INTERNATIONAL STANDARD

ISO 9493

First edition
2010-11-01

Geometrical product specifications (GPS) — Dimensional measuring equipment: Dial test indicators (lever type) — Design and metrological characteristics

Spécification géométrique des produits (GPS) — Équipement de mesurage dimensionnel: Comparateurs à levier mécaniques — Caractéristiques de conception et caractéristiques métrologiques

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 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 9493 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

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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 chains of standards on size, distance, form of a line independent of datum, form of a line dependent of datum, form of a surface independent of datum, form of a surface independent of datum, orientation, location, circular run-out and total run-out in the general GPS matrix.

When using this International Standard, see ISO 14978.

For more detailed information on the relation of this International Standard to other standards and the GPS matrix, see Annex E.

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Geometrical product specifications (GPS) — Dimensional measuring equipment: Dial test indicators (lever type) — Design and metrological characteristics

1 Scope

This International Standard specifies the most important design and metrological characteristics of dial test indicators (lever type).

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 14253-1:1998, *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:—[1)], *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*

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/IEC Guide 99, ISO 14253-1, ISO 14253-2, ISO 14978 and the following apply.

3.1
dial test indicator
⟨lever type⟩ measuring instrument in which the displacement of a pivoting stylus is transmitted and magnified by suitable mechanical means to a pointer which rotates in front of a circular scale

1) To be published. (Revision of ISO/TS 14253-2:1999)

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4 Design characteristics

4.1 General design features

4.1.1 The general design and workmanship of the dial test indicator shall be such that its metrological characteristics comply with the requirements of this International Standard under all orientations of operation.

4.1.2 Dial test indicators indicate displacement in a direction normal to the axis of the stylus, and in the same plane as the rotational direction of the stylus, unless otherwise stated. See Figure D.1 as an example. If used at some other angle, a correction shall be made (see Annex D).

4.1.3 Dial test indicators shall be capable of measuring when the stylus is displaced in either direction from its rest position.

NOTE Some dial test indicators have the ability to measure in both directions without external adjustments and some dial test indicators are provided with a bias lever to change the measuring direction.

4.2 Type

Dial test indicators are commonly manufactured in three types [see Figure 1 a), b) and c)]. These types have the following names.

— Type S, Standard, where the dial face is mounted on the body of the dial test indicator, in a plane perpendicular to the plane in which the stylus moves.

— Type H, Horizontal, where the dial face is mounted on the body of the dial test indicator, in a plane parallel to the plane in which the stylus moves.

— Type V, Vertical, where the dial face is mounted at the end of the dial test indicator opposite that of the stylus.

NOTE Although less common, configurations of dial test indicators, which do not fall into the above three categories, exist. The above-mentioned list of three named types includes those that are the most common.

