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Plastics — Determination of Charpy impact properties —

Part 2: Instrumented impact test

Plastiques — Détermination des caractéristiques au choc Charpy —

Partie 2: Essai de choc instrumenté

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*, 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 second edition cancels and replaces the first edition (ISO 179-2:1997), which has been technically revised. It also incorporates the Technical Corrigendum ISO 179-2:1997/Cor 1:1998 and the Amendment ISO 179-2:1997/Amd 1:2011.

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

— references to ISO 13802:2015 have been updated;

— force calibration requirements have been clarified;

— a new subclause for the determination of test speed when using falling mass instruments has been added (see 5.1.6).

A list of all parts of the ISO 179 series can be found on the ISO website.

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.

Plastics — Determination of Charpy impact properties —

Part 2: Instrumented impact test

1 Scope

1.1 This document specifies a method for determining Charpy impact properties of plastics from force-deflection diagrams. Different types of rod-shaped test specimens and test configurations, as well as test parameters depending on the type of material, the type of test specimen and the type of notch, are defined in ISO 179-1.

Dynamic effects such as load-cell/striker resonance, test specimen resonance and initial-contact/inertia peaks are described in this document (see Figure 1, Curve b, and Annex A).

1.2 ISO 179-1 is suitable for characterizing the impact behaviour by the impact strength only and for using apparatus whose potential energy is matched approximately to the particular energy to break to be measured (see ISO 13802:2015, Annex E). This document is used to record a force-deflection or force-time diagram for detailed characterization of the impact behaviour, and for developing automatic apparatus, i.e. avoiding the need to match energy.

The method described in this document is also suitable for:

— acquiring more and different materials characteristics under impact conditions;

— supervising the Charpy test procedure, as this instrumentation allows detection of typical operational mistakes, such as the specimen not being in close contact with the supports;

— automatically detecting the type of break;

— pendulum type instruments to avoid frequent changes of pendulum hammers;

— measuring fracture mechanical properties described in other ISO standards.

1.3 For the range of materials which can be tested by this method, see ISO 179-1:2010, Clause 1.

1.4 For the general comparability of test results, see ISO 179-1:2010, Clause 1.

1.5 Information on the typical behaviour of materials can be obtained by testing at different temperatures, by varying the notch radius and/or specimen thickness and by testing specimens prepared under different conditions.

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

1.6 The test results obtained with this method are comparable only if the conditions of test specimen preparation, as well as the test conditions, are the same. The impact behaviour of finished products cannot, therefore, be predicted directly from this test.

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 179-1:2010, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

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

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

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

ISO 13802:2015, *Plastics — Verification of pendulum impact-testing machines — Charpy, Izod and tensile impact-testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 179-1 and the following 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
impact velocity
v_I
velocity of the striker relative to the test specimen supports at the moment of impact

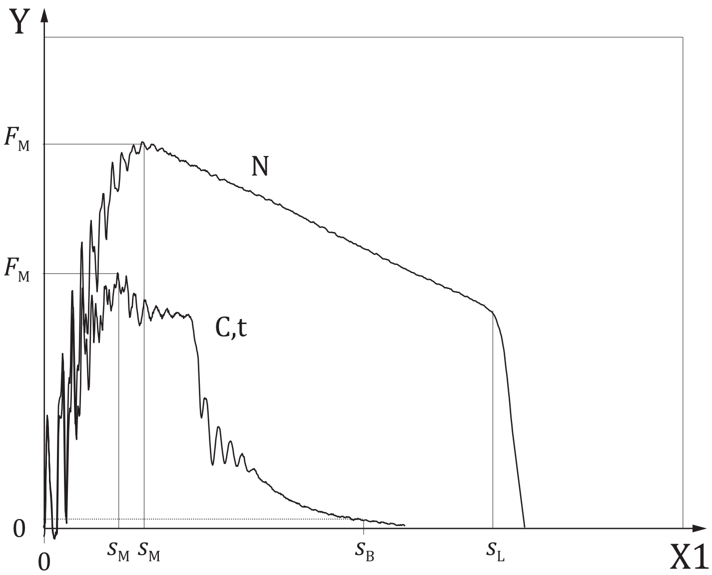
Note 1 to entry: It is expressed in metres per second (m/s).

