SLOVENSKI STANDARD
SIST EN 10291:2002

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Kovinski materiali - Preskušanje lezenja pri enoosni natezni obremenitvi - Preskusna metoda

Metallic materials - Uniaxial creep testing in tension - Method of test

Metallische Werkstoffe - Einachsiger Zeitstandversuch unter Zugbeanspruchung - Prüfverfahren

Matériaux métalliques - Essai de fluage uniaxial en traction - Méthode d'essai

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Metallic materials - Uniaxial creep testing in tension - Method of test

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

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

It is based on ISO 204 with addition of the provisions concerning the interrupted creep test.

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of an identical text or by endorsement, at the latest by April 2001, and conflicting national standards shall be withdrawn at the latest by April 2001.

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 draft European Standard specifies the method for the uninterrupted and interrupted creep tests and defines the properties of metallic materials which can be determined from these tests, in particular the creep elongation and the time of creep rupture, at a specified temperature.

NOTE The stress rupture test is also covered by 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 ISO 7500-2, *Metallic materials — Verification of static uniaxial testing machines — Part 2 : Tensile creep testing machines — Verification of the force applied (ISO 7500-2:1996).*

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

EN 10002-5, *Metallic materials — Tensile test — Part 5: Method of testing at elevated temperature.*

EN 20286-2, *ISO system of limits and fits — Part 2 : Table of standard tolerances grades and limit deviations for holes and shafts (ISO 286-2 :1998).*

3 Terms and definitions

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

3.1
reference length (L_r)
base length used for the calculation of elongation

NOTE In some cases, the reference length needs to be calculated. An example of a procedure is given in Figure 2.

Distinction is made between :

3.1.1
original reference length (L_{ro})
reference length determined at ambient temperature before the test

3.1.2
final reference length (L_{ru})
reference length determined at ambient temperature after rupture, with the pieces carefully fitted back together with their axes in a straight line

3.2
original gauge length (L_o)
length between gauge length marks on the test piece measured at ambient temperature before the test

3.3
final gauge length after rupture (L_u)
length between gauge length marks on the test piece measured after rupture, at ambient temperature, with the pieces carefully fitted back together with their axes in a straight line

3.4
parallel length (L_c)
length of the parallel reduced section of the test piece

3.5
extensometer gauge length (L_e)
distance between the measuring points of extensometer

NOTE In some cases, $L_e = L_o$.

3.6
original cross-sectional area (S_o)
cross-sectional area of the parallel length as determined at ambient temperature prior to testing

3.7
minimum cross-sectional area after rupture (S_u)
minimum cross-sectional area of the parallel length as determined at ambient temperature after rupture, with the pieces carefully fitted back together with their axes in a straight line

3.8
initial stress (σ_o)
applied force divided by the original cross-sectional area (S_o) of the test piece

3.9
elongation (ΔL_r)
increase of the reference length (L_r), see 6.2

3.10
percentage elongation (A)
elongation expressed as a percentage of the original reference length L_{ro}, see Figure 1

NOTE In the case of the terms for elongation in 3.10 (except A_u, in 3.10.6), the symbol "ε" may replace "A". However, when "ε" is used, the following convention should apply :
- ε % = percentage strain/elongation ;
- ε = absolute strain.

3.10.1
percentage initial plastic elongation (A_i)
non-proportional increase of the original reference length L_{ro} due to the application of the test force

3.10.2
percentage creep elongation (A_f)
increase in reference length at time t (ΔL_{rt}) at a specified temperature expressed as a percentage of the original reference length (L_{ro}):

$$A_f = \frac{\Delta L_{rt}}{L_{ro}} \times 100$$

NOTE 1 A_f may have the specified temperature (T) in Celsius degrees as superscript and s the initial stress (σ_o) in megapascals [1)] and time t (in hours) as subscript.

NOTE 2 By convention the beginning of creep elongation measurement is the time at which the initial stress (σ_o) is applied to the test piece (see Figure 1).

3.10.3
percentage plastic elongation (A_p)
non proportional increase of the original reference length (L_{ro}) at time t :

$$A_p = A_i + A_f$$

3.10.4
percentage anelastic elongation (A_k)
non-proportional decrease of the original reference length (L_{ro}) at time t due to unloading

1) 1 MPa = 1 N/mm^2.

