



**International
Standard**

ISO 18183-1

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

**Part 1:
Vocabulary and basic concepts**

Spécification géométrique des produits (GPS) — Partition —

Partie 1: Vocabulaire et concepts de base

**First edition
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Foreword

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This document was prepared by Technical Committee ISO/TC 213, *Dimensional and Geometrical product specifications and verification*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 290, *Dimensional and Geometrical product specification and verification*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 18183 series can be found on the ISO website.

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

Introduction

This document is a geometrical product specification (GPS) standard and is to be regarded as a general ISO GPS standard (see ISO 14638). It influences chain links B, C and E of all the chains of standards in the ISO GPS matrix model.

The ISO GPS matrix model given in ISO 14638 gives an overview of the ISO GPS system, of which this document is a part. The fundamental rules of ISO GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise indicated.

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

Partition is one of the feature ISO GPS operations defined in ISO 17450-1.

The partition can be applied to the surface of the nominal model (reading of an ISO GPS specification) or to the model of non-ideal surface (skin model) of a part (verification).

The information needed to apply a partition to a nominal model is:

- geometrical information contained in the nominal model;
- partition information contained in the ISO GPS specification, such as nature of the specification, symbols such as CZ or UF, restricted areas and so on;
- the method and criterion used for partition.

The information needed to apply a partition to a model of non-ideal surface (skin model) is:

- the result of the partition applied to the nominal model for the corresponding considered ISO GPS specification;
- the method and criterion used for partition.

The approach taken for partition is based on the concept of a single surface (single line), where a nominal model is first separated into a set of single surfaces which become an initial set of partitioned features. This initial set of partition features can then be modified, if required, by ISO GPS modifiers from the specification to obtain the required set of partitioned features of design intent.

This approach taken for partition allows interpretation of the specification to determine the required set of partitioned features of design intent in specification and also allows algorithms to be developed that compute the linked measured partitioned features in verification.

The ISO 18183 series addresses the description of the methods and criteria that can be used to apply a partition.

Both the data and the methods used for the partition of the nominal model or the model of non-ideal surface (skin model) are different. This motivates the splitting of the series into several parts: ISO 18183-2 for partition of the nominal model, ISO 18183-3 for partition of the model of non-ideal surface (skin model) and this document for terms and concepts applicable to partition in general. ISO 18183-4 is foreseen to deal with explicit partition with one or more specific section tools.

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Geometrical product specifications (GPS) — Partition —

Part 1: Vocabulary and basic concepts

1 Scope

This document defines the basic terms for partitioned features and establishes a framework for the fundamental procedures used in partition.

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 8015, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

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

ISO 22432, *Geometrical product specifications (GPS) — Features utilized in specification and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8015, ISO 17450-1 and ISO 22432 and the following apply.

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

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

3.1 geometrical feature

point, line, surface, volume or a set of these terms

[SOURCE: ISO 17450-1:2011, 3.3, modified — Notes 1 and 2 to entry removed.]

3.2 partition

feature operation used to identify a portion of a *geometrical feature* (3.1) belonging to the real surface of the workpiece or to a surface model of the workpiece

[SOURCE: ISO 17450-1:2011, 3.4.1.1.]

3.3 nominal model

<of a workpiece> model of the perfect shape defined by the designer

Note 1 to entry: Nominal model represents the design intent.

Note 2 to entry: Partition information is part of the nominal model.

[SOURCE: ISO 17450-1:2011, 3.2.1, modified — Note 2 to entry added.]

3.4

non-ideal surface model skin model

<of a workpiece> model of the physical interface of the workpiece with its environment

Note 1 to entry: See Reference [7] for different types of physical interfaces of the workpiece with its environment.

[SOURCE: ISO 17450-1:2011, 3.2.2, modified — Note 1 to entry added.]

3.5

fuzzy set

set whose elements have degrees of membership

Note 1 to entry: These degrees of membership range from 1, when the element is in the set, to 0, when it is out of the set, see Reference [8] for more details.

