# INTERNATIONAL STANDARD

# ISO 463

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# Geometrical Product Specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges

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

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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

This first edition of ISO 463 cancels and replaces ISO/R 463:1965, which has been technically revised.

# 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.

For more detailed information of the relation of the standard to other standards and the GPS matrix model see Annex D.

# Geometrical Product Specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of mechanical dial gauges

## 1 Scope

This International Standard specifies the most important design and metrological characteristics of mechanical dial gauges.

## 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/TS 14253-2, *Geometrical Product Specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

ISO 14978:—[1)], *Geometrical Product Specification (GPS) — General concepts and requirement for GPS measuring equipment*

*Guide to the expression of uncertainty in measurement (GUM).* BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1st edition, 1993, corrected and reprinted in 1995.

*International Vocabulary of Basic and General Terms in Metrology (VIM)*. BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993.

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14253-1, ISO/TS 14253-2, ISO 14978, VIM and the following apply.

**3.1**
**mechanical dial gauge**
measuring instrument in which the axial displacements of a plunger are transmitted and magnified by suitable mechanical means to a pointer which rotates in front of an analog circular scale

NOTE It may also be provided with a revolution-counting device, e.g. in which a pointer rotates in front of a scale which indicates the number of revolutions of the pointer or the axial displacement of the plunger.

1) To be published.

# 4 Design characteristics

## 4.1 General

The general design and workmanship shall be such that the performance of the dial gauge complies with the requirements of this International Standard unless otherwise specified by the manufacturer.

The design and rigidity of the dial gauge shall be such that the freedom of movement of the plunger is not impaired by clamping the stem of the instrument, providing that such clamping is applied to the minimum extent necessary to achieve a stable mounting. Where alternative methods of mounting are used, e.g. attaching the lug on the back plate, the design and rigidity of that mounting shall be such that the performance is not impaired.

## 4.2 Dimensions

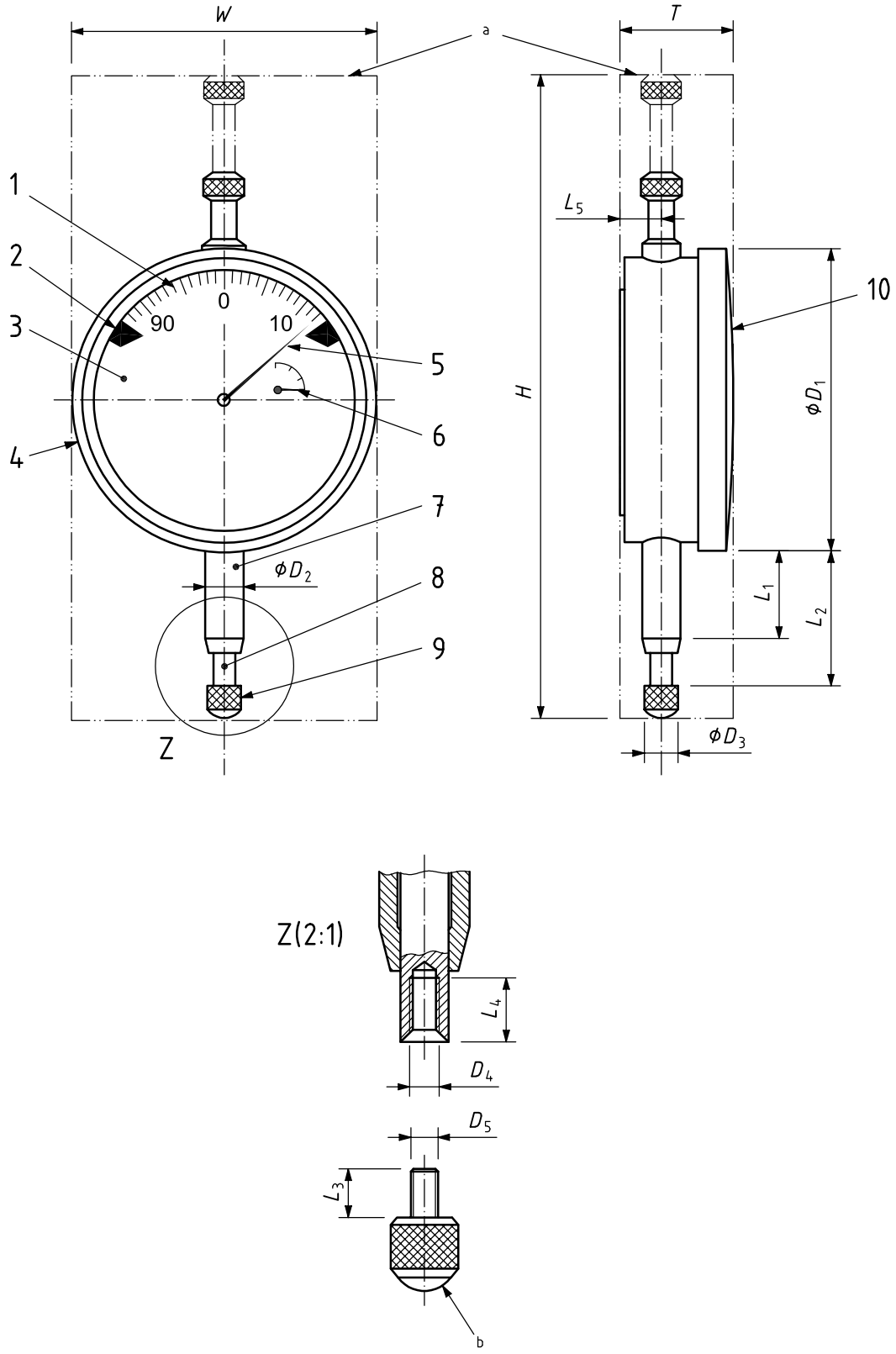
The dial gauge shall conform to the dimensions specified in Figures 1, 2 and Table 1 to ensure interchangeability.

