

JIS

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS K 7111 – 1996

**Plastics — Determination of Charpy
impact strength**

UDC 678. 07 : 620. 178. 7

K 7111-1996

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

Date of Establishment: 1971-11-01

Date of Revision: 1996-10-20

Date of Public Notice in Official Gazette: 1996-10-21

Investigated by: Japanese Industrial Standards Committee
Divisional Council on High-Molecular
Materials

JIS K 7111-1996, First English edition published in 1997-05

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107 JAPAN

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Printed in Japan

Plastics — Determination of Charpy impact strength

Introduction This is the Japanese Industrial Standard prepared on the basis of ISO 179: 1993, *Plastics — Determination of Charpy impact strength*, without alteration of the technical contents and of the form of standard. This Standard has been prepared without any alteration of the technical contents except the content specified below.

[Outline of the difference in content of specification]

The methods of Charpy impact test for rigid plastics which were so far specified in former Japanese Industrial Standard are specified in Annexes 1 to 4.

1 Scope

1.1 This Japanese Industrial Standard specifies the test method for determination of Charpy impact strength of plastics under defined conditions. This Standard defines many different types of specimen. The type of test specimen and type of notch are specified in the standard of material.

1.2 This test method is employed to evaluate such as the behaviour of a test specimen and the brittleness or toughness of a specimen, under defined inherent impact condition. This test method has a greater range of applicability than that given in ISO 180 — *Determination of Izod impact strength*, and is suitable for the material showing interlaminar shear fracture strength or for the material easily influenced by environmental factors.

1.3 The test method is suitable for the following range of materials:

- rigid thermoplastics moulding and extrusion materials, including compounds containing filler and reinforcement; rigid thermoplastics sheets;
- rigid thermosetting moulding including compounds containing filler and reinforcement; rigid thermosetting sheets including laminates;
- fibre-reinforced thermoset and thermoplastics composites incorporating unidirectional or non-unidirectional reinforcements such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings, and milled fibres; sheets made from pre-impregnated materials (prepregs);
- thermotropic liquid-crystal polymers.

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

1.4 This test method is adopted to the use of specimens which are either moulded to the specified dimensions, or which are composed of central parallel portions made of a multipurpose test specimen (see JIS K 7139) by cutting off gripping part at both ends, or which are machined by cutting from finished or semifinished products such as mouldings, laminates, extruded sheet, and cast sheet.

1.5 This test method specifies preferred dimensions for the test specimen. The test results which are carried out on specimens of different dimensions and notches, or on specimens which are prepared under different conditions, cannot be compared each other. Other factors, such as the energy capacity of the pendulum, its impact velocity, and conditioning of the specimens can also influence the results. Consequently, when comparative data are required, these factors shall be carefully controlled and recorded.

1.6 The results came from this test method shall not be used as data for structural design. Information on the typical behaviour of a material can be obtained, however, by testing the test specimen at different temperatures or by changing the notch radius and/or thickness of the test specimen.

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the normative references were valid with respect to the standards of editions shown here. Because all standards are subject to revision, the parties, who are employing this Standard, are encouraged to investigate the possibility of applying the most recent editions of the cited standards.

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

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

Informative reference: JIS K 7151 *Plastics — Compression moulding test specimens of thermoplastic materials* coincides with this International Standard.

ISO 294:1995 *Plastics — Injection moulding of test specimens of thermoplastic materials*

Informative reference: JIS K 7152 *Plastics Injection moulding of test specimens of thermoplastic materials* coincides with this International Standard.

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

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

ISO 2557-1:1989 *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion — Part 1: Bars*

Note (1) ISO 2557-1 will be abrogated with the revision of ISO 294.

ISO 2557-2:1986 *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified reversion — Part 2: Plates*

Note (2) ISO 2557-2 will be abrogated with the revision of ISO 294.

