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Metallic materials — Ductility testing — High speed compression test for porous and cellular metals

*Matériaux métalliques — Essais de ductilité — Essai de compression
à haute vitesse des métaux poreux et cellulaires*

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Foreword

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This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

This second edition cancels and replaces the first edition (ISO 17340:2014), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

- the title of ISO 7500-1 has been updated in [Clause 2](#);
- a list of symbols and units has been added as [Clause 4](#);
- information about the use of adhesives in [8.2 b\)](#) has been revised;
- minor editorial changes have been made to align with ISO/IEC Directives Part 2:2018.

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Introduction

Porous and cellular metals have attractive properties due to their unique cell morphology. When they are used as impact energy absorbing components in automotive structures, knowledge of their high-speed compressive properties is necessary for industrial design. The high-speed compressive deformation behaviour of porous and cellular metals is quite different from their static compressive properties. Testing methods for static compressive deformation are, therefore, insufficient for characterization of high-speed compressive deformation. Standardization of a testing method for the high-speed compressive behaviour of porous and cellular metals is required.

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Metallic materials — Ductility testing — High speed compression test for porous and cellular metals

1 Scope

This document specifies methods for high speed compression testing, at room temperature, of porous and cellular metals having a porosity of 50 % or more. The speed range applicable to this test method is 0,1 m/s to 100 m/s (or 1 s^{-1} to 10^3 s^{-1} in terms of the initial strain rate when the specimen height is 100 mm).

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 376, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 13314, *Mechanical testing of metals — Ductility testing — Compression test for porous and cellular metals*

ISO 80000-1, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13314 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 test speed

movement speed of the pressing jig, which applies the compressive force to the test piece, when the pressing jig contacts the test piece

3.2 initial strain rate

value derived by dividing the test speed by the initial height of the test piece

3.3 sampling frequency

frequency used to sample the measurement data per unit time

3.4 drop height

initial distance between the pressure application plane of the pressing jig and the top surface of the test piece in the drop weight impact testing machine

3.5

approach length

initial distance between the pressure application plane of the pressing jig and the top surface of the test piece in the servo-type high-speed compression testing machine

4 Symbols and units

Symbol	Unit	Designation
m	kg	mass of the weight
h	m	drop height
V_0	m/s	test speed
g	m/s ²	acceleration of gravity
a	s ⁻¹	initial strain rate of the test piece
H_0	mm	initial height of the test piece
H_1	mm	test piece height at a time when the weight contacts the absorber
A	mm ²	initial cross-sectional area of the test piece
ΔL	mm	displacement of the pressing jig from the initial contact position with the test piece
e	%	compressive strain
F	N	compressive force
σ	N/mm ²	compressive stress
σ_{pl}	N/mm ²	plateau stress defined in ISO 13314
e_{ple}	%	plateau end strain defined in ISO 13314
W	MJ/m ³	energy absorption per unit volume
e_{max}	%	upper limit value of the compressive strain
W_{sta}	MJ/m ³	energy absorption up to 50% of the compressive strain, as determined in 8.1 a)

5 Principle

This test consists of applying an impact force at test speeds between 0,1 m/s and 100 m/s to porous and cellular metals and measuring the compressive force and displacement for evaluation of their high-speed compressive deformation characteristics, such as plateau stress and energy absorption. Test methods that apply high-speed compressive forces to porous and cellular metals are the drop weight impact test and the servo-type high-speed compression test.

The drop weight impact test applies the compressive force by dropping a weight from a specified height. The test speed is controlled by the drop height. Due attention should be paid to the fact that the weight will be decelerated during the period of compressive deformation. When the drop height necessary to reach the specified test speed cannot be obtained, application of an initial velocity to the weight is possible.

The servo-type high-speed compression test applies the compressive force using a hydraulic or electric high-speed servo mechanism. The test speed is changed by the servo control. The drive unit shall be capable of following the test speed.

6 Testing machine

6.1 Type of testing machine

The testing machines to be used for high-speed compression testing of porous and cellular metals are the drop weight impact testing machine and the servo-type high speed compression testing machine.

