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Geometrical product specifications (GPS) — Transition specification

Spécifications géométriques des produits (GPS) — Spécification de transition

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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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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).

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 GPS standard (see ISO 14638). It influences chain links A, B and C of the chains of standards on form, orientation and location, see Annex D.

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 stated.

In technical drawings, the ideal geometric shape of the workpiece is represented without any deviations and, in general, without consideration of the states of the transitions between adjacent integral features. Nevertheless, for many purposes (the functioning of a part, or out of safety considerations, for example) particular states of transition features need to be indicated. ISO 13715 provides the tools for indicating requirements to edges of undefined shape. These tools are insufficient when the shape of the transition feature is important for functional reasons. Therefore, this document provides a set of tools for indicating transition specifications.

IMPORTANT — Most specification illustrations in this document show edges drawn as sharp corners. They could equally have been drawn showing the nominal geometry of the transition feature, without changing the meaning of the indications. In a computer aided design (CAD) system, the transition feature geometry can be modelled or not without changing the meaning of the indications.

All the specification illustrations in this document show a 90° angle between the two adjacent features. Specifications according to this document have the same meaning, taking the nominal angle into account, regardless of the angle between the two adjacent features.

All figures in this document have been drawn with dimensions and tolerances in millimetres. It should be understood that other units of measurement could have been used equally well without prejudice to the principles established.

Geometrical product specifications (GPS) — Transition specification

1 Scope

This document defines a number of specification operators for the specification of extended edge transition features between features. An edge transition feature is an integral feature connecting two adjacent integral features. The extended edge transition feature includes portions of the adjacent features. All these specifications apply to any line in a defined direction in the extended edge transition feature. This document also defines the specification modifiers and the drawing indications for such transition specifications.

The proportions and dimensions of the graphical symbols to be used are also specified.

The specifications defined in this document are suitable for relatively simple edge transition functions, for example ensuring assembly without interference. For more complex functions, geometrical tolerancing offers more precise tools.

This document is by intention limited to only edge transition features between two planes and between a cylinder and a plane nominally perpendicular to it.

Annex A gives the first approach for an algorithm to identify toleranced features and adjacent reference sections. This algorithm is subject to change as more experience is gathered.

This document provides a set of tools to express several transition specifications. It does not present any information on the relationship between a function or a use and a transition specification.

NOTE 1 Corners (the transition between three or more features) are not edge transition features and are consequently not covered by this document.

NOTE 2 An edge transition feature exists between two single features. A defined edge transition feature has a defined nominal shape and is not sharp ($r = 0$).

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 1101:2017, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
transition feature
single integral feature connecting two or more adjacent integral surfaces

Note 1 to entry: A single integral feature connecting three or more adjacent integral surfaces (corner) is not covered in this document.

3.2
edge transition feature
single integral feature connecting two adjacent integral surfaces

3.3
extended transition feature
collected integral surface including a transition feature and specified contiguous portions of the adjacent features

3.3.1
extended edge transition feature
collected integral surface including an edge transition feature and specified contiguous portions of the adjacent features

3.3.1.1
extended edge transition section
line resulting from the intersection of an extended edge transition feature with a specified plane

3.4
transition specification
GPS requirement applied to an extended transition feature

3.5
reference portion
line segment in an adjacent feature beyond the extended edge transition section

3.6
adjacent reference section
straight line associated to a reference portion

Note 1 to entry: An adjacent reference section is used as a datum in a transition specification.

3.7
separation point
point separating the search areas for finding the ends of the adjacent features

3.8
specification origin
intersection point between two straight lines established from the adjacent surfaces in an intersection plane defined in a specified direction

Note 1 to entry: See Figure A.4.

3.9
specification direction
direction in which one of the distances defining the toleranced feature and the reference portion applies

4 Basic concepts

An edge transition feature is an areal feature.

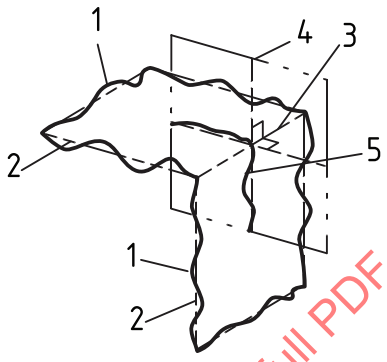
Specifications for edge transition features according to this document specify either extended edge transition sections defined in a specified set of intersection planes, where the specification for each

section is independent of the other sections, or collections of such sections, for example a requirement that the radius shall be consistent along the edge transition feature.

By default, transition specifications apply to all extended edge transition sections along the extended edge transition feature.

Figure 1 shows the case where the two adjacent features are planes. The intersection planes that defines the toleranced features are in theoretically exact relationships to the situation feature (straight line) of the collection of associated features adjacent to the edge transition feature. The associations are performed individually to each adjacent feature with the total least squares (Gaussian) criterion. The intersection planes are perpendicular to the intersection straight line between the two associated planes.

The length of the toleranced extended edge transition feature is limited as proposed in A.3.

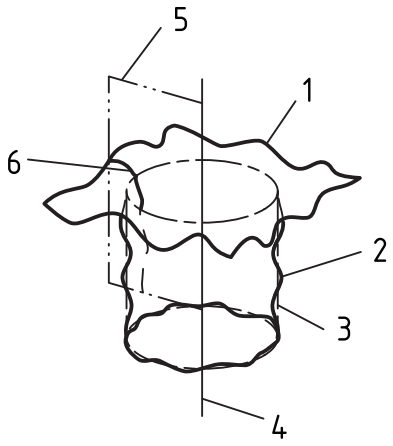


Key

1 nominally flat real features adjacent to the edge transition feature
2 total least squares (Gaussian) planes associated to 1 independently
3 intersection straight line between 2
4 one of the infinite set of intersection planes perpendicular to 3
5 one of the infinite set of line profiles containing a toleranced extended edge transition section

Figure 1 — Intersection planes defining the toleranced features for an edge transition feature between two planar features

Figure 2 shows the case where one adjacent feature is a plane and the other is a cylinder. In this case the associations are performed simultaneously to the two adjacent features with the constraint that the associated features are perpendicular to each other, like a common datum, but with the total least squares (Gaussian) criterion. The intersection plane contains the axis of the associated cylinder and is also by definition perpendicular to the associated plane.



Key

1 nominally flat real feature adjacent to the edge transition feature
2 nominally cylindrical real feature adjacent to the edge transition feature
3 total least squares (Gaussian) cylinder associated to 2
4 axis of 3
5 one of the infinite set of intersection half planes including 4
6 one of the infinite set of line profiles containing a toleranced extended edge transition section

Figure 2 — Intersection planes defining the toleranced features for an edge transition feature between a planar feature and a cylindrical feature

The figures given in Clauses 6 to 9 are not intended to describe the partition. The process of the partitioning of the extended edge transition features is illustrated in Annex A.

The extent of the reference portions is limited as proposed in A.3. This means that the real surface of the workpiece beyond this extent does not influence the location and orientation for the adjacent reference sections and that material constraints only apply within the defined extent, see, for example, Figure 12 b) where the material constraint does not apply beyond the extent of the reference portion.

If the intersection between the intersection plane and the adjacent feature is not nominally straight, a suitable shape, for example a circle, shall be associated instead with the relevant shape and size parameters being variable in the association, see A.1.

Adjacent reference sections are associated to the reference portions of the adjacent features using the L2 norm with the constraint outside the material, except for least material boundaries, where the L2 norm with the constraint inside the material is used.

Annex B shows an example of approximately equivalent specification of an extended edge transition feature using a geometrical specification.

5 General indication rules

5.1 Symbols

The basic transition specification symbol is shown in Figure 3. The reference line of the symbol shall always be indicated horizontally on the drawing, as shown in Figure 3.

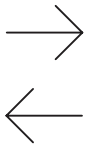


Figure 3 — Basic transition specification indicator

A leader line shall be used to connect the basic symbol to the toleranced feature, see Figure 4. The leader line shall be terminated (using an arrow or a dot) according to the rules specified in ISO 1101.

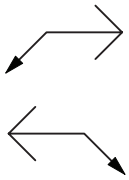


Figure 4 — Transition specification indicator with leader line

The dimensions of the transition specification indicator shall be as shown in Annex C. The description for each symbol used in transition specifications and the clause where they are defined are shown in Table 1.

Table 1 — Symbols for transition specification indications and their meaning

Letter	Description	Clause
C	chamfer	7.1
CF	chamfer of consistent (fixed) dimensions	7.3
CL	chamfer least material boundary	7.5, 7.8
CM	chamfer maximum material boundary	7.4, 7.8
D	extent of the toleranced feature from the specification origin	10.2
E	ellipse	8.1
EF	ellipse of consistent (fixed) dimensions	8.3
EL	ellipse least material boundary	8.5, 8.8
EM	ellipse maximum material boundary	8.4, 8.8
P	fixed profile defined by CAD	9.1
PL	profile defined by CAD least material boundary	9.3
PM	profile defined by CAD maximum material boundary	9.2
R	radius	6.1
RF	radius of consistent (fixed) value	6.3
RL	radius least material boundary	6.5, 6.8
RM	radius maximum material boundary	6.4, 6.8
T	(profile) tolerance value	6, 7, 8, 9
UZ	(profile) tolerance zone offset	10.4

5.2 Indications using the transition specification symbol

5.2.1 General

A transition specification may be indicated in a side view directly on an edge, if the transition feature is not modelled, see Figure 5 a) and b), or on the transition feature itself, see Figure 5 c) and d).

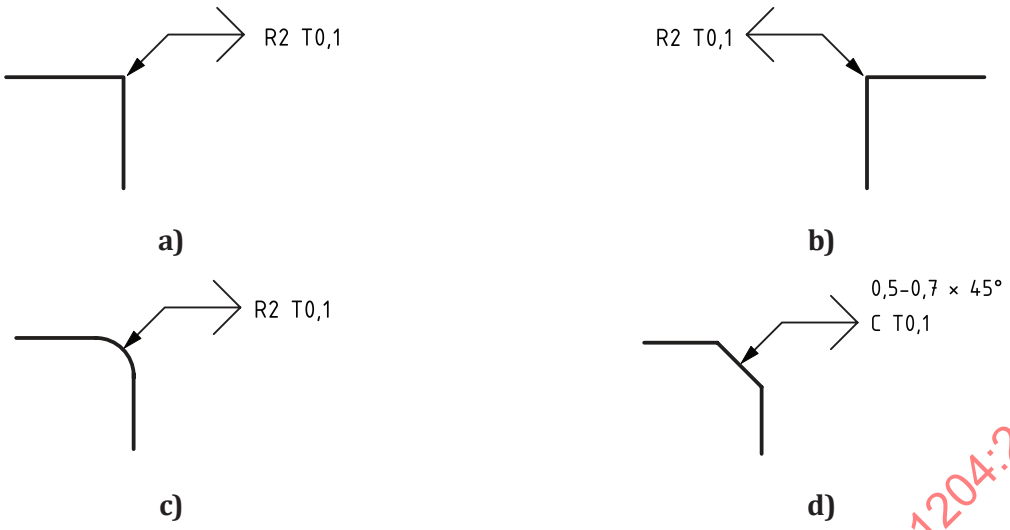


Figure 5 — Side view indications using the transition specification symbol

5.2.2 Indications in face view

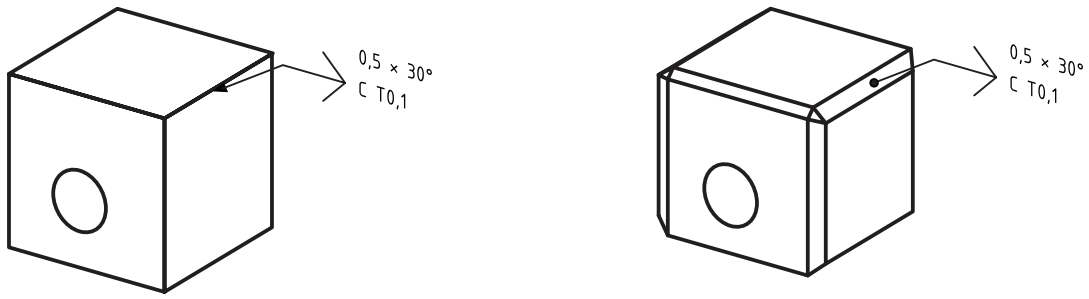
A transition specification may be indicated in a face view directly on an edge, if the transition feature is not modelled, see Figure 6 a), or on the transition feature itself, see Figure 6 b). In this case, the indication in the upper indication area applies to the feature in face view (the plane in Figure 6).

a) Transition feature not modelled **b) Transition feature modelled**

Figure 6 — Face view indications using the transition specification symbol

5.2.3 Indications in 3D

A transition specification may be indicated in 3D directly on an edge, if the transition feature is not modelled, see Figure 7 a), or on the transition feature itself, see Figure 7 b).



a) Transition not modelled **b) Transition modelled**

Figure 7 — 3D indications using the transition specification symbol

The leader line of a transition specification indicated on a modelled transition feature shall terminate in the middle part of the modelled transition feature, clearly separated from its transition points to the two adjacent features.

