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ISO 17450-3

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Geometrical product specifications (GPS) — General concepts —

Part 3: Toleranced features

Spécification géométrique des produits (GPS) — Concepts généraux —

Partie 3: Éléments tolérancés

Reference number
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Contents

Page

Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 213, *Dimensional and geometrical product specifications and verifications*.

This first edition of ISO 17450-3 cancels and replaces ISO 14660-2:1999, which has been technically revised.

ISO 17450 consists of the following parts, under the general title *Geometrical product specification (GPS) — General concepts*:

— *Part 1: Model for geometrical specification and verification*

— *Part 2: Basic tenets, specifications, operators, uncertainties and ambiguities*

— *Part 3: Toleranced features*

— *Part 4: Geometrical characteristics for quantifying form, orientation, location and run-out deviations*

Introduction

This part of ISO 17450 is a geometrical product specifications (GPS) standard and is to be regarded as a fundamental GPS standard (see ISO 14638). It influences all chain links of all chains of standards in the general 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 of the relation of this part of ISO 17450 to the GPS matrix model, see Annex A.

Geometrical product specifications (GPS) — General concepts —

Part 3: Toleranced features

1 Scope

This part of ISO 17450 gives default definitions for the extracted features (integral or derived) of workpieces, which are toleranced features in GPS specifications (dimensional, geometrical, or surface texture specifications). This part of ISO 17450 defines default geometrical features used to define GPS characteristics.

2 Normative references

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

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*

ISO 25378, *Geometrical product specification (GPS) — Characteristics and conditions — Definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17450-1, ISO 22432, ISO 25378 and the following apply.

3.1
opposing point pair
collection of two points established simultaneously, the separation of which is a local size of a feature of size

Note 1 to entry: The distance between the two points constituting an opposing point pair is a two point size (see ISO 14405-1).

Note 2 to entry: In the case of a feature of size defined as “two opposed planes”, the median point of the two points constituting an extracted opposing point pair belongs to its median extracted surface.

3.2
elementary toleranced feature
smallest part of a complete geometrical feature for which a GPS characteristic is defined

EXAMPLE 1 For an unrestricted flatness specification, a global GPS characteristic is defined for the complete integral feature, which in this case is an elementary toleranced feature.

EXAMPLE 2 For a straightness specification, a local GPS characteristic may be defined for each line feature in a given direction in the complete integral feature. Each of these line features is the intersection between a planar feature and the complete integral feature and is an elementary toleranced feature. The complete integral feature is the toleranced feature.

3.3
toleranced feature
complete toleranced feature
set of one or more geometrical features, for which a GPS characteristic is defined or a collection of elementary toleranced features

Note 1 to entry: "Toleranced feature" without a qualifier is a complete feature, not an elementary feature.

Note 2 to entry: A toleranced feature is a set of geometrical features on which a GPS specification is defined.

3.4
median centre
centre point calculated as the centre of an opposing point pair

Note 1 to entry: A centre of an associated sphere is a directly associated median point (see ISO 22432 and 5.3.2.1) and not a median centre.

4 General

A GPS characteristic (see ISO 25378) is a basic characteristic (an intrinsic characteristic or a location or an orientation situation characteristic).

— The size of a deviated feature (see ISO 22432), which is nominally a feature of size is an intrinsic characteristic (see ISO 17450-1), which is used for dimensional specification (see ISO 14405).

— The value calculated from the local distances between a deviated feature and a reference feature (see ISO 22432) is a situation characteristic (see ISO 17450-1), which is used for geometrical specification (see ISO 1101) or for surface texture characteristic (see ISO 25378 and ISO 1302).

A deviated feature is obtained from an input feature (see ISO 25378) by using or not using the operation of filtration and/or association.

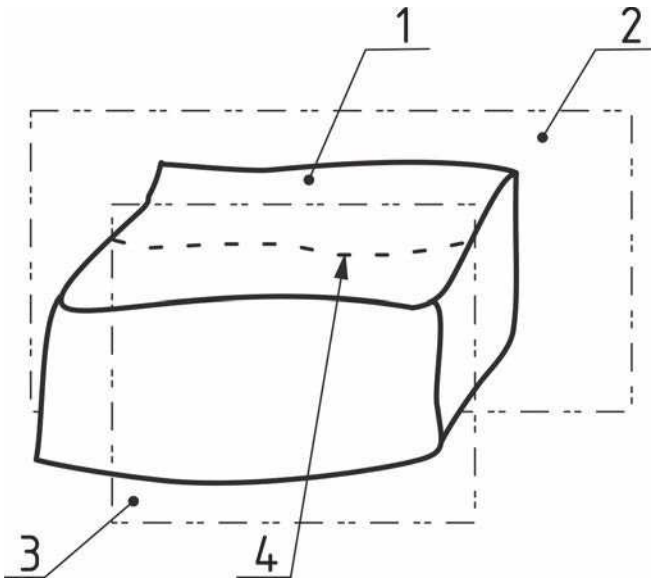
By default, the input integral feature is defined by an extraction of an infinite number of points from the real feature. In verification, the extracted integral feature does not contain an infinite number of points.

By default, the input feature is a single feature, see ISO 22432.

By default, a boundary belongs to both adjacent single extracted integral features.

If the complete extracted integral feature is a line, then the complete extracted line is defined by the intersection of the complete extracted integral surface feature with an intersection feature.

