
**Geometrical product specifications
(GPS) — General concepts and
requirements for GPS measuring
equipment**

*Spécification géométrique des produits (GPS) — Concepts et exigences
généraux pour les équipements de mesure GPS*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee 213, *Dimensional and geometrical product specifications and verification*.

This second edition cancels and replaces the first edition (ISO 14978:2006), which has been technically revised. It also incorporates the Technical Corrigendum ISO 14978:2006/Cor. 1:2008.

The main changes compared to the previous edition are as follows:

- the terms and definitions have been updated relative to ISO/IEC Guide 99:2007;
- a number of design characteristics common in GPS measuring equipment have been added;
- an updated discussion of calibration and verification, including concepts from ISO 14253-5:2015, has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences chain links F and G for measuring equipment and calibration in the general GPS matrix model (see [Annex E](#)).

The ISO/GPS matrix model given in ISO 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise indicated; see ISO/TR 14253-6 for additional information on the selection of alternative decision rules.

For more detailed information of the relation of this document to other standards and the GPS matrix model, see [Annex E](#).

This document contains guidance for writing the standards for specific GPS measuring equipment.

This document is intended to give the user a basic understanding of the use of ISO standards for GPS measuring equipment. This document presents and defines general concepts to be used in connection with GPS measuring equipment to avoid multiple repetitions in the ISO standards for specific GPS measuring equipment. This document is also intended as guidance for the manufacturer/supplier to evaluate and present specifications for characteristics for GPS measuring equipment.

This document is necessary when reading and using ISO standards for specific GPS measuring equipment.

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Geometrical product specifications (GPS) — General concepts and requirements for GPS measuring equipment

1 Scope

This document specifies the general requirements, calibration, terms and definitions of characteristics of GPS measuring equipment, for example micrometers, callipers, gauge blocks and rotary axis form measuring instruments. This document forms the basis for standards defining and describing the design characteristics and metrological characteristics for measuring equipment and gives guidance for the development and content of standards for GPS measuring equipment.

This document is intended to ease the communication between manufacturer/supplier and customer/user and to make the specification phase of GPS measuring equipment more accurate. This document is also intended as a tool to be used in companies in the process of defining and selecting relevant characteristics for measuring equipment.

This document includes terms which are frequently used in connection with the characterization of specific measuring equipment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 verifying conformity or nonconformity with specifications*

ISO 14253-5:2015, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 5: Uncertainty in verification testing of indicating measuring instruments*

ISO/TR 14253-6, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces*

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

ISO/IEC Guide 98-4:2012, *Uncertainty of measurement — Part 4: Role of measurement uncertainty in conformity assessment*

ISO/IEC Guide 99:2007, *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 99:2007, ISO/IEC Guide 98-4:2012, ISO 14253-1, ISO 14253-5:2015, ISO/TR 14253-6 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 ISO/IEC Guide 99:2007 terms

For the terms shown in [Table 1](#), the definitions from ISO/IEC Guide 99:2007 specifically apply in the use of this document. This non-exhaustive list is included to avoid ambiguity with other possible terms and definitions.

Table 1 — ISO/IEC Guide 99:2007 terms applicable in the use of this document

Term	Terminological entry number
calibration	2.39
indicating measuring instrument	3.3
indication	4.1
material measure	3.6
maximum permissible measurement error maximum permissible error limit of error	4.26
measurand	2.3
measured quantity value measured value	2.10
measurement method	2.5
measurement repeatability repeatability	2.21
measurement result result of measurement	2.9
measurement standard	5.1
measurement uncertainty uncertainty of measurement uncertainty	2.26
measuring instrument	3.1
measuring system	3.2
quantity value value	1.19
rated operating condition	4.9
reference material	5.13
reference measurement standard reference standard	5.6
reference quantity value reference value	5.18
resolution	4.14
uncertainty budget	2.33
verification	2.44

3.2 Synonym terms to ISO/IEC Guide 99:2007 terms

The terms shown in [Table 2](#), as used in this document, are synonyms for the ISO/IEC Guide 99:2007 terms as shown in the table. These synonym terms are used for consistency with previous versions of this document.

Table 2 — Synonym terms to ISO/IEC Guide 99:2007 terms

Synonym term used in this document	Notes	ISO/IEC Guide 99:2007	
measuring range	See Figure 5	measuring interval	4.7
nominal range	See Figure 5	nominal indication interval	4.4
nominal span	See Figure 5	range of a nominal indication interval	4.5
error of indication indication error		measurement error error	2.16

3.3 ISO/IEC Guide 98-4:2012 terms

For the terms shown in [Table 3](#), the definitions from ISO/IEC Guide 98-4:2012 specifically apply in the use of this document. This non-exhaustive list is included to avoid ambiguity with other possible terms and definitions.

Table 3 — ISO/IEC Guide 98-4:2012 terms applicable in the use of this document

Term	Terminological entry number
decision rule	3.3.12
specified requirement	3.3.3
tolerance limit specification limit	3.3.4

3.4 ISO 14253-5:2015 terms

For the terms shown in [Table 4](#), the definitions from ISO 14253-5:2015 specifically apply in the use of this document. This non-exhaustive list is included to avoid ambiguity with other possible terms and definitions.

Table 4 — ISO 14253-5:2015 terms applicable in the use of this document

Term	Terminological entry number
test measurand	3.4
test protocol	3.5
test value	3.8
test value uncertainty test uncertainty	3.9

3.5 Terms related to GPS measuring equipment

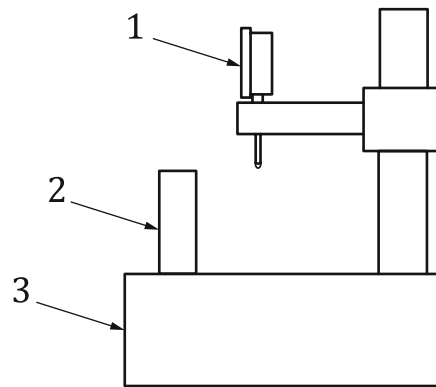
3.5.1 measuring equipment

indicating measuring instrument, material measure, software, measurement standard, reference material or auxiliary equipment used in a measurement

Note 1 to entry: This definition is necessarily wider than that of a measuring instrument since it includes all the devices used in a measurement.

Note 2 to entry: Measuring equipment should not be confused with a measuring system, which is a set of measuring equipment used together for a specific measurement.

Note 3 to entry: See [Figure 1](#).



Key

- 1 indicating measuring instrument (dial gauge)
- 2 material measure (gauge block)
- 3 auxiliary equipment (measuring stand)

Figure 1 — A measuring system composed of various pieces of measuring equipment

3.5.2 metrological characteristic

<measuring equipment> characteristic of measuring equipment, which may influence the results of measurement when using the measuring equipment

Note 1 to entry: The influence on the results of measurement is a contributor to measurement uncertainty (see [Clause 6](#)).

Note 2 to entry: The values of a metrological characteristic are expressed in numerical values or as a function and can be evaluated in units other than that of the measurement results.

Note 3 to entry: Measuring equipment usually has several metrological characteristics.

Note 4 to entry: Metrological characteristics can be subject to calibration and verification.

3.5.3 task-related calibration

<measuring equipment> calibration of only those metrological characteristics which influence the measurement uncertainty for the intended use

3.5.4 design characteristic

<measuring equipment> characteristic of measuring equipment which does not influence the measurement directly, but which may be of interest for other reasons when the measuring equipment is used

Note 1 to entry: Design characteristics can influence, for example, interchangeability, scale mark readability for a straight or circular scale, or wear resistance (see [Clause 5](#)).

Note 2 to entry: Some design characteristics can influence the equipment's long-term capacity to make measurements (influencing design characteristics), for example its wear resistance or its environmental resistance. Other design characteristics have no influence on measurements (non-influencing design characteristics).

Note 3 to entry: A design characteristic might be expressed as, for example, dimensions, material properties or interface protocols.

3.5.5**maximum permissible limit****MPL**

tolerance limit for a metrological characteristic which is not an error of indication

Note 1 to entry: MPE, not MPL, should be used for metrological characteristics associated with errors of indication.

EXAMPLE 1 MPL for the measuring force for micrometers for external measurements.

EXAMPLE 2 MPL for the size of the gauge element of a plain limit gauge of linear size.

