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Metallic materials — Tensile testing —

Part 2:
Method of test at elevated temperature

Matériaux métalliques — Essai de traction —

Partie 2: Méthode d'essai à température élevée

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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.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing*.

This second edition cancels and replaces the first edition (ISO 6892-2:2011), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— a note has been added after the first sentence of 10.2.1;

— some references to subclauses of ISO 6892-1 have been deleted.

A list of all parts in the ISO 6892 series can be found on the ISO website.

Introduction

In this document, two methods of testing speeds are described. The first, Method A, is based on strain rates (including crosshead separation rate) with narrow tolerances (±20 %) and the second, Method B, is based on conventional strain rate ranges and tolerances. Method A is intended to minimize the variation of the test rates during the moment when strain rate-sensitive parameters are determined and to minimize the measurement uncertainty of the test results.

The influence of the testing speed on the mechanical properties, determined by the tensile test, is normally greater at an elevated temperature than at room temperature.

Traditionally, mechanical properties determined by tensile tests at elevated temperatures have been determined at a slower strain or stressing rate than at room temperature. This document recommends the use of slow strain rates but, in addition, higher strain rates are permitted for particular applications, such as comparison with room temperature properties at the same strain rate.

During discussions concerning the speed of testing in the preparation of this document, it was decided to consider deleting the stress rate method in future revisions.

Metallic materials — Tensile testing —

Part 2:
Method of test at elevated temperature

WARNING — This document calls for the use of substances and/or procedures that can be injurious to health if adequate safety measures are not taken. This document does not address any health hazards, safety or environmental matters associated with its use. It is the responsibility of the user of this document to establish appropriate health, safety and environmentally acceptable practices.

1 Scope

This document specifies a method of tensile testing of metallic materials at temperatures higher than room temperature.

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 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6892-1 apply with the following exceptions and supplements.

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

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

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

In general, all test piece geometries/dimensions are based on measurements taken at room temperature. The exception may be the extensometer gauge length (see 3.3 and 10.2.2).

NOTE The following properties are generally not determined at elevated temperature unless required by relevant specifications or agreement:

— permanent set strength (R_r);

— percentage permanent elongation;

— percentage permanent extension;

— percentage yield point extension (A_e);

— percentage total extension at maximum force (A_{gt});

— percentage plastic extension at maximum force (A_g);

— percentage total extension at fracture (A_t).

3.1
original gauge length
L_o
gauge length measured at room temperature before heating of the test piece and before application of force

3.2
percentage elongation after fracture
A
permanent elongation at room temperature of the gauge length after fracture ($L_u - L_o$)

Note 1 to entry: It is expressed as a percentage of the *original gauge length* (L_o) (3.1).

Note 2 to entry: For further details, see ISO 6892-1.

3.3
extensometer gauge length
L_e
length within the parallel portion of the test piece used for the measurement of *extension* (3.4) by means of an extensometer

3.4
extension
increase in the *extensometer gauge length* (L_e) (3.3) at a given moment during the test

3.5
percentage extension
extension (3.4) expressed as a percentage of the *extensometer gauge length* (L_e) (3.3)

3.6
percentage reduction of area
Z
maximum change in cross-sectional area which has occurred during the test ($S_o - S_u$)

Note 1 to entry: It is expressed as a percentage of the original cross-sectional area (S_o), where S_o and S_u are calculated from the dimensions at room temperature.

3.7
stress
R
force at any moment during the test divided by the original cross-sectional area (S_o) of the test piece

Note 1 to entry: All stresses referred to in this document are engineering stresses, calculated using the cross-sectional area of the test piece derived from dimensions measured at room temperature.

3.8
soaking time
t_s
time taken to stabilize the temperature of the test piece prior to mechanical loading

4 Symbols and designations

ISO 6892-1 provides an extensive listing of symbols and their related designations.

The additional symbols used in this document are given in Table 1.

Table 1 — Symbols and designations

Symbol	Unit	Designation
T	°C	specified temperature or nominal temperature at which the test should be performed
T_i	°C	indicated temperature or measured temperature on the surface of the parallel length of the test piece
t_s	min	soaking time

5 Principle

The test involves straining a test piece by tensile force for the determination of one or more of the mechanical properties defined in Clause 3.

The test is carried out at a temperature higher than 35 °C, which means at temperatures higher than room temperature as specified in ISO 6892-1.

6 Test piece

For requirements concerning test pieces, see ISO 6892-1.

NOTE Additional examples of test pieces are given in Annex A.

7 Determination of original cross-sectional area (S_o)

For requirements concerning determination of the original cross-sectional area, see ISO 6892-1.

NOTE This parameter is calculated from measurements taken at room temperature.

8 Marking the original gauge length (L_o)

For requirements concerning marking the original gauge length, see ISO 6892-1.

