INTERNATIONAL STANDARD

ISO 5436-2

Second edition
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Geometrical product specifications (GPS) — Surface texture: Profile method; Measurement standards —

Part 2: **Software measurement standards**

Spécification géométrique des produits (GPS) — État de surface: Méthode du profil; Étalons —

Partie 2: Étalons logiciels

Reference number
ISO 5436-2:2012(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5436-2 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This second edition cancels and replaces the first edition (ISO 5436-2:2001), which has been technically revised. It also incorporates the Technical Corrigenda ISO 5436-2:2001/Cor.1:2006 and ISO 5436-2:2001/Cor.2:2008.

ISO 5436 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Surface texture: Profile method; Measurement standards*:

— *Part 1: Material measures*

— *Part 2: Software measurement standards*

Introduction

This part of ISO 5436 is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences chain link 6 of the chain of standards on roughness, waviness and primary profiles.

The ISO/GPS Masterplan given in ISO/TR 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.

For more detailed information on the relationship of this part of ISO 5436 to other standards and the GPS matrix model, see Annex B.

This part of ISO 5436, together with ISO 5436-1, introduces two new measurement standards:

— Type E, for calibrating the profile co-ordinate system;

— Type F, for calibrating software.

This part of ISO 5436 is concerned with software measurement standards.

Geometrical product specifications (GPS) — Surface texture: Profile method; Measurement standards —

Part 2: Software measurement standards

1 Scope

This part of ISO 5436 defines Type F1 and Type F2 software measurement standards (etalons) for verifying the software of measuring instruments. It also defines the file format of Type F1 software measurement standards for the calibration of instruments used for measuring the surface texture by the profile method defined in ISO 3274.

NOTE 1 Throughout this part of ISO 5436, the term "softgauge" is used as a substitute for "software measurement standard Type F1".

NOTE 2 Formerly, "measurement standards" were referred to as "calibration specimens".

NOTE 3 ISO 3274 only refers to instruments with independent reference datums.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3274:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

ISO 5436-1:2000, *Geometrical Product Specifications (GPS) — Surface texture: Profile method; Measurement standards — Part 1: Material measures*

ISO 12085:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Motif parameters*

ISO 16610-21:2011, *Geometrical product specifications (GPS) — Filtration — Part 21: Linear profile filters: Gaussian filters*

ISO 17450-2:2012, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators, uncertainties and ambiguities*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in Measurement (GUM:1995)*

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 3274, ISO 5436-1, ISO 12085, ISO 16610-21:2011, ISO/IEC Guide 99 and the following apply.

3.1
software measurement standard
reference data or reference software intended to reproduce the value of a measurand with known uncertainty in order to verify the software used to calculate the measurand in a measuring instrument

3.2
ASCII string
array of ASCII characters terminating in <ASCII 0>

3.3
integer
2-byte representation of whole number

NOTE 1 Integers have a minimum value of –32 768 and a maximum value of +32 767.

NOTE 2 The less significant bytes are stored in memory addresses lower than those in which are stored the more significant bytes.

3.4
unsigned integer
2-byte representation of a positive whole number

NOTE 1 Unsigned integers have a minimum value of 0 and a maximum value of 65 535.

NOTE 2 The less significant bytes are stored in memory addresses lower than those in which are stored the more significant bytes.

3.5
long integer
4-byte representation of a whole number

NOTE 1 Long integers have a minimum value of –2 147 483 648 and a maximum value of +2 147 483 647.

NOTE 2 The less significant bytes are stored in memory addresses lower than those in which are stored the more significant bytes.

3.6
single precision float
4-byte representation consisting of a sign bit, an 8-bit excess –127 binary exponent and a 23-bit mantissa representing numbers between 1,0 and 2,0

NOTE 1 Since the high-order bit of the mantissa is always 1, it is not stored in the number.

NOTE 2 Single precision floats have an approximate range of $\pm 1{,}17e^{-38}$ to $\pm 3{,}4e^{+38}$.

NOTE 3 The less significant bytes are stored in memory addresses lower than those in which the more significant bytes are stored.

3.7
double precision float
8-byte representation consisting of a sign bit, an 11-bit excess –1 023 binary exponent, and a 52-bit mantissa, plus the implied high-order 1 bit

NOTE 1 Double precision floats have an approximate range of $\pm 2{,}22e^{-308}$ to $\pm 2{,}22e^{+308}$.