3.5.6**verification test****test**

operation that, under specified conditions and with sufficient objective evidence, establishes that measuring equipment conforms or does not conform to stated specifications

Note 1 to entry: A verification test can be used as the calibration when both the first and second step in the definition of calibration are appropriately satisfied (see 6.1.4).

Note 2 to entry: This definition is consistent with the definition of a test in ISO 14253-5:2015, but is broader in scope as the concept of a test in ISO 14253-5:2015 is limited to indicating measuring instruments.

Note 3 to entry: The detailed specification of a verification test is defined in a test protocol.

Note 4 to entry: The specified conditions of a verification test are defined by relevant standards and by the stated rated operating conditions of the measuring equipment.

3.5.7**acceptance test**

verification test (3.5.6) agreed upon by the measuring equipment manufacturer/supplier and the customer to verify that the performance of the measuring equipment is as stated by the manufacturer/supplier

Note 1 to entry: Acceptance tests are commonly used by the customer in the purchase of measuring equipment.

3.5.8**reverification test**

verification test (3.5.6) to verify that the performance of the measuring equipment is as stated by the user

Note 1 to entry: The specifications chosen might or might not be the same as those used in the original acceptance test for the measuring equipment.

Note 2 to entry: Reverification tests are not used in the purchase of measuring equipment.

3.5.9**test point**

specific point within the measuring range used in a verification test

Note 1 to entry: Test points are usually defined relative to a reference point.

3.5.10**reference point****setting point**

point within the measuring range of measuring equipment where the error of indication is stated or adjusted to be zero whenever permitted by the design of the measuring equipment

Note 1 to entry: Depending on the measuring equipment, the reference point might or might not be considered fixed (established in a permanent manner) for the intended use of the equipment.

3.5.11

hysteresis

property of measuring equipment, or a metrological characteristic, whereby the indication of the equipment or value of the metrological characteristic depends on the orientation of the preceding stimulus

3.5.12

digital step

smallest possible change in the least significant digit in a digital indicating device

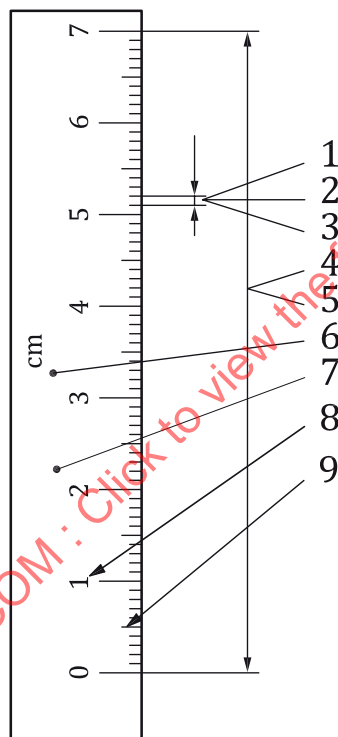
Note 1 to entry: For a digital indicating device, the resolution is equal to the digital step.

3.5.13

scale division

space on a scale between any two successive scale marks

Note 1 to entry: See [Figures 2](#) and [3](#).



Key

- 1 scale division
- 2 scale interval: in this example, 0,1 cm
- 3 scale spacing: in this example, 0,1 cm
- 4 scale length: in this example, 7 cm
- 5 scale range: in this example, 0 to 7 cm; scale span: in this example, 7 cm
- 6 units marked on the scale (in this example, cm)
- 7 scale face
- 8 scale numbering: in this example 0, 1,...,7
- 9 scale mark

Figure 2 — Terms related to an analogue straight scale

3.5.14**scale interval**

absolute value of the difference between the values corresponding to two successive scale marks, in the units marked on the scale

Note 1 to entry: Scale interval should not be confused with resolution, which is not necessarily equal to the scale interval.

Note 2 to entry: See [Figures 2](#) and [3](#).

3.5.15**scale spacing**

<analogue straight scale> distance between two successive scale marks

Note 1 to entry: See [Figure 2](#).

3.5.16**scale spacing**

<analogue circular scale> arc length between two successive scale marks of the circle passing through the centres of all the shortest scale marks

Note 1 to entry: See [Figure 3](#).

3.5.17**scale length**

<analogue straight scale> length between the first and the last scale marks

Note 1 to entry: See [Figure 2](#).

3.5.18**scale length**

<analogue circular scale> arc length of the circle passing through the centres of all the shortest scale marks

Note 1 to entry: See [Figure 3](#).

3.5.19**scale range**

set of values bounded by the extreme indications

Note 1 to entry: The lower limit of the scale range is not necessarily zero, for example in the case of an internal micrometer whose scale range starts at 5 mm.

Note 2 to entry: See [Figures 2](#) and [3](#).

3.5.20**scale span**

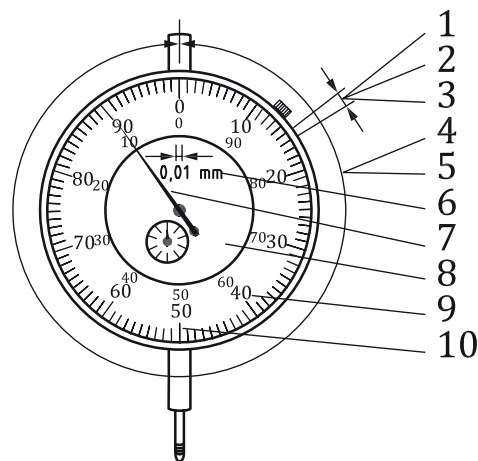
absolute value of the difference between the two limits of a scale range

Note 1 to entry: See [Figures 2](#) and [3](#).

3.5.21**index**

fixed or movable part of an analogue indicating device whose position with reference to the scale marks enables an indicated value to be determined

Note 1 to entry: For some measuring equipment, the index is called the “pointer”.



Key

- 1 scale division
- 2 scale interval: in this example, 0,01 mm
- 3 scale spacing: in this example, approximately 1 mm
- 4 scale length: in this example, approximately 100 mm (for a diameter of 32 mm)
- 5 scale range: in this example, 0,00 to 1,00 mm; scale span: in this example, 1 mm
- 6 units marked on the scale (in this example, mm)
- 7 pointer
- 8 scale face
- 9 scale numbering: in this example there are two sets of scale numbering
- 10 scale mark

Figure 3 — Terms related to an analogue circular scale

3.5.22

scale face

surface of measuring equipment that carries the scale

Note 1 to entry: See [Figures 2](#) and [3](#).

3.5.23

scale numbering

ordered set of numbers associated with the scale marks

Note 1 to entry: See [Figures 2](#) and [3](#).

3.5.24

scale mark

lines on the scale face

Note 1 to entry: See [Figures 2](#) and [3](#).

3.5.25

probe

device that generates a signal which is used in the determination of a measured value

Note 1 to entry: For some measuring equipment, the probe is called the “sensor” or “detector”.

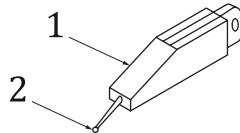
Note 2 to entry: See [Figure 4](#).

3.5.26**measuring element**

element of measuring equipment that interacts with a measured item during a measurement

Note 1 to entry: For some measuring equipment, the measuring element is called the “measuring face”, the “stylus tip” or the “contact element”.

Note 2 to entry: See [Figure 4](#).

**Key**

- 1 probe
- 2 measuring element (stylus tip)

Figure 4 — Terms related to a probe

3.5.27**measuring span**

absolute value of the difference between the extreme quantity values of a measuring range

Note 1 to entry: See [Figure 5](#).

3.5.28**pre-range**

range of indications obtainable with a particular setting of measuring equipment from the lowest possible indication to the lower limit of the measuring range

Note 1 to entry: See [Figure 5](#).

3.5.29**pre-span**

absolute value of the difference between the two limits of a pre-range

Note 1 to entry: See [Figure 5](#).

3.5.30**post-range**

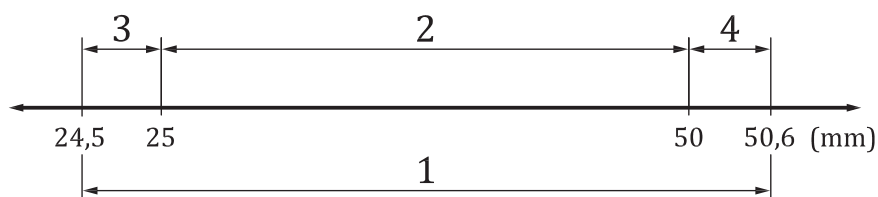
range of indications obtainable with a particular setting of measuring equipment from the upper limit of the measuring range to the highest possible indication

Note 1 to entry: See [Figure 5](#).