6.2 Drop weight impact testing machine

6.2.1 General

An example of the basic composition of the drop weight impact testing machine is shown in [Figure 1](#).

The drop weight impact testing machine consists of a weight, guide frame, pressing jig, load cell, displacement sensor, and absorber, as described in [6.2.2](#) through [6.2.6](#).

6.2.2 Weight

The weight shall drop vertically along the guide frame and shall be capable of applying the compressive force to the test piece.

The weight shall not be deformed by the impact when dropped and it should be possible to change the mass freely.

6.2.3 Pressing jig

The pressing jigs are located above and below the test piece and are used to apply the compressive force to the test piece. The pressing jig shall be of a construction such that it does not deform due to the compressive force, allowing correct transmission of the compressive force in the axial direction and preventing the action of forces, such as bending stress, etc., other than the compressive force on the test piece.

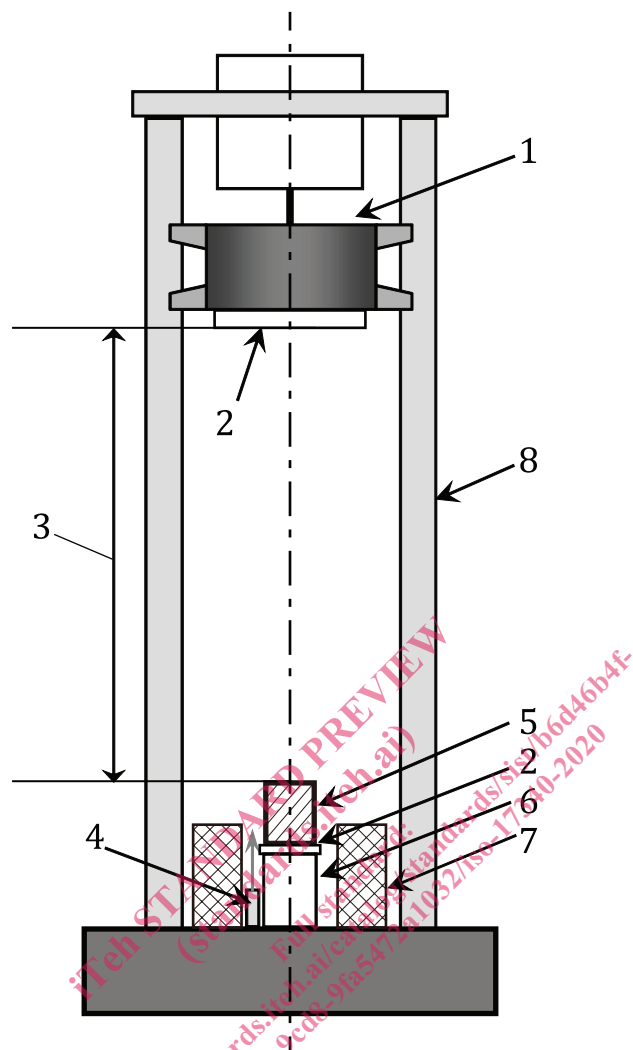
The area of the pressing surfaces shall be sufficiently large to ensure an even application of the compressive force over the entire end surface of the test piece until compressive deformation is complete.

The pressing surfaces shall be polished flat and installed in such a manner that the centre of the planes is aligned with the centre line of the testing machine and the planes are parallel to each other.

6.2.4 Load cell

The load cell shall be capable of measuring the compressive force acting on the test piece. For calibration of the load cell, ISO 376 shall be taken into consideration.

The resonant frequency and stiffness of the load cell shall be sufficiently high and the compressive force shall be measured to an accuracy of ± 1 %.



Key

- 1 weight
- 2 pressing jig
- 3 drop height
- 4 displacement sensor
- 5 test piece
- 6 load cell
- 7 absorber
- 8 guide frame

Figure 1 — Schematic of a drop weight impact testing machine

6.2.5 Displacement sensor

The displacement sensor shall be capable of measuring the travel of a drop weight during tests and shall be of a non-contact type to avoid inertia effects.

The response speed of the displacement sensor shall be higher than the test speed. Measurement with laser-type displacement sensors, optical displacement sensors, etc. with high accuracy is recommended.