INTERNATIONAL STANDARD

ISO 3611

Second edition
2010-11-01

Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics

Spécification géométrique des produits (GPS) — Équipement de mesurage dimensionnel: Micromètres d'extérieur — Caractéristiques de conception et caractéristiques métrologiques

Reference number
ISO 3611:2010(E)

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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 3611 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This second edition cancels and replaces the first edition (ISO 3611:1978), which has been technically revised.

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Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences the chain link 5 of the chain of standards on size in the general GPS matrix.

For more detailed information on the relation between this International Standard, other standards and the GPS matrix model, see Annex F.

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Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics

1 Scope

This International Standard specifies the most important design and metrological characteristics of micrometers for external measurements:

— with analogue indication;

— with digital indication: mechanical or electronic digital display.

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 14253-1, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 1: Decision rules for proving conformance or non-conformance with specifications*

ISO 14253-2, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

ISO 14978:2006, *Geometrical product specifications (GPS) — General concepts and requirements for GPS measuring equipment*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14978, ISO/IEC Guide 99 and the following apply.

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3.1
micrometer for external measurements
measuring instrument which gives the evaluation of a dimensional quantity of an external feature of a workpiece on the basis of movement of a spindle with a measuring face, moving relatively to a material measure and an anvil, with the movement generated by a screw thread

NOTE 1 The guiding elements of the spindle and of the anvil are connected by a frame.

NOTE 2 Usually, micrometers for external measurements have a thread as a material measure with the anvil, spindle and material measure arranged in a line.

3.2
measuring face contact
contact between the measuring face and a feature of a workpiece

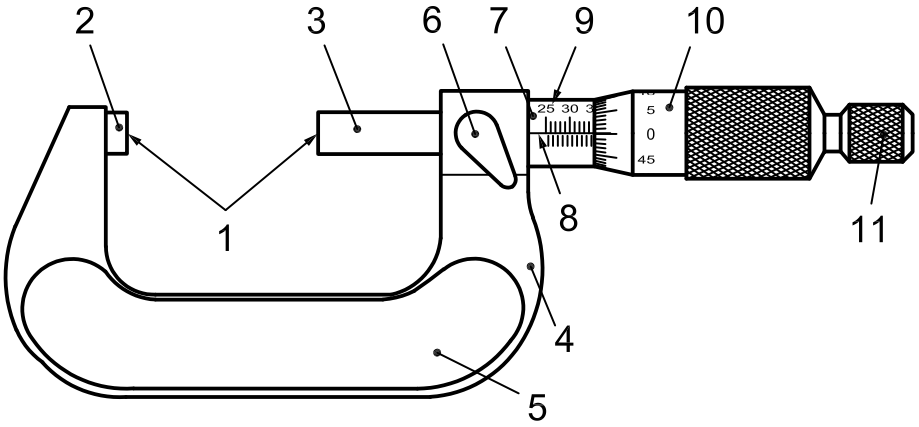
3.2.1
full measuring face contact
contact between the full area of the measuring face and a feature of a workpiece

3.2.2
partial measuring face contact
contact between a partial area of the measuring face and a feature of a workpiece

4 Design characteristics

4.1 General design and nomenclature

The general design and workmanship of the micrometer for external measurements shall be such that its metrological characteristics comply with the requirements of this International Standard under all operational orientations, unless otherwise specified by the manufacturer. See Figure 1 for the general design.



Key

1	measuring faces	7	sleeve
2	anvil	8	fiducial line
3	measuring spindle	9	analogue indication
4	frame	10	thimble
5	thermally insulating plate	11	fast drive
6	spindle clamp		

Figure 1 — Nomenclature and general design of a micrometer for external measurements

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4.2 Main dimensions

The micrometer for external measurements shall conform to the dimensions specified in Figure 2 and Table 1.

