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Geometrical product specifications (GPS) — Surface texture: Areal —

Part 71: Software measurement standards

Spécification géométrique des produits (GPS) — État de surface: Surfacique —

Partie 71: Étalons logiciels

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document 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 25178-71:2012), which has been technically revised.

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

— the definition of 3.7 has been changed;

— Table 1 has been changed.

A list of all parts in the ISO 25178 series can be found on the ISO website.

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 the chain link G of the chains of standards on profile and areal surface texture.

The ISO/GPS Masterplan 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.

For more detailed information of the relation of this document to the GPS matrix model, see Annex B.

This document is concerned with software gauges (Type S1) and reference software (Type S2). It also defines the SDF file format for Type S1 software gauges.

The surface data file (SDF) format is already used by the industry, in particular, by instrument manufacturers and academia. The SDF file format as defined in this document is a standardized sub-set of the possibilities included in the SDF file format as initially defined in the European Surfstand project and EUR15178. It is envisaged that the SDF file format could evolve (as more experience in its usage and future requirements are identified) later in a version 2.0 with additional fields and possibilities.

Geometrical product specifications (GPS) — Surface texture: Areal —

Part 71:
Software measurement standards

1 Scope

This document defines Type S1 and Type S2 software measurement standards (etalons) for verifying the software of measuring instruments. It also defines the file format of Type S1 software measurement standards for the calibration of instruments for the measurement of surface texture by the areal method as defined in the areal surface texture chain of standards, chain link G.

NOTE Throughout this document, the term "softgauge" is used as a substitute for "software measurement standard Type S1".

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 5436-2, *Geometrical product specifications (GPS) — Surface texture: Profile method; Measurement standards — Part 2: Software measurement standards*

ISO 16610 (all parts), *Geometrical product specifications (GPS) — Filtration*

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

ISO 25178-2, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 2: Terms, definitions and surface texture parameters*

ISO 25178-3, *Geometrical product specifications (GPS) — Surface texture: Areal — Part 3: Specification operators*

ISO/IEC Guide 98-1, *Uncertainty of measurement — Part 1: Introduction to the expression of uncertainty in measurement*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5436-2, ISO 16610 (all parts), ISO 17450-2, ISO 25178-2, ISO 25178-3, ISO/IEC Guide 98-1 and ISO/IEC Guide 99 and the following apply.

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

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

3.2
CHAR[n]
array of n ASCII characters

3.3
BYTE
1-byte (8-bit) representation of an ASCII character

3.4
UINT16
2-byte representation of an unsigned integer

Note 1 to entry: Unsigned integers have a minimum value of 0 and a maximum value of 65 535.

Note 2 to entry: The less significant bytes are stored in lower memory addresses; the more significant bytes are stored in higher memory addresses.

3.5
INT16
2-byte representation of a signed integer

Note 1 to entry: Short integers have a minimum value of −32 768 and a maximum value of 32 767.

Note 2 to entry: The less significant bytes are stored in lower memory addresses; the more significant bytes are stored in higher memory addresses.

3.6
INT32
4-byte representation of a signed integer

Note 1 to entry: Long integers have a minimum value of −2 147 483 648 and a maximum value of 2 147 483 647.

Note 2 to entry: The less significant bytes are stored in lower memory addresses; the more significant bytes are stored in higher memory addresses.

3.7
DOUBLE
8-byte representation of a real number consisting of a sign bit, an 11-bit binary exponent, and a 52-bit mantissa, plus the implied high-order 1 bit

Note 1 to entry: Normalized double precision floating point numbers have a range of $\pm[1 + (1 - 2^{-52})] \cdot 2^{1\,023} \approx \pm\, 1{,}797\,693\,134\,862\,315\,7 \cdot e^{308}$. The smallest value is $2{,}225\,073\,858\,507\,201\,4 \cdot e^{-308}$.

Note 2 to entry: The less significant bytes are stored in lower memory addresses; the more significant bytes are stored in higher memory addresses.

Note 3 to entry: See IEEE 754-2008 for binary floating-point arithmetic.

4 Type S software measurement standards

4.1 General

These measurement standards are designed to verify the measuring instrument's software (i.e. filter algorithms, parameter calculation, etc.).