A transition specification on one or both transition points on a modelled chamfer may only be specified with a transition specification (defined according to this standard or undefined according to ISO 13715) if the surface of the chamfer is specified by other means, for example a surface or line profile specification according to ISO 1101.

5.3 Indication areas around the transition specification symbol

Letter symbols, numbers that indicate the nominal profile and the tolerance values and other symbols shall be indicated in five areas around the transition specification symbol, see Figure 8. Indications in the centre area apply to the transition feature in general or symmetrically. Indications in the upper and lower areas apply to the adjacent feature or in the direction of the adjacent feature on the same side of the terminator of the leader line, see Figure 8. These rules also apply in 3D. For indications in face view, the indications in the upper areas refer to the adjacent feature in face view and the indications in the lower areas refer to the other adjacent feature.

CAD systems shall be able to adjust the indications, as the view is rotated.

Key

1 centre indication area
2 upper main indication area
3 lower main indication area
4 upper primary reference section indication area (see 10.5)
5 lower primary reference section indication area (see 10.5)
6 adjacent feature that indications in 2 and 4 refer to
7 adjacent feature that indications in 3 and 5 refer to

Figure 8 — Indication areas around the transition specification symbol

When there is more than one string of information in a main indication area, they shall be separated by a space, see, for example, Figure 9.

Strings of information belonging together and given in more than one line shall be left aligned under each other, see, for example, Figure 42.

6 Circular edge transition feature indications

6.1 Fixed radius profile specification

When the nominal profile of the edge transition section is circular with a fixed radius, with its centre located to ensure continuity with the adjacent features, and the specification requires the extended

edge transition section to be within a tolerance zone of a defined width, the indication shall follow the template in Figure 9.

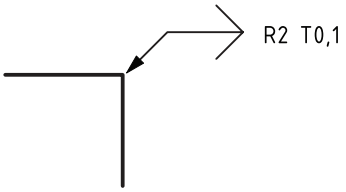
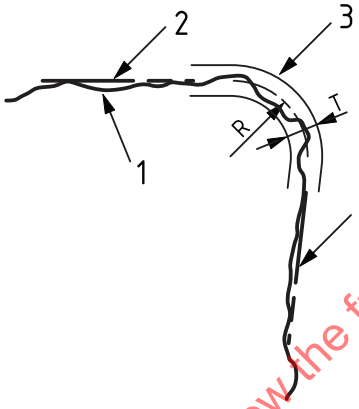


Figure 9 — Radius profile specification

The meaning of the indication in Figure 9 is that the radius of the nominal profile is 2 and the width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the nominal profile, see Figure 10.



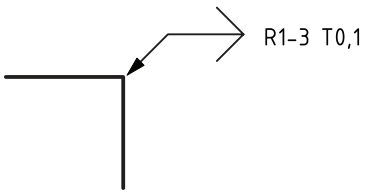
Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
R nominal radius of the transition profile
T tolerance value for the transition tolerance

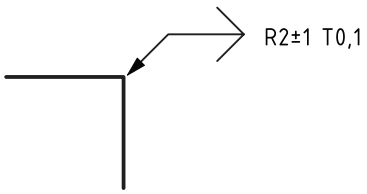
Figure 10 — Tolerance zone defined by the specification in Figure 9

6.2 Variable radius profile specification

When the nominal profile of the edge transition section is circular, with a radius of any value within a range, with its centre located to ensure continuity with the adjacent features, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual radius, extended by straight lines, the indication shall follow one of the templates in Figure 11.



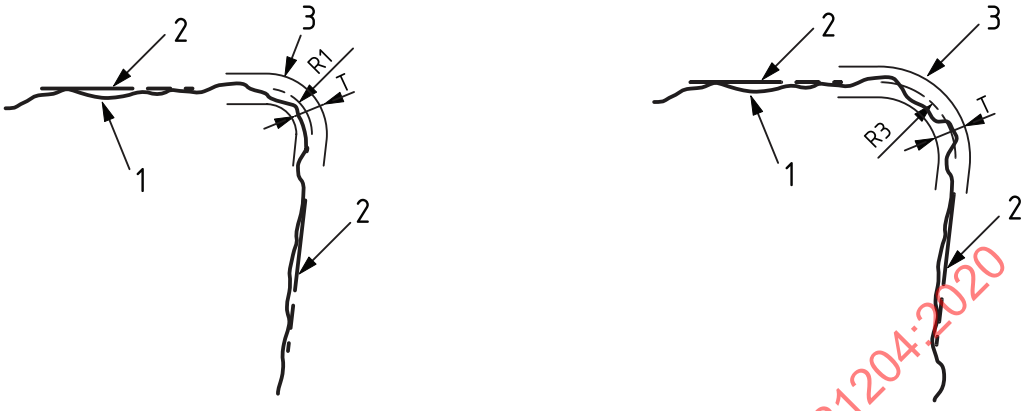
a)



b)

Figure 11 — Variable radius profile specification

The meaning of the indication in Figure 11 is that the radius of the nominal profile in each cross section may be any value between 1 and 3 and the width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the actual profile radius, see Figure 12.



a) Minimum radius **b) Maximum radius**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
T tolerance value for the transition tolerance

Figure 12 — Tolerance zone defined by the specification in Figure 11

6.3 Consistent radius profile specification

When the nominal profile of the edge transition section is circular, with a radius of any value within a range, with its centre located to ensure continuity with the adjacent features, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual radius and with the additional requirement that the radius shall be the same for all cross sections of the edge transition feature, the indication shall follow one of the templates in Figure 13.

a) **b)**

Figure 13 — Consistent radius profile specification

The meaning of the indication in Figure 13 is that the radius of the nominal profile may be any value between 1 and 3, but shall be the same (fixed) value for all cross sections of the transition. The width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the actual profile radius, see Figure 12.

NOTE The difference between the specifications in Figure 11 and Figure 13 is that the specification in Figure 11 allows the radius in each cross section to be any value within the specified range, independent of the other cross sections, whereas the specification in Figure 13 requires all cross sections to have the same unique value from within the specified range.

6.4 Maximum material radius boundary specification

When the extended edge transition section is contained by a maximum material circular boundary of a defined radius, extended by straight lines, the indication shall follow the template in Figure 14.

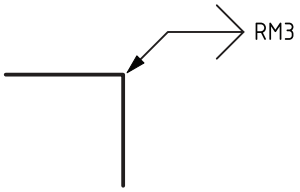
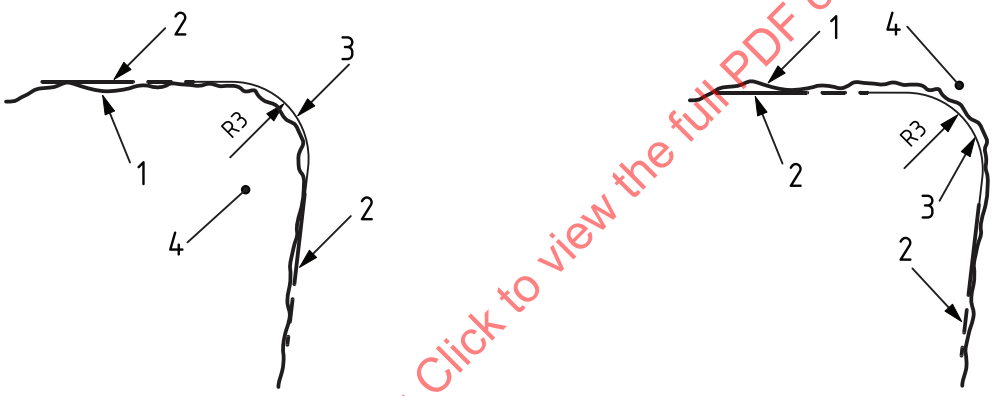


Figure 14 — Maximum material radius boundary specification

The meaning of the indication in Figure 14 is that the extended edge transition section shall be contained by a maximum material circular boundary of radius 3, extended by straight lines, continuous with the adjacent reference sections, see Figure 15.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the least material direction.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (1.2 norm outside the material)
3 limiting maximum material boundary
4 material side

Figure 15 — Limiting maximum material boundary defined by the specification in Figure 14

6.5 Least material radius boundary specification

When the extended edge transition section contains a least material circular boundary of a defined radius, extended by straight lines, the indication shall follow the template in Figure 16.

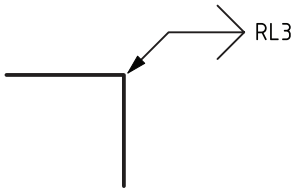


Figure 16 — Least material radius boundary specification

The meaning of the indication in Figure 16 is that the edge transition section shall contain a least material circular boundary of radius 3, extended by straight lines, continuous with the adjacent reference sections, see Figure 17.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the maximum material direction.

a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 material side

Figure 17 — Limiting least material boundary defined by the specification in Figure 16

6.6 Maximum material radius boundary with profile specification

When the extended edge transition section is contained by a maximum material circular boundary of a defined radius, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width inside the extended circular boundary, the indication shall follow the template in Figure 18.

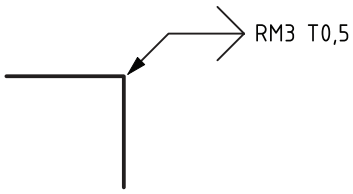
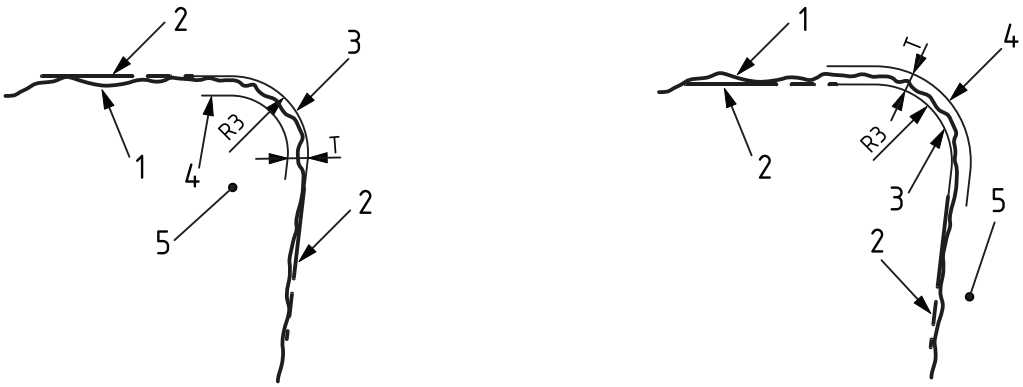


Figure 18 — Maximum material radius boundary with profile specification

The meaning of the indication in Figure 18 is that the extended edge transition section shall be contained by a maximum material circular boundary of radius 3, extended by straight lines, continuous with the adjacent reference sections, and the extended edge transition section shall be within a 0,5-wide tolerance zone inside the extended circular boundary, see Figure 19.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 least material limit of the tolerance zone
5 material side
T tolerance value for the transition tolerance

Figure 19 — Limiting boundary and tolerance zone defined by the specification in Figure 18

6.7 Least material radius boundary with profile specification

When the extended edge transition section contains a least material circular boundary of a defined radius, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width outside the extended circular boundary, the indication shall follow the template in Figure 20.