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 3167:1993 *Plastics — Multipurpose test specimens*

3 Definitions For the purpose of this Standard, the following definitions apply.

3.1 Charpy impact strength of unnotched specimens, a_{cU} : Impact energy absorbed in breaking an unnotched specimen, referred to the original cross-sectional area of the specimen. Unit kJ/m^2

3.2 Charpy impact strength of notched specimens, a_{cN} : Impact energy absorbed in breaking a notched specimen, referred to the original cross-sectional area of the specimen at the notch. Notch type (N) shall be any one of A, B or C (see 6.3.1.1.2). Unit 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 Fig. 1 left, Fig. 2, and Fig. 5).

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 Fig. 1 right, Fig. 3 and Fig. 5).

3.5 normal impact (n): Direction of blow normal to the plane of reinforcement. It is used for laminar-type reinforced plastics (see Fig. 5).

3.6 parallel impact (p): Direction of blow parallel to the plane of reinforcement (see Fig. 5).

4 Principle The test specimen, put on the horizontally set supports for the test specimen, is broken by a single swing of a pendulum which passes midway between the supports for the test specimen. In the case of edgewise impact on notched specimens, the impact surface is opposite to notched part (see Fig. 1 left and Fig. 2).

5 Apparatus

5.1 Testing machine

5.1.1 The testing machine shall be of the pendulum type and of rigid construction. This testing machine shall be capable of measuring the impact energy (W) absorbed in breaking a test specimen. The value of this energy is defined as the difference between the initial potential energy (E) of the pendulum before falling and the energy remained in the pendulum after breaking the test specimen. The energy shall be accurately corrected for losses due to friction and air resistance (see Table 1 and 7.4).

5.1.2 The machine shall have the characteristics shown in Table 1.

In order to apply this test to every material specified in 1.3, it is necessary to use more than one machine or to use the machine with interchangeable pendulums (see 7.3). It is not advisable to compare results obtained with different pendulums. The frictional losses shall be periodically checked.

Table 1 Characteristics of pendulum impact testing machines

Energy E (nominal) J	Velocity of impact V_0 m/s	Maximum permissible frictional loss without specimen (loadless test) J	Permissible error after correction with speci- men ¹⁾ J
0.5	2.9 ($\pm 10\%$)	0.02	0.01
1.0			0.01
2.0			0.01
4.0			0.02
5.0			0.02
7.5	3.8 ($\pm 10\%$)	0.04	0.05
15.0		0.05	0.05
25.0		0.10	0.10
50.0		0.20	0.10

Note 1) Absorbed energy shall not exceed the range from 10 % to 80 % of pendulum capacity.

5.1.3 The testing machine shall be securely fixed on a foundation having a mass at least 40 times that of the heaviest pendulum in use. The striker and specimen supports shall be adjusted in accordance with the specification in 5.1.4 and 5.1.6.

5.1.4 The striking edge of the pendulum shall be hardened steel tapered to an included angle of $30^\circ \pm 1^\circ$, and shall be rounded hemi-cylindrical with a radius (R_1) of $2 \text{ mm} \pm 0.5 \text{ mm}$. The striking edge shall pass midway (within $\pm 0.2 \text{ mm}$) between the test specimen supports, and shall linearly contact with the surface (width or thickness) of the test specimen (see Fig. 1). The line of contact shall be perpendicular, within $\pm 2^\circ$, to the longitudinal axis of the test specimen.

5.1.5 The distance between the axis of rotation of pendulum and the point of impact shall be within $\pm 1\%$ of the pendulum length (L_p).

Remarks 1 The pendulum length L_p (unit: m) may be determined experimentally from the period of small amplitude oscillations of the pendulum by means of the following equation.

$$L_p = \frac{g_n}{4\pi^2} \times T^2 \dots \dots \dots (1)$$

where, g_n : standard gravitational acceleration (9.81 m/s^2)

T : value obtained by dividing the duration needed for at least 50 consecutive swings (accuracy of $1/2000$) by the number of swings (unit: s).

The angle of swing shall be less than 5° from its centre.

5.1.6 The specimen supports shall be composed of two rigidly mounted smooth blocks, arranged so that the longitudinal axis of a perfectly rectangular test specimen is horizontal to within 1 part in 200, and so that the striking face of such a test specimen is parallel to the striking edge of the pendulum to within 1 part in 200 at the moment of impact. The specimen supports shall not disturb the movement of the specimen.