3.5.1

feature uncertainty zone identity set

fuzzy set (3.5) of a cloud of points representing a *geometrical feature (3.1)* or its boundary in specification or verification

Note 1 to entry: There are three types of feature uncertainty zone identity sets: surface, line and point.

Note 2 to entry: Feature uncertainty zone identity set is the geometrical realization of fuzzy sets.

3.5.2

surface feature uncertainty zone identity set (F2)

feature uncertainty zone identity set (3.5.1) generated from a *geometrical feature (3.1)* of type surface

EXAMPLE Planar face, facet, cylinder.

Note 1 to entry: Different partition algorithms (see ISO 18183-3) can generate different surface feature uncertainty zone identity sets.

3.5.3

line feature uncertainty zone identity set (F1)

feature uncertainty zone identity set (3.5.1) generated from a *geometrical feature (3.1)* of type line

EXAMPLE Edge between facets, line profile, roundness profile, line on a surface.

Note 1 to entry: Different partition algorithms (see ISO 18183-3) can generate different line feature uncertainty zone identity sets.

3.5.4

point feature uncertainty zone identity set (F0)

feature uncertainty zone identity set (3.5.1) generated from a *geometrical feature (3.1)* of type point

EXAMPLE Corner between three or more facets, datum of type point, end point of a line.

Note 1 to entry: Different partition algorithms (see ISO 18183-3) can generate different point feature uncertainty zone identity sets.

3.6

invariance class

group of ideal features defined by the same displacement(s) of the ideal feature for which the feature is kept identical in the space

[SOURCE: ISO 17450-1:2011, 3.3.1.2]

3.7

feature discontinuity

<partition> unintentional break in the continuity of a *geometrical feature* ([3.1](#))

Note 1 to entry: Feature discontinuity can never appear in the nominal model, see [4.3.2](#) for an example.

Note 2 to entry: The concept of continuity used here is by open sets in a topology, since this also allows for point cloud 'surfaces'^[9]. The open sets in the topological space (surface, line) are defined from the basis of open disks and open intervals, respectively.

3.8

feature transition

<partition> meeting or merging of features by design

Note 1 to entry: Feature transition shall appear in the nominal model.

3.9

selection

identification of the partitioned feature(s) required to be modified

Note 1 to entry: Examples appear in ISO 18183-2.

Note 2 to entry: This term is an abstraction, abstracted from all the different ways, within the ISO GPS system, to identify partitioned feature(s).

3.10

subdivision

identification of a portion of the selected partitioned feature

Note 1 to entry: This term is an abstraction, abstracted from all the different ways, within the ISO GPS system, to identify a portion of the selected partitioned feature.

3.11

simplification

merging of the selected partitioned features into one partitioned feature

Note 1 to entry: This term is an abstraction, abstracted from all the different ways, within the ISO GPS system, to merge partitioned features.

3.12

face

<nominal> single surface bounded by one or more vertices or edges

3.13

edge

<nominal> line along which two single surfaces meet

Note 1 to entry: the edge is bounded by two vertices or has no vertices

3.13.1

blend edge

<nominal> edge defined by a line along which two single surfaces meet that have a continuous gradient orthogonal to the edge

3.14

vertex

<nominal> meeting point of three or more different single surfaces or the meeting point of two or more edges or the point of intersection of a pencil of lines

Note 1 to entry: An example of a pencil of lines is the vertex of a cone.

3.14.1

blend vertex

<nominal> vertex that has a smooth gradient, in all directions, through the vertex

3.14.2

sharp vertex

<nominal> vertex that is not a blend vertex

3.15

single feature

geometrical feature which is a single point, a single line or a single surface

[SOURCE: ISO 22432:2011, 3.2.9, modified — Note 1 to entry and example removed.]

3.15.1

single surface

continuous surface which is nominally a plane, a cylinder, a sphere, a cone, a torus, another surface of revolute invariance class, a surface of prismatic invariance class, a helix, a surface of complex invariance class or a restricted part of one of them

Note 1 to entry: A revolute surface is a single surface if its generatrix is a single line (see ISO 22432:2011, Figure 11).

