
**Metallic materials — Charpy pendulum
impact test —**

**Part 1:
Test method**

*Matériaux métalliques — Essai de flexion par choc sur éprouvette
Charpy —*

Partie 1: Méthode d'essai

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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 148-1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing — Fracture (F), Pendulum (P), Tear (T)*.

This first edition of ISO 148-1 cancels and replaces ISO 148:1983 and ISO 83:1976, which have been technically revised.

ISO 148 consists of the following parts, under the general title *Metallic materials — Charpy pendulum impact test*:

- *Part 1: Test method*
- *Part 2: Verification of test machines*
- *Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines*

Metallic materials — Charpy pendulum impact test —

Part 1: Test method

1 Scope

This part of ISO 148 specifies the Charpy pendulum impact (V-notch and U-notch) test method for determining the energy absorbed in an impact test of metallic materials.

This part of ISO 148 does not address instrumented impact testing, which is specified in ISO 14556.

2 Normative references

The following referenced documents are indispensable for the application 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 148-2:1998, *Metallic materials — Charpy pendulum impact test — Part 2: Verification of test machines*

ISO 286-1, *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits*

3 Terms and definitions

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

3.1 Energy

3.1.1

actual initial potential energy
potential energy

K_p

value determined by direct verification

[ISO 148-2:1998 definition 3.2.2]

3.1.2

absorbed energy

K

energy value indicated by the pointer or other readout device

NOTE The letter V or U is used to indicate the notch geometry, that is: KV or KU . The number 2 or 8 is used as a subscript to indicate striker radius, that is KV_2 for example.

3.2 Test piece

With the test piece placed in the test position on the supports of the machine, the following nomenclature shall apply (see Figure 1).

3.2.1 height

h
distance between the notched face and the opposite face

3.2.2 width

w
dimension perpendicular to the height that is parallel to the notch

3.2.3 length

l
the largest dimension at right angles to the notch

4 Symbols (and abbreviated terms)

The designations applicable to this part of ISO 148 are indicated in Tables 1 and 2, and are illustrated in Figure 2.

Table 1 — Symbols and their unit and designation

Symbol	Unit	Designation
K_p	J	Actual initial potential energy (potential energy)
FA	%	Shear-fracture appearance
h	mm	Height of test piece
KU_2	J	Absorbed energy for a U-notch test piece using a 2 mm striker
KU_8	J	Absorbed energy for a U-notch test piece using an 8 mm striker
KV_2	J	Absorbed energy for a V-notch test piece using a 2 mm striker
KV_8	J	Absorbed energy for a V-notch test piece using a 8 mm striker
LE	mm	Lateral expansion
l	mm	Length of test piece
T_t	°C	Transition temperature
w	mm	Width of test piece

5 Principle

This test consists of breaking a notched test piece by a single blow from a swinging pendulum, under the conditions defined hereafter. The notch in the test piece has specified geometry and is located in the middle between two supports, opposite to the location that is struck in the test. The energy absorbed in the impact test is determined.

Because the impact values of many metallic materials vary with temperature, tests are made at specified temperatures. When this temperature is other than ambient, the test piece shall be heated or cooled to that temperature, under controlled conditions.

6 Test pieces

6.1 General

The standard test piece shall be 55 mm long and of square section with 10 mm sides. In the centre of the length there shall be either a V-notch or a U-notch, as described in 6.2.1 and 6.2.2.

If the standard test piece cannot be obtained from the material, one of the subsidiary test pieces having a width of 7,5 mm, 5 mm or 2,5 mm (see Figure 2 and Table 2) shall be used.

NOTE For low energies, the use of shims is important, as excess energy will be absorbed by the pendulum. For high energies, this might not be important. Shims may be placed on or under the test piece supports so that the mid-height of the specimen is 5 mm above the 10 mm specimen-support surface.

The test pieces shall have a surface roughness better than Ra 5 μm except for the ends.

