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Plastics — Determination of Charpy impact properties —

Part 1: Non-instrumented impact test

Plastiques — Détermination des caractéristiques au choc Charpy —

Partie 1: Essai de choc non instrumenté

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 179 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 179-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

It cancels and replaces ISO 179:1993, which has been technically revised.

ISO 179 consists of the following parts, under the general title *Plastics — Determination of Charpy impact properties*:

— *Part 1: Non-instrumented impact test*

— *Part 2: Instrumented impact test*

Annexes A and B of this part of ISO 179 are for information only.

Plastics — Determination of Charpy impact properties —

Part 1:
Non-instrumented impact test

1 Scope

1.1 This part of ISO 179 specifies a method for determining the Charpy impact strength of plastics under defined conditions. A number of different types of specimen and test configurations are defined. Different test parameters are specified according to the type of material, the type of test specimen and the type of notch.

1.2 The method is used to investigate the behaviour of specified types of specimen under the impact conditions defined and for estimating the brittleness or toughness of specimens within the limitations inherent in the test conditions. It may also be used for the determination of comparative data from similar types of material.

1.3 The method has a greater range of applicability than that given in ISO 180[1)] and is more suitable for the testing of materials showing interlaminar shear fracture or of materials exhibiting surface effects due to environmental factors.

1.4 The method is suitable for use with the following range of materials:

— rigid thermoplastic moulding and extrusion materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheets;

— rigid thermosetting moulding materials, including filled and reinforced compounds; rigid thermosetting sheets, including laminates;

— fibre-reinforced thermosetting and thermoplastic composites incorporating unidirectional or non-unidirectional reinforcements such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings and milled fibres, sheet made from pre-impregnated materials (prepregs), including filled and reinforced compounds;

— thermotropic liquid-crystal polymers.

1.5 The method is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material. Also, notched specimens are not normally used for long-fibre-reinforced composites or thermotropic liquid-crystal polymers.

1.6 The method is suited to the use of specimens which may be either moulded to the chosen dimensions, machined from the central portion of a standard multipurpose test specimen (see ISO 3167) or machined from finished or semifinished products such as mouldings, laminates and extruded or cast sheet.

1.7 The method specifies preferred dimensions for the test specimen. Tests which are carried out on specimens of different dimensions or with different notches, or specimens which are prepared under different conditions, may produce results which are not comparable. Other factors, such as the energy capacity of the apparatus, its impact

1) ISO 180:2000, *Plastics — Determination of Izod impact strength*.

velocity and the conditioning of the specimens can also influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

1.8 The method should not be used as a source of data for design calculations. Information on the typical behaviour of a material can be obtained, however, by testing at different temperatures, by varying the notch radius and/or the thickness and by testing specimens prepared under different conditions.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 179. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 179 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*.

ISO 293:1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294-1:1996, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens.*

ISO 294-3:1996, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 3: Small plates.*

ISO 295:1991, *Plastics — Compression moulding of test specimens of thermosetting materials*.

ISO 1268:1974[2)], *Plastics — Preparation of glass fibre reinforced, resin bonded, low pressure laminated plates or panels for test purposes*.

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*.

ISO 2818:1994, *Plastics — Preparation of test specimens by machining*.

ISO 3167:—[3)], *Plastics — Multipurpose test specimens.*

ISO 10724-1:1998, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens.*

ISO 13802:1999, *Plastics — Verification of pendulum impact-testing machines — Charpy, Izod and tensile impact-testing.*

3 Terms and definitions

For the purposes of this part of ISO 179, the following terms and definitions apply.

2) Under revision as a series of 11 parts.

3) To be published. (Revision of ISO 3167:1993)

3.1
Charpy unnotched impact strength
a_{cU}
impact energy absorbed in breaking an unnotched specimen, referred to the original cross-sectional area of the specimen

NOTE It is expressed in kilojoules per square metre (kJ/m^2).

