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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

Reference number
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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 3.

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.

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

This second edition cancels and replaces the first edition (ISO 376:1987) which has been technically revised.

Annexes A and B of this International Standard are for information only.

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

1 Scope

This International Standard covers 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 classifying these instruments. A force-proving instrument is defined as being the whole assembly from the force transducer through to and including the indicator. This International Standard generally applies 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 reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system.*

3 Principle

Calibration consists of applying precisely-known forces to the loaded member and recording the data from the deflection measuring system, 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 indicator shall be at least equal to the resolution of the 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 influence the uncertainty of the whole assembly of the force-proving instrument. It is recommended that the uncertainty of the replacement indicator should be no greater than 1/3 of the uncertainty of the entire system.

4 Characteristics of force-proving instruments

4.1 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.

4.2 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.

4.3 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 localised 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.

5 Symbols, units and designations

For the purpose of this International Standard, the symbols, units and designations given in Table 1 shall apply.

Table 1 — Symbols, units and designations

Symbol	Unit	Designation
F_N	N	Maximum capacity of the measuring range
F_f	N	Maximum capacity of the transducer
i_o	–	Reading[a] on the indicator before application of force
i_f	–	Reading[a] on the indicator after removal of force
X	–	Deflection with increasing test force
X'	–	Deflection with decreasing test force
$\overline{X}_r$	–	Average value of the deflections with rotation
$\overline{X}_{wr}$	–	Average value of deflections without rotation
X_{max}	–	Maximum deflection
X_{min}	–	Minimum deflection
X_a	–	Computed value of deflection
X_N	–	Deflection corresponding to the maximum capacity
b	%	Relative reproducibility error with rotation
b'	%	Relative repeatability without rotation
f_o	%	Relative zero error
f_c	%	Relative interpolation error
r	–	Resolution of the indicator
v	%	Relative reversibility error of the force-proving instrument

a Reading value corresponding to the deflection.

6 Calibration of the force-proving instrument

6.1 General

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.

6.1.1 Overloading test

This optional test is described in clause B.1.

6.1.2 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 which can be used.

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

6.1.3 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.

6.2 Resolution of the indicator

6.2.1 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.

6.2.2 Digital scale

The resolution is considered to be one increment of the last active number on the numerical indicator, provided that the indication does not fluctuate by more than one increment with no force applied to the instrument.

6.2.3 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.

6.2.4 Units

The resolution (r) shall be converted to units of force.

6.3 Minimum force

Taking into consideration the accuracy with which the deflection of the instrument may 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.

6.4 Calibration procedure

6.4.1 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 1 min and 1,5 min.

6.4.2 Procedure

The calibration shall be carried out 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 decreasing values. Between each of the further series of forces, the force-proving instrument shall be rotated 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).

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.

NOTE 1 If a periodic error is suspected, it is recommended that intervals between the forces which correspond to the periodicity of this error should be avoided.

NOTE 2 This procedure determines only the maximum hysteresis of the device. Accurate determination of the hysteresis can only be performed on dead-weight machines.

The force-proving instrument shall be pre-loaded 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.

NOTE 3 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).

6.4.3 Loading conditions

The time interval between two successive loadings shall be as uniform as possible, and no reading shall be taken at least 30 s after the start of the force change. The calibration shall be performed at a temperature stable to ± 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.

NOTE 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.

6.4.4 Determination of deflection

A deflection is defined as the difference between a reading under force and a reading without force.

NOTE This definition of deflection applies to output readings in electrical units as well as to output readings in length units.