3.5.31**post-span**

absolute value of the difference between the two limits of a post-range

Note 1 to entry: See [Figure 5](#).

**Key**

- | | | |
|---|------------------|---------------------------------------|
| 1 | nominal range: | 24,5 mm to 50,6 mm |
| | nominal span: | 26,1 mm (50,6 mm – 24,5 mm = 26,1 mm) |
| 2 | measuring range: | 25 mm to 50 mm |
| | measuring span: | 25 mm (50 mm – 25 mm = 25 mm) |
| 3 | pre-range: | 24,5 mm to 25 mm |
| | pre-span: | 0,5 mm (25 mm – 24,5 mm = 0,5 mm) |
| 4 | post-range: | 50 mm to 50,6 mm |
| | post-span: | 0,6 mm (50,6 mm – 50 mm = 0,6 mm) |

NOTE An external micrometer with a measuring range of 25 mm – 50 mm has been used as an example.

Figure 5 — Range and span terms

4 Abbreviations

For the purposes of this document, the abbreviations in [Table 5](#) apply.

Table 5 — Abbreviations

Abbreviation	Term	Reference
MPE	maximum permissible measurement error maximum permissible error limit of error	ISO/IEC Guide 99:2007, 4.26
MPL	maximum permissible limit	3.5.5

5 Design characteristics

5.1 General

5.1.1 Importance of design characteristics

Design characteristics for measuring equipment can be of interest even if they do not have an influence on the uncertainty of measurement, for example for the sake of interchangeability. Important design characteristics may be subject to specification by the manufacturer/supplier and/or the user/customer of the measuring equipment. The kinds of important design characteristics are dependent on the type, design and intended use of the measuring equipment.

Some design characteristics may have an influence on the equipment's long-term ability to measure, for example wear may influence some of the metrological characteristics.

Design characteristics common to a variety of measuring equipment are as specified in [Annex C](#).

5.1.2 Standards for measuring equipment

Relevant design characteristics are subject to standardization in specific ISO standards concerning the individual types of measuring equipment. This standardization shall be limited to the most important design characteristics so as not to limit development of measurement technology.

The specific ISO standards concerning the individual types of measuring equipment can use two approaches for design characteristics:

- listing of the design characteristics to be explicitly stated by the manufacturer/supplier, including associated values and/or tolerance limit values;

EXAMPLE 1 Calliper manufacturer/supplier states length of jaws for external measurements (ISO 13385-1).

- listing of the design characteristics and associated values and/or tolerance limit values to be standardized.

EXAMPLE 2 Standardized diameter of stem for interchangeability of dial gauges (ISO 463).

Those design characteristics, if any, which are of uppermost importance and therefore are to be standardised shall be evaluated and decided for the specific measuring equipment. The lists in 5.2 and 5.3 shall be used as guidance for the ISO standards on specific measuring equipment.

5.1.3 Measuring equipment — Commerce

In product documentation, for example data sheets, intended to give customers information on a product, manufacturers and suppliers of GPS measuring equipment shall at least present the suggested design characteristics given in the relevant specific standard.

It may be in the interests of the manufacturer/supplier to supply additional relevant information about design characteristics (see [Annex B](#)).

A customer may have special requirements for additional design characteristics. This document may be used as a tool to establish those specifications.

5.1.4 Measuring equipment — Internal use in a company

Design characteristics shall be used in trade but not necessarily used or verified in daily operation in a company. Design characteristics and possible requirements standardised in an ISO standard for specific measuring equipment shall not be taken as mandatory in the daily operation of the measuring equipment unless specific decisions in the organization/company make them mandatory.

Generally speaking, an organization or a company may establish a set of design characteristics based on local needs and conditions. These technical decisions should also be evaluated in terms of costs and communicated on a data sheet (see [Annex B](#)).

5.2 Design characteristics for indicating measuring instruments

Typical design characteristics for indicating measuring instruments are related to the importance of the characteristics in the use of the indicating measuring instrument. The following non-exhaustive list of reasons and design characteristics shall only be considered as examples. In many cases, specific design characteristics exist for a specific use and for specific types of indicating measuring instruments.

- interchangeability;

EXAMPLE 1 Overall and detail measures, measuring range, clamping or mounting system, relevant geometry/tolerances.

- wear resistance;

EXAMPLE 2 Material and/or hardness of relevant parts of the equipment.

- environment protection;

EXAMPLE 3 Water protection, dust protection, electrical protection, corrosion protection, radiation protection.

- electrical requirements;

EXAMPLE 4 Interface protocols, power supply.

- special operating features;

EXAMPLE 5 Hoisting/lifting devices, alignment devices.

- operating limitations;

EXAMPLE 6 Maximum speed of travel, temperature range, power and air supply stability, pressure resistance.

- special auxiliary equipment.

EXAMPLE 7 Surface plate, V-block, clamping devices.

5.3 Design characteristics for material measures

Typical design characteristics for material measures are related to the importance of the characteristics in the use of the material measure. The following non-exhaustive list of reasons and design characteristics shall only be considered as examples. In many cases, specific design characteristics exist for specific types of material measures.

- interchangeability;

EXAMPLE 1 Overall and detail measures, measuring range, clamping or mounting system, relevant geometry/tolerances.

- wear resistance;

EXAMPLE 2 Material and/or hardness of relevant parts of the material measure.

- environment protection ;

EXAMPLE 3 Corrosion protection.

- operating limitations;

EXAMPLE 4 Humidity, chemical environment.

- special auxiliary equipment.

EXAMPLE 5 Surface plate, V-block, clamping devices.

6 Metrological characteristics

6.1 General

6.1.1 Importance of metrological characteristics

Metrological characteristics of measuring equipment are of interest for the control of errors and uncertainty contributors originating from the measuring equipment and for the evaluation of measurement uncertainty when using the measuring equipment. An awareness of the metrological characteristics and the magnitude of their values may serve as a basis for the choice of the measuring equipment and measurement method. MPEs and MPLs are specified requirements that limit permissible values of metrological characteristics and therefore are of interest in commerce and in the use of measuring equipment.

6.1.2 Standards for measuring equipment

Metrological characteristics relevant for common use of specific measuring equipment shall be identified, designated (by name and symbol) and defined in the standards for specific types of measuring equipment. These standards shall state which metrological characteristics require MPEs or MPLs, shall designate these MPEs or MPLs, and shall include templates for MPE or MPL values as a guidance for the user of the standard. Where necessary and practical, the standards for specific measuring equipment may include numerical values for the MPEs and MPLs, and in those cases, the standards shall be clear on how alternative values can be stated. For the format and definition of some general metrological characteristics and their MPE or MPL values or functions see [Clause 7](#).

The standards for specific measuring equipment shall include a decision rule when defining an MPE or MPL that applies if no decision rule is stated by the manufacturer/supplier and if the manufacturer/supplier and customer/user have no other agreement. See ISO 14253-1 and ISO/TR 14253-6 for more information on decision rules.

6.1.3 Identification, definition and choice of metrological characteristics

Metrological characteristics of measuring equipment may be chosen and defined in several ways. As far as possible, the metrological characteristics, the definition of any requirements (MPE or MPL definitions) for these characteristics and the associated rated operating conditions shall be chosen and defined with respect to:

- the common intended use of the equipment;
- the independence of other metrological characteristics;
- the uncertainty in measurement of the equipment in the measuring process;
- the relevance of the physical principles inherent in the measuring equipment;
- the use in calibration activities and error identification;
- the relation to specific parts and/or functions in the measuring equipment;
- the measurement principle or method;
- the relevance of magnitude compared to the other metrological characteristics.

In special cases, it may be beneficial for a user of measuring equipment to define metrological characteristics other than those given in the standards in order to better fit the needs and intended use of the measuring equipment.

6.1.4 Calibration and verification of measuring equipment

This document considers cases where the calibration of measuring equipment is established through measurement results for specific metrological characteristics. As shown in [Figure 6](#), the calibration of metrological characteristics involves one of the following two methods:

- measurement used to assign reference value(s) associated with metrological characteristics of measuring equipment and which are intended to be applied in subsequent use of the measuring equipment for obtaining measurement results (see [Figure 6](#), left column);

EXAMPLE 1 For a gauge block, the calibration can involve measuring and assigning a value for the central length (l_c) as defined in ISO 3650 when this central length is intended to be applied in subsequent use of the gauge block.