**Table 1 — Main dimensions**

Values in millimetres

| | **Bezel diameter $D_1$** | | | | |
|---|---|---|---|---|---|
| **Size classification** | **30** | **40** | **60** | **80** | **100** |
| Range of bezel diameter $D_1$ [a] | 28 to 36 | 37 to 50 | 51 to 70 | 71 to 89 | 90 to 115 |
| Stem diameter $D_2$ | 8 h6 | 8 h6 | 8 h6 | 8 h6 | 8 h6 |
| Contact element outside diameter $D_3$ | $\leqslant$ 7,5 | $\leqslant$ 7,5 | $\leqslant$ 7,5 | $\leqslant$ 7,5 | $\leqslant$ 7,5 |
| Thread size $D_4$ | M2,5-6H | M2,5-6H | M2,5-6H | M2,5-6H | M2,5-6H |
| Thread size $D_5$ | M2,5-6g | M2,5-6g | M2,5-6g | M2,5-6g | M2,5-6g |
| Clamp diameter $D_6$ [b] | 28 h6 | 28 h6 | 28 h6 | 28 h6 | 28 h6 |
| Stem length $L_1$ | $\geqslant$ 8,5 | $\geqslant$ 10 | $\geqslant$ 12 | $\geqslant$ 15,5 | $\geqslant$ 9,5 |
| Length $L_2$ [c] | $\leqslant$ 12 | $\leqslant$ 28 | $\leqslant$ 34 | [d] | [d] |
| Thread length $L_3$ | $\leqslant$ 5 | $\leqslant$ 5 | $\leqslant$ 5 | $\leqslant$ 5 | $\leqslant$ 5 |
| Thread length $L_4$ | $\geqslant$ 6 | $\geqslant$ 6 | $\geqslant$ 6 | $\geqslant$ 6 | $\geqslant$ 6 |
| Contact distance, centreline to back, $L_5$ | $\leqslant$ 10 | $\leqslant$ 10 | $\leqslant$ 10 | $\leqslant$ 10 | $\leqslant$ 10 |