When a heat-treated material is being evaluated, the test piece shall be finish-machined, including notching, after the final heat treatment, unless it can be demonstrated that there is no difference when machined prior to heat treatment.

6.2 Notch geometry

The notch shall be carefully prepared so that the root radius of the notch is free of machining marks that could affect the absorbed energy.

The plane of symmetry of the notch shall be perpendicular to the longitudinal axis of the test piece (see Figure 2).

6.2.1 V-notch

The V-notch shall have an included angle of 45°, a depth of 2 mm, and a root radius of 0,25 mm [see Figure 2 a) and Table 2].

6.2.2 U-notch

The U-notch shall have a depth of 5 mm (unless otherwise specified) and a root radius of 1 mm [see Figure 2 b) and Table 2].

6.3 Tolerance of the test pieces

The tolerances on the specified test piece and notch dimensions are shown in Figure 2 and Table 2.

6.4 Preparation of the test pieces

Preparation shall be carried out in such a way that any alteration of the test piece, for example, due to heating or cold working, is minimized.

6.5 Marking of the test pieces

The test piece may be marked on any face not in contact with supports, anvils or striker and at a position that avoids the effects of plastic deformation and surface discontinuities on the absorbed energy measured in the test (see 8.7).

7 Test equipment

7.1 General

The equipment used for all measurements shall be traceable to national or International standards. They shall be calibrated within suitable intervals.

7.2 Installation and verification

The testing machine shall be installed and verified in accordance with ISO 148-2.

7.3 Striker

The striker geometry shall be specified as being either the 2 mm striker or the 8 mm striker. It is recommended that the striker radius be shown as a subscript as follows: KV_2 or KV_8 .

Refer to the product specification for striker geometry guidance.

NOTE Some materials may give significantly different results (percent difference) at low energy levels, and the 2 mm results can be higher than the 8 mm results.

8 Test procedure

8.1 General

The test piece shall lie squarely against the anvils of the test machine, with the plane of symmetry of the notch within 0,5 mm of the midplane between the anvils. It shall be struck by the striker in the plane of symmetry of the notch and on the side opposite the notch (see Figure 1).

8.2 Test temperature

8.2.1 Unless otherwise specified, tests shall be made at $(23 \pm 5) ^\circ\text{C}$. When a temperature is specified, the test piece shall be conditioned to that temperature within $\pm 2 ^\circ\text{C}$.

8.2.2 For conditioning, either heating or cooling, using a liquid medium, the test piece shall be positioned in a container on a grid that is at least 25 mm above the bottom of the container and covered by at least 25 mm of liquid and at least 10 mm from the sides of the container. The medium shall be constantly agitated and brought to the specified temperature by any convenient method. The device used to measure the temperature of the medium should be placed in the centre of the group of test pieces. The temperature of the medium shall be held at the specified temperature within $\pm 1 ^\circ\text{C}$ for at least 5 min.

NOTE When a liquid medium is near its boiling point, evaporative cooling can dramatically lower the test-piece temperature during the interval between removal from the liquid and fracture (see reference [4] in the Bibliography).

8.2.3 For the test at elevated temperatures of not more than $200 ^\circ\text{C}$, the test piece shall be kept at a constant temperature for at least 10 min in a liquid bath maintained at the specified temperature within $\pm 2 ^\circ\text{C}$. For the test at elevated temperatures over $200 ^\circ\text{C}$, the test piece shall be kept at a constant temperature for at least 20 min in an oven maintained at the specified temperature within $\pm 5 ^\circ\text{C}$.

8.3 Specimen transfer

When testing is performed at other than ambient temperature, not more than 5 s shall pass from the time the test piece is removed from the heating or cooling medium and it is struck by the striker.

The transfer device shall be designed and used in such a way that the temperature of the test piece is maintained within the temperature range permitted.

The parts of the device in contact with the specimen during transfer from the medium to the machine shall be conditioned with the specimens.