- measurement of test value(s) used in the determination of conformance to stated specifications (a verification test) following an established test protocol, when conformance to specification is the information applied in subsequent use of the measuring equipment for obtaining measurement results (see [Figure 6](#), right column).

EXAMPLE 2 For a gauge block, the calibration can involve determining conformance to specification for limit deviation of length (t_e) and variation in length (t_v) as defined in ISO 3650 when this conformance to specification is intended to be applied in subsequent use of the gauge block.

EXAMPLE 3 For a micrometer, the calibration can involve determining conformance to specification for full surface contact error (MPE_f) as defined in ISO 3611 when this conformance to specification is intended to be applied in subsequent use of the micrometer.

In some situations, depending on the metrological characteristic, an assigned reference value can also be used as a test value in a verification test.

There are many cases for GPS measuring equipment when the verification of metrological characteristics to stated specifications is used as the calibration. In this document, the concept of calibration includes both verification and assignment of reference values, but this document also applies to verifications that are not used as calibrations. Verifications of metrological characteristics of measuring equipment, whether used as the calibration or not, follow the same sequence of events as shown in the right column of [Figure 6](#).

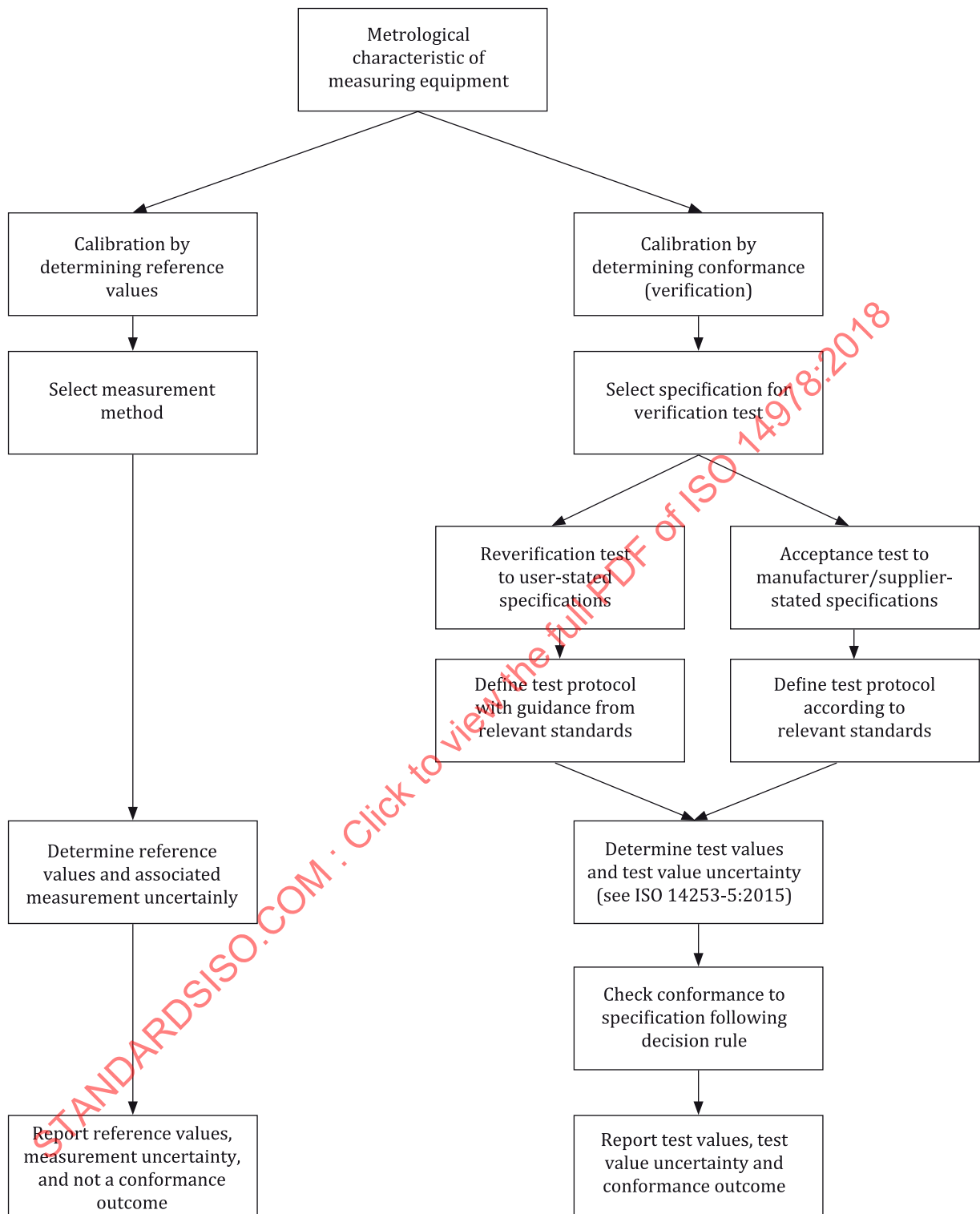


Figure 6 — Calibration and verification of metrological characteristics

6.1.5 Calibration and verification methods

6.1.5.1 General

The standards for specific measuring equipment shall include sufficient details such that all relevant metrological characteristics have adequately defined measurands. For those metrological

characteristics with MPEs or MPLs, this information shall sufficiently define the test protocol used in verification testing.

6.1.5.2 Definition of indication and error of indication

The standards for specific measuring equipment shall appropriately define an indication. In general, the specified MPE or MPL values or functions should apply to any and all unique measured indications made under reasonable use of the measuring equipment. Averaging of several indications to determine a measured value, or other data treatment, is generally not permitted unless explicitly stated in the definition of the error of indication.

6.1.5.3 Rated operating conditions

6.1.5.3.1 General

All metrological characteristics and any associated MPE or MPL values or functions apply at the rated operating conditions of the specific measuring equipment. Rated operating conditions shall be given in standards for specific measuring equipment or shall be stated by the measuring equipment manufacturer/supplier. In general, the user/customer of the measuring equipment is permitted to choose any conditions for calibration and verification testing within the rated operating conditions of the measuring equipment. In verification testing, when a rated operating condition is defined as an interval, then the test conditions shall be within this interval. When a rated operation condition is defined as an exact value, then the exact value shall be included in the definition of the measurand.

The following are some examples of rated operating conditions that may apply:

- reference point being fixed or not;
- specific direction of travel or both directions of travel included (hysteresis included or not);
- permissible environmental conditions;
- use of interchangeable accessories, if applicable, for example probe or measuring element;
- setup of the measuring equipment, if applicable, for example magnification or resolution;
- other measurement conditions, for example maximum speed of travel, measuring force.

All metrological characteristics and associated MPE or MPL values or functions apply to all possible orientations in space of the measuring equipment unless particular restrictions on the orientation are stated in the rated operating conditions in the standard for the specific measuring equipment or by the manufacturer/supplier.

6.1.5.3.2 Temperature

The standards for specific measuring equipment shall address the influence of temperature. A metrological characteristic shall be defined at either 20 °C or have a rated operating condition of a defined temperature interval, for example 18 °C to 22 °C, where the interval is typically defined by the manufacturer/supplier (for acceptance tests) or the user (for reverification tests). The selection of the exact value versus interval should take into account the complexity of the measuring equipment, and for verification tests, the likely testing method (see ISO 14253-5:2015 for further details).

EXAMPLE The MPE values for a height gauge, according to ISO 13225, are defined at 20 °C. This rated operating condition, being an exact value, cannot be met during verification testing. In this case, 20 °C becomes part of the definition of the test measurand.

6.1.5.3.3 Reasonably skilled user

Unless otherwise specified, metrological characteristics apply under condition of use by reasonably skilled users. A skilled user of the measuring equipment should expect to be able to operate the

measuring equipment within stated specifications. This reasonable user principle is an implicit rated operating condition associated with stated specifications that is required to be met during a verification test. In this manner, the user becomes part of the measuring system under test, and variation in errors of indication due to the skills of a reasonable user are part of what is being tested.

Some measuring equipment, in and of itself, does not consist of a complete measuring system capable of producing a measurement result. In these cases, when the measuring equipment is only used as part of a larger measuring system, the conditions of actual use may be varied and possibly unknown during calibration. In these cases, the user might not be considered part of the measuring equipment being tested and the reasonable user principle may not apply.