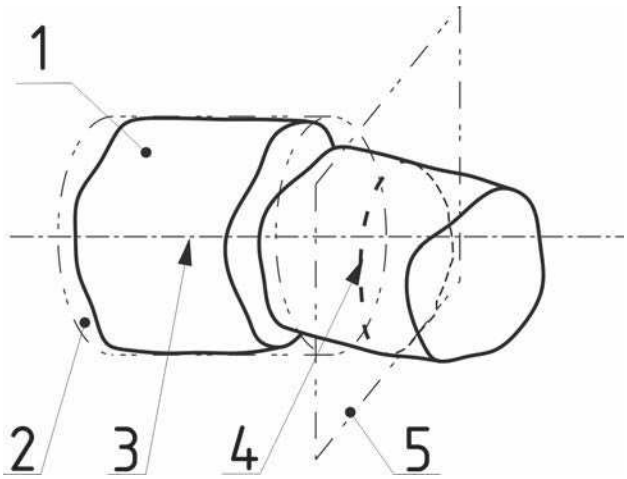
The intersection plane is a full plane (see Figure 1 and Figure 2) or a half plane (see Figure 3). The intersection plane can be explicitly or implicitly defined by GPS specification with or without a specific location. When the intersection has no specific location, then it belongs to a set of planes containing an axis or a set of parallel planes or a set of planes oriented from an associated feature.



Key

1 tolerance feature: complete extracted feature
2 associated feature
3 intersection plane which is established parallel to the associated surface
4 elementary toleranced feature: complete extracted section line

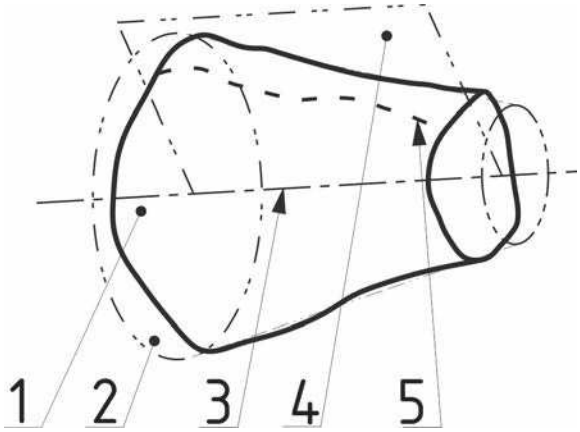
Figure 1 — Example of intersection plane used to establish an elementary toleranced feature



Key

1 complete extracted feature
2 associated feature
3 situation feature of the associated feature (in this case, its axis)
4 elementary toleranced feature: complete extracted section line
5 intersection plane perpendicular to the axis of the associated feature

Figure 2 — Example of intersection plane constrained in orientation used to establish an elementary toleranced feature



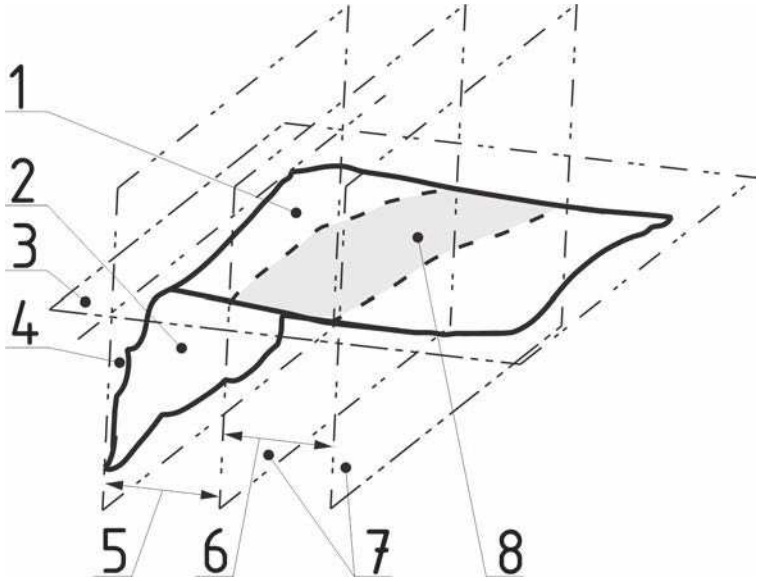
Key

1 toleranced feature: complete extracted feature
2 associated feature
3 situation feature of the associated feature (in this case, its axis)
4 intersection plane including the situation feature of the associated feature
5 elementary toleranced feature: complete extracted section line

Figure 3 — Example of intersection plane, as a half plane, used to establish an elementary toleranced feature

If the input feature is a restricted feature, then its boundaries are defined from the single feature's boundaries with other features. The nominal location of the boundaries of the restricted feature shall be given in the specification. To identify a location intrinsically defined on a single integral feature, a primary datum is defined from the single integral feature. The location is defined from this primary datum.

To identify a location on a single integral feature defined in a given distance from an adjacent feature, a primary datum is first defined from the single integral feature. Subsequently, a secondary datum as a single datum or a common datum is defined from one or more adjacent features from which the location is defined. The location is defined in this datum system (see Figure 4).



Key

1 toleranced feature: complete extracted feature
2 adjacent extracted integral surface
3 associated feature to the complete extracted surface establishing the primary datum
4 associated feature (to the adjacent surface) constrained in orientation from the primary datum (3)
5 theoretical exact dimension (TED) defining a location of a boundary of the restricted extracted surface (8)
6 theoretical exact dimension (TED) defining the extent of the restricted extracted surface (8)
7 intersection planes used to define boundaries of the restricted extracted surface (8)
8 elementary toleranced feature: restricted extracted surface

Figure 4 — Example of identification of a restricted area

5 Default rules for establishing geometrical features

5.1 General

By default, without specific indication, all intermediate associations for establishing a geometrical feature as a portion of an integral surface, an integral line, an integral point or a derived feature are established from the total least squares (Gaussian) objective function without material constraint.

The final association for establishing datums, wherever the datum is applied, depends on the specification.

The final association for establishing characteristics depends on the specification.