Care should be taken to ensure that the device used to centre the test piece on the anvils does not cause the fractured ends of low-energy, high-strength test pieces to rebound off this device into the pendulum and cause erroneously-high indicated energy. It has been shown that clearance between the end of a test piece in the test position and the centring device, or a fixed portion of the machine, shall be greater than approximately 13 mm or else, as part of the fracture process, the ends may rebound into the pendulum.

NOTE Self-centring tongs, similar to those for V-notched test pieces shown in Annex A, are often used to transfer the test piece from the temperature-conditioning medium to the proper test position. Tongs of this nature eliminate potential clearance problems due to interference between the fractured specimen halves and a fixed centring device.

8.4 Exceeding machine capacity

The absorbed energy, K , should not exceed 80 % of the actual initial potential energy, K_p . If the absorbed energy exceeds this value, the absorbed energy shall be reported as approximate and it shall be noted in the test report that it exceeded 80 % of the machine capacity.

NOTE Ideally, an impact test would be conducted at a constant impact velocity. In a pendulum-type test, the velocity decreases as the fracture progresses. For specimens that have impact energies approaching the capacity of the pendulum, the velocity of the pendulum decreases during fracture to the point that accurate impact energies are no longer obtained.

8.5 Incomplete fracture

If a test piece is not completely broken in a test, the impact energy may be reported or averaged with the results of the completely broken test pieces.

8.6 Test piece jamming

If any test piece jams in the machine, disregard the results and check the machine thoroughly for damage that would affect its calibration.

8.7 Post-fracture inspection

If post-fracture inspection shows that any portion of the marking is in a portion of the test piece that is visibly deformed, the test result might not be representative of the material and this shall be noted in the test report.

9 Test report

9.1 Mandatory information

The test report shall include the following information:

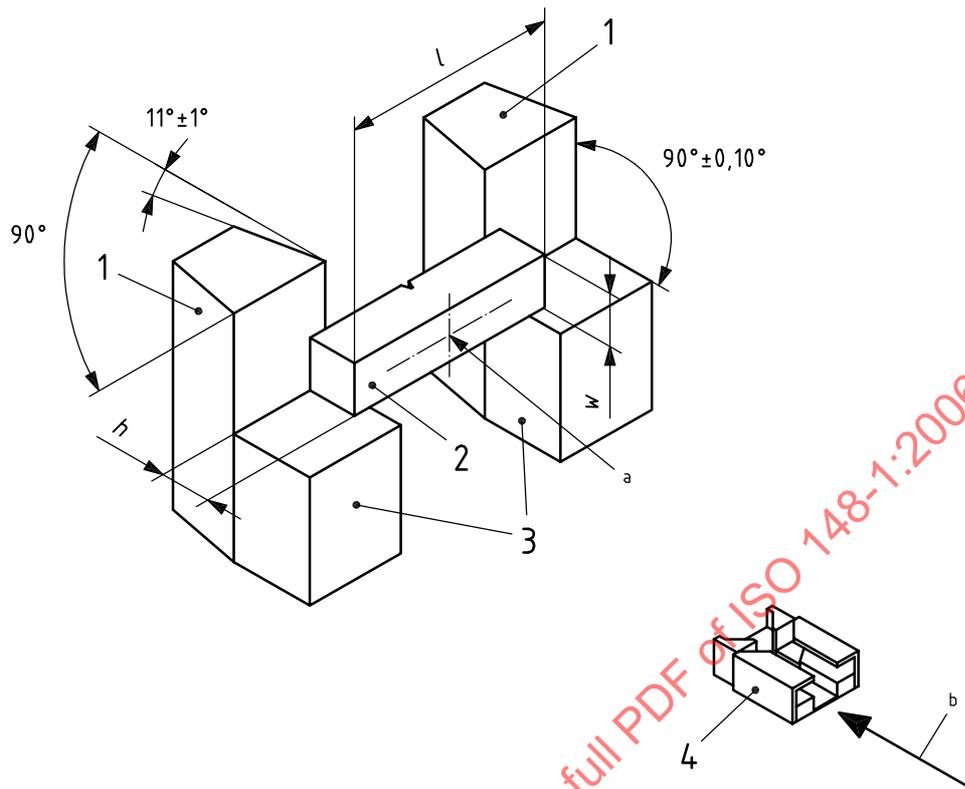
- a) a reference to this part of ISO 148;
- b) identification of the test piece (e.g. type of steel, cast number, etc.);
- c) type of notch;
- d) size of the test piece, if other than full size;
- e) conditioning temperature of the test piece
- f) absorbed energy, KV_2 , KV_8 , KU_2 , or KU_8 as appropriate;
- g) any abnormalities that may have affected the test.

