SLOVENSKI STANDARD
SIST EN 10002-1:2002

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Kovinski materiali - Natezni preskus - 1. del: Metoda preskušanja pri temperaturi okolice

Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature

Metallische Werkstoffe - Zugversuch - Teil 1: Prüfverfahren bei Raumtemperatur

Matériaux métalliques - Essai de traction - Partie 1: Méthode d'essai a température ambiante

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English version

Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature

Matériaux métalliques - Essai de traction - Partie 1: Méthode d'essai à température ambiante

Metallische Werkstoffe - Zugversuch - Teil 1: Prüfverfahren bei Raumtemperatur

This European Standard was approved by CEN on 12 May 2001.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 1 "Steel - Mechanical testing", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2002, and conflicting national standards shall be withdrawn at the latest by January 2002.

This European Standard supersedes EN 10002-1:1990.

The European Standard EN 10002-1 "Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature)" was approved by CEN on 27 November 1989.

After a first 5 years lifetime, ECISS decided to revise this standard.

The revised prEN 10002-1 was discussed during two meetings of ECISS/TC1/SC1 with the participation of 4 CEN member countries (Belgium, France, Germany, United Kingdom).

EN 10002 was composed of five parts :

Part 1 : Method of test (at ambient temperature)

Part 2 : Verification of the force measuring system of the tensile testing machines

Part 3 : Calibration of force proving instruments used for the verification of uniaxial testing machines

Part 4 : Verification of extensometers used in uniaxial testing

Part 5 : Method of testing at elevated temperature

NOTE Part 2 has been already replaced by EN ISO 7500-1. Parts 3 and 4 will be replaced by corresponding ISO standards.

The annexes B, C, D and E are normative. The annexes A, F, G, H and J are informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the method for tensile testing of metallic materials and defines the mechanical properties which can be determined at ambient temperature.

NOTE Informative annex A indicates complementary recommendations for computer controlled testing machines. It is the intention, based on further developments by manufacturers and users that annex A will become normative in the next revision of this standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10002-4, *Metallic materials - Tensile testing - Part 4: Verification of extensometers used in uniaxial testing*.

EN 20286-2, *ISO system of limits and fits - Part 2 : Tables of standard tolerances grades and limits deviations for holes and shafts (ISO 286-2:1988)*.

EN ISO 377, *Steel and steel products - Location of samples and test pieces for mechanical testing (ISO 377:1997).*

EN ISO 2566-1, *Steel conversion of elongation values - Part 1 : Carbon and alloy steels (ISO 2566-1:1984)*.

EN ISO 2566-2, *Steel conversion of elongation values - Part 2 : Austenitic steels (ISO 2566-2:1984)*.

EN ISO 7500-1, *Metallic materials - Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of force measuring (ISO 7500-1:1999)*.

3 Principle

The test involves straining a test piece in tension, 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 ambient temperature between 10 °C and 35 °C, unless otherwise specified. Tests carried out under controlled conditions shall be made at a temperature of 23 °C ± 5 °C.

4 Terms and definitions

For the purpose of this European Standard, the following terms and definitions apply :

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

4.1.1
original gauge length (L_o)
gauge length before application of force

4.1.2
final gauge length (L_u)
gauge length after rupture of the test piece (see 11.1)

4.2
parallel length (L_c)
parallel portion of the reduced section 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 any moment during 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 gauge length (L_o)

NOTE In the case of proportional test pieces, only if the original gauge length is other than 5,65 $\sqrt{S_o}$ [1)] where S_o is the original cross-sectional area of the parallel length, the symbol A should be supplemented by an index indicating the coefficient of proportionality used, for example :

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

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

$A_{80\text{ mm}}$ = percentage elongation of 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)

4.4.4
percentage elongation at maximum force
increase in the gauge length of the test piece at maximum force, expressed as a percentage of the original gauge length (L_o)

NOTE A distinction is made between the percentage total elongation at maximum force (A_{gt}) and the percentage non-proportional elongation at maximum force (A_g) (see Figure 1).

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

NOTE It is recommended that for measurement of yield and proof strength parameters $L_e \geq L_o/2$. It is further recommended that for measurement of parameters "at" or "after" maximum force, L_e is approximately equal to L_o.

4.6
extension
increase in the extensometer gauge length (L_e) at a given moment of the test

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[1)] $5{,}65\sqrt{S_o} = 5\sqrt{\frac{4S_o}{\pi}}$.