NOTE An unequal repartition of the points extracted on a surface can influence the result of an association. This includes the case, when a portion of the feature is removed from the complete mathematical definition of the feature, e.g. a cylinder with a key way: the key way creates an asymmetrical repartition of the points on the cylinder. This produces, e.g. with the total least square association criteria, an artificial shift of the location of the cylinder axis (compared to the associated location without the key way). This shift appears in the opposite direction of the key way.

5.2 Integral feature

5.2.1 General

An integral feature and its nature (a point, a line, a surface or a volume) are defined in ISO 17450-1. It is observed in different models (e.g. nominal model, discrete surface model). When an integral feature is an extracted feature, then it is called extracted integral feature (point, line or surface).

By default, the toleranced feature is the complete extracted integral feature.

The elementary toleranced feature can be the complete integral feature, any areal portion of it, any complete line or portion line on it or a set of one or more specific points in it.

5.2.2 Extracted integral line

An extracted integral line is obtained by the intersection of the non-ideal integral feature and an areal intersection feature.

If the intersection feature is not totally locked, then a set of extracted integral lines is to be considered as the complete toleranced feature (see Figure 5). In this case, each extracted integral line is an elementary toleranced feature.

If the intersection feature is totally locked, then only one extracted integral line is to be considered (see Figure 6). In this case, the extracted integral line is an elementary toleranced feature but also the complete toleranced feature.

5.2.3 Extracted integral point

An extracted integral point is obtained by the intersection of the non-ideal integral feature and an intersection straight line.

For each extracted integral point, the location of the intersection straight line shall be totally locked.

5.2.4 Opposing point pair

The two-point size is only obtained from an opposing point pair, which is established from an extracted integral feature of size with linear size.

The centre point of the opposing point pair is used to define the extracted derived surface of a feature of size with linear or angular size (e.g. extracted median surface of a wedge or a slot).

An opposing point pair is obtained by the intersection of a non-ideal integral feature of size with a straight line enabling feature.

If the intersection does not result in exactly two points, then an opposing point pair is not defined at this location of the enabling feature.

By default, an opposing point pair is obtained by the following sequence of operations:

a) partition of the single input feature from the non-ideal surface model or from the real surface of the workpiece;

b) reconstruction of the surface, if the extracted feature does not contain an infinite number of points;

c) filtration of the extracted feature.

The primary enabling feature is established from the skeleton feature of the total least square associated feature of the real integral input feature (see Table 1).

The opposing point pair is obtained directly by the intersection between the input feature and the primary enabling feature, unless a secondary enabling feature is necessary (see Table 1).

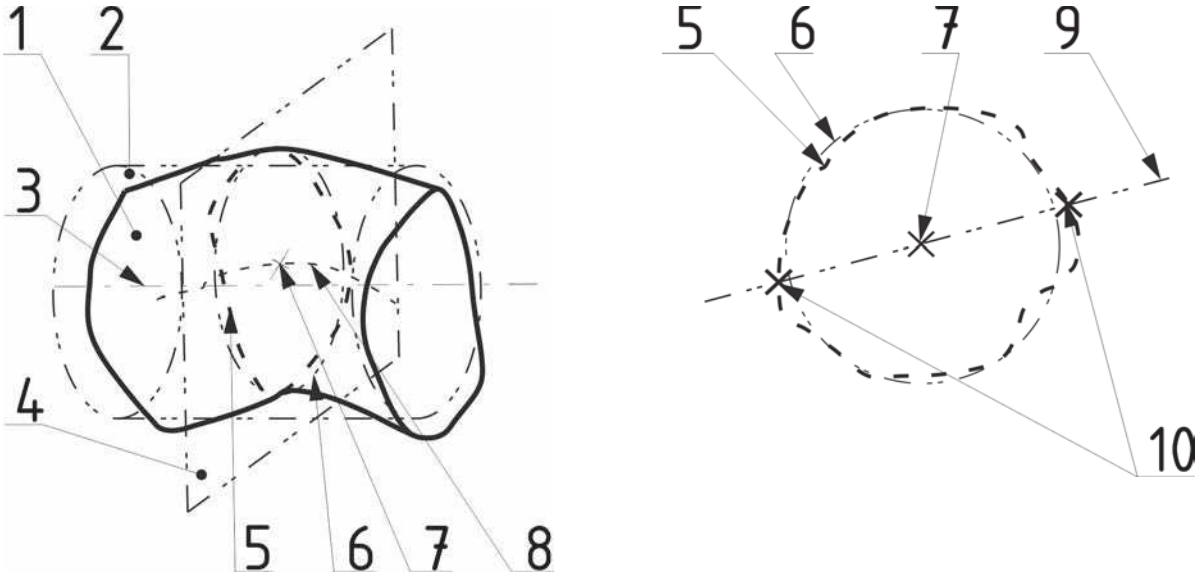
If a secondary enabling feature is necessary, then the first enabling feature defines a set of section lines. Each secondary enabling feature is an associated feature to one of these section lines. Each opposing point pair is obtained by the intersection of a section line (extracted integral line) and its secondary enabling feature.

In the case of the cylinder, two kinds of enabling feature are necessary to define an opposing point pair. See Figure 5 as presented in Table 1.

In the case of the two parallel planes, one kind of enabling feature is necessary to define an opposing point pair as presented in Table 1.