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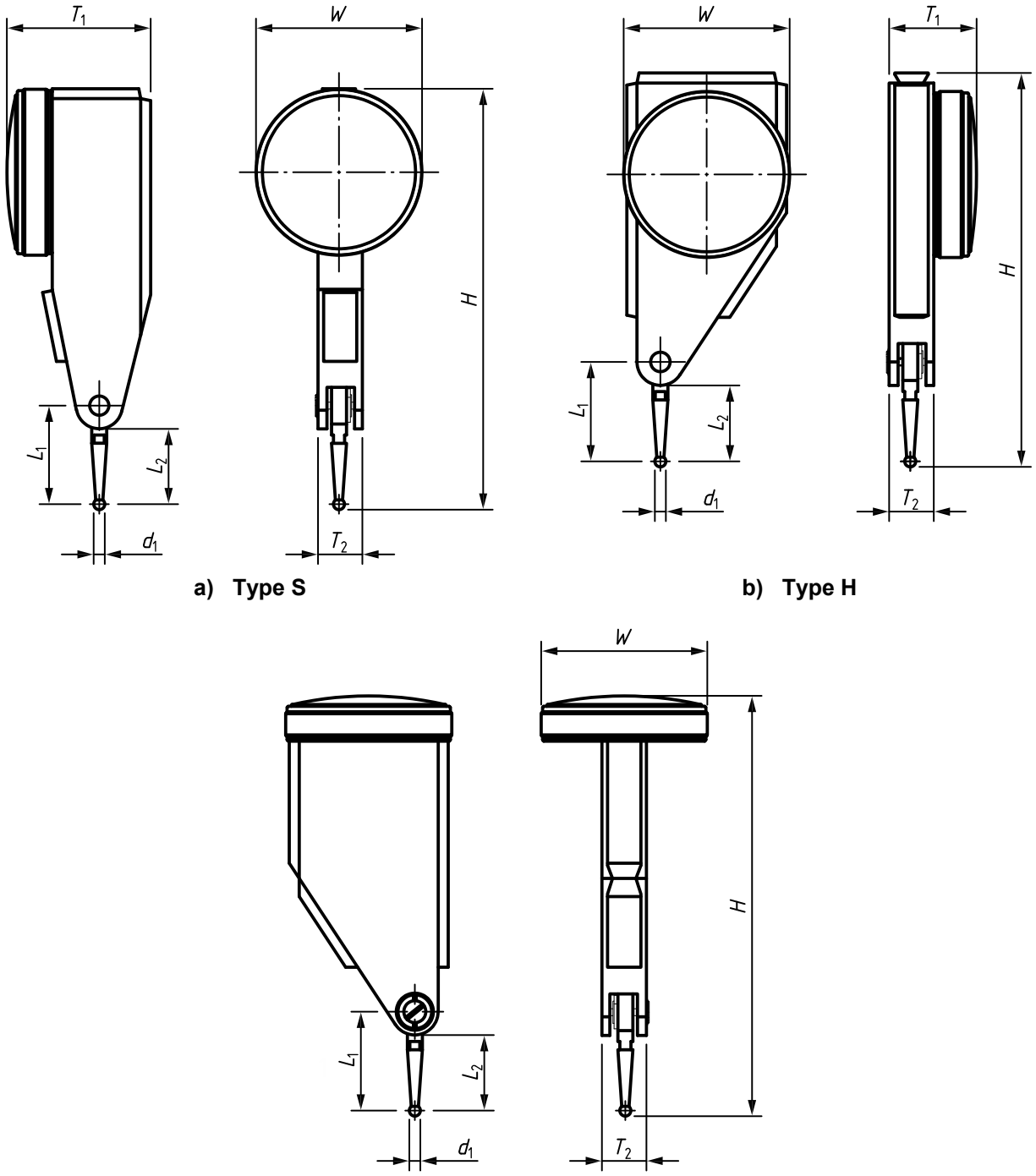

a) Type S

b) Type H

c) Type V

Figure 1 — Examples of dial test indicator types

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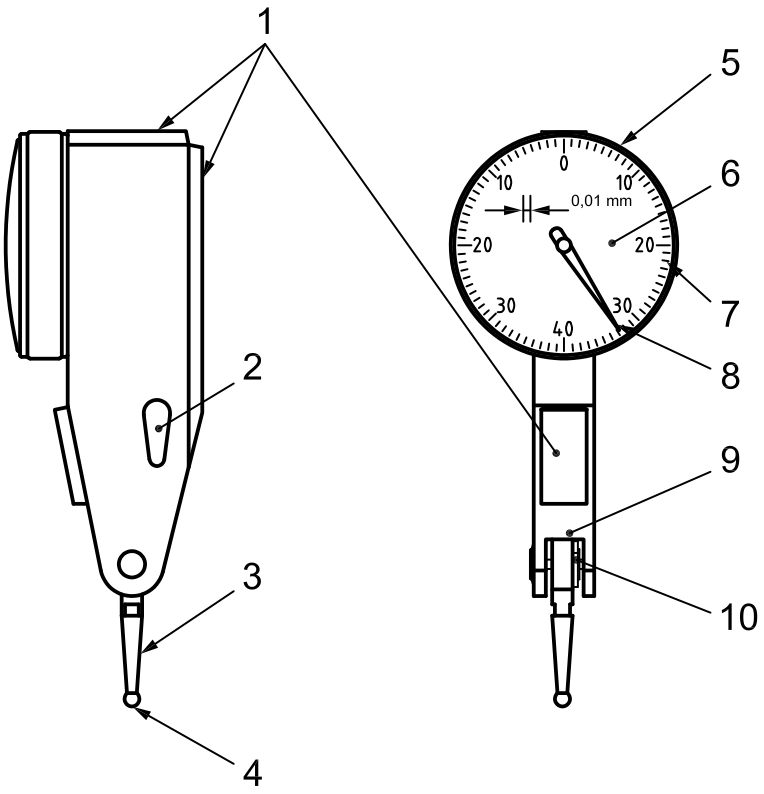
4.3 Nomenclature

Design features of dial test indicators are shown in Figure 2. The descriptions in this International Standard use the nomenclature shown in this figure.



