BRITISH STANDARD

BS EN 10319-1:2003

Incorporating Corrigendum No. 1

Metallic materials — Tensile stress relaxation testing —

Part 1: Procedure for testing machines

The European Standard EN 10319-1:2003 has the status of a British Standard

ICS 77.040.10

British Standards

National foreword

This British Standard is the official English language version of EN 10319-1:2003. This document supersedes BS 3500-6:1969 which is now withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/NFE/4, Mechanical testing of metals, to Subcommittee ISE/NFE/4/1, Uniaxial testing of metals, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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

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

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

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of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.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 ± 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 ± 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 mm^2.

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.

Table 3 - Shape tolerances of test pieces with circular cross-section

Dimensions in millimetres

Nominal diameter *d*	**Shape tolerances** [a]
$3 < d \leq 6$	0,02
$6 < d \leq 10$	0,03
$10 < d \leq 18$	0,04
$18 < d \leq 30$	0,05

[a] Maximum deviation between the measurements of a transverse dimension determined along the entire parallel length of the test piece (see EN 20286-2).

7.3 Determination of the original cross-sectional area

The original cross-sectional area (S_o) shall be calculated from measured dimensions of the parallel length. Each appropriate dimension shall be measured to an accuracy of ± 0,1 % or ± 0,01 mm whichever is greater. The variation in room temperature during these measurements shall not exceed ± 2 °C.

8 Test procedure

8.1 Determination of the modulus of elasticity at ambient temperature

A determination of the modulus of elasticity at ambient temperature shall be conducted to ensure correct operation of the extensometry. The measured value of modulus shall be within ± 10 % of the expected value ; this is usually determined from a tensile test using extensometry with equivalent performance to that used in the stress relaxation test.

NOTE For guidance, see EN 10002-1:2001, annex A.

8.2 Heating of the test piece

The test piece shall be heated to the specified temperature (T). Adjustments shall be made to the test furnace control system to achieve the thermal gradient requirement set out in Table 2. The test piece, gripping system and the extensometer shall be at thermal equilibrium before commencement of the test.

This condition shall be maintained for a stabilisation period of at least one hour before application of the force to the test piece, unless the product standard states otherwise. The maximum time that the test piece is held at the test temperature before applying the force shall not exceed 24 hours.

During the heating period, the temperature of the test piece should not, at any time, exceed the specified temperature (T) with its tolerances. If these tolerances are exceeded, it shall be reported.

8.3 Application of the total strain

The test force shall be applied along the test piece axis in such a manner as to minimise bending and torsion of the test piece.

The initial total (ε_{to}) strain and the corresponding initial stress (σ_0) shall be determined to an accuracy of at least ± 1 %. Loading may be either strain or force controlled. The increase of the strain or force shall be made without shock and application of the initial total strain shall be completed within 10 minutes**.** The loading time shall be recorded.

During loading, a stress-strain or force-extension diagram shall be obtained either by using autographic equipment or by applying the test force incrementally and taking extension readings at each increment. The elevated temperature stress-strain diagram should be produced and assessed to ensure correct functioning of the extensometry.

8.4 Maintaining of strain

Throughout the test, the value of total strain corresponding to the prescribed loading condition shall be maintained constant within a control band amplitude of ± 1 % of its observed initial value for force controlled loading or its specified value for strain controlled loading by gradual reduction of the stress. Force adjustments which are manually performed should only be decremental in nature and return the measured strain to the total strain ε_t. For servo-control of total strain force adjustments may be decremental or incremental and the strain amplitudes should approximate the ± 1 % control band.

NOTE In the case of stress relief tests or structural ordering experiments the force adjustments may be either positive or negative, depending upon the structural changes taking place within the test piece during the test.

8.5 Records

8.5.1 Temperature

Sufficient recordings of the temperature of the test piece shall be made throughout the test to demonstrate that the temperature conditions comply with the requirements of 6.3.1.

8.5.2 Residual stress

The residual stress values shall be determined either from a continuous record or from a sufficient number of force readings over the duration of the test.

8.5.3 Time

For each value of stress recorded, the corresponding time during which the test piece has been subjected to the test strain shall be known to an accuracy within ± 1 %.

