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Geometrical Product Specifications (GPS) — General concepts and requirements for GPS measuring equipment

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

ICS 17.040.30

ISO/CEN PARALLEL ENQUIRY

The CEN Secretary-General has advised the ISO Secretary-General that this ISO/DIS covers a subject of interest to European standardization. **In accordance with subclause 5.1 of the Vienna Agreement, consultation on this ISO/DIS has the same effect for CEN members as would a CEN enquiry on a draft European Standard.** Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month FDIS vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

Contents

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 or non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote

ISO 14978 was prepared by the Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

Annex A forms an integral part of this International Standard. Annexes B, C and D are for information only.

Introduction

This International Standard is a geometrical product specification (GPS) standard and is to be regarded as a global GPS standard (see ISO/TR 14638). It influences link 5 and 6 of all chain of standards in the general GPS matrix.

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

This International Standard contains guidance for writing the standards for specific measuring equipment.

This International Standard is intended to give the user a basic understanding of the use of ISO standards for GPS measuring equipment. This international standard 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 International Standard is also intended as guidance for the manufacturer to evaluate and present specifications for characteristics for GPS measurement equipment.

This International Standard should be close at hand when reading and using ISO standards for a specific GPS measuring equipment.

Geometrical Product Specifications (GPS) — General concepts and requirements for GPS measuring equipment

1 Scope

This International Standard specifies the general requirements, terms and definitions of characteristics of simple GPS measuring equipment, e.g., micrometers, dial gauges, calipers, surface plates, height gauges, gauge blocks, but not necessarily excluding more complicated equipment. It forms the basis for standards defining and describing the design characteristics and metrological characteristics for measuring equipment. It also gives guidance for the development and content of standards for GPS measuring equipment.

This international standard 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 International Standard is also intended as a tool to be used in companies in the process of defining and selecting relevant characteristics for measuring equipment to be used in the quality assurance of measuring processes, i.e., in calibration and in workpiece measurements.

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

2 Normative references

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

ISO 1: — [1], *Geometrical product specifications (GPS) — Standard reference temperature for geometrical product specifications*.

ISO 1101: — [2], *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out*.

ISO 5459: 1981 [3], *Technical drawings — Geometrical tolerancing — Datums and datum systems for geometrical tolerances*.

ISO 14253-1:1998, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Decision rules for proving conformance or non-conformance with specifications*.

ISO/TS 14253-2:1999, *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment — Part 2: Guide to the estimation of uncertainty of measurement in calibration of measuring equipment and product verification.*

International vocabulary of basic and general terms in metrology (VIM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993.

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

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[1] To be published. (Revision ISO 1)

[2] To be published. (Revision ISO 1101)

[3] Under revision

3 Definitions

For the purpose of this International Standard, the terms and definitions given in ISO 14253-1:1998, ISO/TS 14253-2:1999, ISO/TS 17450-2, VIM:1993, and GUM and the following definitions apply.

3.1
measuring equipment
ME
any instrument, measurement standard, reference material and/or auxiliary apparatus or any combination thereof necessary to implement a measurement process for carrying out a specified and defined measurement.

NOTE 1 This definition is necessarily wider than that of a measuring instrument [VIM:1993, 4.1] since it has to include all the means necessary for producing a measurement result.

NOTE 2 The concept measuring equipment includes, e.g. ,indicating measuring **instrument** (3.2) and material measures (3.3).

3.2
Indicating measuring instrument
measuring equipment that displays an indication

EXAMPLES
a) analogue mechanical dial gauge;
b) digital calliper;
c) micrometer.

NOTE 1 The display may be analogue (continuous or discontinuous) or digital.

NOTE 2 Values of more than one quantity may be displayed simultaneously.

NOTE 3 A displaying measuring instrument may also provide a record.

NOTE 4 (This note is an addition to the VIM:1993 definition) The examples given in VIM:1993 defined terms are in this standard changed to examples in length units.