NOTE This document does not define the skills necessary to be considered a reasonably skilled user.

EXAMPLE A calliper (ISO 13385-1) is a manually operated measuring instrument designed to be used by a skilled user. The specifications of a calliper are valid for a user of reasonable skill.

6.1.5.4 Number of test points in verification testing

The verification testing of MPEs or MPLs shall be carried out with a sufficient number of test points and with a calibration process that has a sufficiently small test uncertainty. The standards for specific measuring equipment shall include requirements and guidance on the selection of test points to sufficiently define the test protocol used in verification testing and to eliminate ambiguity in the verification testing. What constitutes a sufficient number of test points depends on the design of the measuring equipment, the metrological characteristic and the rated operating conditions.

6.1.6 Measuring equipment — Commerce

For acceptance tests, MPE or MPL values or functions for metrological characteristics shall be supplied by the manufacturer/supplier. The specified MPE or MPL values or functions should include the applicable decision rule; see ISO/TR 14253-6 for the selection of an economically optimal decision. If no decision rule is stated, then the default rule in ISO 14253-1 applies.

The manufacturer/supplier may add additional information about metrological characteristics and their MPE or MPL values or functions. The manufacturer/supplier may set up restrictions and rated operating conditions not stated in this document or in the standard for the specific measuring equipment.

Information about MPE or MPL values or functions, additions, conditions and restrictions shall be indicated by the manufacturer/supplier in data sheets or other documents.

6.1.7 Measuring equipment — Internal use in a company

For reverification tests, MPE or MPL values or functions for metrological characteristics shall be supplied by the user. The user should identify and understand the important metrological characteristics by means of evaluating the measurement uncertainty.

6.2 Indicating measuring instruments

6.2.1 General

In many cases, the following metrological characteristics will be relevant for indicating measuring instruments.

6.2.2 Scale interval — Resolution

6.2.2.1 General

In analogue measuring instruments, the scale interval and/or the resolution are relevant metrological characteristics and shall be stated in the standards for specific measuring equipment.

6.2.2.2 Scale interval

A “scale interval” and a “vernier scale interval” are to be understood in a similar way, but the vernier scale interval is the (main) scale interval divided by the number of the scale divisions of the vernier. A reading on a vernier scale takes place when a main scale line is at the nearest point of coincidence with a vernier scale line.

6.2.2.3 Resolution of reading

The resolution can be smaller than the scale interval, but this is dependent on the design of the scale and the quality of the scale marks and index.

6.2.3 Digital step

Digital step is the resolution of a digital indicating device, and is therefore mandatory information.

6.2.4 Error of indication

6.2.4.1 General

Appropriate errors of indication shall be defined in the standards for specific measuring equipment. The limits of error are to be defined as an MPE value or function in accordance with one of the options given in [Clause 7](#).

6.2.4.2 Error of indication of length

Errors of indication of length are determined as a measured length minus the value of a reference standard of length according to the test protocol.

6.2.4.3 Error of indication of form

The determination of errors of indication of form usually require a reference standard of form, for example optical flat. The method to determine errors of indication of form is as either a single overall value or individual values at multiple points, and the method shall be included in the standards for specific measuring equipment.

6.2.4.4 Error of indication of orientation

The determination of errors of indication of orientation, for example parallelism or perpendicularity, usually require a specially designed reference standard, such as precision square. The method to determine errors of indication of orientation shall be included in the standards for specific measuring equipment.

6.2.4.5 Repeatability

Repeatability is typically expressed as either the range or standard deviation of measured values. The standards for specific measuring equipment shall either define the method by which repeatability is to be determined or require the method to be stated with the MPE specifications.

6.2.4.6 Hysteresis

Metrological characteristics expressing hysteresis of indication are typically defined as the difference in indication associated with two (or more) different orientations of the preceding stimulus at any point in the measuring range. Hysteresis may, for simplification, be included in other errors of indication, for example an error of indication of length. Hysteresis may be of interest in connection with other metrological characteristics.

6.2.5 Temperature-related metrological characteristics

If relevant, the coefficient of thermal expansion of the measuring equipment, and its uncertainty, shall be given.

6.2.6 Characteristics related to measuring force

MPL values or functions for measuring forces shall be a metrological characteristic, if relevant. For reasons of interchangeability, measuring forces for specific measuring equipment may also be given in the ISO standards as design characteristics.

The repeatability of measuring force is an important characteristic in many cases, but the effect may be included in the repeatability of indication. Only in special cases is the repeatability of measuring force(s) of specific interest.

6.2.7 Geometry of contact element

Contact element geometry, for example rounding and surface texture, may influence measurement results and therefore may be subject to metrological characteristic requirements.

6.2.8 Auxiliary equipment

When measuring instruments are mounted in auxiliary equipment during operation, the auxiliary equipment can add uncertainty contributions and therefore may be subject to metrological characteristic requirements.

A common example where the characteristic of a piece of auxiliary equipment influences the measurements is shown on [Figure 7](#). The measuring stand is an important part of the measuring loop, which is the closed chain necessary for an indication which comprises all items connecting the workpiece and measuring equipment. In the example shown in [Figure 7](#), the measurements are influenced by the stiffness of the stand, the temperature and the temperature gradients of the measuring stand.

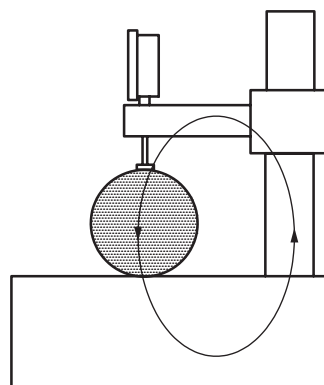


Figure 7 — Measurement loop involving auxiliary equipment

6.3 Material measures

6.3.1 General

In many cases, the following metrological characteristics will be relevant for material measures.

6.3.2 Scale interval — Resolution of reading

6.3.2.1 General

In the case of a graduated material measure, the scale interval and/or the resolution of reading shall be given in the specifications (see [6.2.2](#)).

6.3.2.2 Scale interval

See [6.2.2.2](#).

6.3.2.3 Resolution of reading

See [6.2.2.3](#).

6.3.3 Form of feature characteristics

Form specifications for geometrical features of a material measure, when necessary, shall be given with reference to relevant ISO standards. As far as possible, form characteristics and error of the relevant metrological characteristic inherent in the material measure shall be defined independently of each other.

6.3.4 Orientation of feature characteristics

Orientation specifications for geometrical features of a material measure, when necessary, shall be given with reference to relevant ISO standards. As far as possible, orientation characteristics and error of the relevant metrological characteristic inherent in the material measure shall be defined independently of each other.

6.3.5 Temperature-related metrological characteristics

If relevant, the coefficient of thermal expansion of the measuring equipment, and its uncertainty, shall be given.

6.3.6 Geometrical stability

For material measures, the geometrical stability of measuring equipment in time is a relevant and important metrological characteristic. This characteristic shall be considered in the ISO standard for the specific material measure.

6.3.7 Other possible metrological characteristics

A number of additional metrological characteristics may exist. Examples are:

- effective Young's modulus;
- orientation and support sensitivity;
- measuring force and gravity force sensitivity;
- effect of contact element geometry.

7 Specification and presentation of metrological characteristics

7.1 General

A metrological characteristic of measuring equipment can be expressed as:

- a single characteristic value;
- a set of characteristic values;
- a function of values.

7.2 Specification of metrological characteristics

7.2.1 General

Specification limits for metrological characteristics of measuring equipment expressed as a single characteristic value shall be defined and given as MPE or MPL values.

Specification limits for metrological characteristics of measuring equipment defined in a measuring range shall be defined and given as an MPE or MPL function. The MPE or MPL functions shall preferably be continuous and linear within a given measuring range.

MPE or MPL values or functions may be given as one-sided or two-sided specifications. When indicating MPE or MPL values or functions, the plus/minus symbol ($\pm$) shall be used for symmetrical specifications. For either one-sided or asymmetrical specifications, the plus symbol (+) and/or the minus symbol (–) shall be used; however, the plus symbol (+) is optional for one-sided positive specifications.

MPE values or functions for an error of indication of length shall generally be two-sided symmetrical specifications limiting the absolute value of the error (see [Figures 8, 9 and 10](#)). MPE values or functions for an error of indication of form or orientation may be either one-sided or two-sided.

