SLOVENSKI STANDARD
SIST EN 10319-2:2007

01-marec-2007

Kovinski materiali ï Preskuğanje sprostitve pri natezni obremenitvi ï 2. del: Postopek za modele vijaļ nih zvez

Metallic materials - Tensile stress relaxation testing - Part 2: Procedure for bolted joint models

Metallische Werkstoffe - Relaxationsversuch unter Zugbeanspruchung - Teil 2: Prüfverfahren mit Schraubenverbindungsmodellen

Matériaux métalliques - Essai de relaxation en traction - Partie 2: Mode opératoire pour modeles d'assemblages boulonnés

Ta slovenski standard je istoveten z: **EN 10319-2:2006**

ICS:

77.040.10 Mehansko preskušanje kovin Mechanical testing of metals

SIST EN 10319-2:2007 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10319-2

October 2006

ICS 77.040.10

English Version

Metallic materials - Tensile stress relaxation testing - Part 2: Procedure for bolted joint models

Matériaux métalliques - Essai de relaxation en traction - Partie 2: Mode opératoire pour modèles d'assemblages boulonnés

Metallische Werkstoffe - Relaxationsversuch unter Zugbeanspruchung - Teil 2: Prüfverfahren mit Schraubenverbindungsmodellen

This European Standard was approved by CEN on 6 August 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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 Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 10319-2:2006: E

Contents

Foreword

This document (EN 10319-2:2006) 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 April 2007, and conflicting national standards shall be withdrawn at the latest by April 2007

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

— *Part 1: Procedure for testing machines*

— *Part 2: Procedure for bolted joint models*

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

1 Scope

This part of EN 10319 specifies the test method for determining the stress relaxation of bolts tensioned in bolted joint models subjected throughout the test to overall constant strain and constant temperature conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

3 Terms and definitions

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

3.1
nominal diameter (d)
diameter of the bolt in the cylindrical length L_c

3.2
thread diameter (D)
diameter of the threaded ends of the bolt

3.3
cylindrical length (L_c)
length of the cylindrical reduced section of the bolt

3.4
reference length (L_r)
base length of the bolt used for calculating strain

3.5
overall length (L_t)
overall length of the bolt

3.6
original cross-sectional area (S_o)
cross-sectional area of the cylindrical length of the bolt determined at ambient temperature prior to testing:

$$S_o = \pi d^2 / 4$$

3.7
extension
increase in the overall length L_t

A distinction is made between:

3.7.1
extension during tensioning (ΔL_o)
extension of the overall length L_t of the bolt during tensioning

3.7.2
elastic reverse extension during unloading (ΔL_t)
back extension of the overall length L_t of the bolt during unloading at the end of the test

3.8
strain
extension divided by the reference length L_r
A distinction is made between:

3.8.1
specified initial elastic strain (ε_{eo})
initial elastic strain of the bolt at the beginning of the test

NOTE The specified initial elastic strain is calculated from the extension during tensioning ΔL_o ($\varepsilon_{eo} = \Delta Lo / L_r$) or is measured directly on the cylindrical length of the bolt with strain gauges.

3.8.2
residual elastic strain (ε_{er})
strain calculated from the reverse extension ΔL_t ($\varepsilon_{er} = \Delta L_t / L_r$) or directly measured in the cylindrical length of the bolt with strain gauges during unloading of the bolt at the end of the test

3.9
stress
at any time during the test, force divided by the original cross-sectional area (S_o) of the bolt between:

A distinction is made between:

3.9.1
initial stress (σ_o)
stress at the start of the test, expressed as a product of the static elastic modulus E_T at the test temperature and the specific initial elastic strain ε_{eo}

$$\sigma o = E_T \times \varepsilon_{eo} \quad (1)$$

3.9.2
residual stress (σ_{rt})
value to which the stress of the bolt has relaxed at the specified time t, after the test, expressed as the product of the elastic modulus E_T or E_{Td} and the residual elastic strain

$$\sigma_{rt} = E_T \times \varepsilon_{er} \quad (2)$$

NOTE The dynamic modulus of elasticity E_{Td} should be taken, if the static modulus of elasticity E_T at test temperature is not available.

4 Symbols and designations

The symbols and corresponding designations are given in Table 1.

Table 1 — Symbols and designations

Symbol	Unit	Designation
d	mm	Nominal diameter of the cross-section of the cylindrical length of the bolt
L_c	mm	Cylindrical length of the bolt
L_r	mm	Reference length of the bolt
L_t	mm	Overall length of the bolt
S_o	mm^2	Original cross-sectional area of the cylindrical length of the bolt
ε_{eo}		Specified initial elastic strain
ε_{er}		Residual elastic strain
E_T	GPa	Static modulus of elasticity at test temperature
E_{Td}	GPa	Dynamic modulus of elasticity at test temperature
σ_o	MPa[a]	Initial stress
σ_{rt}	MPa	Residual stress at time t
t	h	Test duration
T	°C	Specified temperature
T_i	°C	Indicated temperature
a 1 MPa=1 N/mm^2.		

5 Principle

The test consists of tensioning a test piece in the form of a bolt in a bolted joint model device to a specified initial elastic strain, subjecting the bolt to that strain for specific temperature and time and determining the residual stress in the bolt by unloading at the end of the test.

The constant tensile strain and residual stress are derived from an extension measurement referring to the overall length of the bolt (bolted joint model A) or from strain gauge measurements at the cylindrical length of the bolt (bolted joint model B), all measurements being performed at room temperature.