Key

1 dovetail segments
2 bias lever (if required)
3 stylus
4 stylus tip
5 bezel
6 dial
7 scale
8 pointer
9 housing
10 friction or ratchet drive

Figure 2 — Nomenclature

4.4 Dovetail mounting

Dial test indicators shall be provided with a means to facilitate attachment to test stands or other similar devices. This is often accomplished by means of dovetail segments on the body of the dial test indicator (see Figure 2) and a dovetail clamp. The exact design and location of these dovetail segments is left to the manufacturer's discretion.

Clamping stems shall conform to the fit tolerance h6 (see Figure 3 and Table 1) to ensure interchangeability. Common nominal diameters of clamping stems include 4 mm, 6 mm and 8 mm. A portion of the clamping stem (L_3 in Figure 3) no shorter than 12 mm shall be held to the fit tolerance (controlled diameter). The clamping stem can be longer than this minimum length, but it is not necessary to hold the h6 tolerance on the entire length.

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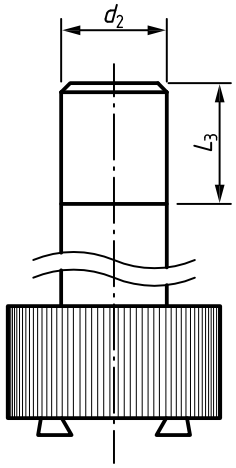


Figure 3 — Example of clamping stems

4.5 Dial and pointer

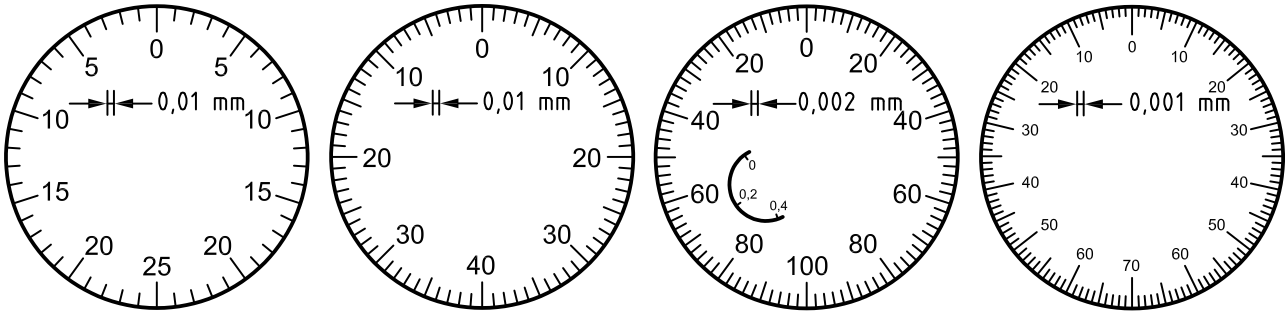
The circular scale shall be graduated in scale intervals. The scale interval and its unit shall be labelled. Examples of scale layouts are shown in Figure 4 (e.g. scale intervals of 0,01 mm, 0,001 mm, and 0,002 mm).

At rest, the pointer shall be at least 1/10 revolution counterclockwise from the point representing the beginning of the measuring range. This beginning point is normally the 12 o'clock or the 6 o'clock position on the dial. The pointer shall move at least one full revolution beyond this beginning point of the measuring range, to the next occurrence of this point, plus at least another 1/10 revolution before reaching the end of its travel. This range before the measuring range begins is called pre-span, and the range after one full revolution is called post-span. The pre-span and post-span movements shall not be considered in the measuring range of the dial test indicator.

NOTE There are dial test indicators in use with less than 1/10 revolution of pre-span or post-span. In these cases, it is the responsibility of the user and the manufacturer to agree on the amount of pre-span allowed.

In any case, there shall be at least one full revolution of measuring range, plus some agreed upon amount of pre-span and post-span.

