
**Geometrical product specifications
(GPS) — Filtration —**

**Part 1:
Overview and basic concepts**

*Spécification géométrique des produits (GPS) — Filtrage —
Partie 1: Vue d'ensemble et concepts de base*

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Foreword

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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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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/TS 16610-1 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO/TS 16610 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Filtration*:

- *Part 1: Overview and basic concepts*
- *Part 20: Linear profile filters: Basic concepts*
- *Part 22: Linear profile filters: Spline filters*
- *Part 29: Linear profile filters: Spline wavelets*
- *Part 31: Robust profile filters: Gaussian regression filters*
- *Part 32: Robust profile filters: Spline filters*
- *Part 40: Morphological profile filters: Basic concepts*

- Part 41: Morphological profile filters: Disk and horizontal line-segment filters
- Part 49: Morphological profile filters: Scale space techniques

The following parts are under preparation:

- Part 21: Linear profile filters: Gaussian filters
- Part 26: Linear profile filters: Filtration on nominally orthogonal grid planar data sets
- Part 27: Linear profile filters: Filtration on nominally orthogonal grid cylindrical data sets
- Part 30: Robust profile filters: Basic concepts
- Part 42: Morphological profile filters: Motif filters
- Part 60: Linear areal filters: Basic concepts
- Part 61: Linear areal filters: Gaussian filters
- Part 62: Linear areal filters: Spline filters
- Part 69: Linear areal filters: Spline wavelets
- Part 70: Robust areal filters: Basic concepts
- Part 71: Robust areal filters: Gaussian regression filters
- Part 72: Robust areal filters: Spline filters
- Part 80: Morphological areal filters: Basic concepts
- Part 81: Morphological areal filters: Sphere and horizontal planar segment filters
- Part 82: Morphological areal filters: Motif filters
- Part 89: Morphological areal filters: Scale space techniques

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Introduction

This part of ISO/TS 16610 is a geometrical product specification (GPS) Technical Specification and is to be regarded as a global GPS Technical Specification (see ISO/TR 14638). It influences the chain links 3 and 6 of all chains of standards.

For more detailed information about the relation of this part of ISO/TS 16610 to the GPS matrix model, see Annex F.

This part of ISO/TS 16610 develops the terminology and concepts for GPS filtration. This document generalises the concept of filtration. The series of ISO/TS 16610 documents presents a toolbox of filtration techniques to enable the user to choose an appropriate filter for the functional requirements. They are fundamental documents upon which other ISO documents are built.

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Geometrical product specifications (GPS) — Filtration —

Part 1: Overview and basic concepts

1 Scope

This part of ISO/TS 16610 sets out the basic terminology for GPS filtration and the framework for the fundamental procedures used in GPS filtration.

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 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO/TS 17450-1:2005, *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

ISO/TS 17450-2:2002, *Geometrical product specifications (GPS) — General concepts — Part 2: Basic tenets, specifications, operators and uncertainties*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in VIM, ISO 14660-1, ISO 17450-1, ISO 17450-2 and the following apply.

3.1

integral feature

surface or line on a surface

NOTE An integral feature is intrinsically defined.

[ISO 14660-1:1999, 2.1.1]

3.1.1

surface portion

SP

portion of a partitioned integral surface

3.1.2

surface profile

line resulting from the intersection between the **surface portion** (3.1.1) and an ideal plane.

NOTE The concept of profiles is under development and it is possible that the definition of surface profile will be reworded.

3.2

primary mathematical model

set of nested mathematical representations of the **surface portion** (3.1.1), wherein each representation in the set can be described by a finite number of parameters

3.2.1

nesting index

NI
number, or set of numbers, indicating the relative level of nesting for a particular **primary mathematical model** (3.2)

NOTE 1 Given a particular nesting index, models with lower indices contain more surface information, whereas models with higher nesting indices contain less surface information.

NOTE 2 By convention, as the nesting index approaches zero (or a series of all zeros), there exists a primary mathematical model that approximates the real surface of a workpiece to within any given measure of closeness.

NOTE 3 The cut-off value for the Gaussian filter is an example of a nesting index. For the morphological filter, the nesting index is the size of the structuring element (e.g. the radius of the disk), which is different from the wavelength concept that underlies the notion of "cut-off".