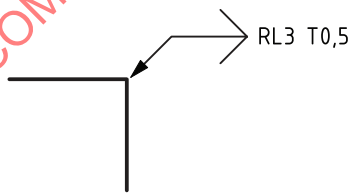
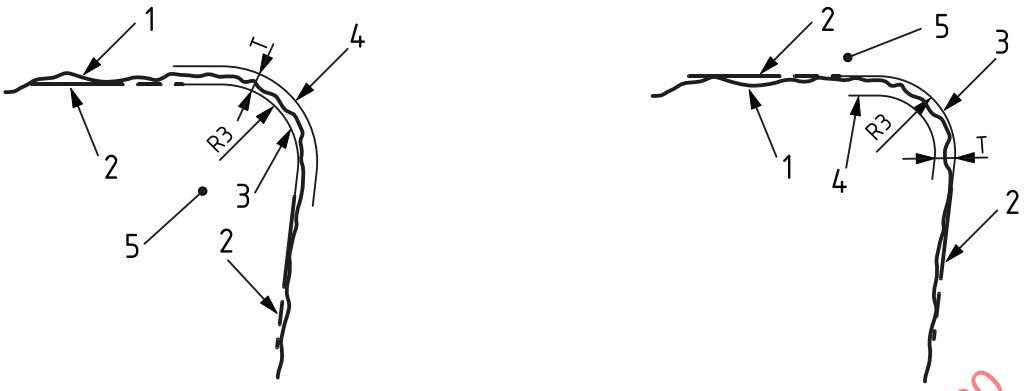


Figure 20 — Least material radius boundary with profile specification

The meaning of the indication in Figure 20 is that the extended edge transition section shall contain a least material circular boundary of radius 3, extended by straight lines, continuous with the adjacent reference sections and the extended edge transition section shall be within a 0,5-wide tolerance zone outside the extended circular boundary, see Figure 21.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 maximum material limit of the tolerance zone
5 material side
T tolerance value for the transition tolerance

Figure 21 — Limiting boundary and tolerance zone defined by the specification in Figure 20

6.8 Combined maximum material and least material radius boundary specification

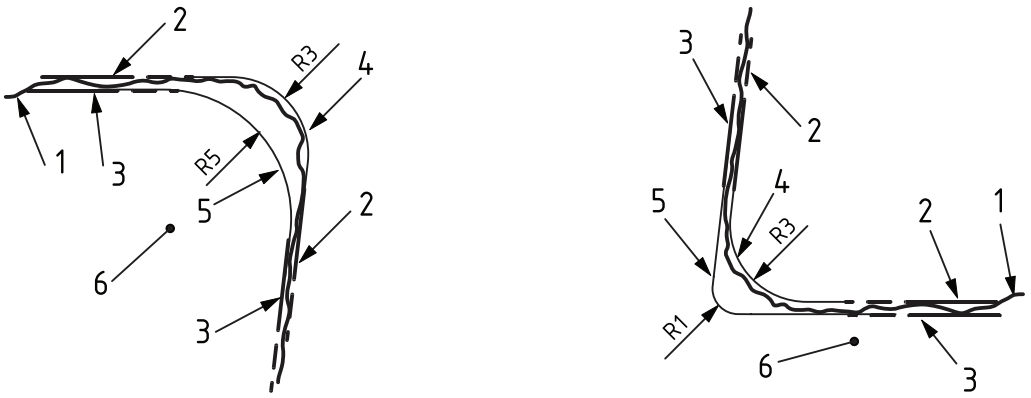
When the extended edge transition section is contained by a maximum material circular boundary of a defined radius and contains a least material circular boundary of a defined radius, both extended by straight lines, the indication shall follow the template in Figure 22.

a) External transition feature **b) Internal transition feature**

Figure 22 — Combined maximum material and least material radius boundary specification

The meaning of the indication in Figure 22 a) is that the external edge transition feature shall be contained by a maximum material circular boundary of radius 3 and that the external edge transition feature shall contain a least material circular boundary of radius 5, both extended by straight lines, see Figure 23 a).

The meaning of the indication in Figure 22 b) is that the internal edge transition feature shall be contained by a maximum material circular boundary of radius 3 and that the internal edge transition feature shall contain a least material circular boundary of radius 1, both extended by straight lines, see Figure 23 b).



a) External transition **b) Internal transition**

Key

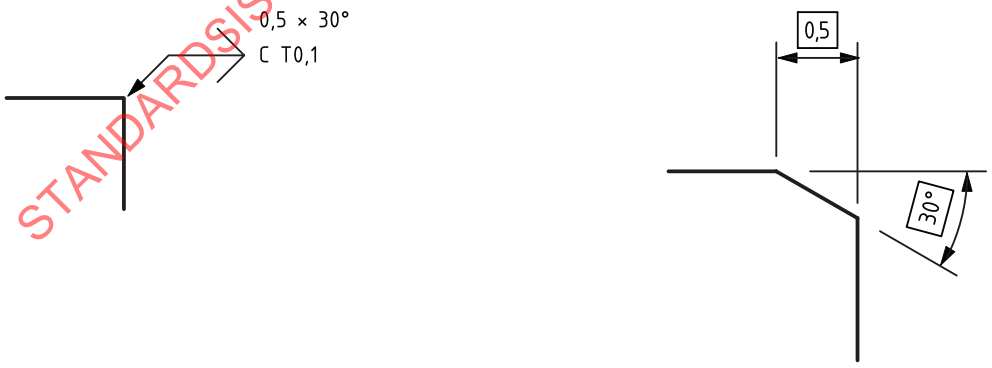
1 real workpiece/skin model
2 adjacent outside reference sections (L2 norm outside the material)
3 adjacent inside reference sections (L2 norm inside the material)
4 maximum material boundary
5 least material boundary
6 material side

Figure 23 — Limiting boundaries defined by the specification in Figure 22

7 Chamfer edge transition feature indications

7.1 Fixed chamfer profile specification

When the nominal profile of the extended edge transition section is a chamfer with fixed nominal geometry and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the nominal geometry, the indication shall follow the template in Figure 24 a), Figure 26 a) or Figure 28 a).

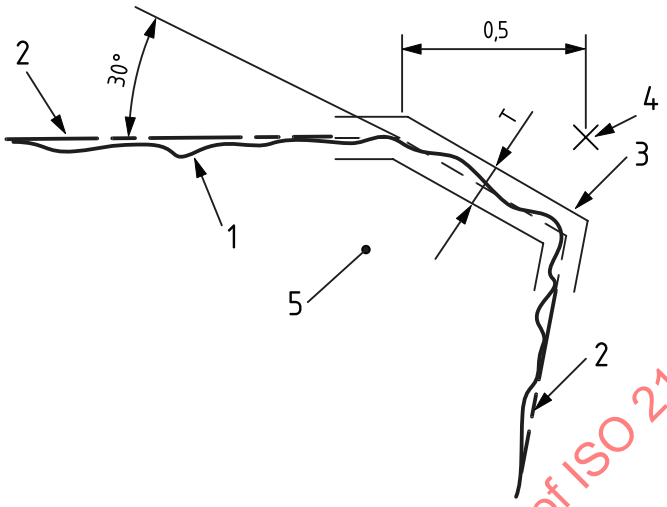


a) Specification **b) Nominal geometry**

Figure 24 — Chamfer defined by a fixed nominal distance and a fixed nominal angle to the adjacent feature on one side of the edge transition feature with profile specification

The meaning of the indication in Figure 24 a) is that the nominal profile is a chamfer because of the indicated C. The indication 0,5 × 30° defining the nominal dimensions of the chamfer applies to the same side of the edge transition feature as the indication is relative to the transition specification

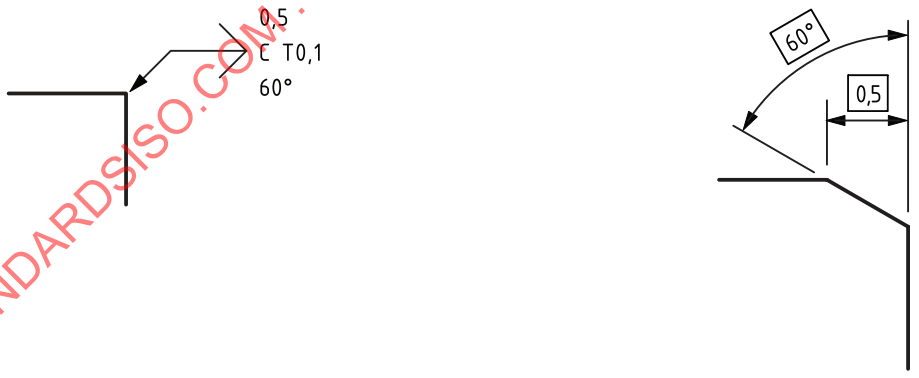
symbol. Because the indication here is above the C indication, it applies in the direction to the left of the arrowhead as shown in Figure 24 b). The indication T0,1 in Figure 24 a) defines a tolerance zone with a width of 0,1. The tolerance zone is symmetrical around the nominal profile. The resulting tolerance zone is shown in Figure 25.



Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
4 specification origin, see A.2.2 (intersection of 2)
5 material side
T tolerance value for the transition tolerance

Figure 25 — Tolerance zone defined by the specification in Figure 24 a)

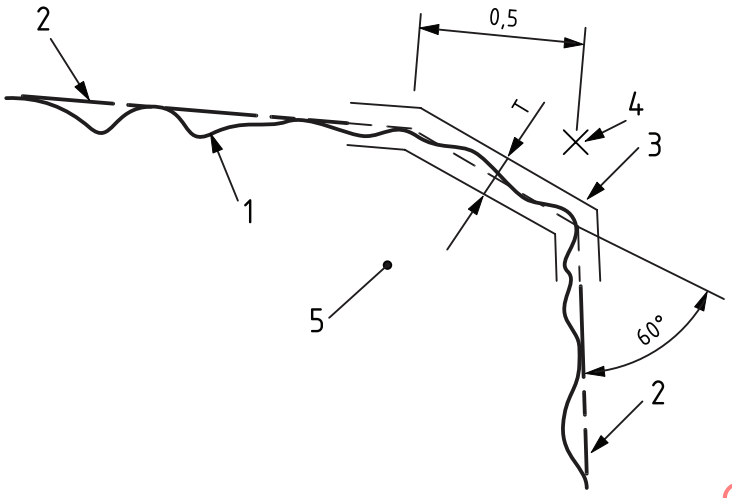


a) Specification **b) Nominal geometry**

Figure 26 — Chamfer defined by a fixed nominal distance on one side of the edge transition feature and a fixed nominal angle to the adjacent feature on the other side of the edge transition feature with profile specification

The meaning of the indication in Figure 26 a) is that the nominal profile is a chamfer because of the indicated C. The indications 0,5 and 60° defining the nominal dimensions of the chamfer apply to the respective sides of the edge transition feature as each indication is shown relative to the transition specification symbol. Because the 0,5 indication is above the C indication, it applies in the direction to the left of (above) the arrowhead, as shown in Figure 26 b). Because the 60° indication is below the C indication, it applies in the direction to the right of (below) the arrowhead, as shown in Figure 26 b).

The indication T0,1 in Figure 26 a) defines a tolerance zone with a width of 0,1. The tolerance zone is symmetrical around the nominal profile. The resulting tolerance zone is shown in Figure 27.