[VIM:1993, 4.6]

3.3
material measure
device intended to reproduce or supply, in a permanent manner during its use, one or more known values of a given quantity

EXAMPLES
a) a gauge block
b) a ball plate
c) an angle block
d) a limit gauge (e.g., gap gauge)
e) a functional gauge
f) a surface texture standard
g) a reference ring
h) a tape measure

NOTE 1 The quantity concerned may be called the supplied quantity.

NOTE 2 (This note is an addition to the VIM:1993 definition). Material measure is included in the concept measuring equipment.

NOTE 3 (This note is an addition to the VIM:1993 definition). The examples given in VIM:1993, defined terms are in this standard changed to examples in length units.

[VIM:1993, 4.2]

3.4
mono-characteristic measuring equipment
measuring equipment which can be characterised by a single metrological characteristic

NOTE 1 Mono-characteristic measuring equipment is a simplifying theoretical concept which is described in this standard as a contrast to the case of actual multi-characteristic measuring equipment.

NOTE 2 For simplification, especially when evaluating uncertainty contributions, a multi-characteristic measuring equipment (3.5) may be considered as a “black box” and therefore can be assumed to be a mono-characteristic measuring equipment.

3.5
multi characteristic measuring equipment
measuring equipment which is characterised by two or more metrological characteristics

NOTE All GPS measuring equipment is multi-characteristic (see 3.4 note 2).

3.6
measurement process
set of interrelated resources, activities and influences which produce a measurement

NOTE 1 The term measurement process is used as a common term for the calibration of measuring equipment and the measurement of workpieces.

NOTE 2 Resources might be human or material.

3.7
intended use (of measuring equipment)
measurement process in which specific measuring equipment is to be used

NOTE 1 Knowledge about intended use usually will reduce the number of metrological requirements which need to be calibrated.

NOTE 2 Knowledge about intended use of the MPEs for the metrological requirements, that need to be calibrated, usually will allow adjustment to more economical and less restrictive values.

3.8
calibration (of measuring equipment)
set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards

NOTE 1 The result of a calibration permits either the assignment of values of measurands to the indications or the determination of corrections with respect to indications.

NOTE 2 A calibration may also determine other metrological properties such as the effect of influence quantities.

NOTE 3 The result of a calibration may be recorded in a document, sometimes called a calibration certificate or a calibration report.

NOTE 4 (This note is an addition to the VIM:1993 definition) The VIM:1993 definition of calibration only applies to mono-metrological characteristic measuring equipment and therefore usually does not apply to GPS measuring equipment (see 3.4 and 3.5).

[VIM:1993, 6.11]

3.9
calibration of a metrological characteristic
set of operations that establish, under specified conditions, the relationship between values of quantities of a metrological characteristic, and the corresponding values realized by standards

NOTE Metrological characteristics may be defined and calibrated as quantities that need mathematical or geometrical transformations to be compatible to the measurement result of the measuring equipment, e.g., flatness and parallelism of the measuring faces of an external micrometer.

3.10
global calibration (of measuring equipment)
calibration of all metrological characteristics for measuring equipment

NOTE 1 Global calibration may be used if the intended use of the equipment is not known at the time of calibration, or as an acceptance test to verify the agreed specifications in connection with the delivery of new measuring equipment.

NOTE 2 In cases of daily operation of the metrology system in a company global calibration is usually not needed (see 3.11).

3.11
task-related calibration (of measuring equipment)
calibration of only the metrological characteristics which influence the measurement uncertainty for the intended use

NOTE 1 Usually a task-related calibration will include only the calibration of the metrological characteristics that have a major influence on the measurement uncertainty for the intended use.

NOTE 2 Task related-calibrations may be performed using other more economically procedures than in global calibration; and a task-related calibration may be designed to deliver information (values and conditions) optimised for use in the specific uncertainty budget.

NOTE 3 This definition of task-related calibration is intentionally formulated otherwise than in ISO 12179, but the meaning is the same. The difference in the text indicates a development in the GPS field.

3.12
metrological characteristic (of measuring equipment)
MC
characteristic of measuring equipment, which may influence the results of measurement

NOTE 1 The influence on the results of measurement is an immediate (short-term) uncertainty contribution (see clause 6).

