British Standard

BRITISH STANDARD

BS EN
10002-2:1992

Tensile testing of metallic materials —

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

Cooperating organizations

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Contents

National foreword

This British Standard has been prepared under the direction of the Iron and Steel and the Non-ferrous Metals Standards Policy Committees and is the English language version of EN 10002-2 *"Metallic materials — Tensile testing — Part 2: Verification of the force measuring system of the tensile testing machine"* ratified by the CEN/BT on 25 September 1991. Together with BS 1610-1:1992, it supersedes BS 1610-1:1985 which is withdrawn.

A new edition of BS 1610-1 will be published simultaneously with this standard and is to be used for verification in the compression mode (which is not addressed in BS EN 10002-2).

NOTE Although the scope of EN 10002-2 is limited to the tensile testing of metallic materials, it should be noted that the test described could be used for the tensile testing of all materials.

Other Parts of EN 10002, either published or in preparation, are listed in the foreword to EN 10002-2.

National appendix NA gives the constitution of the committees for UK participation in the preparation of this standard.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10002-2

September 1991

UDC 669:620:172

Descriptors: Metal products, mechanical tests, tension tests, tensile testing machines, measurements, loads, verification

English version

Metallic materials — Tensile testing — Part 2: Verification of the force measuring system of the tensile testing machine

Matériaux métalliques — Essai de traction — Partie 2: Vérification du système de mesure de la charge de la machine d'essai de traction

Metallische Werkstoffe — Zugversuch — Teil 2: Prüfung der Kraftmesseinrichtungen von Zugprüfmaschinen

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 10002-2:1991 E

Foreword

The proposal for this European Standard was prepared by the Technical Committee ECISS/TC 1A "Mechanical and physical tests" the Secretariat of which has been allocated to the Association Française de Normalisation (AFNOR).

It forms Part 2 of the general standard EN 10002.

This standard is based on the international standard:

ISO 7500/1–1986, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines.*

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

The standard EN 10002 will comprise the following Parts:

— *Part 1: Metallic materials; Tensile test; Method of test (at ambient temperature)*;

— *Part 2: Verification of the force measuring system of the testing machine*;

— *Part 3: Metallic materials; Tensile test; Calibration of force proving instruments used for the verification of uniaxial testing machines*;

— *Part 4: Metallic materials; Tensile test; Verification of extensometers used in uniaxial testing*;

— *Part5: Metallic materials; Tensile test; Method of test at elevated temperatures.*

Contents

1 Scope

This European Standard specifies the verification of the force measuring system of tensile testing machines.

This verification shall be preceded by a general inspection of the testing machine (see clause **4**).

The dynamic verification of the forces applied by tensile testing machines is excluded from this standard.

This standard is not concerned with the verification of extensometers (see EN 10002-4).

2 Normative references

EN 10002-3[1)], *Part 3: Metallic materials; Tensile test: Calibration of force proving instruments used for the verification of uniaxial testing machines.*

EN 10002-4[1)], *Part 4: Metallic materials; Tensile test; Verification of extensometers used in uniaxial testing.*

3 Symbols and definitions

For the purpose of this European Standard the symbols and definitions of Table 1 shall, apply.

4 General inspection of the testing machine

The verification of the testing machine shall only be carried out if the machine is in good working order. For this purpose, a general inspection of the machine shall be carried out before verification of the force measuring system of the machine (see Annex A).

5 Verification of the force-measuring system of the testing machine

5.1 General

This verification shall be carried out for each of the force ranges used and with the most frequently employed force indicator. Accessory devices (slave pointer, recorder) which may affect the force-measuring system shall, where used, be verified in accordance with **5.4.6**.

If the testing machine has several force-measuring systems, each system shall be regarded as a separate testing machine. The same procedure shall be followed for double-piston hydraulic machines.

This verification shall be carried out using tension force-proving instruments. For small forces ($\leq$ 500 N) this verification should be carried out with known masses.In the latter case, the value of local acceleration due to gravity shall be recorded in the verification report.

