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Plastics moulded parts — Tolerances and acceptance conditions

National foreword

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*.

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

In comparison to metal materials, significantly larger deviations with respect to dimension, form and location are expected when manufacturing moulded parts. Based on particular properties, such as high deformability and low stiffness, the functional accuracy requirements in order to economically manufacture moulded parts are much lower for plastics than for metals.

The physical and chemical properties as well as the material modification options of plastics are vastly different from those of metals. Properties of plastics relevant to dimensional accuracy in the moulding application and during processing by the original mould method (injection moulding, compression moulding, rotational moulding) require a different evaluation and quantification of geometrical tolerances in comparison to metal materials. The tolerance standards applicable for metal parts, therefore, cannot be adopted for plastic structures or can only be applied to a very limited extent which led to the development of this document.

The unique properties of plastics mean that three different dimensional reference levels defined in Annex A and characterized in respect to the main influential factors are taken into consideration.

The following is the preferred sequence of steps to ensure effective cooperation in the effective design and development of moulded parts.

a) The part designer specifies the functionally required tolerances based on the application requirements including, part functionality, use environment, and any assembly requirements.

b) The moulded part manufacturer confirms that the functionally required tolerance is greater than or equal to the tolerance capability of the manufacturing technology to be used. This is to avoid impractical tolerances which cannot be achieved without incurring adverse economic or productivity effects. The functionally required tolerances should always be defined in the design documentation.

c) The functionally required tolerances should always be defined in the design documentation in order to establish the basis for determining the moulding shrinkage. This is to prevent situations in which the functionally required tolerances cannot be achieved, if at all, without excessive scrap generation and excessive cost. After order placement, calculated values with respect to the moulding shrinkage should be agreed between the part manufacturer and toolmaker or tool designer, with consultation with the material supplier as necessary.

Dimensional control of the moulded part is primarily affected by the material specified, the part design and tool layout, and the processing conditions.

In addition to the factors affecting dimensional control, there are other factors which influence dimensions, part integrity and mechanical properties. These factors include anisotropic behaviour, warpage and distortion due to non-uniform thicknesses and resulting non-uniform cooling rates, and fill profiles. These factors and the basic complexity of polymer systems make standardization much more difficult in comparison to conventional materials such as metals.

Because of the unavoidable process-induced factors, deviations are therefore expected in the moulded part. The procedure in case of deviations depends on the function of the moulded part and is subject to mandatory contractual agreement.

- eliminate deviation by design measures (strengthening ribs, optimized material thickness, optimized fill profiles, etc.);
- correct deviation by specified retention in the tool, i.e. extended cooling cycles;
- acceptance of non-conformance.

The acceptance of non-conformance requires appropriate documentations including drawing corrections, production deviation documentations or updated reference parts.

NOTE 1 Process-induced deviations can be reduced both by effective design of the moulded part and by optimization of the production process.

NOTE 2 The conventional tolerance chain calculation presupposes rigid bodies and is therefore primarily unsuitable for plastic parts.

Plastics moulded parts — Tolerances and acceptance conditions

1 Scope

This document specifies possible manufacturing tolerances for plastic moulded parts.

This document specifies all integral features with general tolerances with surface profile tolerance within a specified datum system. It allows for additional specifications in case of functional needs and requirements using the ISO-GPS-tools for dimensional and geometrical tolerating.

This document addresses injection moulding, injection compression moulding, transfer moulding, compression moulding and rotational moulding of non-porous moulded parts made from thermoplastics, thermoplastic elastomers and thermosets of thermoplastics. This document is applicable to other plastic processes if agreed to by the contractual parties.

Moulded part surface imperfections such as sink marks, undesired flow structures and roughness, as well as joint lines are not addressed in this document.

This document is not intended to supplant, replace or in any way interfere with requirements for tolerances found in product standards.