The dial test indicator may have a measuring range great enough to allow the pointer to move multiple complete dial revolutions. In practice, some dial test indicators with a measuring range of more than one complete revolution may include a secondary scale and pointer to denote the number of revolutions travelled by the primary pointer [e.g. Figure 4 c)]. When a revolution counting device is provided, the secondary pointer shall indicate the appropriate division on its scale when the pointer is at 12 o'clock on each of its revolutions.



a) Example 1 b) Example 2 c) Example 3 d) Example 4

Figure 4 — Examples of scale layout

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4.6 Stylus

4.6.1 General

The stylus shall be easily interchangeable and shall, unless otherwise specified, have a spherical stylus tip. The stylus tip shall be manufactured from hard, wear-resistant material. It shall be well finished and free of flats or other irregularities which could affect the accuracy of the instrument.

The length of the stylus is an integral part of the accuracy of the instrument. When replacing the stylus, the user should ensure that the replacement stylus is of the same length as the original.

4.6.2 Friction linkage

The stylus of a dial test indicator is affixed to a friction linkage or ratchet mechanism, which allows the stylus to be positioned over a wide range of possible positions.

4.6.3 Friction linkage forces

The friction linkage force shall be sufficiently higher than the measuring force, so as to allow use of the dial test indicator at any position or orientation of the stylus, without introducing errors to the measurement.

4.6.4 Range of adjustment

The mechanism shall allow for positioning of the stylus at any position within a range from −90° to 0° up to +90° of the long axis of the dial test indicator, as shown in Figure 5.

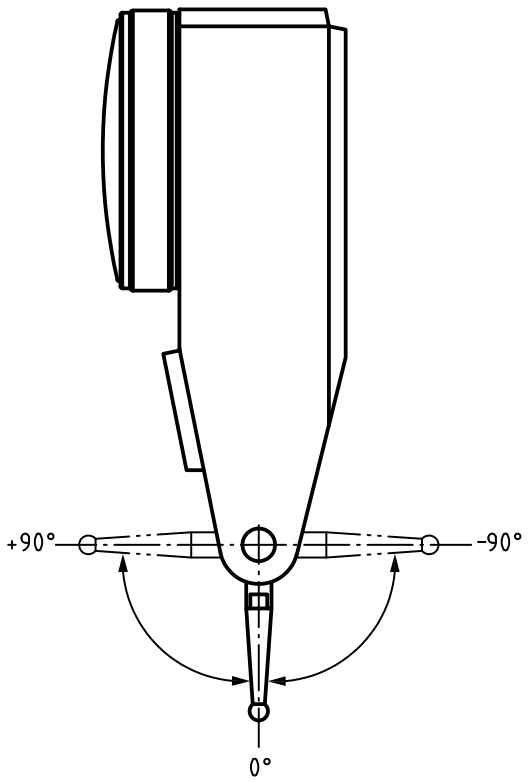

Figure 5 — Range of adjustment

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4.7 Zero adjustment

Each dial test indicator shall be provided with means for setting the indicator to zero. This is achieved by rotating the bezel. There shall be sufficient frictional resistance to rotation to ensure that the setting is maintained.

4.8 Design characteristics (manufacturer's specification)

As a minimum requirement, the manufacturers shall specify the following design characteristics for dial test indicators (see Figures 1 and 3, Table 1 and Annex B).

Table 1 — Design characteristics

Characteristics			
Overall dimensions	Overall height	H	mm
	Width	W	
	Overall thickness (if different from W)	T_1	
	Body thickness	T_2	
	Stylus length (ball centre to pivot axis)	L_1	
	Stylus length (ball centre to shoulder)	L_2	
	Stylus ball diameter	d_1	
	Bezel diameter (if different from W)	D	
	Clamping stem diameter (if supplied) For example: 4h6, 6h6, 8h6	d_2	
	Minimum length of controlled stem diameter	L_3	
Measuring range			
Scale interval			
Type (S, H, V, etc.)	Standard, horizontal, vertical, other		
Presence of	Bias lever	(Yes/No)	

5 Metrological characteristics

5.1 Maximum permissible error (MPE) and maximum permissible limit (MPL) for a number of metrological characteristics

The manufacturer shall specify the MPE and MPL information for the dial test indicator characteristics listed in Table 2. Unless otherwise specified by the manufacturer, the static response of the dial test indicator shall comply with these hysteresis and repeatability of error of indication MPE/MPL values at any position within the measuring range and at any orientation of the dial test indicator (see Table 2). It shall comply in both displacement directions of the stylus (see Annex A).