8.5.4 Stress relaxation curve

On the basis of records of time and residual stress, a stress relaxation curve can be drawn.

8.6 Termination of test

At the end of the test the test piece should be cooled with the residual force, F_{rt}, applied. When at ambient temperature an unloading modulus may be determined, such data are essential in the event that a test piece is reloaded at some time in the future.

8.7 Test interruption

In the case of a test interruption, the following sequence of events shall be applied :

a) Cool under residual force F_{rt}, whenever it is possible;

b) Determine the room temperature modulus of elasticity;

c) Assess the modulus of elasticity and, if acceptable, apply approximately half of the residual force, F_{rt}, which the test piece experienced just prior to termination;

d) Heat to the specified temperature and stabilise for one hour;

e) Increase the force to F_{rt}, monitor the extensometer output signal and, after five minutes, record the extensometer output value. Use this value as the control datum and proceed as per a new test. A schematic diagram for this procedure is given in Figure 3.

9 Accuracy of the results

9.1 Expression of the results

For the expression of the results, the values shall be expressed taking into account the following requirements concerning the rounding rules:

- specified temperature: to 1 °C;
- diameter *d*: to 0,01 mm;
- ratio L_0/d: to one decimal place;
- initial and residual stress: 3 significant figures;
- time: 3 significant figures.

9.2 Uncertainty

Due to the fact that the uncertainty of the results depends on the nature of the tested material and the testing conditions, it is not possible to give precise values for the uncertainty.

10 Test report

10.1 Where the material under test is covered by a product specification then the report shall contain the information required by that specification plus the items defined in 10.2. For materials not covered by a product specification the report shall be in accordance with 10.2. At the client's request, at the time of order, the test report shall contain the items specified in 10.2, and those items in 10.3 requested by the client.

10.2 Information to be reported in the test report shall include when applicable:

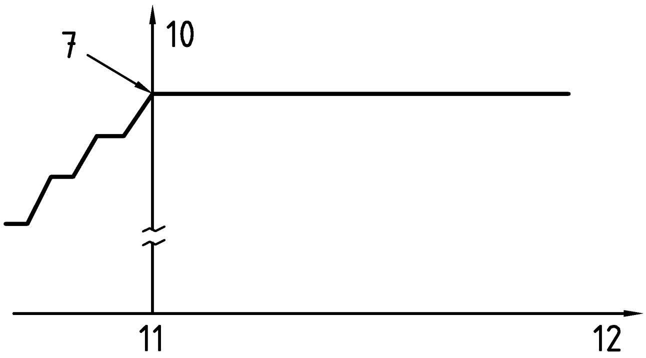
- reference to this European Standard;
- material and test piece identification;
- type and dimensions of the test piece (value of the proportionality coefficient *k* included), including the original gauge length (L_0) or the original extensometer gauge length (L_e) if $L_e \neq L_0$ and the reference length (L_r) if $L_r \neq L_e$;
- specified temperature and indicated temperature if it is outside the permitted limits;
- specified total strain;
- test results;
- type of the testing machine;
- any occurrence which can affect the results for example, deviations from the specified tolerances or equipment performance.

10.3 Information to be available on request made at the time of order shall include when applicable:

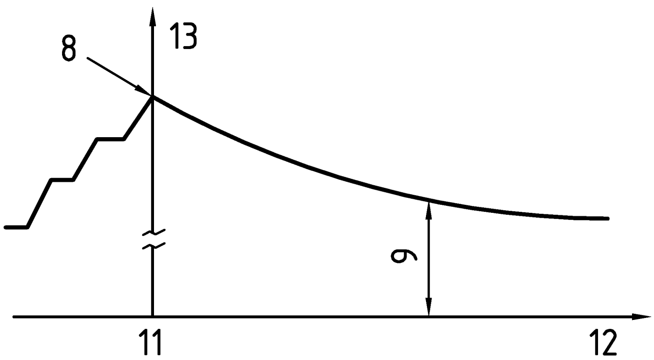
- force application time;
- heating time and stabilisation period;
- elongation-time diagram with sufficient recordings to accurately construct the diagram;

— loading time and type of loading (strain- or stress controlled);