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 286-1, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits*

ISO 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 291:2008, *Plastics — Standard atmospheres for conditioning and testing*

ISO 294-4, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 4: Determination of moulding shrinkage*

ISO 2577, *Plastics — Thermosetting moulding materials — Determination of shrinkage*

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

ISO 10135, *Geometrical product specifications (GPS) — Drawing indications for moulded parts in technical product documentation (TPD)*

ISO 14405-1, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 1: Linear sizes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8015 and the following 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
design documentation
documents and data necessary for complete structural description of components, assemblies or machines and devices

Note 1 to entry: These are initially 3D data records and drawings as well as part lists. They might be supplemented by measuring and test specifications. 3D data records or drawings alone only fully describe plastic moulded parts in rare exceptional cases.

Note 2 to entry: For further information, see ISO 17450-1, ISO 17450-2 and ISO 17450-3.

3.2
size
dimensional parameter considered variable for a feature of size that can be defined on a nominal feature or on an associated feature

Note 1 to entry: In this document, the size is linear, e.g. the diameter of a cylinder or the distance between two parallel opposite planes, two opposing lines, and two concentric circles. Depending on the type of linear feature of size, the terms “diameter”, “width”, and “thickness” are synonyms for size.

Note 2 to entry: A size is angular (e.g. angle of a cone) or linear (e.g. diameter of a cylinder). This document only deals with linear size.

Note 3 to entry: For further information on linear size, see ISO 17450.

[SOURCE: ISO 17450-1:2011, 3.4, modified — References to ISO 14405 have been replaced with “this document” and a Note 3 to entry has been added.]

3.3
general tolerance
tolerance on geometrical elements used as default, if the element has no direct tolerance (individual tolerance)

4 Symbols and abbreviated terms

4.1 General

The symbols and abbreviated terms according to ISO 1043, ISO 18064 and the following symbols and abbreviated terms apply for the application of this document.

4.2 Symbols

C	tolerance mean dimension
C_{A}	tolerance mean dimension for moulded part application
C_{F}	tolerance mean dimension for moulded part production
C_{W}	tolerance mean dimension for tool contour production
D_{P}	furthest distance in the space between the element to be toleranced and the origin of the datum system used for this positional tolerancing
L_{F}	moulded part dimension
L_{W}	tool contour dimension
N_{F}	nominal dimension for moulded part drawings

P_g	total number of points
P_i	point evaluation of the individual influences
T	tolerance
t	form and location tolerance
T_A	moulded part application tolerance
T_F	moulded part production tolerance
T_W	tool contour production tolerance
VS	moulding shrinkage
$VS_{\perp}$	moulding shrinkage transverse to the melt flow direction
VS_{II}	moulding shrinkage parallel to the melt flow direction
VS_{max}	maximum moulding shrinkage
VS_{min}	minimum moulding shrinkage
VS_R	average calculated value for the moulding shrinkage
ΔL	dimensional shift
ΔL_A	application-induced dimensional shift
ΔL_V	moulding-induced dimensional shift
ΔS	distribution of the moulding shrinkage
ΔVS	difference between $VS_{\perp}$ and VS_{II}

4.3 Abbreviated terms

ABF	acceptance conditions for moulded part production
ABW	acceptance conditions for tool production
GA	maximum permissible deviation
IRHD	International Rubber Hardness Degree
IT	standard tolerance
NW	non-tool-specific dimensions
TG	tolerance grade
W	tool-specific dimensions

5 Tolerancing of plastic moulded parts

5.1 General

The independency principle according to ISO 8015 applies when using this document.

Change of the default specification operator for size shall be indicated on the drawing in or near the title block according to ISO 14405-1, e.g. “Linear size ISO 14405 E” for the envelope principle.

Moulded part drawings or CAD data records correspond to the nominal geometry. The tolerances are symmetrical to the nominal geometry.

The procedure for the verification of tolerances shall be unambiguously defined and shall be a part of the contract. It is recommended to separate between ISIR (Initial Sample Inspection Report) and running production report (requalification). This may include or exclude the individual tolerances and general tolerances or specified functional tests (e.g. tightness, dielectric strength). If nothing has been stated in the contract, only individually indicated tolerances are subject for verification.