3.2
inertial peak
first peak in a force-time or force-deflection diagram

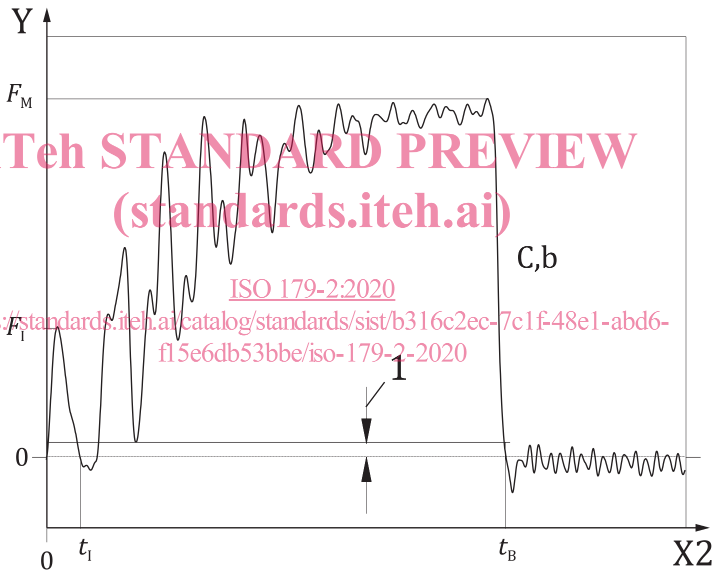
Note 1 to entry: Inertial peak arises from the inertia of that part of the test specimen accelerated after the first contact with the striker (see Figure 1, Curve b, and Annex A).

3.3
impact force
F
force exerted by the striking edge on the test specimen in the direction of impact

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



a) Force-deflection (N and C,t)



b) Force-time (C,b)

Key

X1 deflection (s) after impact in millimetres
X2 time after impact in milliseconds, ms
Y force (F) in newtons, N
F_M maximum impact force
F_I peak force of inertial peak
s_M deflection at maximum impact force F_M
s_L limiting deflection, beginning off pull-through
t_B time at break
s_B deflection at break
N no break, specimen pulled through
C,t complete break, tough
C,b complete break, brittle
1 5% of the maximum impact force

NOTE For the types of failure, see Figure 2.

Figure 1 — Typical force-deflection and force-time curves

3.4
deflection
s
displacement of the striker relative to the test specimen supports after impact, starting at first contact between striker and test specimen

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

3.5
impact energy
W
energy expended in accelerating, deforming and breaking the test specimen during the *deflection* (3.4)

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

3.6
maximum impact force
F_M
maximum value of the *impact force* (3.3) in a force-time or force-deflection diagram

Note 1 to entry: See Figure 1.

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

3.7
deflection at maximum impact force
s_M
deflection (3.4) at which the *maximum impact force* (3.6) occurs

Note 1 to entry: See Figure 1.

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

3.8
energy to maximum impact force
W_M
energy expended up to the *deflection at maximum impact force* (3.7)

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

3.9
deflection at break
s_B
deflection (3.4) at which the impact force is reduced to less than or equal to 5 % of the *maximum impact force* (3.6)

Note 1 to entry: See Figure 1.

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

3.10
impact energy at break
W_B
impact energy (3.5) up to the *deflection at break* (3.9)

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

3.11
Charpy impact strength
Charpy notched impact strength
a_{cU} (a_{cN})
impact energy at break (3.10) relative to the initial central cross-sectional area A (A_N) of the unnotched (notched) specimen

Note 1 to entry: It is expressed in kilojoules per square metre (kJ/m^2).

Note 2 to entry: See 8.4 and ISO 179-1:2010, 3.1 and 3.2.