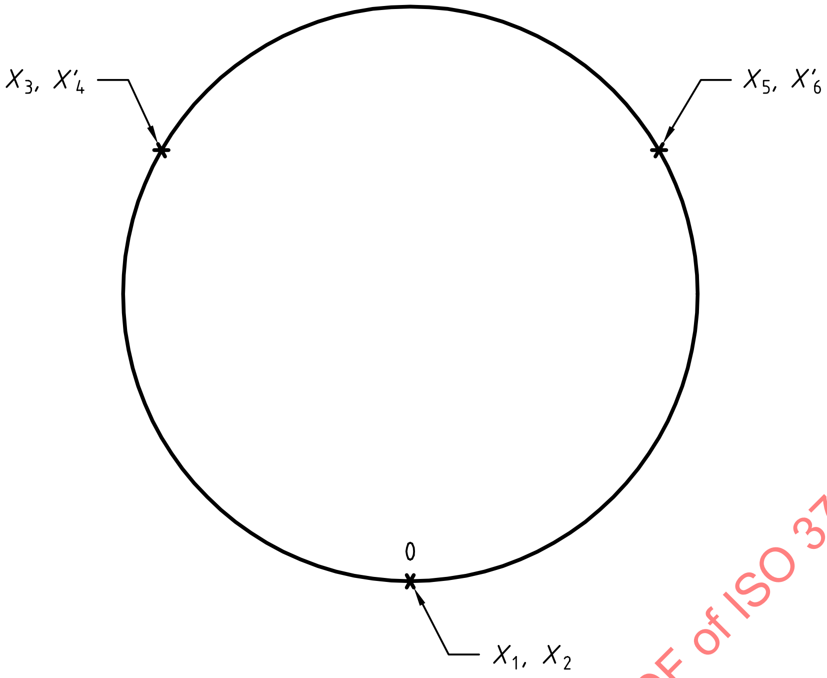


Figure 1 — Positions of the force-proving instrument

6.5 Assessment of the force-proving instrument

6.5.1 Relative reproducibility and repeatability errors, b and b'

These errors are calculated for each calibration force and in the two cases: with rotation of the proving instrument (b) and without rotation (b'), using the following equations:

$$b = \left| \frac{X_{\max} - X_{\min}}{\bar{X}_{r}} \right| \times 100$$

where

$$\bar{X}_{r} = \frac{X_1 + X_3 + X_5}{3}$$

$$b' = \left| \frac{X_2 - X_1}{\bar{X}_{wr}} \right| \times 100$$

where

$$\bar{X}_{wr} = \frac{X_1 + X_2}{2}$$

6.5.2 Relative interpolation error, f_c

This error is determined using a first-, second-, or third-degree equation giving the deflection as a function of the calibration force.

NOTE For other methods of determining this error, see the Bibliography.

The equation used shall be indicated in the calibration report. The relative interpolation error shall be calculated from the equation:

$$f_c = \frac{\overline{X}_r - X_a}{X_a} \times 100$$

6.5.3 Relative zero error, f_o

The zero shall be adjusted before and recorded after each series of tests. The zero reading shall be taken approximately 30 s after the force has been completely removed.

The relative zero error is calculated from the equation:

$$f_o = \frac{i_f - i_o}{X_N} \times 100$$

6.5.4 Relative reversibility error, v

The relative reversibility error is determined at each calibration, by carrying out a verification with increasing forces and then with decreasing forces.

NOTE If determination of the relative reversibility error is not practical, a note in the calibration certificate should state that the device has been calibrated with increasing forces only.

The difference between the values obtained for both series with increasing force and with decreasing force enables the relative reversibility error to be calculated using the following equations:

$$v_1 = \left| \frac{X_4' - X_3}{X_3} \right|$$

$$v_2 = \left| \frac{X_6' - X_5}{X_5} \right|$$

v is calculated as the mean value of v_1 and v_2:

$$v = \frac{v_1 + v_2}{2}$$

7 Classification of the force-proving instrument

7.1 Principle of classification

The range for which the force-proving instrument is classified is determined by considering each calibration force, one after the other, starting with the maximum force and decreasing to the lowest calibration force. The classification range ceases at the last force for which the classification requirements are satisfied.

The force-proving instrument can be classified either for specific forces or for interpolation.