Note 2 to entry: ISO 17450-1:2011, Table 1 illustrates the types of single surfaces with their invariance degree.

Note 3 to entry: If a surface contains a surface portion of higher invariance degree than itself, then it is not a single surface. A partial ordering of single-surface types, based on whether they can contain each other, is given in ISO 22432:2011, Figure 12. The ordering is partial because some surface types cannot be contained within each other.

[SOURCE: ISO 22432:2011, 3.2.9.4]

3.15.2

single line

continuous line which is nominally a straight line, a circle or a complex line

Note 1 to entry: An arc is a restricted circle (see ISO 22432:2011, Figure 10).

Note 2 to entry: A single line does not intersect itself.

[SOURCE: ISO 22432:2011, 3.2.9.2]

3.16

compound feature

geometrical feature which is a collection of several single features

[SOURCE: ISO 22432:2011, 3.2.10]

3.17

integral feature

surface or line on a surface

[SOURCE: ISO 22432:2011, 3.3, modified - Notes 1 to 4 to entry removed.]

3.17.1

integral surface portion

integral surface which is a portion of the complete surface

[SOURCE: ISO 22432:2011, 3.3.1]

3.17.2

integral line portion

integral line which is a portion of the complete line

[SOURCE: ISO 22432:2011, 3.3.2]

3.18

complete feature

total feature

geometrical feature containing the totality of the points corresponding to one or more single geometrical features and pertaining to the surface model

[SOURCE: ISO 22432:2011, 3.2.13]

3.19

restricted feature

geometrical feature corresponding to a portion of a complete/total non-ideal feature or having a portion of an (ideal) infinite feature

[SOURCE: ISO 22432:2011, 3.2.14]

3.20

slippable motion

rigid transformation ([3.20.1](#)) in which the displacement of every point **P** belonging to the surface *S* is tangent to *S* at the point **P**

3.20.1

rigid transformation

geometrical transformation that preserves the Euclidean distance between every pair of points

Note 1 to entry: Rotations and translations or any combination of these are rigid transformations.

Note 2 to entry: An example of a non-rigid transformation is a plane translated along its normal.

3.21

curvature

local property of a line or a surface defined at every point quantifying second-order derivative of a line from a straight line or a surface from a plane

Note 1 to entry: Curvature is a fundamental concept in differential geometry. Although the mathematical fundamentals apply to continuous and differentiable lines and surfaces (nominal surface or model of non-ideal surface (skin model)), curvature can be extended to elements of a discrete type (discrete surface, sampled surface or real surface) and referred to discrete curvature (see ISO 18183-3:2024, Clause A.1).

3.21.1

curvature of a planar line

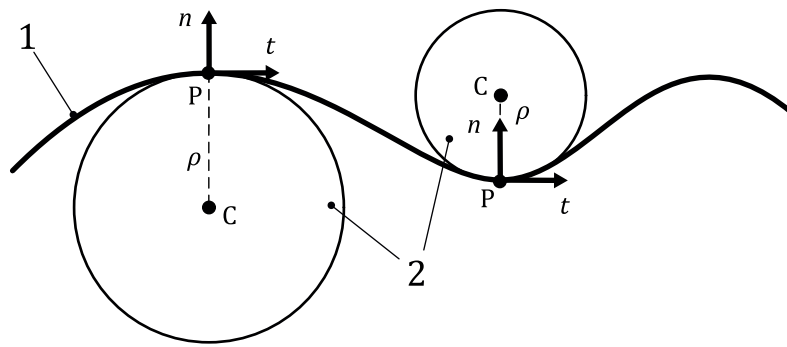
inverse of the radius of the osculating circle

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

Note 2 to entry: The osculating circle is the circle that has the same tangent in given point as the line and has its centre located on the normal to the line at the given point.

Note 3 to entry: The normal vector is anti-clockwise with respect to the tangent vector.