Table 1 — Enabling features to construct opposing point pairs on a feature of size

Type of associated feature of size	Type of feature of size	Skeleton feature of the associated feature	Enabling feature	Secondary enabling feature necessary
Sphere	linear	Point	Straight line through the skeleton feature (Free orientation)	No
Cylinder	linear	Straight line	Plane perpendicular to the skeleton feature (Free location)	Yes
Cone	angular	Straight line		
Revolute surface (e.g. torus)	linear	circle		
Complex surface (e.g. oblong hole)	linear	Segment of a surface	Straight line perpendicular to the skeleton feature (Free location)	
Two intersecting planes	angular	Plane	Straight line perpendicular to the skeleton feature (Stated orientation and free location)	No
Two parallel planes	linear			
Two coaxial cylinders	linear	Cylinder		
Two equidistant complex surfaces	linear	Complex surface		
Circle	linear	Point	Straight line through the skeleton feature (Free orientation)	
Complex line	linear	Segment of line	Straight line perpendicular to the skeleton feature	
Two parallel straight lines	linear	Straight line		
Two intersecting straight lines	angular			
Two equidistant complex lines	linear	Complex line		



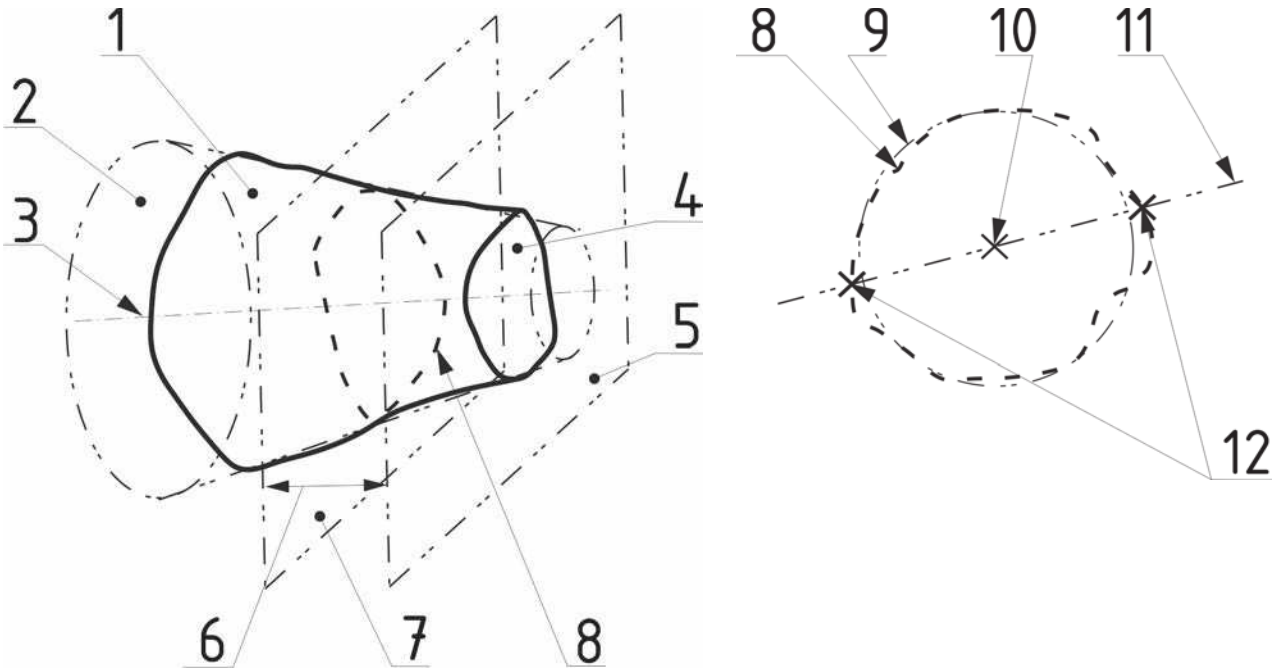
a) extracted integral line (nominally circular) and extracted median line

b) opposing point pair

Key

1 extracted integral surface
2 associated cylinder
3 associated cylinder axis
4 primary enabling feature: intersection plane perpendicular to the axis
5 extracted integral line
6 associated circle
7 centre of associated circle
8 extracted median line: set of the centres of associated circles (7) for any location of the intersection plane (4)
9 secondary enabling feature: straight line including the centre of associated circle (7)
10 opposing point pair: intersection of the secondary enabling feature (9) and the extracted integral line (5)

Figure 5 — Extracted median line and opposing point pair on a cylinder



a) extracted integral line in a specific section plane

b) opposing point pair on an extracted integral line

Key

1 complete extracted integral surface
2 associated integral surface
3 situation feature of the associated integral surface (2)
4 adjacent extracted integral surface
5 associated plane with orientation constrained perpendicular to the situation feature (3) and external to the material
6 specified distance
7 intersection plane (1st enabling feature) constructed parallel to (5) at a specified distance (6)
8 extracted integral (section) line in the specific intersection plane
9 associated circle
10 centre of the associated circle
11 straight line (2nd enabling feature) including the circle centre (10)
12 opposing point pair

Figure 6 — Opposing point pair in a specific section of a conical surface

5.3 Median feature

5.3.1 General

A median feature, which is a point, a line or a surface, is defined in ISO 22432. It is observed in different models (e.g. nominal model, discrete surface model).

When a median feature (point, line or surface) is

— an extracted feature, then it is called extracted median feature, or

— an associated feature, then it is called indirectly or directly associated median feature.

A median feature only exists when the intersection between a feature of size and an intersection feature defines exactly two points. Nominally, the median feature is a symmetry feature.

Several types of median features can be defined from the same real (integral) feature such as the following:

— the skeleton of the associated feature (obtained when the value of the size of the feature of size becomes 0 mm or 0°);

— the extracted median feature;

— the associated feature of the extracted derived feature.

A feature of size (linear or angular) can have one or more symmetry features, i.e. one or more median features, see examples in Table 2.