7.2 Classification criteria

The range of classification of a force-proving instrument shall at least cover the range 50 % to 100 % of F_N.

7.2.1 For instruments classified only for specific forces, the criteria which shall be considered are:

— the relative reproducibility and repeatability errors;

— the relative zero error;

— the relative reversibility error.

7.2.2 For instruments classified for interpolation, the following criteria shall be considered:

— the relative reproducibility and repeatability errors;

— the relative interpolation error;

— the relative zero error;

— the relative reversibility error.

Table 2 gives the values of these different parameters in accordance with the class of the force-proving instrument and the uncertainty of the calibration forces.

Table 2 — Characteristics of force-proving instruments

Class	**Relative error of the force-proving instrument** %					**Uncertainty [a] of applied calibration force**
	of reproducibility b	of repeatability b'	of interpolation f_c	of zero f_0	of reversibility ν	%
00	0,05	0,025	± 0,025	± 0,012	0,07	± 0,01
0,5	0,10	0,05	± 0,05	± 0,025	0,15	± 0,02
1	0,20	0,10	± 0,10	± 0,050	0,30	± 0,05
2	0,40	0,20	± 0,20	± 0,10	0,50	± 0,10

[a] The uncertainty of the calibration force is obtained by combining the random and systematic errors of the force calibration machine (see Bibliography).

7.3 Calibration certificate and duration of validity

7.3.1 If a force-proving instrument has satisfied the requirements of this International Standard at the time of calibration, the calibration authority shall draw up a certificate stating at least the following information:

a) identity of all elements of the force-proving instrument and loading fittings and of the calibration machine;

b) the mode of force application (tension/compression);

c) that the instrument is in accordance with the requirements of preliminary tests;

d) the class and the range (or forces) of validity;

e) the date and results of the calibration and, when required, the calibration curve;

f) the temperature at which the calibration was performed.

7.3.2 For the purposes of this International Standard, the maximum period of validity of the certificate shall not exceed 26 months.

A force-proving instrument shall be recalibrated when it sustains an overload higher than the test overload (see clause B.1) or after repair.

8 Use of calibrated force-proving instruments

Force-proving instruments shall be loaded in accordance with the conditions under which they were calibrated. Precautions shall be taken to prevent the instrument from being subjected to forces greater than the maximum calibration force.

Instruments classified only for specific forces shall be used only for these forces.

Instruments classified for interpolation may be used for any force in the interpolation range.

If a force-proving instrument is used at a temperature other than the calibration temperature, the deflection of the instrument shall be, if necessary, corrected for any temperature variation (see clause B.3).

NOTE A change of zero of the unloaded force transducer indicates plastic deformation due to overloading of the force transducer. Permanent long-time drifting indicates the moisture influence of the strain gauges base or a bonding defect of the strain gauges.

Annex A
(informative)

Example of dimensions of force transducers and corresponding loading fittings

NOTE In order to calibrate force transducers in force standard machines and to enable easy axial installation in materials testing machines to be verified, the following design specifications and dimensions may be considered.

A.1 Tensile force transducers

To aid assembly, it is recommended that the clamping heads on the face be machined down to the core diameter over a length of about two threads.

The centring bores used in the manufacture of the force transducer should be retained.

Table A.1 — Dimensions of tensile force transducers for nominal forces of not less than 10 kN

Maximum (nominal) force of force-proving instrument [a]	Maximum overall length [b] mm	Size of external thread of heads [c] mm	Minimum length of thread mm	Maximum width or diameter mm
10 kN to 20 kN	500	M20 × 1,5 [d]	16	110
40 kN and 60 kN	500	M20 × 1,5 [d]	16	125
100 kN	500	M24 × 2	20	150
200 kN	500	M30 × 2	25	–
400 kN	600	M42 × 3	40	–
600 kN	650	M56 × 4	40	–
1 MN	750	M64 × 4	60	–
2 MN	950	M90 × 4	80	–
4 MN	1300	M125 × 4	120	–
6 MN	1 500	M160 × 6	150	–
10 MN	1 700	M200 × 6	180	–
15 MN	2 000	M250 × 6	225	–
25 MN	2 500	M330 × 6	320	–

a Dimensions of tensile force transducers for nominal forces of less than 10 kN are not standardized.

b Length of tensile force transducer including any necessary thread adapters.

c Of the tensile force transducer or of the thread adapters.

d Pitch of 2 mm also permissible.

