INTERNATIONAL STANDARD

**ISO 148-2**

Third edition
2016-10-15

# Metallic materials — Charpy pendulum impact test —

## Part 2:
## Verification of testing machines

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

*Partie 2: Vérification des machines d'essai (mouton-pendule)*



Reference number
ISO 148-2:2016(E)

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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 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.



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 148-2:2008), 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*

 

# Introduction

The suitability of a pendulum impact testing machine for acceptance testing of metallic materials has usually 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 that could 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 pendulum impact testing machines used for acceptance testing of material sold to them are to 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.

This part of ISO 148 describes both the original direct verification and the indirect verification procedures.

# Metallic materials — Charpy pendulum impact test —

## Part 2:
## Verification of testing machines

## 1 Scope

This part of ISO 148 covers the verification of pendulum-type impact testing machines, in terms of their constructional elements, their overall performance and the accuracy of the results they produce. It is applicable to machines with 2 mm or 8 mm strikers used for pendulum impact tests carried out, for instance, in accordance with ISO 148-1.

It can be applied to pendulum impact testing machines of various capacities and of different design.

Impact machines used for industrial, general or research laboratory testing of metallic materials in accordance with this part of ISO 148 are referred to as industrial machines. Those with more stringent requirements are referred to as reference machines. Specifications for the verification of reference machines are found in ISO 148-3.

This part of ISO 148 describes two methods of verification.



a) The direct method, which is static in nature, involves measurement of the critical parts of the machine to ensure that it meets the requirements of this part of ISO 148. Instruments used for the verification and calibration are traceable to national or international standards.

b) The indirect method, which is dynamic in nature, uses reference test pieces to verify points on the measuring scale for absorbed energy. The requirements for the reference test pieces are found in ISO 148-3.

A pendulum impact testing machine is not in compliance with this part of ISO 148 until it has been verified by both the direct and indirect methods and meets the requirements of Clause 6 and Clause 7.

This part of ISO 148 describes how to assess the different components of the total energy absorbed in fracturing a test piece. This total absorbed energy consists of

— the energy needed to fracture the test piece itself, and

— the internal energy losses of the pendulum impact testing machine performing the first half-cycle swing from the initial position.

NOTE Internal energy losses are due to the following:

— air resistance, friction of the bearings of the rotation axis and of the indicating pointer of the pendulum which can be determined by the direct method (see 6.4.5);

— shock of the foundation, vibration of the frame and pendulum for which no suitable measuring methods and apparatus have been developed.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 148-3, *Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines*

## 3 Terms and definitions

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

### 3.1 Definitions pertaining to the machine

**3.1.1**
**anvil**
portion of the machine that serves to properly position the test piece for impact with respect to the striker and the test piece supports, and supports the test piece under the force of the strike

**3.1.2**
**base**
part of the framework of the machine located below the horizontal plane of the supports

**3.1.3**
**centre of percussion**
point in a body at which, on striking a blow, the percussive action is the same as if the whole mass of the body were concentrated at the point

Note 1 to entry: When a simple pendulum delivers a blow along a horizontal line passing through the centre of percussion, there is no resulting horizontal reaction at the axis of rotation.



Note 2 to entry: See Figure 4.



**3.1.4**
**centre of strike**
point on the striking edge of the pendulum at which, in the free hanging position of the pendulum, the vertical edge of the striker meets the upper horizontal plane of a test piece of half standard thickness (i.e. 5 mm) or equivalent gauge bar resting on the test piece supports

Note 1 to entry: See Figure 4.

**3.1.5**
**industrial machine**
pendulum impact machine used for industrial, general or most research-laboratory testing of metallic materials

Note 1 to entry: Industrial machines are not used to establish reference values, unless they also meet the requirements of a reference pendulum (see ISO 148-3).

Note 2 to entry: Industrial machines are verified using the procedures described in this part of ISO 148.

**3.1.6**
**reference machine**
pendulum impact testing machine used to determine certified values for batches of *reference test pieces* (3.3.4)

Note 1 to entry: Reference machines are verified using the procedures described in ISO 148-3.

