SLOVENSKI STANDARD
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Kovinski materiali - Preskušanje relaksacije pri natezni obremenitvi - 1. del: Postopek na preskuševalnih strojih

Metallic materials - Tensile stress relaxation testing - Part 1: Procedure for testing machines

Metallische Werkstoffe - Relaxationsversuch unter Zugbeanspruchung - Teil 1: Prüfverfahren für die Anwendung in Prüfmaschinen

Matériaux métalliques - Essai de relaxation en traction - Partie 1: Mode opératoire pour machines d'essai

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This European Standard was approved by CEN on 21 March 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Contents

Foreword

This document (EN 10319-1:2003) has been prepared by Technical Committee ECISS/TC 1 “Steel - Mechanical tests”, 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of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.

This European Standard consists of the following parts under the general title *Metallic materials – Tensile stress relaxation testing*

— *Part 1: Procedure for testing machines*

— *Part 2: Procedure for model bolts*

Annexes A and B are for informative.

This document includes a bibliography.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the test method for the determination of relaxation of stress of metallic test pieces subjected throughout the test to nominally constant strain and constant temperature conditions.

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 10002-4:1994, *Metallic materials - Tensile test - Part 4: Verification of extensometers used in uniaxial testing.*

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

3 Terms and definitions

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

3.1
gauge length
prescribed part of the test piece on which extension measurements are made

Distinction is made between:

3.1.1
original gauge length (L_o)
gauge length before the test piece is heated and strained

3.1.2
extensometer gauge length (L_e)
distance between the measuring points of the extensometer

NOTE In some cases, $L_e = L_o$.

3.1.3
reference length (L_r)
base length used for the calculation of the strain

NOTE See also Figure 2b.

3.2
parallel length (L_c)
length of the parallel reduced section of the test piece

3.3
original cross-sectional area (S_o)
cross-sectional area of the parallel length determined at ambient temperature prior to testing

3.4
extension
increase in the extensometer gauge length (L_e) or, if $L_r \neq L_e$, in the reference length (L_r)

3.5
strain
extension divided by the extensometer gauge length (L_e) or, if $L_r \neq L_e$, by the reference length (L_r)

3.5.1
total strain (ε_t)
strain applied to the test piece at any time, *t,* during the test

NOTE Total strain is the sum of elastic and plastic strain, see Figure 1.

3.5.2
initial total strain (ε_{to})
strain applied to the test piece at the commencement of the test

3.6
stress
at any time during the test, force divided by the original cross-sectional area (S_o) of the test piece

Distinction is made between:

3.6.1
initial stress (σ_o)
stress at the commencement of the test

3.6.2
residual stress (σ_{rt})
value to which the stress in the test piece has relaxed, at any time, *t*, during the test

4 Symbols and designations

The symbols and corresponding designations are given in Table 1.

Table 1 - Symbols and designations

Reference number[a]	Symbol	Unit	Designation
1	d	mm	Diameter of the cross-section of the parallel length of a cylindrical test piece
2	L_o	mm	Original gauge length
3	L_c	mm	Parallel length
4	L_e	mm	Extensometer gauge length
5	r	mm	Transition radius
6	L_r	mm	Reference length
	S_o	mm²	Original cross-sectional area of the parallel length
7	ε_{to}		Initial total strain
8	σ_o	MPa[b]	Initial stress
9	σ_{rt}	MPa	Residual stress at time t
10	ε_t		Total strain
11	t_0		End of the application of the initial total strain
12	t		Time from the end of the application of the initial total strain
13	σ		Stress
14	ε_{eo}		Initial elastic strain
15	ε_{po}		Initial plastic strain
16	ε_{pt}		Plastic strain for residual stress σ_{rt} at time t
17	ε_{et}		Elastic strain for residual stress σ_{rt} at time t
-	T	°C	Specified temperature
-	T_i	°C	Indicated temperature
-	n		Exponent

[a] See Figures 1 and 2.

[b] 1 MPa = 1 N/mm².

5 Principle

The test consists of maintaining a test piece at a specified temperature, subjecting to a constant tensile strain at this temperature and determining values of the residual stress in the test piece, either continuously or at suitable times throughout the test.

NOTE See 8.7 regarding the re-starting of a test after interruption.

6 Apparatus

6.1 Testing machine

The machine shall apply a force along the axis of the test piece in such a way that inadvertent bending or torsion of the test piece reduced to a minimum.

The force shall be applied to the test piece without shock.

NOTE It is recommended that the machine be isolated from external vibration and shock.

The testing machine shall be verified and shall meet the requirements of at least class 1 in accordance with EN ISO 7500-1:1999.

The type of machine (e.g. servo-controlled electro-mechanic, servo-controlled hydraulic or sliding weight machine) shall be indicated in the test report.

6.2 Extension measuring device

The extension shall be measured using an extensometer which meets the bias requirements of at least class 1 in accordance with EN 10002-4:1994 and a resolution lower than or equal to one tenth of this bias value.

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, the extensometer shall be calibrated prior to commencement of the relaxation test.