NOTE 2 A metrological characteristic is expressed in numerical values and may be evaluated in a unit other than that of the measurement result of the actual measuring equipment.

NOTE 3 Measuring equipment usually has several metrological characteristics.

NOTE 4 Metrological characteristics may be subject to calibration (see 3.10 and 3.11).

3.13
design characteristic (of measuring equipment)
DC
characteristic of measuring equipment which does not influence the measurement directly, but may be of interest for the use of the measuring equipment for other reasons

NOTE 1 Design characteristics influence is, e.g., interchangeability, readability of line scales and digital read-outs, wear resistance, etc. (see clause 5).

NOTE 2 Some design characteristics may influence the equipment's ability to make measurements on the long-term (influencing design characteristics), e.g., wear resistance, environmental resistance, etc. Other design chraracteristics have no influence the measurements (non-influencing design characteristics).

3.14
metrological requirement of measuring equipment

MR
requirement for a metrological characteristic (of measuring equipment)

NOTE 1 Metrological requirements may be derived from specified requirements for a product/feature to be measured or may be decided on a general basis.

NOTE 2 A metrological requirement may be given as a maximum permissible error (MPE - see 3.21) or as permissible limits (MPL - see 3.20).

NOTE 3 Measuring equipment usually have several metrological requirements, one for each metrological characteristic.

3.15
design requirement of measuring equipment
DR
requirement for a design characteristic (of measuring equipment)

NOTE 1 Design requirements may be derived from the intended use of the measuring equipment or may be decided on a general basis and may be given in a standard.

NOTE 2 A design requirement may be given as dimensions, material requirements, interface protocols, etc (see clause 5) .

3.16
error (of indication) of measuring equipment
indication of measuring equipment minus a true value of the corresponding input quantity

NOTE 1 Since a true value cannot be determined, in practice a conventional true value is used (see VIM:1993, 1.19 and 1.20).

NOTE 2 This concept applies mainly where the instrument is compared to a reference standard.

NOTE 3 For a material measure, the indication is the value assigned to it.

NOTE 4 (This note is an addition to the VIM:1993 definition) This VIM:1993 term and definition generally do not apply to set up specifications for GPS measuring equipment and certainly not to the concept of a metrological characteristic in a multi-characteristic measuring equipment. Term 3.17 shall be used instead.

[VIM:1993, 5.20]

3.17
value of the actual metrological characteristic
value found by calibration and characterising the metrological characteristic

3.18
error (deviation value) of a metrological characteristic
error value characterising the actual metrological characteristic (actual value minus ideal value of the characteristic)

NOTE 1 An error of a metrological characteristic may be evaluated in another unit other than the measurement result of the actual measuring equipment.

NOTE 2 This term is used for multi characteristic measuring equipment (see 3.16 NOTE 4).

3.19
maximum permissible errors (of measuring equipment)
extreme values of an error permitted by specifications, regulations, etc. for a given measuring equipment

See 7.5 and Figures 9 to 12.

NOTE 1 This definition is a parallel to VIM:1993, 5.21 for measuring instruments.

NOTE 2 This term is only applicable to mono-metrological characteric measuring equipment.

NOTE 3 (This note is an addition to the VIM:1993 definition) This term and definition generally do not apply to specifications for GPS measuring equipment and certainly not to the concept of a metrological characteristic in a multi-characteristic measuring equipment - Term 3.20 or 3.21 shall be used instead.

3.20
permissible limits of a metrological characteristic
MPL
extreme values of a metrological characteristic permitted by specifications, regulations, etc. for a given measuring equipment

See 7.5.6 and Figure 13.

NOTE MPL may be a value or set of values or a function (MPL-function).

3.21
maximum permissible errors for a metrological characteristic
MPE
extreme values of an error of a metrological characteristic permitted by specifications, regulations, etc. for a given measuring equipment

See 7.5 and Figures 9 to 12.

NOTE 1 This definition is a parallel to VIM:1993, 5.21 for measuring instruments (see 3.19).

NOTE 2 MPE may be a value or set of values or a function (MPE-function).