3.2
Charpy notched impact strength
a_{cN}
impact energy absorbed in breaking a notched specimen, referred to the original cross-sectional area of the specimen at the notch, where N = A, B or C depending on the notch type (see 6.3.1.1.2)

NOTE It is expressed in kilojoules per square metre (kJ/m^2).

3.3
edgewise impact
e
direction of blow parallel to the dimension b, with impact on the narrow longitudinal surface $h \times l$ of the specimen (see Figure 1, left, and Figures 2 and 4)

3.4
flatwise impact
f
direction of blow parallel to the dimension h, with impact on the broad longitudinal surface $b \times l$ of the specimen (see Figure 1, right, and Figures 3 and 4)

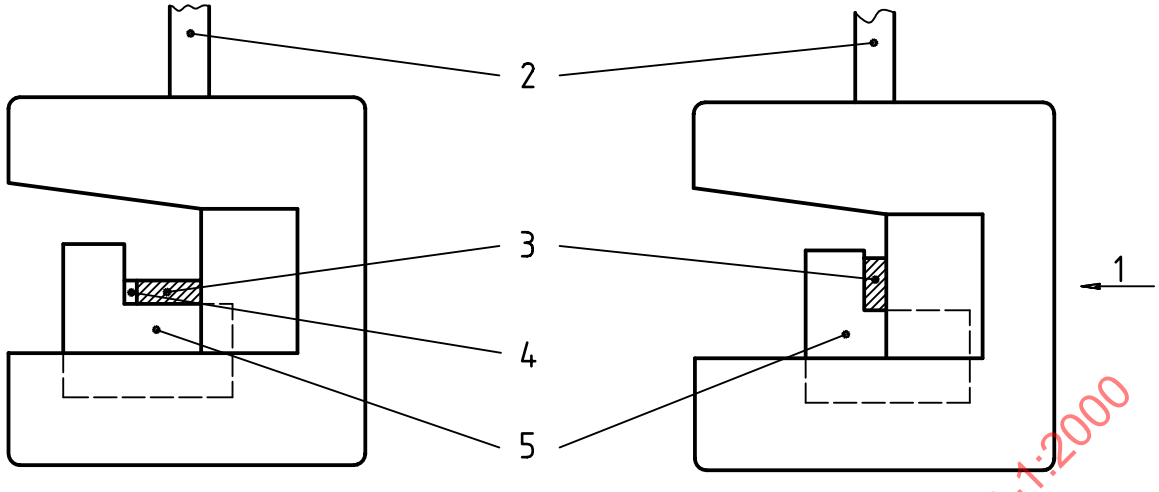
3.5
normal impact
n
⟨laminar-reinforced plastics⟩ impact with the direction of blow normal to the plane of reinforcement (see Figure 4)

3.6
parallel impact
p
⟨laminar-reinforced plastics⟩ impact with the direction of blow parallel to the plane of reinforcement (see Figure 4)

4 Principle

The test specimen, supported near its ends as a horizontal beam, is impacted by a single blow of a striker, with the line of impact midway between the supports, and bent at a high, nominally constant, velocity.

In the case of edgewise impact with notched specimens, the line of impact is directly opposite the single notch (see Figure 1, left, and Figure 2).



Key

1 Direction of blow
2 Rod of pendulum
3 Test specimen
4 Notch
5 Support

Figure 1 — Striking edge and support blocks for type 1 test specimen at moment of impact

5 Apparatus

5.1 Test machine

The principles, characteristics and verification of suitable test machines are detailed in ISO 13802.