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3.2.2

degree of freedom

primary mathematical model number of independent parameters required to fully describe a particular **primary mathematical model** (3.2)

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3.3

primary surface

PS
surface portion (3.1.1) obtained when the latter is represented as a specified **primary mathematical model** (3.2) with specified **nesting index** (3.2.1)

3.3.1

primary profile

line resulting from the intersection between the **primary surface** (3.3) and an ideal plane

NOTE The concept of profiles is under development and it is possible that the definition of primary profile will be reworded.

3.4

primary mapping

PM(| NI)
mapping indexed by the **nesting index** (3.2.1), used to identify a particular **primary surface** (3.3) with the specified nesting index, in order to represent a **surface portion** (3.1.1) that satisfies the sieve and projection criteria

NOTE 1 The primary mapping is defined in terms of mathematical mappings as

$$PS = PM(SP | NI) \tag{1}$$

where

PS is the primary surface,

SP is the surface portion.

NOTE 2 Other filters can be constructed using a combination of primary mappings, e.g. the weighted mean of primary mappings, the supremum of primary mappings.

3.4.1

sieve criterion

criterion where two **primary mappings** (3.4) applied one after another to a surface portion is entirely equivalent to only applying one of these two primary mappings to the surface portion, namely that primary mapping with the highest **nesting index** (3.2.1)

NOTE The sieve criterion is defined in terms of mathematical mappings as

$$PM[PM(SP | NI_1) | NI_2] = PM(SP | NI) \text{ with } NI = \max(NI_1, NI_2) \quad (2)$$

where

SP is the surface portion.

3.4.2

projection criterion

criterion wherein a **primary surface** (3.3) with a specified **nesting index** (3.2.1) is mapped onto itself using the **primary mapping** (3.4) with the same specified nesting index

3.5

filtration

operation used to create a non-ideal feature by reducing the level of information of a non-ideal feature

[ISO/TS 17450-1:2005, 3.12]

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3.5.1

profile filter

operator consisting of a **filtration** (3.5) operation for use on a **surface profile** (3.1.2)

NOTE Throughout this document, the term "operator" is interpreted in its mathematical context. When it is used in the context of ISO/TS 17450-2:2002, the qualifier "specification" or "verification" is used in front of the term "operator".

3.5.2

areal filter

operator consisting of a **filtration** (3.5) operation for use on a **surface portion** (3.1.1)

3.6

outlier

local portion in a data set that is not representative, or not typical, for the partitioned **integral feature** (3.1), and which is characterized by magnitude and scale

NOTE Not all outliers can be determined using data alone: only those that are physically inconsistent with stylus tip geometry. It is sometimes possible to give a warning based on magnitude/scale criteria.

3.7

open profile

finite length **surface profile** (3.1.2) with two ends

NOTE The surface profile does not intersect with itself.

3.8

closed profile

connected finite length **surface profile** (3.1.2) without ends

NOTE The surface profile does not intersect with itself, i.e. it is a simple closed curve or Jordan curve.

3.9

robustness

insensitivity of the output data against specific phenomena in the input data

NOTE Outliers, scratches and steps are examples of specific phenomena; more details can be found in ISO/TS 16610-30.

3.10

filter equation

equation for the mathematical description of the filter

NOTE Filter equations do not necessarily specify an algorithm for the numerical realization of the filter.

4 General discussion

4.1 General

A filter is a way of separating features of interest from other features in data.

EXAMPLE Sieving particles, where soil particles are filtered into different sizes, depending on the size of the sieve holes.

The nesting index is the size at which features are separated. In the above example, the nesting index corresponds to the size of the holes in the sieve.

More precisely, filtration consists in the first place of defining a set of nested representations (similar to a set of Russian dolls) to be used to model the real surface, such that the further into the nesting, the smoother the model used to represent the surface. The nesting index is a number that indicates the level of the nesting/smoothness of the model, such that the higher the value of the nesting index, the smoother the model used to represent the surface. By convention, as the nesting index approaches zero, there exists a model that represents the real surface.