Unless otherwise defined or by agreement, plastic moulded parts, in which the general tolerances are not met, do not have to be automatically rejected if the functionality of the part is not compromised.

Certain parts, when removed from their manufacturing environment, can deform significantly from their defined limits owing to their weight, flexibility or the release of internal stresses resulting from the manufacturing processes.

Functionally reasonable references with adequate form stiffness have to be specified.

In the case of non-rigid parts, the measuring concept is of special importance (functional orientation, datum system and overdetermination, gravitational influence, pretension, etc.). See also ISO 10579.

For the orientation of the part, datum target points or small datum target areas have to be used instead of datum features (e.g. complete planes).

NOTE The datum system reflects the orientation of the part in the assembly. It is important that the datum system is stable.

In the case of parts moulded from dissimilar materials (e.g. over-moulding) or assemblies using multiple component parts moulded from different materials, a separate tolerance grade shall be specified for each material used.

A standard atmosphere in the plastic range is 23 °C ± 2 K and 50 % ± 10 % relative air humidity as defined in ISO 291.

5.2 Intention

This document has two intentions. One intention is to give the part designer a guideline for producible tolerances. The other is to serve as a standard for general tolerances for all geometrical features as well as for direct tolerances (individual tolerances).

Figure 1 gives an overview about the intentions and about the composition of tolerance.

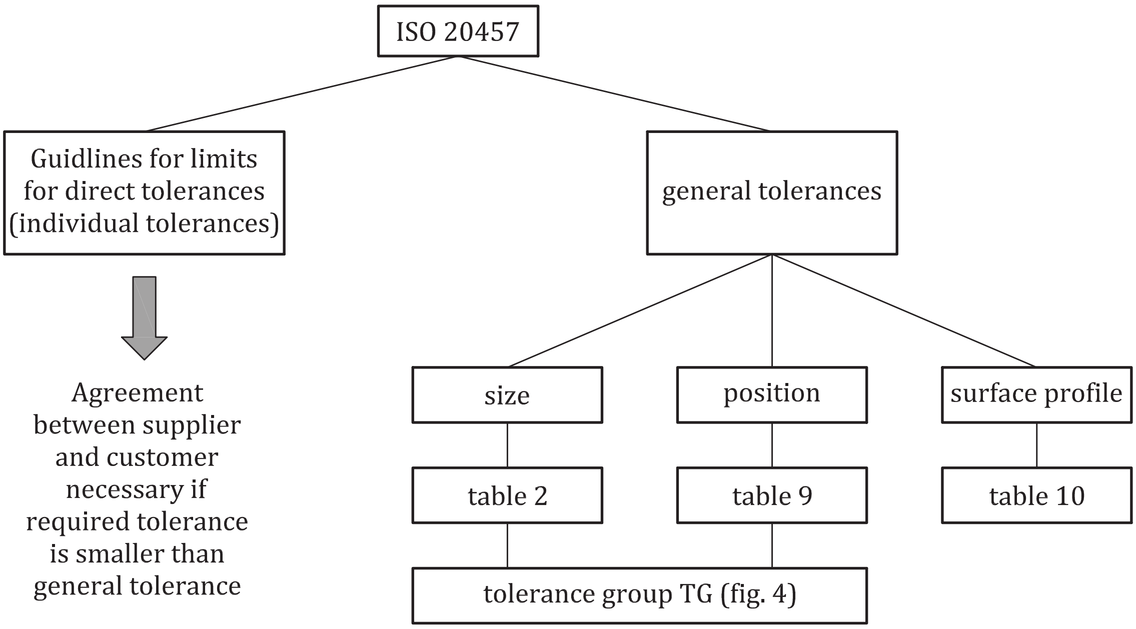


Figure 1 — Determination of tolerances for plastic moulded parts

Tolerances of features with functional requirements shall be directly specified. General tolerances apply to non-functional features (e.g. surface profiles, line profiles) and can be as large as practically possible.