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Table 2 — Metrological characteristics

Characteristics		MPE MPL
Hysteresis of error of indication (MPE_H)		µm
Repeatability of error of indication (MPE_R)		
Error of indication over a range of:	Any 10 scale divisions	
	Any half revolution	
	Any one revolution	
	Measuring range (if different from one revolution)	
Measuring forces	Maximum	N
	Minimum	

5.2 Stylus

The stylus and its metrological characteristics shall be appropriate for the intended measuring task.

5.3 Measuring forces

Measuring forces shall be given as the maximum measuring force and the minimum measuring force. For the indication of the MPL, the data sheet given in Annex B may be used.

The measuring force characteristics shall be based on a two-sided specification given in 7.5.5 of ISO 14978:2006.

6 Proving of conformance with specification

6.1 General

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

6.2 Measurement standards for calibration of metrological characteristics

Measurement standards shall be used in accordance with the applicable International Standards.

7 Marking

The dial test indicator shall be marked with serialized alpha-numeric identification.

Any marking shall be easily readable and permanent and shall be placed on the surface of the dial test indicator in a place that does not impair the metrological quality of the equipment.

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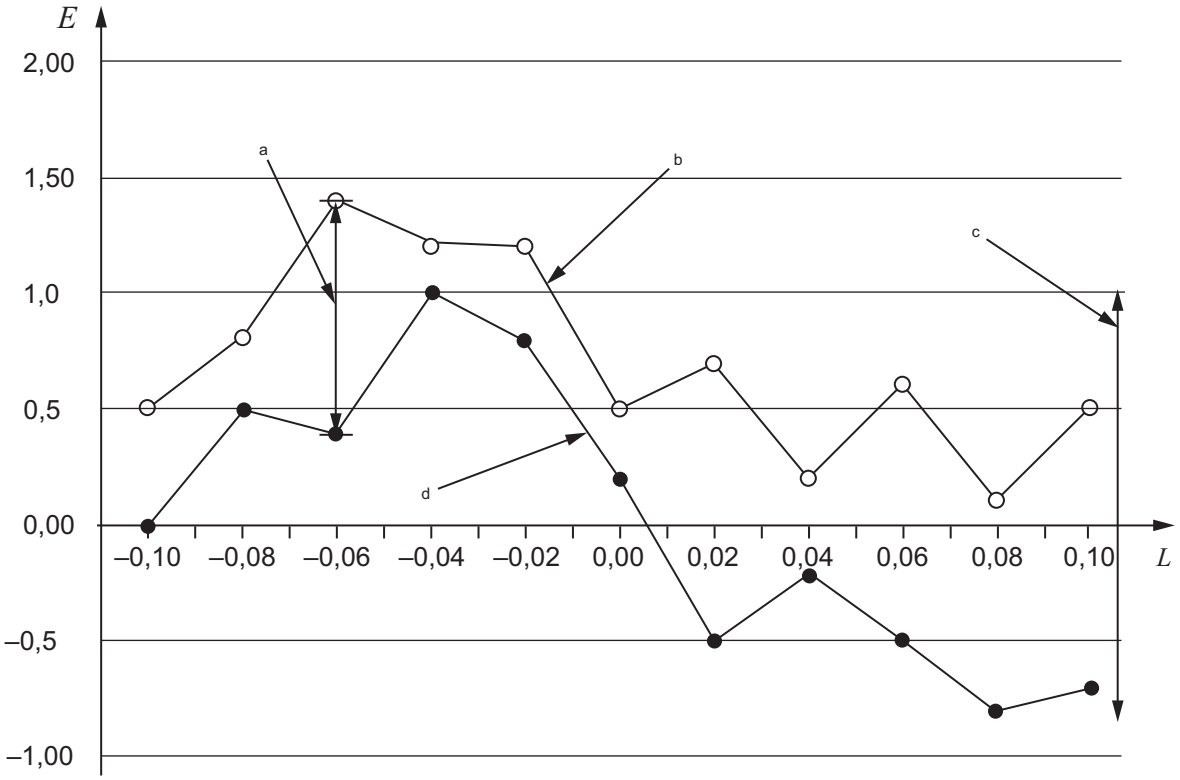
Annex A
(informative)

