SLOVENSKI STANDARD
SIST EN 10002-5:1997

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Kovinski materiali - Natezni preskus - 5. del: Metoda preskušanja pri povišani temperaturi

Metallic materials - Tensile testing - Part 5: Method of testing at elevated temperature

Metallische Werkstoffe - Zugversuch - Teil 5: Prüfverfahren bei erhöhter Temperatur

Matériaux métalliques - Essai de traction - Partie 5: Méthode d'essai a température élevée

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ICS:

77.040.10 Mehansko preskušanje kovin Mechanical testing of metals

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English version

Metallic materials - Tensile testing - Part 5: Method of testing at elevated temperature

Matériaux métalliques - Essai de traction - Partie 5: Méthode d'essai à température élevée

Metallische Werkstoffe - Zugversuch - Teil 5: Prüfverfahren bei erhöhter Temperatur

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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CONTENTS

Foreword

This draft European Standard was prepared by the Technical Committee ECISS/TC1A 'Mechanical and physical tests', the Secretariat of which has been allocated to the Association Francaise de Normalisation (AFNOR).

It represents the fifth part of the general standard : Metallic materials - Tensile testing.

This European Standard replaces the EURONORMS:

EU 22-70 Determination or verification of the yield point of steel at elevated temperatures.

This European Standard EN 10002-5 was approved by CEN on 1991-08-05

According to the Common CEN/CENELEC Rules, being part of the Internal Regulations of CEN, the following countries are bound to implement this European Standard

Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

Introduction

The Standard EN 10 002 will comprise the following parts:

Part 1 : Metallic materials; Tensile test; Method of test (at ambient temperature

Part 2 : Verification of the force measuring system of the *tensile testing machine*

Part 3 : Metallic materials; Tensile test; Calibration of proving devices used for the verification of uniaxial testing machines

Part 4 : Metallic materials; Tensile test; Verification of extensometers used in uniaxial testing

Part 5 : Metallic materials; Tensile test; Method of test at elevated temperatures.

1 Scope

This european standard specifies the method for tensile testing of metallic materials and defines the mechanical properties which can be determined thereby at elevated temperature.

For certain particular metallic materials and applications, the tensile test may be the subject of specific standards or particular requirements.

It should be noted that tests carried out at the same temperature in accordance with the tensile testing method at ambient temperature (EN 10 002/1) and this standard should give different results by reason of different testing conditions, for example the loading rate ... (see bibliography).

Annex G
An harmonising of the two tests operating conditions should be envisaged on the occasion of the next revision of the corresponding standards.

2 Normative references

EN 10 002-1	:	Metallic materials - Tensile testing - Part 1 : Method of test at ambient temperature
EN 10-002-2	:	Tensile testing - Verification on the load cell of tensile testing machine
ISO 2566-1	:	Steel - Conversion of elongation values - Part 1 : Carbon and low alloy steels
ISO 2566-2	:	Steel - Conversion of elongation values - Part 2 : Austenitic steels
EN 10002-4 (1)	:	Metallic materials - Verification of extensometers used in uniaxial testing
EU 18-1979 (2)	:	Selection and preparation of samples and test pieces for steel and iron and steel products

3 PRINCIPLE

The test involves straining a test piece by tensile force, generally to fracture, for the purpose of determining one or more of the mechanical properties defined in clause 4.

The test is carried out at the specified temperature.

4 DEFINITIONS

For the purposes of this european standard, the following definitions apply.

4.1 Gauge length (L) : length of the cylindrical or prismatic portion of the test piece on which elongation is measured at any moment during the test. In particular, a distinction is made between :

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(1) In preparation

(2) Until this Euronorm is transformed into European Standards, it can either be used or reference made to the corresponding national standards, a list of which is given in annex F of these European Standards.

4.1.1 **Original gauge length** (L_o): Gauge length before heating of the test piece and before application of force.

4.1.2 **Final gauge length** (L_u): Gauge length after rupture of the test piece (see 11.1). This length shall be measured at ambient temperature.

4.2 **Parallel length** (L_c): Length of the reduced section parallel portion of the test piece.

Note. The concept of parallel length is replaced by the concept of distance between grips for non-machined test pieces.

4.3 **Elongation**: Increase in the original gauge length (L_o) at the end of the test.

4.4 **Percentage elongation**: Elongation expressed as a percentage of the original gauge length (L_o).

4.4.1 **Percentage permanent elongation**: Increase in the original gauge length of a test piece after removal of a specified stress (see 4.9), expressed as a percentage of the original gauge length (L_o)

4.4.2 **Percentage elongation after fracture**: (A) Permanent elongation of the gauge length after fracture ($L_u - L_o$) expressed as a percentage of the original length (L_o).