9.2 Optional information

The test report may optionally include, in addition to the information in 9.1:

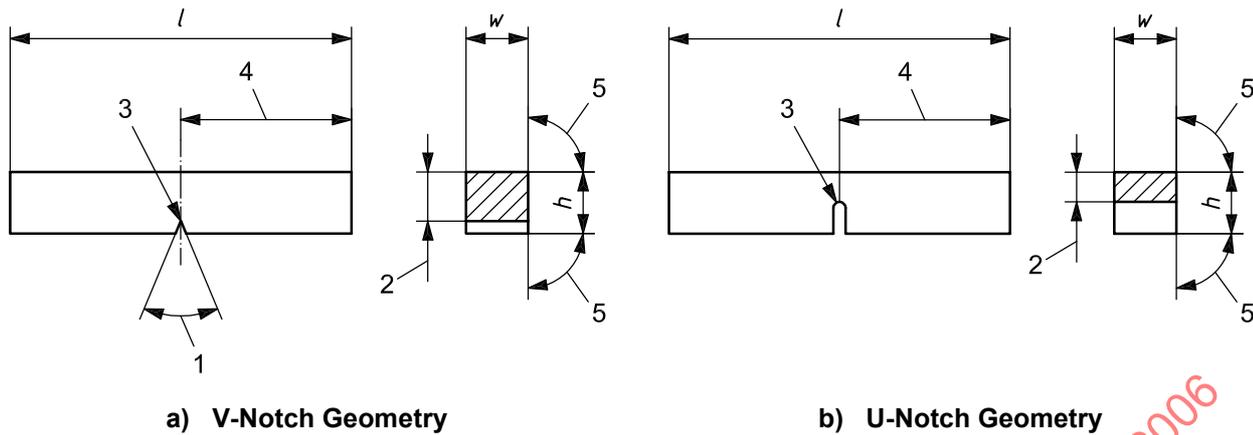
- a) test-piece orientation (see ISO 3785);
- b) nominal energy of the testing machine, in joules;
- c) lateral expansion (see Annex B);
- d) fracture appearance, percent shear (see Annex C);
- e) energy absorbed/temperature curve (see D.1);
- f) transition temperature, criteria used (see D.2);
- g) number of test pieces that were not completely broken in the test.

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**Key**

- h height of test piece
- l length of test piece
- w width of test piece
- 1 anvil
- 2 standard-size test piece
- 3 test piece supports
- 4 shroud
- a Centre of Strike.
- b Direction of pendulum swing.

Figure 1 — Test piece terminology showing configuration of test piece supports and anvils of an industrial, pendulum-type impact-testing machine



NOTE The symbols l , h , w and the numbers 1 to 5 refer to Table 2.