Examples of a diagram of errors of indication

Figure A.1 gives examples of errors of indication. Simplified data sets (for data points) are used in order to illustrate the characteristics of the dial test indicator. See also Clause 7 of ISO 14978:2006.



a) Tested from −0,1 mm **to** +0,1 mm **dial test indicator graduated in** 0,002 mm **graduations similar to Figure 4 c)**

Figure A.1 — Diagrams of errors of indication for one direction of displacement of the stylus of a dial test indicator (*continued*)

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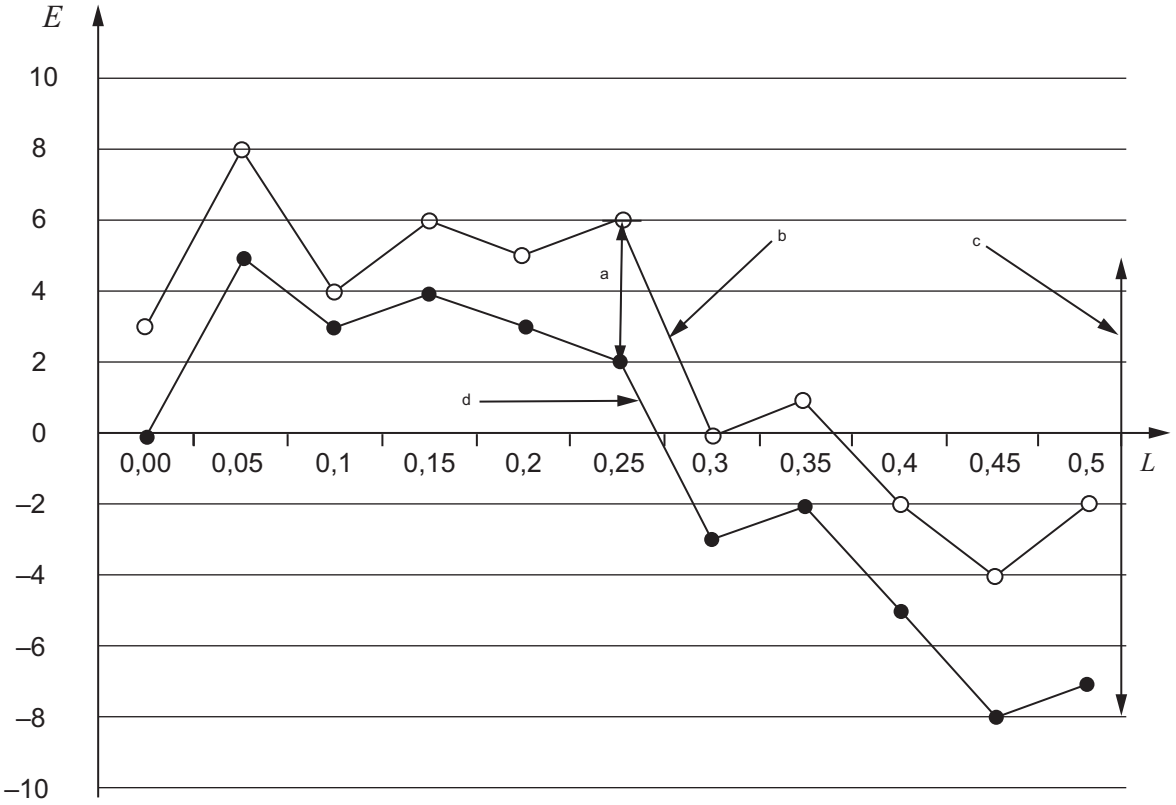

b) Tested from 0,0 mm **to** +0,5 mm **dial test indicator graduated in** 0,01 mm **graduations similar to Figure 4 a)**

Key

E error of indication (µm)

L nominal value (mm)

a Hysteresis at one point.

b Stylus moving with measuring force.

c Error of indication, max. (floating zero, stylus moving against measuring force).

d Stylus moving against measuring force.

NOTE In general, dial test indicators have two possibilities for direction of displacement of the stylus, and a diagram of errors of indication is useful for both directions. This is not to be confused with an evaluation of hysteresis.

