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AMENDMENT 1
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Steel — Charpy V-notch pendulum impact test — Instrumented test method

AMENDMENT 1: Annex D — Instrumented Charpy V-notch pendulum impact test of sub-size test pieces

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

AMENDEMENT 1: Annexe D — Essai de flexion par choc instrumenté sur éprouvettes Charpy à entaille en V de dimensions réduites

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Foreword

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Amendment 1 to ISO 14556:2000 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing — Fracture (F), Pendulum (P), Tear (T)*.

Steel — Charpy V-notch pendulum impact test — Instrumented test method

AMENDMENT 1: Annex D — Instrumented Charpy V-notch pendulum impact test of sub-size test pieces

Page iii, **Contents**

Add

"**Annex D** (informative) **Instrumented Charpy V-notch pendulum impact test of sub-size test pieces** .....**14**"

after **Annex C**.

Change the page number of the Bibliography to **21**.

Page iv, **Foreword**

Replace the last sentence with the following:

"Annexes A to D of this International Standard are for information only."

Page 14

Insert the following annex before the Bibliography.

Annex D
(informative)

Instrumented Charpy V-notch pendulum impact test of sub-size test pieces

D.1 Introduction

This annex defines the instrumented Charpy V-notch pendulum impact testing of sub-size test pieces on steel products and the requirements concerning the measurement and recording equipment.

This International Standard can be applied, by agreement, to other metallic materials and to other impact testing machines, such as drop-weight towers or high-speed servo-hydraulic machines.

This test provides further information on the fracture behaviour of the tested product.

The user should be aware that data obtained from sub-size test pieces may not be directly comparable to those obtained from full-size standard Charpy V-notch test pieces and that suitable correlation procedures have to be employed.

D.2 Apparatus

D.2.1 Testing machine

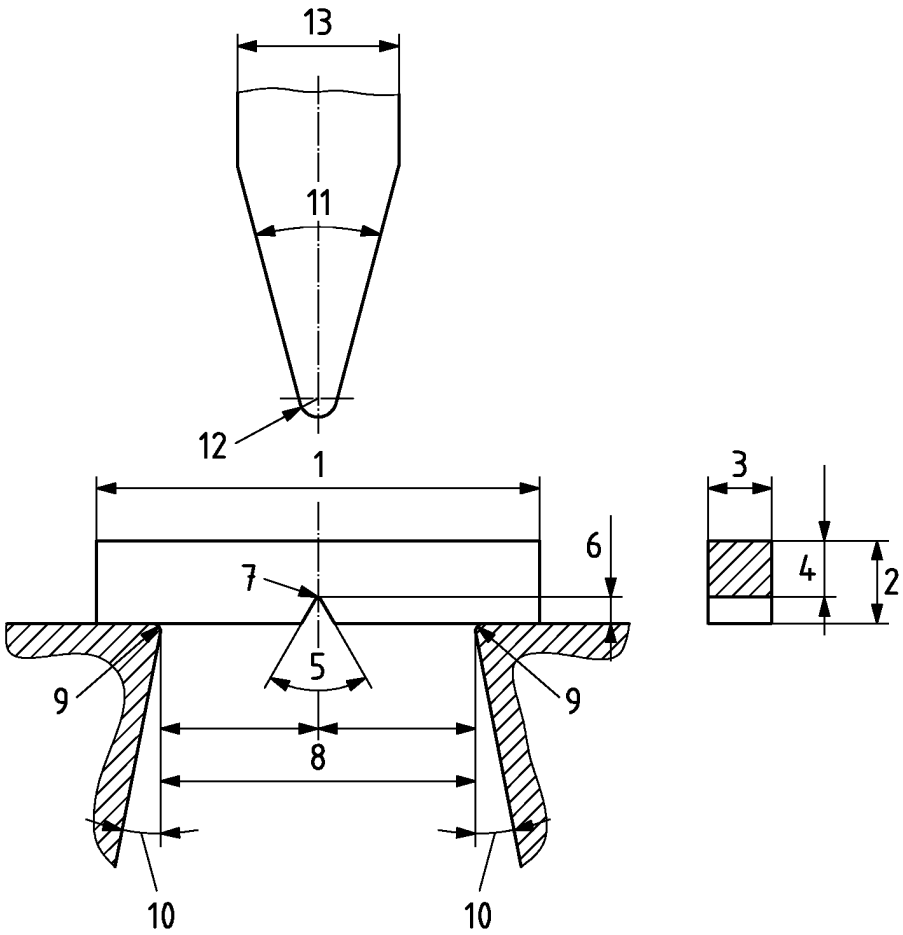
The testing machine is similar to that used for conventional Charpy V-notch test pieces, with the exception of the following characteristics, which have to be suitably modified taking into account the dimensions of the test piece (Figure D.1): impact velocity, distance between the anvils, positioning of the specimen with respect to the striking edge.