5.2 Micrometers and gauges

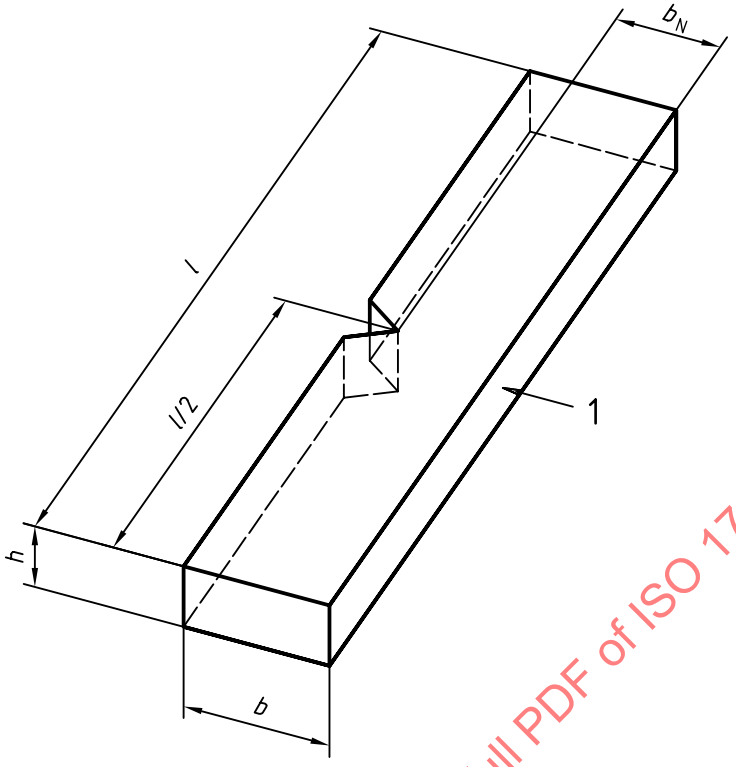
Micrometers and gauges capable of measuring the essential dimensions of test specimens to an accuracy of 0,02 mm are required. For measuring the dimension b_N of notched specimens, the micrometer shall be fitted with an anvil of width 2 mm to 3 mm and of suitable profile to fit the shape of the notch.

6 Test specimens

6.1 Preparation

6.1.1 Moulding and extrusion compounds

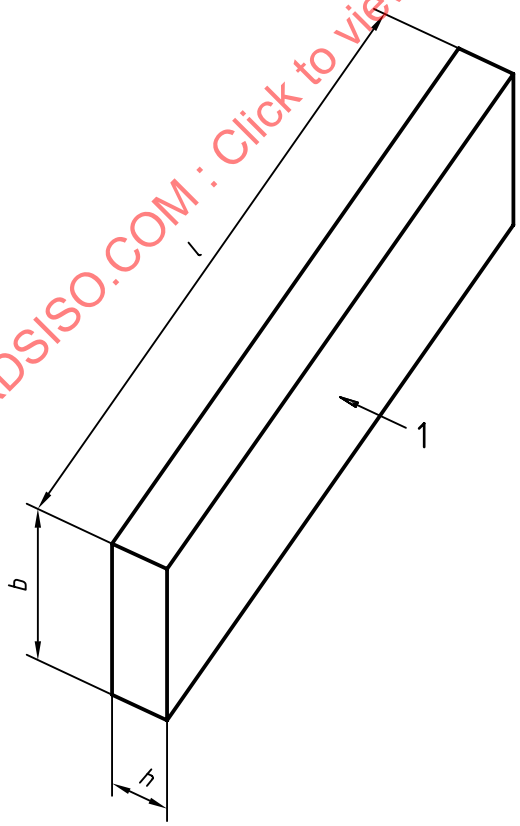
Specimens shall be prepared in accordance with the relevant material specification. When none exists, and unless otherwise specified, specimens shall be either directly compression moulded or injection moulded from the material in accordance with ISO 293, ISO 294-1, ISO 294-3, ISO 295 or ISO 10724-1 as appropriate, or machined in accordance with ISO 2818 from sheet that has been compression or injection moulded from the compound. Type 1 specimens may be cut from multipurpose test specimens complying with ISO 3167, type A.