The specific standard for the measuring equipment shall state whether or not a fixed reference point applies to the metrological characteristic(s).

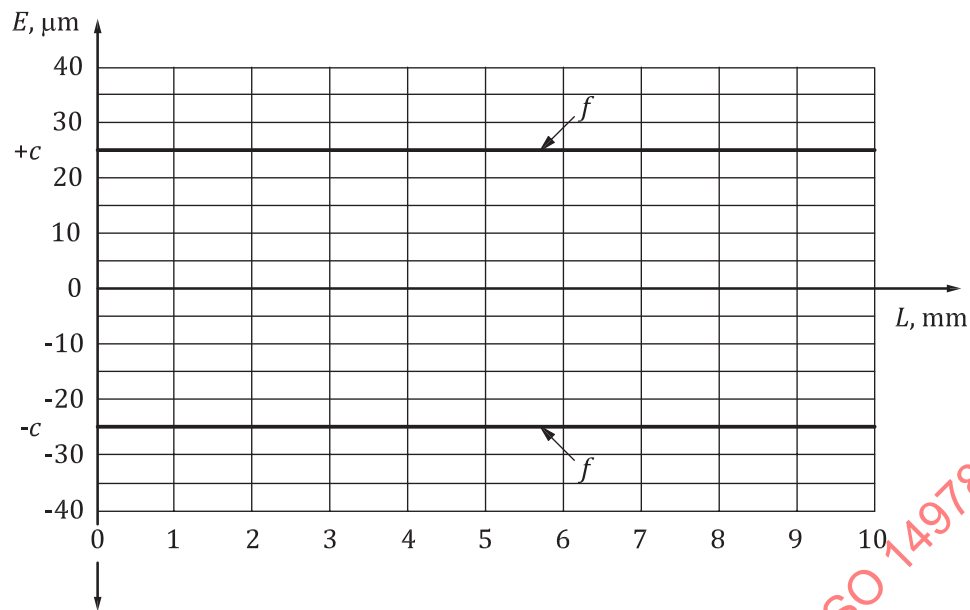
7.2.2 Constant value MPE function

The simplest MPE function is a constant, c , in the measuring range:

upper limit MPE = c

lower limit MPE = $-c$

where $c > 0$. See [Figure 8](#).



Key

- L nominal length
- E error of indication
- f MPE function

Figure 8 — Example of symmetrical MPE function with a constant value, c

7.2.3 Proportional value MPE function

The MPE function can be expressed as a combination of a constant, a , and proportional value, b :

$$\text{upper limit MPE} = + (a + L \times b)$$

$$\text{lower limit MPE} = - (a + L \times b)$$

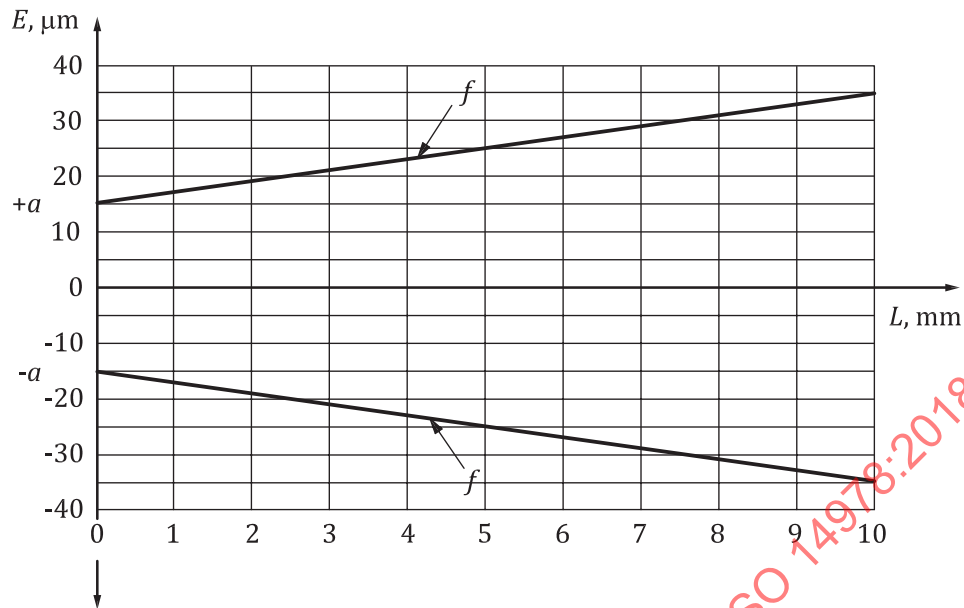
where

L is the nominal length;

$a > 0$;

$b > 0$.

See [Figure 9](#).

**Key**

- L nominal length
 E error of indication
 f MPE function

Figure 9 — Example of symmetrical MPE function with a proportional value

7.2.4 Proportional and maximum value MPE function

The MPE function can be expressed as a combination of a constant, a , proportional value, b , and maximum value, c :

$$\text{upper limit MPE} = (a + L \times b) \text{ for } 0 < L \leq L_1$$

$$\text{lower limit MPE} = -(a + L \times b) \text{ for } 0 < L \leq L_1$$

$$\text{upper limit MPE} = c \text{ for } L > L_1$$

$$\text{lower limit MPE} = -c \text{ for } L > L_1$$

where

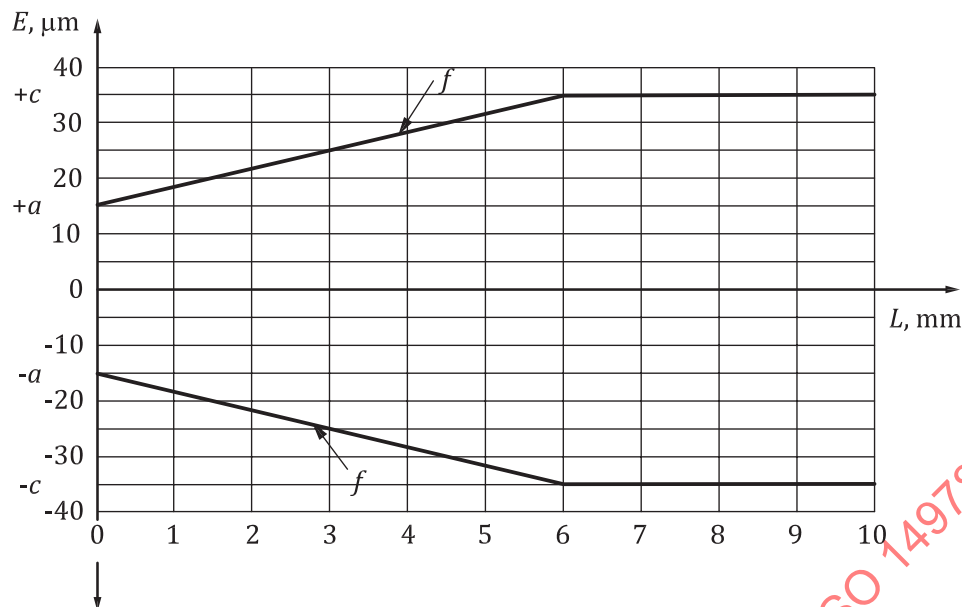
L is the nominal length;

$a > 0$;

$b > 0$;

$c > 0$.

See [Figure 10](#).

**Key**

- L nominal length
 E error of indication
 f MPE function

Figure 10 — Example of symmetrical MPE function with a proportional value and a maximum value, c

7.3 Presentation of characteristic curves

7.3.1 General

A set of metrological characteristic values has a series of corresponding values forming coordinate-pairs (points), for example in a table (see [Table 6](#)) or diagram (see [Figure 11](#)). When shown in a diagram, the lines connecting the points in the diagram form a characteristic curve, or an error curve, representing the characteristic in a range. The most common characteristic curve is a plot of errors of indication across a measuring range (see [Figure 11](#)). More rarely, curves are used for other characteristics, for example measuring force.

7.3.2 Presentation of characteristic curves – Reference point

Characteristic curves are often determined based on an established reference point of the measuring equipment. As shown in [Table 6](#) and [Figure 11](#), the maximum error of indication (highest point) and the minimum error of indication (lowest point) correspond to the reference point.

