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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

ICS: 77.040.10

ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

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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. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing — Fracture (F), Pendulum (P), Tear (T)*.

This third edition cancels and replaces the second edition (ISO 148-1:2009), which has 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 testing machines*

— *Part 3: Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines*

Annexes B and C are based on ASTM E23 (*Standard Test Methods for Notched Bar Impact Testing of Metallic Materials)*, copyright ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, USA.

Metallic materials — Charpy pendulum impact test —

Part 1:
Test method

1 Scope

This part of ISO 148 specifies the Charpy (V-notch and U-notch) pendulum impact test method for determining the energy absorbed in an impact test of metallic materials. This part of ISO 148 does not cover instrumented impact testing, which is specified in ISO 14556.

2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and 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, *Metallic materials — Charpy pendulum impact test — Part 2: Verification of testing machines*

ISO 2861, *Vacuum technology — Dimensions of clamped-type quick-release couplings*

ISO 3785, *Metallic materials — Designation of test specimen axes in relation to product texture*

ISO 14556, *Metallic materials — Charpy V-notch pendulum impact test — Instrumented test method*

3 Terms and definitions

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

3.1 Energy

3.1.1
initial potential energy
potential energy
K_p
difference between the potential energy of the pendulum hammer prior to its release for the impact test, and the potential energy of the pendulum hammer at the position of impact, as determined by direct verification

3.1.2
absorbed energy
K
energy required to break a test piece with a pendulum impact testing machine, after correction for friction

Note 1 to entry: 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 the radius of the striker, for example KV_2.

3.2 Test piece (see Figure 1)

3.2.1
width
W
distance between the notched face and the opposite face

Note 1 to entry: In previous versions of this standard the distance between the notched face and the opposite face was specified as “height”. Changing this dimension to “width” makes ISO 148-1 consistent with the terminology used in other ISO fracture standards.

3.2.2
thickness
B
dimension perpendicular to the width and parallel to the notch

Note 1 to entry: In previous versions of this standard the dimension perpendicular to the width that is parallel to the notch was specified as “width”. Changing this dimension to “thickness” makes ISO 148-1 consistent with the terminology used in other ISO fracture standards.

3.2.3
length
L
the largest dimension perpendicular to the notch

4 Symbols and abbreviated terms

The symbols and 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	Initial potential energy (potential energy)
SFA	%	Shear fracture appearance
B	mm	Thickness 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
T_{t27}	°C	Transition temperature defined at a specific value of absorbed energy, for example 27 J
$T_{t50\%US}$	°C	Transition temperature defined at a particular percentage of the absorbed energy of the upper shelf, for example 50 %
$T_{t50\%SFA}$	°C	Transition temperature defined at a particular portion of shear fracture, for example 50 %
$T_{t0,9}$	°C	Transition temperature defined at a particular amount of lateral expansion, for example 0,9 mm

5 Principles of the test

This test consists of breaking a notched test piece with a single blow from a swinging pendulum, under the conditions defined in Clauses 6, 7 and 8. The notch in the test piece has specified geometry and is located in the middle between two supports, opposite to the location which is impacted in the test. The energy absorbed in the impact test, the lateral expansion, and the shear fracture appearance are normally determined.

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

The Charpy pendulum impact test is often used in routine, high-throughput pass/fail acceptance tests in industrial settings. For these tests, it may not be important whether the test sample is completely broken, partially broken, or simply plastically deformed and dragged through the anvils. In research, design, or academic settings, the measured energy values are studied in more detail, in which case it can be highly relevant whether the sample is broken or not.

It is important to note that not all Charpy pendulum impact test results can be directly compared. For example, the test can be performed with hammers having strikers with different radii, or with different test piece shapes. Tests performed with different strikers can give different results,[1] and test results obtained with differently shaped test pieces can as well. This is why not only the adherence to the ISO 148 standard but also a clear and complete reporting of the type of instrument, the test piece, and the details of the post-test test pieces can be crucial for comparability of results.