Key

1 Direction of blow

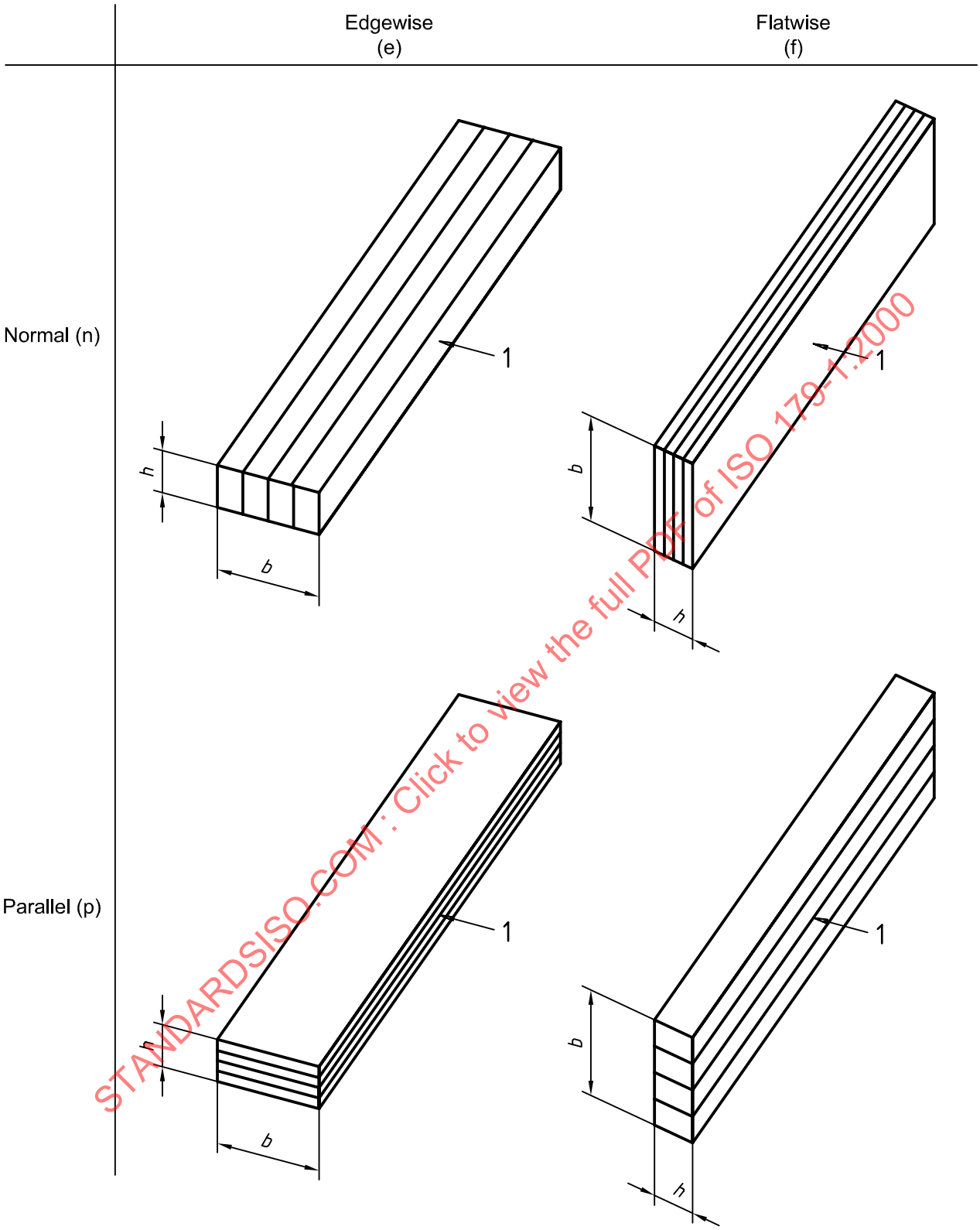
Figure 2 — Charpy edgewise impact (e) with single-notched specimen



Key

1 Direction of blow

Figure 3 — Charpy flatwise impact (f)



Key

1 Direction of blow

Edgewise (e) and flatwise (f) indicate the direction of the blow with respect to the specimen thickness h and specimen width b. Normal (n) and parallel (p) indicate the direction of the blow with respect to the laminate plane.

The Charpy "fn" and "ep" tests are used for laminates, while the Charpy "e" test is used for all other materials. The Charpy "f" test is used for testing materials exhibiting surface effects.