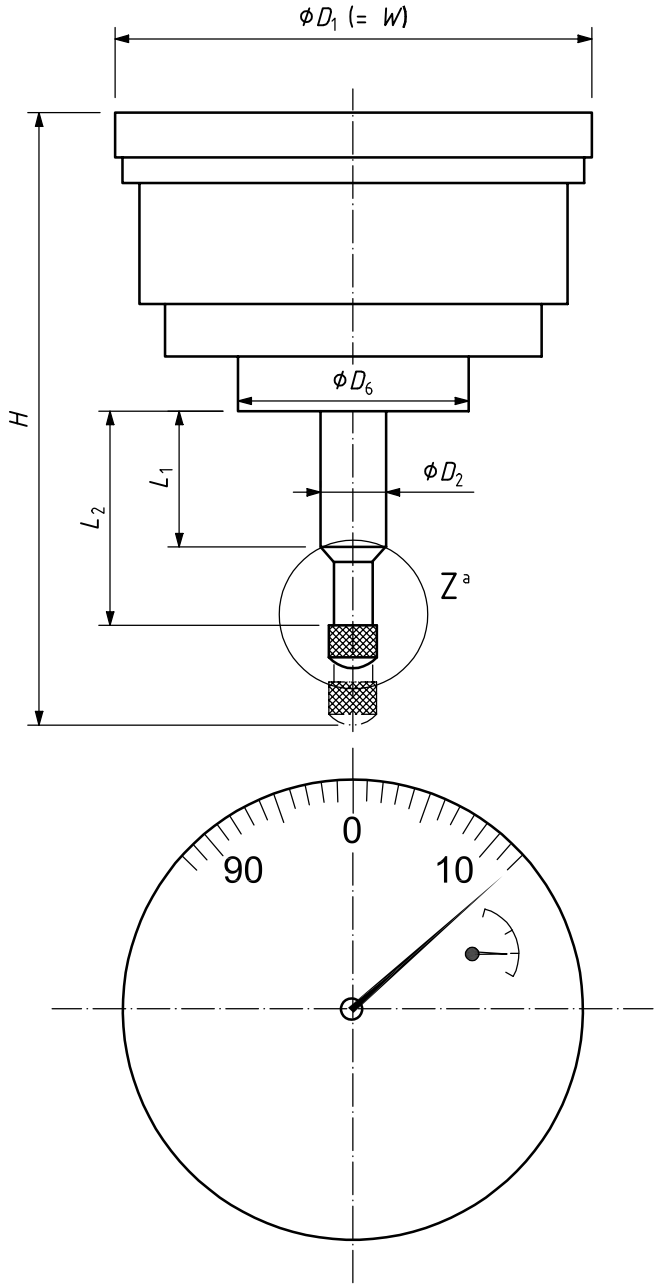
[a] Actual bezel diameter equals width.
[b] The clamp diameter $D_6$ is optional.
[c] Plunger pressed in.
[d] Depending on the measuring range.




**Key**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | scale | 4 | bezel | 7 | stem | 10 | dial cover |
| 2 | limit indicator | 5 | pointer | 8 | plunger | a | Maximum required space. |
| 3 | dial | 6 | revolution counting device | 9 | contact element | b | Measuring face. |