9 Apparatus

9.1 Force-measuring system.

The force-measuring system of the testing machine shall be calibrated in accordance with ISO 7500-1, class 1, or better.

9.2 Extensometer.

For the determination of proof strength (plastic or total extension), the used extensometer shall be in accordance with ISO 9513, class 1 or better, in the relevant range. For other properties (with higher extension), an ISO 9513 class 2 extensometer in the relevant range may be used.

The extensometer gauge length shall be not less than 10 mm and shall correspond to the central portion of the parallel length.

Any part of the extensometer projecting beyond the furnace shall be designed or protected from draughts so that fluctuations in the room temperature have only a minimal effect on the readings. It is advisable to maintain reasonable stability of the temperature and speed of the air surrounding the testing machine.

9.3 Heating device.

9.3.1 Permitted deviations of temperature

The heating device for the test piece shall be such that the test piece can be heated to the specified temperature, T.

The indicated temperatures, T_i, are the temperatures measured on the surface of the parallel length of the test piece with corrections applied for any known systematic errors, but with no consideration of the uncertainty of the temperature measurement equipment.

The permitted deviations between the specified temperature, T, and the indicated temperatures, T_i, and the maximum permissible temperature variation along the test piece are given in Table 2.

For specified temperatures greater than 1 100 °C, the permitted deviations shall be defined by previous agreement between the parties concerned.

Table 2 — Permitted deviations between T_i and T and maximum permissible temperature variations along the test piece

Specified temperature, T °C	Permitted deviation between T_i and T °C	Maximum permissible temperature variation along the test piece °C
$T \leq 600$	±3	3
$600 < T \leq 800$	±4	4
$800 < T \leq 1\,000$	±5	5
$1\,000 < T \leq 1\,100$	±6	6

9.3.2 Measurement of temperature

When the gauge length is less than 50 mm, one temperature sensor shall measure the temperature at each end of the parallel length directly. When the gauge length is equal to or greater than 50 mm, a third temperature sensor shall measure near the centre of the parallel length.

This number may be reduced if the general arrangement of the furnace and the test piece is such that, from experience, it is known that the variation in temperature of the test piece does not exceed the permitted deviation specified in 9.3.1. However, at least one sensor shall be measuring the test piece temperature directly.

Temperature sensor junctions shall make good thermal contact with the surface of the test piece and be suitably screened from direct radiation from the furnace wall.

9.3.3 Verification of the temperature-measuring system

The temperature-measuring system shall have a resolution equal to or better than 1 °C and an accuracy of ±0,004 T °C or ±2 °C, whichever is greater.

NOTE The temperature-measuring system includes all components of the measuring chain (sensor, cables, indicating device and reference junction).

All components of the temperature-measuring system shall be verified and calibrated over the working range at intervals not exceeding 1 year. Errors shall be recorded on the verification report. The components of the temperature-measuring system shall be verified by methods traceable to the international unit (SI unit) of temperature.

10 Test conditions

10.1 Setting the force zero point

The force-measuring system shall be set to zero after the testing equipment has been assembled but before the test piece is actually placed in the gripping jaws. Once the force zero point has been set, the force-measuring system may not be changed in any way during the test.

NOTE The use of this method ensures that the weight of the gripping system is compensated in the force measurement and that any force resulting from the clamping operation does not affect the force zero point.

10.2 Gripping of the test piece, fixing of the extensometer and heating of the test piece, not necessarily in the following sequence

10.2.1 Method of gripping

For requirements concerning the method of gripping, see ISO 6892-1.

NOTE Maintaining a very small tensile load (e.g. test machine in load control) during heating period and soaking time can prevent possible compressive stresses due to thermal expansion.

10.2.2 Fixing of the extensometer and establishing the gauge length

10.2.2.1 General

Different methods of establishing the extensometer gauge length are used in practice. This can lead to minor differences in the test results. The method used shall be documented in the test report.

10.2.2.2 L_e based on room temperature (Method 1)

The extensometer is set on the test piece at room temperature with nominal gauge length. The extension is measured at test temperature and the percentage extension is calculated with the gauge length at room temperature.

The thermal extension is not considered.

10.2.2.3 L_e based on test temperature (Method 2)

This L_e includes the thermal extension of the test piece.

10.2.2.3.1 Nominal L_e at test temperature (Method 2 a)

The extensometer is set on the test piece at the test temperature with nominal gauge length before mechanical loading.

10.2.2.3.2 Reduced L_e at room temperature (Method 2 b)

An extensometer with reduced gauge length is set on the test piece at room temperature such that at test temperature, the nominal gauge length is achieved.

For the calculation of percentage extension, the nominal gauge length is used.

10.2.2.3.3 Corrected L_e at test temperature (Method 2 c)

The extensometer is set on the test piece at room temperature with the nominal gauge length.

For the calculation of percentage extension, the corrected nominal gauge length at test temperature (gauge length at room temperature and thermal expansion) is used.