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

Part 3:

Preparation and characterization of Charpy V
reference test pieces for verification of test
machines

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

*Partie 3: Préparation et caractérisation des éprouvettes de référence
Charpy V pour la vérification des machines d'essai (mouton-pendule)*



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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.

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.

International Standard ISO 148-3 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing*.

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*

Annex A of this part of ISO 148 is for information only.

Introduction

The suitability of a pendulum impact testing machine for acceptance testing of metallic materials usually has been based on a calibration of its scale and verification of compliance with specified dimensions, such as the shape and spacing of the anvils supporting the specimen. The scale calibration is commonly verified by measuring the mass of the pendulum and its elevation at various scale readings. This procedure for evaluation of machines had the distinct advantage of requiring only measurements of quantities which can be traced to national standards. The objective nature of these traceable measurements minimized the necessity for arbitration regarding the suitability of the machines for material acceptance tests.

However, sometimes two machines that had been evaluated by the direct-verification procedures described above, and which met all dimensional requirements, were found to give significantly different impact values when testing test pieces of the same material. This difference was commercially important when values obtained using one machine met the material specification, while the values obtained using the other machine did not.

To avoid such disagreements, some purchasers of materials added the requirement that all impact machines used for acceptance testing of material sold to them must be indirectly verified by testing reference test pieces supplied by them. A machine was considered acceptable only if the values obtained using the machine agreed, within specified limits, with the value furnished with the reference test pieces. Successful experience in the use of reference test pieces led to the requirement in ISO 148-2 that indirect verification must be performed using reference test pieces in addition to direct verification. Many national standards and codes also require indirect verification using reference test pieces: for example, EN 10045-2:1992, *Metallic materials — Charpy impact test — Part 2: Verification of the testing machine (pendulum impact)*, and ASTM E 23:1994b, *Test methods for notched bar impact testing of metallic materials*, require the use of notched test pieces. The purpose of this part of ISO 148 is to specify the requirements, preparation and methods of qualifying these reference test pieces by means of a reference machine. The indirect verification of the reference machine is carried out with reference test pieces which have been certified by a third party. As information, annex A shows this approach schematically.

Metallic materials — Charpy pendulum impact test —

Part 3:

Preparation and characterization of Charpy V reference test pieces for verification of test machines

1 Scope

This part of ISO 148 covers the requirements, preparation and methods of qualifying test pieces that are used to indirectly verify pendulum impact testing machines in accordance with ISO 148-2 and with the certificate for reference test pieces.

It describes notched test pieces with nominal dimensions identical to those specified in ISO 148-1. However, the tolerances are more stringent. The chemical composition or heat treatment or both are varied according to the energy level desired.

Reference test pieces are qualified on reference pendulum impact machines which are also described in this document.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 148. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 148 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 148-1:—¹⁾, *Metallic materials — Charpy pendulum impact test — Part 1: Test method.*

ISO 148-2:1998, *Metallic materials — Charpy pendulum impact test — Part 2: Verification of test machines.*

3 Definitions

For the purposes of this part of ISO 148, the following definitions apply.

3.1 industrial machine: Pendulum impact testing machine used for industrial and most research-laboratory testing of metallic materials. These machines are not used to establish reference values. Industrial machines are verified using direct verification and indirect verification with reference test pieces.

¹⁾ To be published. (Revision of ISO 83:1976 and ISO 148:1983)

3.2 reference machine: Pendulum impact testing machine used to determine the reference energy of a reference test piece. The verification requirements for this grade of machine are more stringent than those for industrial machines.

3.3 Definitions pertaining to energy

3.3.1 actual absorbed energy (absorbed energy), A_v : The total energy required to break a test piece when tested by a pendulum impact testing machine. It is equal to the difference in the potential energy from the starting position of the pendulum to the end of the first half-swing during which the test piece is broken.

3.3.2 indicated absorbed energy (indicated energy), A_s : The energy value indicated by the pointer or other readout device of a pendulum impact testing machine.

3.3.3 reference energy, A_R : The absorbed energy associated with reference test pieces, determined from tests made using reference machines. It is the mean value of the set tested (see also clause 6).

3.4 lot: A definite quantity of reference test pieces manufactured under identical conditions of production.

3.5 reference test piece: An impact test piece used to verify the suitability of an industrial pendulum impact testing machine by comparing the indicated energy measured by that machine to the reference energy associated with the test piece (see clause 8).

3.6 certified reference test piece: An impact test piece used to verify reference machines by comparing the impact energy measured by that machine to the certified reference value associated with the test piece.

NOTE — The certified reference value is the value determined by a national or international body following an inter-comparison exercise carried out on a group of reference machines within its jurisdiction.

3.7 set: A group of test pieces chosen at random from a lot.

3.7.1 characterization set: A set of test pieces taken from a lot in accordance with clause 6 and used to determine the reference energy of the lot.