5.3 General tolerances

Only series 1 (simple production) according to Table 8 applies for general tolerances. General tolerances shall be indicated in or near the title block.

EXAMPLE General tolerances ISO 20457:JJJJ – TG6.

General tolerances for size apply only on explicitly drawn dimensions on the drawing indicated without direct tolerances (individual tolerances). General tolerances for positions apply to features of sizes with respect to the master datum system only.

Profile tolerances of a surface shall be applied as general tolerances, specified in detail in the drawing, restricting all 6 degrees of freedom.

General tolerances for features of linear size apply only on explicitly drawn nominal dimensions in the drawing.

5.4 Direct tolerancing (individual tolerancing)

Tolerances (dimensional or geometrical) for functional elements/dimensions shall be explicitly specified.

The dimensional tolerance shall be indicated directly by dimensions for moulded parts with justifiably high dimensional stability requirements. When doing so, it shall be noted that the dimensional boundary lines or points represent inspection dimensions (reference dimensions, acceptance dimensions). The number of directly toleranced functional elements/dimensions per moulded part shall be kept as low as possible for economic reasons.

5.5 Tolerancing of draft angles

Drafts (also draft angles) are production-induced inclinations on the moulded part in the demoulding orientation of moving tool parts (e.g. punches, gate valves, jaws), which are specified as an integral component of the moulded part drawings or the CAD data records of the moulded part manufacturer for tool design and tool making as well as parts production. Inclination dimension differences specified in terms of design are not a component of dimensional tolerances or form and location deviations.

Measuring points shall be defined at suitable areas for functional dimensions in the specification in order to allow for comparable measuring results.

5.6 Dimensioning, tolerancing and measuring of radii

Minimum 90° of the circle segment shall be provided as a measurable contour for the specification of radii.

NOTE Radii can alternatively be toleranced by profile forms.

5.7 Specification of freeform surfaces

Functional free form surfaces shall be specified with a surface profile tolerance. The verification shall be fixed in the contract between producer and costumer.

6 Moulding compound properties

6.1 General

This document does not contain any type lists for moulding compounds or their assignment to attainable production accuracies. Accuracy-relevant properties shall be considered in order to indicate a general assignment scheme for the large number and variety of moulding compounds.

6.2 Moulding shrinkage and shrinkage anisotropies

The moulding shrinkage (VS) is the relative difference between the tool contour dimension L_W at 23 °C ± 2 K and the corresponding moulded part dimensions L_F 16 h to 24 h after production, stored until measurement and measured according to ISO 291:2008, Table 1, unless otherwise specified by contract or the relevant ISO-material specification. It is calculated according to Formula (1).

$$VS = \left(1 - \frac{L_F}{L_W}\right) \times 100\% \tag{1}$$

where

L_F is the moulded part dimension;

L_W is the tool contour dimension.

The relative moulding shrinkage for thermoplastics and thermoplastic elastomers is determined (e.g. test panels) according to ISO 294-4 and for thermosets according to ISO 2577 on standard test specimens. Physical causes of the moulding shrinkage and the effect of influencing factors are indicated in Annex B and Annex E.

Shrinkage anisotropy is quantified by the absolute difference ΔVS from moulding shrinkage transverse to the melt flow direction $VS_\perp$ and the moulding shrinkage parallel to the melt flow direction VS_{II}. See Formula (2).

$$\Delta VS = I\, VS_\perp - VS_{II}\, I \tag{2}$$

Primary causes for anisotropicity include:

- moulding impediments as a result of different thermal contraction by solidified boundary layers, material concentrations and locally different tool contour temperatures as well as by the effect of the moulded part design;

- shrinkage differences due to over-moulded parts for example metal inserts;
- orientation of fillers and reinforcements, and molecular orientation as a result of shear and elongation flows. In particular, particle shape and aspect ratio (length-thickness ratio or side-thickness ratio) of the fillers and reinforcements affect the anisotropy characteristics.