Figure 2 — Charpy-impact test piece

Table 2 — Tolerances on specified test piece dimensions

Designation	Symbol and No.	V-notch test piece			U-notch test piece		
		Nominal dimension	Machining tolerance		Nominal dimension	Machining tolerance	
				Tolerance class ^a			Tolerance class ^a
Length	l	55 mm	$\pm 0,60$ mm	js15	55 mm	$\pm 0,60$ mm	js15
Height ^b	h	10 mm	$\pm 0,075$ mm	js12	10 mm	$\pm 0,11$ mm	js13
Width ^b :	w						
— standard test piece		10 mm	$\pm 0,11$ mm	js13	10 mm	$\pm 0,11$ mm	js13
— reduced-section test piece		7,5 mm	$\pm 0,11$ mm	js13	—	—	—
— reduced-section test piece		5 mm	$\pm 0,06$ mm	js12	—	—	—
— reduced-section test piece		2,5 mm	$\pm 0,05$ mm	js12	—	—	—
Angle of notch	1	45°	$\pm 2^\circ$	—	—	—	—
Height below notch	2	8 mm	$\pm 0,075$ mm	js12	5 mm ^c	$\pm 0,09$ mm	js13
Radius of curvature at base of notch	3	0,25 mm	$\pm 0,025$ mm	—	1 mm	$\pm 0,07$ mm	js12
Distance of plane of symmetry of notch from ends of test piece ^b	4	27,5 mm	$\pm 0,42$ mm ^d	js15	27,5 mm	$\pm 0,42$ mm ^d	js15
Angle between plane of symmetry of notch and longitudinal axis of test piece		90°	$\pm 2^\circ$	—	90°	$\pm 2^\circ$	—
Angle between adjacent longitudinal faces of test piece	5	90°	$\pm 2^\circ$	—	90°	$\pm 2^\circ$	—

^a In accordance with ISO 286-1.

^b The test pieces shall have a surface roughness better than Ra 5 μ m except for the ends.

^c If another height (2 or 3 mm) is specified, the corresponding tolerances shall also be specified.

^d For machines with automatic positioning of the test piece, it is recommended that the tolerance be taken as $\pm 0,165$ mm instead of $\pm 0,42$ mm.

Annex A
(informative)

Self-centring tongs

The tongs shown in Figure A.1 are often used to transfer the test piece from the temperature-conditioning medium and to properly position the test piece in the Charpy-test machine.

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Annex B (informative)

Lateral expansion

B.1 General

A measure of the ability of the material to resist fracture when subjected to triaxial stresses, such as those at the root of the notch in a Charpy test piece, is the amount of deformation that occurs at this location. The deformation in this case is contraction. Because of the difficulties in measuring this deformation, even after fracture, the expansion that occurs at the opposite end of the fracture plane is customarily measured and used as a proxy for the contraction.

B.2 Procedure

The method of measuring lateral expansion should take into account the fact that the fracture plane seldom bisects the point of maximum expansion on both sides of a test piece. One-half of a broken test piece might include the maximum expansion for both sides, one side only, or neither. The techniques used should therefore provide an expansion value, equal to the sum of the higher of the two values obtained for each side, by measuring the two halves separately. The amount of expansion on each side of each half should be measured relative to the plane defined by the undeformed portion of the side of the test piece (see Figure B.1). Expansion may be measured by using a gauge similar to that shown in Figures B.2 and B.3. Measure the two broken halves individually. First, however, check the sides perpendicular to the notch to ensure that no burrs were formed on these sides during impact testing; if such burrs exist, they should be removed, for example, by rubbing on emery cloth, making sure that the protrusions to be measured are not rubbed during the removal of the burr. Next, place the half specimens together so that the surfaces originally opposite the notch are facing one another. Take one of the half specimens (shown as X in Figure B.1) and press it firmly against the reference supports, with the protrusions against the gauge anvil. Note the reading, and then repeat this step with the other half specimen (shown as Y in Figure B.1), ensuring that the same side is measured. The larger of the two values is the expansion of that side of the test piece. Next, repeat this procedure to measure the protrusions on the opposite side, and then add the larger values obtained for each side. For example, if $A_1 > A_2$ and $A_3 = A_4$, then $LE = A_1 + (A_3 \text{ or } A_4)$. If $A_1 > A_2$ and $A_3 > A_4$, then $LE = A_1 + A_3$.