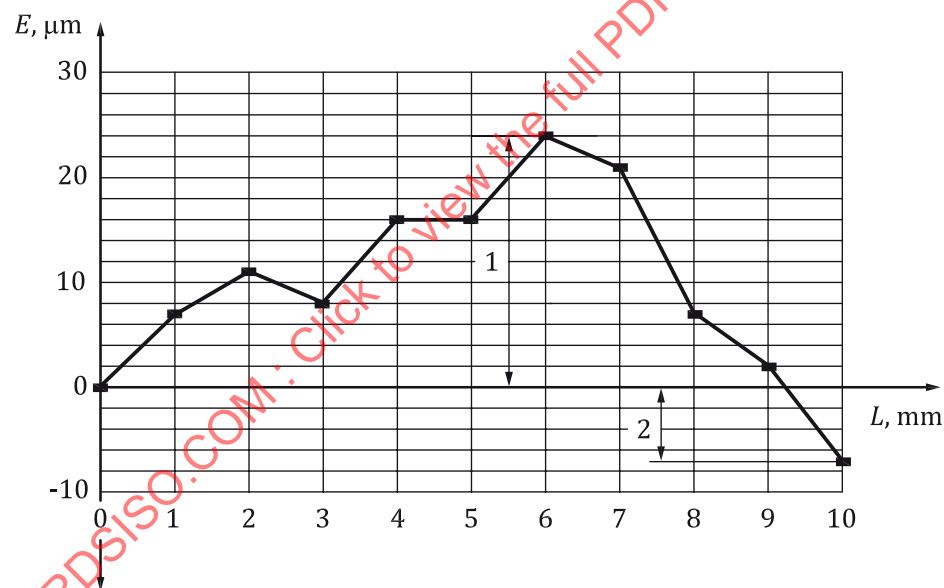
The reference point may or may not be fixed depending on the design of the measuring equipment. For measuring equipment without a fixed reference point, the reference point in the characteristic curve is arbitrarily chosen within the measuring range. In these cases, during verification testing, shifting the reference point to the largest positive or negative error might be useful to simulate the choice of a different reference point. When the reference point is moved to different test points in the measuring range, the error curve moves vertically in the diagram, and there are changes in the errors of indication. As shown in [Figure 12](#), the maximum and minimum errors of indication are the highest and lowest points across all the shifted error curves.

Simulating the choice of a different reference point is not necessarily equivalent to making measurements with a different reference point. Shifting the errors as shown in [Figure 12](#) is only valid under all the following conditions:

- the measuring equipment does not have a fixed reference point, as defined in the specific measuring equipment standard or in the stated rated operating conditions;
- the reference point is established, during calibration, in the same general manner as any other test point;
- the same reference point is used in determining all the errors in the characteristic curve;
- the measurement uncertainty of the errors of indication is negligibly dependent on the measured length and the location within the measuring range of the measuring equipment.

Table 6 — Example of errors of indication for measuring equipment with reference point fixed at 0 mm and 10 test points over a 10 mm measuring range

Nominal length mm	0	1	2	3	4	5	6	7	8	9	10
Error of indication μm	0	7	11	8	16	16	24	21	7	2	-7

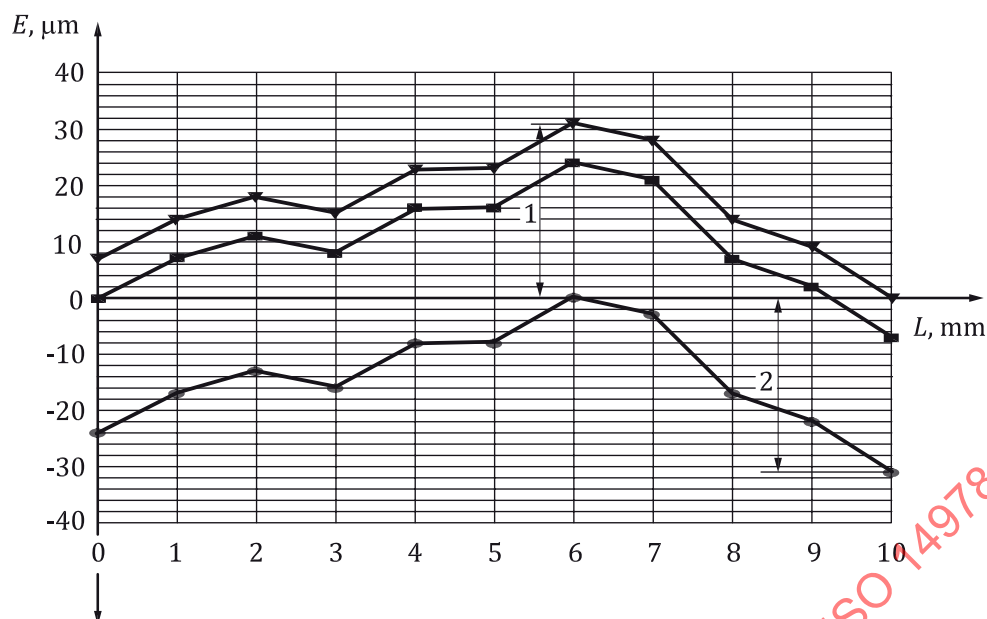


Key

- 1 maximum error of indication
- 2 minimum error of indication
- L nominal length
- E error of indication

NOTE Reference point at zero indication point (data from [Table 6](#)).

Figure 11 — Example of an error of indication curve



Key

- 1 maximum error of indication
- 2 minimum error of indication
- L nominal length
- E error of indication

NOTE Reference point shifted to highest and lowest points in the curve (data from [Table 6](#)).

Figure 12 — Example of shifting the reference point in error of indication curves

8 Calibration of metrological characteristics

8.1 Manufacturer and supplier of measuring equipment

In an acceptance test, the manufacturer and/or the supplier shall calibrate or verify the suggested metrological characteristics and document the conformance with the stated MPE or MPL values or functions.

8.2 User of measuring equipment

The metrological characteristics necessary for the intended use of the measuring equipment shall be chosen by the user and shall be calibrated. For assigned reference values, the reference values of the metrological characteristics shall be stated with the related measurement uncertainty. For verification tests, the test values and related test uncertainty of the metrological characteristics shall be stated along with a statement of conformance or not with the related MPE and MPL values or functions.

8.3 Measurement uncertainty

In the calibration of the metrological characteristics of measuring equipment, the measurement uncertainty shall be evaluated according to ISO/IEC Guide 98-3. For verification tests, the test uncertainty shall be evaluated following the concepts in ISO 14253-5:2015; see [Annex D](#).

9 Marking

GPS standards for specific measuring equipment shall contain a requirement that all measuring equipment shall be marked with durable serialised identification using unique alphanumeric identification to identify the individual measuring equipment or part of measuring equipment. Manufacturers' serial numbers are an example of serialised identification.

In cases where it is not feasible to mark the item, special procedures shall be produced to ensure the identity of the item. Additional marking may be required by the standards for specific measuring equipment. Any marking shall be easily readable and long-lasting, and shall be positioned on the surface of the measuring equipment at a place that does not influence metrological quality.

10 GPS standards for specific measuring equipment

Minimum requirements and guidance in the development of GPS standards for specific measuring equipment are as specified in [Annex A](#).

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Annex A (normative)

General minimum requirements and guidance for clauses in GPS standards for specific measuring equipment

The following elements of content shall be adhered to in GPS standards for specific measuring equipment.

— Title of the standard

The title of the standard shall follow this model:

Geometrical product specifications (GPS) — Dimensional measuring equipment; [Name of the instrument] — Design and metrological characteristics

— Contents

A list of contents shall be included.

— Foreword

The ISO standard foreword as per the ISO/IEC Directives, Part 2, shall be used with applicable modifications.

— Introduction

The ISO/TC 213 standard introduction shall be used, together with a minimum of the guidance that ISO 14978 should also be available when reading this document.

— Scope

The scope shall include the following:

This document specifies the most important design and metrological characteristics of <name of equipment>.

— Normative references

— As a minimum, reference shall be made to ISO 14978, ISO 14253-1, ISO 14253-5, ISO/IEC Guide 98-3 and ISO/IEC Guide 99.

— Other standards already referenced in ISO 14978 do not need to be cited again.

— Terms and definitions

Only special terms and definitions related to the specific equipment shall be given. General terms and definitions shall refer to ISO 14978 or ISO/IEC Guide 99.

— Design characteristics

Concerning identification of the design characteristics for specific measuring equipment, only the most important design characteristics, such as those that affect interchangeability, shall be included in the standard.