3.7.2 reference set: A set of test pieces chosen in accordance with clauses 6 and 8 and used to verify a pendulum impact testing machine.

3.8 Definitions pertaining to the test piece (placed in the test position on the supports of the machine (see figures 1 and 2))

3.8.1 height: The distance between the notched face and the opposite face.

3.8.2 width: The dimension perpendicular to the height and parallel to the notch.

3.8.3 length: The largest dimension at right angles to the notch.

4 Symbols

The symbols used in this part of ISO 148 are as indicated in table 1.

Table 1 — Symbols and their meanings

Symbol	Unit	Meaning
A_v	J	Actual absorbed energy; absorbed energy
A_s	J	Indicated absorbed energy; indicated energy
A_R	J	Reference energy of a set of Charpy reference test pieces

5 Reference test machine

5.1 Characteristics

The characteristics of reference machines used to determine the reference energy of reference test pieces shall comply with the requirements of ISO 148-2 except as modified below:

5.1.1 Geometrical characteristics (see table 2 and figures 1 and 2)

- The radius of curvature of the anvils shall be $\left(1^{+0,1}_0\right)$ mm.
- The distance between the anvils shall be $\left(40^{+0,1}_0\right)$ mm.
- The striking edge shall remain within 0,25 mm of the plane of symmetry of the anvils.
- The striker shall conform to the geometry specified in ISO 148-2 for either the 2 mm or the 8 mm striker.

Table 2 — Geometrical characteristics (see figures 1 and 2)

Number	Designation	Size	Tolerance	Units
1	Length of test piece	55,00	$\begin{smallmatrix} +0 \\ -0,30 \end{smallmatrix}^*$	mm
2	Half-length of test piece	27,5	$\pm 0,20^*$	mm
3	Height of test piece	10,00	$\pm 0,06$	mm
4	Width of test piece	10,00	$\pm 0,075^*$	mm
5	Ligament length	8,00	$\pm 0,06$	mm
6	Angle of notch	45	$\pm 1^*$	deg
7	Radius of curvature of base of notch	0,250	$\pm 0,025$	mm
8	Angle between adjacent faces	90	$\pm 0,15^*$	deg
9	Angle between plane of symmetry of notch and longitudinal axis	90	± 2	deg
10	Radius of anvils	1	$\begin{smallmatrix} +0,1 \\ -0 \end{smallmatrix}^*$	mm
11	Angle of taper of anvils	11	± 1	deg
12	Distance between anvils	40,0	$\begin{smallmatrix} +0,1 \\ -0 \end{smallmatrix}^*$	mm
13	Distance of striking edge from plane of symmetry of anvils	—	$\pm 0,25^*$	mm
14	Angle of striker	30	± 1	deg
15A	Radius of curvature of striking edge of 2 mm striker	2 to 2,5		mm
15B	Radius of curvature of striking edge of 8 mm striker	8,0	$\pm 0,05$	mm
15C	Radius of shoulder of 8mm striker	0,2 to 1,0		mm
15D	Width of striking edge of 8 mm striker	4,0	$\pm 0,05$	mm
NOTE — Tolerances followed by an asterisk (*) are tighter than those in ISO 148-1 or ISO 148-2.				

The radius at the base of the notch shall be tangential to the notch angle.

The surface finish shall not exceed 1,6 μm on the notched surface or 3,2 μm on the other surfaces.

Identification marks shall not be placed in any area of the test piece that contacts the striker edge, anvils or test piece supports, or within 5 mm of the notch.

5.1.2 Capacity

The capacity of a reference machine shall be 300 J or greater.

5.1.3 Hardness

The portions of the striker and the anvils (see figure 1) which contact the specimen and apply or react to the impacting force shall have a minimum hardness of 56 HRC.

5.1.4 Vibration

Ensure that the reference machine is not subjected to external (random) vibrations induced by other equipment in close proximity, such as forging hammers, presses, moving vehicles.

NOTE — Such vibrations can be detected by placing a small container of water at any convenient location on the machine framework; the absence of ripples on the water surface indicates that this requirement is met. Excessive vibration in a machine firmly fastened to the floor indicates the need for a separate foundation and/or the use of vibration isolators.

5.1.5 Energy-indicating mechanism

The resolution shall be at least 1/400th of the nominal energy.

5.2 Qualification of reference test machine

Direct verification shall be carried out in accordance with ISO 148-2 and with the additional requirements of 5.1.

Indirect verification shall be carried out using certified reference test pieces. The repeatability and the error shall be as specified in table 3.