Figure 4 — Scheme of designations describing the direction of blow

6.1.2 Sheets

Specimens shall be machined from sheets in accordance with ISO 2818.

6.1.3 Long-fibre-reinforced materials

A panel shall be prepared in accordance with ISO 1268 or another specified or agreed upon preparation procedure. Specimens shall be machined in accordance with ISO 2818.

6.1.4 Checking

The specimens shall be free of twist and shall have mutually perpendicular parallel surfaces. The surfaces and edges shall be free from scratches, pits, sink marks and flash.

The specimens shall be checked for conformity with these requirement by visual observation against straightedges, squares and flat plates, and by measuring with micrometer callipers.

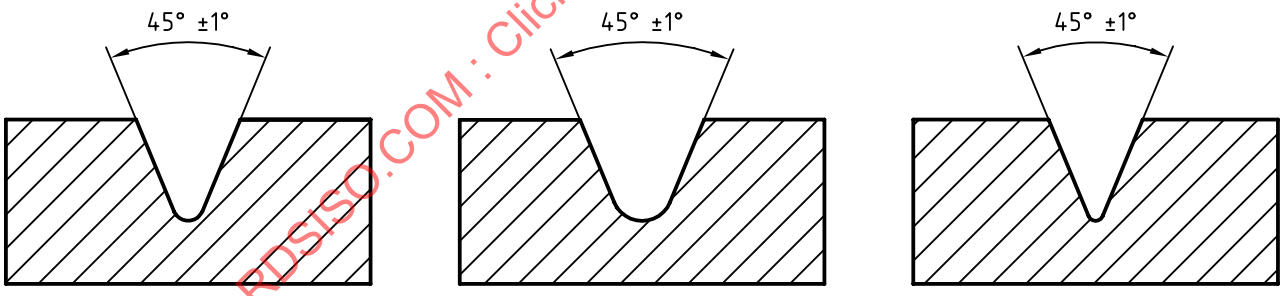
Specimens showing measurable or observable departure from one or more of these requirements shall be rejected or machined to proper size and shape before testing.

6.1.5 Notching

6.1.5.1 Machined notches shall be prepared in accordance with ISO 2818. The profile of the cutting tooth shall be such as to produce in the specimen a notch of the contour and depth shown in Figure 5, at right angles to its principal axes.

6.1.5.2 Specimens with moulded-in notches may be used if specified for the material being tested.

NOTE Specimens with moulded-in notches do not give results comparable to those obtained from specimens with machined notches.



Radius of notch base
r_N = 0,25 mm ± 0,05 mm
a) Type A

Radius of notch base
r_N = 1,00 mm ± 0,05 mm
b) Type B

Radius of notch base
r_N = 0,10 mm ± 0,02 mm
c) Type C

Figure 5 — Notch types

6.2 Anisotropy

Certain types of sheet or panel material may show different impact properties depending on the direction in the plane of the sheet or panel. In such cases, it is customary to cut groups of test specimens with their major axes respectively parallel and perpendicular to the direction of some feature of the sheet or panel which is either visible or inferred from knowledge of the method of manufacture.

6.3 Shape and dimensions

6.3.1 Materials not exhibiting interlaminar shear fracture

6.3.1.1 Moulding and extrusion compounds

6.3.1.1.1 Type 1 test specimens with one of three different types of notch shall be used as specified in Tables 1 and 2 and shown in Figures 2 and 5. The notch shall be located at the centre of the specimen. Type 1 specimens (see Table 1) may be taken from the central part of the type A multipurpose test specimen complying with ISO 3167.