It can be derived from the variety of influences on the moulding shrinkage and shrinkage anisotropy that numerical values are only realistic as range data. The resultant distribution of the moulding shrinkage ΔS is derived from the extreme values $VS_{\max}$ and $VS_{\min}$ It is calculated according to Formula (3).

$$\Delta S = VS_{\max} - VS_{\min} \tag{3}$$

The degree and uniformity of the shrinkage distribution can be affected by many factors including production conditions (process optimization), batch-relevant moulding compound differences, moulded part shape and sprue technology.

Average calculated values of the moulding shrinkage VS_R are specifications for tool design, construction and sampling of the tools. It is calculated according to Formula (4).

$$VS_R = 0{,}5\left(VS_{\max} + VS_{\min}\right) \tag{4}$$

This calculated value, which is a basis for the tool design, is primarily expected from the moulded part manufacturer, as the latter can actively influence the shrinkage in limits and usually has corresponding data. They can be generated as a by-product from dimensional check measurements. In special cases, the shrinkage values are to be made more precise by sampling with similar tools. In addition, the moulded part manufacturer can use corresponding data and experience of the moulding compound manufacturer. In the case of distinct shrinkage anisotropy, the shrinkage differences can be considered to a limited extent by dimensional provisions in the tool. Computer-assisted shrinkage and deformation statements might be able to provide information in respect to this.

The shrinkage distribution is also of major significance for the attainable production accuracy. This value range is to be estimated according to experience of the moulded part manufacturer.

NOTE If the shrinkage anisotropy cannot be considered adequately in the contour calculation, a larger shrinkage distribution and, hence, deformation is to be expected. A timely coordination between the customer and moulded part manufacturer is necessary in respect to this.

6.3 Moulded material stiffness or hardness

The elastic recovery (relaxation) of the moulding material after removal of the part has a significant effect on the linear and angular sizes and dimensions. The required data shall be provided in the specifications of the raw material suppliers.

NOTE The main cause for this is the different stiffness or hardness of the moulding material directly after removal from the mould. It is related to the original modulus of elasticity from the short-term test according to ISO 527 as well as by the Shore indentation hardness according to ISO 868:2003, method A and method D or by the ball indentation hardness for elastomers according to ISO 48 (International Rubber Hardness Degree). All tests refer to 23 °C and normally conditioned test specimens.

7 Dimensional and geometrical tolerancing

7.1 Dimensional tolerancing

7.1.1 Tolerance grades for features of sizes

In order to approximately adapt the distribution of the production tolerances resulting from the moulding compound and process, and their particular nominal dimensional relation for plastic moulded parts to the ISO system for limit dimensions and fits according to ISO 286-1 and ISO 286-2, nine tolerance grades (TG1 to TG9) in three nominal dimension ranges were assigned to the ISO basic tolerance grades (IT) for tool-specific dimensions in Table 1.

Table 1 — Tolerance grades (TG) with associated ISO standard tolerance grades (IT) according to ISO 286-1

Nominal dimension mm	**ISO standard tolerance grades (IT) for tool-specific dimensions**								
	TG1	TG2	TG3	TG4	TG5	TG6	TG7	TG8	TG9
1 to 6	8	9	10	11	12	13	14	15	16
>6 to 120	9	10	11	12	13	14	15	16	17
>120 to 1 000	—	11	12	13	14	15	16	17	18
The tolerances are subject to mandatory agreement as a rule for nominal dimensions below 1 mm and above 1 000 mm.									

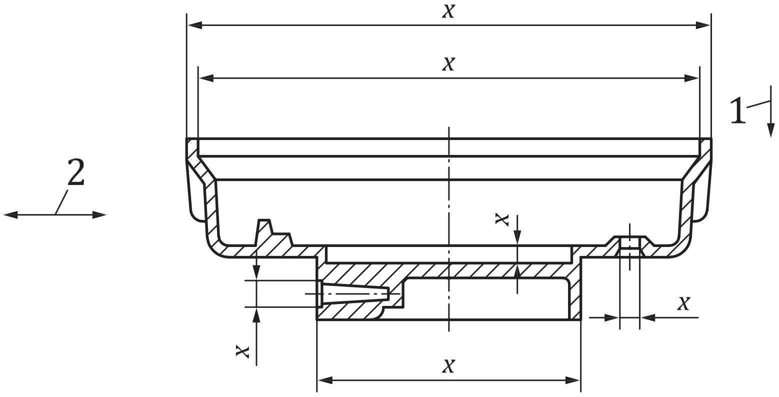
NOTE 1 Table 1 serves as information for the basic layout and content of Table 2. Further usage is not required.