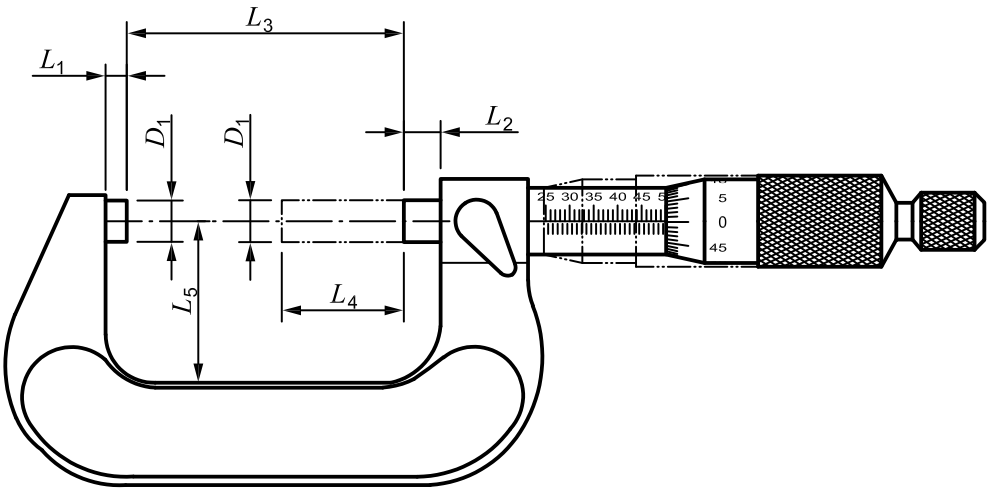

Figure 2 — Dimensions of a micrometer for external measurements

Table 1 — Dimensions of a micrometer for external measurements

Dimension	Nominal value
Anvil length, L_1	
Spindle length in end position, L_2	
Maximum dimension measurable, L_3	
Measuring span, L_4	25 mm[c]
Frame depth, L_5[b]	
Spindle and anvil diameter, D_1	6,35 mm, 6,5 mm, 7,5 mm, 8 mm[a]
NOTE The dimensions D_1, L_1 and L_2 are important for the interchangeability of accessories mounted on the measuring faces.	
[a] At the manufacturer's discretion. Other diameters are possible.	
[b] Usually, the frame is shaped to permit the measurement of a cylinder whose diameter is equal to the last value of the measuring range.	
[c] Usually, the measuring span L_4 is 25 mm. Other measuring spans are possible.	

4.3 Types of indicating devices

4.3.1 General

Several types of indicating devices are possible:

— analogue indicating devices;

— digital indicating devices with mechanical digital display;

— digital indicating devices with electronic digital display.

On micrometers with analogue indicating devices, the scale interval and its unit shall be labelled.

On micrometers with a digital indicating device, the unit of the indication shall be labelled.

NOTE Combinations of analogue and digital indicating devices are possible.

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4.3.2 Analogue indicating devices

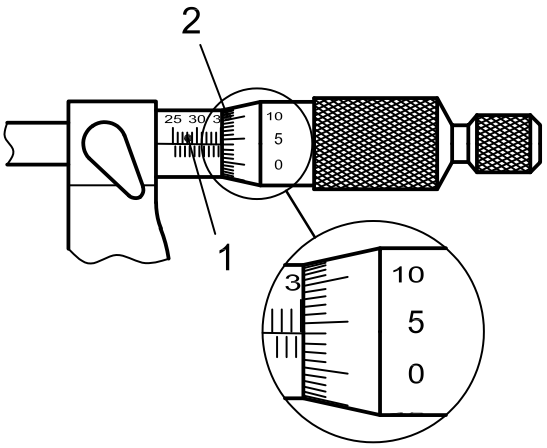
4.3.2.1 General

The measuring spindle should have a pitch of 0,5 mm or 1 mm. In the case of micrometers with spindles having a pitch of 0,5 mm, the 0,5 mm graduation lines on the main scale shall be clearly distinguishable from the 1 mm graduation lines by means of their arrangement above and below the fiducial line.

The secondary scale on the thimble should have a scale graduated with 50 (pitch 0,5 mm) or 100 (pitch 1 mm) graduation lines, each scale interval representing 0,01 mm. For graduations of 0,001 mm, a vernier scale can be added on the sleeve.