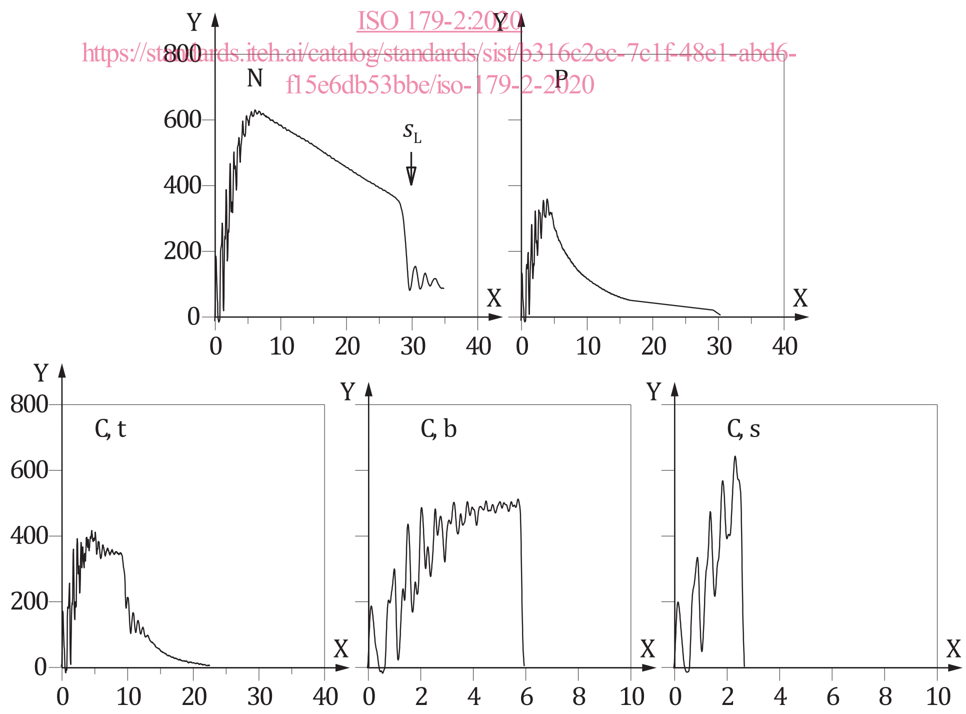
3.12
type of failure
type of deformation behaviour of the material under test up to and including the breaking event

Note 1 to entry: Failure types are: *complete break* (3.13), *hinge break* (3.14), *partial break* (3.15), *non-break* (3.16). See Figure 2.

Note 2 to entry: Types t, b and s represent subgroups of the complete break C and hinge break H defined below. For these types, values of the impact energy at break W_B, and thus for the Charpy impact strength, may be averaged to give a common mean value. For specimens giving a partial break P and for materials exhibiting interlaminar shear fracture, see ISO 179-1:2010, 7.7. For specimens showing more than one failure type, see ISO 179-1:2010, 7.7 and ISO 179-1:2010, Clause 10 l).

Note 3 to entry: As can be seen from Figure 2, the deflection and the impact energy at maximum force are identical to the deflection and impact energy at break in the case of splintering failure (see Curve s) and brittle failure (see Curve b), where unstable cracking takes place at the maximum impact force.

Note 4 to entry: Usually, complete and hinge breaks cannot be differentiated in an automatic assessment based on the force-time or force deflection-curve.



Key

N *no break* (3.16)

P *partial break* (3.15)

C *complete break* (3.13)

s_L deflection limit; beginning of pull-through

x deflection s after impact in millimetres

y impact force in newtons, N

NOTE 1 Due to the different modes of deformation, force-deformation curves obtained using this document show features which are different from those obtained using ISO 6603-2[1]. In particular, the first damage event in instrumented puncture tests frequently appears as a slight sudden force decrease (crack initiation), followed by a gradual force increase. Force increases after crack initiation are never observed in instrumented three-point-bending impact tests. Furthermore, inertial effects are not as pronounced in plate impact tests as they are in bending impacts tests (see Annex A).