Table 2 — Examples of symmetry features for nominal integral features of linear or angular size

Type of nominal integral feature	Symmetry feature
Sphere	Point
Cylinder	Axis: straight line
Cone	Axis: straight line
Torus	Circle Point Axis Plane
Oblong hole	Axis Two perpendicular planes
Two parallel planes	Plane
Two intersecting planes	Plane
Two coaxial cylinders	Cylinder
Circle	Point
Two parallel straight lines	Straight line
Two intersecting straight lines	Straight line

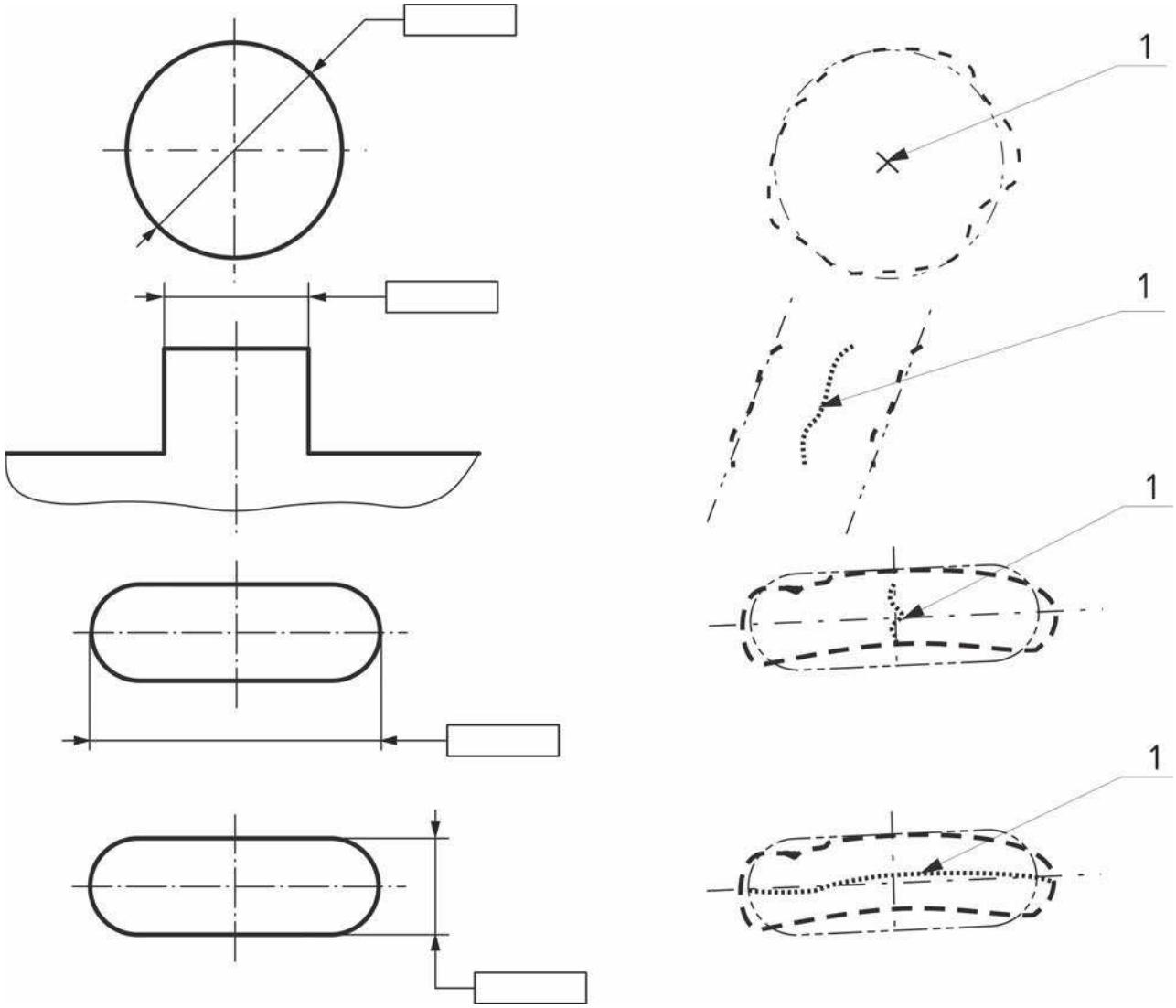
The default associated feature is the total least square associated feature.

The default type of a toleranced extracted median feature depends on the shape of the nominal integral feature (see Table 3).

Table 3 — Default extracted median feature

Type of nominal integral feature		Default extracted median feature
3D-feature	Sphere	3D-associated centre
	Cylinder	Set of 2D-associated centres
	Cone	
	Torus	
	Revolute surface	
	Complex surface	Set of median centres
	Two parallel planes	
	Two intersecting planes	
	Two coaxial cylinders	
	Two complex surfaces	
2D-feature	Circle	2D associated centre
	Two parallel straight lines	Set of median centres
	Two intersecting straight lines	
	Two complex lines	
1D-feature	Opposing point pair	Median centre

Depending on the geometrical feature, one or more median features can exist for the same extracted integral feature. To determine the toleranced median feature, it is necessary to decode the geometrical specification. Illustrations of this are given in Figure 7.