A.2 Compressive force transducers

To allow for the restricted mounting height in materials testing machines, compressive force transducers should not exceed the overall heights given in Table A.2.

The overall height comprises the height of the associated loading fittings.

Table A.2 — Overall height of compressive force transducers

Maximum (nominal) force of force-proving instrument	Maximum overall height[a] of devices for the verification of materials testing machines mm	
	class 1[b]	classes 2[b] and 3[b]
⩽ 40 kN	145	115
60 kN	170	145
100 kN	220	145
200 kN	220	190
400 kN	290	205
600 kN	310	205
1 MN	310	205
2 MN	310	205
3 MN	330	205
4 MN	410	205
5 MN	450	350
6 MN	450	400
10 MN	550	400
15 MN	670	–

a The use of transducers having a greater overall height is permissible if the actual mounting clearances of the materials testing machines make this possible.

b In accordance with ISO 7500-1.

A.3 Loading fittings

Loading fittings should be designed in such a way that the line of force application is not distorted. As a rule, tensile force transducers should be fitted with two ball nuts, two ball cups and, if necessary, with two intermediate rings, while compressive force transducers should be fitted with one or two compression pads.

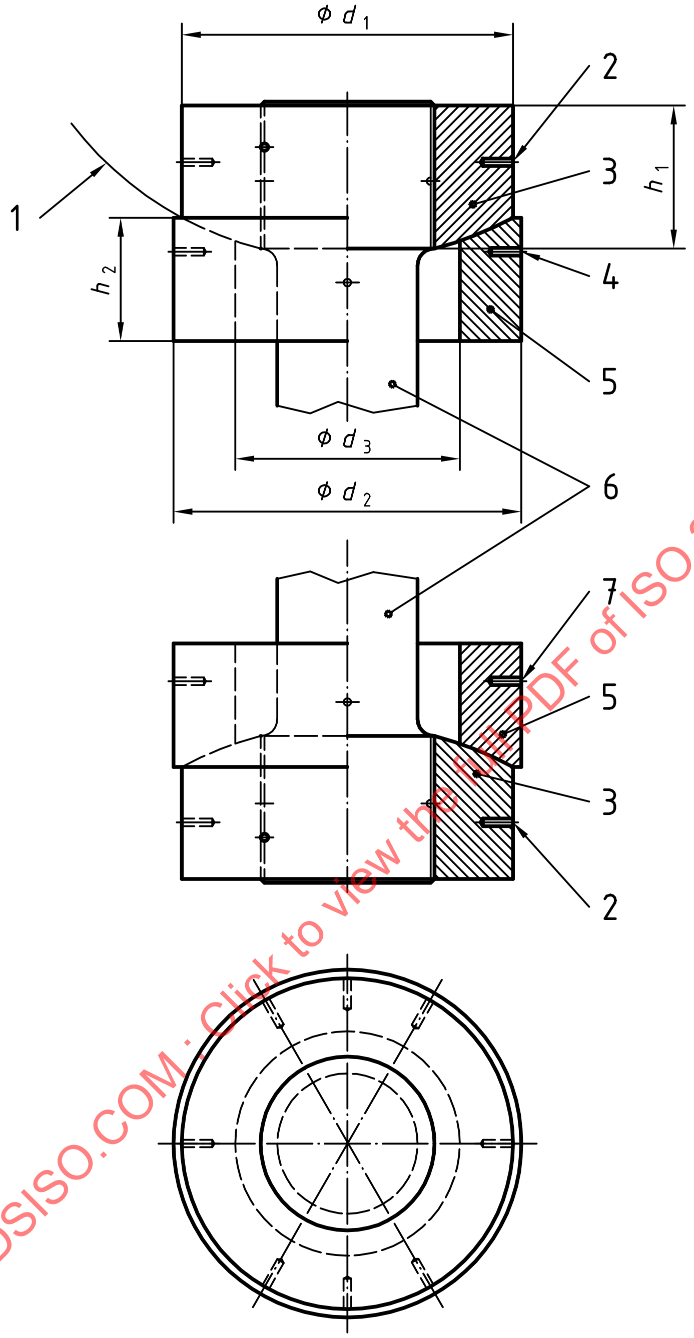
The dimensions recommended in A.3.1 to A.3.4 require the use of material with a yield strength of at least 350 N/mm^2.

