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Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines

Matériaux métalliques — Étalonnage des instruments de mesure de force utilisés pour la vérification des machines d'essais uniaxiaux

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 376 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing*.

This fourth edition cancels and replaces the third edition (ISO 376:2004), which has been technically revised (for details, see the introduction).

Introduction

An ISO/TC 164/SC 1 working group has developed procedures for determining the measurement uncertainty of force-proving instruments, and these procedures have been added to this fourth edition as a new annex (Annex C).

In addition, this fourth edition allows the calibration to be performed in two ways:

- with reversible measurement for force-proving instruments which are going to be used with increasing and decreasing forces;
- without reversible measurement for force-proving instruments which are going to be used only with increasing forces.

In the first case, i.e. when the force-proving instrument is going to be used for reversible measurements, the calibration has to be performed with increasing and decreasing forces to determine the hysteresis of the force-proving instrument. In this case, there is no need to perform a creep test.

In the second case, i.e. when the force-proving instrument is not going to be used for reversible measurements, the calibration is performed with increasing forces only but, in addition, a creep test has to be performed. In this case, there is no need to determine the hysteresis.

Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines

1 Scope

This International Standard specifies a method for the calibration of force-proving instruments used for the static verification of uniaxial testing machines (e.g. tension/compression testing machines) and describes a procedure for the classification of these instruments.

This International Standard is applicable to force-proving instruments in which the force is determined by measuring the elastic deformation of a loaded member or a quantity which is proportional to it.

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.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

3.1
force-proving instrument
whole assembly from the force transducer through to, and including, the indicator

4 Symbols and their designations

Symbols and their designations are given in Table 1.

Table 1 — Symbols and their designations

Symbol	Unit	Designation
b	%	Relative reproducibility error with rotation
b'	%	Relative repeatability error without rotation
c	%	Relative creep error
F_f	N	Maximum capacity of the transducer
F_N	N	Maximum calibration force
f_c	%	Relative interpolation error
f_0	%	Relative zero error
i_f	—	Reading[a] on the indicator after removal of force
i_o	—	Reading[a] on the indicator before application of force
i_{30}	—	Reading[a] on the indicator 30 s after application or removal of the maximum calibration force
i_{300}	—	Reading[a] on the indicator 300 s after application or removal of the maximum calibration force
r	N	Resolution of the indicator
v	%	Relative reversibility error of the force-proving instrument
X	—	Deflection with increasing test force
X_a	—	Computed value of deflection
X'	—	Deflection with decreasing test force
X_{max}	—	Maximum deflection from runs 1, 3 and 5
X_{min}	—	Minimum deflection from runs 1, 3 and 5
X_N	—	Deflection corresponding to the maximum calibration force
$\bar{X}_r$	—	Average value of the deflections with rotation
$\bar{X}_{wr}$	—	Average value of the deflections without rotation

[a] Reading value corresponding to the deflection.

5 Principle

Calibration consists of applying precisely known forces to the force transducer and recording the data from the indicator, which is considered an integral part of the force-proving instrument.

When an electrical measurement is made, the indicator may be replaced by another indicator and the force-proving instrument need not be recalibrated provided the following conditions are fulfilled.

a) The original and replacement indicators have calibration certificates, traceable to national standards, which give the results of calibration in terms of electrical base units (volt, ampere). The replacement indicator shall be calibrated over a range equal to or greater than the range for which it is used with the force-proving instrument, and the resolution of the replacement indicator shall be at least equal to the resolution of the original indicator when it is used with the force-proving instrument.

b) The units and excitation source of the replacement indicator should be respectively of the same quantity (e.g. 5 V, 10 V) and type (e.g. AC or DC carrier frequency).

c) The uncertainty of each indicator (both the original and the replacement indicators) shall not significantly influence the uncertainty of the whole force-proving instrument assembly. It is recommended that the uncertainty of the replacement indicator be no greater than 1/3 of the uncertainty of the entire system (see C.2.11).

6 Characteristics of force-proving instruments

6.1 Identification of the force-proving instrument

All the elements of the force-proving instrument (including the cables for electrical connection) shall be individually and uniquely identified, e.g. by the name of the manufacturer, the model and the serial number. For the force transducer, the maximum working force shall be indicated.