**Figure 1 — Nomenclature and general design of dial gauge**

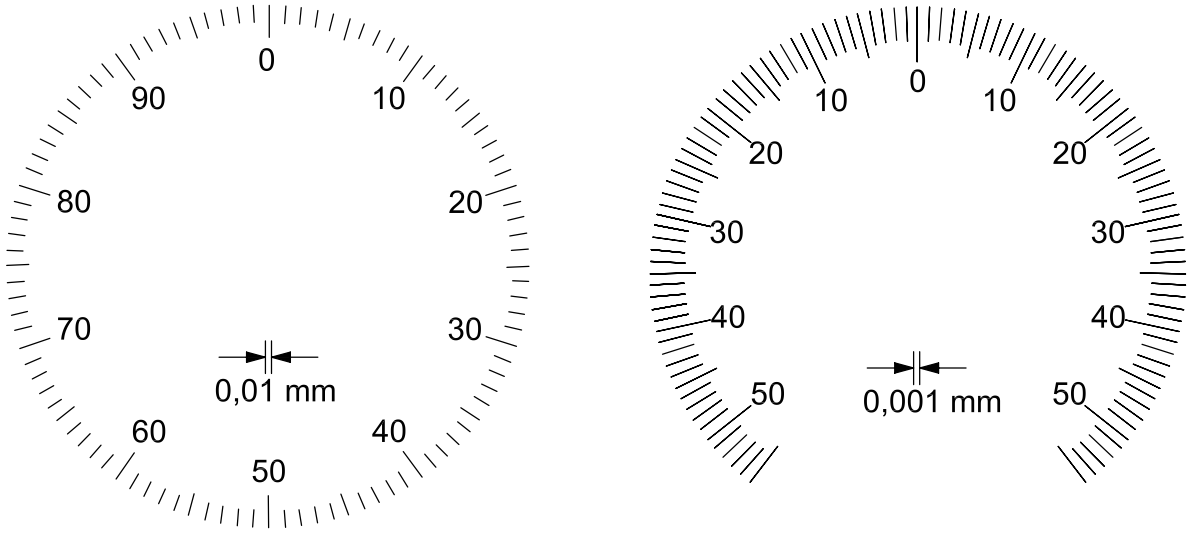



a See Figure 1.

**Figure 2 — Nomenclature and general design of dial gauge with plunger at rear**

### 4.3 Dial and pointer

The circular scale shall be graduated in scale intervals. The scale interval and its unit shall be clearly identified. Two examples of scale layouts are shown in Figure 3 (scale interval: 0,01 mm, 0,001 mm).




**a) Scale for multiple revolutions** **b) Scale for partial revolution**

**Figure 3 — Examples of scale layouts**

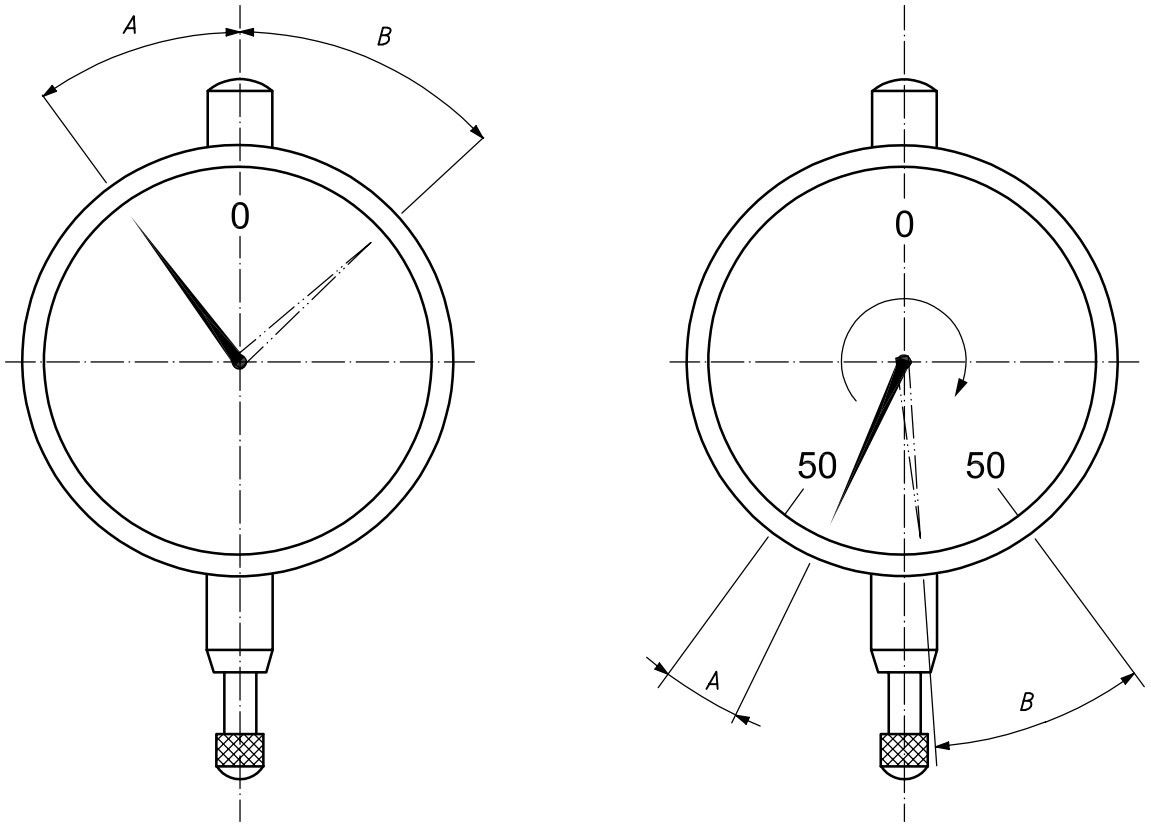
The pointer shall move in a clockwise direction when the plunger is pressed into the gauge.