A.3.1 Ball nuts and ball cups

Figure A.1 shows the shape of ball nuts and ball cups required for tensile force transducers. Their dimensions should be in accordance with Table A.3.

Large ball cups and ball nuts for maximum (nominal) forces of 4 MN and greater should be provided with blind holes distributed around the periphery as an aid to transportation and assembly. In the case of ball cups, two pairs of opposite bores are sufficient, one of which should be made in the centre plane and the other in the upper third of the top ball cup and in the lower third of the bottom ball cup (see Figure A.1).

In ball nuts, two opposite blind holes offset by 60° should be made in an upper plane, a mid plane and a lower plane.



Key

1 Sphere
2 6 bores
3 Ball nut
4 4 bores
5 Ball cup
6 Tensile force measuring rod
7 4 bores

Figure A.1 — Ball nut, ball cup and tensile force measuring rod

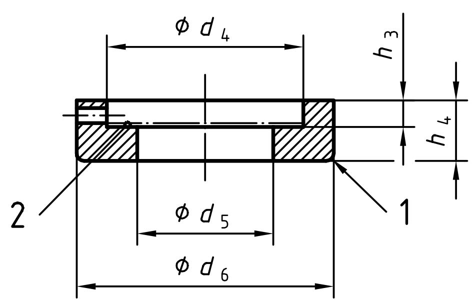
Table A.3 — Dimensions of ball nuts and ball cups for tensile force transducers with a maximum force of not less than 10 kN

Maximum (nominal) force of force-proving instrument	d_1 mm	d_2 (c11) mm	d_3 mm	h_1 mm	h_2 mm	r mm
From 10 kN to 40 kN	32	$35^{-0,120}_{-0,280}$	22	16	12	30
60 kN	43	$45^{-0,130}_{-0,290}$	27	18	15	30
100 kN	47	$50^{-0,130}_{-0,290}$	32	20	15	50
200 kN	60	$64^{-0,140}_{-0,330}$	44	25	15	50
400 kN and 600 kN	86	$90^{-0,170}_{-0,390}$	60	40	18	80
1 MN	115	$120^{-0,180}_{-0,400}$	74	60	25	100
2 MN	160	$165^{-0,230}_{-0,480}$	100	90	30	150
4 MN	225	$235^{-0,280}_{-0,570}$	150	120	40	250
6 MN	260	$270^{-0,300}_{-0,620}$	170	150	45	250
10 MN	335	$345^{-0,360}_{-0,720}$	220	180	55	300
15 MN	410	$420^{-0,440}_{-0,840}$	265	225	65	350
25 MN	550	$580^{-0,5}_{-1,5}$	345	310	85	500

A.3.2 Intermediate rings

Wherever necessary, type A or type B intermediate rings as shown in Figures A.2 and A.3 respectively and specified in Table A.4, should be used for the verification of multi range materials testing machines.

Intermediate rings should have a suitable holding fixture (e.g. threaded pins) for securing other mounting parts.