See Figures 3 to 5 for scales and arrangement of scales.

4.3.2.2 Main scale and secondary scale



Key
1 main scale
2 secondary scale

NOTE The reading in Figure 3 is 35,04 mm.

Figure 3 — Analogue indicating device with spindle pitch of 0,5 mm

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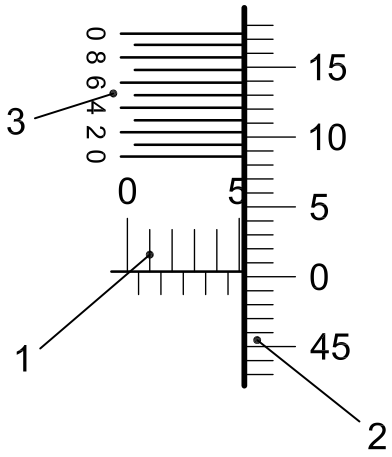
4.3.2.3 Vernier scale



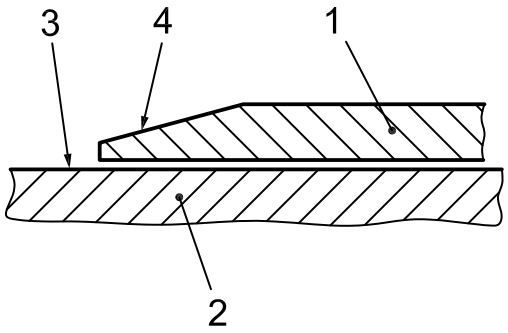
Key

1 main scale
2 secondary scale
3 vernier scale

NOTE The reading in Figure 4 is 5,005 mm.

Figure 4 — Analogue indicating device with spindle pitch of 0,5 mm and vernier scale interval of 0,001 mm

4.3.2.4 Arrangement of scales



Key

1 thimble
2 sleeve
3 main scale
4 secondary scale

Figure 5 — Arrangement of sleeve and thimble

The height difference between the edges of the secondary scale surface and the main scale surface should be as small as possible, for example 0,4 mm.

4.3.3 Digital indicating devices, with mechanical digital display

The mechanical digital display (see Figure 6) should have a digital step of 0,01 mm or 0,001 mm. The digits of the display should provide a good contrast with the background.

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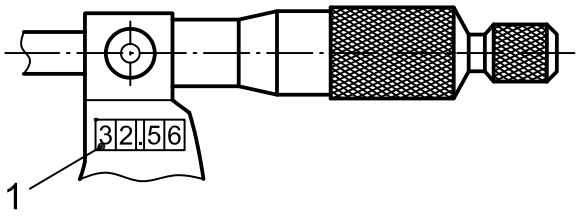


Key

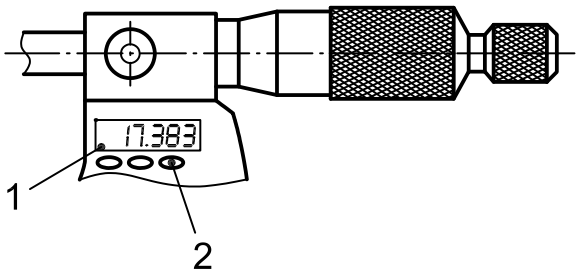
1 mechanical digital display

Figure 6 — Mechanical digital display

4.3.4 Digital indicating devices with electronic digital display

4.3.4.1 General

The electronic digital display (see Figure 7) should have a digital step of 0,01 mm or 0,001 mm. The design of the digital indication should be such that the measured value is clearly displayed in any position of the spindle.



Key

1 electronic digital display

2 control buttons

Figure 7 — Electronic digital display

4.3.4.2 Error messages

Micrometers for external measurements with electronic digital indication shall include a device suitable for displaying all operation and system error messages.

EXAMPLE Error message caused by excessively rapid spindle rotation or insufficient power supply.

4.3.4.3 Interface

In the case of micrometers for external measurements with electronic digital indication having an interface, the manufacturer should describe the transmission format of the data outputs with as much detail as possible. The interface may also be fitted on an auxiliary instrument.