**3.1.7**
**striker**
portion of the pendulum that contacts the test piece

Note 1 to entry: The edge that actually contacts the test piece has a radius of 2 mm (the 2 mm striker) or a radius of 8 mm (the 8 mm striker).

Note 2 to entry: See Figure 2.

 

**3.1.8**
**test piece supports**
portion of the machine that serves to properly position the test piece for impact with respect to the *centre of percussion* (3.1.3) of the pendulum, the *striker* (3.1.7) and the *anvils* (3.1.1)

Note 1 to entry: See Figure 2 and Figure 3.

## 3.2 Definitions pertaining to energy

**3.2.1**
**total absorbed energy**
$K_T$
total absorbed energy required to break a test piece with a pendulum impact testing machine, which is not corrected for any losses of energy

Note 1 to entry: It is equal to the difference in the *potential energy* (3.2.2) from the starting position of the pendulum to the end of the first half swing during which the test piece is broken (see 6.3).

**3.2.2**
**initial potential energy**
**potential energy**
$K_P$
potential energy of the pendulum hammer prior to its release for the impact test, as determined by direct verification

Note 1 to entry: See 6.4.2.



**3.2.3**
**absorbed energy**
$K$
energy required to break a test piece with a pendulum impact testing machine, after correction for friction as defined in 6.4.5



Note 1 to entry: The letter V or U is used to indicate the notch geometry, which is *KV* or *KU*. The number 2 or 8 is used as a subscript to indicate striker radius, for example $KV_2$.

**3.2.4**
**calculated energy**
$K_{calc}$
energy calculated from values of angle, length and force measured during direct verification

**3.2.5**
**nominal initial potential energy**
**nominal energy**
$K_N$
energy assigned by the manufacturer of the pendulum impact testing machine

**3.2.6**
**indicated absorbed energy**
$K_S$
energy indicated by the display/dial of the testing machine, which may or may not need to be corrected for friction and air resistance to determine the *absorbed energy*, *K* (3.2.3)

**3.2.7**
**reference absorbed energy**
$K_R$
certified value of *absorbed energy* (3.2.3) assigned to the *reference test pieces* (3.3.4) used to verify the performance of pendulum impact machines

 

## 3.3 Definitions pertaining to test pieces

**3.3.1**
**width**
*W*
distance between the notched face and the opposite face

Note 1 to entry: In previous versions of the ISO 148 series (prior to 2016), the distance between the notched face and the opposite face was specified as “height”. Changing this dimension to “width” makes ISO 148-2 consistent with the terminology used in other ISO fracture standards.

**3.3.2**
**thickness**
*B*
dimension perpendicular to the *width* (3.3.1) and parallel to the notch

Note 1 to entry: In previous versions of the ISO 148 series (prior to 2016), the dimension perpendicular to the width that is parallel to the notch was specified as “width”. Changing this dimension to “thickness” makes ISO 148-2 consistent with the terminology used in other ISO fracture standards.

**3.3.3**
**length**
*L*
largest dimension perpendicular to the notch

**3.3.4**
**reference test piece**
impact test piece used to verify the suitability of a pendulum impact testing machine by comparing the *indicated absorbed energy* (3.2.3) measured by that machine with the *reference absorbed energy* (3.2.7) associated with the test pieces



Note 1 to entry: Reference test pieces are prepared in accordance with ISO 148-3.

# 4 Symbols and abbreviated terms

**Table 1 — Symbols/abbreviated terms and their designations and units**

| Symbol/ abbreviated term[a] | Unit | Designation |
|---|---|---|
| $B_V$ | J | Bias of the pendulum impact machine as determined through indirect verification |
| $b$ | J | Repeatability |
| $F$ | N | Force exerted by the pendulum when measured at a distance $l_2$ |
| $F_g$ | N | Force exerted by the pendulum due to gravity |
| $g$ | m/s$^2$ | Acceleration due to gravity |
| GUM | — | Guide to the expression of uncertainty in measurement[1] |
| $h$ | m | Height of fall of pendulum |
| $H_1$ | m | Height of rise of pendulum |
| $K$ | J | Absorbed energy (expressed as $KV_2$, $KV_8$, $KU_2$, $KU_8$, to identify specific notch geometries and the radius of the striking edge) |
| $K_T$ | J | Total absorbed energy |
| $K_S$ | J | Indicated absorbed energy |
| $K_{calc}$ | J | Calculated energy |
| $KV_R$ | J | Certified *KV* value of the reference material used in the indirect verification |

[a] See Figure 4.