Note 4 to entry: The curvature is positive when the vector from the centre of the osculating circle to the considered point is collinear and the same direction to the normal vector. The curvature is negative when the vector from the centre of the osculating circle to the considered point is collinear and opposite to the normal vector.



Key

- 1 planar line
- 2 osculating circle
- P point on the line
- n normal vector
- t tangent vector
- c centre of the osculating circle
- ρ radius of the oscillating circle

Figure 1 — Curvature of a planar line

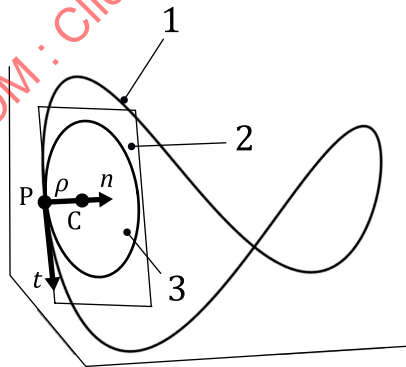
3.21.2

curvature of a non-planar line

inverse of the radius of the 3D osculating circle

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

Note 2 to entry: The 3D osculating circle is the circle contained on the osculating plane spanned by the tangent vector and the normal vector that has the same tangent in given point as the line and has its centre located on the normal to the line at the given point.



Key

- 1 non-planar line
- 2 osculating plane
- 3 osculating circle
- P point on the line
- n normal vector
- t tangent vector
- c centre of the osculating circle
- ρ radius of the osculating circle

Figure 2 — Curvature of a non-planar line

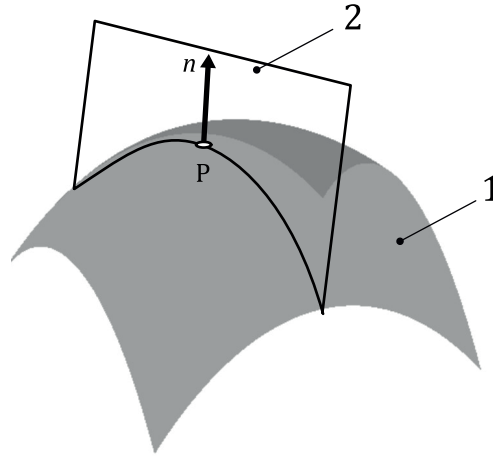
3.21.3

normal curvature of a surface

curvature of the line lying in the surface and in a normal section of a surface at a given point

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

Note 2 to entry: See ISO 18183-3 for more details.



Key

- 1 surface
- 2 normal section
- n normal vector
- P point of surface

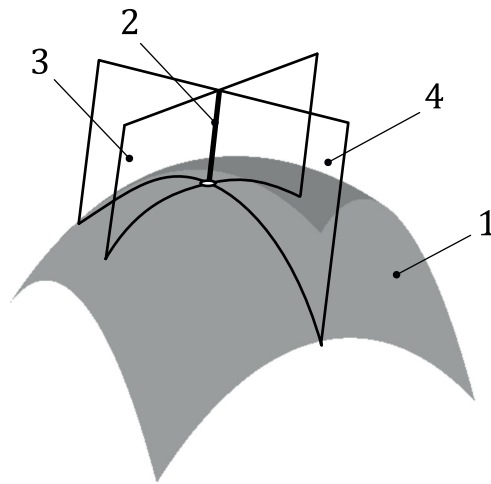
Figure 3 — Normal curvature of a surface

3.21.4

principal curvatures of a surface

minimum ($k_{\min}$) and maximum ($k_{\max}$) values of the normal curvatures at a given point on a surface

Note 1 to entry: See [Figure 4](#).



