
**Method for evaluation of tensile
properties of metallic superplastic
materials**

*Méthode de détermination des caractéristiques de traction des
matériaux métalliques superplastiques*

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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.

ISO 20032 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

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Introduction

Superplastic forming requires the characterization of metallic superplastic materials. The tensile test specified in this International Standard permits the evaluation of superplastic properties, such as superplastic elongation, flow stress, strain-rate sensitivity exponent (m -value), stress-strain relation and flow stress-strain-rate relation.

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Method for evaluation of tensile properties of metallic superplastic materials

1 Scope

This International Standard specifies a method for evaluating the tensile properties of metallic superplastic materials which exhibit fine-grained superplasticity, without significant work-hardening or dynamic microstructure evolution, by means of a tensile test at constant cross-head velocity, for flat-form test pieces, without an extensometer attached.

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 31-0, *Quantities and units — Part 0: General principles*

ISO 783, *Metallic materials — Tensile testing at elevated temperature*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

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*

IEC 60584-1, *Thermocouples — Part 1: Reference tables*

IEC 60584-2, *Thermocouples — Part 2: Tolerances*

3 Symbols, terms and definitions

For the purposes of this document, the symbols, terms and definitions given in Table 1 apply.

Table 1 — Symbols, terms and definitions

Symbol	Term	Definition	Unit
Superplasticity			
—	Superplastic state	Deformation conditions on onset of superplasticity and its continuation	—
Test piece			
—	R-type test piece	Test piece that has the shape of a conventional tensile test piece without its parallel portion	—
—	R portion	Principal portion of the R-type test piece to be elongated, which has an arc-like shape between grips	—
b	Width of parallel-sided portion or minimum width of the R portion	Original width of parallel-sided portion of the S-type test piece or original minimum width of the R portion of the R-type test piece	mm
$b_0[i]$	Original width in division, i , of the R portion	Original width in a specific division, i , of the R portion	mm
$b[i]$	Width in division, i , of the R portion	Width in a specific division, i , of the R portion after the interrupted test	mm
A	Superplastic elongation	Elongation at fracture in a superplastic state	%
B_g	Grip portion width	Width of grip portion of the S- or R-type test piece	mm
L_o	Original gauge length	Original distance between gauge marks measured by appropriate apparatus with an accuracy of at least 1 % of the distance or 0,01 mm, whichever is greater	mm
L_u	Final gauge length after fracture	Final distance between gauge marks measured after fracture with fracture surfaces placed together with care, so that the centre line of either fracture surface is on a single straight line	mm
L_c	Parallel length	Original length of parallel portion of the S-type test piece	mm
L_t	Total length of test piece	Original total length of test piece	mm
L_g	Grip portion length	Length of grip portion of test piece	mm
L_R	R portion length	Original length of the R portion	mm
ΔL_R	Elongation of the R portion	Increase in the R portion length at any moment during the test	mm
R	Radius of fillet or R portion radius	Original radius of fillet of the S-type test pieces or original R portion radius of the R-type test piece	mm
S_o	Original cross-sectional area of test piece in the reduced section	Original cross-sectional area of a test piece measured by an appropriate apparatus with an accuracy not more than 2 %	mm ²
$S_o[i]$	Original cross-sectional area in division, i , of the R portion	Original cross-sectional area in a specific division, i , of the R portion	mm ²
$S[i]$	Cross-sectional area in division, i , of the R portion	Cross-sectional area in a specific division, i , of the R portion after the interrupted test	mm ²
t	Thickness of test piece	Thickness of the S- or R-type test piece	mm
$t_0[i]$	Original thickness in division, i , of the R portion	Original thickness in a specific division, i , of the R portion	mm
$t[i]$	Thickness in division, i , of the R portion	Thickness in a specific division, i , of the R portion after the interrupted test	mm

Table 1 (continued)

Symbol	Term	Definition	Unit
Force			
F_{10}	10 % deformation force	Force at 10 % nominal strain	N
Stress			
K	K value	A constant-with-stress dimension, which is defined by Equation (1)	MPa
σ_{10}	10 % flow stress	True stress when 10 % nominal strain is achieved	MPa
σ_f	Flow stress	True stress during superplastic deformation	MPa
σ_N	Nominal stress	A load during deformation divided by the minimum area of the original cross-section in the R portion, which is defined for the R-type test piece	MPa
$\sigma[i]$	True stress	A load during deformation divided by the cross-sectional area in a specific division, i , of the R portion, which is defined for the R-type test piece	MPa
Strain			
$\varepsilon[i]$	True strain	True strain given by deformation in a specific division, i , of the R portion	s^{-1}
Period			
τ_{inter}	Period required for interrupted test	Period required from the time when the axial force starts to increase linearly against strain in the elastic deformation stage, until elongation of the R portion, ΔL_R , reaches 3 mm	s
Strain rate and m-value			
$\dot{\varepsilon}_N$	Nominal strain rate	Crosshead velocity divided by the original parallel length, L_c for the S-type test piece, and divided by the original gauge length, L_0 for the R-type test piece	s^{-1}
$\dot{\varepsilon}$	True strain rate	Increment of true strain per unit time	s^{-1}
$\dot{\varepsilon}[i]$	True strain rate during deformation	True strain rate during deformation in a specific division, i , of the R portion	s^{-1}
m	m -value	Index representing the strain-rate sensitivity of flow stress in superplastic materials	—

4 Principle

The test consists of straining a test piece by a tensile force, for the purpose of determining the superplastic properties, such as superplastic elongation (A), flow stress and strain-rate sensitivity exponent (m -value).

The tensile testing is carried out at elevated temperatures and strain rates.

An S-type test piece is employed to evaluate mechanical properties for general superplastic materials, or at an early stage of deformation.

Due to the limitation of furnace length, S-type test pieces are more suitable for lower-strain superplastic testing. R-type test pieces are more suitable for higher-strain superplastic testing, as most of the strain is developed in a small section at the centre of the specimen.