NOTE 2 Features of sizes cover inner and outer cylinders (hole/shafts), inner and outer parallel, opposite planes (slot/keys) (see ISO 17450-1).

The permissible limit dimensions for plastic moulded parts are summarized for the practical application in Table 2.

The manufacturing method rotational moulding is classified into tolerance grade 9.

Different deformations and deviations of location of tool parts caused during the pressure load taken into account by the differentiation of tool-specific and non-tool-specific moulded part dimensions, as the different types of tool contour fixations result in different degrees of accuracy. Tool-specific dimensions are dimensions in the same tool part, while non-tool-specific dimensions are derived from the interaction of different tool parts and which hence tend to cause larger dimensional distributions (Figure 2 and Figure 3).

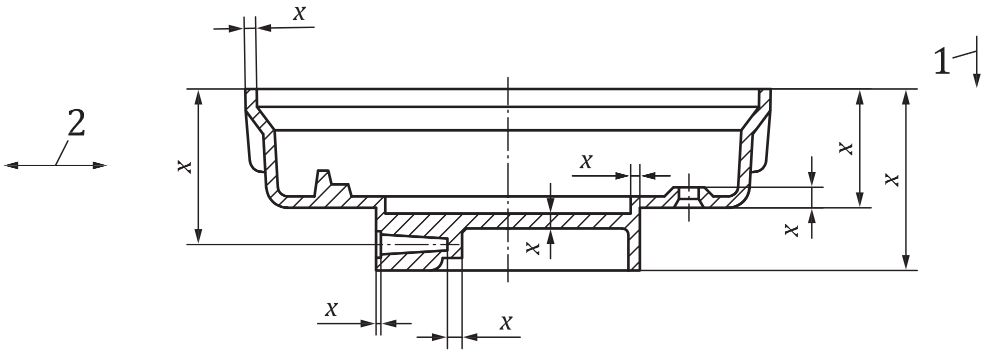


Key

1 closing direction

2 movement direction of the slide

Figure 2 — Tool-specific dimensions



Key

1 closing direction

2 movement direction of the slide

Figure 3 — Non-tool-specific dimensions

Table 2 — Plastic moulded part tolerances as symmetrical limit dimensions for features of sizes