Key

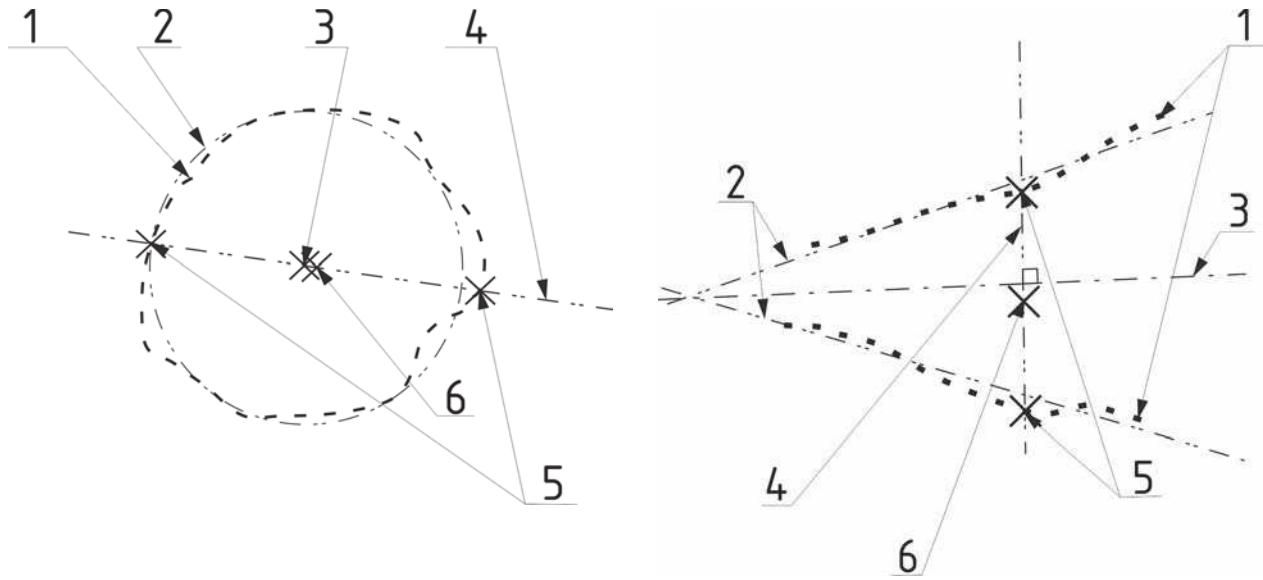
1 toleranced median feature

Figure 7 — Examples of specifications indicating toleranced median features

5.3.2 Median point

5.3.2.1 Median centre

A median centre is obtained as a calculated median point which is a calculated centre of an opposing point pair (see Figure 8).



a) Example of a centre point taken on a nominally circular line

b) Example of a centre point taken on a line pair

Key

1 extracted integral line (section line)

2 associated feature(s)

3 median feature of the associated feature(s) (centre of the associated circle, or median straight line of the two associated straight lines)

4 straight line enabling feature (going through 3 in the case of a circle and perpendicular to 3 in the case of a line pair)

5 opposing point pair

6 median centre

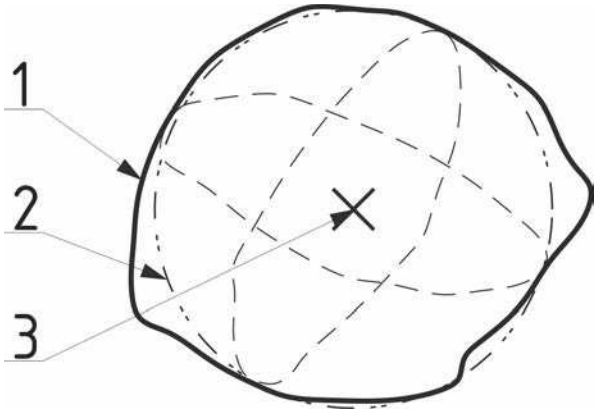
Figure 8 — Example of a median centre built from a section feature

5.3.2.2 Associated centre

An associated centre is the centre of an associated sphere (3D-associated centre), or a set of associated circle centres (2D-associated centres), or the median point in the case of an opposing point pair. The associated feature can be associated to the entire toleranced feature (defining a 3D-associated centre) or to an elementary toleranced feature that is either a line or an opposing point pair (defining a 2D-associated centre). In the first case, the centre is a global centre. In the second case, the centre is a local centre.

5.3.2.2.1 3D-associated centre

A 3D-associated centre is the centre point of the associated sphere (see Figure 9).



Key

1 extracted integral surface, which is nominally a sphere

2 associated sphere

3 3D-associated centre (centre of the associated sphere)

Figure 9 — Example of a 3D-associated centre

5.3.2.2.2 2D-associated centre

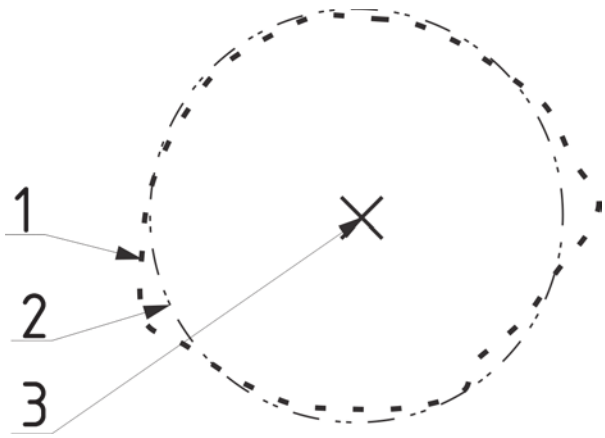
A 2D-associated centre is the centre point of the associated feature to a section feature (see Figure 10) or the median point for the opposing point pair.

The section plane defining the section line shall be determined from the set of situation features of the associated feature.

— If the relevant skeleton feature is a point: the section plane shall contain the 3D-associated centre (see Figure 9).

— If the relevant skeleton feature is a line: the section plane shall be perpendicular to this line.

— If the relevant skeleton feature is a plane: the section plane shall be perpendicular to this plane.



Key

1 extracted integral line

2 associated circle

3 centre of the associated feature

Figure 10 — Example of a 2D-associated centre

5.3.3 Median line

5.3.3.1 Directly associated median line portion

A directly associated median line portion is a directly associated median line restricted to the length of the input feature.