4.4 Protection for field use

Manufacturers should indicate clearly which kind of fluid, dust protection (IP code, according to IEC 60529), and, for instruments with electronic digital indication, electromagnetic field protection is provided.

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4.5 Frame

For hand-held micrometers, the frame can be insulated to prevent body heat from being transmitted. The rigidity of the frame shall be consistent with the measuring force.

4.6 Measuring faces

Measuring faces shall have a wear-resistant and suitable surface finish.

4.7 Measuring force limiting device

Each micrometer for external measurements shall be provided with a measuring force limiting device integrated in the thimble or in the fast drive. For notes on now to use the measuring force limiting device, see Annex E.

The measuring force generated by the measuring force limiting device should supersede the frictional force of the spindle. Usually, micrometers for external measurements have a measuring force between 5 N and 10 N.

4.8 Adjustment devices

Each micrometer for external measurements shall be provided with user-accessible means for setting the micrometer to zero or to the reference point. An adjustment device shall be provided to compensate for wear of the spindle and nut threads.

NOTE To set the reference point, setting bars or gauge blocks are used.

4.9 Design characteristics (manufacturer's specification)

As a minimal requirement, manufacturers shall specify the design characteristics indicated in Table 2. For further information, see Annex B.

Table 2 — Design characteristics

Characteristics			
Dimensions	Spindle and anvil diameter, D_1		mm
	Anvil length, L_1		
	Spindle length in end position, L_2		
	Frame depth, L_5		
Spindle thread pitch			
Measuring range	from … to		
Scale interval/digital step			
Type of measuring force limiting device	Ratchet in fast drive Yes/No		
	Ratchet in thimble Yes/No		
	Friction in thimble Yes/No		
Indicating device	Analogue		
	Mechanical digital		
	Electronic digital		
Presence of:	Spindle clamp Yes/No		
	Fluid and dust protection[a]		
	Interface including type		

[a] IP code according to IEC 60529.

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5 Metrological characteristics

5.1 General

The metrological characteristics specified in this International Standard apply when the zero or reference point is set at any position within the measuring range, i.e. in floating zero mode. Unless otherwise specified by the manufacturer, micrometers for external measurements shall comply with the maximum permissible error (MPE) and permissible limit (MPL) values at any orientation of the micrometer. For test methods to evaluate the performance of the micrometer, refer to Annexes C and D.

5.2 Effect of spindle clamp

If the spindle is clamped (in cases where the frame is equipped with a clamping device), the dimension which is set shall not change and the indication should not change by more than 2 µm.

5.3 Maximum permissible error of indication (limited by MPE)

5.3.1 General

The requirements on the error of indication apply to any indication based on the zero or reference point setting stated in 5.1. For an example of a diagram of error of indication, see Annex A.

5.3.2 Full surface contact error, J (limited by MPE_J)

Error of indication when full measuring face contact (3.2.1) is employed at any position of the measuring range.

If the micrometer has a rotating measuring spindle, the measurements should be carried out in fractions of one revolution.

5.3.3 Repeatability, R (limited by MPE_R)

Error of indication when full measuring face contact (3.2.1) is employed on successive measurements of the same measurand, carried out under the same conditions of measurement.

5.3.4 Partial surface contact error, E (limited by MPE_E)

The error of indication MPE_E applies when partial measuring face contact (3.2.2) is employed on successive measurements of the same measurand, carried out at any position of the measuring faces, under the same conditions of measurement.

If the micrometer has a rotating measuring spindle, the measurements should be carried out in fractions of one revolution.

NOTE The partial surface contact error includes the flatness of the measuring faces, the parallel deviation of the measuring faces and the perpendicularity deviation of each measuring face to, respectively, anvil's and spindle's axis.

5.4 Measuring forces (limited by MPL)

The measuring force shall be given as a maximum and minimum measuring force.