The content of a measurement standard shall be considered a scale limited surface (i.e. an S-F surface or an S-L surface). No part of the content of a measurement standard shall be considered form and thus, no form removal shall be undertaken on a measurement standard prior to presenting it to the software being tested.

4.2 Type S1, reference data

This type of measurement standard is a computer data file that contains a digital representation of a scale limited surface in a suitable recording medium.

Type S1 reference data are used to test software by inputting them as data into the software under test/calibration and comparing the results from the software under test with the certified results from the calibration certificate of the softgauge.

NOTE The certified results for mathematically designed synthetic data can often be calculated directly without the need for certification by Type S2 measurement standards.

4.3 Type S2, reference software

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

NOTE 1 Traceable here means a traceable chain of comparisons, with uncertainty, back to a mathematically designed synthetic data set whose results can be calculated directly.

Type S2 reference software are used to test software by inputting a common data set into the software under test/calibration and the reference software and comparing the results from the software under test with the certified results from the reference software. Reference software values shall be traceable.

NOTE 2 Type S2 measurement standards can also be used to certify Type S1 reference data.

5 File format for Type S1 reference data

5.1 General

The file extension of this file protocol is SDF. The file protocol for the softgauge is divided into three separate sections or records. For implementation of the ASCII and BINARY representations of an SDF data format, see Annex A.

NOTE For the purposes of this document, a right-handed coordinate system is assumed (see ISO 25178-2). Looking from the top, the first point in the data file is in the top left corner.

5.2 Record 1 — Header

5.2.1 General

The header contains general information about each specific measurement. The record is composed of various “fields” in which the information is coded.

The BINARY format consists of fixed length fields defined in Table 1.

Except for the version number, the ASCII format, for the header, consists of a series “keyword = value of field” where the keyword is the ASCII field name given in Table 1.

5.2.2 Version number

The version of a softgauge file format is an array of eight characters formatted the following way: “aISO-1.0” for the ASCII file format or “bISO-1.0” for the BINARY file format. Future evolutions of this format will modify the version number, such as “-2.0”.

5.2.3 Measurement instrument manufacturer's identifier

The identifier includes the source of the data and might also include hardware and software identifiers.

5.2.4 Original creation date and time

This twelve-character field (DDMMYYYYHHMM) stores the date and time that the measurement was completed. Redundant separator characters are not stored but clearly zero padding of fields is required (i.e. 0307 for 3 July not 37).

5.2.5 Last modification date and time

This twelve-character field (DDMMYYYYHHMM) stores the date and time that the SDF file was last modified.

5.2.6 Number of points per profile, *M*

The maximum number of points per profile (along the *x*-direction) shall not exceed one UINT16 of storage (65 535).

5.2.7 Number of profiles or traces, *N*

The maximum number of profiles (along the *y*-direction) or traces shall not exceed one UINT16 of storage (65 535). If $N = 1$, the data can be loaded as a profile; however, its size is limited to 65 535 points.

5.2.8 *X*, *Y* and *Z* axis scale factors

The three scaling factors provide scaling to the standard unit of the meter. The *X*-scale is the sampling interval along the *x*-direction, the *Y*-scale is the profile spacing along the *y*-direction, and the *Z*-scale is the quantization step along the *z*-direction. Thus, an *X*-scale, *Y*-scale or *Z*-scale value of 1,00 E-6 represents a sample spacing of 1 µm. Valid scale factors shall be non-zero positive numbers.

5.2.9 *Z* axis resolution

The *Z* axis resolution specifies the quantization steps in the *z*-direction in the digital data. After certain processing operations (e.g. removal of datum), the data type may have changed or have been re-scaled such that the original quantized data have been re-quantized. Thus, the inclusion of this value enables the user to be aware of the original base resolution of the measurement instrument. The units of the resolution value are in metres. If the value is unknown, this field should be set to a negative number, e.g. −1.

5.2.10 Compression type

This field normally defines the type of compression used for the data. “NO COMPRESSION” shall be used. Therefore, this field value is 0.

5.2.11 Data type

This field defines the base data type used for storage. The field value 5 is for data type INT16; 6 is for data type INT32; 7 is for data type DOUBLE.