NOTE Only in the case of test machines with available energy not greater than 50 J, the quality of the instrumentation can be assessed by comparing the total impact energy, W_t, from the instrumentation with the absorbed energy indicated by the machine dial, KV. If deviations between the values exceed ± 0,5 J, the following should be investigated:

a) the friction of the machine;

b) the calibration of the measuring system;

c) the software used.



Reference number	Designation	Value
1	Specimen length	27 mm ± 0,50 mm
2	Specimen height	4 mm ± 0,05 mm
3	Specimen width	3 mm ± 0,05 mm
4	Height below notch	3 mm ± 0,05 mm
5	Angle of notch	60°± 1°
6	Notch depth	1 mm ± 0,05 mm
7	Notch-root radius	0,1 mm ± 0,025 mm
8	Distance between anvils (span)	$22\ \text{mm}^{+0,10}_{0}$ mm
9	Radius of anvils	$1\ \text{mm}^{+0,50}_{0}$ mm
10	Angle of taper of anvils	11°± 1°
11	Angle of taper of striker	30°± 1°
12	Radius at tip of striker	$2\ \text{mm}^{+0,50}_{0}$ mm
13	Width of the striker	6 mm to 12 mm

Notch length to edge: 90° ± 2° — Adjacent sides shall be at 90° ± 1°.

Finish requirements: roughness Ra 2 on notched surface and Ra 4 on the other two surfaces.

Figure D.1 — Impact test on sub-size Charpy V-notch specimen

D.2.2 Force measuring system

Due to the more dynamic behaviour of sub-size test pieces with respect to full-size test pieces, the force measuring system (transducer, amplifier, recording system) shall have an upper frequency of at least 250 kHz. If only the maximum force and the absorbed energy are to be measured from the curve, an upper frequency limit of 100 kHz is sufficient.

NOTE 1 The dynamic assessment of the force measuring chain can be simplified by measuring the maximum value of the first initial peak. By experience, the dynamics of the measurement chain can be considered satisfactory, if a steel V-notch sub-size test piece shows an initial peak greater than $(0{,}23 \times v_o)$ kN.

NOTE 2 Experience shows that, with the sub-size test piece shown in Figure D.1, nominal impact forces up to 4 kN occur for most steel types.

D.2.3 Calibration

An example of the support block for the static calibration of a 2 mm striker used for testing sub-size test pieces is shown in Figure D.2.

Dimensions in millimetres

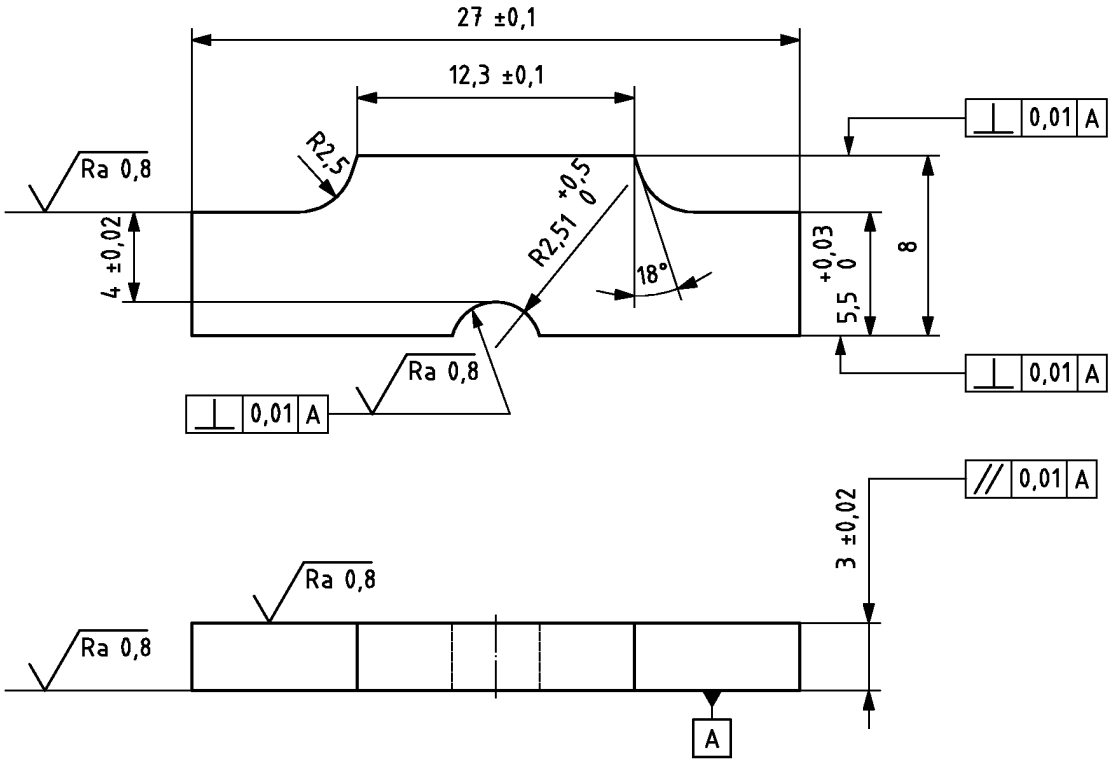


Figure D.2 — Example of a support block for the calibration of a 2 mm striker used for testing sub-size test pieces