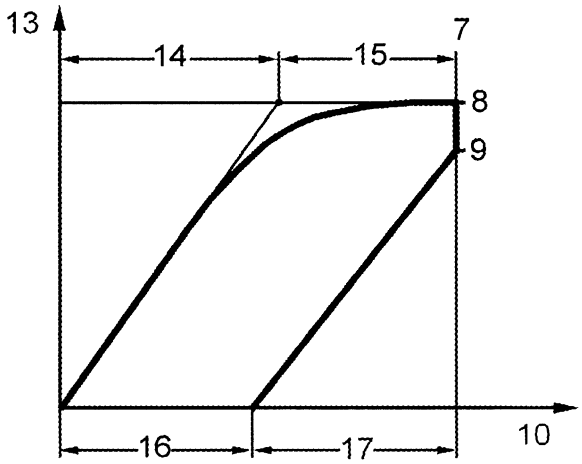
— information concerning the recorded values of any indicated temperature excursions outside the permitted temperature limits defined in 6.3.1.



a) Schematic total strain – time diagram

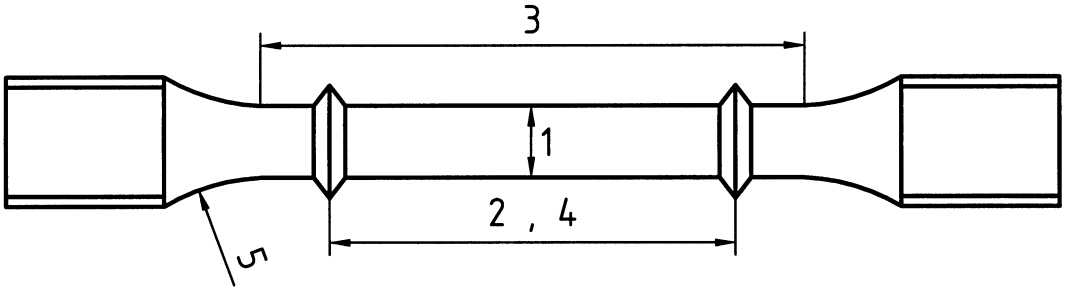


b) Schematic stress – time diagram

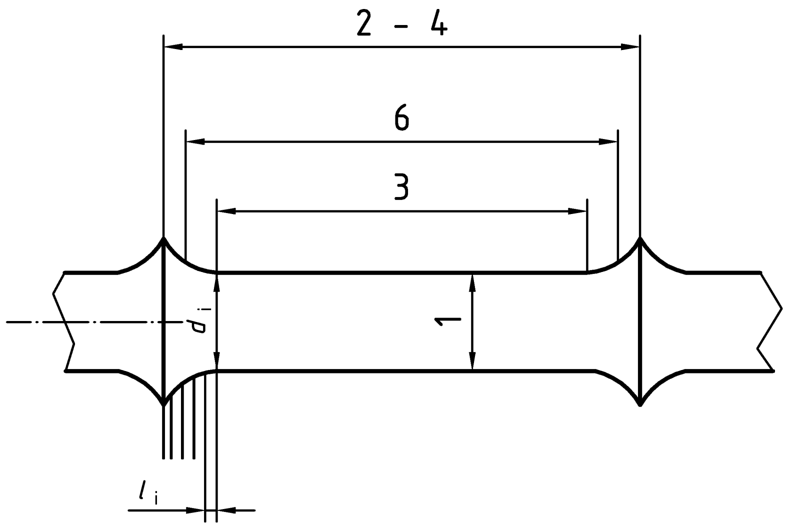


c) Schematic stress – total strain diagram

Figure 1 - Principle of the tensile relaxation test in relation with reference numbers in Table 1