NOTE 2 The less significant bytes are stored in memory addresses lower than those in which the more significant bytes are stored.

4 Type F software measurement standards

4.1 General

Type F software measurement standards are designed to verify the measuring instrument’s software (i.e. filter algorithms, parameter calculations, etc.).

These measurement standards can contain a form component which it shall be possible to remove.

4.2 Type F1 — Reference data

Type F1 measurement standards are computer data files that depict a digital representation of a primary profile in a suitable recording medium.

Most of the operations between the total profile and primary profile are instrument-specific and, as a result, are difficult to standardize. The primary profile is currently the first point where all the subsequent operations for the definition of surface texture measurands are standardized and is thus chosen as the standardized point of entry for type F1 softgauges.

A non-exhaustive, non-ordered, informative list of operations between the total profile and primary profile may include the following.

— **Adjustment for calibration** — There are many different calibration models: gain factor, polynomial corrections for curvilinear co-ordinates, interpolation method corrections for curvilinear co-ordinates, etc.

— **Stylus tip correction** — Corrects for the finite size and shape of the stylus.

— **Decimation** — Reduces the number of the data points for subsequent calculation.

— **Equalization of interval of data points** — Makes the data by using mathematical interpolation.

— **Ls filtering** — Convolutes with previous filtering (i.e. an anti-aliasing filter of an A/D convertor) to make a true Gaussian filter.

— **End effects** — Removes a portion of the profile at the beginning and at the end to reduce possible end effects due to, for example, Ls filtering, stylus tip correction, etc.

— **Fitting of form by association** — Total least squares, linear least squares, Chebychev (minimum zone), fitting using robust norms (i.e. L1), one-sided fitting, Theil-Sen-type estimators.

— **Removal of form from profile** — Projection, orthogonal to line normal.

If the entry point for the F1 standard is before the primary profile (e.g. the total profile), the signal flow to generate the primary profile (by steps like those exemplarily listed above) shall be agreed upon between the producer and the user of the F1 standard.

NOTE The certified results for mathematically designed synthetic data can often be calculated directly without the need for certification by Type F2 measurement standards.

4.3 Type F2 — Reference software

Type F2 measurement standards are reference software. Reference software consists of traceable computer software against which software in a measuring instrument can be compared.

Type F2 measurement standards are used to test software by inputting a common data set into both the software under test/calibration and the reference software, then comparing the results from the software under test with the certified results from the reference software.

NOTE Type F2 measurement standards can also be used to certify Type F1 measurement standards.

Reference software values shall be traceable.

5 File format for Type F1 reference data

5.1 General

The file extension of this file protocol is `.smd`. The file protocol for the softgauge is divided into four separate sections or records. Each record is composed of lines of information and, within each line, there are various “fields” in which the information is coded. The file format is in 7-bit ASCII character code. Each line is terminated by a carriage return (`<cr>`) and line feed (`<lf>`).

Each record is terminated by an end of record (<ASCII 3>) with a carriage return (<cr>) and line feed (<lf>). The last record is further terminated by an end of file (<ASCII 26>). For each field, the separator consists of at least one space.

An example of a software file format is given in Annex A.

5.2 Record 1 — Header

The first record contains a fixed header that includes the following information:

— revision of the softgauge file format;

— file identifier;

— GPS feature type, number and name of the stored feature — axis information;

— number of data points in the profile;

— scaling of the data points;

— resolution of the data points.

The first line of record 1 contains two fields:

— `The_revision_number`;

— `File_identifier`.

Table 1 gives valid options for these fields.

Table 1 — Fields for line 1 of record 1

Field name	Valid options/examples	Comment
The_revision_number	'ISO 5436-2 - 2012'	ASCII string
File_identifier	'XXXXXX'	ASCII string

The second line of record 1 contains three fields:

— `Feature_type`;

— `Feature_number`;

— `Feature_name`.

Table 2 gives valid options for these fields.

Table 2 — Fields for line 2 of record 1

Field name	Valid options/Examples	Comment(s)
Feature_type	'PRF'	Profile data {i.e. (X,Z), (R,A), etc.}
	'SUR'	Surface data {i.e. (X,Y,Z), (R,A,Z), etc.}
Feature_number	0	Unsigned integer
Feature_name	'ISO000'	ASCII string

Each of the remaining lines of record 1 contains at least six fields:

— `Axis_name`;

— `Axis_type`;

— Number_of_points;

— Units;

— Scale_factor;

— Axis_data_type.