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)
in discontinuous yielding materials, the extension between the start of yielding and the start of uniform work hardening

NOTE 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

For materials, without yield point, it is the maximum value during the test.

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, stress corresponding to the point 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 initial 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)

NOTE The symbol used is followed by a suffix giving the prescribed percentage, 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 a specified percentage of the extensometer gauge length (L_e) (see Figure 4)

NOTE The symbol used is followed by a suffix giving the prescribed percentage for example : $R_{t0,5}$.

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)

NOTE The symbol used is followed by a suffix giving the specified percentage of the original gauge length (L_o) or of the extensometer gauge length (L_e), for example : $R_{r0,2}$.

4.10
fracture
phenomena which is deemed to occur when total separation of the test piece occurs or force decreases to become nominally zero

5 Symbols and designations

Symbols and corresponding designations are given in Table 1.

Table 1 — Symbols and designations

Reference number [a]	Symbol	Unit	Designation
			Test piece
1	a [b]	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	L_o	mm	Original gauge length
-	L'_o	mm	Initial gauge length for determination of A_g (see annex H)
6	L_c	mm	Parallel length
-	L_e	mm	Extensometer gauge length
7	L_t	mm	Total length of test piece
8	L_u	mm	Final gauge length after fracture
-	L'_u	mm	Final gauge length after fracture for determination of A_g (see annex H)
9	S_o	mm^2	Original cross-sectional area of the parallel length
10	S_u	mm^2	Minimum cross-sectional area after fracture
-	k	-	Coefficient of proportionality
11	Z	%	Percentage reduction of area : $\frac{S_o - S_u}{S_o} \times 100$
12	-	-	Gripped ends
			Elongation
13	-	mm	Elongation after fracture : $L_u - L_o$
14	A [c]	%	Percentage elongation after fracture : $\frac{L_u - L_o}{L_o} \times 100$
15	A_e	%	Percentage yield point extension
-	ΔL_m	mm	Extension at maximum force
16	A_g	%	Percentage non-proportional elongation at maximum force (F_m)
17	A_{gt}	%	Percentage total elongation at maximum force (F_m)
18	A_t	%	Percentage total elongation at fracture
19	-	%	Specified percentage non-proportional extension
20	-	%	Percentage total extension (see R_t)
21	-	%	Specified percentage permanent set extension or elongation

"continued"

Table 1 (concluded)

Reference number [a]	Symbol	Unit	Designation
			Force
22	F_m	N	Maximum force
			Yield strength - Proof strength - Tensile strength
23	R_{eH}	MPa [d]	Upper yield strength
24	R_{eL}	MPa	Lower yield strength
25	R_m	MPa	Tensile strength
26	R_p	MPa	Proof strength, non-proportional extension
27	R_r	MPa	Permanent set strength
28	R_t	MPa	Proof strength, total extension
-	E	MPa	Modulus of elasticity

[a] See Figures 1 to 13.

b The symbol *T* is also used in steel tube product standards.

c See 4.4.2.

d 1 MPa = 1 N/mm^2.

6 Test piece

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 product from which the test pieces are taken.

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. for cast irons and non-ferrous alloys) may be tested 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 may 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

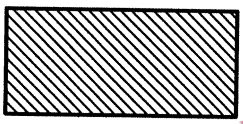
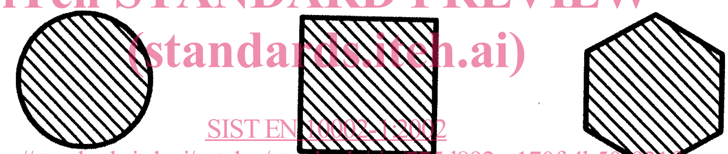
If the test piece consists of an unmachined length of the product or of an unmachined test bar, the free length between the grips shall be sufficient for gauge marks to be at a reasonable distance from the grips (see annexes B to E).

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 pieces are defined in annexes B to E according to the shape and type of product, as shown in Table 2. Other types of test pieces can be specified in product standards.

Table 2 — Main types of test piece according to the product type

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

6.3 Preparation of test pieces

The test pieces shall be taken and prepared in accordance with the requirements of the relevant European Standards for the different materials (e.g. EN ISO 377, 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 B to E 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 or scribed lines, 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 %.

If the parallel length (L_c) is much greater than the original gauge length, as, for instance, with unmachined test pieces, a series of overlapping gauge lengths may be marked.