3.10.5
percentage permanent elongation (A_{per})
total increase of the original reference length (L_{ro}) at time t determined after unloading :

$$A_{per} = A_p - A_k$$

3.10.6
percentage elongation after creep rupture (A_u)
permanent increase of the original reference length (L_{ro}) after rupture (L_{ru} - L_{ro}) expressed as a percentage of the original reference length (L_{ro}) :

$$A_u = \frac{L_{ru} - L_{ro}}{L_{ro}} \times 100$$

NOTE A_u may have the specified temperature (T) in Celsius degrees as superscript and the initial stress (σ_o) in megapascals [2)] as subscript.

3.11
percentage reduction of area after creep rupture (Z_u)
maximum change in cross-sectional area measured after rupture (S_o - S_u) expressed as a percentage of the original cross-sectional area (S_o) :

$$Z_u = \frac{S_o - S_u}{S_o} \times 100$$

NOTE Z_u may have the specified temperature (T) in Celsius degrees as superscript and the initial stress (σ_o) in megapascals [2)] as subscript.

3.12
creep elongation time (t_{fx})
time required for a strained test piece to obtain at the specified values of temperature (T) and initial stress (σ_o) a specified percentage creep elongation (x)

EXAMPLE $t_{f0,2}$

3.13
plastic elongation time (t_{px})
time required to obtain at the specified values of temperature (T) and initial stress (σ_o) a specified percentage plastic elongation (x)

3.14
creep rupture time (t_u)
time required for the test piece maintained at the specified temperature (T) and strained by the specified tensile force to rupture

NOTE The symbol t_u may have as superscript the specified temperature (T) in Celsius degrees and as subscript the initial stress (σ_o) in megapascals [2)].

3.15
simple machine
a testing machine that permits straining of a single test piece

3.16
multiple machine
a testing machine that permits straining of more than one test piece simultaneously at the same temperature

2) 1 MPa = 1 N/mm^2.

4 Symbols and designations

The symbols and corresponding designations are given in Table 1.

Table 1 — Symbols and designations

Reference number [a]	Symbol [b]	Unit	Designation
1	d	mm	Diameter of the cross-section of the parallel length of a cylindrical test piece
2	b	mm	Width of the cross-section of the parallel length of a test piece of square or rectangular cross-section
3	L_r	mm	Reference length
4	a	mm	Thickness of a test piece of square or rectangular cross-section
-	L_{ro}	mm	Original reference length
-	L_{ru}	mm	Final reference length
-	ΔL_r	mm	Elongation
	ΔL_{rt}	mm	Increase in reference length at time t
5	L_o	mm	Original gauge length
-	L_u	mm	Final gauge length after rupture
6	L_c	mm	Parallel length
7	L_e	mm	Extensometer gauge length
8	r	mm	Transition radius
9	S_o	mm^2	Original cross-sectional area of the parallel length
-	S_u	mm^2	Minimum cross-sectional area after rupture
10	σ_o	MPa	Initial stress
11	A_e [c]	%	Percentage elastic elongation
12	A_i [c]	%	Percentage initial plastic elongation
13	A_k [c]	%	Percentage anelastic elongation
14	A_p [c]	%	Percentage plastic elongation
15	A_{per} [c]	%	Percentage permanent elongation

continued

Table 1 — Symbols and designations (*continued*)

Reference number [a]	Symbol [b]	Unit	Designation
16	A_f [c]	%	Percentage creep elongation : $$A_f = \frac{\Delta L_{rt}}{L_{ro}} \times 100$$ NOTE As an example, the symbol may be completed as follows : $A_{f\,50/5000}^{375}$: percentage creep elongation with an initial stress of 50 MPa after 5 000 h at the specified temperature of 375 °C.
23	A_u [c]	%	Percentage elongation after creep rupture : $$A_u = \frac{L_{ru} - L_{ro}}{L_{ro}} \times 100$$ NOTE As an example, the symbol may be completed as follows : $A_{u\,50}^{375}$: percentage elongation after creep rupture with an initial stress of 50 MPa at the specified temperature of 375 °C.
-	Z_u	%	Percentage reduction of area after creep rupture : $$Z_u = \frac{S_o - S_u}{S_o} \times 100$$ NOTE As an example, the symbol may be completed as follows : $Z_{u\,50}^{375}$: percentage reduction of area after creep rupture with an initial stress of 50 MPa at the specified temperature of 375 °C.
	t_{fx}	h	Creep elongation time
	t_{px}	h	Plastic elongation time
24	t_u	h	Creep rupture time NOTE As an example, the symbol may be completed as follows : $t_{u\,50}^{375}$: creep rupture time with an initial stress of 50 MPa at the specified temperature of 375 °C.
-	t_{ue}	h	Creep rupture time of a notched test piece
-	T	°C	Specified temperature

continued

Table 1 — Symbols and designations (*end*)

Reference number [a]	Symbol [b]	Unit	Designation
-	T_i	°C	Indicated temperature
-	x	%	Specified percentage creep or plastic elongation
-	n		Creep exponent

[a] See Figures 1 and 2.