A seventh field, containing the incremental value, is added if the axis type is incremental.

See Figure 1 for an example.

Each axis in the softgauge has a line allocated to it. Thus, for a profile there will be two remaining lines — one for the X axis and one for the Z axis.

Table 3 gives valid options for these fields.

Table 3 — Fields for the remaining lines of record 1

Field name	**Valid options/Examples**	**Comments**
Axis_name	'CX' 'CY' 'CZ' 'PR' 'PA'	Cartesian X axis Cartesian Y axis Cartesian Z axis Polar radius Polar angle
Axis_type	'A' 'I' 'R'	Absolute data [a] Incremental data [b] Relative data [c]
Number_of_points	4003	Number of data points (Unsigned long integer)
Units	'm' 'mm' 'um' 'nm' 'rad' 'deg'	metres millimetres micrometres nanometres radians degrees
Scale_factor	1.0e0	Scale to indicated units (double-precision float)
Axis_data_type	'I' 'L' 'F' 'D'	Integer Long integer Single precision float Double precision float
Incremental_value [d]	1e-3	Value of increment (double precision float)

[a] Absolute data: each data value is the distance along the axis to the axis origin.

[b] Incremental data: assumes that the data is equally spaced in this axis so only an increment is required.

[c] Relative data: each data value is the distance along the axis to the previous data point. The first value is the distance to the axis origin.

[d] Axis type I only.

```
ISO 5436 – 2000<0>WIDGET&CO<0><cr><lf>
PRF<0> 0 ISO0001<0><cr><lf>
CX<0> I<0> 9600 mm<0> 1.0e0 D<0> 2.5e-4 <cr><lf>
CZ<0> A<0> 9600 µm<0> 1.0e0 D<0><cr><lf>
<3><cr><lf>
```

Figure 1 — Example of record 1

5.3 Record 2 — Other information (optional and non-mandatory)

The second record may contain other information. This information shall start with a keyword. The following list of examples is non-exhaustive and new keywords may be specified and used (see Table 4). If record 2 is not used, an end of record (<ASCII 3>) shall follow immediately after the end of record from record 1. See Figure 2 for an example.

Information contained in record 2 is optional and non-mandatory. While it may be read and used by computers, it shall be possible to use the data without information from record 2.

Table 4 — Examples of keywords for record 2

Keyword	Type	Comments
DATE	ASCII string	Date of measurement
TIME	ASCII string	Time of measurement
CREATED_BY	ASCII string	Name of person making measurement
INSTRUMENT_ID	ASCII string	Identification of measuring instrument (manufacturer and model)
INSTRUMENT_SERIAL	ASCII string	Serial number of measuring instrument
LAST_ADJUSTMENT	ASCII string	Date and time of latest adjustment
PROBING_SYSTEM	See Table 5	Details of probing system used for measurement
COMMENT	ASCII string delimited by “/*” and “*/” (e.g. /* some text */)	General comments (can span several lines and shall not be nested)
OFFSET_mm	Double precision float	Offset of start of measurement, in mm, from the origin
SPEED	Double precision float	Traverse speed, in mm/s
PROFILE_FILTER	See Table 6	—
PARAMETER_VALUE	See Table 7	—

Table 5 — Fields for the PROBING_SYSTEM option of record 2

Field name	**Valid examples**	**Comments**
Keyword	PROBING_SYSTEM	
Probing_system_identification	String_ASCII	Identification of probing system type
Probing_system_type	Contacting Non_contacting	Probing system which needs material contact Probing system which needs no material contact
Tip_radius_value [a]	Double_precision_float	Radius value
Units	'm' 'mm' 'um' 'nm'	metres millimetres micrometres nanometres
Tip_angle [a]	Double_precision_float	Cone angle of spherical portion of stylus in degrees

[a] Only valid with contacting probing systems.

Table 6 — Fields for the FILTER option of record 2

Field name	**Valid examples**	**Comments**
Keyword	FILTER	
Filter_type	'Gaussian' 'Motif'	Gaussian filter according to ISO 16610-21. Motif filter according to ISO 12085.
Ls_cutoff_value	Ls0.25e+1	"Ls" and double precision float. Value of λ_s cut-off in µm.
Lc_cutoff_value	Lc0.8e+0	"Lc" and double precision float. Value of λ_c cut-off in mm.
Lf_cutoff_value	Lf8.0e+0	"Lf" and double precision float. Value of λ_f cut-off in mm.
Motif_A	MA0.5	"MA" and single precision float. Value of A according to ISO 12085.
Motif_B	MB2.5	"MB" and single precision float. Value of B according to ISO 12085.

