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Metallic materials — Charpy V-notch pendulum impact test — Instrumented test method

Matériaux métalliques — Essai de flexion par choc sur éprouvette Charpy à entaille en V — Méthode d'essai instrumenté

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Foreword

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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).

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For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Fatigue, fracture and toughness testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459, *Mining and Metals*, SC 1, *Test methods for steel (other than chemical analysis)*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 14556:2015), which has been technically revised.

The main changes are as follows:

— in Clause 1, a sentence was added to state that results shall not be directly used in design calculations;

— in Clause 4, the symbol K_p (potential energy of the pendulum hammer) was added; the symbol *KV* (absorbed energy) was changed to K_V;

— in 6.1 and D.2.1, the application of the “dynamic force adjustment” was added;

— in 6.2.3, a generic statement about the stiffness of the support block was removed;

— in 6.2.5, the possibility of directly determining characteristic values from printed graphs was removed;

— in Clauses 7 and 8, statements referring to Annex D when testing miniature test pieces were added;

— in 9.2, the characteristic values of force that can be evaluated from curves of Type A and B were changed;

— in 9.3, it is now specified that F_m is determined after general yield;

— in Figure 2, force-displacement curves in columns 3 (actual recording) were replaced with better-quality ones;

— in Clause 10, a requirement to report the type of test piece (standard, subsize, or miniature) was added;

— in Annex A, it was clarified that those shown are examples of instrumented strikers;

— in Annex D, alternative miniature test pieces were removed;

— in D.2.1, the deviation range between W_t and K_V was changed from ±0,5 J to ±10 % of K_V;

— in D.3.1, dimensions for the standard miniature test piece were added; test temperature requirements were removed; the test report section was removed;

— in the Bibliography, a new reference, [8], was added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Metallic materials — Charpy V-notch pendulum impact test — Instrumented test method

1 Scope

This document specifies a method of instrumented Charpy V-notch pendulum impact testing on metallic materials and the requirements concerning the measurement and recording equipment.

With respect to the Charpy pendulum impact test described in ISO 148-1, this test provides further information on the fracture behaviour of the product under impact testing conditions.

The results of instrumented Charpy test analyses are not directly transferable to structures or components and shall not be directly used in design calculations or safety assessments.

NOTE General information about instrumented impact testing can be found in References [1] to [5].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

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

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Characteristic values of force (see Figure 2)

3.1.1
general yield force
F_{gy}
force at the transition point from the linearly increasing part, discarding inertia peak(s), to the curved increasing part of the force-displacement curve

Note 1 to entry: It represents an approximation of the force at which yielding occurs across the entire test piece ligament (see 9.3).

3.1.2
maximum force
F_m
maximum force in the course of the force-displacement curve

3.1.3
unstable crack initiation force
F_{iu}
force at the beginning of a steep drop in the force-displacement curve (unstable crack initiation)

3.1.4
crack arrest force
F_a
force at the end (arrest) of unstable crack propagation

3.2 Characteristic values of displacement (see Figure 2)

3.2.1
general yield displacement
s_{gy}
displacement corresponding to the general yield force, F_{gy}

3.2.2
displacement at maximum force
s_m
displacement corresponding to the maximum force, F_m

3.2.3
displacement at unstable crack initiation
s_{iu}
displacement corresponding to the force at unstable crack initiation, F_{iu}

3.2.4
crack arrest displacement
s_a
displacement corresponding to the force at the end (arrest) of unstable crack propagation, F_a

3.2.5
total displacement
s_t
displacement at the end of the force-displacement curve

3.3 Characteristic values of impact energy

3.3.1
energy at maximum force
W_m
partial impact energy from $s = 0$ to $s = s_m$

Note 1 to entry: Calculated as the area under the force-displacement curve from $s = 0$ to $s = s_m$.

3.3.2
energy at unstable crack initiation
W_{iu}
partial impact energy from $s = 0$ to $s = s_{iu}$

Note 1 to entry: Calculated as the area under the force-displacement curve from $s = 0$ to $s = s_{iu}$.

3.3.3
crack arrest energy
W_a
partial impact energy from $s = 0$ to $s = s_a$

Note 1 to entry: Calculated as the area under the force-displacement curve from $s = 0$ to $s = s_a$.

3.3.4
total impact energy
W_t
energy absorbed by the test piece during the test

Note 1 to entry: Calculated as the area under the force-displacement curve from $s = 0$ to $s = s_t$.

4 Symbols and abbreviated terms

Symbol	Designation	Unit
f_g	Output frequency limit	Hz
F	Force	N
F_a	Crack arrest force	N
F_{gy}	General yield force	N
F_{iu}	Unstable crack initiation force	N
F_m	Maximum force	N
g	Local acceleration due to gravity	m/s^2
h	Height of fall of the centre of strike of the pendulum (see ISO 148-2)	m
K_p	Initial potential energy (potential energy), as specified in ISO 148-1	J
K_V	Absorbed energy for a V-notch test piece, as specified in ISO 148-1	J
m	Effective mass of the pendulum corresponding to its effective weight	kg
s	Displacement	m
s_a	Crack arrest displacement	m
s_{gy}	General yield displacement	m
s_{iu}	Displacement at unstable crack initiation	m
s_m	Displacement at maximum force	m
s_t	Total displacement	m
$s(t)$	Displacement of the test piece at time t	m
t	Time	s
t_o	Time at the beginning of deformation of the test piece	s
t_r	Signal rise time	s
v_o	Initial striker impact velocity	m/s
$v(t)$	Striker impact velocity at time t	m/s
W_a	Crack arrest energy	J
W_{iu}	Energy at unstable crack initiation	J
W_m	Energy at maximum force	J
W_t	Total impact energy	J

5 Principle

5.1 This test consists of measuring the impact force, in relation to the test piece bending displacement, during an impact test carried out in accordance with ISO 148-1. The area under the force-displacement curve is a measure of the energy absorbed by the test piece.