D.2.4 Recording apparatus

An 8 bit analogue-digital converter with a sampling rate of 500 kHz (2 µs sample interval) is necessary; however, 12 bit is recommended.

D.3 Test piece

The test piece is a sub-size Charpy V-notch test piece, conforming to the dimensions specified in Figure D.1. Other specimen geometries can be used, by agreement; designs of other sub-size test pieces that have been successfully used are shown in Figure D.3.

NOTE Some aspects of the present test procedure may not be fully applicable to other sub-size test pieces.

Side-grooving of the test piece is optional.

D.4 Test procedure

D.4.1 Test temperature

The temperature of the test piece at impact shall be within ± 2 °C of the nominal test temperature. The temperature shall be measured in the notch area; uncertainty in temperature measurements has to be accounted for.

Due to the small size of the test piece, in tests below or above room temperature, special attention should be given to temperature control within the above-mentioned tolerance. Consequently, techniques for conditioning the specimen temperature *in situ* (on location) are preferred; if a liquid or gaseous medium is used for cooling or heating the test piece, the time of transfer from the bath to the impact position shall be appropriately minimised in order to meet the above-mentioned temperature tolerance.

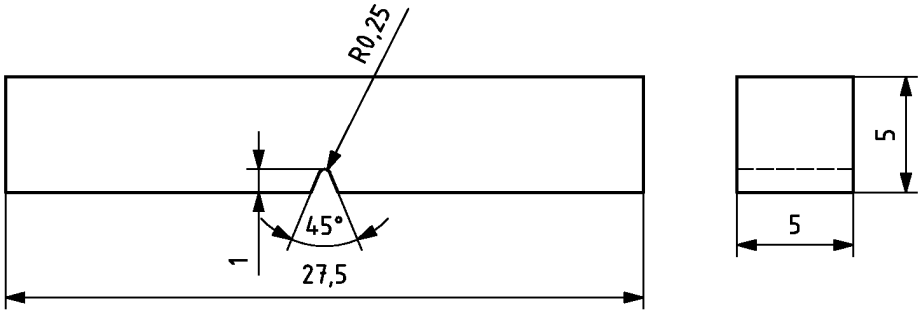
D.4.2 Test velocity

The velocity of the moving striker at impact can be chosen within a range of values (normally from 1,0 ms^{-1} to 5,5 ms^{-1}), according to the specific characteristics of the material to be tested. In choosing the impact velocity, and consequently the potential energy W_p available for the test, the following criterion shall be satisfied:

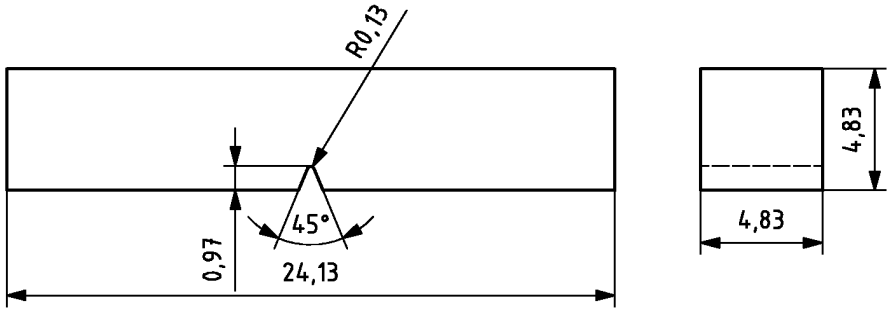
$$W_p \geqslant 3W_m$$

NOTE Experience shows that impact velocities above 4 ms^{-1} are not advisable for sub-size test pieces, since excessive oscillations are then superimposed on the initial portion of the test diagram and errors in the evaluation of the force-displacement curve can occur.