Key

- 1 surface
- 2 normal direction
- 3 normal section of minimum curvature
- 4 normal section of maximum curvature

Figure 4 — Principal curvatures of a surface

3.21.5

Gaussian curvature

K

product of the principal curvatures at a given point

$$K = k_{\max} \times k_{\min}$$

3.21.6

mean curvature

H

half of the sum of the principal curvatures at a given point

$$H = \frac{k_{\max} + k_{\min}}{2}$$

3.21.7

shape index

s

function of principal curvatures that takes value on the interval $[-1, 1]$

$$s = \frac{-2}{\pi} \arctan \left(\frac{\kappa_{\max} + \kappa_{\min}}{\kappa_{\max} - \kappa_{\min}} \right)$$

3.21.8

curvedness

c

positive-defined function of principal curvatures that specifies the magnitude of curvature

$$c = \sqrt{\frac{\kappa_{\max}^2 + \kappa_{\min}^2}{2}}$$

3.22**classification of points**

method of classifying points into categories based on curvatures

Note 1 to entry: See ISO 18183-3:2024, Clause A.2.

3.22.1**Gaussian curvature-mean curvature classification*****K-H* classification**

classification of points based on the sign of *Gaussian curvature* (3.21.5) and *mean curvature* (3.21.6)

Note 1 to entry: See Table 1.

Note 2 to entry: See ISO 18183-3:2024, Figure A.3 for examples of *K-H* classification.

Table 1 — *K-H* classification of points on a surface

	$K > 0$	$K = 0$	$K < 0$
$H < 0$	Peak	Ridge	Saddle ridge
$H = 0$	—	Flat	Minimal surface
$H > 0$	Pit	Valley	Saddle valley

3.22.2**shape index-curvedness classification*****s-c* classification**

<partition> classification of points based on the values of *shape index* (3.21.7) and *curvedness* (3.21.8)

Note 1 to entry: See Table 2.

Note 2 to entry: See ISO 18183-3:2024, Figure A.4 for examples of *s-c* classification.

Table 2 — *s-c* classification of points on a surface

Surface type	Shape index interval	Surface type	Shape index interval
Spherical pit	$s \in \left[-1, -\frac{7}{8}\right]$	Spherical peak	$s \in \left(+\frac{7}{8}, +1\right]$
Pit	$s \in \left(-\frac{7}{8}, -\frac{5}{8}\right]$	Peak	$s \in \left(+\frac{5}{8}, +\frac{7}{8}\right]$
Valley	$s \in \left(-\frac{5}{8}, -\frac{3}{8}\right]$	Ridge	$s \in \left(+\frac{3}{8}, +\frac{5}{8}\right]$
Saddle valley	$s \in \left(-\frac{3}{8}, -\frac{1}{8}\right]$	Saddle ridge	$s \in \left(+\frac{1}{8}, +\frac{3}{8}\right]$
Saddle	$s \in \left(-\frac{1}{8}, +\frac{1}{8}\right]$	Flat	s undefined; $c = 0$

3.23**discrete surface**

reconstructed surface composed of triangular meshes

3.24**discrete normal vectors**

discrete analogue of normal vectors for discrete lines and surfaces

3.25**discrete curvature**

discrete analogue of curvatures for discrete lines and surfaces

4 Partition concepts

4.1 General

A feature operation called partition is used to identify features.

Partition can be used to:

- obtain ideal features from the nominal model, see ISO 18183-2;
- obtain non-ideal features from the non-ideal surface model (skin model) corresponding to nominal features, see ISO 18183-3 and [Figure 5](#);
- obtain limited parts of ideal features (e.g. a portion of a straight line) or non-ideal features (e.g. a section of a non-ideal surface).