— Metrological characteristics and their MPEs and MPLs

Concerning user-oriented identification and definition of the most important metrological characteristics for specific equipment, the metrological characteristics and the actual chosen

definition shall be based on an evaluation of the uncertainty budget for the most common use of the equipment. The necessary conditions, including any rated operating conditions, to make the definition of the characteristics unambiguous shall be given.

If more than one type of use results in different sets of metrological characteristics and definitions, the most common set shall be chosen and explained in the main body of the standard. Other possibilities may be placed in a normative annex. Reference shall be made to the relevant clauses in ISO 14978 in cases where the metrological characteristic is included and defined in ISO 14978.

A suitable definition of the related MPE or MPL shall be given for each metrological characteristic when applicable (not every metrological characteristic has an MPE or MPL).

— Acceptance test

For metrological characteristics subject to verification of their MPE or MPL values, the specific standards shall provide sufficient normative and informative details to adequately define a test protocol used in acceptance testing of the measuring equipment.

The acceptance test may be different from methods used in calibration or reverification tests; however, it may be useful to the user to consider the applicability of the acceptance test, possibly with extensions or reductions, when developing calibration or reverification tests.

— Measurement standards for the calibration of metrological characteristics

Relevant measurement standards shall be related to each of the identified metrological characteristics. A reference to a possible ISO standard shall be made (if one exists), or else the measurement standard(s) may be included in the standard for specific measuring equipment.

— Demonstration of conformance with metrological specifications

A separate clause in the standard entitled “Conformance with specification” shall be included. The text in this clause shall be as follows:

When demonstrating conformance or non-conformance to specifications, the decision rule accompanying the specifications shall be followed. If no decision rule is stated with the specifications, and no special agreement is made between supplier and customer, then the default rule of ISO 14253-1 applies. Evaluation of measurement uncertainty shall be performed in accordance with ISO/IEC Guide 98-3 and, when appropriate, ISO 14253-5.

NOTE Information on the selection of an alternative decision rule can be found in ISO/TR 14253-6.

— Calibration and verification of metrological characteristics

A possible calibration or verification method should be considered in an informative annex in the standard.

The use of task-related calibration or verification should be discussed. Information should be provided to enable a user to determine which metrological characteristics apply for the intended use of the measuring equipment.

— Normative/informative annexes

If possible and relevant, normative or informative annexes that provide useful information to the user of the measuring equipment should be considered. Examples of possible annexes include:

- outlines of uncertainty budgets for the calibration of specific metrological characteristics;
- notes on use that provide good practice guidance.

— Informative annex — Relation to the GPS matrix model

The relation annex with ISO/TC 213 shall be included (see [Annex E](#)).

— **Bibliography**

A bibliography shall be added including at least ISO 14638 and ISO 14253-2.

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Annex B (informative)

Data sheet for measuring equipment requirements

B.1 Explanation

Since GPS standards for measuring equipment do not include requirements for all design characteristics and generally do not include specifications for metrological characteristics, it is not possible for a customer/user to define requirements for measuring equipment exclusively by referring to the specific ISO standard issue number. The design and metrological characteristics may be chosen by the customer/user with reference to the specific ISO standard, and if it is possible with a filled-in data sheet, for a customer/user to set up individual requirements for specific types of measuring equipment.

The purpose of a data sheet is to provide a means to communicate between technical experts and purchasing agents regarding the specifications of measuring equipment. The data sheet described in this annex is a model for the specific data sheets to be given in all GPS standards for measuring equipment standards.

B.2 Contents of a data sheet

The data sheet is separated into six parts, each dealing with a different subject. The data sheets to be given in the standards for specific measuring equipment should contain the leading text and an empty space for the customer/user to fill in relevant information and requirements.

- a) Name and identification of the equipment:
 - name (general) of the equipment;
 - identification of a possible subgroup of the equipment;
 - accessories.
- b) Purchasing requirements:
 - possible suppliers;
 - price range;
 - special requirements (e.g. documentation, calibration certificate).
- c) Reference to an ISO standard.

A reference to relevant standards can be made by means of the following sentence: "For the definition of design and metrological characteristics in this data sheet, see ISO XXXXX and ISO 14978".

NOTE ISO XXXXX is the specific standard to which the measuring equipment is related. The reference to ISO 14978 is necessary because the more general definitions of characteristics are only given in this document and not in the standards for specific measuring equipment.

- d) Requirements of design characteristics:
 - all relevant design characteristics from the specific standard and the (space for) requirement values and units.

NOTE A customer/user can reduce or expand the list of design characteristics and design requirements.

e) Requirements of metrological characteristics:

- all relevant metrological characteristics from the specific standard and the (space for) requirement values and units;

NOTE A customer/user can reduce, expand or change the list of metrological characteristics and metrological requirements.

- possible changes or limitations in the standard conditions for the function of the equipment and/or the requirements of metrological characteristics given in the specific standard or in ISO 14978.

f) Company-relevant information and requirements:

- company name;
- identification of the department or other part of the company organization;
- person(s) responsible, in accordance with quality assurance requirements;
- data sheet edition, date(s);
- other relevant quality assurance requirements.

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Annex C (normative)

Common design characteristics

C.1 General

This annex addresses a number of design characteristics that are common in measuring equipment.

The general design and workmanship of measuring equipment shall be such that all metrological characteristics conform with the requirements of the specific equipment standard under all operational orientations, unless otherwise specified by the manufacturer/supplier.

C.2 Protection for field use

Where applicable, the manufacturer/supplier should indicate clearly which kind of water and dust protection is provided (IP code, according to IEC 60529) as well as any type of electromagnetic field protection.

C.3 Measuring elements

Measuring elements that establish contact with measured items, for example measuring faces, shall consist of wear-resistant material of suitable surface finish.

C.4 Zero adjustment

Measuring equipment that provides a means for setting the readings to zero or other preset value shall be designed to prevent unintentional changes, for example through provision of a locking device, by frictional resistance or an assigned operation button.

C.5 Locking mechanisms

For measuring equipment that provides a physical mechanism to lock an indication, for example a slider that is equipped with a locking device, the indication shall fulfil the following conditions, unless stated otherwise:

- for analogue indication, the indication shall not change;
- for digital indication, the indication shall not change by more than one digital step.

C.6 Types of indicating devices

C.6.1 General

Measuring equipment can utilize any number of means for producing indications. This subclause discusses the design characteristics for the following types of common indicating devices:

- analogue indicating devices with vernier scale (see [Figures C.1 to C.5](#));
- analogue indicating devices with circular scale (see [Figures C.6 and C.7](#));
- digital indicating devices with mechanical digital display (see [Figure C.8](#));

— digital indicating devices with electronic digital display (see [Figure C.9](#)).

NOTE Combinations of these types of indicating devices are possible.

On instruments with analogue indicating devices the scale interval and its unit shall be labelled. On instruments with digital indicating devices the unit of the indication shall be labelled.

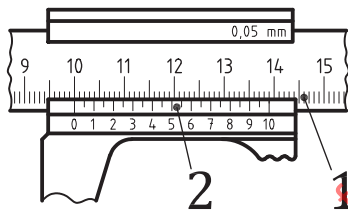
C.6.2 Vernier scale

C.6.2.1 General

The scale interval of the main scale on measuring equipment with a vernier scale shall be specified in millimetres. The main scale shall be longer by at least one vernier scale length than the measuring range of the instrument.

C.6.2.2 Main scale and vernier scale

Example measuring equipment with a vernier scale is shown in [Figure C.1](#).



- Key
- 1 main scale
 - 2 vernier scale

Figure C.1 — Example of analogue indicating device with vernier scale

C.6.2.3 Design of vernier scale

The graduating method of vernier scales is shown in [Table C.1](#).

Table C.1 — Graduating methods of vernier scales

Main scale interval	Graduating method of vernier	Nominal vernier scale interval	Explanatory figure
1	Divide 9 mm into 10 equal parts	0,1	Figure C.2
1	Divide 19 mm into 10 equal parts	0,1	
1	Divide 19 mm into 20 equal parts	0,05	
1	Divide 39 mm into 20 equal parts	0,05	
1	Divide 49 mm into 50 equal parts	0,02	Figure C.3

Examples of vernier scales with vernier scale intervals of 0,1 mm and 0,02 mm are shown in [Figures C.2](#) and [C.3](#).