5.5 Instrument specification sheet

Each type of micrometer for external measurements has a specification sheet, which is intended to supply the following minimum information to the user (see Table 3). The manufacturer shall specify the values of the maximum permissible errors and shall give information about design requirements. For the purposes of

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verification after the sale, customers are free to define their own values for MPEs and MPLs according to their company needs.

According to ISO 14978:2006, 7.5, MPEs shall be given as a continuous function (e.g. straight lines connecting given points). See the model in ISO 14978:2006, 7.5.3.

Table 3 — Metrological characteristics

Characteristics	Value		
Scale interval or digital step			mm
Maximum permissible error of indication	MPE_J		µm
	MPE_R		µm
	MPE_E		µm
Measuring force	Maximum		N
	Minimum		

6 Proof of conformance with specifications

For proving conformance or non-conformance with specifications, ISO 14253-1 applies. Uncertainty evaluation shall be performed according to ISO/IEC Guide 98-3 and ISO 14253-2.

7 Marking

The marking shall indicate at least the following data:

— the scale interval (only for analogue indication);

— the measuring range;

— the unique alphanumeric identification (i.e. serial number).

Any marking shall be easily readable and permanent; it shall be placed on the surface of the micrometer, at a place that will not impair the metrological quality of the equipment.

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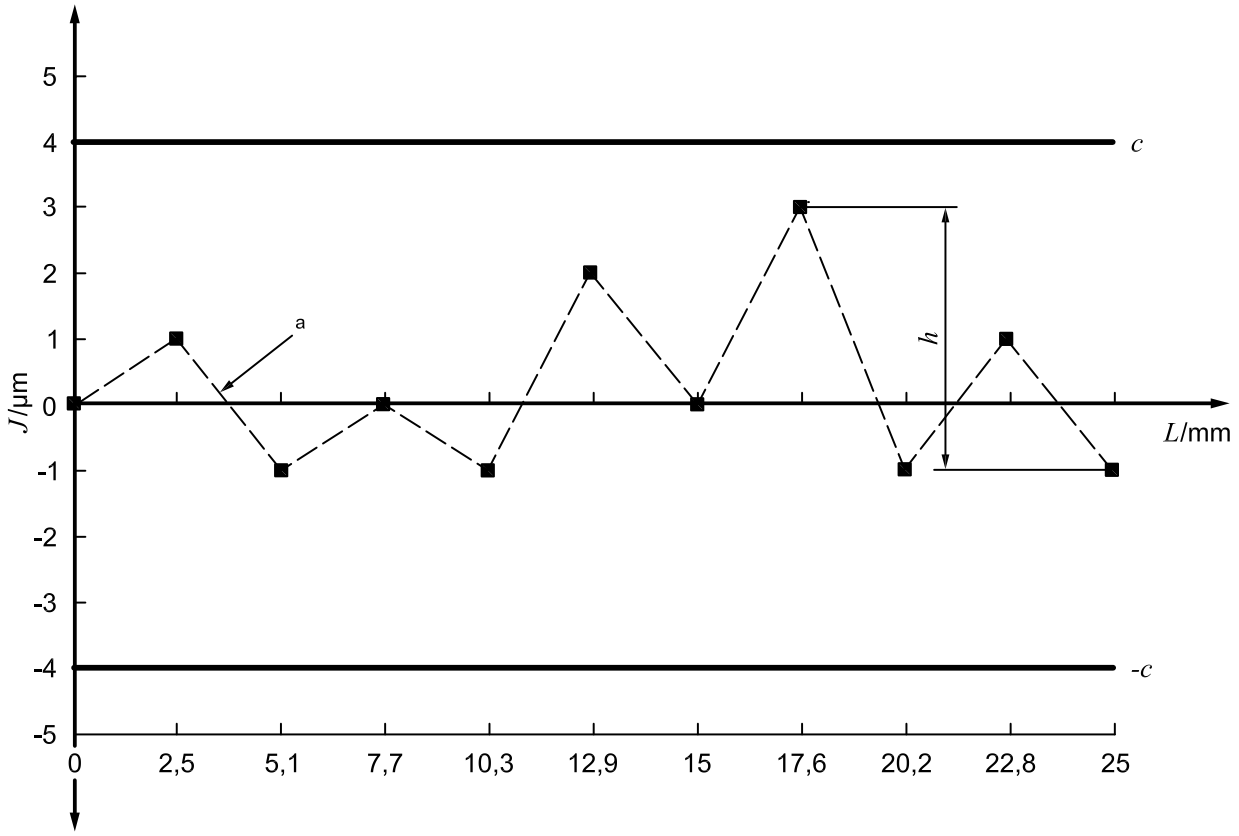
Annex A
(informative)