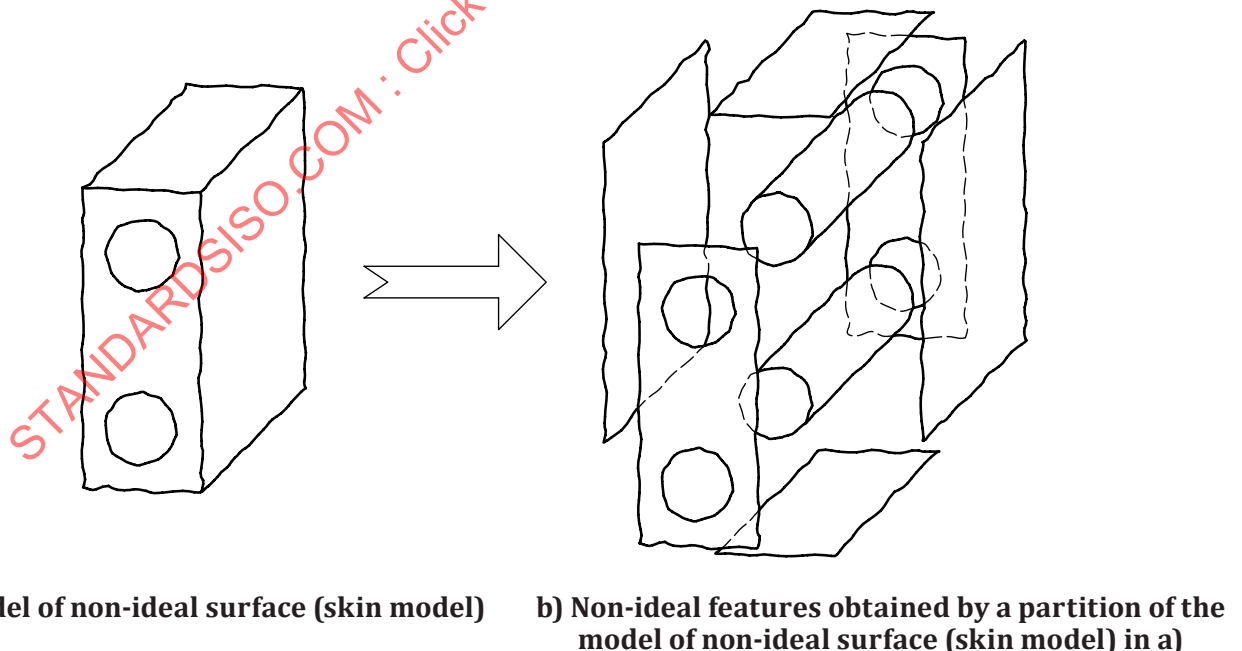
4.2 Determination of the partition

The concept of the single surface (single line), the associated concepts of invariance class and the partial ordering of invariance classes is used in the determination of the initial set of partitioned features of a geometrical product (see ISO 18183-2 and ISO 18183-3 for more detail).

The nominal model shall define an initial set of partitioned features by decomposing itself into single surfaces (single lines). This initial set of partitioned features shall then be modified if required by ISO GPS modifiers in the specification to obtain the required set of partitioned features of design intent.

NOTE The nominal model contains sufficient information so that the partition to single surfaces (single lines) can be obtained unambiguously.

Throughout the ISO 18183 series, the partition of a geometrical product always begins with the initial set of partitioned features induced by the single surface (single lines) concept, which is used to define the initial set of partitioned features. Also, all other non-default partitions are subsequently derived from the initial set of partitioned features (see ISO 18183-2 and ISO 18183-3 for more detail).



SOURCE: ISO 17450-1:2011, Figure 17.

Figure 5 — Complete partition of a model of non-ideal surface (skin model)

4.3 Partitioned feature types

4.3.1 General

Within the ISO 18183 series there exist two basic types of partitioned feature:

- a) partition of the nominal model. See rules in ISO 18183-2;
- b) partition of the measured real surface corresponding to the nominal partitioned features. See rules in ISO 18183-3.

The same partition is defined for both specification and verification; however, the former is defined on a model of non-ideal surface (skin model) (continuous surface) whereas the latter is defined on a discrete surface model.

This implies that the specification and verification partitions can be mapped onto each other by isomorphisms, as specified by the duality principle. If, in practice, this is not the case, then an additional uncertainty contributor shall be considered for each of the measurands resulting from the difference between the two sets of specification and verification partitioned features.

NOTE This uncertainty calculation is not always possible, particularly when the resulting changed partitioned features are of different invariance classes.

4.3.2 Feature discontinuity

The nominal model defines the initial set of partitioned features. It is possible that during manufacture a discontinuity is produced that is not part of the design intent and which divides a single surface. This is a feature discontinuity and is not part of the associated single surface on the nominal model; as a result this single surface remains part of the initial set of partitioned features.