If one or more protrusions of a test piece have been damaged by contacting the anvil, machine mounting surface, etc., do not measure the test piece and so indicate the condition in the test report.

Measure each test piece.

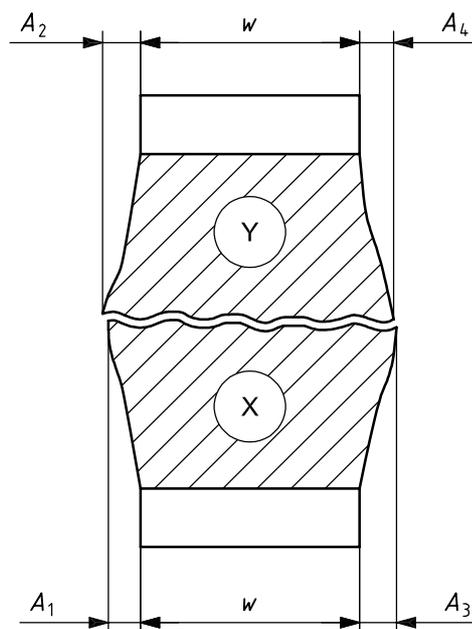


Figure B.1 — Halves of broken Charpy V-notched impact specimen illustrating the measurement of lateral expansion, dimensions A_1 , A_2 , A_3 , A_4 , and the original width, dimension w