The shape of the supports shall be as shown in Fig. 1. The span (L) between two supports is the distance between the two contact lines of specimen on the supports, and shall be as specified in Table 2. Means shall be provided for the striker to blow centre of the test specimen, with tolerance of ± 0.5 mm or less. The distance between supports for test specimen shall be adjustable for each type of test specimen.

5.2 Micrometers and gauges Micrometers and gauges suitable for measuring the 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 compounds or extrusion compounds Specimens shall be prepared in accordance with the relevant material specification. When no standard exists, or unless otherwise specified, specimens shall be either directly compression moulded or injection moulded from the material in accordance with ISO 293, ISO 294, or ISO 295. Otherwise, they shall be prepared by cutting according to ISO 2818 from the sheet that has been compression or injection moulded from the compound.

Remarks 2 Type 1 specimens may be cut from multipurpose test specimens complying with ISO 3167 Type A.

Table 2 Specimen type, dimensions and span
between specimen supports (see Fig. 1)

Unit: mm

Specimen type ¹⁾	Length ²⁾ l	Width ²⁾ b	Thickness ²⁾ h	Span between specimen supports L
1	80 ± 2	10.0 ± 0.2	$4.0^{3)} \pm 0.2$	$62 \pm \begin{smallmatrix} 0.5 \\ 0 \end{smallmatrix}$
2 ⁴⁾	$25h$	10 or 15 ⁵⁾	3 ³⁾	$20h$
3 ⁴⁾	$(11 \text{ or } 13) h$			$(6 \text{ or } 8) h$

Notes 1) Attention is drawn to the changes in the type numbers of specimens from those used in ISO 179:1982.

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

3) Preferred thickness. If the specimen is cut from a sheet or moulding, its thickness can be made equal to the thickness of the sheet or moulding, up to 10.2 mm.

- 4) Specimen types 2 and 3 shall be used only for materials described in 6.3.2.
- 5) 10 mm for materials reinforced with a fine structure, and 15 mm with a large stitch structure (see 6.3.2.2).

6.1.2 Sheets Specimens shall be machined by cutting from sheets in accordance with ISO 2818.

6.1.3 Long-fibre-reinforced polymers A panel shall be prepared from moulding compounds in accordance with ISO 1268 or another specified or agreed between the parties concerned with delivery. Specimens shall be machined by cutting in accordance with ISO 2818.

6.1.4 Checking The specimens shall be free from 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 requirements 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 Fig. 4, at right angles to its principal axes.

6.1.5.2 Specimens with notches shaped at moulding (moulded-in notch) may be used if there is a specification in the standard of test material. Specimens with moulded-in notches do not give results the same as that made by the specimens with machined notches.

6.2 Anisotropy In the case of sheets or panels, when their impact properties show different values according to the measuring direction, it is customary to prepare groups of test specimens with their axes respectively parallel and perpendicular to the direction along which the sheet or panel has been shaped. The direction for shaping sheet or panel is judged by the observing or by the knowledge of the method of its 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 three different types of notch shall be used as specified in Table 2 and Table 3 (shown in Fig. 2 and Fig. 4). The notch shall be located at the center of the specimen.

Remarks 3 Type 1 test specimens (see Table 2) may be taken from the central part of the multi-purpose test specimen Type A complying with ISO 3167.

Table 3 Method designations, specimen types, notch type and notch dimensions
— Materials not exhibiting interlaminar shear fracture

Unit: mm

Method designation ^{1) 2)}	Specimen type ¹⁾	Blow direction	Notch type ¹⁾	Notch base radius r_N	Width at notch base b_N
ISO 179/leU ³⁾	1	edgewise	unnotched		
			single notch		
			A	0.25 ± 0.05	8.0 ± 0.2
			B	1.00 ± 0.05	8.0 ± 0.2
ISO 179/leA ³⁾	1	edgewise	B	1.00 ± 0.05	8.0 ± 0.2
ISO 179/leB			C	0.10 ± 0.02	8.0 ± 0.2
ISO 179/leC					
ISO 179/lfU ⁴⁾	1	flatwise	unnotched		

Notes 1) Attention is drawn to the changes in the specimen type number, notch type letter designations, and method designation number from those used in ISO 179:1982.