 

**Table 1** *(continued)*

| Symbol/ abbreviated term[a] | Unit | Designation |
|---|---|---|
| $\overline{KV}_V$ | J | Mean $KV$ value of the reference test pieces tested for indirect verification |
| $K_N$ | J | Nominal initial potential energy (nominal energy) |
| $K_P$ | J | Initial potential energy (potential energy) |
| $K_R$ | J | Reference absorbed energy of a set of Charpy reference test pieces |
| $K_1$ or $\beta_1$ | J or ° | Indicated absorbed energy or angle of rise when the machine is operated in the normal manner without a test piece in position |
| $K_2$ or $\beta_2$ | J or ° | Indicated absorbed energy or angle of rise when the machine is operated in the normal manner without a test piece in position and without resetting the indication mechanism |
| $K_3$ or $\beta_3$ | J or ° | Indicated absorbed energy or angle of rise after 11 half swings when the machine is operated in the normal manner without a test piece in position and without resetting the indication mechanism |
| $l$ | m | Distance to centre of test piece (centre of strike) from the axis of rotation (length of pendulum) |
| $l_1$ | m | Distance to the centre of percussion from the axis of rotation |
| $l_2$ | m | Distance to the point of application of the force $F$ from the axis of rotation |
| $M$ | N·m | Moment equal to the product $F \cdot l_2$ |
| $n_V$ | — | Number of reference samples tested for the indirect verification of a pendulum impact testing machine |
| $p$ | J | Absorbed energy loss caused by pointer friction |
| $p'$ | J | Absorbed energy loss caused by bearing friction and air resistance |
| $p_\beta$ | J | Correction of absorbed energy losses for an angle of rise $\beta$ |
| $r$ | J | Resolution of the pendulum scale |
| RM | — | Reference material |
| $s_V$ | J | Standard deviation of the $KV$ values obtained on $n_V$ reference samples |
| $S$ | J | Bias in the scale mechanism |
| $t$ | s | Period of the pendulum |
| $T$ | s | Total time for 100 swings of the pendulum |
| $T_{max}$ | s | Maximum value of $T$ |
| $T_{min}$ | s | Minimum value of $T$ |
| $u$ | — | Standard uncertainty |
| $u\left(\overline{KV}_V\right)$ | J | Standard uncertainty of $\overline{KV}_V$ |
| $u(B_V)$ | J | Standard uncertainty contribution from bias |
| $u(F)$ | J | Standard uncertainty of the measured force, $F$ |
| $u(F_{ftd})$ | J | Standard uncertainty of the force transducer |
| $u(r)$ | J | Standard uncertainty contribution from resolution |
| $u_{RM}$ | J | Standard uncertainty of the certified value of the reference material used for the indirect verification |
| $u_V$ | J | Standard uncertainty of the indirect verification result |
| $\alpha$ | ° | Angle of fall of the pendulum |
| $\beta$ | ° | Angle of rise of the pendulum |

[a] See Figure 4.

**Table 1** *(continued)*

| Symbol/ abbreviated term[a] | Unit | Designation |
|---|---|---|
| $\upsilon_B$ | — | Degrees of freedom corresponding to $u(B_V)$ |
| $\upsilon_V$ | — | Degrees of freedom corresponding to $u_V$ |
| $\upsilon_{RM}$ | — | Degrees of freedom corresponding to $u_{RM}$ |

[a] See Figure 4.

## 5 Testing machine

A pendulum impact testing machine consists of the following parts (see Figure 1 to Figure 3):

a) foundation/installation;

b) machine framework: the structure supporting the pendulum, excluding the foundation;

c) pendulum, including the hammer;

d) anvils and supports (see Figure 2 and Figure 3);

e) indicating equipment for the absorbed energy (e.g. scale and friction pointer or electronic readout device).