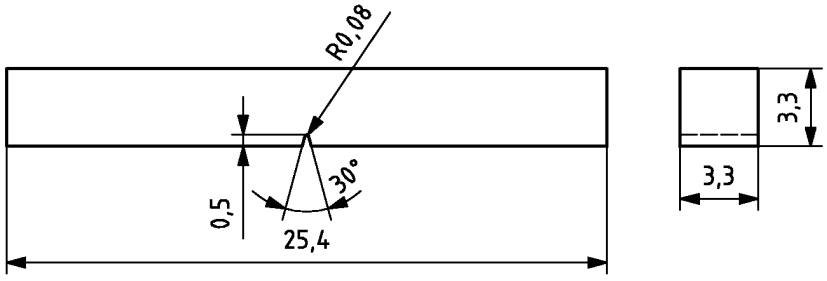
Dimensions in millimetres



a) Half-size (span: 20 mm)



b) Reduced half-size (span: 20 mm)



c) Third-size (span: 20 mm)

Finish requirements and geometrical tolerances are as in Figure D.1.

Figure D.3 – Alternative sub-size Charpy V-notch specimens

D.5 Evaluation of the force-displacement curve

D.5.1 General

The evaluation of the force-displacement curve, with the determination of the characteristic values of force and displacement, is restricted to the case where the upper frequency limit of the measuring instrumentation is at least 250 kHz. If such a condition is not fulfilled, test evaluation is restricted to the determination of the maximum force F_m, as defined in 3.1.2, and of the total impact energy W_t, as defined in 3.3.4.

NOTE Experience shows that, for the sub-size test piece shown in Figure D.1, tests in the upper shelf condition (type F curves in Figure 2) usually terminate with the specimen not fully broken.

D.5.2 Determination of the general yield force F_{gy}

For sub-size test pieces, the general yield force F_{gy} is determined as the force at the intersection of the straight line fitted through the oscillations of the initial part of the force-displacement curve (Hooke's line) and the fitted curve through the oscillations of the force-displacement curve following the onset of plastic collapse of the ligament (Figure 2: force-displacement curves of types C – F).

NOTE 1 Attention is drawn to the fact that, due to the more dynamic performance of sub-size test pieces, the determination of the general yield force F_{gy} is more difficult than in the case of standard Charpy V-notch test pieces. Furthermore, for sub-size test pieces, Hooke's line does not correspond to the slope of the second inertia peak, as generally found in the case of standard specimens.

NOTE 2 Analytical procedures for determining the value of the general yield force F_{gy}, and more specifically for determining the straight line which corresponds to Hooke's line for different values of impact velocity v_o, are described in References [6] to [8] in the Bibliography.

D.6 Test report

In addition to the information listed in Clause 10 of this International Standard, the following additional items shall be indicated in the case of sub-size test pieces:

l) if applicable, side-grooving of the test piece;

m) test velocity, in metres per second.

D.7 Repeatability and reproducibility of the test method

An interlaboratory study used sub-size Charpy-V notch specimens of the type shown in Figure D.1 to establish the sources of variation in the characteristic values of force, displacement and energy evaluated from curves of type F (upper-shelf conditions). Data from 13 laboratories were included in the analysis, with each laboratory testing 1 to 5 specimens at room temperature (21 °C to 25 °C), using impact velocities from 2,64 m/s to 3,85 m/s. ISO 5725-3:1994 [11] was followed for the analysis of the data; details are given in [9] in the Bibliography.

Table D.1 gives, for each characteristic value considered in the analysis, the values of m (general mean values of all test results), r (repeatability index) and R (reproducibility index).

Table D.1 — Interlaboratory study results

Characteristic value	m	r (%)	R (%)
F_{gy}	0,997 kN	6,1	10,4
F_m	1,298 kN	3,9	10,8
s_{gy}	0,190 mm	34,8	64,8
s_m	1,911 mm	16,5	24,8
W_m	2,233 J	14,9	25,1
W_t	8,144 J	15,7	15,7

The terms repeatability index and reproducibility index are used as defined in ISO 5725-2 [10].

Page 14, **Bibliography**

Add the following references.

[6] KALTHOFF, J.F. and GREGOR, M. "Instrumented Impact Testing of Subsize Charpy V-Notch Specimens", *Small Specimen Test Techniques*, ASTM STP 1329, CORWIN, W.R. ROSINSKI, S.T. and. VAN WALLE, E. Eds., American Society for Testing and Materials, 1998, pp.123-136

[7] TAYLOR, H. "Determination of the Characteristic Yield Force (F_{gy}) and Displacement (s_{gy}) for Instrumented Mini Charpy-V Specimens", Proceedings of ECF12, *Fracture from Defects*, Brown, De Los Rios and Miller, Eds., EMAS Sheffield Sep 1998, pp.1249-1254

[8] ESIS TC5, "Proposed Standard Method for Instrumented Impact Testing of Sub-Size Charpy V-Notch Specimens of Steels" (Annex C), Draft 10a, 23/5/02

[9] LUCON, E. "Round-Robin On Instrumented Impact Testing Of Sub-Size Charpy-V Specimens: Results Of Phase 1", ESIS TC5 Instrumented Impact Testing, Final Report, 2 April 1998

[10] ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

[11] ISO 5725-3:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method*

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