Figure A.1 — Diagrams of errors of indication for one direction of displacement of the stylus of a dial test indicator

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Annex B
(informative)

Example of data sheet for dial test indicators

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

Name of equipment .....

Detailed characteristics: .....
(e.g. scale layout, contact, element) .....
.....

Accessories: .....

Possible suppliers: .....

Delivery requirements: .....
Price range (optional): .....
Additional requirements: .....
(e.g. inspection report, calibration certificate)

The design and metrological characteristics refer to this International Standard, i.e. ISO 9493

Design characteristics:

Type (S, H, V, other): .....

Overall dimensions:

- Overall height, H: ..... mm
- Width, W: ..... mm
- Overall thickness, T_1: ..... mm
- Body thickness, T_2: ..... mm
- Stylus length, L_1 (ball centre to pivot axis): ..... mm
- Stylus length, L_2 (ball centre to shoulder): ..... mm
- Stylus ball diameter, d_1: ..... mm
- Bezel diameter, D (if different from W): ..... mm
- Clamping stem diameter, d_2: ..... mm
- Minimum length of controlled stem diameter, L_3: ..... mm

Measuring range: ..... mm

Scale interval: ..... mm

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Metrological characteristics:

Hysteresis of indication (MPE_H): ..... µm

Repeatability of indication (MPE_R): ..... µm

Errors of indication (MPE) over a range of:

any 10 scale divisions: ..... µm

any half revolution: ..... µm

any one revolution: ..... µm

measuring range (where range is greater than one revolution) …… µm

Measuring forces (MPL)

Maximum: ..... N

Minimum: ..... N

Unless otherwise specified, MPE and MPL apply in any orientation and in both displacement directions of the stylus

---

Company: .....

Department: .....

Person responsible: .....

Date: .....

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Annex C
(informative)

Calibration of metrological characteristics

C.1 General — Calibration of metrological characteristics

The methods shall evaluate the performance of the instrument within its measuring range using both directions of displacement of the stylus.

It is essential that the dial test indicator be held rigidly in a fixture which is undisturbed by the operating force of the instrument itself.

The global calibration of a sufficient number of scale points over the measuring range necessitates a large number of readings to be taken. When it is considered that the intended use of the dial test indicator does not warrant global calibration, partial calibration or task related calibration shall be considered.

For the determination of the indication errors according to Table 2, a suitable number of intervals are necessary which are dependent on the scale interval and the measuring range or the used measuring range. By these values calibration curves with fixed or floating zeros can be recorded. The MPE function for the characteristics is given as only one two-sided specification within the constant symmetrical limits upper specification limit (USL) and lower specification limit (LSL) as the MPE for the measuring range (see Figure 9 in ISO 14978:2006).

It is possible to perform a modified global calibration with a reduced number of scale points using a suitable sampling technique, but this results in an increase in the uncertainty of measurement.

Figure A.1 shows examples of diagrams (with a very small number of scale points) of errors of indication (calibration curve) and the hysteresis band of a dial test indicator where zero was fixed at the centre of the measuring span.

By means of these measuring values, the errors for various measured lengths over the total measuring range can be calculated (see Figure 7 in ISO 14978:2006), i.e. the dial test indicator is also used with floating zero indicating measuring equipment (see 7.2.2 in ISO 14978:2006).

C.2 Test methods for checking metrological characteristics

Checks for the metrological characteristics of dial test indicators should include error of indication, hysteresis and repeatability. Separate tests should be performed for each of the sensitive directions of the dial test indicator.

C.2.1 Gauge blocks

The error of indication can be checked by securing the dial test indicator on a stand and placing a gauge block under the stylus tip. The pointer can be brought to the first calibration point by adjusting the stand. Subsequent calibration points can be checked by replacing the original gauge block with blocks of different values which cover the measuring range of the dial test indicator.

This method is an adequate test for error of indication, but is not an adequate method for checking hysteresis (MPE_H).

Repeatability (MPE_R) can be evaluated by this method by multiple checks using the same gauge block. Repeatability should be evaluated at several places within the measuring range.

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C.2.2 Micrometer-based test stands

Micrometer-based inspection stands are commonly used for checking dial test indicators. In these stands, after initial positioning of the dial test indicator, the micrometer is advanced, one calibration point at a time, to compare the reading of the dial test indicator to the reading generated by the micrometer.