a) Test piece of circular cross-section with ridges

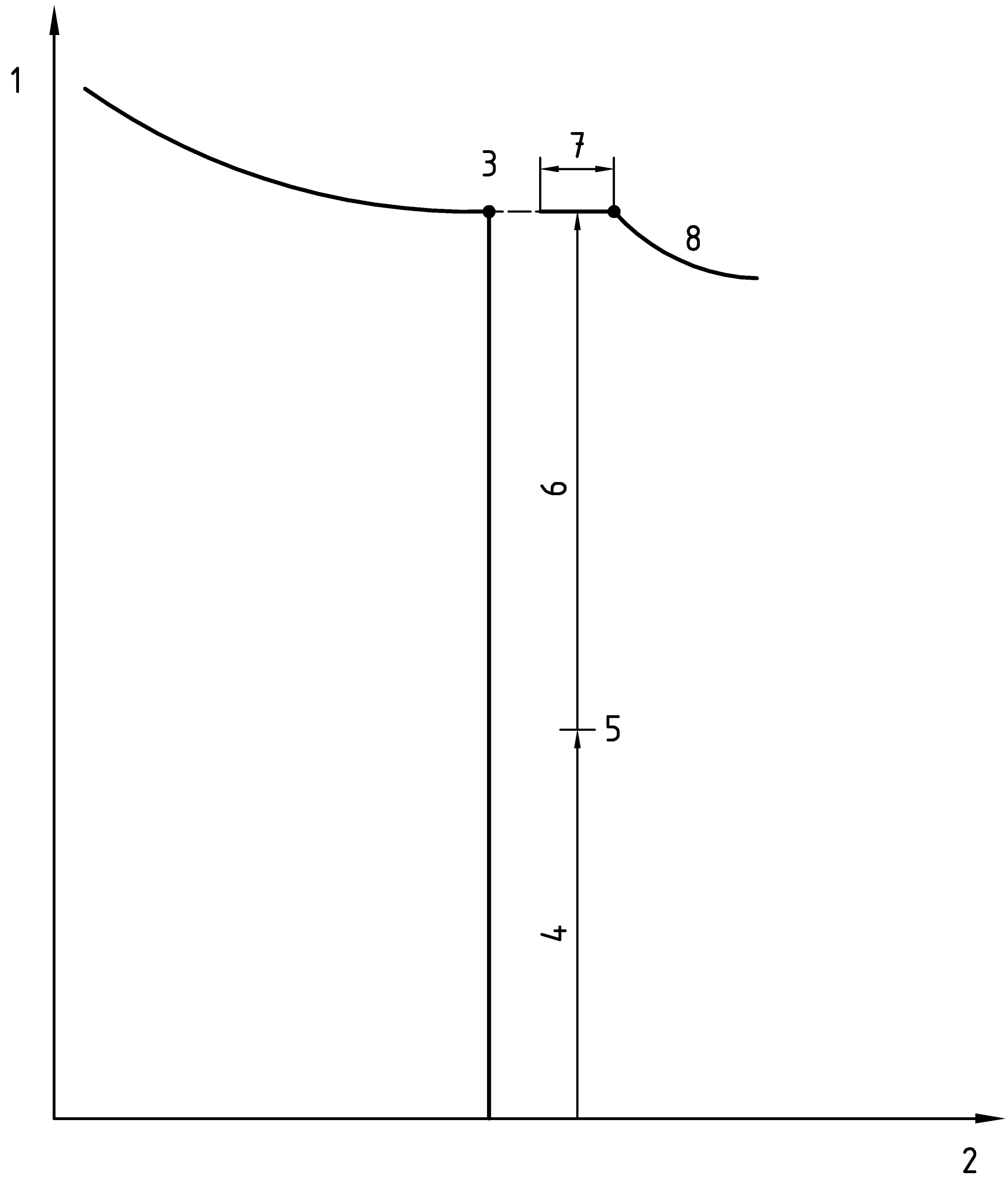


$L_r = L_c + 2\sum_i \left[(d/d_i)^{2n} l_i \right]$ with an exponent $n = 1$

b) Test piece with collars

Figure 2 — Examples of test pieces [1)] in relation with reference numbers in Table 1

1) The shape of the grip ends is only given for information



Key

1 Force

2 Time

3 Cool under residual force (F_{rt})

4 Apply approximately 50% of residual force (F_{rt})

5 Heat to the specified temperature

6 Apply the remainder of the residual force to achieve F_{rt}

7 Wait 5 minutes for new extensometer reference

8 Operate under strain control

Figure 3 – Schematic representation of unloading and re-loading for a test interruption

Annex A
(informative)

Information concerning different types of thermocouples

Information concerning different types of thermocouples is given in IEC 584-1 [1] and IEC 584-2 [2].