Example of an error-of-indication curve

Figure A.1 shows an example of an error-of-indication curve. This is a simplified data set (for data points) in order to illustrate the characteristics of the micrometer. See also ISO 14978:2006, Clause 7.



Key

L length indication

J error of indication

h error-of-indication span

c limit MPE_J

a Error curve.

Figure A.1 — Error-of-indication curve

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Annex B
(informative)

Example of data sheet for micrometers for external measurements

This data sheet is intended for communication between the technical experts and the purchasing department of the same company.

Name of the equipment:

Detailed requirements (e.g. scale layout, locking device, material of frame, weight, hardness of measuring faces, etc.): .....

.....

Accessories: .....

Possible suppliers: .....

Price range (optional): .....

Additional requirements (e.g. inspection report, calibration certificate): .....

The design and metrological characteristics refer to ISO 3611

Design characteristics:

Spindle and anvil diameter, D_1: …… mm

Anvil length, L_1: …… mm

Spindle length in end position, L_2: …… mm

Frame depth, L_5: …… mm

Spindle thread pitch: …… mm

Measuring range: from …… to …… mm

Scale interval or digital step: …… mm

Measuring force limiting device: .....

Indicating device: .....

Presence of spindle clamp (yes/no): .....

Fluid and dust protection: .....

Interface: .....

Metrological characteristics:

Full surface contact error (MPE_J): …… µm

Repeatability (MPE_R): …… µm

Partial surface contact error (MPE_E): …… µm

Measuring force (MPL): Minimum …… N, Maximum …… N

Company: .....

Department: .....

Person responsible: .....

Date: .....

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Annex C
(informative)

Calibration of metrological characteristics

The methods should permit evaluation of the performance of the instrument within its measuring range. The global calibration of each scale point or each digital step over the measuring range will necessitate a large number of readings to be taken. When it is considered that the intended use of the instrument does not warrant global calibration, partial calibration or task-related calibration should be taken into consideration. When determining the errors of indication, it is necessary to choose a suitable number of intervals, dependent on the scale interval or digital step, the measuring range and the used measuring range. The values of maximum permissible errors can be calculated according to ISO 14978. With these values, calibration curves with a floating zero can be recorded (see ISO 14978:2006, Figure 7).

It is possible to perform a calibration by using a suitable sampling technique, but this will result in an increase in the uncertainty of measurement.

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Annex D
(informative)

Error tests

D.1 Test methods

The methods should evaluate the performance of the micrometer for external measurements throughout its measuring range. The methods described below do not purport to be the only valid test methods, but their use is recommended.

A calibration curve provides the simplest means of evaluating the performance of the micrometer under test (see ISO 14978). Such a curve also provides useful certification evidence of calibration.

D.2 Error of indication

D.2.1 General

The error of indication may be tested with suitable instruments or a material measure with an appropriate uncertainty, for example with gauge blocks in accordance with ISO 3650.

D.2.2 Full contact error (limited by MPE_J)

The full contact error may be tested with a material measure, e.g. gauge blocks, which covers the whole measuring face for any size (position within the measuring span).