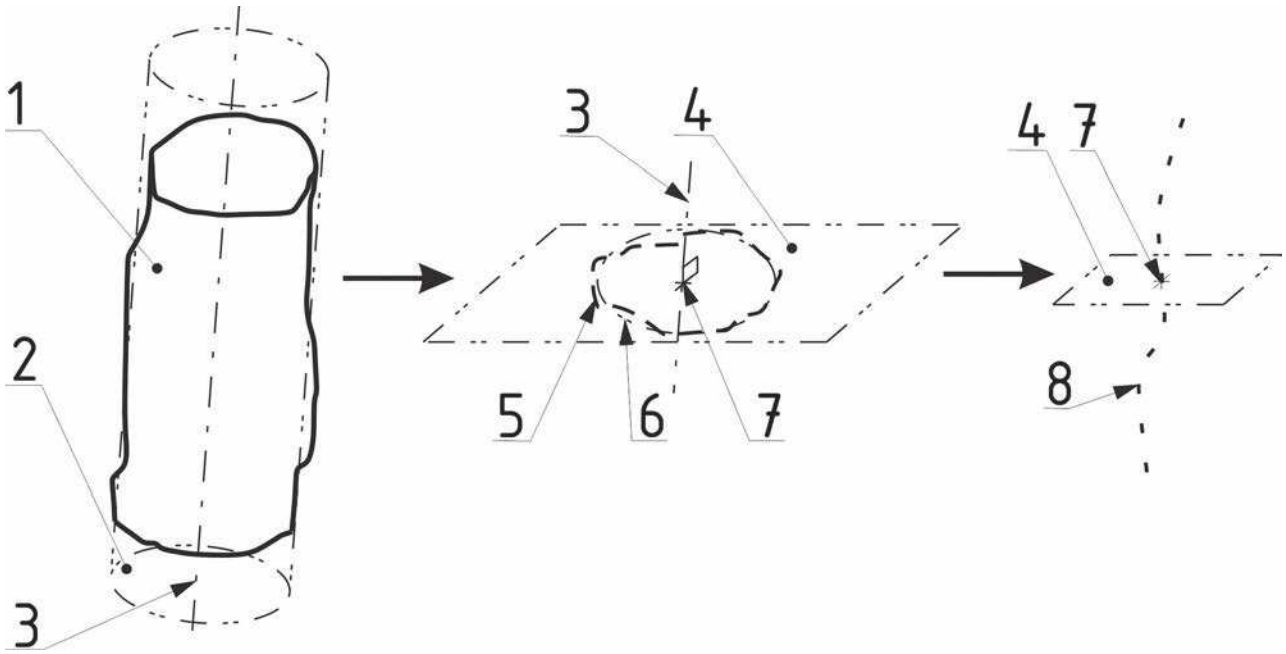
NOTE A directly associated median line portion is a straight line.

This restriction is obtained by the associated features to the features adjacent to the input feature. These associated features are constrained in orientation by the associated feature of the input feature and constrained to be external to the material of the adjacent features.

5.3.3.2 Extracted median line

An extracted median line is a set of 2D-associated centres.

EXAMPLE In the case of a nominally cylindrical surface, the extracted median line is the collection of 2D-associated centres (see Figure 11).



Key

1 extracted integral surface
2 associated cylinder
3 axis of associated integral feature
4 intersection plane constructed perpendicular to (3)
5 extracted integral line
6 associated circle
7 2D-associated centre: centre of (6)
8 extracted median line: set of the 2D-associated centre for all possible location of (4)

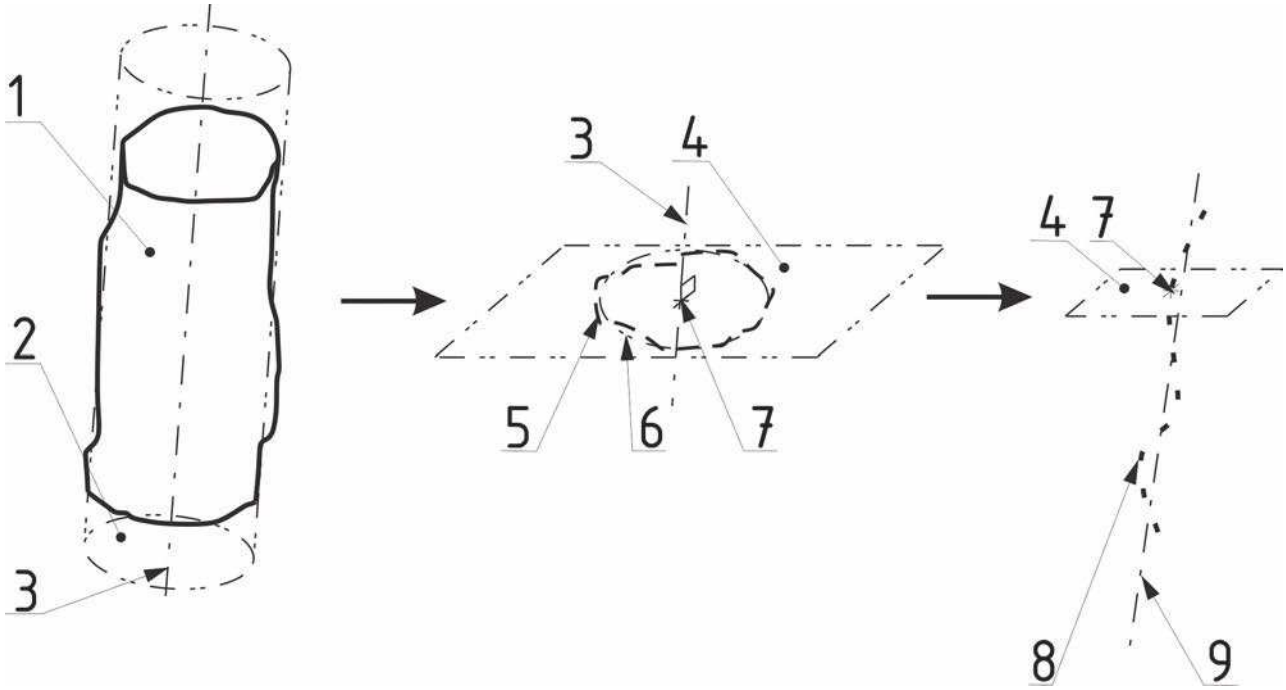
Figure 11 — Extracted median line of a cylinder

5.3.3.3 Indirectly associated median line portion

An indirectly associated median line portion is an indirectly associated median line restricted to the length of the extracted line.