6 Apparatus

6.1 Bolted joint model device

6.1.1 General

In the bolted joint model, a bolt with a cylindrical length and threaded ends is tensioned by two nuts against a flange (Figure 1).

Bolts, flanges and nuts shall be of the same material.

The bolted joint model shall apply a force along the axis of the bolt in such a way that inadvertent bending or torsion of the bolt are minimal. The flange shall have a sufficient stiffness.

Unloading the bolt at the end of the test shall be possible by destroying the flange or a nut.

6.1.2 Bolted joint model A

In bolted joint model A (Figure 2) the ends of the bolt allow the application of an extension measuring device (Figure 4).

6.1.3 Bolted joint model bolt B

In bolted joint model B the flange allows access for the application of two opposite strain gauges onto the cylindrical length of the bolt (Figure 3).

6.2 Extension measuring device

6.2.1 Measuring device for the overall length

With the measuring device (Figure 4) the extension of the bolt of the bolted joint model A shall be measured at room temperature with and without tensioning at the beginning and at the end of the test.

The accuracy of the measurement with a dial gauge shall be ± 0,001 mm.

NOTE The use of a reference bar (Figure 4) facilitates the extension measurements.

6.2.2 Measuring device for the strain

With the measuring device (Figure 5) the strain of the cylindrical length of the bolt of bolted joint model B shall be measured at room temperature without and with tensioning at the beginning and the end of the test.

Two active strain gauges are mounted on opposite sides at the cylindrical length of the bolt. They are connected in a series for measuring additional bending. The strain gauges should have a gauge length of at least 6 mm.

NOTE To avoid undesired reaction products, which may be gaseous or firmly adhere to the surface of the bolt, the strain gauges, including the adhesive, have to be removed before the model is heated up to the test temperature.

To compensate for variations in strain caused by room temperature variations, two passive compensating strain gauges shall be mounted on a reference piece of material identical to the material of the bolted joint model in the initial state and shall also be connected in series. The total configuration of all the strain gauges mounted on the bolted joint model and on the reference piece should be set up as a half-bridge circuit.

The accuracy of the measuring device shall be $\pm 1 \cdot 10^{-6}$ in strain.

6.3 Heating device

6.3.1 General purpose

The heating device shall heat the bolted joint model, hold it at the specified temperature for a specified time and cool it down to room temperature.

The heating device shall be capable of performing limited heating and cooling rates.

6.3.2 Permissible temperature deviations

The permitted deviations between the indicated temperature, T_i of the bolted joint model, 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 bolted joint model.

Table 2 — Permitted deviations between $T_{i,}$ T and the 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 cylindrical length of the test piece, errors from all sources being taken into account.

NOTE Instead of measuring the temperature at the surface of the bolted joint model, it is permitted to indirectly measure the temperature of each heating zone of the furnace provided it is demonstrated that the tolerance defined above is fulfilled.

The variation of the room temperature during all extension measurements shall not exceed ± 2 °C.

6.3.3 Temperature measurement

6.3.3.1 General

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

6.3.3.2 Number of thermocouples

It is recommended that at least one thermocouple should be used for each bolted joint model and where only one thermocouple is used, it should be positioned at the middle of the bolted joint model.

In the case of indirect temperature measurement, regular control measurements are required to determine the differences between the thermocouple(s) of each heating zone and a significant number of model bolts within a given zone. The non-systematic components of the temperature differences shall not exceed ± 2 °C up to 800 °C and ± 3 °C above 800 °C. The total number of thermocouples may not be reduced to less than three, if the thermocouples located at suitable places in the furnace and the indicated temperature do not exceed the permitted deviations given in Table 2.

6.3.3.3 Thermocouples

In all cases, thermocouple junction shall make good thermal contact with the surface of the bolted joint model 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.

NOTE This clause is not applicable in the case of indirect temperature measurement.

6.3.4 Calibration of the thermocouples and temperature measuring system

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

6.3.4.1 Calibration of thermocouples

Thermocouples used for test durations for less than one year should be calibrated at least every 12 months. Thermocouples used for longer 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 6.3.2, the period between two calibrations can be longer.

NOTE 3 If the lubricant applied to the bolted joint model surfaces generates gaseous reaction products at elevated temperatures the period between calibrations should be shortened.

NOTE 4 Thermocouple drift is dependent on the type of thermocouple used and the exposure duration at temperature.

NOTE 5 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 6 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.

6.3.4.2 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 made depends on the size of the range.

7 Shape, dimensions and preparation of bolted joint models

7.1 Shape and dimensions

An example of bolted joint model A for extension measuring on the overall length is detailed in Figure 2, an example of bolted joint model B for strain gauge measurement at the cylindrical length is detailed in Figure 3.

All parts of the bolted joint model are cylindrical pieces with a circular cross section. As an exception, the flange of bolted joint model B is provided with two opposite windows for the application of strain gauges onto the cylindrical length of the bolt.

The shape and the recommended dimensions of the individual parts are shown in Figure 2 and 3. The cross-sectional area of the flange shall be at least ten times the cross-sectional area (S_o) of the bolt.

NOTE The shape and dimensions of the threaded bolt in Figures 2 and 3 are chosen with reference to DIN 2510 Part 3, Bolted connections with reduced shank; stud bolts.

If other dimensions than those recommended in Figures 2 and 3 are selected, the cylindrical length L_c shall be between 3,5 d and 12 d, the transition radius R from the cylindrical length to the threaded ends of the bolt shall be between 0,5 d and 1 d and the thread diameter D shall be between 1,2 d and 1,4 d.

The type of bolted joint model used for the test and deviations from the dimension recommended shall be indicated in the test report.