## 6 Direct verification

### 6.1 General



Direct verification of the machine involves the inspection of the items a) to e) listed in Clause 5.

Uncertainty estimates are required under Clause 6 for direct verification measurements to harmonize the accuracy of the applied verification procedures. Uncertainty estimates required in Clause 6 are not related to product standards or material property databases in any way.

The uncertainty of dial gauges, micrometres, callipers, and other commercial instrumentation used for the direct verification measurements shall be estimated once, by the producer.

Uncertainty of a method to measure a direct verification parameter is assessed as part of the method validation. Once method validation is completed, the uncertainty can be routinely used (provided the same method is followed, the same instrumentation is used, and the operators are trained).

### 6.2 Foundation/installation

**6.2.1** The foundation to which the machine is fixed and the method(s) of fixing the machine to the foundation are of the utmost importance.

**6.2.2** Inspection of the machine foundation can usually not be made once the machine has been installed; thus, documentation made at the time of installation shall be produced to provide assurance that the mass of the foundation is not less than 40 times that of the pendulum.

**6.2.3** Inspection of the installed machine shall consist of the following.

a) Ensuring that the bolts are torqued to the value specified by the machine manufacturer. The torque value shall be noted in the document provided by the manufacturer of the machine (see 6.2.1). If other mounting arrangements are used or selected by an end user, equivalency shall be demonstrated.

b) Ensuring that the machine is not subject to external vibrations transmitted through the foundation at the time of the impact test.

NOTE This can be accomplished, for example, by placing a small container of water on any convenient location on the machine framework. The absence of ripples on the water surface during an impact test indicates that this requirement has been met.

## 6.3 Machine framework

**6.3.1** Inspection of the machine framework (see Figure 1) shall consist of determining the following items:

a) free position of the pendulum;

b) location of the pendulum in relation to the supports;

c) transverse and radial play of the pendulum bearings;

d) clearance between the hammer and the framework.

Machines manufactured after 1998 shall have a reference plane from which measurements can be made.

Annex C is provided for information.

**6.3.2** The axis of rotation of the pendulum shall be parallel to the reference plane to within 2/1 000. This shall be certified by the manufacturer.



**6.3.3** The machine shall be installed so that the reference plane is horizontal to within 2/1 000.

For pendulum impact testing machines without a reference plane, the axis of rotation shall be established to be horizontal to within 4/1 000 directly or a reference plane shall be established from which the horizontality of the axis of rotation can be verified as described above.



**6.3.4** When hanging free, the pendulum shall hang so that the striking edge is within 2,5 mm of the position where it would just touch the test specimen.

NOTE This condition can be determined using a gauge in the form of a bar that is approximately 55 mm in length and of rectangular section 7,5 mm by 12,5 mm (see Figure 3).

**6.3.5** The plane of swing of the pendulum shall be 90,0° ± 0,1° to the axis of rotation ($u < 0{,}05°$).

**6.3.6** The striker shall make contact over the full thickness of the test piece.

One method of verifying this is to use a test piece having dimensions of 55 mm × 10 mm × 10 mm that is tightly wrapped in thin paper (e.g. by means of adhesive tape) and a striking edge that is tightly wrapped in carbon paper with the carbon side outermost (i.e. not facing the striker). From its position of equilibrium, the pendulum is raised a few degrees, released so that it contacts the test piece, and prevented from contacting the test piece a second time. The mark made by the carbon paper on the paper covering the test piece should extend completely across the paper. This verification can be performed concurrently with that of checking the angle of contact between the striker and the test piece (see 6.4.8).

**6.3.7** The pendulum shall be located so that the centre of the striker and the centre of the gap between the anvils are coincident to within 0,5 mm ($u < 0{,}1$ mm).

**6.3.8** Axial play in the pendulum bearings shall not exceed 0,25 mm ($u < 0{,}05$ mm) measured at the centre-of-rotation under a transverse force of approximately 4 % of the effective weight of the pendulum, $F_g$ [see Figure 4 b)], applied at the centre of strike.

 