6.2 Application of force

The force transducer and its loading fittings shall be designed so as to ensure axial application of force, whether in tension or compression.

Examples of loading fittings are given in Annex A.

6.3 Measurement of deflection

Measurement of the deflection of the loaded member of the force transducer may be carried out by mechanical, electrical, optical or other means with adequate accuracy and stability.

The type and the quality of the deflection measuring system determine whether the force-proving instrument is classified only for specific calibration forces or for interpolation (see Clause 7).

Generally, the use of force-proving instruments with dial gauges as a means of measuring the deflection is limited to the forces for which the instruments have been calibrated. The dial gauge, if used over a long travel, may contain large localized periodic errors which produce an uncertainty too great to permit interpolation between calibration forces. The dial gauge may be used for interpolation if its periodic error has a negligible influence on the interpolation error of the force-proving instrument.

7 Calibration of the force-proving instrument

7.1 General

7.1.1 Preliminary measures

Before undertaking the calibration of the force-proving instrument, ensure that this instrument is able to be calibrated. This can be done by means of preliminary tests such as those defined below and given as examples.

7.1.2 Overloading test

This optional test is described in Clause B.1.

7.1.3 Verification relating to application of forces

Ensure

— that the attachment system of the force-proving instrument allows axial application of the force when the instrument is used for tensile testing;

— that there is no interaction between the force transducer and its support on the calibration machine when the instrument is used for compression testing.

Clause B.2 gives an example of a method that can be used.

NOTE Other tests can be used, e.g. a test using a flat-based transducer with a spherical button or upper bearing surface.

7.1.4 Variable voltage test

This test is left to the discretion of the calibration service. For force-proving instruments requiring an electrical supply, verify that a variation of ±10 % of the line voltage has no significant effect. This verification can be carried out by means of a force transducer simulator or by another appropriate method.

7.2 Resolution of the indicator

7.2.1 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.

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 being 1:2, 1:5 or 1:10, a spacing of 1,25 mm or greater being required for the estimation of a tenth of the division on the scale.

A vernier scale of dimensions appropriate to the analogue scale may be used to allow direct fractional reading of the instrument scale division.

7.2.2 Digital scale

The resolution is considered to be one increment of the last active number on the numerical indicator.

7.2.3 Variation of readings

If the readings fluctuate by more than the value previously calculated for the resolution (with no force applied to the instrument), the resolution shall be deemed to be equal to half the range of fluctuation.

7.2.4 Units

The resolution, r, shall be converted to units of force.

7.3 Minimum force

Taking into consideration the accuracy with which the deflection of the instrument can be read during calibration or during its subsequent use for verifying machines, the minimum force applied to a force-proving instrument shall comply with the two following conditions:

a) the minimum force shall be greater than or equal to:

— $4\,000 \times r$ for class 00;

— $2\,000 \times r$ for class 0,5;

— $1\,000 \times r$ for class 1;

— $500 \times r$ for class 2.

b) the minimum force shall be greater than or equal to 0,02 F_f.

7.4 Calibration procedure

7.4.1 Preloading

Before the calibration forces are applied, in a given mode (tension or compression), the maximum force shall be applied to the instrument three times. The duration of the application of each preload shall be between 60 s and 90 s.

7.4.2 Procedure

Carry out the calibration by applying two series of calibration forces to the force-proving instrument with increasing values only, without disturbing the device.

Then apply at least two further series of increasing and, if the force-proving instrument is to be calibrated in an incremental/decremental loading direction, decreasing values. Between each of the further series of forces, rotate the force-proving instrument symmetrically on its axis to positions uniformly distributed over 360° (i.e. 0°, 120°, 240°). If this is not possible, it is permissible to adopt the following positions: 0°, 180° and 360° (see Figure 1).