Table 7 — Fields for the PARAMETER_VALUE option of record 2

Field name	Valid options	Comments
Keyword	PARAMETER_VALUE	
Parameter_name	String ASCII	Example "*Wq*"
Parameter_value	Double_precision_float	Value of the parameter
Units	'm'	metres
	'mm'	millimetres
	'um'	micrometres
	'nm'	nanometres
Uncertainty	Double_precision_float	Uncertainty calculated according to the GUM (ISO/IEC Guide 98-3).

```
DATE 15 August 2000<0><cr><lf>
TIME 11:57 AM <0><cr><lf>
CREATED_BY A.Metrologist<0><cr><lf>
INSTRUMENT_ID Acme Type A<0><cr><lf>
INSTRUMENT_SERIAL AAA0001 <0><cr><lf>
LAST_ADJUSTMENT 9 April 1998 <0><cr><lf>
PROBING_SYSTEM type1<0>1.0 mm<0> 90.0<cr><lf>
COMMENT /* This is the prototype of Acme type 1 instrument<0><cr><lf>
           Still has problems with stylus damage to surface */<0><cr><lf>
OFFSET<0>1.34 <cr><lf>
SPEED<0>0.5 <cr><lf>
PROFILE_FILTER Gaussian Ls0.25e+1 Lc0.8e+3<cr><lf>
<3><cr><lf>
```

Figure 2 — Example of record 2

5.4 Record 3 data

The third record contains the data. Each axis defined in record 1 that is not an incremental axis will require data. The data in record 3 is written in blocks in the order in which the axes are defined in record 1. Each line of record 3 relates to a single data value. It contains one field:

— Data_value.

Multiplication of the data value by the scale factor contained in record 1 gives the value in the units specified in record 1.

NOTE The data in record 3 are raw data and have not been adjusted after a calibration.

Table 8 gives valid options for this field.

See Figure 3 for an example of record 3.

Table 8 — Field for record 3

Field name	Type	Comments
`Data_value`	Integer Long integer Single precision float Double precision float	The data value is in the format defined in record 1: `'Axis_data_type'`

```
128<cr><lf>
133<cr><lf>
156<cr><lf>
.
.
.

2345<cr><lf>
2643<cr><lf>
<3><cr><lf>
```

Figure 3 — Example of record 3

5.5 Record 4 checksum

This record contains a checksum for the data contained in records 1, 2 and 3. Checksums are used to maintain data integrity.

The checksum is obtained by summing all the individual byte values (including `<cr>`, `<lf>`, end of records, etc.) over records 1, 2 and 3 to an unsigned long integer, modulo 65535.

See Figure 4 for an example of record 4.

```
23243<cr><lf>
<3><cr><lf>
<26>
```

Figure 4 — Example of record 4

6 Software measurement standard certificate

After each software measurement standard has been individually calibrated, it shall be accompanied by at least the following information:

a) title, for example "Calibration certificate" (for both Type F1 and Type F2);

b) name and address of the software measurement standard supplier (for both Type F1 and Type F2);

c) unique identification of the certificate, such as the serial number and number of each page, and the total number of pages (for both Type F1 and Type F2);

d) the actual specification operator (see ISO 17450-2) for each relevant metrological characteristic (for both Type F1 and Type F2);

e) the calibrated value with its estimated uncertainty, U [see the GUM (ISO/IEC Guide 98-3)] for each relevant metrological characteristic (for both Type F1 and Type F2)[1)];

f) details of the calibration, including

— whether the certified results for mathematically designed synthetic data have been calculated directly without the need for certification by Type F2 measurement standards, and

— where a Type F2 measurement standard has been used, information on which particular Type F2 measurement standard has been used, together with its uncertainty values,

for both Type F1 and Type F2;

g) any other reference conditions to which each calibration applies, for example the basis of digital evaluation (lateral and vertical quantization) for both Type F1 and Type F2;

h) a statement that the values declared refer to direct measurement or are derived synthetically; where direct measurement is used, relevant detail of the probe shall be provided (for Type F1);

i) identification of the hardware/operating systems to which the reference software has been calibrated (for Type F2).