In some cases, it may be helpful to draw, on the surface of the test piece, a line parallel to the longitudinal axis, along which the gauge lengths are marked.

9 Accuracy of testing apparatus

The force-measuring system of the testing machine shall be calibrated in accordance with EN ISO 7500-1 and shall be at least of class 1.

When an extensometer is used it shall be at least of class 1 (according to EN 10002-4) for the determination proof strength (non-proportional extension) ; for other properties (with higher extension) a class 2 extensometer (according to EN 10002-4) can be used.

NOTE For the determination of upper and lower yield strengths, the use of an extensometer is not necessary.

10 Conditions of testing

10.1 Method of gripping

The test pieces shall be held by suitable means such as wedges, screwed grips, parallel jaw faces, shouldered holders, etc.

Every endeavour should be made to ensure that test pieces are held in such a way that the tension is applied as axially as possible, in order to minimize bending. This is of particular importance when testing brittle materials or when determining proof strength (non-proportional extension) or proof strength (total extension) or yield strength.

NOTE In order to obtain a straight test piece and assure the alignment of the test piece and grip arrangement, a preliminary force may be applied provided it does not exceed a value corresponding to 5 % of the specified or expected yield strength. A correction of the extension should only be carried out to take into account the effect of the preliminary force.

10.2 Test rate

10.2.1 General

Unless otherwise specified in the product standard, the test rate shall conform to the following requirements depending on the nature of the material.

NOTE The stress rates in Table 3 and the strain rates referred to throughout 10.2 do not imply specific modes of control by the testing machine.

10.2.2 Yield and proof strengths

10.2.2.1 Upper yield strength (R_{eH})

Within the elastic range and up to the upper yield strength, the rate of separation of the crossheads of the machine shall be kept as constant as possible and within the limits corresponding to the stress rates in Table 3.

Table 3 — Stress rate

Modulus of elasticity of the material (E) MPa	**Stress rate** MPa·s^{-1}	
	min	max
< 150 000	2	20
≥ 150 000	6	60

10.2.2.2 Lower yield strength (R_{eL})

If only the lower yield strength is being determined, the strain rate during yield of the parallel length of the test piece shall be between 0,000 25 s^{-1} and 0,002 5 s^{-1}. The strain rate within the parallel length shall be kept as constant as possible. If this rate cannot be regulated directly, it shall be fixed by regulating the stress rate just before yield begins, the controls of the machine not being further adjusted until completion of yield.

In no case, the stress rate in the elastic range shall exceed the maximum rates given in Table 3.

10.2.2.3 Upper and lower yield strengths (R_{eH} and R_{eL})

If the two yield strengths are determined during the same test, the conditions for determining the lower yield strength shall be complied with (see 10.2.2.2).

10.2.2.4 Proof strength (non-proportional extension) and proof strength (total extension) (R_p and R_t)

The stress rate shall be within the limits given in Table 3.

Within the plastic range and up to the proof strength (non-proportional extension or total extension) the strain rate shall not exceed 0,002 5 s^{-1}.

10.2.2.5 If the testing machine is not capable of measuring or controlling the strain rate, a cross head separation speed equivalent to the stress rate given in Table 3 shall be used until completion of yield.

10.2.3 Tensile strength (R_m)

After determination of the required yield/proof strength properties the test rate may be increased to a strain rate (or equivalent crosshead separation rate) to no greater than 0,008 s^{-1}.

If only the tensile strength of the material is required to be measured, the test rate shall not exceed 0,008 s^{-1} throughout the test.

11 Determination of percentage elongation after fracture (A)

11.1 Percentage elongation after fracture shall be determined in accordance with the definition given in 4.4.2.

For this purpose, the two broken pieces of the test piece are carefully fitted back together so that their axes lie in a straight line.

Special precautions shall be taken to ensure proper contact between the broken parts of the test piece when measuring the final gauge length. This is particularly important in the case of test pieces of small cross-section and test pieces having low elongation values.

Elongation after fracture (L_u - L_o) shall be determined to the nearest 0,25 mm with a measuring device with a sufficient resolution and the value of percentage elongation after fracture shall be rounded to the nearest 0,5 %. If the specified minimum percentage elongation is less than 5 %, it is recommended that special precautions be taken when determining elongation (see annex F).

This measurement is, in principle, valid only if the distance between the fracture and the nearest gauge mark is not less than one third of the original gauge length (L_o). However, the measurement is valid, irrespective of the position of the fracture, if the percentage elongation after fracture is equal to or greater than the specified value.