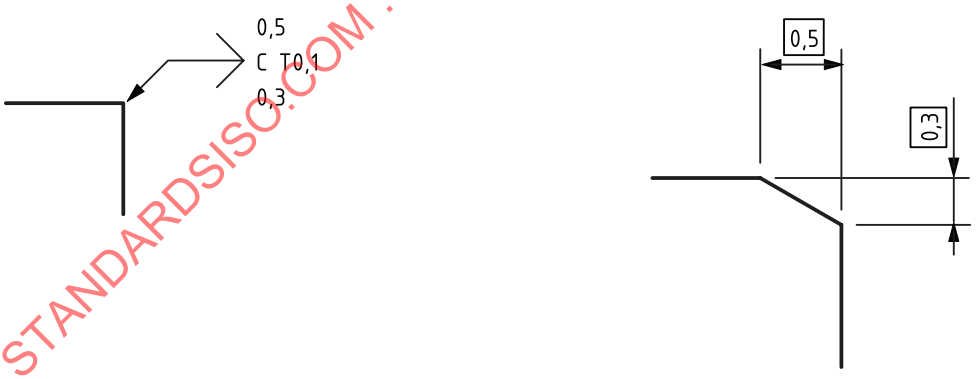


Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
4 specification origin, see A.2.2 (intersection of 2)
5 material side
T tolerance value for the transition tolerance

Figure 27 — Tolerance zone defined by the specification in Figure 26 a)

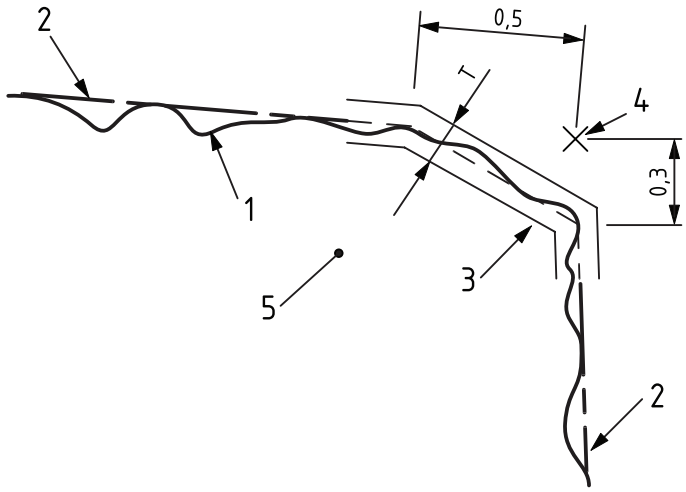
NOTE The meaning of the specifications in Figure 24 a) and Figure 26 a) are slightly different, because the adjacent features are never exactly perpendicular to each other.



a) Specification **b) Nominal geometry**

Figure 28 — Chamfer defined by two fixed nominal distances with profile specification

The meaning of the indication in Figure 28 a) is that the nominal profile is a chamfer because of the indicated C. The indications 0,5 and 0,3 defining the nominal dimensions of the chamfer apply to the respective sides of the edge transition feature as each indication is shown relative to the transition specification symbol, see Figure 8. The indication T0,1 in Figure 28 a) defines a tolerance zone with a width of 0,1. The tolerance zone is symmetrical around the nominal profile. The resulting tolerance zone is shown in Figure 29.



Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
4 specification origin, see A.2.2 (intersection of 2)
5 material side
T tolerance value for the transition tolerance

Figure 29 — Tolerance zone defined by the specification in Figure 28 a)

7.2 Variable chamfer profile specification

When the nominal profile of extended edge transition section is a chamfer with one or both nominal dimensions allowed to vary within a range, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual chamfer geometry, the indication shall follow one of the templates in Figure 30, Figure 31 or Figure 32.

a) **b)**

Figure 30 — Chamfer defined by a variable nominal distance and a fixed nominal angle to the adjacent feature on one side of the edge transition feature with profile specification

The meaning of the indication in Figure 30 is similar to that in Figure 24 a), except the 0,5 distance in Figure 24 b) is allowed to vary between 0,5 and 0,7.

a) b)

Figure 31 — Chamfer defined by a fixed nominal distance on one side of the edge transition feature and a variable nominal angle to the adjacent feature on the other side of the edge transition feature with profile specification

The meaning of the indication in Figure 31 is similar to that in Figure 26 a), except the 60° angle in Figure 26 b) is allowed to vary between 55° and 65°.

a) b)

Figure 32 — Chamfer defined by two variable nominal distances with profile specification

The meaning of the indication in Figure 32 is similar to that in Figure 28 a), except the 0,5 distance in Figure 28 b) is allowed to vary between 0,5 and 0,7 and the 0,3 distance in Figure 28 b) is allowed to vary between 0,3 and 0,5.

7.3 Consistent chamfer profile specification

When the nominal profile of the extended edge transition section is a chamfer with one or both nominal dimensions allowed to vary within a range, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual chamfer geometry, with the additional requirement that the chamfer dimensions shall be the same for all cross sections of the transition feature, the indication shall follow one of the templates in Figure 33.

a) b)

Figure 33 — Consistent chamfer profile specification

The meaning of the indication in Figure 33 is that the nominal dimensions of the chamfer may vary as described for Figure 30, but have to be the same (fixed) values for all cross sections of the transition. The width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the actual chamfer.

NOTE The difference between the specifications in Figure 30 and Figure 33 is that the specification in Figure 30 allows the chamfer in each cross section to be any set of values within the specified range, independent of the other cross sections, whereas the specification in Figure 33 requires all cross sections to have the same unique set of chamfer values from within the specified range.

7.4 Maximum material chamfer boundary specification

When extended edge transition section is contained by a maximum material chamfer boundary of fixed dimensions, the indication shall follow the template in Figure 34.

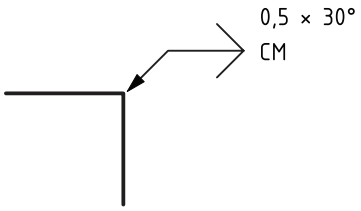
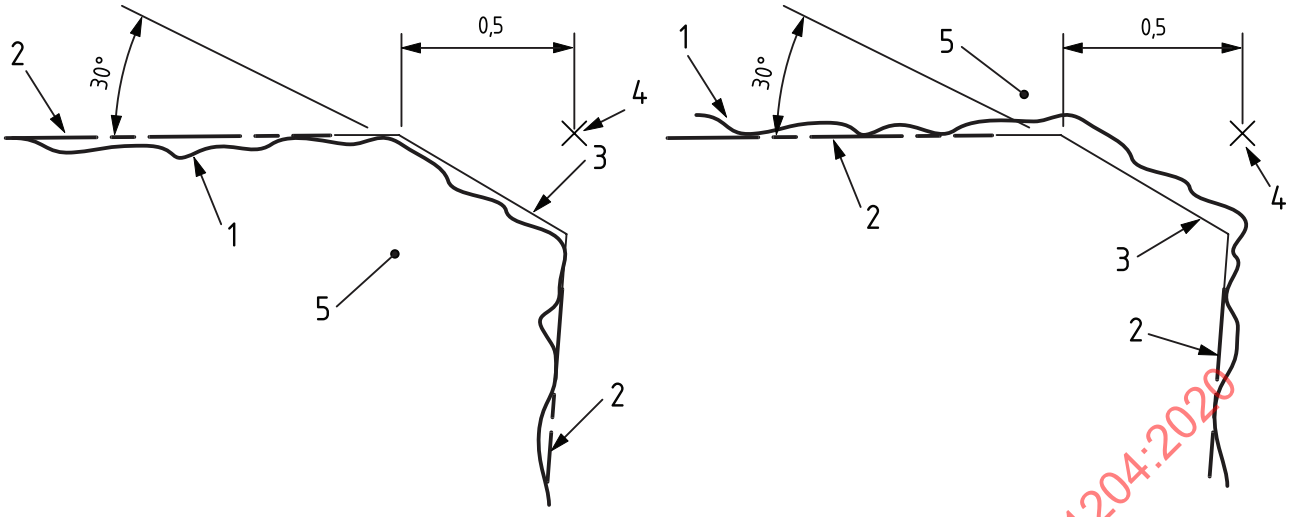


Figure 34 — Chamfer maximum material boundary specification

The dimensions of the nominal chamfer can be defined in any of the ways shown in Figure 24 a), Figure 26 a) or Figure 28 a).

The meaning of the indication in Figure 34 is that the extended edge transition section shall be contained by a maximum material chamfer boundary with nominal dimensions as shown in Figure 24 b), see Figure 35.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the least material direction.



a) External chamfer **b) Internal chamfer**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 specification origin, see A.2.2 (intersection of 2)
5 material side

Figure 35 — Limiting maximum material boundary defined by the specification in Figure 34

7.5 Least material chamfer boundary specification

When the extended edge transition section contains a least material chamfer boundary of fixed dimensions, the indication shall follow the template in Figure 36.

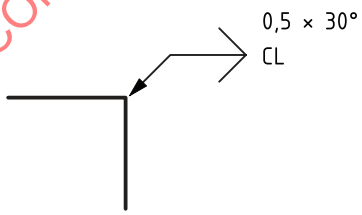
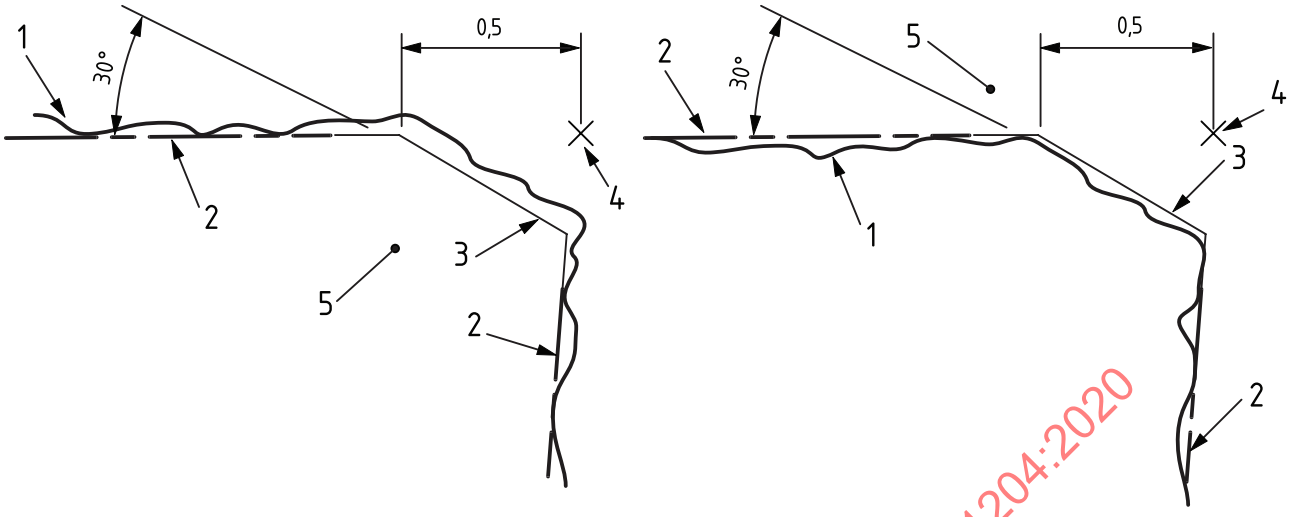


Figure 36 — Chamfer least material boundary specification

The dimensions of the nominal chamfer can be defined in any of the ways shown in Figure 24 a), Figure 26 a) or Figure 28 a).

The meaning of the indication in Figure 36 is that the extended edge transition section shall contain a least material chamfer boundary with nominal dimensions as shown in Figure 24 b), see Figure 37.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the maximum material direction.



a) External chamfer **b) Internal chamfer**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 specification origin, see A.2.2 (intersection of 2)
5 material side

Figure 37 — Limiting least material boundary defined by the specification in Figure 36

7.6 Maximum material chamfer boundary with profile specification

When the extended edge transition section is contained by a maximum material chamfer boundary of fixed dimensions, and the extended edge transition section is required to be within a tolerance zone of a defined width inside the chamfer boundary, the indication shall follow the template in Figure 38.