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, respectively.

If the standard test piece cannot be obtained from the material, one of the subsize test pieces, having a thickness of 7,5 mm, 5 mm or 2,5 mm (see Figure 2 and Table 2), shall be used if not otherwise specified.

NOTE 1 Direct comparison of results is only of significance when made between test pieces of the same form and dimensions.

NOTE 2 For low energies, the use of shims to better position subsize test pieces relative to the center of strike is important to avoid excess energy absorption by the pendulum. For high energies, this might not be as important. Shims can be placed on or under the test piece supports, with the result that the mid-thickness of the specimen is 5 mm above the 10 mm supports. Shims can be temporarily fixed to the supports using tape or another means.

When a heat-treated material is being evaluated, the test piece shall be finish-machined and notched after the final heat treatment, unless it can be demonstrated that machining before heat treatment does not affect test results.

6.2 Notch geometry

The notch shall be carefully prepared so that the root radius of the notch is free of machining marks which 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 executed 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 where plastic deformation and surface discontinuities caused by marking do not affect the absorbed energy (see 8.8).

7 Test equipment

7.1 General

The measurements of the instrument and test piece details shall be traceable to national or international standards. Equipment used for measurements shall be calibrated within suitable intervals.

7.2 Installation and verification

The testing machine shall be installed and verified in accordance with ISO 1482.

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 radius on the striker be shown as a subscript as follows: KV_2 or KV_8 and KU_2 or KU_8.

Reference shall be made to the product specification for striker geometry guidance.

NOTE Tests carried out with 2 mm and 8 mm strikers can give different results.[1]

8 Test procedure

8.1 General

The test piece shall lie squarely against the anvils of the testing machine, with the plane of symmetry of the notch within 0,5 mm of the mid-plane 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 Friction measurement

The energy absorbed by friction includes, but is not limited to, air resistance, bearing friction and the friction of the indicating pointer. Increases in friction on a machine can influence the measure of absorbed energy. Therefore friction shall be checked on every testing day prior to the first test. The friction losses may be estimated as follows.

8.2.1 To determine the loss caused by pointer friction the machine is operated in the normal manner, but without a test piece in position, and the angle of rise, β_1, or energy reading, K_1, is noted. A second test is then carried out without resetting the indication pointer and the new angle of rise, β_2, or energy reading, K_2, is noted. Thus, the loss due to friction in the indicating pointer during the rise is equal to

$$p = M(\cos \beta_1 - \cos \beta_2) \quad (1)$$

when the scale is graduated in degrees, or

$$p = K_1 - K_2 \quad (2)$$

when the scale is graduated in energy units.

8.2.2 The procedure to determine the losses caused by bearing friction and air resistance for one half swing is as follows.

After determining β_2 or K_2, the pendulum is returned to its initial position. Without resetting the indicating mechanism, release the pendulum without shock and vibration and permit it to swing 10 half swings. After the pendulum starts its 11th half swing, move the indicating mechanism to about 5 % of the scale-range capacity and record the value as β_3 or K_3. The losses by bearing friction and air resistance for one half swing are equal to

$$p' = 1/10\ M(\cos \beta_3 - \cos \beta_2) \quad (3)$$

when the scale is graduated in degrees, or

$$p' = 1/10\ (K_3 - K_2) \quad (4)$$

when the scale is graduated in energy units.

NOTE 1 The number of swings can be changed at the discretion of machine users. p' should be corrected on account of the applied number of swings.

NOTE 2 If it is required to take into account these losses in an actual test giving an angle of rise, β, the quantity

$$p_\beta = p\frac{\beta}{\beta_1} + p'\frac{\alpha + \beta}{\alpha + \beta_2} \quad (5)$$

can be subtracted from the value of the absorbed energy.