3.22
repeatability (of a measuring instrument)
ability of a measuring instrument to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement

NOTE 1 These conditions include:
- reduction to a minimum of the variations due to the observer
- the same measurement procedure
- the same observer
- the same measuring equipment, used under the same conditions
- the same location

- repetition over a short period of time.

NOTE 2 Repeatability may be expressed quantitatively in terms of the dispersion characteristics of the indications.

NOTE 3 (This note is an addition to the VIM:1993 definition) This term and definition generally do not apply to specifications for GPS measuring equipment and certainly not to the concept of a metrological characteristic in a multi-characteristic measuring equipment - Term 3.23 shall be used instead.

[VIM:1993, 5.27]

3.23
repeatability of a metrological characteristic
ability of a metrological characteristic of a measuring equipment to provide closely similar values for repeated measurements under the same conditions during calibration of the characteristic

NOTE This definition is parallel to 3.22 for the total measurement equipment.

3.24
hysteresis
property of measuring equipment or a characteristic whereby the indication of the equipment or value of the characteristic depends on the orientation of the preceding stimuli

NOTE Hysteresis may also depend on, e.g., the length of the travel after the orientation of stimuli has changed.

3.25
discrimination (threshold)
largest change in a stimulus that produces no detectable change in the response of a measuring instrument, the change in the stimulus taking place slowly and monotonically

NOTE The discrimination threshold may depend on, for example, noise (internal or external) or friction. It may also depend on the value of the stimulus.

[VIM:1993, 5.11]

3.26
resolution (of a displaying device)
smallest difference between indications of a displaying device that can be meaningfully distinguished

NOTE 1 See 6.3.2.2 (This note is not part of VIM)

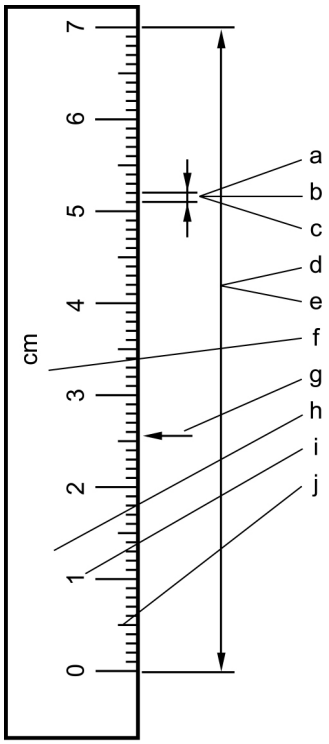
NOTE 2 For a digital displaying device, the resolution is equal to the digital step.

NOTE 3 This concept applies also to a recording device.

[VIM:1993, 5.12]

3.27
digital step
in a digital displaying device the smallest possible change in the least significant digit

NOTE The resolution may depend on whether the display is rounded or truncated.



Key

a **scale division** [VIM:1993, 4.20]: part of a scale between any two successive scale marks (*the space between two successive scale marks*)

b **scale interval** [VIM:1993, 4.22]: distance between the values corresponding to two successive scale marks (*in the unit marked on the scale - here 0,1 cm or 1 cm*)

c **scale spacing** [VIM:1993, 4.21]: distance between two successive scale marks (*the physical length between two successive scale marks - here 0,1 cm or 1 cm*)

d **scale length** [VIM:1993, 4.18]: for the given scale the physical length between the first and the last scale marks (*here here 70 mm or 1 cm*)

e **scale range** [VIM:1993, 4.19]: for the given scale the physical length between the first and the last scale marks in the units marked (*here 0 to 7 cm or 0 to 70 mm*)

f units marked on the scale (*here centimetres*)