The verification shall, in general, be carried out with a constant indicated force F_i. When this method is not applicable, the verification may be carried out with a constant true force F (see note).

NOTE When the machine allows, all the verifications shall be carried out with a slowly increasing force. The word "constant" signifies that the same value of F_i (or F) is used for the three series of measurements made (see **5.4.5**).

The instruments used for the verification shall have a certified traceability using the International System of Units (SI).

The force-proving instruments shall comply with the requirements specified in EN 10002-3. The class of the instrument shall be equal or better to the class in which the tensile testing machine has been verified. In the case of dead weights, the relative error of the force generated by these weights shall be less than or equal to ± 0.1 %.[2)]

The verification shall be carried out at ambient temperature between 10 °C and 35 °C.

[1)] In preparation.

[2)] The exact equation giving the force F, in newtons created by the dead weights of mass M, in kilograms, is

$$F = Mg_1\left(1 - \frac{d}{D}\right)$$

where

g_1 is the local acceleration due to gravity, in metres per second squared;

d is the density of air, in kilograms per cubic metre;

D is the density of the dead weights, in kilograms per cubic metre.

This force shall be calculated using the following approximate formula

$$F = Mg_1$$

The relative error of the force is calculated in this instance using the formula

$$\frac{\Delta F}{F} = \frac{\Delta M}{M} + \frac{\Delta g_1}{g_1}$$

Table 1 — Symbols and definitions

Symbol	Unit	Definition
F_N	N	Maximum capacity of the measuring range of the force indicator of the testing machine
F_i	N	Force reading on the force indicator of the testing machine to be verified, with increasing test force
F'_i	N	Force reading on the force indicator of the testing machine to be verified, with decreasing test force
F	N	True force indicated by the force-proving instrument or exerted by the masses, with increasing test force
F'	N	True force indicated by the force-proving instrument or exerted by the masses, with decreasing test force
F_c	N	True force indicated by the force-proving instrument or exerted by the masses, with increasing test force, for the complementary series of measurement for the smallest range which is used
F_{ic}	N	Force reading on the force indicator of the testing machine to be verified, with increasing test force, for the complementary series of measurements for the smallest range which is used
$\overline{F}_i$, $\overline{F}$	N	Arithmetic mean of several measurement of F_i and F for the same discrete force
$F_{i\,max}$, $F_{i\,min}$ F_{max}, F_{min}	N	Highest or lowest value of F_i or F for the same discrete force
F_{io}	N	Residual indication on the force indicator of the testing machine to be verified after removal of force
a	%	Relative resolution of the force indicator of the testing machine
b	%	Relative repeatability error of the force measuring system of the testing machine
f_o	%	Relative zero error of the force-measuring system of the testing machine
q	%	Relative accuracy error of the force-measuring system of the testing machine
u	%	Relative error in reversibility of the force-measuring system of the testing machine

5.2 Determination of the resolution

5.2.1 *Analogue scale*

The width of the graduation marks on the scale shall be uniform and the width of the pointer (or the width of the trace if a recorder is used) shall be approximately equal to the width of a graduation mark.

The resolution r of the indicator shall be obtained from the ratio between the width of the pointer or the trace and the centre-to-centre distance between two adjacent scale graduation marks (scale interval). The recommended ratios are 1/2, 1/5 or 1/10, a spacing of 2.5 mm or greater being required for the estimation of one-tenth of a scale division.

5.2.2 *Digital scale*

The resolution is considered to be one increment of the number on the numerical indicator, provided that the indication does not fluctuate by more than one increment when the instrument is unloaded.

5.2.3 *Variation of readings*

If the readings fluctuate by more than the value previously calculated for the resolution (with the instrument unloaded), this resolution r shall be deemed to be equal to half the range of fluctuation.

5.2.4 *Unit*

The resolution r shall be expressed in units of force.