An example of a feature discontinuity is a sphere that has been manufactured as two half-spheres which, when put together, have a feature discontinuity. The partitioned feature defined in the nominal model is the complete sphere, not the set of partitioned features of two half-spheres.

The definition of continuity used here is by open sets in a topology, since this also allows for digitization of surfaces. The topology is defined by the open sets generated by the set of all disks, which do not include their boundary and which are portions of the surface, see Reference [9].

4.3.3 Feature transition

Feature transition does not require classification as it is part of the nominal model.

4.4 Use of feature uncertainty zone identity sets in partition

For partition of a workpiece in verification and specification it is necessary to accept the concept that features and their boundaries are fuzzy [feature uncertainty zone identity], due to the real (verification) or implied (specification) fuzziness of assignment of a point to a geometrical element, see [Figure 6](#).

Three types of feature uncertainty zone identity sets are identified:

- a) surface feature uncertainty zone identity set;
- b) line feature uncertainty zone identity set;
- c) point feature uncertainty zone identity set.

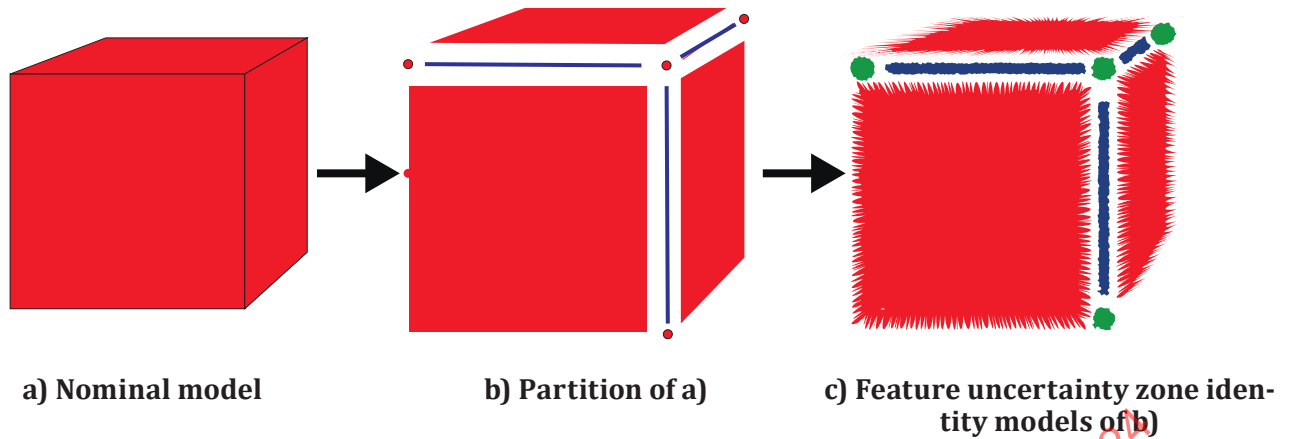


Figure 6 — A nominal model, total partition and the corresponding feature uncertainty zone identity models

Each of these sets can be empty or non-empty and in particular, the point type feature uncertainty zone identity set can have more than one element. For specification, the feature uncertainty zone identity sets are continuous; for verification, they are discrete.

The working model of a feature uncertainty zone identity set consists of: for each particular point, the fuzzy degree of membership, of that point, representing the amount of fuzziness that belongs to a particular partitioned feature. In the case of adjacent features, these sets will overlap. The outstanding issues are the assignment of fuzzy degree of membership and what criterion will be used as a threshold for the partition operation.

4.5 Notation

The partition operation shall be determined by the specification (see ISO 18183-2 and ISO 18183-3 for details).

5 General information

[Annex A](#) contains a concept diagram and [Annex B](#) explains the relationship of this document to the ISO GPS matrix model.

Annex A (informative)

Concept diagram

A.1 Basic concepts used in partition

Figure A.1 is the concept diagram for the basic concepts used in partition.