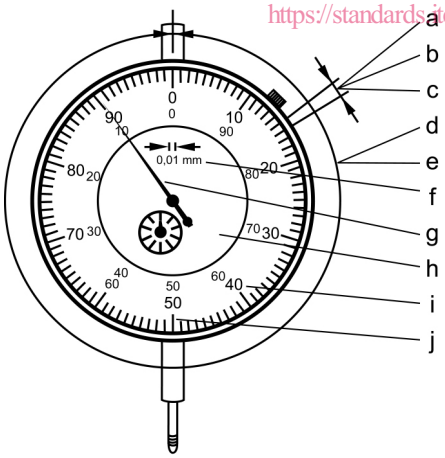
g **index** [VIM:1993, 4.16]: pointer

h **face dial** [VIM:1993, 4.27]: the physical part (surface) which carries the scale

i **scale numbering** [VIM:1993, 4.28]: ordered set of numbers associated with the scale marks

j **scale mark** [VIM 1st edition, 4.17]: the lines

Figure 1 — Terms related to an analogue straight scale



Key

a **scale division** [VIM:1993, 4.20]: part of a scale between any two successive scale marks (*the area between two successive scale marks*)

b **scale interval** [VIM:1993, 4.22]: distance between the values corresponding to two successive scale marks (*in the unit marked on the scale - here 0,1 cm or 1 cm*)

c **scale spacing** [VIM:1993, 4.21]: distance between two successive scale marks (*the physical length between two successive scale marks - here 0,1 cm or 1 cm*)

d **scale length** [VIM:1993, 4.18]: for the given scale the physical length between the first and the last scale marks (*here here 70 mm or 1 cm*)

e **scale range** [VIM:1993, 4.19]: for the given scale the physical length between the first and the last scale marks in the units marked (*here 0 to 7 cm or 0 to 70 mm*)

f units marked on the scale (*here centimetres*)

g **index** [VIM:1993, 4.16]: pointer

h **face dial** [VIM:1993, 4.27]: the physical part (surface) which carries the scale

i **scale numbering** [VIM:1993, 4.28]: ordered set of numbers associated with the scale marks

j **scale mark** [VIM 1st edition, 4.17]: the lines

Figure 2 — Terms related to an analogue circular scale

3.29
fixed zero
fixed reference point of indication or value (of a metrological characteristic of measuring equipment), where the error of the characteristic is zero

3.30
floating zero
floating reference point of indication or value (of a metrological characteristic of measuring equipment), where the error of the characteristic is zero

3.31
fixed zero error or value
error-of-indication or value referenced to a fixed zero (of a metrological characteristic of measuring equipment)

3.32
floating zero error or value
error-of-indication or value referenced to a floating zero (of a metrological characteristic of measuring equipment)

3.33
reference point
setting point for error (of indication) evaluation in the range of measuring equipment

3.34
nominal range
range of indications obtainable with a particular setting of the controls of a measuring instrument

See Figure 3.

NOTE 1 Nominal range is normally stated in terms of its lower and upper limits, for example, "24,5 mm to 50,6 mm". Where the lower limit is zero, the nominal range is commonly stated solely in terms of its upper limit.

NOTE 2 See VIM:1993, 5.2 NOTE (equal to note in 3.35).

NOTE 3 (This note is an addition to the VIM:1993 definition) The examples given in VIM:1993 defined terms are in this standard changed to examples in length units.

[VIM:1993, 5.1]

3.35
nominal span
modulus of the difference between the two limits of a nominal range

See Figure 3.

EXAMPLE For a nominal range of 24,5 mm to 50,6 mm, the nominal span is 26,1 mm.

NOTE 1 In some fields of knowledge, the difference between the greatest and smallest values is called **range**.

NOTE 2 (This note is an addition to the VIM:1993 definition) The examples given in VIM:1993 are in this standard changed to examples in length units.

NOTE 3 (This note is an addition to the VIM:1993 definition)“nominal” is added here to distinguish “nominal span” from the three other types of span (see 3.37, 3.39 and 3.41)

[VIM:1993, 5.2]

3.36
measuring range
set of values of measurands for which the error of a measuring instrument is intended to lie within specified limits

See Figure 3.

NOTE 1 "error" is determined in relation to a conventional true value.

NOTE 2 See VIM:1993, 5.2 NOTE (equal to note in 3.35).

NOTE 3 (This note is an addition to the VIM:1993 definition) Specified limits might be given as a set of MPEs or MPLs.

[VIM:1993, 5.4]