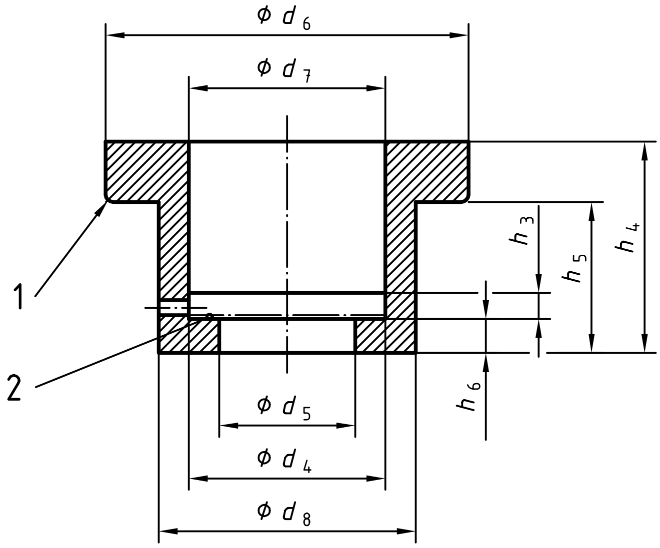


Key

1 Chamfer

2 Undercut

Figure A.2 — Type A intermediate ring



Key

1 Chamfer
2 Undercut

Figure A.3 — Type B intermediate ring

A.3.3 Adapters (extensions, reducer pieces, etc.)

If, owing to the design of the materials testing machine, adapters are required for mounting the force transducer, they should be designed so as to ensure the central loading of the force transducer.

A.3.4 Loading pads

Loading pads are to be used as the force introduction components of compressive force transducers. If a loading pad has two flat surfaces for force transmission, they should be ground plane parallel.

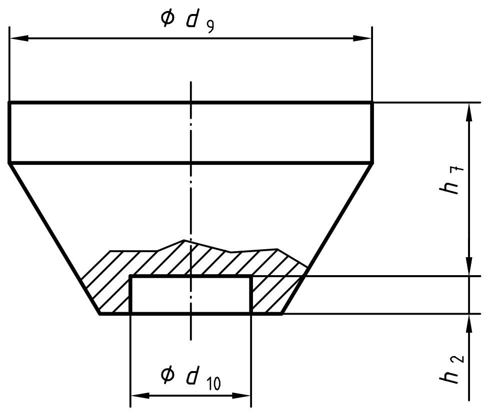
In the verification of force-proving instruments used in a force calibration machine or a force standard machine, the surface pressure on the compression platens of the machine should not be greater than 100 N/mm^2; if necessary, additional intermediate plates should be selected and installed (see Figure A.4) with a diameter d_9, large enough to ensure that this condition is met.

Figure A.4a) shows, by way of example, the shape of a loading pad for compressive force transducers having a convex area of force introduction; its height h_7 should be equal to or greater than $d_9/2$.

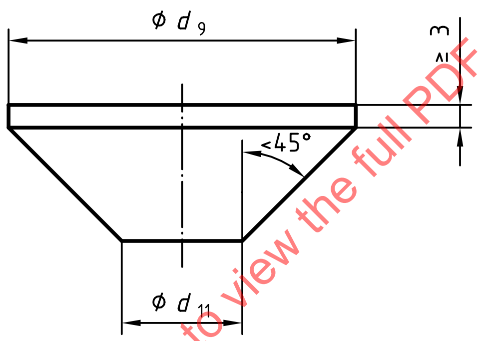
Height h_8 and diameter d_{10} of all loading pads should, however, be adapted to the force introduction components in such a way that the loading pad can be located both centrally and without lateral contact to the force introduction component. Diameter d_{10} should therefore be 0,1 mm to 0,2 mm greater than the diameter of the forces introduction component.

Figure A.4b) shows, by way of example, the shape of a loading pad for compressive force transducers having a flat area of force introduction. Diameter d_{11} should be greater than or equal to the diameter of the force introduction component.