Table 1 — Specimen types, dimensions and spans (see Figure 1)

Dimensions in millimetres

Specimen type	Length[a] l	Width[a] b	Thickness[a] h	Span L
1	80 ± 2	10,0 ± 0,2	4,0 ± 0,2	$62^{+0,5}_{-0,0}$
2[b]	25h	10 or 15[c]	3[d]	20h
3[b]	11h or 13h			6h or 8h

a The specimen dimensions (thickness h, width b and length l) are defined according to $h \leqslant b < l$.

b Specimen types 2 and 3 shall be used only for materials described in 6.3.2.

c 10 mm for materials reinforced with a fine structure, 15 mm for those with a large stitch structure (see 6.3.2.2).

d Preferred thickness. If the specimen is cut from a sheet or a piece, h shall be equal to the thickness of the sheet or piece, up to 10,2 mm (see 6.3.1.2)

Table 2 — Method designations, specimen types, notch types and notch dimensions — Materials not exhibiting interlaminar shear fracture

Dimensions in millimetres

Method designation[a]	Specimen type	Blow direction	Notch type	Notch base radius, r_N (see Figure 5)	Remaining width, b_N, at notch base (see Figure 2)
ISO 179-1/1eU[b]	1	Edgewise	Unnotched		
			Single notch		
ISO 179-1/1eA[b]			A	0,25 ± 0,05	8,0 ± 0,2
ISO 179-1/1eB			B	1,00 ± 0,05	8,0 ± 0,2
ISO 179-1/1eC			C	0,10 ± 0,02	8,0 ± 0,2
ISO 179-1/1fU[c]		Flatwise	Unnotched		

a If specimens are taken from sheet or products, the thickness of the sheet or product shall be added to the designation. Unreinforced specimens shall not be tested with their machined surface under tension.

b Preferred method.

c Especially for study of surface effects (see 6.3.1.1.3).

6.3.1.1.2 The preferred type of notch is type A (see Table 2 and Figure 5). For most materials, unnotched specimens or specimens with a single type A notch tested by edgewise impact (see 3.3) are suitable. If specimens with a type A notch do not break during the test, specimens with a type C notch shall be used. If information on the notch sensitivity of the material is desired, specimens with notch types A, B and C shall be tested.

6.3.1.1.3 Unnotched or double-notched specimens tested by flatwise impact (see 3.4) can be used to study surface effects (see 1.3 and annex A).

6.3.1.2 Sheet materials

The recommended thickness h is 4 mm. If the specimen is cut from a sheet or a piece taken from a structure, the thickness of the specimen, up to 10,2 mm, shall be the same as the thickness of the sheet or the structure.

Specimens taken from pieces thicker than 10,2 mm shall be machined to 10 mm ± 0,2 mm from one surface, providing that the sheet is homogeneous in its thickness and contains only one type of reinforcement uniformly distributed. If unnotched or double-notched specimens are tested by flatwise impact, the original surface shall be tested under tension.

6.3.2 Materials exhibiting interlaminar shear fracture (e.g. long-fibre-reinforced materials)

6.3.2.1 Unnotched specimens of type 2 or 3 are used. There are no specified specimen sizes. The only important parameter is the ratio of the span to the specimen dimension in the direction of the blow (see Table 1).

Usually specimens are tested in the normal direction (see Figure 4).

6.3.2.2 "Flatwise normal" testing (see Figure 4): the width of specimen shall be 10 mm for materials reinforced with a fine structure (thin fabrics and parallel yarns) and 15 mm for materials reinforced with a large stitch structure (roving fabrics) or an irregularly manufactured structure.

6.3.2.3 "Edgewise parallel" testing (see Figure 4): when testing specimens in the parallel direction, the specimen dimension perpendicular to the blow direction shall be the thickness of the sheet from which the specimen was cut.

6.3.2.4 The length l of the specimen shall be chosen according to the span-to-thickness ratio L/h of 20 (for type 2 specimens) and 6 (for type 3 specimens) as indicated in Table 1.

If the apparatus does not allow a ratio L/h = 6, a ratio L/h = 8 may be used, especially for thin sheets.

6.3.2.5 With type 2 specimens, tensile-type failure occurs; with type 3 specimens, interlaminar shear failure of the sheet can occur. The different types of failure which can occur are summarized in Table 3.