In order for this to be a valid test method, the MPE of the micrometer should be small, compared to the desired level of accuracy of the calibration of the dial test indicator.

If the micrometer has a sufficiently low hysteresis error, this may be an adequate tool for checking the hysteresis (MPE_H) of the dial test indicator. Hysteresis may be evaluated by a point-by-point comparison of the results when moving the stylus against the measuring force to the results when moving the stylus in the direction of the measuring force.

Repeatability (MPE_R) may be evaluated by bringing the micrometer back to a reference position from the same direction a number of times.

C.2.3 Universal length measuring machines

Universal length measuring machines, utilizing glass scale transducers of high accuracy, provide a useful tool for checking each of the MPE values on dial test indicators. The general procedure would be the same as for micrometer-based test stands.

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Annex D
(informative)

Notes on use

D.1 Stylus length

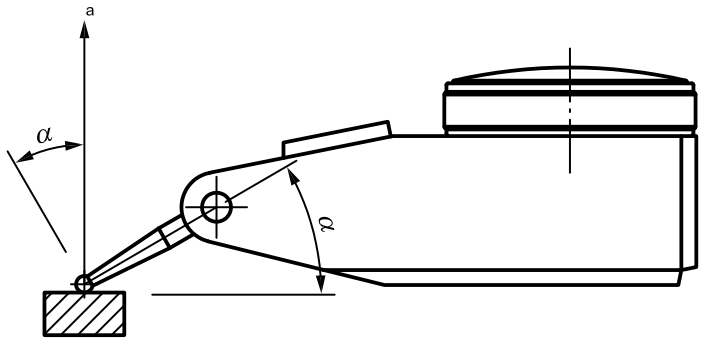
The length of the stylus influences the transmission ratio of the input to the output of the measurement, and thus also influences the result of the measurement. When replacing the stylus, care should be taken to ensure that only styli that have been designed for the specific dial test indicator are used.

If a stylus of a different length than that originally provided is used, the instrument shall be calibrated with a stylus of that length.

D.2 Angle, α, of inclination

In order to avoid having to correct the observed measurement, the stylus should, wherever possible, lie normal to the direction of measurement.

If the conditions of measurement do not permit such an arrangement, the effective stylus length is changed, leading to a change in the transmission ratio (see D.1 above). For this reason, the measurement observed should be corrected, after the angle, α, of inclination (see Figure D.1) has been determined, according to the following:



Result of measurement = indication × cos α

[a] Direction of measurement.

Figure D.1 — Angle, α, of inclination

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Table D.1 — Cosine correction values for selected angles of inclination

Angle	cos α
5°	0,996
10°	0,985
15°	0,966
30°	0,866
45°	0,707
60°	0,500

D.3 Use with indicator stands

Dial test indicators are often used mounted on indicator stands resting on a datum plane. As a general principle, the indicator stand should be kept stationary on the datum plane and the setting standard and the workpiece should be brought to the indicator. This practice minimizes the effects of an out-of-flat condition of the surface creating the datum plane. Where this practice is not practical, the flatness of the reference surface should be considered when evaluating the quality of the result of the measurement.

In general, when using an indicator stand, the distance from the tip of the dial test indicator to the post of the stand should be kept as short as possible.

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Annex E
(informative)

Relation to the GPS matrix model

E.1 General

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

E.2 Information about this International Standard and its use

This International Standard provides and specifies the most important design and metrological characteristics of dial test indicators. Only those design characteristics which are critical to interchangeability have been assigned requirement values. The metrological characteristics are not subject to requirement values, as it is the philosophy of ISO/TC 213, as expressed in ISO 14978, that the requirement for values of these characteristics are matters which should be specified by the manufacturer and/or user. However, this International Standard provides a definition of the metrological characteristics and states those metrological characteristics for which the manufacturer shall state an MPE or MPL value.

E.3 Position in the GPS matrix model

This International Standard is a general geometrical product specification (GPS) standard, which influences the chain link 5 of the chains of standards on size, distance, form of line independent of datum, form of line dependent on datum, form of surface independent of datum, form of surface dependent on datum, orientation, location, circular run-out and total run-out in the general GPS matrix, as graphically illustrated in Figure E.1.

Fundamental GPS standards

Global GPS standards

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

Figure E.1 — Position in the GPS matrix model

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E.4 Related International Standards

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

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Bibliography

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

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