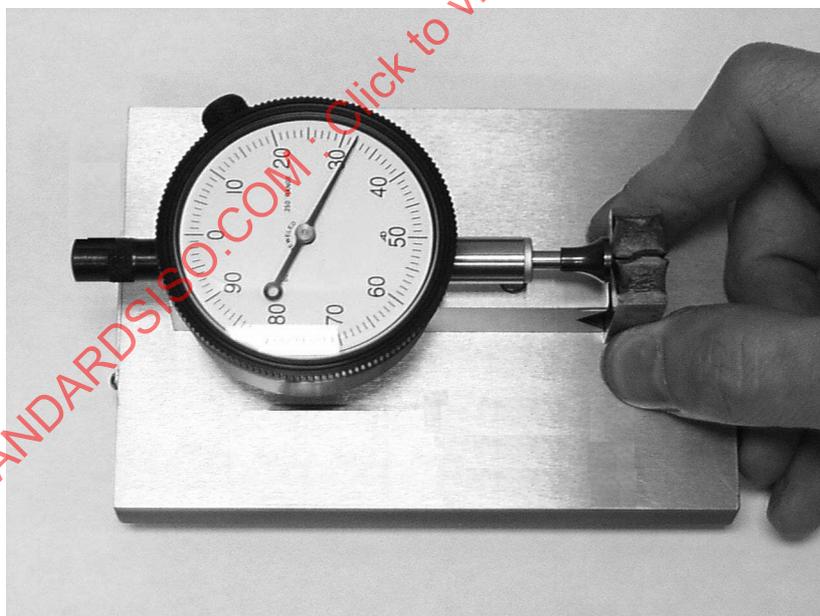
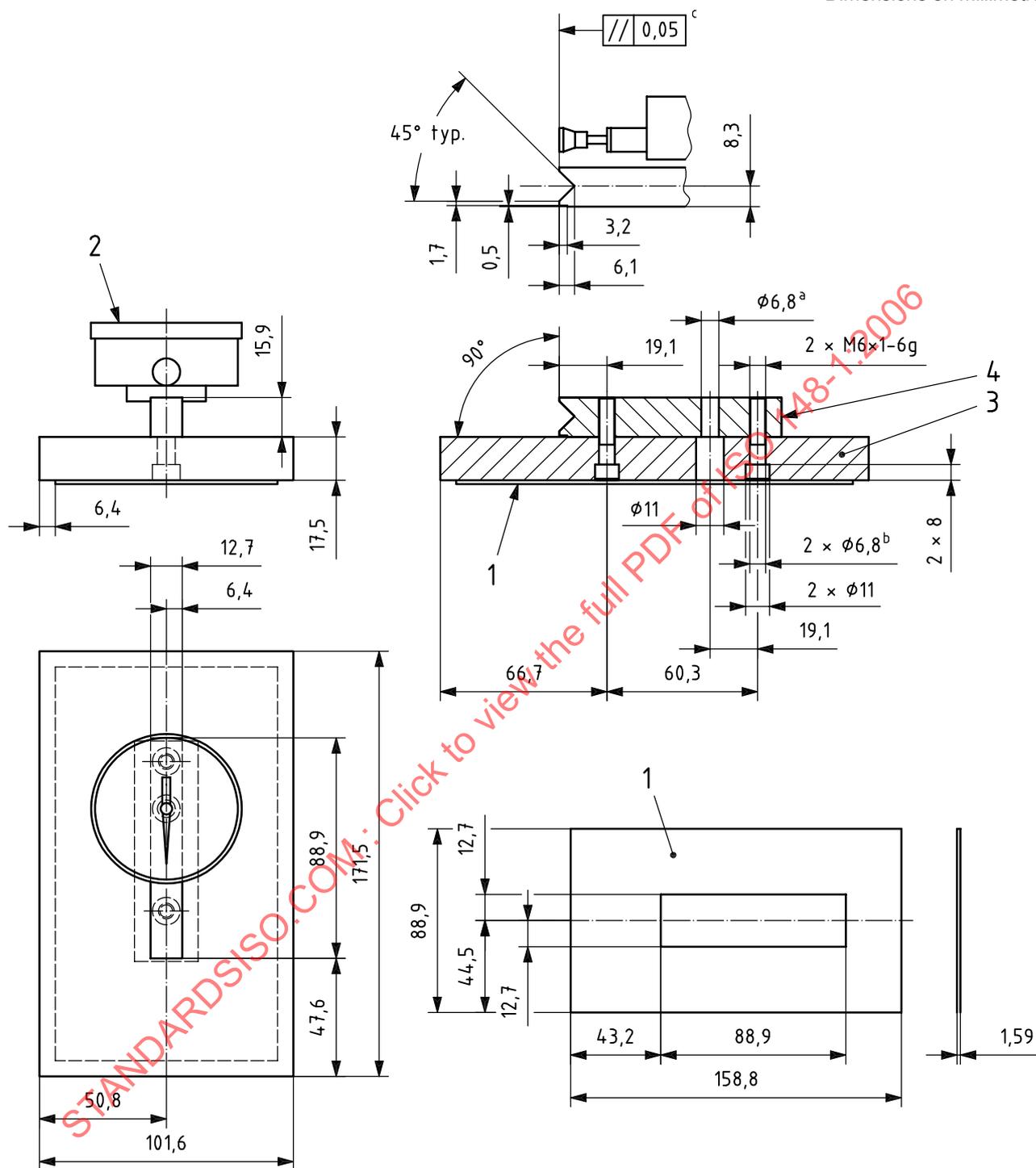


Figure B.2 — Lateral expansion gauge for Charpy specimens

Dimensions en millimetres



Key

- 1 pad made of rubber
 - 2 indicator (metric) Starret #25-481 graduations in 1/100 mm
 - 3 base plate made of stainless steel or chrome-plated steel
 - 4 dial mount made of stainless steel or chrome-plated steel
- a For 1/4-20 UNC screw with 7/8" long socket head to mount the indicator.
 b For M6 × 1 screw with 25 mm socket head.
 c Lap at assembly.