Dimensions in millimetres



a) Loading pad designed so as to reduce surface pressure for force transducers having a convex area of force introduction



b) Loading pad designed so as to reduce surface pressure for force transducers having a flat area of force introduction

Figure A.4 — Loading pads

Table A.4 — Dimensions of intermediate rings

Maximum (nominal) force of materials testing machine [a]	Maximum force of force-proving instrument	Type of intermediate ring	d_4 H7 mm	d_5 mm	d_6 c11 mm	d_7 mm	d_8 mm	h_3 mm	h_4 mm	h_5 mm	h_6 mm
60 kN	40 kN	A	$35^{+0,025}_{0}$	24	$45^{-0,130}_{-0,290}$	–	–	5	10	–	–
100 kN	40 kN	A	$35^{+0,025}_{0}$	24	$50^{-0,130}_{-0,290}$	–	–	7	15	–	–
	60 kN	A	$45^{+0,025}_{0}$	29		–	–	7	15	–	–
200 kN	40 kN	B	$35^{+0,025}_{0}$	24	$64^{-0,140}_{-0,330}$	36	46	5	34	22	12
	60 kN	A	$45^{+0,025}_{0}$	29		–	–	7	15	–	–
	100 kN	A	$50^{+0,025}_{0}$	34		–	–	7	15	–	–
400 kN and 600 kN	40 kN	B	$35^{+0,025}_{0}$	24	$120^{-0,170}_{-0,390}$	36	61	5	57	42	12
	60 kN	B	$45^{+0,025}_{0}$	29		46	61	7	57	42	12
	100 kN	B	$50^{+0,025}_{0}$	34		51	61	7	57	42	15
	200 kN	A	$64^{+0,030}_{0}$	47		–	–	12	20	–	–
1 MN	60 kN	B	$45^{+0,025}_{0}$	29	$120^{-0,180}_{-0,400}$	46	77	7	60	45	15
	100 kN	B	$50^{+0,025}_{0}$	34		51	77	7	60	45	15
	200 kN	B	$64^{+0,030}_{0}$	47		65	77	12	60	45	15
	400 kN and 600 kN	A	$90^{+0,035}_{0}$	65		–	–	18	32	–	–
2 MN	200 kN	B	$64^{+0,030}_{0}$	47	$165^{-0,230}_{-0,480}$	67	103	12	87	60	15
	400 kN and 600 kN	A	$90^{+0,035}_{0}$	65		–	–	18	48	–	–
	1 MN	A	$120^{+0,035}_{0}$	78		–	–	25	50	–	–
4 MN	400 kN and 600 kN	B	$90^{+0,035}_{0}$	65	$235^{-0,280}_{-0,570}$	92	158	18	130	95	35
	1 MN	A	$120^{+0,035}_{0}$	78		122	158	25	130	95	45
	2 MN	A	$165^{+0,040}_{0}$	105		-	-	27	62	-	-
6 MN	400 kN and 600 kN	B	$90^{+0,035}_{0}$	65	$270^{-0,300}_{-0,620}$	92	173	18	155	115	35
	1 MN	B	$120^{+0,035}_{0}$	78		122	173	25	155	115	45
	2 MN	A	$165^{+0,040}_{0}$	105		-	-	27	77	-	-
	4 MN	A	$235^{+0,046}_{0}$	160		-	-	35	60	-	-
10 MN	1 MN	B	$120^{+0,035}_{0}$	78	$345^{-0,360}_{-0,720}$	122	223	25	200	150	40
	2 MN	B	$165^{+0,040}_{0}$	105		167	223	27	200	150	60
	4 MN	A	$235^{+0,046}_{0}$	160		-	-	35	90	-	-
	6 MN	A	$270^{+0,052}_{0}$	185		-	-	40	75	-	-

[a] Tensile testing machines for nominal forces greater than 10 MN are special versions for which any necessary intermediate rings should be made by arrangement.