For dial gauges with more than one pointer revolution [dial layout according to Figure 3 a)]:

— When the long pointer is in the position of rest and the zero mark on the dial is at 12 o'clock, the pointer shall lie at least 1/10th of the scale range in an anticlockwise position (pre-span). Travel beyond the measuring range (post-span) shall be not less than 1/10th of the scale range [see Figure 4 a)].

For dial gauges with less than one pointer revolution [dial layout according to Figure 3 b)]:

— When the plunger is in the position of rest, the pointer shall lie at least 3 scale intervals in an anticlockwise position (pre-span). The post-span (travel beyond the measuring range) shall be such that the pointer does not reach the position which it has in the position of rest. But the post-span shall be at least 3 scale intervals [see Figure 4 b)].




**a) Dial gauge with multiple revolutions** **b) Dial gauge with partial revolution**

**Key**

A pre-span

B post-span

**Figure 4 — Examples of pre-span and post-span**

## 4.4 Revolution counting device

When a revolution counting device is provided, its pointer shall indicate the appropriate division on its scale when the pointer is at 12 o'clock on each of its revolutions.

## 4.5 Contact element

The contact element shall be replaceable. It shall have a wear-resistant measuring surface and shall be of suitable form and surface finish (see Figure 1).

## 4.6 Zero adjustment

Each dial gauge shall be provided with a reliable means of resetting the gauge to zero that cannot be unintentionally displaced (other than by the application of excessive force), e.g. through provision of setting a locking device such as a clamp or by frictional resistance.

### 4.7 Movable limit indicators

Limit indicators, where provided shall not unduly impair visibility of the scale markings (see Figure 1).

### 4.8 Design characteristics (manufacturer's specification)

As a minimum requirement the manufacturer shall specify at least the information set out in Table 2 (see Annex B).

**Table 2 — Design characteristics**

| Characteristic | | | | |
|---|---|---|---|---|
| Maximum required space | Width $W$ | | | mm |
| | Thickness $T$ | | | |
| | Height $H$ | | | |
| Measuring range | | | | |
| Scale interval | | | | |
| Presence of | plunger lifting device | Yes/No | | |
| | attachment mounting and type [a] | Yes/No | | |
| | fluid and dust protection | (Code IP)/No | | |
| | plunger shock protection | Yes/No | | |
| [a] To be defined by the manufacturer. | | | | |

## 5 Metrological characteristics

### 5.1 MPE and MPL for a number of metrological characteristics

Maximum permissible error MPE is the extreme value of an error of a metrological characteristic permitted by the specification.