Other data types that may have been used in prior definitions of the SDF format are not allowed.

5.2.12 Checksum type

This field defines the type of checksum used for the data. “NO CHECKSUM” shall be used. Therefore, this field value is 0.

Table 1 gives header description of these fields.

Table 1 — ASCII and Binary fields for Record 1

Information	ASCII format	Binary format	
	Field name	Data type	Length in byte
Version number	N/A	CHAR[8]	8
Manufacturer's ID	ManufacID	CHAR[10]	10
Creation date and time	CreateDate	CHAR[12]	12
Last modification date and time	ModDate	CHAR[12]	12
Number of points per profile (*x*-axis)	NumPoints	UINT16	2
Number of profiles (*y*-axis)	NumProfiles	UINT16	2
X-scale	Xscale	DOUBLE	8
Y-scale	Yscale	DOUBLE	8
Z-scale	Zscale	DOUBLE	8
Z-resolution	Zresolution	DOUBLE	8
Compression type	Compression	BYTE	1
Data type	DataType	BYTE	1
Checksum type	CheckType	BYTE	1
		Total	81

5.3 Record 2 — Data area

5.3.1 The data area of the data file contains the coded height information of the surface for the number of points, M, and the number of profiles, N. The actual height values (i.e. in metres) are obtained by scaling the coded values by the Z-scale factor defined in the file header. The data area contains the topographic data in a serial fashion. Profiles are stored successively in the order of their position in the y-direction.

NOTE The x-data are identified with the rows in the data file and the y-data identified with the columns in the data file.

5.3.2 The identification of bad and missing data points is achieved by setting them to the minimum value for the particular data type used, within the data range which is not allowable for any valid data points (e.g. value = −2 147 483 648 for INT32 and value = qNAN for DOUBLE). In ASCII format, the string "BAD" will be used.

NOTE 1 Treatment of "bad" data (outliers): Certain topography measurement systems, as a consequence of the measurement process, produce data points within the complete measurement map that are incorrect. These data points can be referred to as "bad" data.

NOTE 2 Treatment of "missing" data (dropouts): Certain topography measurement systems, as a consequence of the measurement process, produce data points within the complete measurement map that have no value (i.e. the values are missing). These data points can be referred to as "missing" data.

5.4 Record 3 — Trailer

The trailer part of the data file contains historical information that is associated with a particular measurement. For example, when a measurement is made, information such as the operator's name, measurement conditions, and sample specification might be stored with the data file. Also, operator information applied to the data file such as filtering, data inversion, and other process parameters may be attached to the data file. Any other information which the owner of the data believes would be of use and which is not already stored in the header could also be written in the trailer. In order to maintain flexibility of extendibility, it is important that the trailer be of variable length and, for simplicity, exists at the end of the data file. The trailer is, thus, stored at the end of the files as a series of CHARACTER values.

It is suggested that a tagged format be used (as XML format) for information stored in this section.

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 S1 and S2 types);

b) name and address of the software measurement standard supplier (for both S1 and S2 types);

c) unique identification of the certificate (such as the serial number) and of each page, as well as the total number of pages (for both S1 and S2 types);

d) the actual specification operator [see ISO 17450-2 for each relevant metrological characteristic (for both S1 and S2 types)];

e) the calibrated value with its estimated uncertainty, *U* [see ISO/IEC Guide 98-3 (GUM)] for each relevant metrological characteristic (for both S1 and S2 types)[1)];

f) details of calibration, including whether the certified results for mathematically designed synthetic data have been calculated directly without the need for certification by Type S2 measurement standards, and, where a Type S2 measurement standard has been used, information on which particular Type S2 measurement standard has been used together with its uncertainty values[2)] (for both S1 and S2 types);

g) any other reference conditions to which each calibration applies, for example, the basis of digital evaluation (lateral and vertical quantization) for both S1 and S2 types;

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 S1 types);

i) identification of the hardware/operating systems on which the reference software has been developed, checked or verified (for S2 types)[2)].

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 may 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 user to calculate the uncertainty for themselves.

2) This identification applies to the whole chain from measuring instrument to calculation/computers.

Annex A
(informative)

Examples

A.1 Example of an ASCII SDF representation

— The data file consists of a series of lines terminated with CR (ASCII #13), LF (ASCII #10) or CR+LF.