[b] The main subscripts (r, o and u) of the symbols are used as follows :

r corresponds to reference ;

o corresponds to original ;

u corresponds to ultimate (after rupture).

[c] See note in 3.10.

5 Principle

The test consists of heating a test piece to the specified temperature and of straining the test piece by means of a constant tensile force or constant tensile stress (see note) applied along its longitudinal axis for a period of time to obtain either :

— a specified creep elongation or to rupture the test piece (uninterrupted test), or ;

— to obtain values of permanent elongation at suitable intervals throughout the test or to rupture the test piece (interrupted test).

NOTE "Constant stress" means that the ratio of the force to the instantaneous cross-section remains constant throughout the test. The results obtained with constant stress are generally different from those with constant force.

6 Apparatus

6.1 Testing machine

The testing machine shall apply a force along the axis of the test piece while keeping inadvertent bending or torsion of the test piece to a minimum.

NOTE 1 The force should be applied to the test piece without shock.

NOTE 2 It is recommended that the machine be isolated from external vibration and shock. The machine should be equipped, with a device which minimizes shock when the test piece ruptures.

The machine shall be verified and shall meet the requirements of at least class 1 in EN ISO 7500-2.

6.2 Elongation measuring device

In uninterrupted tests, the elongation shall be measured using an extensometer, which meets the performance requirements of class 1 or better of EN 10002-4 or by other means which ensure the same accuracy without interruption of the test.

The extensometer shall be calibrated at intervals not exceeding 3 years. If the predicted test time exceeds the date of the expiry of the calibration certificate then the extensometer shall be recalibrated prior to commencement of the creep test.

The extensometer gauge length shall be not less than 10 mm.

The extensometer shall be able to measure the elongation either on one side or on the opposite sides of the test piece.

NOTE 1 When the elongation is measured on the opposite sides, the average elongation should be reported.

NOTE 2 For uninterrupted creep tests, i.e. with an extensometer attached directly to the parallel section of a test piece, the percentage creep elongation is measured over L_o (or L_e).

When the elongation is measured with an extensometer attached to the grip ends of the test piece, the ends shall be of such shape and size that it can be assumed that the observed elongation has occurred completely within the reference length of the test piece.

The increase in the reference length is considered to be the increase in the original gauge length or in the extensometer gauge length.

NOTE 3 The extensometer gauge length should normally be as near as possible to the reference length : In the case of accurate creep measurements, a gauge length as long as possible should be used to improve the accuracy of measurements.

NOTE 4 If only the percentage elongation after creep rupture or the percentage creep elongation for a specified test duration is determined, the use of an extensometer is not necessary.

In interrupted tests, periodically unload the test piece cool to ambient temperature and measure the permanent elongation on the gauge length with an appropriate device. The precision of this measurement shall be 0,01 ΔL_r or 0,01 mm whichever is the greater. After this measurement the test piece is reheated and reloaded.

NOTE For low creep strain measurements, e.g. ≤ 1% strain, on test pieces with short gauge lengths, careful consideration needs to be given to ensure that the measuring device used has sufficient resolution.

6.3 Heating device

6.3.1 Permissible temperature deviations

The heating device shall heat *t* the test piece to the specified temperature (T).

The permitted deviations between the indicated temperature (T_i) and the specified temperature (T) and the permitted maximum temperature gradient shall be as given in Table 2 :

Table 2 — Permitted deviations between T_i and T and maximum admissible temperature gradient

Specified temperature T °C	Permitted deviation between T_i and T °C	Maximum admissible temperature gradient °C
$T \leq 600$	± 3	3
$600 < T \leq 800$	± 4	4
$800 < T \leq 1\,000$	± 5	5

For specified temperatures greater than 1 000 °C, the permitted values shall be defined by agreement between the parties concerned.

The indicated temperatures (T_i) are the temperatures measured at the surface of the parallel length of the test piece, errors from all types being taken into account and systematic errors being corrected.

NOTE 1 Instead of measuring the temperature at the surface of the test piece, it is permitted to carry out indirect measurement of the temperature of each heating zone of the furnace provided that it is demonstrated that the tolerance defined above is fulfilled.