2) If specimens are taken from sheet or moulded product, the thickness of the sheet or moulded product shall be added to the designation. Unreinforced test specimen shall not be tested with their machined surface under tension.

3) Preferred method.

4) Especially for study of surface effects (see 1.2 and 6.3.1.1.3).

6.3.1.1.2 The preferred type of notch is type A (see Table 3 and Fig. 4). For most materials, unnotched specimens or specimens with a single notch of type A tested according to 3.3 are suitable. If specimens with notch type A do not break during the test, specimens with notch C shall be used. If information on the notch sensitivity of the material is desired, specimens with notch type A, notch type B, and notch type C shall be tested.

Remarks 4 Notch type C replaces the former U notch, which in some cases gives test results that are not comparable.

6.3.1.1.3 Unnotched or double-notched specimens tested according to 3.4 can be used to study surface effects (see 1.2 and Annex A).

6.3.1.2 Sheet materials The recommended thickness h is 4 mm. If the specimen is prepared from a sheet or a moulded product, the thickness of the specimen, up to 10.2 mm, may be the same as the thickness of the sheet or the moulded product.

Specimens taken from pieces thicker than 10.2 mm shall be machined to 10 ± 0.2 mm from one surface. Providing that original sheet is homogeneous in its thickness, and if contains reinforcement, it shall be the type of only one reinforcement uniformly distributed. If unnotched or double-notched specimens are tested according to 3.4, the original surface shall be tested under tension, in order to avoid surface effects.

6.3.2 Moulding materials exhibiting interlaminar shear fracture (long-fibre-reinforced materials)

6.3.2.1 Unnotched specimens of Type 2 or Type 3 are used. There are no specified specimen sizes. The important parameter is the ratio of the span L , i.e. distance between specimen supports to the specimen dimension in the direction of blow (see Table 2).

Usually, specimens are tested in the normal direction (see Fig. 5).

6.3.2.2 Flatwise normal testing (see Fig. 5) The width of the 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 Fig. 5) 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 ratio of the span between specimen supports to the thickness L/h of 20 (for type 2 specimens) and 6 (for type 3 specimens) as shown in Table 2.

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

- Informative reference
- 1 With type 2 specimens, tensile-type failure can occur and with type 3 specimens, interlaminar shear failure can occur. Table 4 summarizes the various types of failure.
 - 2 In such a case that the material is reinforced with thin fabric, 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 a tensile failure.

Table 4 Method designations, specimen types, notch types and notch dimensions
— Materials exhibiting interlaminar shear fracture

Unit: mm

Method designation	Specimen type	L/h	Type of failure	Schematic figure
ISO 179/2 n or p ¹⁾	2	20	tension t	
			compression c	
			buckling b	
ISO 179/3 n or p ¹⁾	3	6 or 8	shear s	
			multiple shear ms	
			shear followed by tensile failure st	

Note 1) "n" is the normal direction and "p" is parallel direction with respect to the sheet plane (see Fig. 5).

6.4 Number of test specimens

6.4.1 Unless otherwise specified in the standard for the material being tested, a set consisting of a minimum of ten 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, ten 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 according to ISO 291. Other conditions than above may be agreed upon between the parties concerned with delivery.

7 Procedure

7.1 Conduct the test in the same atmosphere as that used for conditioning. Other conditions than above (for instance, high temperature or low temperature) may be agreed upon between the parties concerned with delivery.

7.2 Measure the thickness h and the width b of each test specimen, in the center, 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.

Remarks 5 With multiple cavity moulds, ensure that the dimensions of the specimens are the same for each cavity. In the case of specimens Type 2 or Type 3, adjust the span between specimen supports L according to Table 2.

Informative reference: 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 2.

7.3 Check that the pendulum type impact testing machine has the specified velocity of impact (see Table 1). If more than one of the pendulums described in Table 1 meet these requirements, the pendulum having the highest energy shall be used.

Informative reference: It is suitable for test to make the absorbed energy (W) fall in the range between 10 % to 80 % of pendulum energy (E).