5.2 Force-displacement curves for different steel products and different temperatures can be quite different, even though the areas under the curves and the absorbed energies are identical. If the force-displacement curves are divided into characteristic parts, various phases of the test can be deduced which provide considerable information about the behaviour of the test piece at impact loading rates.

6 Apparatus

6.1 Testing machine

A pendulum impact testing machine, in accordance with ISO 148-2, and instrumented to determine the force-time or force-displacement curve shall be used.

Comparisons between the total impact energy, W_t, from the instrumentation (see Clause 9.5) and the absorbed energy indicated by the machine dial or encoder, K_V, shall be made.

NOTE The instrumentation and the machine dial or encoder measure similar but different quantities. Differences are to be expected (see Reference [6]).

If deviations between K_V and W_t exceed the larger between 10 % of K_V or 2 J, the following should be checked:

a) friction of the machine;

b) calibration of the measuring system;

c) software used;

d) the possibility of applying the so-called “dynamic force adjustment”, see Reference [7], whereby forces are adjusted until W_t and K_V become equal.

6.2 Instrumentation and calibration

6.2.1 Traceable measurement

The equipment used for all calibration measurements shall be metrologically traceable to national or international standards of measurement.

6.2.2 Force measurement

Force measurement is usually achieved by using two active electric resistance strain gauges attached to the standard striker to form a force transducer. Examples of designs are shown in Annex A.

A full bridge circuit is made by two equally stressed (active) strain gauges bonded to opposite sides of the striker and by two compensating (passive) strain gauges, or by substitute resistors. Compensating strain gauges shall not be attached to any part of the testing machine which experiences impact or vibration effects.

NOTE 1 Alternatively, any other instrumentation to form a force transducer, which meets the required performance levels, can be used.

The force measuring system (instrumented striker, amplifier, recording system) shall have a response of at least 100 kHz, which corresponds to a rise time, t_r, of no more than 3,5 µs.

A simple dynamic assessment of the force measuring chain can be performed by measuring the value of the first inertia peak. By experience, the dynamics of the measuring chain can be considered satisfactory if a steel V-notch test piece shows an initial peak greater than 8 kN when using an impact velocity between 5 m/s and 5,5 m/s. This is valid if the centres of the active strain gauges are 11 mm to 15 mm away from the striker contact point.

The instrumentation of the striker shall be adequate to give the required nominal force range. The instrumented striker shall be designed to minimize its sensitivity to non-symmetric loading.

NOTE 2 Experience shows that with the V-notch test piece, nominal impact forces up to 40 kN can occur for most steel types.

6.2.3 Calibration

Calibration of the recorder and measuring system may be performed statically in accordance with the accuracy requirements given below and in 6.2.4.

It is recommended that the force calibration be performed with the striker built into the hammer assembly.

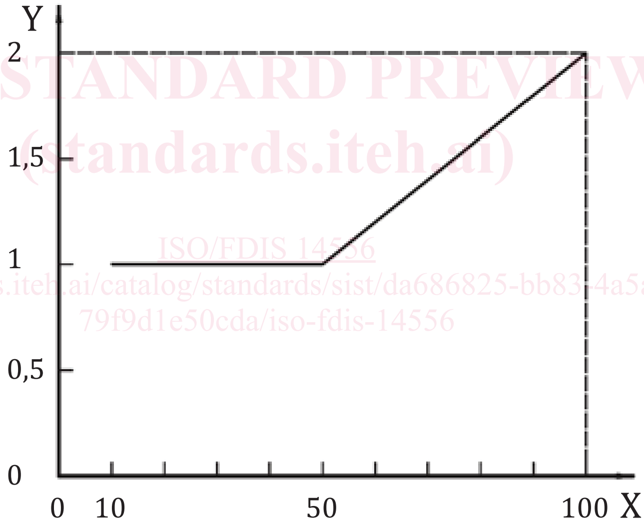
Force is applied to the striker through a special load frame equipped with a calibrated load cell and using a special support block in the position of the test piece.

The contact conditions shall be approximately equal to those of the test and give reproducible results.

NOTE An example of a suitable support block for the calibration of a 2 mm striker is given in Annex B.

The static linearity error of the built-in, instrumented striker, including all parts of the measurement system up to the recording apparatus (printer, plotter, etc.), shall be within ±2 % of the recorded force, between 50 % and 100 % of the nominal force range, and within ±1 % of the full scale force value between 10 % and 50 % of the nominal force range (see Figure 1).

For the instrumented striker and the measuring system alone (without hammer assembly), it is recommended that the accuracy be ±1 % of the recorded value between 10 % and 100 % of the nominal range.



Key

X recorded value as percentage of nominal range

Y absolute error as percentage of nominal range

Figure 1 — Maximum permissible error of recorded values within the nominal force range

6.2.4 Displacement measurement

Displacement is normally determined from force-time measurements. See Clause 9.

Displacement can also be determined by non-contacting measurement of the displacement of the striker, relative to the anvil, using optical, inductive, or capacitive methods. The signal transfer characteristics of the displacement measurement system shall correspond to that of the force measuring system in order to make the two recording systems synchronous.

The displacement measuring system shall be designed for nominal values up to 30 mm; linearity errors in the measuring system shall yield measured values to within ±2 % in the range 1 mm to 30 mm. A