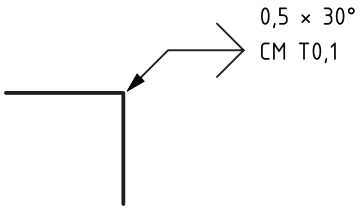
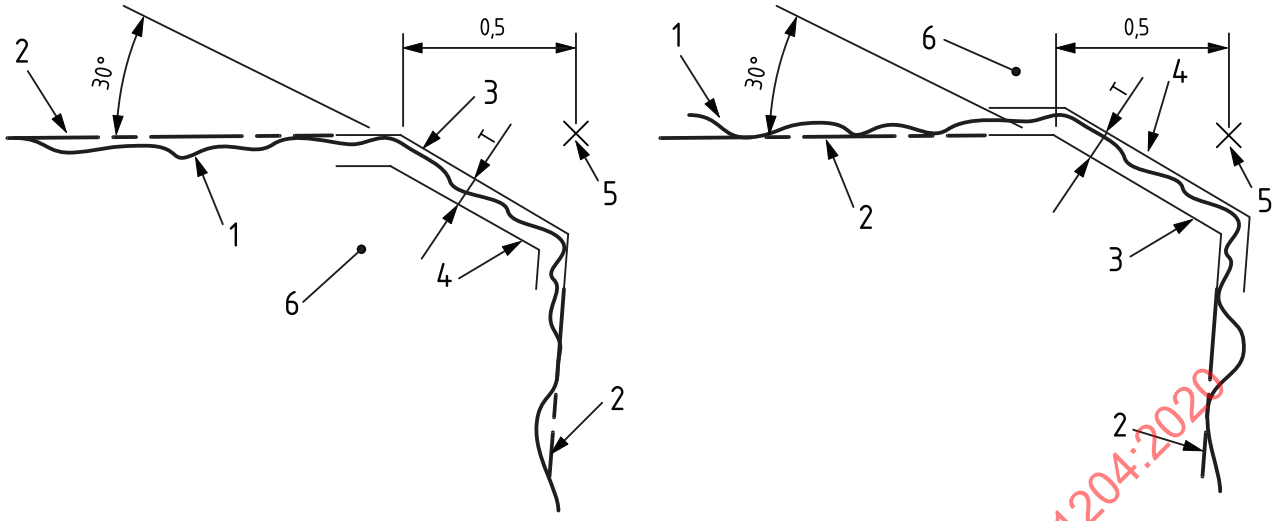


Figure 38 — Maximum material chamfer boundary with profile specification

The meaning of the indication in Figure 38 is that the extended edge transition section shall be contained by a maximum material chamfer boundary with nominal dimensions as shown in Figure 24 b) and the extended edge transition section shall be within a 0,1-wide tolerance zone inside the chamfer boundary, see Figure 39.



a) External chamfer **b) Internal chamfer**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 least material limit of the tolerance zone
5 specification origin, see A.2.2 (intersection of 2)
6 material side
T tolerance value for the transition tolerance

Figure 39 — Limiting boundary and tolerance zone defined by the specification in Figure 38

7.7 Least material chamfer boundary with profile specification

When the extended edge transition section contains a least material chamfer boundary of fixed dimensions, and the extended edge transition section is required to be within a tolerance zone of a defined width outside the chamfer boundary, the indication shall follow the template in Figure 40.

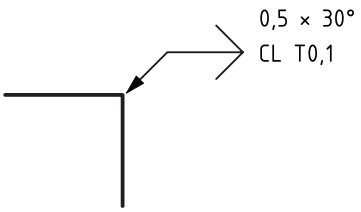
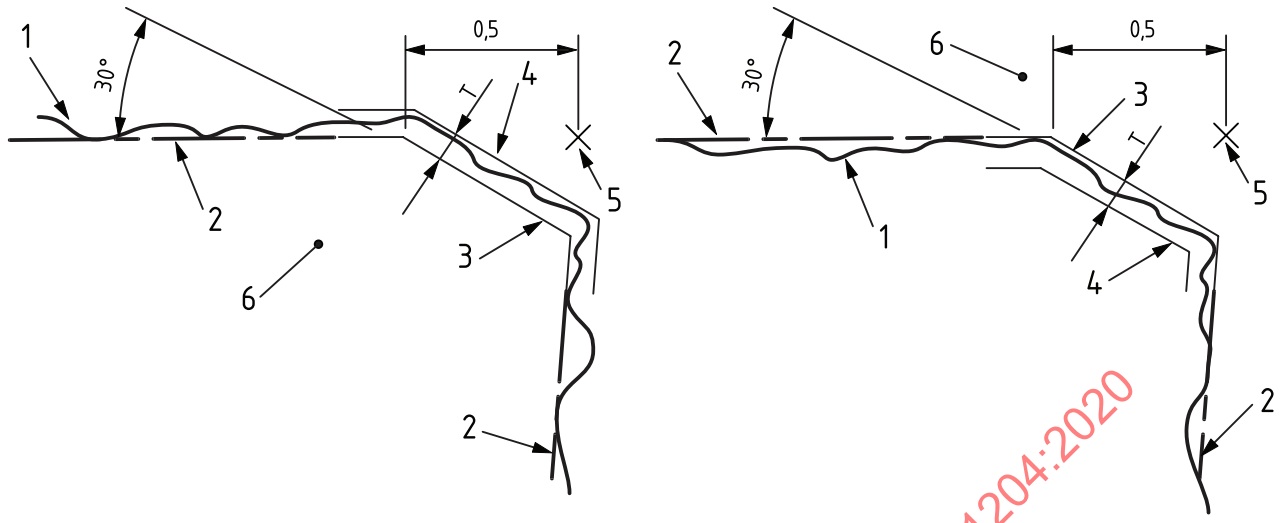


Figure 40 — Least material chamfer boundary with profile specification

The meaning of the indication in Figure 40 is that the extended edge transition section shall contain a least material chamfer boundary with nominal dimensions as shown in Figure 24 b) and the extended edge transition section shall be within a 0,1-wide tolerance zone outside the chamfer boundary, see Figure 41.



a) External chamfer **b) Internal chamfer**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 maximum material limit of the tolerance zone
5 specification origin, see A.2.2 (intersection of 2)
6 material side
T tolerance value for the transition tolerance

Figure 41 — Limiting boundary and tolerance zone defined by the specification in Figure 40

7.8 Combined maximum material and least material chamfer boundary specification

When the extended edge transition section is contained by a maximum material chamfer boundary of fixed dimensions and contains a least material chamfer boundary of fixed dimensions, the indication shall follow the template in Figure 42.

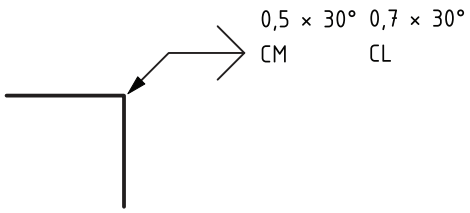
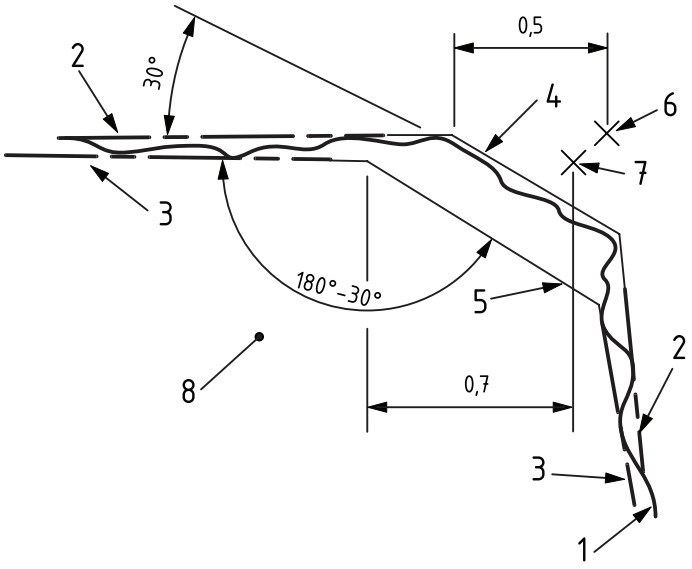


Figure 42 — Combined maximum material and least material chamfer boundary specification

The meaning of the indication in Figure 42 is that the extended edge transition section shall be contained by a maximum material chamfer boundary of a length of 0,5 at an angle of 30° and that the transition feature section shall contain a least material chamfer boundary of a length of 0,7 at an angle of 30°, see Figure 43.



Key

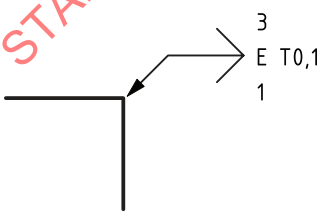
1 real workpiece/skin model
2 adjacent outside reference sections (L2 norm outside the material)
3 adjacent inside reference sections (L2 norm inside the material)
4 maximum material boundary
5 least material boundary
6 specification origin for maximum material boundary, see A.2.2 (intersection of 2)
7 specification origin for least material boundary, see A.2.2 (intersection of 3)
8 material side

Figure 43 — Limiting boundary and tolerance zone defined by the specification in Figure 42

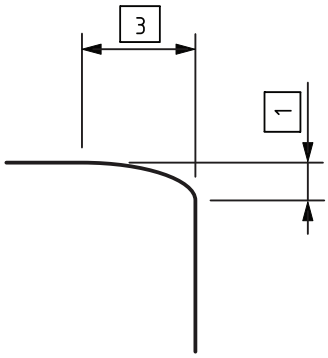
8 Elliptical edge transition feature indications

8.1 Fixed elliptical profile specification

When the nominal profile of the edge transition section is elliptical with fixed nominal geometry located to ensure continuity with the adjacent features and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the nominal geometry, the indication shall follow the template in Figure 44 a).



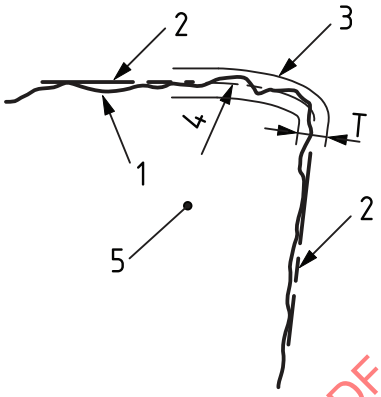
a) External chamfer



b) Internal chamfer

Figure 44 — Elliptical profile specification

The meaning of the indication in Figure 44 a) is that the nominal profile of the edge transition section is an ellipse because of the indicated E. The indications 3 and 1 defining the nominal dimensions of the ellipse apply to each their side of the edge transition feature as each indication is shown relative to the transition specification symbol. Because the 3 indication is above the E indication, it applies in the direction to the left of (above) the arrowhead, as shown in Figure 44 b). Because the 1 indication is below the E indication, it applies in the direction to the right of (below) the arrowhead, as shown in Figure 44 b). The indication T0,1 in Figure 44 a) defines a tolerance zone with a width of 0,1. The tolerance zone is symmetrical around the nominal profile. The resulting tolerance zone is shown in Figure 45.



Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
4 nominal elliptical shape of the transition feature section
5 material side
T tolerance value for the transition tolerance

Figure 45 — Tolerance zone defined by the specification in Figure 44

8.2 Variable elliptical profile specification

When the nominal profile of the edge transition section is an ellipse with one or both nominal dimensions allowed to vary within a range, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual ellipse geometry, extended by straight lines, the indication shall follow one of the templates in Figure 46.

a) **b)**

Figure 46 — Ellipse defined by two variable nominal distances with profile specification

The meaning of the indication in Figure 46 is similar to that in Figure 44 a), except the distance 3 in Figure 44 b) is allowed to vary between 3 and 5, and the distance 1 in Figure 44 b) is allowed to vary between 1 and 2. The distance in the two directions can vary independently of each other.