Secondly, a primary mapping is defined. The primary mapping is a method of choosing a particular model, with a specified nesting index and which satisfies certain properties, to represent a real surface. The primary mapping is a basic filter from which other filters can be constructed. Illustrative examples are given in Annex A.

A toolbox of new and novel filter tools is recommended, which includes mean line filters, morphological filters, robust filters and techniques that decompose surface texture into different scale components. The recommended toolbox has been developed to meet current and future GPS requirements in filtration, with the aim of publishing the filtration toolbox in the form of ISO Technical Specifications, so that GPS users can first assess their utility, before deciding upon their publication as full International Standards. These ISO Technical Specifications form the ISO/TS 16610 series of documents. The filtration masterplan (see Annex B) shows the structure of the part number allocation for the ISO/TS 16610 series. The particular filter tool and its default value are provided in other ISO application documents.

The advantages and disadvantages of different filter types are given in Annex C. Concept diagrams for the basic concepts of filtration are given in Annex D, and the relationship to the filtration matrix is given in Annex E.

4.2 Primary mathematical models

The primary mathematical models have been developed to generalise the concept of wavelength band. The aim of the nesting index is to generalise the concept of wavelength.

Given a particular model within a set of nested models, higher nestings (with a smaller nesting index) contain more surface information, whereas lower nestings (with a larger nesting index) contain less surface information. By convention, as the nesting index approaches zero, there exists a primary mathematical model that approximates the partitioned integral feature to within any given measure of closeness (as defined by a suitable mathematical norm).

The sieve criterion is derived from Matheron's size criteria^[33], and is a necessary condition for the following reason: if a primary mapping is applied to a partitioned integral feature, any further primary mapping with a larger nesting index is exactly equivalent to applying the second primary mapping with the larger nesting index directly to the partitioned integral feature. In other words, for a primary mapping with a specified nesting index, no information is lost concerning primary mappings of the partitioned integral feature with a larger nesting index.

The projection criterion is necessary in order to ensure that the nesting index corresponds to Matheron's definition of size.

Since the nesting index of the primary mathematical models corresponds to scale/size, and the primary mappings satisfy the sieve criterion, the nesting index can be used to define the generalised concept of wavelength.

5 Filter designations

Table 1 indicates the basic semantics in designating filters. Table 2 indicates the filter designations.

Table 1 — Basic semantics in designating filters

Filter	Type	Category
F = Filter	A = Areal (3D)	L = Linear
		M = Morphological
	R = Robust	R = Robust
		L = Linear
	P = Profile (2D)	M = Morphological
		R = Robust

Table 2 — Filter designations

Type	Category	Designation	Name	ISO document
FA	FAL	FALG	Gaussian	ISO/TS 16610-61
		FALS	Spline	ISO/TS 16610-62
		FALW	Spline Wavelet	ISO/TS 16610-69
	FAM	FAMCB	Closing Ball	ISO/TS 16610-81
		FAMCH	Closing Horizontal segment	ISO/TS 16610-81
		FAMOB	Opening Ball	ISO/TS 16610-81
		FAMOH	Opening Horizontal segment	ISO/TS 16610-81
		FAMAB	Alternating series Ball	ISO/TS 16610-89
		FAMAH	Alternating series Horizontal segment	ISO/TS 16610-89
	FAR	FARG	Robust Gaussian	ISO/TS 16610-71
FARS		Robust Spline	ISO/TS 16610-72	
FP	FPL	FPLG	Gaussian	ISO/TS 16610-21
		FPLS	Spline	ISO/TS 16610-22
		FPLW	Spline Wavelet	ISO/TS 16610-29
	FPM	FPMCD	Closing Disk	ISO/TS 16610-41
		FPMCH	Closing Horizontal segment	ISO/TS 16610-41
		FPMOD	Opening Disk	ISO/TS 16610-41
		FPMOH	Opening Horizontal segment	ISO/TS 16610-41
		FPMAD	Alternating series Disk	ISO/TS 16610-49
		FPMAH	Alternating series Horizontal segment	ISO/TS 16610-49
	FPR	FPRG	Robust Gaussian	ISO/TS 16610-31
FPRS		Robust Spline	ISO/TS 16610-32	
FP (special case)	F2RC	2RC	ISO 3274	