As far as possible, this required information shall be marked on the media containing each measurement standard, but if there is insufficient space, the values may be stated separately and uniquely identified with the measurement standard, for example by means of a serial number.

NOTE A nominal value is used as an aid to identification. The difference between the nominal value and the calibrated value does not constitute an error.

1) For reference software, it might not be possible to give a closed-form equation for the uncertainty of some values of metrological characteristics. In these cases, all relevant information should be given to allow the users to calculate the uncertainty for themselves.

Annex A
(informative)

Example of file format

Figure A.1 shows a softgauge file format example.

```
ISO 5436 - 2000<0>WIDGET&CO<0><cr><lf>
PRF<0> 2 ISO5436<0><cr><lf>
CX<0> I<0> 250 m<0> 1.0e0 D<0> 1.0e-3<cr><lf>
CZ<0> A<0> 250 m<0> 1.0e0 D<0><cr><lf>
<3><cr><lf>
DATE 10 May 1999<0><cr><lf>
TIME 14:05<0><cr><lf>
CREATED_BY ISO TC213 WG5<0><cr><lf>
COMMENT/* Artificial Data for illustrative purposes only */<0><cr><lf>
<3><cr><lf>
```

```
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-2.000000 <cr><lf>
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<3><cr><lf>
<26>
```

.../continues
next column

Figure A.1 — Softgauge example

Figure A.2 contains an illustration of the data given in the example.

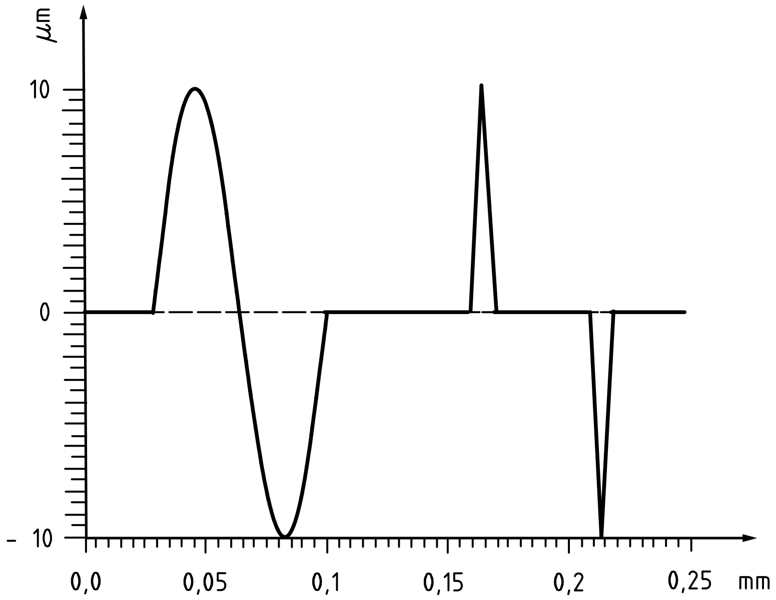

Figure A.2 — Illustration of data given in softgauge example

Annex B
(informative)

Relation to the GPS matrix model

B.1 General

For full details about the GPS matrix model, see ISO/TR 14638. The ISO/GPS Masterplan given in ISO/TR 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.

B.2 Information about this part of ISO 5436 and its use

This part of ISO 5436 defines Type F1 and Type F2 software measurement standards (etalons), as well as the file format of Type F1 software measurement standards for the calibration of instruments for the measurement of surface texture by the profile method as defined in ISO 3274.

B.3 Position in the GPS matrix model

This part of ISO 5436 is a general GPS standard, which influences chain link 6 of the chains of standards on roughness, waviness and primary profiles in the general GPS matrix, as graphically illustrated in Figure B.1.

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

Figure B.1 — Position in the GPS matrix model

B.4 Related standards

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

Bibliography

[1] ISO 8015, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

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

[3] ISO/TR 14638, *Geometrical product specifications (GPS) — Masterplan*

[4] ISO/IEC 10967-1, *Information technology — Language independent arithmetic — Part 1: Integer and floating point arithmetic*

[5] IEC 60559:1989, *Binary floating-point arithmetic for microprocessor systems*

[6] ANSI/IEEE 754-85, *IEEE Standard for Binary Floating-Point Arithmetic*

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