Because β_1 and β_2 are nearly equal to α, for practical purposes Formula (5) can be reduced to:

$$p_\beta = p\frac{\beta}{\alpha} + p'\frac{\alpha + \beta}{2\alpha} \quad (6)$$

For machines graduated in energy units, the value of β can be calculated as follows:

$$\beta = \arccos[1 - 1/M(K_P - K_T)] \quad (7)$$

The total friction loss $p + p'$, so measured, shall not exceed 0,5 % of the nominal energy, K_N. If it does, and it is not possible to bring the friction loss within the tolerance by reducing the pointer friction, the bearings shall be cleaned or replaced.

8.3 Test temperature

8.3.1 Unless otherwise specified, tests shall be carried out at 23 ± 5 °C (ambient temperature). If a temperature is specified, the test piece shall be conditioned to that temperature to within ± 2 °C.

8.3.2 For conditioning (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 be 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 to within ± 1 °C for at least 5 min.

NOTE When a liquid medium is near its boiling point, evaporative cooling can dramatically lower the temperature of the test piece during the interval between removal from the liquid and fracture (see ASTM STP 1072[2]).

8.3.3 For conditioning (heating or cooling) using a gaseous medium, the test piece shall be positioned in a chamber at least 50 mm from the nearest surface. Individual test pieces shall be separated by at least 10 mm. The medium shall be constantly circulated 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 gaseous medium shall be held at the specified temperature within ± 1 °C for at least 30 min before the test piece is removed from the medium for testing.

8.3.4 Other methods for heating or cooling are allowed, if the other pertinent requirements of 8.3 are fulfilled.

8.4 Specimen transfer

When testing is performed at other than ambient temperature, not more than 5 s shall elapse between the time the test piece is removed from the heating or cooling medium and the time it is impacted by the striker. An exception is made if the difference between the abient or instrument temperature and the test piece temperature is less than 25 °C, in which case the time for specimen transfer shall be less than 10 s.

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

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 the device into the pendulum. This pendulum/test piece interaction results in 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 can rebound into the pendulum.

NOTE Self-centring tongs, similar to those shown in Annex A for V-notched test pieces, 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.

8.5 Exceeding machine capacity

The absorbed energy, K, should not exceed 80 % of the 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 as exceeding 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 with 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.

8.6 Incomplete fracture

Test pieces do not always break into two pieces during the test.

For material acceptance testing, it is not required to report information concerning incomplete fracture.

For tests, other than material acceptance testing, it is required that unbroken test pieces are reported.

NOTE 1 In the case where individual specimens are not identified within test records, the group can be identified as broken or unbroken.

NOTE 2 A test piece that is not fully separated in two half test pieces upon impact can be considered broken if the two halves can be separated by pushing the hinged halves together without the aid of mechanical tools and without fatiguing the specimen.

NOTE 3 A material acceptance test is a test which is used to asses a minimum acceptance requirement.

8.7 Test piece jamming

If a test piece jams in the machine, the results shall be disregarded and the machine thoroughly checked for damage that would affect its state of calibration.

NOTE Jamming occurs when a broken test piece is caught between moving and non-moving parts of the testing machine. It can result in significant energy absorption. Jamming can be differentiated from secondary strike marks, because jamming is associated with a pair of opposing marks on the specimen.

8.8 Post-fracture inspection

If post-fracture inspection shows that any portion of the test specimen identification marking is in a portion of the test piece which 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 contain the following information or, when agreed by the customer, it shall be possible to retrieve this information based on a traceable coding of the test report by the test laboratory:

1) a reference to this part of ISO 148, i.e. ISO 148-1;
2) identification of the test piece (e.g. type of steel and cast number);
3) the size of the test piece, if other than the standard test piece;
4) the temperature of the test or the conditioning temperature of the test specimens;
5) the absorbed energy, KV_2, KV_8, KU_2, or KU_8, as appropriate;
6) whether the specimen, or the majority of specimens in a group of specimens were broken (not required for material acceptance tests);
7) any abnormalities that could have affected the test.

9.2 Optional information

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

1) the test piece orientation (see ISO 3785);
2) the initial potential energy of the testing machine, in joules;