5.3 Prior verification of the relative resolution of the force indicator

The relative resolution a of the force indicator in percent is defined by the relationship

$$a = \frac{r}{F} \times 100$$

where

r is the resolution defined in **5.2**;

F is the force at the point under consideration.

This relative resolution a shall be verified at all discrete forces of the scale above the first one-fifth of the range of the scale. The relative resolution shall not exceed the value given in Table 2 for the class of machine being verified

The verification may be carried out with a limit less than one fifth of the range of the measuring scale and a class may be allocated to the machine if it complies with the requirements given in Table 2.

5.4 Test procedure

5.4.1 *Alignment of the force-proving instrument*

The force-proving instrument shall be mounted so as to ensure axial application of the force.

5.4.2 *Temperature compensation*

A sufficient period of time shall be provided in order that the force-proving instrument reaches a stable temperature, which shall be recorded. If necessary, temperature corrections shall be applied to the readings (see EN 10002-3).

5.4.3 *Conditioning of the testing machine*

The machine, with the force-proving instrument in position, shall be loaded at least three times between zero and the maximum force to be measured.

5.4.4 *Test method*

The method to be used generally is the following: a given force F_i indicated by the force indicator of the machine is applied to the machine and the true force F indicated by the force proving instrument or exerted by the masses is noted.

If it is not possible to use this method, the true force F indicated by the force-proving instrument is applied to the machine and the force F_i indicated by the force indicator of the verified machine is noted.

5.4.5 *Application of test forces*

Three series of measurements shall be carried out with increasing force. Each series shall comprise at least 5 force steps at regular intervals from 20 % of the maximum range of the scale. If a verification is to be carried out on the section lower than 20 % it is necessary to carry out supplementary measurements at the force steps at 10 – 5 – 2 – 1 – 0,5 – 0,2 – 0,1 % of the scale up to and including the limit involved.

For testing machines with auto-ranging indicators, at least 2 force steps shall be verified for each incremental part of the range.

It is recommended that, where possible, the position of the force-proving instrument be modified before the third series of measurements by rotating it through an angle of 90° or 180°.

For each discrete force, the arithmetic mean of the values obtained for each series of measurements shall be calculated. From these mean values, the relative accuracy error and the relative repeatability error of the force-measuring system of the testing machine shall be calculated (see **5.5**).

The zero shall be adjusted and recorded before each series of measurements.In the case of an analogue indicator, it shall also be checked that the pointer balances freely around the zero and, if a digital indicator is used, that any drop below zero is immediately registered, for example by a sign indicator (+ or –). The zero reading shall be taken approximately 30 s after the force is completely removed. The relative zero error calculated in percent using the following equation shall be noted.

$$f_0 = \frac{F_{i0}}{F_N} \times 100$$

5.4.6 *Verification of accessories*

The good working order and resistance due to friction of the accessory devices (slave pointer, recorder) shall be verified by one of the following methods according to whether the machine is normally used with or without accessories.

a) *Machine normally used with accessories:* Three series of measurements shall be made with increasing force (see **5.4.5**) with the accessories connected for each force-measuring range which is used and one complementary series of measurements without accessories for the smallest range which is used.

b) *Machine normally used without accessories:* Three series of measurements shall be made with increasing force (see **5.4.5**) with the accessories disconnected for each force-measuring range which is used and one complementary series of measurements with the accessories connected for the smallest range which is used.

In both cases the relative accuracy error q shall be calculated for the three normal series of measurements, the relative repeatability error b shall be calculated from the four series. The values obtained for b and q shall conform to Table 2 for the Class under consideration, and the following further condition shall be satisfied:

1) verification with constant indicated force:

$$\left|\frac{F_i - F_c}{F_c}\right| \leq 1.5\,|q|\ ^{3)}$$

2) verification with constant true force:

$$\left|\frac{F_{ic} - F}{F}\right| \leq 1.5\,|q|\ ^{3)}$$

5.4.7 *Verification of the effect of differences in piston position*

For hydraulic machines, where the hydraulic pressure of the jack is used to ensure the test force, the influence of a difference in position of the piston shall be verified for the smallest measuring range of the machine used, during the three series of measurements (**5.4.5**). The position of the piston shall be different for each series of measurements.