Maximum permissible limit MPL is the extreme value of a metrological characteristic permitted by the specification.

The manufacturer shall specify MPE and MPL information for the dial gauge metrological characteristics given in Table 3. Unless otherwise specified by the manufacturer, the static response of the dial gauge 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 gauge (see Table 3).

**Table 3 — Metrological characteristics**

| Characteristic | | MPE or MPL | |
|---|---|---|---|
| Hysteresis of error of indication [a] | | | μm |
| Repeatability of error of indication | | | |
| Errors of indication over a range of | any 1/10 revolution | | |
| | any 1/2 revolution | | |
| | one revolution | | |
| | the measuring range | | |
| Measuring force | maximum | | N |
| | minimum | | |
| | hysteresis | | |
| NOTE For the indication of the numerical values of the MPE and MPL, the data sheet given in Annex B can be used. | | | |
| [a] The discrimination is nearly half the hysteresis. | | | |

### 5.2 Contact element

The contact element 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, the minimum measuring force and the hysteresis of the measuring force.

The measuring force characteristics are based on a two-sided specification given in ISO 14978:—, 7.5.6.

## 6 Proving conformance with specification

### 6.1 General

For proving conformance/non-conformance with specification, ISO 14253-1 applies. Uncertainty evaluation shall be performed according to ISO/TS 14253-2 and GUM.

### 6.2 Measurement standards for calibration of metrological characteristics

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

## 7 Marking

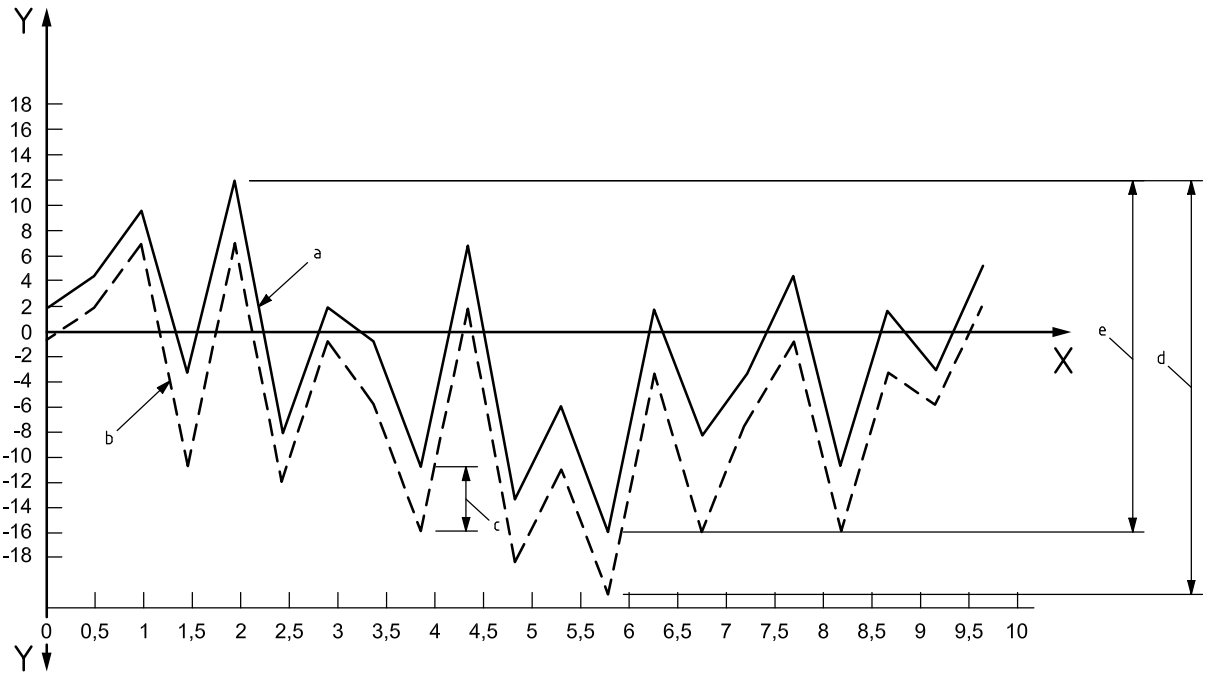
The dial gauge shall be marked with serialized alpha-numeric identification.