NOTE 2 The distinction between break types P and C,t is difficult. As there is some extent of unstable crack growth in the F-s-diagram labelled C,t, the breaking behaviour was rated as less ductile than in case P when drafting the document. Therefore, the letter "t" was used instead of "d", which could be associated with ductile behaviour and would better apply to break types N and P.

NOTE 3 This document can be applied to automatic testing routines. For this it is also necessary to automatically assign the types of break by a suitable assessment of the force-time or force deflection traces observed. The table below is an example of assessment rules that have been used successfully. Both rules are to be met for assignment.

Type of break	Rule for deflection	Rule for force
Non break	$s_B \geq s_L$ s_L = 31mm	$F(s_L)$ $c*F_M$ The factor c was determined experimentally and set to c = 0,3
Partial break	$s_B \geq s_L$	$F_0 \leq F(s_L) \leq c*F_M$ F_0 is the level of force at which the test is considered to be finished, e.g. $F_0 = 0{,}05*F_M$
Complete break	Type s: $(s_B - s_M) \leq 1$mm	
	Type b: $(s_B - s_D) \leq 2$mm	
	Type t: $(s_B - s_D) \geq 2$mm s_D is the deflection after s_M, where the steepest decline of the F-s-curve occurs	

Figure 2 — Typical force-deflection curves showing different failure modes for Type 1 specimens tested edgewise

3.13
complete break
C
break where the specimen separates into two or more pieces, subdivided in the following behaviours:

Note 1 to entry: See Figure 2.

3.13.1
tough break
t
yielding followed by stable cracking, resulting in a force at the deflection limit s_L which is less than or equal to 5 % of the maximum force

3.13.2
brittle break
b
yielding followed by unstable cracking

3.13.3
splintering break
s
unstable cracking followed by splintering

3.14
hinge break
H
incomplete break, such that one part of the specimen cannot support itself above the horizontal when the other part is held vertically (less than 90° included angle)

3.15
partial break
P
incomplete break that does not meet the definition for a hinge or complete break

Note 1 to entry: For automatic detection resulting in a force at the deflection limit s_L which is greater than 5 % of the maximum force.

3.16
non-break
N
yielding followed by plastic deformation up to the deflection limit, s_L

Note 1 to entry: The test specimen shows extended plastic deformation but no visible fracture surfaces.

4 Principle

A rod-shaped test specimen, supported near its ends as a horizontal beam, is impacted perpendicularly, with the line of impact midway between the supports, and bent at a high, nominally constant velocity. During the impact, the impact force is recorded as a function of time and/or deflection. Depending on the method of evaluation, the deflection of the specimen may be either measured directly by suitable measuring devices or, in the case of energy carriers which give a frictionless impact, calculated from the initial velocity and the force as a function of time. The force-deflection diagram obtained in these tests describes the high-bending-rate impact behaviour of the specimen from which several aspects of the material properties may be inferred.

5 Apparatus

5.1 Test machine

5.1.1 Basic components

The basic components of the test machine are the energy carrier, the striker and the frame with its specimen supports. The energy carrier may be of the inertial type (e.g. a pendulum or free-falling dart, which may be spring- or pneumatically assisted before impact) or of the hydraulic type.

The test machine shall ensure that the specimen is bent by the impact at a nominally constant velocity perpendicular to the specimen length. The force exerted on the specimen shall be measurable, and its deflection in the direction of impact shall be derivable or measurable.

If the test machine is of the pendulum type it shall be verified according to ISO 13802:2015, Clause 6 and Annex A, as applicable.

5.1.2 Energy carrier

For the low-energy pendulum types specified in ISO 179-1 (see also ISO 13802:2015, Annex A), the impact velocity, v_I, is (2,90 ± 0,15) m/s and for the high-energy types it is (3,8 ± 0,2) m/s. For the purposes