NOTE In the case of a double-piston hydraulic machine it is necessary consider both pistons (see to **5.1**).

5.4.8 *Determination of relative reversibility error*

This shall only be carried out on request. The relative reversibility error shall be determined by carrying out a verification at the same discrete forces, first with increasing forces and then with decreasing forces. Therefore, the machine shall also be calibrated with a decreasing force.

The difference between the values obtained with increasing force and with decreasing force enables the relative reversibility error to be calculated in percent using the equation (see Figure 1).

$$u = \frac{F - F'}{\bar{F}} \times 100$$

or, for the particular case of the verification carried out with a constant true force

$$u = \frac{F'_i - F_i}{F} \times 100$$

This verification shall be carried out for the lowest and highest forces range of the testing machine.

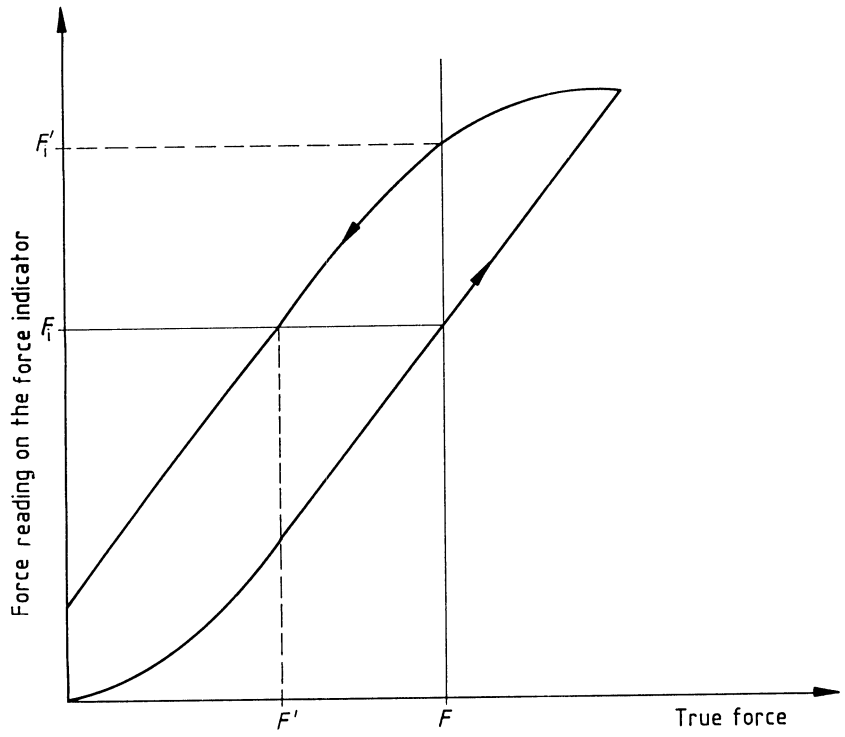

Figure 1 — Force reversibility curve

[3] The q is that of Table 2.

5.5 Assessment of the force indicator

5.5.1 *Relative accuracy error*

The relative accuracy error expressed as a percentage of the true force $\bar{F}$ is given by the equation

$$q = \frac{F_i - \bar{F}}{F} \times 100$$

For the particular case of the verification being carried out with a constant true force, the relative accuracy error is given by the equation

$$q = \frac{\bar{F}_i - F}{F} \times 100$$

5.5.2 *Relative repeatability error*

The relative repeatability error is, for each discrete force, the difference between the highest and lowest values measured with respect to the average.It is given in percent by the equation

$$b = \frac{F_{max} - F_{min}}{\bar{F}} \times 100$$

For the particular case of the verification being carried out with a constant true force, the relative repeatability error is given by the equation

$$b = \frac{F_{i\,max} - F_{i\,min}}{F} \times 100$$

6 Class of the testing machine

Table 2 gives the maximum permissible values for the different relative errors of the force-measuring system and for the relative resolution of the force indicator which characterizes a testing machine in accordance with the appropriate class.