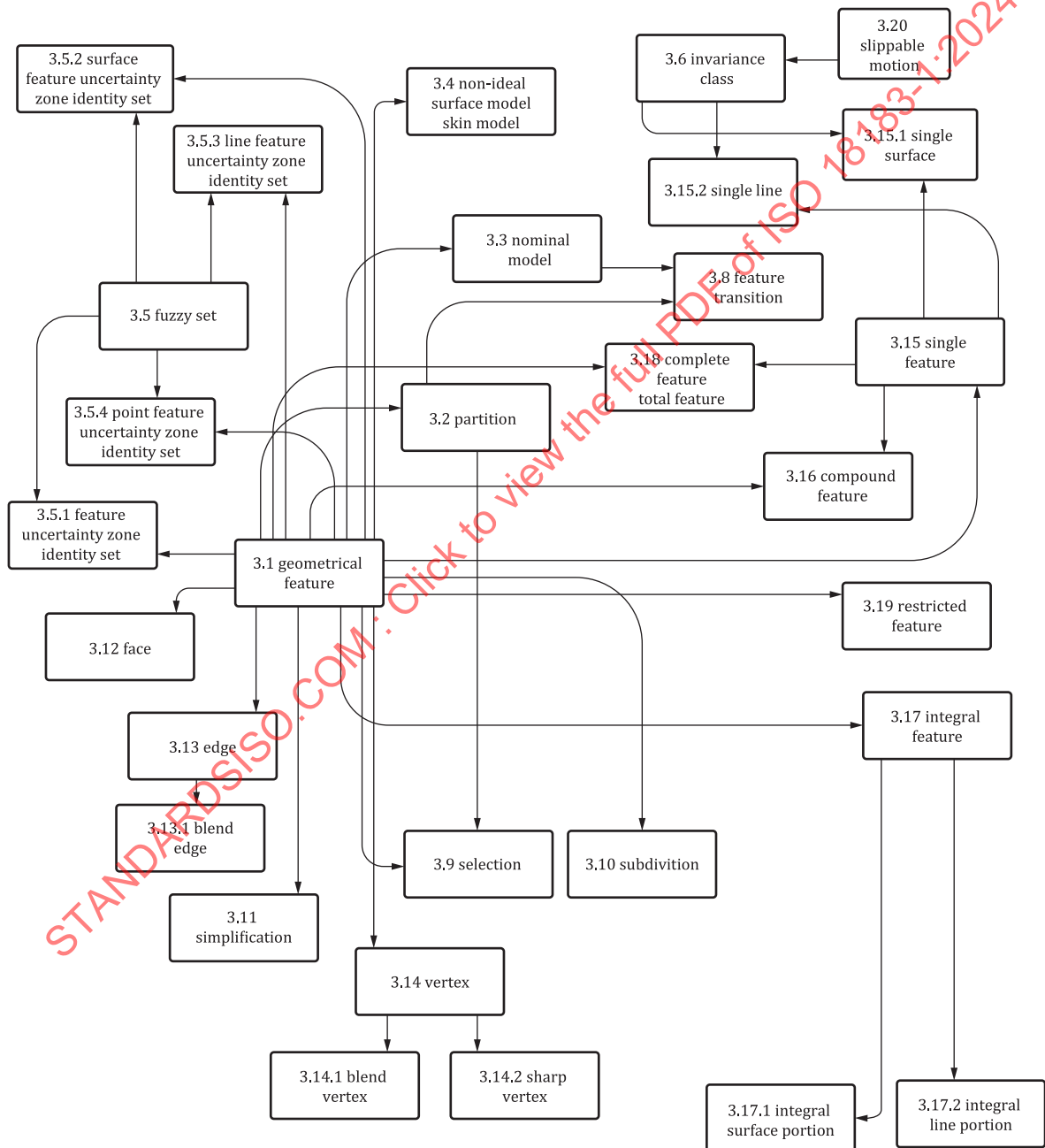


Figure A.1 — Concept diagram for basic concepts for partition