8.3 Consistent elliptical profile specification

When the nominal profile of the edge transition section is an ellipse with one or both nominal dimensions allowed to vary within a range, and the specification requires the extended edge transition section to be within a tolerance zone of a defined width around the actual ellipse geometry, with the additional requirement that the ellipse dimensions shall be the same for all cross sections of the edge transition feature, the indication shall follow the template in Figure 47.

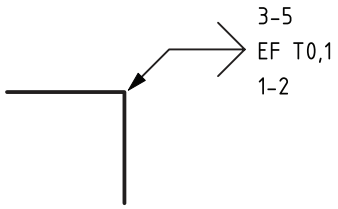


Figure 47 — Consistent ellipse profile specification

The meaning of the indication in Figure 47 is that the nominal dimensions of the ellipse may vary as described for Figure 46, with the distances in the two directions being independent of each other, but they have to be the same (fixed) values for all cross sections of the transition. The width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the actual ellipse.

NOTE The difference between the specifications in Figure 46 and Figure 47 is that the specification in Figure 46 allows the ellipse dimensions in each cross section to be any value within the specified range(s), independent of the other cross sections, whereas the specification in Figure 47 requires all cross sections to have the same unique (pair of) value(s) from within the specified range(s).

8.4 Maximum material elliptical boundary specification

When the extended edge transition section is contained by a maximum material ellipse boundary of fixed dimensions, extended by straight lines, the indication shall follow the template in Figure 48.

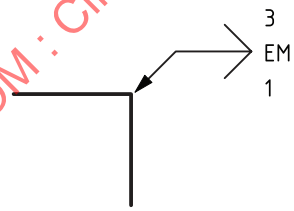
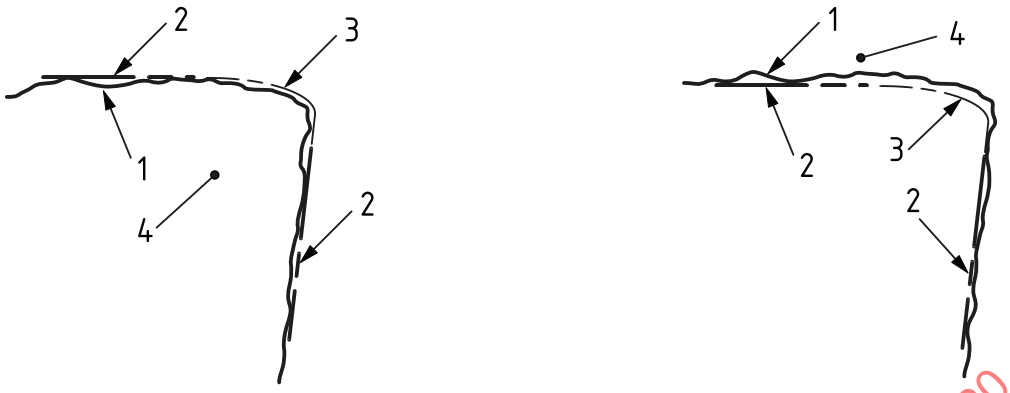


Figure 48 — Maximum material ellipse boundary specification

The meaning of the indication in Figure 48 is that the extended edge transition section shall be contained by a maximum material ellipse boundary, extended by straight lines, continuous with the adjacent reference sections, with nominal dimensions as shown in Figure 44 b), see Figure 49.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the least material direction.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material elliptical boundary
4 material side

Figure 49 — Limiting maximum material boundary defined by the specification in Figure 48

8.5 Least material elliptical boundary specification

When the extended edge transition section contains a least material ellipse boundary of fixed dimensions, extended by straight lines, the indication shall follow the template in Figure 50.

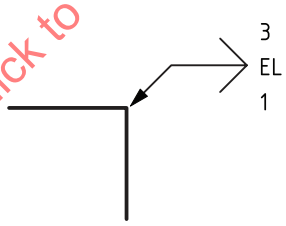


Figure 50 — Least material ellipse boundary specification

The meaning of the indication in Figure 50 is that the extended edge transition section shall contain a least material ellipse boundary, extended by straight lines, continuous with the adjacent reference sections, with nominal dimensions as shown in Figure 44 b), see Figure 51.

NOTE This is a one-sided tolerance that does not constrain the edge transition feature in the maximum material direction.

a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material elliptical boundary
4 material side

Figure 51 — Limiting least material boundary defined by the specification in Figure 50

8.6 Maximum material elliptical boundary with profile specification

When the extended edge transition section is contained by a maximum material elliptical boundary of fixed dimensions, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width inside the extended elliptical boundary, the indication shall follow the template in Figure 52.

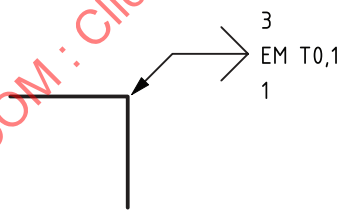
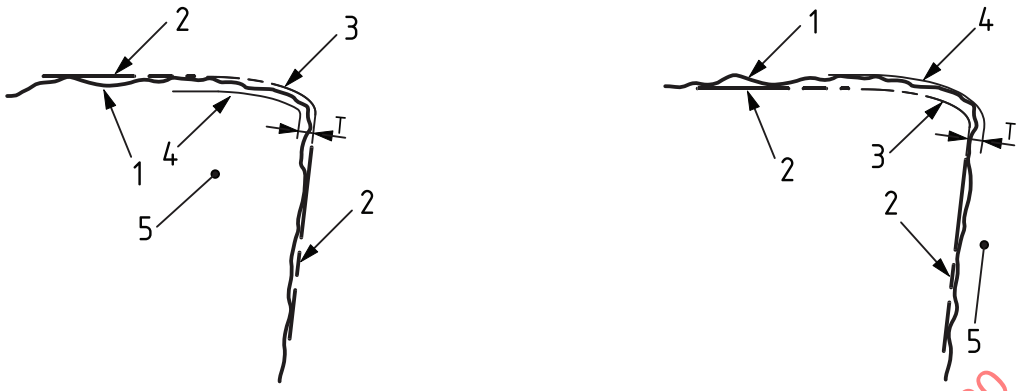


Figure 52 — Maximum material elliptical boundary with profile specification

The meaning of the indication in Figure 52 is that the extended edge transition section shall be contained by a maximum material elliptical boundary, extended by straight lines, continuous with the adjacent reference sections, with nominal dimensions as shown in Figure 44 b), and the toleranced feature shall be within a 0,1-wide tolerance zone inside the extended elliptical boundary, see Figure 53.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 least material limit of the tolerance zone
5 material side
T tolerance value for the transition tolerance

Figure 53 — Limiting boundary and tolerance zone defined by the specification in Figure 52

8.7 Least material elliptical boundary with profile specification

When the extended edge transition section contains a least material elliptical boundary of fixed dimensions, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width outside the extended elliptical boundary, the indication shall follow the template in Figure 54.

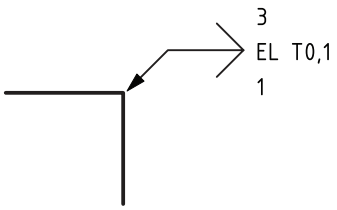
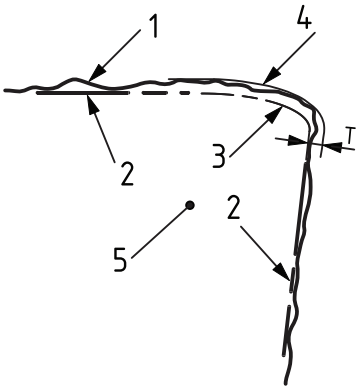
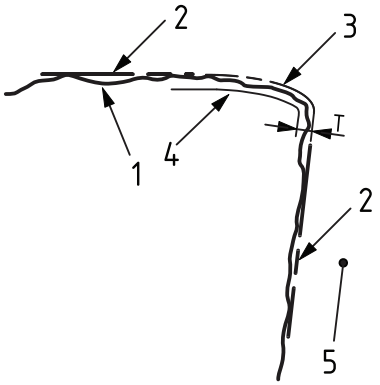


Figure 54 — Least material elliptical boundary with profile specification

The meaning of the indication in Figure 54 is that the extended edge transition section shall contain a least material elliptical boundary, extended by straight lines, continuous with the adjacent reference sections, with nominal dimensions as shown in Figure 44 b) and the extended edge transition section shall be within a 0,1-wide tolerance zone outside the extended elliptical boundary, see Figure 55.



a) External transition



b) Internal transition

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 maximum material limit of the tolerance zone
5 material side
T tolerance value for the transition tolerance

Figure 55 — Limiting boundary and tolerance zone defined by the specification in Figure 54

8.8 Combined maximum material and least material elliptical boundary specification

When the extended edge transition section is contained by a maximum material elliptical boundary of fixed dimensions and contains a least material elliptical boundary of fixed dimensions, both extended by straight lines, the indication shall follow the template in Figure 56.

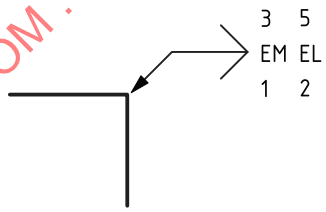
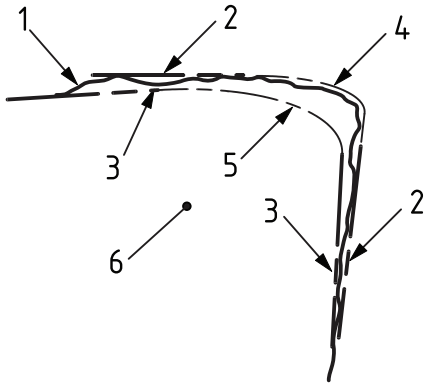


Figure 56 — Combined maximum material and least material elliptical boundary specification

The meaning of the indication in Figure 56 is that the extended edge transition section shall be contained by a maximum material ellipse boundary with dimensions as shown in Figure 44 b) and contain a similar least material boundary with the dimensions 5 and 2, both extended by straight lines, see Figure 57.



Key

1 real workpiece/skin model
2 adjacent outside reference sections (L2 norm outside the material)
3 adjacent inside reference sections (L2 norm inside the material)
4 maximum material boundary
5 least material boundary
6 material side

Figure 57 — Limiting boundary and tolerance zone defined by the specification in Figure 56

9 Edge transition feature defined by CAD

9.1 CAD profile specification

When the nominal profile of the edge transition feature is a fixed nominal geometry defined by CAD and the specification requires the extended edge transition section to be within a tolerance zone of a defined width, the indication shall follow the template in Figure 58.

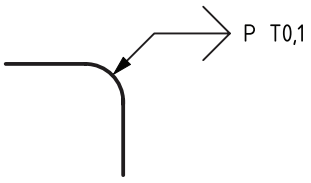
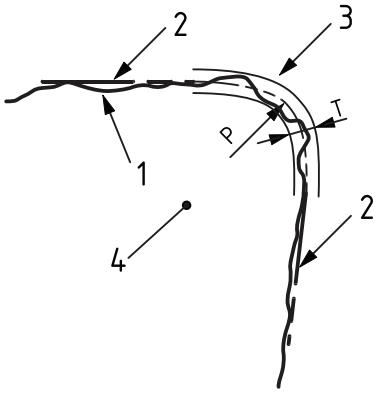


Figure 58 — CAD profile specification

The meaning of the indication in Figure 58 is that the nominal profile is defined by CAD and the width of the tolerance zone is 0,1. The tolerance zone is symmetrical around the nominal profile, see Figure 59.



Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 tolerance zone
4 material side
P nominal profile of the transition defined by CAD
T tolerance value for the transition tolerance

Figure 59 — Tolerance zone defined by the specification in Figure 58

9.2 Maximum material CAD profile boundary specification

When the extended edge transition section is contained by a maximum material boundary of fixed nominal geometry defined by CAD, extended by straight lines, the indication shall be as in Figure 60.

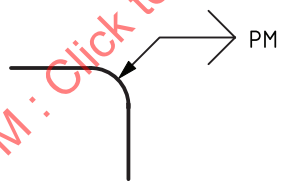
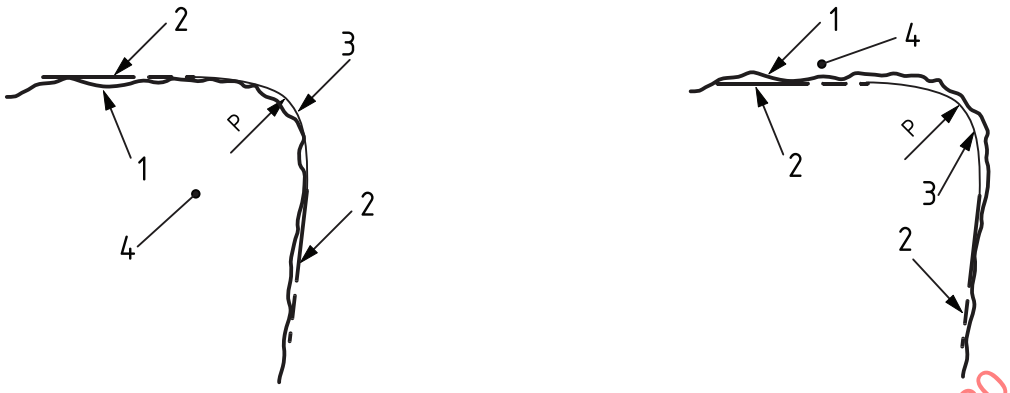


Figure 60 — Maximum material CAD profile specification

The meaning of the indication in Figure 60 is that the extended edge transition section shall be contained by a maximum material boundary nominally defined by CAD, extended by straight lines, continuous with the adjacent reference sections, see Figure 61.

NOTE This is a one-sided tolerance that does not constrain the extended edge transition section in the least material direction.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 material side
P nominal profile of the transition defined by CAD

Figure 61 — Limiting maximum material boundary defined by the specification in Figure 60

9.3 Least material CAD profile boundary specification

When the extended edge transition section contains a least material boundary of fixed nominal geometry defined by CAD, extended by straight lines, the indication shall be as shown in Figure 62.

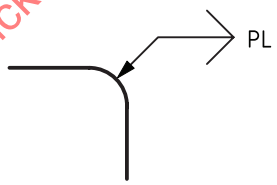


Figure 62 — Least material radius boundary specification

The meaning of the indication in Figure 62 is that the extended edge transition section shall contain a least material boundary profile nominally defined by CAD, extended by straight lines, continuous with the adjacent reference sections, see Figure 63.

NOTE This is a one-sided tolerance that does not constrain the extended edge transition section in the maximum material direction.

a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 material side
P nominal profile of the transition defined by CAD

Figure 63 — Limiting least material boundary defined by the specification in Figure 62

9.4 Maximum material CAD profile boundary with profile specification

When the extended edge transition section is contained by a maximum material boundary of fixed nominal geometry defined by CAD, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width inside the boundary, the indication shall follow the template in Figure 64.

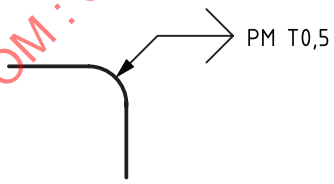
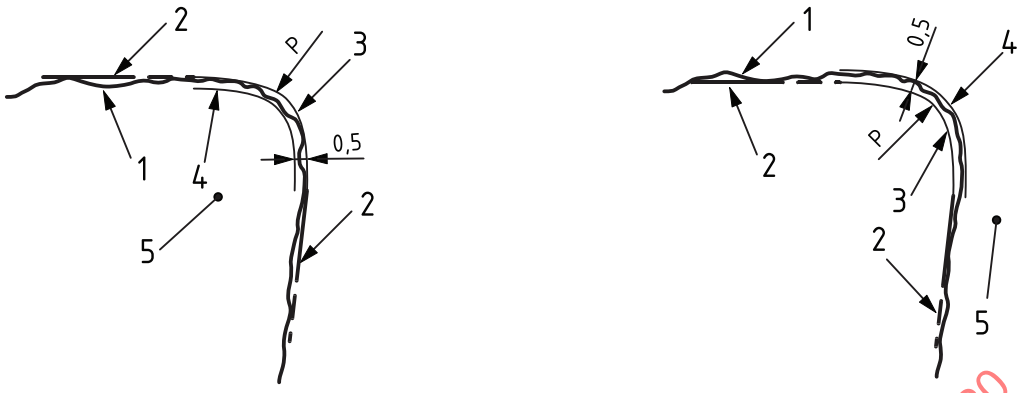


Figure 64 — Maximum material CAD profile boundary with profile specification

The meaning of the indication in Figure 64 is that the extended edge transition section shall be contained by a maximum material boundary nominally defined by CAD, extended by straight lines, continuous with the adjacent reference sections, and the extended edge transition section shall be within a 0,5-wide tolerance zone inside that boundary, see Figure 65.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm outside the material)
3 limiting maximum material boundary
4 least material limit of the tolerance zone
5 material side
P nominal profile of the transition defined by CAD

Figure 65 — Limiting maximum material boundary and tolerance zone defined by the specification in Figure 64

9.5 Least material CAD profile boundary with profile specification

When the extended edge transition section contains a least material profile boundary of fixed nominal geometry defined by CAD, extended by straight lines, and the extended edge transition section is required to be within a tolerance zone of a defined width outside that boundary, the indication shall follow the template in Figure 66.

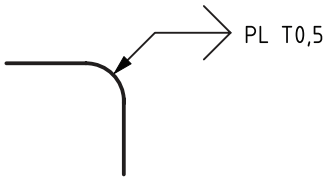
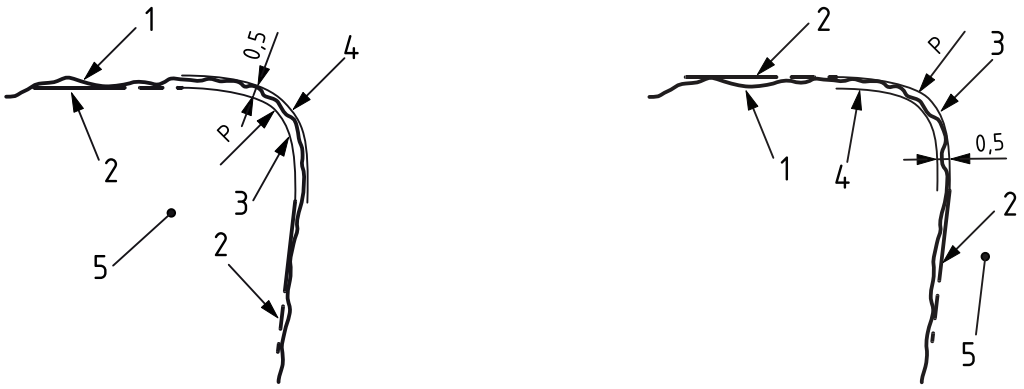


Figure 66 — Least material CAD profile boundary with profile specification

The meaning of the indication in Figure 66 is that the extended edge transition section shall contain a least material boundary nominally defined by CAD, extended by straight lines, continuous with the adjacent reference sections, and the extended edge transition section shall be within a 0,5-wide tolerance zone outside that boundary, see Figure 67.



a) External transition **b) Internal transition**

Key

1 real workpiece/skin model
2 adjacent reference sections (L2 norm inside the material)
3 limiting least material boundary
4 maximum material limit of the tolerance zone
5 material side
P nominal profile of the transition defined by CAD

Figure 67 — Limiting least material boundary and tolerance zone defined by the specification in Figure 66

10 Rules for supplemental indications

10.1 Symbols

The symbols defined in this clause are shown in Table 2.

Table 2 — Supplemental indication symbols

Symbol	Description	Subclause
▲ ▼	Primary reference section	10.6
⟷	Between	10.8

10.2 Limits of different nominal shapes

When the extended edge transition section is contained by a maximum material boundary of defined dimensions and contains a least material boundary of different shape, both extended by straight lines, the indication shall follow the template in Figure 68.

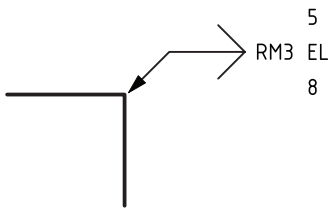


Figure 68 — Combined maximum material radius boundary and least material elliptical boundary specification

The meaning of the maximum material radius boundary is given in Figure 15 and the meaning of the least material elliptical boundary is given in Figure 51.

Other combinations are possible.

10.3 Extent of the toleranced feature

The proposed extents of the extended edge transition feature and reference portions are given in Annex A, see Figures A.5, A.6 and A.7. If the extent of the extended edge transition feature is different from the proposed, this shall be indicated using the symbol D as in Figure 69, if the extent is the same in both directions, and as in Figure 70, if it is different in the two directions. In Figure 69, the extent is 5 mm from the specification origin in both directions. In Figure 70, the extent is 3 mm from the specification origin in the horizontal direction and 5 mm in the vertical direction. In these cases, as in the proposed case, the extent of the reference portions is two times the extent of the extended edge transition feature.

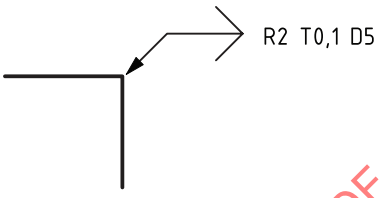


Figure 69 — Indication of identical extents of the extended edge transition feature in both directions

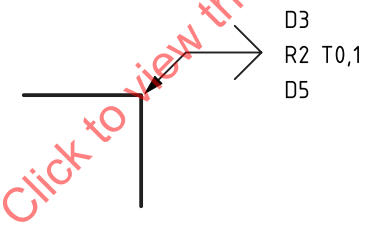


Figure 70 — Indication of different extents of the extended edge transition feature in the two directions

10.4 Tolerance zone offset

For a profile specification that is not combined with a boundary specification, as given in 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3 and 9.1, a tolerance offset can be indicated using the symbol UZ, as in Figure 71. If the indicated offset is positive, the offset is out of the material; if it is negative, the offset is into the material.

The indication in Figure 71 specifies a profile tolerance with a value of 0,1 offset 0,02 into the material from a radius of 2.

NOTE These rules are consistent with the rules for using UZ in geometrical tolerancing, see ISO 1101:2017, 8.2.2.1.3.

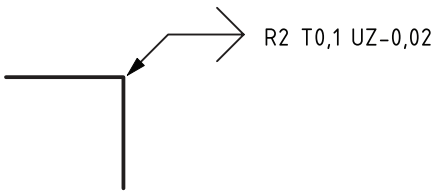


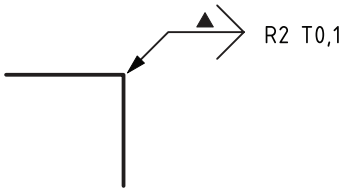
Figure 71 — Indication of tolerance offset for a profile specification

10.5 Indication of primary adjacent reference section

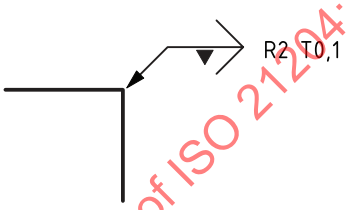
By default, the adjacent reference sections are fitted individually. If one shall be fitted first and the other constrained by it to be in theoretically exact orientation (similar to a primary and secondary datum) at the nominal angle between the two features, a triangle shall be indicated either above or below the transition specification symbol to indicate which adjacent reference section shall be primary, see Figure 72.