Table 3 — Repeatability and error of reference pendulum impact machines
(all values in joules)

Energy E	Repeatability	Error
< 40	≤ 3	≤ 2
≥ 40	$\leq 7,5 \% \text{ of } A_R$	$\leq 5 \% \text{ of } A_R$
Repeatability is given by : $A_{V \max} - A_{V \min}$ Error is given by : $\bar{A}_V - A_R$ where $\bar{A}_V = \frac{A_{V1} + A_{V2} + A_{V3} + \dots + A_{Vn}}{n}$		

5.3 Use of reference test machine

The procedure for the operation of the reference machine shall conform to the requirements of ISO 148 and to the following additional requirements:

5.3.1 The angular position of the pendulum at the extremes of its swing or the impact energy calculated therefrom shall be automatically recorded in digital or graphical form. These records shall be in permanent form suitable for evaluation at any time until one year after the entire batch of reference test pieces has been distributed.

5.3.2 The combined windage and friction loss during 11 successive half-swings shall be measured before and after testing each characterization set and the values recorded.

5.3.3 The anvils and striker shall be removed from the machine annually for a complete inspection. If any parts are found to be damaged, they shall be replaced and the machine shall be re-qualified (see 5.1 and 5.2).

During the annual inspection of the reference machine, the flatness of the anvil surfaces (which absorb the force transmitted through the test piece) and the adjacent radii shall be examined for local wear or damage or both. The results of this examination shall be retained until the anvils are replaced or re-machined.

NOTE — This examination can be done, for example, by making impressions of the surfaces in silicone rubber or another low-shrinkage material, or by holographic methods.

The radius (radii) of the striking edge of the striker and the radii of the anvil surfaces which are contacted by the test piece shall be measured and documented in the same manner.

If it becomes necessary to repair the recording system, it shall be recalibrated before additional tests are made (see 5.2).

5.4 Calibration of inspection, measurement and test equipment

All equipment used by the supplier for final inspection and testing shall be calibrated and shall have a certified traceability to the SI System (the international system of units). The supplier shall maintain calibration records for all inspection, measurement and test equipment.

5.5 Log book

The dates and details of all inspections and repairs shall be documented in a log book maintained for each reference machine.

6 Reference test pieces

6.1 Material

All the test pieces from a lot shall come from a single ingot or melt.

All test pieces shall be made of steel. The composition of the test pieces is not specified. Lots with different energy levels may have different compositions.

All test pieces from a lot shall receive the same heat treatment.

For each lot, the reference energy shall fall within one of the following ranges:

Low: $< 30 \text{ J}$

Medium: $\geq 30 \text{ J to } < 110 \text{ J}$

High: $\geq 110 \text{ J to } < 220 \text{ J}$

Ultra-high: $\geq 220 \text{ J}$

6.2 Dimensions

The reference test pieces shall meet the dimensional requirements given in table 2. These dimensions are identical with those in ISO 148-1 except that the tolerances are tighter.

6.3 Marking

All test pieces shall be permanently marked so that each test piece can be distinguished from all the others.

6.4 Qualification of reference test pieces

6.4.1 Any group of test pieces meeting the requirements of 6.1, 6.2 and 6.3 may be used as the lot from which reference test pieces are randomly selected.

6.4.2 To determine the reference energy of a lot, draw one or more sets of at least 25 test pieces at random from the lot and test them on a reference machine.

6.4.3 Take the reference energy of the lot as the average of the values obtained for the 25 or more test pieces. Also calculate the standard deviation. The standard deviation shall be as specified in table 4.

Table 4 — Standard deviation permitted for reference test pieces (values in joules)

Energy A_R	Standard deviation
< 40	$\leq 2,0$
≥ 40	$\leq 5\%$ of A_R

6.4.4 The report on the impact tests on the reference test pieces shall include the following information:

- the reference machine on which the tests were performed;
- the striker geometry;
- the temperature at which the tests were conducted;
- all details necessary for the identification of each test piece;
- the energy value, corrected for windage and friction, of each test piece;
- the reference energy value for the set, and the standard deviation.

6.5 Reference test piece sets

After the set(s) to be tested by the reference machine have been drawn from the lot, draw the remaining test pieces in sets of five. These are the reference test piece sets. Each reference test piece set shall remain intact with no substitution permitted.

7 Certificates for reference test pieces

Each set of reference test pieces shall be accompanied by

a) a certificate which gives the following information:

- 1) a reference to this part of ISO 148,
- 2) the name, trademark or reference number of the supplier,
- 3) the reference energy of the set and its standard deviation,
- 4) the striker geometry,

5) the temperature at which the reference energy was determined, and all details necessary for the identification of the reference machine(s) used to determine the reference energy;

b) when necessary, information concerning the use of the reference test pieces.

8 Procedure for using sets of reference test pieces

8.1 Indirect verification of an industrial machine shall be performed in accordance with ISO 148-2 using the reference test pieces and the striker and temperature specified by the supplier of the test pieces.

8.2 All the reference test pieces in each set shall be used for a single, indirect verification of the pendulum impact testing machine, testing the test pieces in random order and including all the results in the average. Substitution or replacement of individual test pieces by test pieces from another reference set is not permitted.