NOTE In some cases (thin-fabric reinforcement), shear failure does not occur. In the case of type 3 specimens, the fracture initiates as a single or multiple-shear failure and continues as tensile failure.

6.4 Number of test specimens

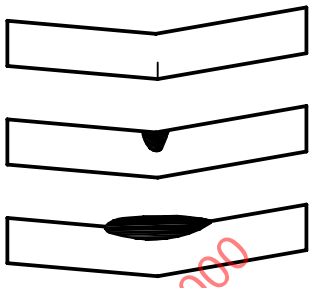
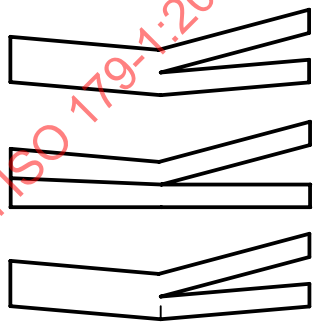
6.4.1 Unless otherwise specified in the standard for the material being tested, a set consisting of 10 specimens shall be tested. When the coefficient of variation (see ISO 2602) has a value of less than 5 %, a minimum number of five test specimens is sufficient.

6.4.2 If laminates are tested in the normal and parallel directions, 10 specimens shall be used for each direction.

6.5 Conditioning

Unless otherwise specified in the standard for the material under test, the specimens shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity in accordance with ISO 291, unless other conditions are agreed upon by the interested parties. In the case of notched specimens, the conditioning time is after notching.

Table 3 — Method designation and specimen types — Materials exhibiting interlaminar shear fracture

Method designation	Specimen type	L/h	Type of failure		Schematic
ISO 179-1/2 n or p[a]	2	20	Tension	t	
			Compression	c	
			Buckling	b	
ISO 179-1/3 n or p[a]	3	6 or 8	Shear	s	
			Multiple shear	ms	
			Shear followed by tensile fracture	st	

[a] "n" is the normal direction and "p" is the parallel direction with respect to the sheet plane (see Figure 4).

7 Procedure

7.1 Conduct the test in the same atmosphere as that used for conditioning, unless otherwise agreed upon by the interested parties, e.g. for testing at high or low temperatures.

7.2 Measure the thickness h and width b of each test specimen, in the centre, to the nearest 0,02 mm. In the case of notched specimens, carefully measure the remaining width b_N to the nearest 0,02 mm.

In the case of injection-moulded specimens, it is not necessary to measure the dimensions of each specimen. It is sufficient to measure one specimen from a set to make sure that the dimensions correspond to those in Table 1. With multiple-cavity moulds, ensure that the dimensions of the specimens are the same for each cavity.

In the case of type 2 or type 3 specimens, adjust the span L in accordance with Table 1.

7.3 Check that the impact machine is able to perform the test with the specified velocity of impact and that it is in the correct range of absorbed energy W which shall be between 10 % and 80 % of the available energy at impact, E. If more than one of the pendulums conform to these requirements, the pendulum having the highest energy shall be used.

7.4 Determine the frictional losses and correct the absorbed energy in accordance with ISO 13802.

7.5 Lift the pendulum to the prescribed height and support it. Place the specimen on the supports in the machine in such a manner that the striking edge will hit the centre of the specimen. Carefully align notched specimens so that the centre of the notch is located directly in the plane of impact (see Figure 1, left).

7.6 Release the pendulum. Record the impact energy absorbed by the specimen and apply any necessary corrections for frictional losses, etc. (see 7.4).

7.7 For moulding and extrusion compounds, four types of failure designated by the following code-letters may occur:

C complete break: a break in which the specimen separates into two or more pieces

H hinge break: an incomplete break such that both parts of the specimen are held together only by a thin peripheral layer in the form of a hinge having low residual stiffness

P partial break: an incomplete break that does not meet the definition for hinge break

N non-break: there is no break, and the specimen is only bent and pushed through the support blocks, possibly combined with stress whitening

8 Calculation and expression of results

8.1 Unnotched specimens

Calculate the Charpy impact strength of unnotched specimens, a_{cU}, expressed in kilojoules per square metre, using the following equation:

$$a_{cU} = \frac{E_c}{h \cdot b} \times 10^3 \quad (1)$$

where

E_c is the corrected energy, in joules, absorbed by breaking the test specimen;

h is the thickness, in millimetres, of the test specimen;

b is the width, in millimetres, of the test specimen.