Figure B.3 — Assembly and details for lateral expansion gauge

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Annex C (informative)

Fracture appearance

C.1 General

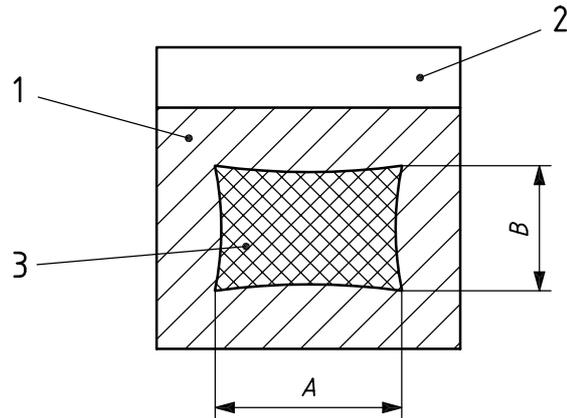
The fracture surface of Charpy test pieces is often rated by the percentage of shear fracture that has occurred. The greater the percentage of shear fracture, the greater the notch toughness of the material. The fracture surface of most Charpy specimens exhibit a mixture of both shear and cleavage (brittle) fracture. Because the rating is extremely subjective, it is recommended that it not be used in specifications.

NOTE The term fibrous-fracture appearance is often used as a synonym for shear-fracture appearance. The terms cleavage-fracture appearance and crystallinity are often used to express the opposite of shear fracture. That is, 0 % shear fracture is 100 % cleavage fracture.

C.2 Procedures

The percentage of shear fracture is commonly determined by any of the following methods:

- a) measure the length and width of the cleavage portion (the “shiny” portion) of the fracture surface, as shown in Figure C.1, and determine the percent shear from Table C.1;
- b) compare the appearance of the fracture of the test piece with a fracture-appearance chart, such as that shown in Figure C.2;
- c) magnify the fracture surface and compare it to a precalibrated overlay chart, or measure the percent cleavage fracture by means of a planimeter, then calculate percent shear fracture as (100 % – percent cleavage fracture);
- d) photograph the fracture surface at a suitable magnification and measure the percent cleavage fracture by means of a planimeter, then calculate percent shear fracture as (100 % – percent cleavage fracture);
- e) measure the percent shear fracture by image analysis techniques



NOTE 1 Measure average dimensions A and B to the nearest 0,5 mm.

NOTE 2 Determine the percent shear fracture using Table C.1.

Key

- 1 shear area (dull)
- 2 notch
- 3 cleavage area (brittle)

Figure C.1 — Determination of percent shear fracture

Table C.1 — Percent shear for measurements made in millimetres

B mm	A mm																		
	1,0	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10
	Percent shear																		
1,0	99	98	98	97	96	96	95	94	94	93	92	92	91	91	90	89	89	88	88
1,5	98	97	96	95	94	93	92	92	91	90	89	88	87	86	85	84	83	82	81
2,0	98	96	95	94	92	91	90	89	88	86	85	84	82	81	80	79	77	76	75
2,5	97	95	94	92	91	89	88	86	84	83	81	80	78	77	75	73	72	70	69
3,0	96	94	92	91	89	87	85	83	81	79	77	76	74	72	70	68	66	64	62
3,5	96	93	91	89	87	85	82	80	78	76	74	72	69	67	65	63	61	58	56
4,0	95	92	90	88	85	82	80	77	75	72	70	67	65	62	60	57	55	52	50
4,5	94	92	89	86	83	80	77	75	72	69	66	63	61	58	55	52	49	46	44
5,0	94	91	88	85	81	78	75	72	69	66	62	59	56	53	50	47	44	41	37
5,5	93	90	86	83	79	76	72	69	66	62	59	55	52	48	45	42	38	35	31
6,0	92	89	85	81	77	74	70	66	62	59	55	51	47	44	40	36	33	29	25
6,5	92	88	84	80	76	72	67	63	59	55	51	47	43	39	35	31	27	23	19
7,0	91	87	82	78	74	69	65	61	56	52	47	43	39	34	30	26	21	17	12
7,5	91	86	81	77	72	67	62	58	53	48	44	39	34	30	25	20	16	11	6
8,0	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

NOTE 100 % shear is to be reported when either A or B is zero.