Note. In the case of proportional test pieces, only if the original gauge length is other than $5{,}65\sqrt{S_o}$ (4), where S_o is the original cross-sectional area of the parallel length, the symbol A shall be supplemented by an index indicating the coefficient of proportionality used, for example:

A 11,3 = percentage elongation on a gauge length (L_o) of $11{,}3\sqrt{S_o}$

In the case of non-proportional test pieces, the symbol A shall be supplemented by an index indicating the original gauge length used, expressed in millimetres, for example:

A 80 mm = percentage elongation on a gauge length (L_o) of 80 mm

4.4.3 **Percentage total elongation at fracture** (A_t): Total elongation (elastic elongation plus plastic elongation) of the gauge length at the moment of fracture expressed as a percentage of the original gauge length (L_o)

4.5 **Extensometer gauge length** (L_e): Length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer (this length may differ from L_o and shall be of any value greater than b, d or D (see table 1) but less than the parallel length (L_c).

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(4) $5{,}65\sqrt{S_o} = 5\sqrt{\frac{4S_o}{\pi}}$

4.6 Extension: Increase in the extensometer gauge length (L_e) at a given moment of the test.

4.6.1 Percentage permanent extension: Increase in the extensometer gauge length after removal from the test piece of a specified stress, expressed as a percentage of the extensometer gauge length (L_e).

4.6.2 Percentage yield point extension (A_e): Extension between the start of yielding giving localized deformation and the commencement of homogeneous deformation giving smooth work hardening. It is expressed as a percentage of the extensometer gauge length (L_e).

4.7. Percentage reduction of area (Z): Maximum change in cross-sectional area which has occurred during the test ($S_o - S_u$) expressed as a percentage of the original cross-sectional area (S_o).

4.8 Maximum force (F_m): The greatest force which the test piece withstands during the test once the yield point has been passed.

4.9 Stress: Force at any moment during the test divided by the original cross-sectional area (S_o) of the test piece.

4.9.1 Tensile strength (R_m): Stress corresponding to the maximum force (F_m).

4.9.2 Yield strength: When the metallic material exhibits a yield phenomenon, a point is reached during the test at which plastic deformation occurs without any increase in the force. A distinction is made between:

4.9.2.1 Upper yield strength (R_{eH}): Value of stress at the moment when the first decrease in force is observed (see figure 2).

4.9.2.2 Lower yield strength (R_{eL}): Lowest value of stress during plastic yielding, ignoring any transient effects (see figure 2).

4.9.3 Proof strength, non-proportional extension (R_p): Stress at which a non-proportional extension is equal to a specified percentage of the extensometer gauge length (L_e) (see figure 3). The symbol used is followed by a suffix giving the prescribed percentage of the extensometer gauge length, for example $R_{p0,2}$.

4.9.4 Proof strength, total extension (R_t): Stress at which total extension (elastic extension plus plastic extension) is equal to the specified percentage of the extensometer gauge length (L_e) (see figure 4). The symbol used is followed by a suffix giving the prescribed percentage of the original gauge length for example: $R_{t\,0,5}$.

4.9.5 Permanent set strength (R_r): Stress at which, after removal of force, a specified permanent elongation or extension expressed respectively as a percentage of the original gauge length (L_o) or extensometer gauge length (L_e) has not been exceeded (see figure 5). The symbol used is followed by a suffix giving the specified percentage of the original gauge length or of the extensometer gauge length (L_e), for example: Rr0,2.

5. SYMBOLS AND DESIGNATIONS

Symbols and corresponding designations are given in table 1.

Table 1 - Symbols and designations

Reference Number 1)	Symbol	Unit	Designation
Test piece			
1	a	mm	Thickness of a flat test piece or wall thickness of a tube
2	b	mm	Width of the parallel length of a flat test piece or average width of the longitudinal strip taken from a tube or width of flat wire
3	d	mm	Diameter of the parallel length of a circular test piece, or diameter of round wire or internal diameter of a tube
4	D	mm	External diameter of a tube
5	Lo	mm	Original gauge length
6	Lc	mm	Parallel length
-	Le	mm	Extensometer gauge length
7	Lt	mm	Total length of test piece
8	Lu	mm	Final gauge length after fracture
9	So	mm2	Original cross-sectional area of the parallel length
10	Su	mm2	Minimum cross-sectional area after fracture
11	Z	%	Percentage reductionof area: $\left(\frac{S_o - S_u}{S_o}\right) 100$
12	-	-	Gripped ends
Elongation			
13	-	mm	Elongation after fracture: $L_u - L_o$
14	A 2)	%	Percentage elongation after fracture: $\left(\frac{L_u - L_o}{L_o}\right) 100$