Any marking shall be easily readable and permanent and shall be placed on the surface of the dial gauge such that it will not impair the metrological quality of the equipment.

# Annex A
(informative)

# Example diagram of errors of indication

Figure A.1 shows an example of a diagram of errors of indication. This is a simplified data set (for data points) in order to illustrate the characteristics of the dial gauge. See also ISO 14978:—, Clause 7.




**Key**

X nominal value

Y error of indication

a Error curve (plunger outward movement).

b Error curve (plunger inward movement).

c Hysteresis at one particular nominal value.

d Error of indication (maximum) in both directions of plunger (floating zero).

e Error of indication in one direction of plunger.

**Figure A.1 — Diagram of errors of indication**

# Annex B
(informative)

# Example data sheet for mechanical dial gauges

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

**Name of equipment:** .....

Detailed requirements: .....

(scale layout, contact element, protection against fluid and dust, shock protection, lifting device, attachment mounting and type, etc.) .....

Accessories: .....

Possible suppliers/manufacturers: .....

Price range (optional): .....

Additional requirements: .....

(e.g. inspection report, calibration certificate) .....

***The design and metrological characteristics refer to ISO 463.***

## Design characteristics

Overall dimensions:

Thickness, $T$: ..... mm  Width, $W$: ..... mm  Height, $H$: ..... mm

Measuring range: ..... mm

Scale interval: ..... mm

## Metrological characteristics

Hysteresis of indication (MPE) ..... µm

Repeatability of indication (MPE) ..... µm

Errors (MPE) of indication over a range of:

| | |
|---|---|
| any 1/10 revolution | ..... µm |
| any 1/2 revolution | ..... µm |
| 1 revolution | ..... µm |
| the measuring range | ..... µm |

Measuring forces (MPL)

| | |
|---|---|
| maximum | ..... N |
| minimum | ..... N |
| hysteresis | ..... N |

*MPE and MPL in the following orientations:*

any ☐  vertical ☐  horizontal ☐

**Company** .....

Department.....  Person responsible .....  Date .....

# Annex C
(informative)

# Calibration of metrological characteristics

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

It is essential that the dial gauge 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 will necessitate a large number of readings to be taken. When it is considered that the intended use of the dial gauge does not warrant global calibration, partial calibration or task-related calibration should be considered.

For the determination of the indication errors according to Table 3, 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 with the constant symmetrical limits USL and LSL as the MPE for the measuring range (see ISO 14978:—, Figure 9).

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

Annex A shows an example of a diagram (with a very small number of scale points) of errors of indication (calibration curve) and hysteresis band of a dial gauge where zero was fixed at the lower limit of the measuring span.

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

# Annex D
(informative)

# Relation to the GPS matrix model

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

## D.1 Information about this International Standard and its use

This International Standard provides the most important design and metrological characteristics of mechanical dial gauges.

ISO 463 specifies the most important metrological and design characteristics of mechanical dial gauges. 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 that the values of these characteristics are matters of the manufacturer and/or user. However, ISO 463 provides definition of the metrological characteristics and states those metrological characteristics for which the manufacturer shall state a MPE or MPL value.

## D.2 Position in the GPS matrix model

This International Standard is a general GPS standard, which 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 dependent of datum, orientation, location, circular run-out and total run-out in the general GPS matrix, as graphically illustrated in Figure D.1

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

**Figure D.1 — GPS matrix**

## D.3 Related standards

The related standards are those of the chains of standards indicated in Figure D.1.

# Bibliography

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

[2] IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

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