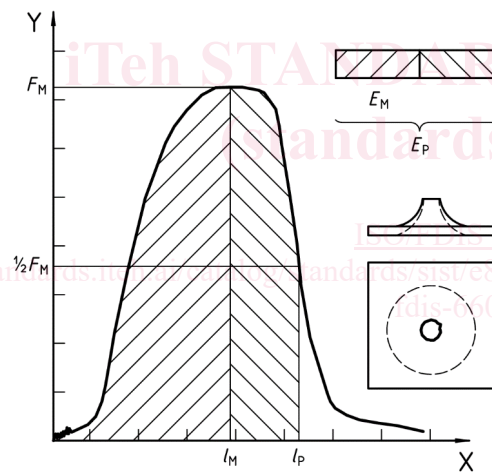
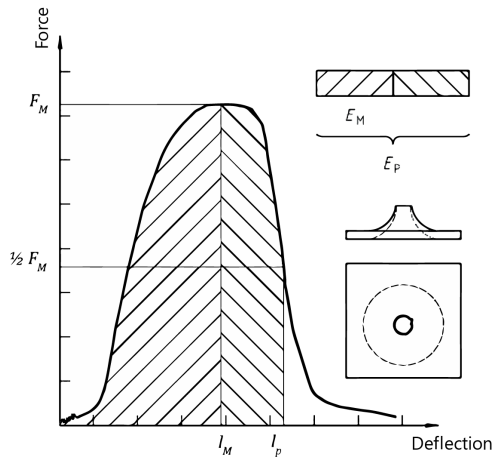
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Note 24 to entry: For more guidance on the classification of failure types, see the informative [annexAnnex F](#).

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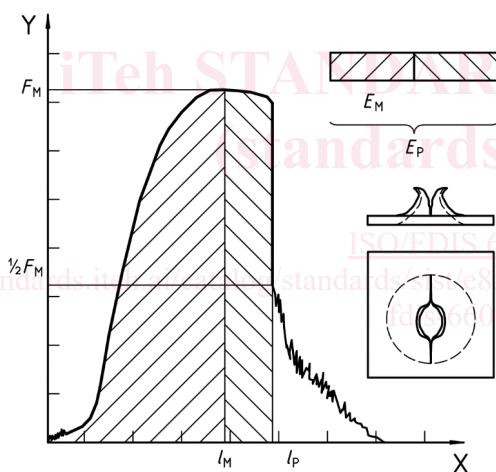
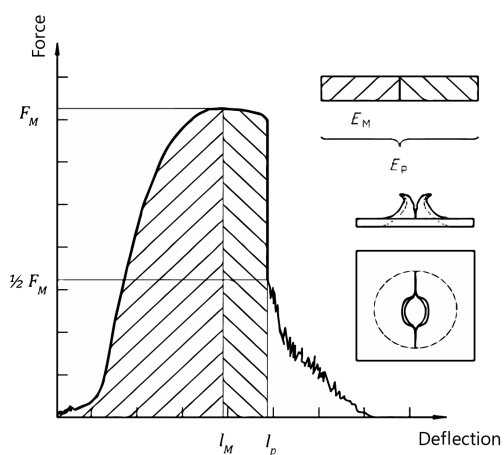
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Key
X deflection
Y force

Figure 1 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by deep drawing, and typical appearance of specimens after testing (with lubrication)

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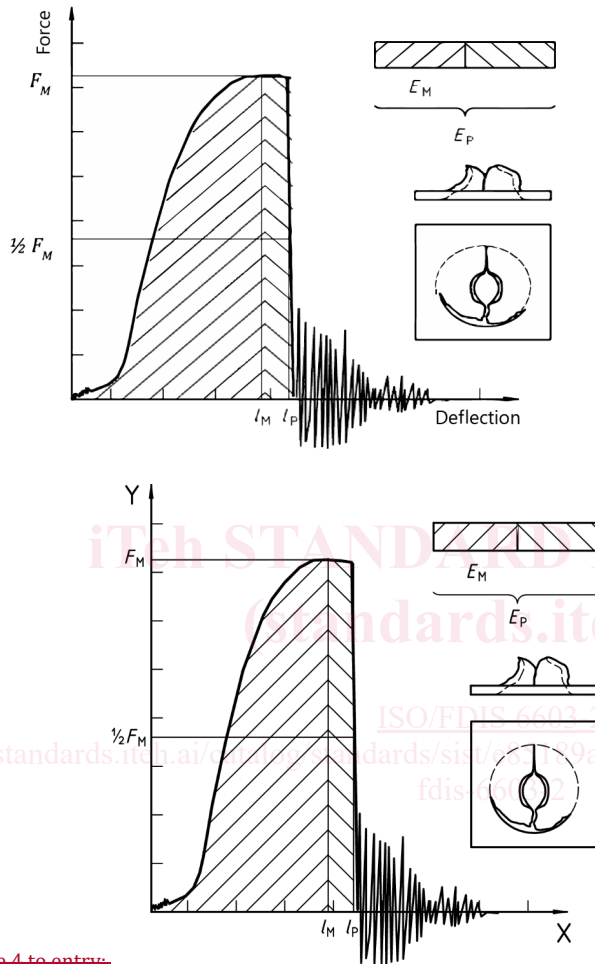
Key

- X deflection
- Y force

Figure 2 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by stable crack growth, and typical appearance of specimens after testing (with lubrication)

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Note 4 to entry: _____

Key

X deflection

Y force

NOTE Natural vibration of the force measurement system appears after unstable cracking (striker and load cell).

Figure 3 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by unstable crack growth, and typical appearance of specimens after testing (with lubrication)

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