International Standard 7500/1

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Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines

Matériaux métalliques — Vérification des machines pour essais statiques uniaxiaux — Partie 1: Machines d'essai de traction

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7500/1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*.

It cancels and replaces ISO Recommendation R 147-1960, of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines

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1 Scope and field of application

This part of ISO 7500 specifies the verification of testing machines used for tensile testing in accordance with ISO 6892.

The verification consists of:

- a general inspection of the testing machine;
- a verification of the force-measuring system of the testing machine.

2 References

ISO 376, *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines.*

ISO 6892, *Metallic materials — Tensile testing.*

3 Symbols and definitions

For the purposes of this part of ISO 7500, 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 the annex).

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. Mechanical accessory devices (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, or, for small forces ($\leqslant$ 500 N), known masses. In the latter case, the value of local acceleration due to gravity shall be recorded in the verification report (see note 1).

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 2).

NOTES

1 When the verification cannot be carried out using tension force-proving instruments, it may be made with compression force-proving instruments and this shall be stated in the verification report.

2 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 (see 5.4.5).

Table 1

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 with increasing test force
F'	N	True force indicated by the force-proving instrument with decreasing test force
F_c	N	True force indicated by the force-proving instrument with increasing test force, for the complementary series of measurements 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 measurements 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_{i0}	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_0	%	Relative zero error
q	%	Relative accuracy error of the force-measuring system of the testing machine
u	%	Relative error in reversibility

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The force-proving instruments shall comply with the requirements specified in ISO 376. 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 %.[1)]

5.2 Determination of the resolution

5.2.1 Analogue scale

The thickness of the graduation marks on the scale shall be uniform and the width of the pointer shall be approximately equal to the width of a graduation mark.

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

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

where

g_l 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:

$$F = M g_l$$

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

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

The resolution r of the indicator shall be obtained from the ratio between the width of the pointer 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 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.

The 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 will be recorded. If necessary, temperature corrections shall be applied to the readings (see ISO 376).

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 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 contain measurements of at least five discrete forces suitably distributed between the lower and upper limits of the measuring range, the first force being at the lower limit and the last force being as near as possible to the upper limit. 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 before each series of measurements. In 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 relative zero error calculated 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 mechanical accessory devices (pointer, recorder) shall be verified by one of the following methods according to whether the machine is normally used with or without accessories:

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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:

— verification with constant indicated force:

$$\left| \frac{F_i - F_c}{F_c} \right| \leqslant 1{,}5 |q|$$ [1)]

— verification with constant true force:

$$\left| \frac{F_{ic} - F}{F} \right| \leqslant 1{,}5 |q|$$ [1)]

5.4.7 Verification of the effect of differences in piston positions

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 (5.1), it is necessary to consider both pistons.

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.

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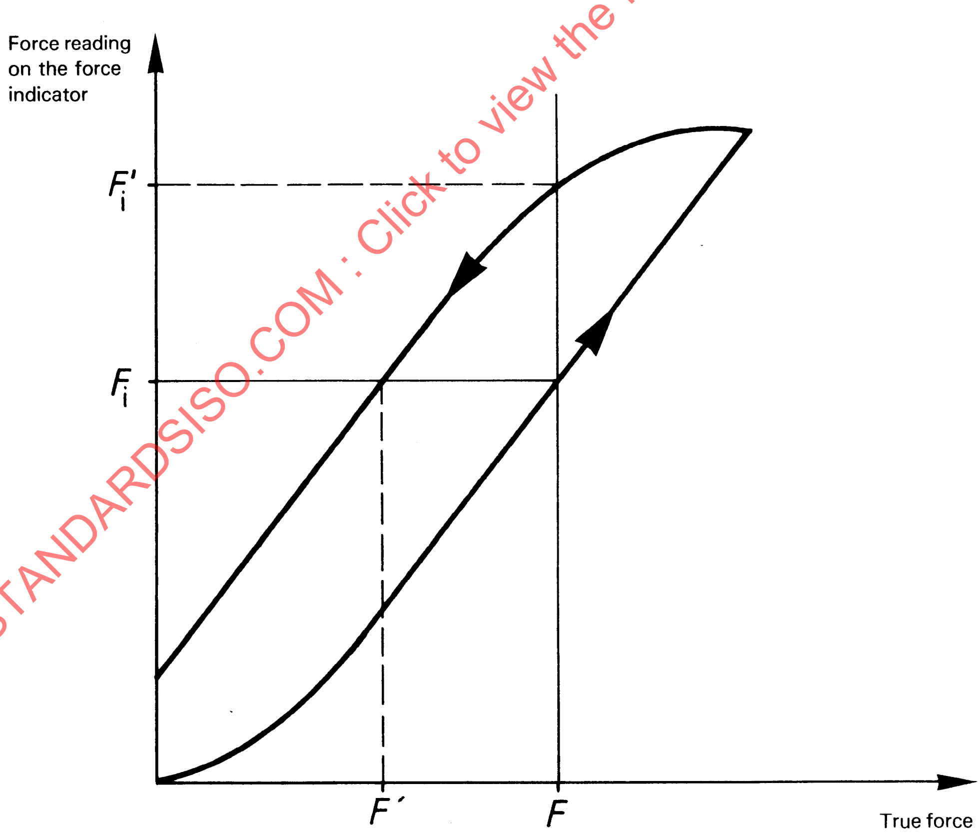

Figure

1) The q is that of table 2.

The difference between the values obtained with increasing force and with decreasing force enables the relative reversibility error to be calculated using the equation (see the figure)

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

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.

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

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

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 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 characterises 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.

Table 2

Class of machine	Maximum permissible value, %				
	Relative error of				Relative resolution
	accuracy q	repeatability b	reversibility[1] $\|u\|$	zero f_0	a
0	± 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

1) The verification of reversibility shall only be carried out on request (see 5.4.8).

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7 Verification report

The verification report shall contain at least the following information:

General information:

a) reference to this part of ISO 7500;

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, reversibility and zero;

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

8 Intervals between verifications

The time between two verifications will depend on the type of testing machine, the standard of maintenance and the amount of usage. Under normal circumstances, it is recommended that verification shall be carried out at intervals not exceeding 12 months.

The machine shall in any case be verified if it is moved to a new location necessitating dismantling or if it is subject to major repairs or adjustments.

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Annex

General inspection of the testing machine

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

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:

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

— 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 indentifiable.

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.

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