— Additional "white space" characters (ASCII #9, ASCII #10, ASCII #32) are ignored (including those in the data section).

— The three records of the file (i.e. header, data, and trailer) are terminated with a single line containing the character "*" (ASCII #42). Thus, the final line "*" identifies the end of the data file.

— All three records for the ASCII representation are of variable length.

— Elements of the header are given as separate fields for readability and for the ease of use of file I/O.

— The first field of the data file shall contain the version number.

— All the other fields pertaining to the header may be placed in any order in the header section.

— Each field contains three parts: (i) the field name (see Table 1; note that field names are not case-sensitive); (ii) a field separator "=" (ASCII #61); (iii) the value.

— The elements of the data area may be separated by any number and type of "white space" characters.

NOTE Often, it is helpful to use a fixed field width and separate (using CR/LF characters) a number of elements (depending on the data type) such that they fit onto a line width of 80 characters. This enables the files to be typed on the screen for verification.

The following example gives relevant details to illustrate the layout of the ASCII representation of an SDF file. Figure A.1 shows an illustration of the data given in the example.

EXAMPLE A typical SDF file.

```
aISO-1.0 < CR >  < LF >
ManufacID = ISOTC213 < CR >  < LF >
CreateDate = 040120100853 < CR >  < LF >
ModDate = 050320101353 < CR >  < LF >
NumPoints = 251 < CR >  < LF >
NumProfiles = 251 < CR >  < LF >
Xscale  = 1.0E-6 < CR >  < LF >
Yscale  = 1.0E-6 < CR >  < LF >
Zscale  = 1.0E-6 < CR >  < LF >
Zresolution = 1.0E-9 < CR >  < LF >
Compression = 0 < CR >  < LF >
DataType = 7 < CR >  < LF >
CheckType = 0 < CR >  < LF >
* < CR >  < LF >
1.00000 0.99874 0.99495 0.98865 0.97986 0.96858 …… 1.00000 < CR >  < LF >
0.99874 0.99748 0.99369 0.98740 0.97862 0.96736 …… 0.99874 < CR >  < LF >
0.99495 0.99369 0.98993 0.98366 0.97491 0.96369 …… 0.99495 < CR >  < LF >
0.97986 0.97862 0.97491 0.96874 0.96012 0.94907 …… 0.97986 < CR >  < LF >
……
* < CR >  < LF >
< OperatorName > Tom Jones < / OperatorName >
< PartName > S2 Softgauges Example < /PartName >
*
```