Table 1

Reference Number	Symbol	Unit	Designation
15	Ae	%	Percentage yield point extension
16	At	%	Percentage total elongation at fracture
17	-	%	Specified percentage non-proportional extension
18	-	%	Percentage total extension
19	-	%	Specified percentage permanent set extension or elongation
Force			
20	Fm	N	Maximum force
Yield strength - Proof strength - Tensile strength			
21	R_{eH}	N/mm^2 (3)	Upper yield strength
22	R_{eL}	N/mm^2	Lower yield strength
23	R_m	N/mm^2	Tensile strength
24	R_p	N/mm^2	Proof strength, non-proportional extension
25	R_r	N/mm^2	Permanent set strength
26	R_t	N/mm^2	Proof strength, total extension

(1) See figures 1 to 13
(2) See 4.4.2
(3) 1 N/mm^2 = 1 MPa

6. Test pieces

6.1 Shape and dimensions

6.1.1 General

The shape and dimensions of the test pieces depend on the shape and dimensions of the metallic products the mechanical properties of which are to be determined.

The test piece is usually obtained by machining a sample from the product or a pressed blank or casting. However products of constant cross-section (sections, bars, wires, etc.) and also as cast test pieces (i.e. cast irons and non-ferrous alloys) may be subjected to test without being machined.

The cross-section of the test pieces may be circular, square, rectangular, annular or, in special cases, of some other shape.

Test pieces, the original gauge length of which is related to the original cross-sectional area by the equation $L_o = k\sqrt{S_o}$, are called proportional test pieces. The internationally adopted value for k is 5,65. The original gauge length shall be not less than 20 mm. When the cross-sectional area of the test piece is too small for this requirement to be met with the coefficient k value of 5,65, a higher value (preferably 11,3) or a non-proportional test piece may be used.

In the case of non-proportional test pieces, the original gauge length (L_o) is taken independently of the original cross-sectional area (S_o).

The dimensional tolerances of the test pieces shall be in accordance with the appropriate annexes (see 6.2).

6.1.2 Machined test pieces

Machined test pieces shall incorporate a transition curve between the gripped ends and the parallel length if these have different dimensions. The dimensions of this transition radius can be important and it is recommended that they be defined in the material specification if they are not given in the appropriate annex (see 6.2).

The gripped ends may be of any shape to suit the grips of the testing machine.

The parallel length (L_c) or, in the case where the test piece has no transition curve, the free length between the grips, shall always be greater than the original gauge length (L_o).

6.1.3 Non-machined test pieces

If the test piece consists of an unmachined length of the product or of an unmachined test bar, the free length between the grips shall be sufficient for gauge marks to be at a reasonable distance from these grips.

As-cast test pieces shall incorporate a transition radius between the gripped ends and the parallel length. The dimensions of this transition radius are important and it is recommended that they be defined in the product standard. The gripped ends may be of any shape to suit the grips of the testing machine. The parallel length (L_c) shall always be greater than the original gauge length (L_o).

6.2 Types

The main types of test piece are defined in annexes A to D according to the shape and type of product, as shown in table 2. Other types of test piece can be specified in product standards or by agreement.

Table 2 - Product types

Type of product		Corresponding annex
Sheets – Flats with a thickness in millimetres of	Wire – Bars – Sections with a diameter or side in millimetres of	
0,1 ≤ thickness < 3	–	A
–	< 4	B
> 3	> 4	C
Tubes		D

6.3 Preparation of test pieces

The test pieces shall be taken and prepared in accordance with the requirements of the European Standards for the different materials (EU 18, etc).

7. DETERMINATION OF ORIGINAL CROSS-SECTIONAL AREA (S_o)

The original cross-sectional area shall be calculated from the measurements of the appropriate dimensions. The accuracy of this calculation depends on the nature and type of the test piece. It is indicated in annexes A to D for the different types of test pieces.

8. MARKING THE ORIGINAL GAUGE LENGTH (L_o)

Each end of the original gauge length shall be marked by means of fine marks, scribed lines or fine collars but not by notches which could result in premature fracture

For proportional test pieces, the calculated value of the original gauge length may be rounded off to the nearest multiple of 5 mm, provided that the difference between the calculated and marked gauge length is less than 10 % of L_o. The original gauge length shall be marked to an accuracy of ± 1 %.