8.2 Notched specimens

Calculate the Charpy impact strength of notched specimens, a_{cN}, expressed in kilojoules per square metre, with notches A, B or C, using the following equation:

$$a_{cN} = \frac{E_c}{h \cdot b_N} \times 10^3 \quad (2)$$

where

E_c is the corrected energy, in joules, absorbed by breaking the test specimen;

h is the thickness, in millimetres, of the test specimen;

b_N is the remaining width, in millimetres, of the test specimen.

8.3 Statistical parameters

Calculate the arithmetic mean of the test results and, if required, the standard deviation of the mean value using the procedure given in ISO 2602. For different types of failure within one sample, the relevant numbers of specimens shall be given and mean values shall be calculated.

8.4 Significant figures

Report all calculated mean values to two significant figures.

9 Precision

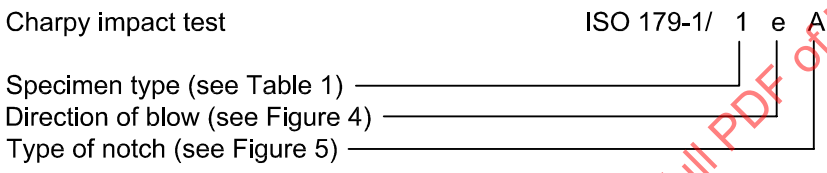
See annex B.

10 Test report

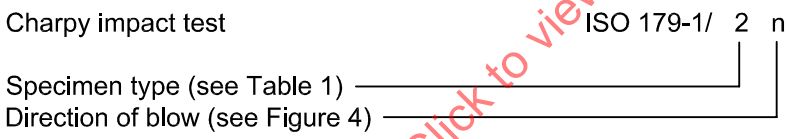
The test report shall include the following information:

a) a reference to this part of ISO 179;

b) the method used, designated in accordance with Table 2, e.g.:



or according to Table 3, e.g.:



c) all information necessary for identification of the material tested, including type, source, manufacturer's code, grade and history, where these are known;

d) a description of the nature and form of the material, i.e. whether a product, semifinished product, test plate or specimen, including principal dimensions, shape, method of manufacture, etc., where these are known;

e) the velocity of impact;

f) the nominal pendulum energy;

g) the method of test specimen preparation;

h) if the material is in the form of a product or a semifinished product, the orientation of the test specimen in relation to the product or semifinished product from which it was cut;

i) the number of specimens tested;

j) the standard atmosphere used for conditioning and testing, plus any special conditioning treatment if required by the standard for the material or product;

k) the type(s) of failure observed;

l) the individual test results, presented as follows (see also Table 4):

1) group the results according to the three basic types of failure:

C complete break, including hinge break H

P partial break

N non-break

2) select the most frequent type and record the mean value x of the impact strength for this type of failure, followed by the letter C or P for the type of failure,

3) if the most frequent failure type is N, record the letter N only,

4) add (between brackets) the letter C, P or N for the second most frequent failure type, but only if its frequency is higher than 1/3 (if not relevant, insert an asterisk);

m) the standard deviations of the mean values, if required;

n) the date(s) of the test.

Table 4 — Presentation of results

Type of failure			Designation
C	P	N	
x	*	*	xC*
x	(P)	*	xC(P)
x	*	(N)	xC(N)
*	x	*	xP*
(C)	x	*	xP(C)
*	x	(N)	xP(N)
*	*	N	N*
(C)	*	N	N(C)
*	(P)	N	N(P)

x	Mean value of impact strength for most frequent failure type, excluding type N.
C, P or N	Most frequent failure type.
(C), (P) or (N)	Second most frequent failure type, to be recorded only if its frequency is higher than 1/3.
*	Not relevant.