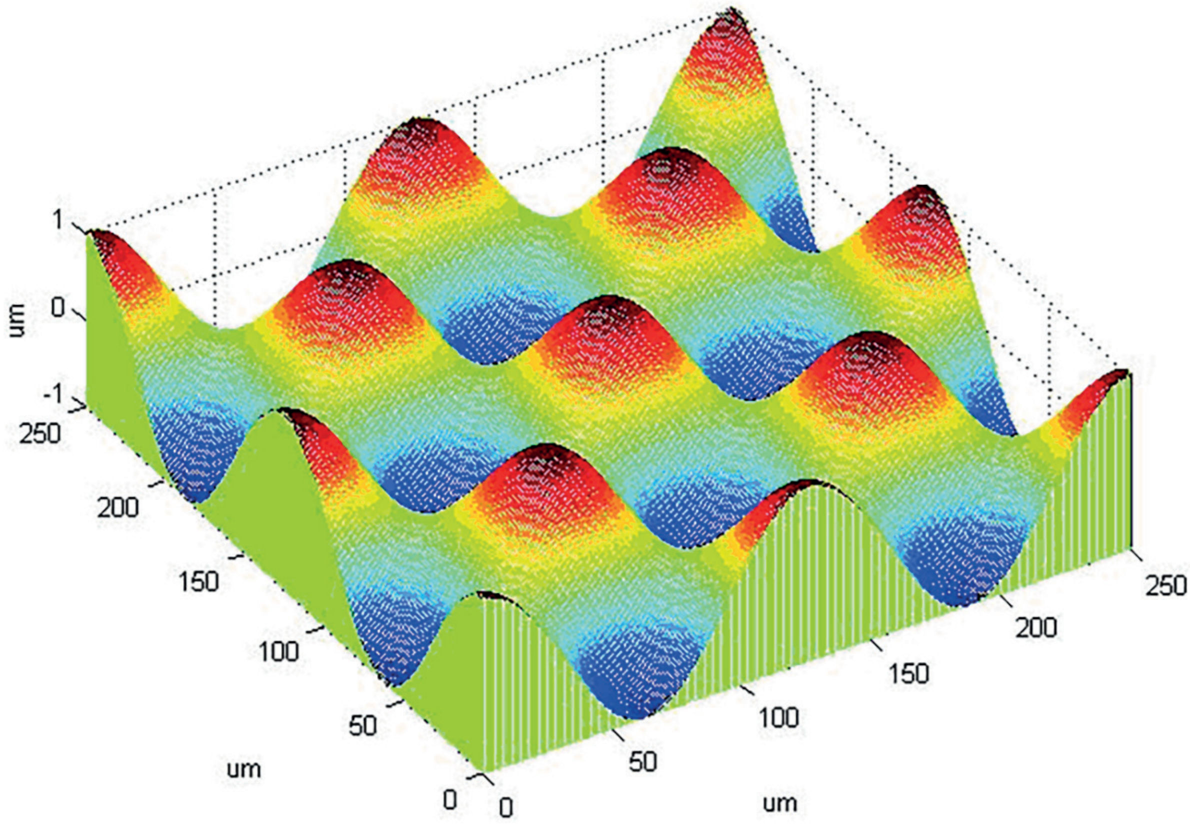

Figure A.1 — Illustration of the data given in the example of a typical SDF file, above

A.2 Implementation of the BINARY SDF representation

The following information pertains to the implementation of the BINARY representation of the SDF file.

— The header shall conform exactly to the sequence of record fields and types given in Table 1. Subsequent revisions of the file format may alter the composition and length of the header section; thus, the version number should be read prior to the header (obviously, the header section is of a fixed length for a given file format version as given in Table 1).

— There are no separator characters to distinguish sections of the data file. The sequence that should be followed is

— read the version number,

— read the header corresponding to the version number (i.e. in this case, that given in Table 1), and

— using information given in the header (data type, number of points, number of profiles, compression type, and checksum type), read the data section.

The remaining information in the file, if any, contains the trailer.

— Strings (unsigned character arrays with more than one character) are assumed to contain valid data for the length of the string. If the valid string data are shorter than the allocated space, then the string shall be filled with spaces (ASCII #32).

— Single unsigned char values in the header (i.e. compression type, data type, and checksum type) are byte representations (i.e. 0 to 255). For example, a compression value of NONE is represented by a value of 0 NOT 48 (i.e. the ASCII code for character "0").

Annex B
(informative)

Relation to the GPS matrix model

B.1 General

The ISO GPS matrix model given in ISO 14638 gives an overview of the ISO GPS system of which this document is a part indicated.

B.2 Information about this document and its use

This document defines Type S1 and Type S2 software measurement standards (etalons), as well as the file format of Type S1 software measurement standards for the calibration of instruments for the measurement of surface texture by the areal method as defined in chain link G of the chains of standards on profile and areal surface texture.

B.3 Position in the GPS matrix model

This document is a general ISO GPS standard. The rules and principles given in this document apply to all segments of the ISO GPS matrix as illustrated in Table B.1 which are indicated with a filled dot (•).

Table B.1 — Position in the GPS matrix model

	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibrations
Size							
Distance							
Radius							
Angle							
Form							
Orientation							
Location							
Run-out							
Profile surface texture							•
Areal surface texture							•
Surface imperfections							
Edges							

B.4 Related International Standards

The related International Standards are those of the chain of standards indicated in Table 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 conformity or nonconformity with specifications*

[3] ISO 14638, *Geometrical product specifications (GPS) — Matrix model*

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

[5] IEEE 754-2008, *IEEE Standard for Floating-Point Arithmetic*

[6] BCR Report EUR 15178N, *The development of methods for the characterisation of roughness in three dimensions* – K.J. STOUT *et al*. – DG XII – E.C. Brussels

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