NOTE An indirectly associated median line portion is a straight line.

The restriction limits the extent of the indirectly associated median line to the portion where a perpendicular distance from the associated feature to the extracted median line exists, (see Figure 12).



Key

1 extracted integral surface
2 associated cylinder
3 axis of associated integral feature
4 intersection plane constructed perpendicular to (3)
5 extracted integral line
6 associated circle
7 2D-associated centre: centre of (6)
8 extracted median line: set of the 2D-associated centre for all possible locations of (4)
9 restricted indirect associated line: associated line to (8)

Figure 12 — Illustration of the process to build a (restricted) indirect associated line

5.3.4 Median surface

5.3.4.1 Directly associated median surface portion

A directly associated median surface portion is a directly associated median surface restricted to the extent of the input feature.

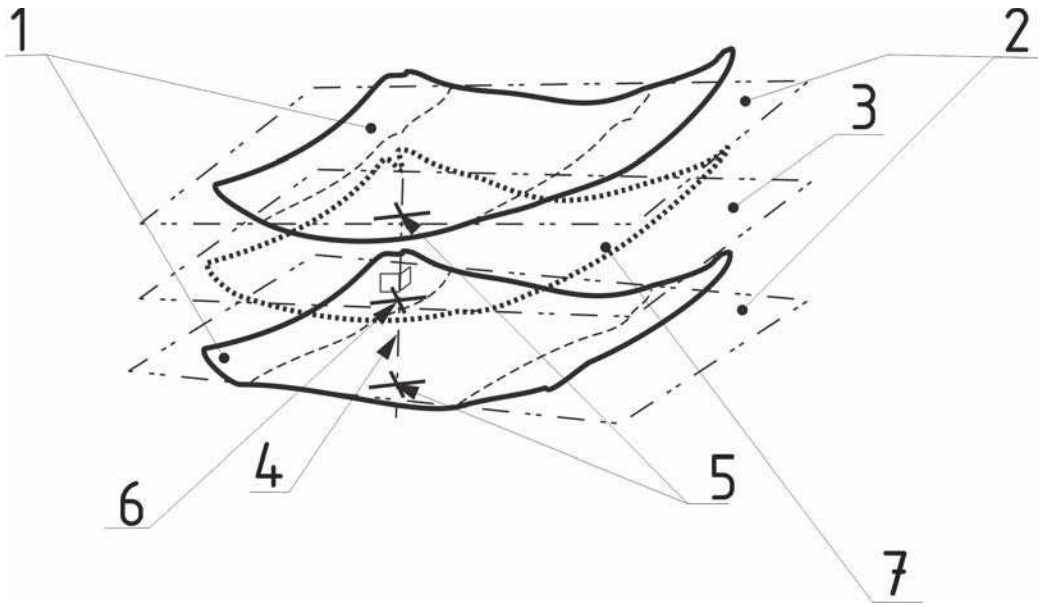
NOTE A directly associated median surface portion is a plane.

This restriction is obtained by the associated features to the features adjacent to the input feature. These associated features are constrained in orientation by the associated feature of the input feature and constrained to be external to the material of the adjacent features.

5.3.4.2 Extracted median surface

An extracted median surface is a set of median centres.

EXAMPLE In the case of two opposing parallel planes, the extracted median surface is the collection of the median centres (see Figure 13).



Key

1 extracted surface pair
2 pair of associated planes, which are not constraint to be parallel between them
3 median surface of the pair of associated planes
4 straight line perpendicular to (3)
5 opposing point pair
6 median centre
7 extracted median surface (collection of the median centres)

Figure 13 — Example of extracted median surface of a feature of size which is nominally two parallel planes

5.3.4.3 Indirectly associated median surface portion

An indirectly associated median surface portion is an indirectly associated median surface restricted to the extent of the extracted median surface.

NOTE An indirectly associated median surface portion is a plane.

The restriction limits the extent of the indirectly associated median surface to the portion where a perpendicular distance from the associated feature to the extracted median surface exists.

Annex A
(informative)

Relation in the GPS matrix model

A.1 General

For full details about the GPS matrix model, see ISO 14638.

A.2 Information about this part of ISO 17450 and its use

This part of ISO 17450 covers a number of fundamental assumptions and principles that apply to all GPS standards and technical product documentation that is based on the GPS matrix model.

A.3 Position in the GPS matrix model

This part of ISO 17450 is a fundamental GPS standard, which influences any other standard in the GPS matrix model, as graphically illustrated in Table A.1.

Table A.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	•	•	•	•	•	•	•
Form	•	•	•	•	•	•	•
Orientation	•	•	•	•	•	•	•
Location	•	•	•	•	•	•	•
Run-out	•	•	•	•	•	•	•
Profile surface texture	•	•	•	•	•	•	•
Areal surface texture	•	•	•	•	•	•	•

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[1] ISO 1101, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

[2] ISO 1302:2002, *Geometrical product specification (GPS) — Indication of surface texture in technical product documentation*

[3] ISO 5459:2011, *Geometrical product specification (GPS) — Geometrical tolerancing — Datums and datum systems*

[4] ISO 8015:2011, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

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