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Mechanical testing of metals — Ductility testing — Compression test for porous and cellular metals

Essais mécaniques des métaux — Essais de ductilité — Essai de compression des métaux poreux et cellulaires

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Foreword

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The main task of technical committees is to prepare International Standards. 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.

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ISO 13314 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

Introduction

Porous and cellular metals have attractive properties due to their unique cell morphology. When they are used as a crush energy absorbing component of automotive machines, compressive properties are necessary for industrial design. However, the deformation behaviour of porous metals and metallic foams is quite different from conventional dense metals. Test methods for conventional metallic materials are not suitable for porous metals and metallic foams. Standardization of a test method for porous metals and metallic foams is required.

Mechanical testing of metals — Ductility testing — Compression test for porous and cellular metals

1 Scope

This International Standard specifies a test method for compressive properties of porous and cellular metals with a porosity of 50 % or more. Compressive tests can be carried out at ambient temperature under quasi-static strain rate conditions.

2 Normative references

The following referenced documents are indispensable for the application 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 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing*

3 Terms and definitions

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

3.1
compressive stress
σ
compressive force divided by the initial cross-sectional area perpendicular to the loading direction

NOTE Compressive stress is expressed in newtons per square millimetre.

3.2
compressive strain
e
overall compressive displacement divided by the initial height (gauge length) of the test specimen

NOTE Compressive strain is expressed as a percentage.

3.3
first maximum compressive strength
compressive stress corresponding to the first local maximum in the stress-strain curve

See Figure 1.

NOTE It cannot be determined if no local maximum occurs.

3.4
plateau stress
σ_{pl}
arithmetical mean of the stresses at 0,1 % or smaller strain intervals between 20 % and 30 % or 20 % and 40 % compressive strain

See Figure 1.

NOTE The strain range/interval, 20 % and 30 % or 20 % and 40 %, for arithmetical mean varies depending on the plateau end strain.

3.5
plateau end
point in the stress-strain curve at which the stress is 1,3 times the plateau stress

See Figure 1.

NOTE If this point does not adequately represent the end of the plateau range, another stress can be selected which corresponds to the curve trace (see 7.4).

3.6
energy absorption
W
area under the stress-strain curve up to 50 % strain or up to the plateau end strain, e_{ple}

NOTE The energy absorption up to other strain values can also be determined (see 7.7).

3.7
energy absorption efficiency
W_e
energy absorption divided by the product of the maximum compressive stress within the strain range and the magnitude of the strain range

3.8
quasi-elastic gradient
gradient of the straight line determined within the linear deformation region at the beginning of the compressive stress-strain curve

NOTE This gradient is not a modulus for the material (see Figure 1). The quasi-elastic gradient is optionally measured and it is used to determine the zero point for the compressive strain [see Figure 2 a)].

3.9
compressive offset stress
compressive stress at the plastic compressive strain of 0,2 %, unless otherwise specified or recorded

NOTE The plastic strain is determined using of the quasi-elastic gradient [see Figure 2 a)]. The compressive 0,2 % offset stress is optionally measured and it can be used as an alternative to the compressive yield strength.

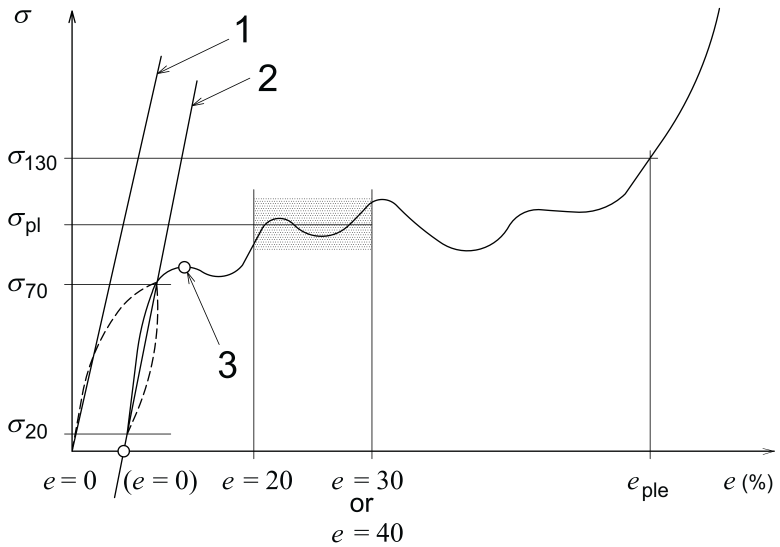
3.10
elastic gradient
gradient of the elastic straight lines determined by elastic loading and unloading between stresses of σ_{70} and σ_{20}

NOTE 1 σ_{70} and σ_{20} correspond to 70 % and 20 %, respectively, of the plateau stress, σ_{pl}.

NOTE 2 The elastic straight line is the secant line obtained from the hysteresis loop which occurs during unloading and subsequent loading (see Figure 1). The elastic gradient represents a porosity-dependent rigidity, not a modulus of the material, and generally changes during the course of compression. The elastic gradient is optionally measured and it is used to determine the zero point for the compressive strain [see Figure 2 b)].

3.11
compressive proof strength
compressive stress at a plastic compressive strain of 1,0 %, unless otherwise specified or recorded

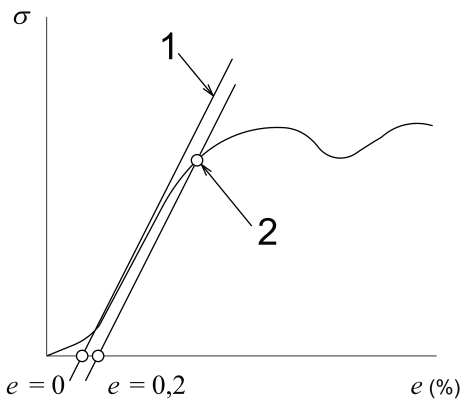
NOTE The plastic strain is determined using of the elastic gradient [see Figure 2 b)]. The compressive proof strength is optionally measured and it can be used as an alternative to the compressive yield strength.



Key

1 quasi-elastic gradient
2 elastic gradient
3 first maximum compressive strength

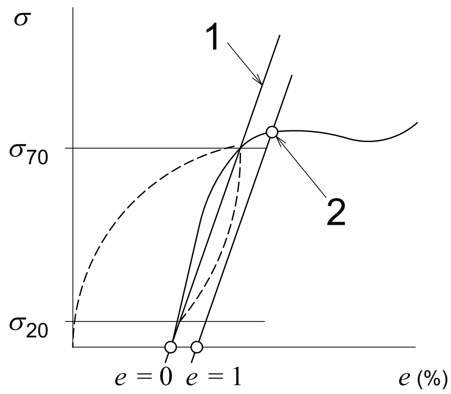
Figure 1 — Stress-strain curve to determine the characteristic values from compression testing of porous and cellular metals



Key

1 quasi-elastic gradient
2 compressive offset stress

a) Quasi-elastic gradient and compressive offset stress



Key

1 elastic gradient
2 compressive proof strength

b) Elastic gradient and compressive proof strength

Figure 2 — Stress-strain curve to determine the optional characteristic values from compression testing of porous and cellular metals