The use of rare metal thermocouples, preferentially of type S or R is recommended for temperatures equal to or greater than 400 °C.

Base metal thermocouples of type K should only be used at temperatures lower than 400 °C or for times less than 1 000 h at higher temperatures, and should not be re-used.

Base metal thermocouples of type N may be used for temperatures lower than 600 °C or for times less than 3 000 h at higher temperatures, and should not be re-used.

The thermocouple drift should not exceed the following values, within the calibration period:

± 1 °C for $T \leq 600$ °C;

± 1,5 °C for 600 °C < $T \leq 800$ °C;

± 2 °C for 800 °C < $T \leq 1\,100$ °C.

For rare metal thermocouples, these requirements are in general fulfilled for the following calibration periods:

4 years for $T \leq 600$ °C;

2 years for 600 °C < $T \leq 800$ °C;

1 year for 800 °C < $T \leq 1\,100$ °C.

Annex B
(informative)

Information concerning methods of calibration of thermocouples

NOTE See [3], [4] and [5]

For thermocouple calibration, two strategies can be recommended. The objective of both is to ensure that the emf indicated by the thermocouple at the calibration temperature (corrected, where necessary, for all systematic errors) equates as closely as possible to the emf defined by the appropriate IEC 584-1 [1] reference table for that temperature. Both strategies employ the use of reference thermocouples, which are directly traceable to a National Standard. A pre-requisite is that the calibration tolerance of the new thermocouple is in accordance with IEC 584-2 [2], Class 1 or an equivalent standard. The calibration of temperature measuring equipment can be carried out during the thermocouple calibration or can be determined independently.

Strategy 1 is based on in-situ-calibration of the thermocouple, i.e. thermocouple calibration either in the actual furnace or in a calibration furnace with the same depth of immersion and temperature gradient along the thermocouple wires. The error determined during in-situ-calibration is used to correct the specified temperature of the thermocouple. If the error exceeds the limit associated with the uncertainty relating the immersion depth, the thermocouple is scrapped. Reference thermocouple drift due to variable immersion depth during active and passive service should be surveyed and minimised.

Strategy 2 involves calibration of the thermocouple in a calibration furnace in which the depth of immersion is similar to that in the testing furnace. If, on calibration, the laboratories tolerance which needs to include the effect due to depth of immersion is exceeded, the thermocouple is cut back and re-welded at the hot junction and/or annealed and calibration repeated. If after repeated calibration, the laboratories calibration tolerance remains exceeded, the thermocouple is scrapped.

Bibliography

EN 10002-1:2001, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature.*

EN 20286-2, ISO system of limits and fits — Part 2: Table of standard tolerances grades and limit deviations for hole and shafts (ISO 286-2:1988).

[1] IEC 584-1, *Thermocouples - Part 1: References tables.*

[2] IEC 584-2, *Thermocouples - Part 2: Tolerances.*

[3] M.P.E. DESVAUX: "The practical realisation of temperature measurement standards in high temperature mechanical testing" - Chapter 7 in Measurement of high temperature mechanical properties of materials. Editors M.S. LOVEDAY, M.F. DAY and B.F. DYSON. HMSO LONDON, 1982.

[4] C. BROOKES, T.R.D CHANDLER and B. CHU "Nicrosil-nisil: a new high stability thermocouple for industrial user", Measurement & Control, Vol 18, 245-248, Sept 1985.

[5] R.L. RUSBY, D.F. CARTER and A. BESWICK. "An evaluation of sheathed Nicrosil/Nisil thermocouples up to 1 300 °C". Materials at High Temperatures, Vol. 10 N° 3, 193-300, August 1992.

[6] G. Coggiola, L. Crovini and A. Mangano: "Behaviour of KP, KN, Nicrosil and Nisil thermoelectric wires between 0 °C and 750 °C, High Temperatures – High Pressures Vol. 20, 419-432, 1988."

[7] McCarthy P.R., Robertson D.G., Orr J and Strang A, “Recent Developments in Stress Relaxation Methodologies within Europe”, Proceedings of the 8th International Conference on Creep and Fatigue of Engineering Materials and Structures, 1-5 November 1999, Tsukuba, Japan ISBN 0-87849-842-7, pp 9-16.

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