A measuring range on the force indicator shall only be considered to conform if the inspection is satisfactory for the range of measurement at least between the first. one-fifth and the nominal range.

7 Verification report

The verification report shall contain at least the following information:

General information:

a) reference to this standard, i.e. EN 10002-2;

b) identification of the testing machine (type, make, year of manufacture, serial number);

c) location of the machine;

d) type and reference number of the force-proving instrument used and calibration certificate reference number and expiry date of this certificate;

e) date of verification;

f) name or mark of the verifying authority;

Results of verification:

g) any anomaly found during the general inspection;

h) for each force-measuring system used, the class of each range verified and, if requested, the discrete values of relative errors of accuracy, repeatability, zero and resolution;

i) the lower limit of each range to which the assessment applies;

j) test temperature.

8 Intervals between verifications

The time between two verifications will depend on the type of testing machine, the standard of maintenance, the amount of usage and the type of material tested. Unless specified otherwise verification shall be carried out at intervals not exceeding 12 months.

A verification shall be carried out when a machine is moved or when it has been submitted to major repairs or adjustments.

Table 2 — Characteristics of the force measuring system

Class of machine	Maximum permissible value %				
	Relative error of				Machine resolution a
	accuracy q	repeatability b	reversibility[a] $\lvert\mu\rvert$	zero f_o	
0,5	± 0.5	0.5	0.75	± 0.05	0.25
1	± 1.0	1.0	1.5	± 0.1	0.5
2	± 2.0	2.0	3.0	± 0.2	1.0
3	± 3.0	3.0	4.5	± 0.3	1.5

[a] The verification of reversibility shall only be carried out on request (see **5.4.8**).

Annex A

(This annex forms an integral part of the Standard.)

General inspection of the testing machine

The general inspection of the testing machine which shall be carried out before the verification of the machine (see clause **4**) shall comprise the following:

A.1 Visual examination

The visual examination shall verify

a) that the machine is in good working order and not adversely affected by certain aspects of its general condition, such as:

1) pronounced wear or defects in the guiding elements of the moving crossheads or grips,

2) looseness in mounting of columns and fixed crossheads;

b) that the machine is not affected by environmental conditions (vibration, effect of corrosion, local temperature variations, etc.);

c) if detachable mass pendulum devices are used, that the masses are correctly identifiable.

A.2 Inspection of the structure of the machine

A check shall be made to ensure that the structure and gripping systems will permit the force to be applied axially.

A.3 Inspection of the crosshead drive mechanism

It shall be verified that the crosshead drive mechanism will permit a uniform and smooth variation of force and will enable various discrete forces to be obtained with sufficient accuracy.

The drive mechanism shall, moreover, enable the deformation speeds of the test piece, specified for the determination of the various mechanical properties, to be complied with.

National appendix NA (informative)

The United Kingdom participation in the preparation of this European Standard was entrusted by the Iron and Steel and the Non-ferrous Metals Standard Policy Committees (ISM/- and NFM/-) to Technical Committee ISM/NFM/4 at which the following bodies were represented:

Aluminium Federation
British Gas plc
British Non-Ferrous Metals Federation
British Railways Board
British Steel Industry
Copper Development Association
Department of Trade and Industry (National Physical Laboratory)
Department of Trade and Industry (National Measurement Accreditation Service)
ERA Technology Ltd.
GAMBICA (BEAMA Ltd.)
Ministry of Defence
Society of British Aerospace Companies Limited
University College London
Welding Institute

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Consulting Scientists
Department of Trade and Industry (National Engineering Laboratory)
Institute of Sheet Metal Engineering
Lloyd's Register of Shipping
Process Plant Association

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