7.4 Carry out a blank test (without a specimen) and record the frictional energy loss. Ensure that this energy loss does not exceed the appropriate value given in Table 1. If frictional losses are equal to or less than the values indicated in Table 1, they may be used in the calculations of corrected energy absorbed. If frictional losses exceed the values indicated in Table 1, check the cause of any excess friction losses, and carry out necessary calibration to the equipment.

7.5 Lift and support the pendulum. Place the specimen on the specimen supports in such a manner that the striking edge will hit the center of the specimen. In the case of notched specimens, place it so that the center of the notch is located directly in the plane of impact (see Fig. 1 left).

7.6 Release the pendulum. Record the impact energy absorbed by the specimen and apply any necessary corrections for frictional losses and so on (see Table 1 and 7.4).

7.7 For moulding compounds and extrusion compounds, when the following four types of failure take place according to the below letter codes, the measured values of complete breaks and hinged breaks can be used for common test values. If in the case of partial breaks a measured value is required, it shall be designated with the letter P. In the case of non-break, no values shall be reported, and NB is marked.

For materials with interlaminar shear fracture, the types of failure and their codes are shown in Table 4.

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 no residual stiffness
P	partial break;	an incomplete break that does not meet the definition for a hinge break
NB	non-break;	in the case where there is no break, and the specimen is only bent and pushed through the support blocks. Possibly it is combined with stress whitening

7.8 If, within one sample, the test specimens show both P and C (or H) failures, the mean value for each failure type shall be reported.

8 Calculation and expression of results

8.1 Unnotched specimens Calculate the Charpy impact strength of unnotched specimens a_{cU} (unit: kJ/m²) according to the following formula.

$$a_{cU} = \frac{W}{hb} \times 10^3 \dots \dots \dots (2)$$

where, W : corrected energy absorbed by breaking the test specimen (J)

h : thickness of the test specimen (mm)

b : width of the test specimen (mm)

8.2 Notched specimens Calculate the Charpy impact strength of notched specimens a_{cN} (unit: kJ/m²), when notch type (N) is A, B, or C, according to the following formula.

$$a_{cN} = \frac{W}{hb_N} \times 10^3 \dots \dots \dots (3)$$

where, W : corrected energy absorbed by breaking the test specimen (J)

h : thickness of notched test specimen (mm)

b_N : remaining width of the notched test specimen (mm)

8.3 Statistical treatment Calculate the arithmetic mean of test results and, if required, the standard deviation and the 95 % confidence interval of the mean value using the procedure given in ISO 2602. When different types of failure are found in one sample, the number of specimens relevant to the number of failure types shall be tested and their means shall be calculated.

8.4 Significant figures Report all calculated mean values to two significant figures.

Informative reference: The precision of this method is not known because interlaboratory data are not available. When interlaboratory data are obtained, a precision statement will be added in the next revision.

9 Report The report shall include the following information:

- a) standard number;
- b) the method designation according to Table 3:

Charpy impact test	ISO 179/1	e	A
Specimen type (see Table 2)	_____	_____	_____
Direction of blow (see Fig. 5)	_____	_____	_____
Type of notch (see Fig. 4)	_____	_____	_____

or the method designation according to Table 4:

Charpy impact test	ISO 179/2	n
Specimen type (see Table 2)	_____	_____
Direction of blow (see Fig. 5)	_____	_____

- c) all the information necessary for identification of the material tested: type, source, manufacturer's code, grade, form, and history;
- d) description of the nature and form of the material: product, semifinished product, test plaque or specimen, principal dimensions, shape, method of manufacture and so on;
- e) the velocity of impact;
- f) the nominal pendulum energy;
- g) method of test specimen preparation;
- h) if the material is in the form of a product or a semifinished product, the direction of its cutting;
- i) number of tested specimens;
- j) the atmosphere for conditioning and for testing: any special conditioning treatment when the special treatment is required by the standard for the material or product to be tested;
- k) the type of failure;

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- l) the individual test results;
- m) the impact strength of the material that was reported as the arithmetic mean value of the results for each specimen type, and type of failure indicated in this Standard (see 7.7);
- n) if required, the standard deviations and the 95 % confidence intervals of these mean values;
- o) the date of the test.