The extensometer gauge length depends upon the performance characteristics of the extensometry used to measure the strain. A minimum gauge length of 100 mm is recommended. If insufficient material is available, shorter gauge lengths may be used provided that the extensometry used has a sufficient resolution. The use of shorter gauge lengths shall be recorded in the test report. The extensometer should be able to measure the extension on two opposite sides of the test piece. Side contact extensometry is permitted; where used this shall be reported in the test report.

NOTE When measured on the opposite sides, the average extension should be reported.

6.3 Heating device

6.3.1 Permissible temperature deviations

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

The permitted deviations between the indicated temperature, T_i, and the specified temperature, T, and the maximum admissible temperature gradient shall be as given in Table 2. The temperature gradient is the maximum difference between the temperatures indicated by the measuring thermocouples attached to the test piece.

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	2
$600 < T \leq 800$	± 4	3
$800 < T \leq 1\,000$	± 5	3

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 sources being taken into account.

The parts of the extensometer outside the furnace shall be designed and protected in such a way that the temperature variations in the air around the furnace do not significantly affect the measurements.

In any case, the variations in temperature of the air surrounding the test machine should not exceed $\pm$ 3 °C.

NOTE If this range is exceeded, corrections for ambient temperature variations should be applied.

6.3.2 Temperature measurement

6.3.2.1 General

Temperature indicator shall have an accuracy (sensitivity) of at least 0,5 °C and the temperature measuring equipment shall have an accuracy of $\pm$ 1 °C.

6.3.2.2 Number of thermocouples

For test pieces with a parallel length less than or equal to 50 mm, at least two thermocouples should be used. For test pieces with a parallel length greater than 50 mm, at least three thermocouples should be used. In all cases, a thermocouple should be placed at each end of the parallel length and, if a third is used it shall be placed in the middle region of the parallel length.

6.3.2.3 Thermocouples

In all cases, thermocouple junction shall make good thermal contact with the surface of the test piece and shall be screened from direct radiation from the heating source. The remaining portions of the wires within the furnace shall be thermally shielded and electrically insulated.

6.3.3 Calibration of the thermocouples and temperature measuring system

NOTE Information concerning different types of thermocouples is given in annex A.

6.3.3.1 Calibration of thermocouples

Thermocouples in use for test durations of less than one year should be calibrated at least every 12 months. Thermocouples in use for test durations greater than 12 months should be calibrated before and after the test.

NOTE 1 Changes in the output of a thermocouple after calibration can be due not only to chemical changes leading to drift, but also as a consequence of, for example, physical damage; information on such changes should be recorded and should be available on request.

NOTE 2 If it is demonstrated that the drift of the thermocouple does not affect the permissible temperature deviations specified in 6.3.1, the period between two calibrations can be longer.

NOTE 3 Thermocouple drift is dependent on the type of thermocouple used and the exposure duration at temperature.

NOTE 4 If the drift affects permissible temperature deviations, either more frequent calibrations should be carried out or a correction for drift may be made to the temperature indicated by the thermocouple.

NOTE 5 Information concerning methods of calibration of thermocouples is given in annex B.

If it is rewelded, the thermocouple shall be recalibrated.

It shall be demonstrated that the error of the thermocouple used has been established either at the test temperature or is typical for a range containing the test temperature.

6.3.3.2 Calibration of the temperature measuring equipment

The calibration of the temperature measuring equipment (including the cable, the connection, the cold junction, the indicator or the recorder, the data line..) shall be carried out by a method traceable to the international unit (SI) of temperature.

If practicable, this calibration should be carried out annually over the working range of the measuring equipment and the readings shall be given in the calibration report.

NOTE The number of temperatures at which the calibration is done depends on the size of the range.

7 Test pieces

7.1 Shape and dimensions

In general, the test piece is a machined proportional cylindrical test piece ($L_o = k\sqrt{S_o}$) with a circular cross-section (see examples in Figure 2). The value k should be equal to or greater than 11,28 and the reference length should be equal to or greater than 100 mm . Where material availability limitations dictate shorter gauge lengths then the value k may be reduced to a value which shall be not less than 3 and shall be recorded in the test report.

In general, L_c should not exceed L_o by more than 20 % for circular cross section test pieces.

The parallel length shall be joined by transition curves to the gripped ends, which may be of any shape to suit the grips of the testing machine. The transition radius (r) should be between 0,25 d and 1 d for the cylindrical test pieces.

NOTE 1 When a test piece having collars in the parallel length is used, the transition radius of the collars may be less than 0,25 d.

NOTE 2 For the calculation of the reference length (L_r) n = 1 is recommended because in relaxation, elastic deformation is dominant.

The grip ends of test pieces shall have the same axis as the parallel length with a coaxiality tolerance of 0,005 d or 0,03 mm, whichever is the greater, for cylindrical test pieces.

Unless the sample size does not permit it, the original cross-sectional area (S_o) shall be greater than or equal to 7 mm².

NOTE 3 A minimum value of 50 mm^2 is recommended.

NOTE 4 When oxidation is a significant factor, test pieces with a larger original cross-sectional area (S_o) should be used.

7.2 Preparation

The test piece shall be machined in such a way to avoid any residual deformation or surface defects.

The shape tolerances shall conform to Table 3 for test pieces with circular cross-section.