For micrometers having a thread as a material measure, gauge blocks or gauge block combinations, which permit testing of the spindles at points having a whole-number multiple of the nominal pitch as well as intermediate positions, should be selected. The following gauge blocks or gauge block combinations are suitable for thread pitches of 0,5 mm and 1 mm:

2,5 mm; 5,1 mm; 7,7 mm; 10,3 mm; 12,9 mm; 15,0 mm; 17,6 mm; 20,2 mm; 22,8 mm and 25 mm

When testing using these gauge blocks, measured values are obtained for different angles of rotation with which any existing periodic deviations may be determined. For micrometers whose initial value of the measuring range is greater than zero, the errors of indication may also be established using the above-mentioned gauge blocks or gauge block combinations, i.e. using a suitable gauge block or gauge block combination whose length is the same as the initial value of the measuring range.

For large micrometers, calibration of the measuring element alone on a suitable length measuring instrument may be advantageous. In this case, the missing influence of the measuring force should be taken into account. Testing the micrometers for external measurements at both the initial and the last values of the measuring range using gauge blocks is then sufficient.

D.2.3 Repeatability of full contact error (limited by MPE_R)

The repeatability of full contact error may be tested by measuring a material measure, e.g. gauge blocks, for any size (position within the measuring span).

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D.2.4 Partial surface contact error (limited by MPE_E)

The partial surface contact error may be tested at several positions of the measuring faces under the same conditions of measurement with a material measure. If the micrometer has a rotating measuring spindle, the defined procedure shall be carried out in fractions of one revolution.

The recommended material measure is a sphere. For larger micrometers a sphere may not be practicable, and the use of the edge of gauge blocks is recommended; in these cases, the flatness of the measuring faces should also be separately measured (for example with an optical flat).

D.3 Measuring force range (limited by MPL)

The measuring force may be tested at several positions within the measuring range under the same conditions of measurement by using a load cell.

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Annex E
(informative)

Notes on use

E.1 To obtain reliable repeatable measuring values, the spindle should be rotated smoothly during the measurement using the measuring-force limiting device.

E.2 In order to avoid heat transfer from the hand, the micrometers for external measurements should be held as much as possible by the insulating plate.

E.3 The micrometer should be verified periodically — based on the frequency and conditions of use — in order to detect wear or faults. Jerking movements of the spindle indicate the presence of dirt in the screw. Sticking of the spindle may also be caused by coaxiality deviations of the nut thread and cylindrical guide section of the frame. Alternating tightening and slackening of the spindle during rotation indicates a bent spindle and/or coaxiality defect of the thimble and sleeve (causing wear on the sleeve).

E.4 The zero or reference point of the micrometer should be monitored periodically — based on the frequency and conditions of use — in order to detect a shifting of the zero or reference point. The reference point shall be tested with gauge blocks according to ISO 3650 or other setting standards under the orientations of use.

E.5 On instruments where a different orientation in use and calibration causes a shifting of the zero or reference point, the zero or reference point has to be reset in the orientation of use.

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Annex F
(informative)

Relation to the GPS matrix model

F.1 General

For full details about the GPS matrix model, see ISO/TR 14638.

F.2 Information about this International Standard and its use

This International Standard provides the most important design and metrological characteristics of micrometers for external measurement:

— with analogue indication;

— with digital indication: mechanical or electronic digital indication.

F.3 Position in the GPS matrix model

This International Standard is a general GPS standard, which influences the chain link 5 of the chain of standards on size in the general GPS matrix, as shown in Figure F.1.

Fundamental GPS standards	Global GPS standards						
	General GPS standards						
	Chain link number	1	2	3	4	5	6
	Size					X	
	Distance						
	Radius						
	Angle						
	Form of a line independent of datum						
	Form of a line dependent on datum						
	Form of a surface independent of datum						
	Form of a surface dependent on datum						
	Orientation						
	Location						
	Circular run-out						
	Total run-out						
	Datums						
	Roughness profile						
	Waviness profile						
	Primary profile						
	Surface imperfections						
	Edges						

Figure F.1 — Position in the GPS matrix model

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F.4 Related International Standards

The related International Standards are those of the chains of standards indicated in Figure C.1.

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Bibliography

[1] ISO 3650:1998, *Geometrical Product Specifications (GPS) — Length standards — Gauge blocks*

[2] ISO/TR 14638:1995, *Geometrical product specification (GPS) — Masterplan*

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