The rule for this indication is similar to the rule for indicating non-symmetrical transition features, i.e. if the triangle is indicated above the symbol, the adjacent reference section to the left of (above) the arrow shall be primary, and if it is indicated below the symbol, the adjacent reference section to the right of (below) the arrow shall be primary.

Only one primary adjacent reference section may be indicated.



a) The horizontal adjacent reference section is primary



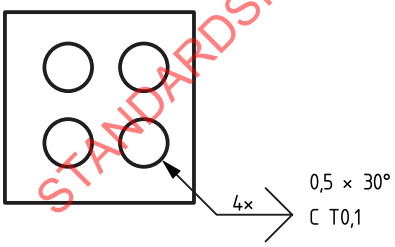
b) The vertical adjacent reference section is primary

Figure 72 — Indication of primary reference section

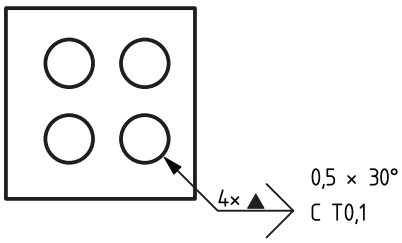
NOTE The symbol is intended to resemble the foot of a datum indicator.

10.6 Indication of several toleranced features

If a transition specification applies to several edge transition features, this can be indicated by a n× indication above the transition specification symbol, see Figure 73 a). If a primary adjacent reference section indication is also indicated in the upper primary reference section indication area and/or the between symbol is used, the n× indication shall come before these other indications, see Figure 73 b). If it is not obvious which transitions are covered by the specification, these can be identified, for example with letters.



a) n× indication alone



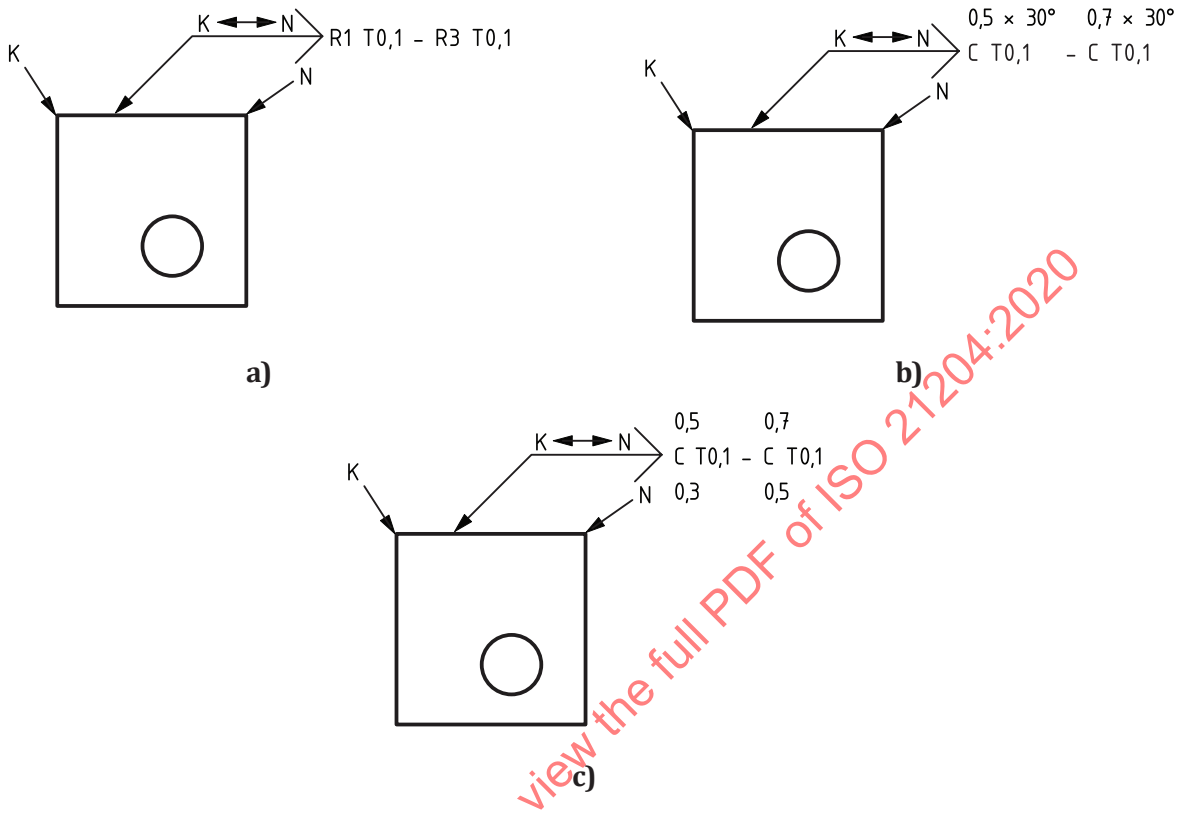
b) n× indication with primary adjacent reference section indication

Figure 73 — Indication of several toleranced features

10.7 Indications using the between symbol

If a transition specification does not apply to one entire transition feature, but to several continuous transition features, or part of one transition feature or several continuous transition features, this can be indicated using the between symbol. The general rules for the use of the between symbol are given

in ISO 1101. If the transition specification changes linearly between two points, it can be indicated as shown in Figure 74. The first indicated (set of) value(s) for the variable(s) in the specification applies at the first letter indicated and the second indicated (set of) value(s) applies at the second letter indicated.

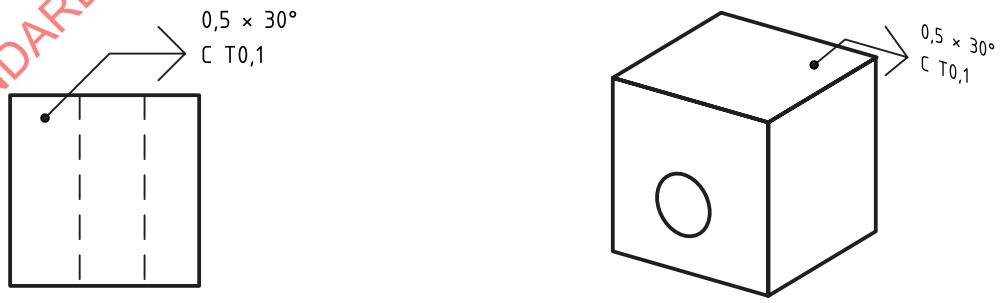


a) b) c)

Figure 74 — Indication using the between symbol

10.8 Around a feature indications

If a transition indication applies to all transitions involving one feature, it can be indicated as shown in Figure 75. If the transitions are not symmetrical, the upper indication refers to the indicated feature and the lower indication refers to the adjacent features. Because the dimensions are given in the upper indication area in the indication in Figure 75, the dimensions refer to the indicated feature.



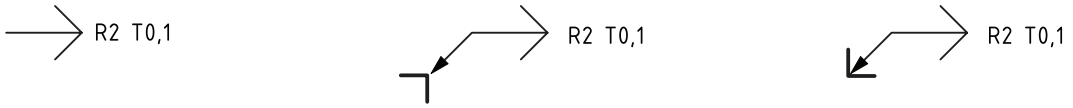
a) 2D b) 3D

Figure 75 — Around a feature indication

NOTE See 5.2 for rules on modelled chamfers, and when the specification applies to the chamfer and when it applies to the transition feature next to the chamfer.

10.9 General transition specifications

Transition specifications can be given as general GPS specifications, indicated near the title block, as shown in Figure 76.



a) For all transitions **b) For external transitions** **c) For internal transitions**

Figure 76 — General specification indications

NOTE The symbol representing the external or internal transition is 14*d* in each direction, where *d* is the width of the narrow line in the drawing, see ISO 13715.

The general transition specifications can be supplemented with either an empty set of parentheses to generically indicate that there are additional, individually indicated, specific transition indications on the drawing, or all the additional, individually indicated, transition indications can be indicated within the parentheses, see Figure 77.

a) Generic indication **b) Specific indication**

Figure 77 — General specification indications with indication that other transition specifications exist in the drawing

Annex A
(informative)

Algorithm for defining extended edge transition sections and adjacent reference sections

A.1 Separation point

The point from which the extended edge transition section is defined and the orientation of the extent of the extended edge transition section and adjacent reference sections are proposed as follows:

Within a defined section, see Figures 1 and 2, associate a pair of lines to the features adjacent to the transition feature with the constraint outside the material as follows:

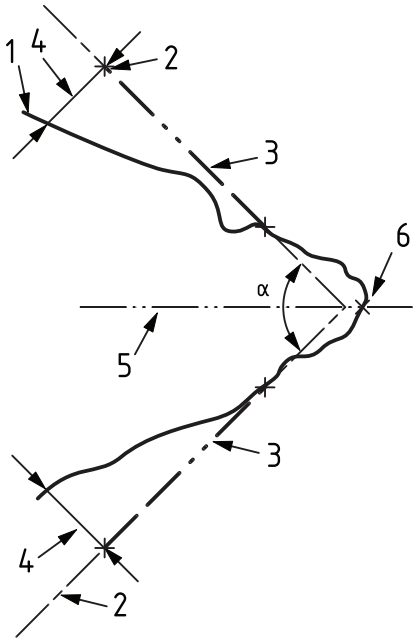
— The lines are constrained to intersect at the nominal angle of the intersection of the two features adjacent to the transition feature.

— The portion of each line considered in the association has a length of 2D, $2D_1$ or $2D_2$, depending on the specification, see Figure A.1. These portions start at a distance of D, D_1 or D_2 from the intersection of the two lines, depending on the type of transition feature (e.g. chamfer, radius), see Figures A.5 to A.7.

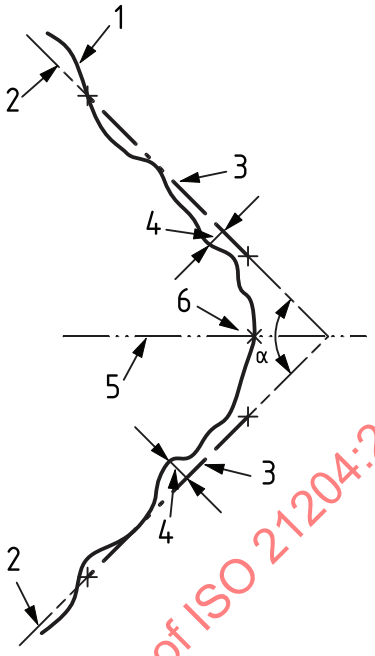
— The association minimizes the maximum perpendicular distance between the pair of lines and the features adjacent to the transition feature.

The intersection between the bisector of the pair of associated lines and the real workpiece is the separation point between the two adjacent features for further association purposes, see Figure A.1.

In cases where there is a burr, or the bisector otherwise intersects the real workpiece more than once, the separation point for an adjacent feature is the one defined by the first intersection that is encountered, when the transition feature section is approached along the profile of the adjacent feature.



a) Transition where the angle between the adjacent features is smaller than the nominal angle



b) Transition where the angle between the adjacent features is larger than the nominal angle

Key

α nominal angle between the adjacent features
1 real workpiece/skin model
2 pair of intersecting lines
3 portions of intersecting lines considered in the association (from X to X)
4 minimized maximum distances
5 bisector of the pair of intersecting lines
6 intersection of bisector and real workpiece/skin model

Figure A.1 — Separation point definition

The algorithm is presented with both adjacent features being straight lines in the considered cross section. If one or both of the adjacent features are not straight lines, for example in the case of the transition between a cylinder and a plane parallel to the axis of the cylinder (the transition of a keyway), their nominal shape, for example circular, is considered fixed in the algorithm, but their size is considered variable. This is not elaborated on in the algorithm at this time.

A.2 Specification origin and directions

A.2.1 General

The specification origin is the point from which the distances defining the extended edge transition feature and the adjacent reference sections originate.

The specification directions are the directions in which the distances defining the extended edge transition section and the reference portions apply.