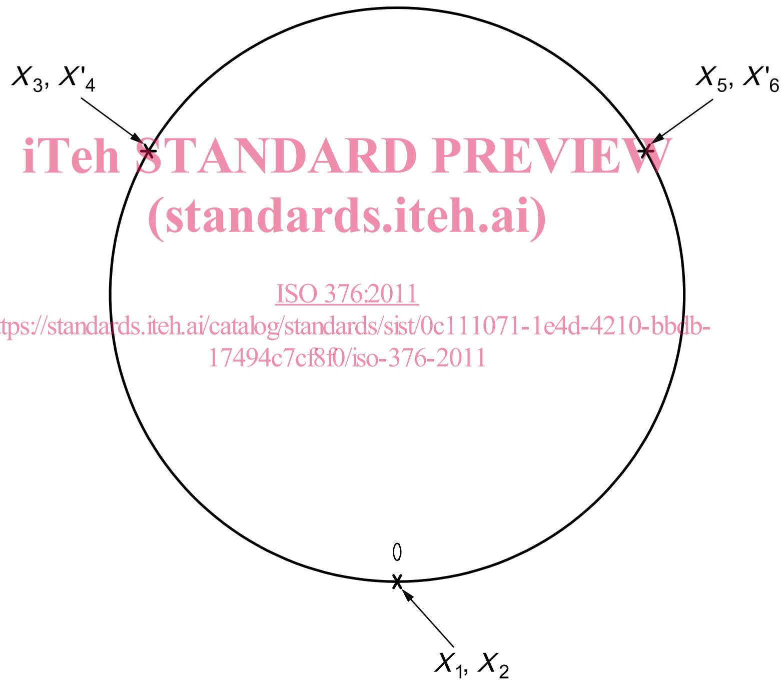

Figure 1 — Positions of the force-proving instrument

For the determination of the interpolation curve, the number of forces shall be not less than eight, and these forces shall be distributed as uniformly as possible over the calibration range. The interpolation curve shall be determined from the average values of the deflections with rotation, $\bar{X}_r$, as defined in 7.5.1.

If a periodic error is suspected, it is recommended that intervals between the forces which correspond to the periodicity of this error be avoided.

This procedure determines only a combined value of hysteresis of the device and of the calibration machine. Accurate determination of the hysteresis of the device may be performed on dead-weight machines. For other types of calibration machine, their hysteresis should be considered.

The force-proving instrument shall be preloaded three times to the maximum force in the direction in which the subsequent forces are to be applied. When the direction of loading is changed, the maximum force shall be applied three times in the new direction.

The readings corresponding to no force shall be noted after waiting at least 30 s after the force has been totally removed.

There should be a wait of at least 3 min between subsequent measurement series.

Instruments with detachable parts shall be dismantled, as for packaging and transport, at least once during calibration. In general, this dismantling shall be carried out between the second and third series of calibration forces. The maximum force shall be applied to the force-proving instrument at least three times before the next series of forces is applied.

Before starting the calibration of an electrical force-proving instrument, the zero signal may be noted (see Clause B.3).

7.4.3 Loading conditions

The time interval between two successive loadings shall be as uniform as possible, and no reading shall be taken within 30 s of the start of the force change. The calibration shall be performed at a temperature stable to within ±1 °C. This temperature shall be within the range 18 °C to 28 °C and shall be recorded. Sufficient time shall be allowed for the force-proving instrument to attain a stable temperature.

When it is known that the force-proving instrument is not temperature-compensated, care should be taken to ensure that temperature variations do not affect the calibration.

Strain gauge transducers shall be energized for at least 30 min before calibration.

7.4.4 Creep test

If the force-proving instrument is to be calibrated in an incremental-only loading direction, record its output at 30 s and 300 s after application or removal of the maximum calibration force, in each mode of force application, to enable its creep characteristics to be determined. If creep is measured at zero force, the maximum calibration force shall be maintained for at least 60 s prior to its removal. The creep test may be performed at any time after preloading during the calibration procedure.

The calibration certificate shall include the following information:

— the method of creep measurement (creep at maximum force or after force removal);

— when the creep measurement was performed (after preloading, after the last measurement series, etc.);

— the length of time for which the force was applied prior to removal (for creep determined at zero force).

7.4.5 Determination of deflection

A deflection is defined as the difference between a reading under force and a reading without force. This definition of deflection applies to output readings in electrical units as well as to output readings in length units.