Dimensions in mllimetres

Tolerance grade		Limit dimensions (GA) for nominal size ranges															
		1 to 3	>3 to 6	>6 to 10	>10 to 18	>18 to 30	>30 to 50	>50 to 80	>80 to 120	>120 to 180	>180 to 250	>250 to 315	>315 to 400	>400 to 500	>500 to 630	>630 to 800	>800 to 1 000
TG1	W	±0,007	±0,012	±0,018	±0,022	±0,026	±0,031	±0,037	±0,044	—	—	—	—	—	—	—	—
	NW	±0,012	±0,018	±0,022	±0,026	±0,031	±0,037	±0,044	±0,055	—	—	—	—	—	—	—	—
TG2	W	±0,013	±0,019	±0,029	±0,035	±0,042	±0,050	±0,060	±0,090	±0,13	±0,15	±0,16	±0,18	±0,20	—	—	—
	NW	±0,019	±0,029	±0,035	±0,042	±0,050	±0,060	±0,090	±0,13	±0,15	±0,16	±0,18	±0,20	±0,22	—	—	—
TG3	W	±0,020	±0,030	±0,05	±0,06	±0,07	±0,08	±0,10	±0,15	±0,20	±0,23	±0,26	±0,29	±0,32	±0,35	±0,40	±0,45
	NW	±0,030	±0,050	±0,06	±0,07	±0,08	±0,10	±0,15	±0,20	±0,23	±0,26	±0,29	±0,32	±0,35	±0,40	±0,45	±0,53
TG4	W	±0,03	±0,05	±0,08	±0,09	±0,11	±0,13	±0,15	±0,23	±0,32	±0,35	±0,41	±0,45	±0,49	±0,55	±0,63	±0,70
	NW	±0,05	±0,08	±0,09	±0,11	±0,13	±0,15	±0,23	±0,32	±0,35	±0,41	±0,45	±0,49	±0,55	±0,63	±0,70	±0,83
TG5	W	±0,05	±0,08	±0,11	±0,14	±0,17	±0,20	±0,23	±0,36	±0,50	±0,58	±0,65	±0,70	±0,78	±0,88	±1,00	±1,15
	NW	±0,08	±0,11	±0,14	±0,17	±0,20	±0,23	±0,36	±0,50	±0,58	±0,65	±0,70	±0,78	±0,88	±1,00	±1,15	±1,30
TG6	W	±0,07	±0,12	±0,18	±0,22	±0,26	±0,31	±0,37	±0,57	±0,80	±0,93	±1,05	±1,15	±1,25	±1,40	±1,60	±1,80
	NW	±0,12	±0,18	±0,22	±0,26	±0,31	±0,37	±0,57	±0,80	±0,93	±1,05	±1,15	±1,25	±1,40	±1,60	±1,80	±2,10
TG7	W	±0,13	±0,20	±0,29	±0,35	±0,42	±0,50	±0,60	±0,90	±1,25	±1,45	±1,60	±1,80	±2,00	±2,20	±2,50	±2,80
	NW	±0,20	±0,29	±0,35	±0,42	±0,50	±0,60	±0,90	±1,25	±1,45	±1,60	±1,80	±2,00	±2,20	±2,50	±2,80	±3,30
TG8	W	±0,20	±0,30	±0,45	±0,55	±0,65	±0,80	±0,95	±1,40	±2,00	±2,30	±2,60	±2,85	±3,15	±3,50	±4,00	±4,50
	NW	±0,30	±0,45	±0,55	±0,65	±0,80	±0,95	±1,40	±2,00	±2,30	±2,60	±2,85	±3,15	±3,50	±4,00	±4,50	±5,30
TG9		±0,48	±0,75	±0,90	±1,05	±1,25	±1,50	±2,25	±3,15	±3,60	±4,05	±4,45	±4,90	±5,40	±6,20	±7,10	±8,50

NOTE 1 W: Tool-specific dimensions; NW: Non-tool-specific dimensions.

NOTE 2 The differentiation of tool-specific and non-tool-specific dimension is not necessary for TG9.

NOTE 3 Tolerance mean dimensions apply as nominal sizes for moulded part drawings ($N_F = C_F$). For tolerancing of the distance between parallel surfaces that do not face each other directly but are arranged shifted to one another, the D_P dimension according to 7.2 of this document is used as nominal size.

NOTE 4 Dimensions under 1 mm and above 1 000 mm are subject to mandatory agreement.

NOTE 5 Only the limit values for non-tool-specific dimensions are used for general tolerances.

NOTE 6 Tolerances for material thicknesses are subject to mandatory agreement.

NOTE 7 General tolerances are indicated in the design documentation as follows. Example: ISO 20457:JJJJ-MM – TG6.

NOTE 8 For validation of machine and process capability, see Annex D.

7.1.2 Determination of the tolerance grades

7.1.2.1 General

The required degree of accuracy of the moulded part production is defined with the corresponding tolerance grade according to Table 3. An oriented assignment scheme using point evaluation of five individual influences P_i with the total number of points P_g yields the tolerance grade according to Table 3 (exception is the rotational moulding which always equals TG9):

$$P_\mathrm{g} = P_1 + P_2 + P_3 + P_4 + P_5 \tag{5}$$

where

P_g is the total number of points;

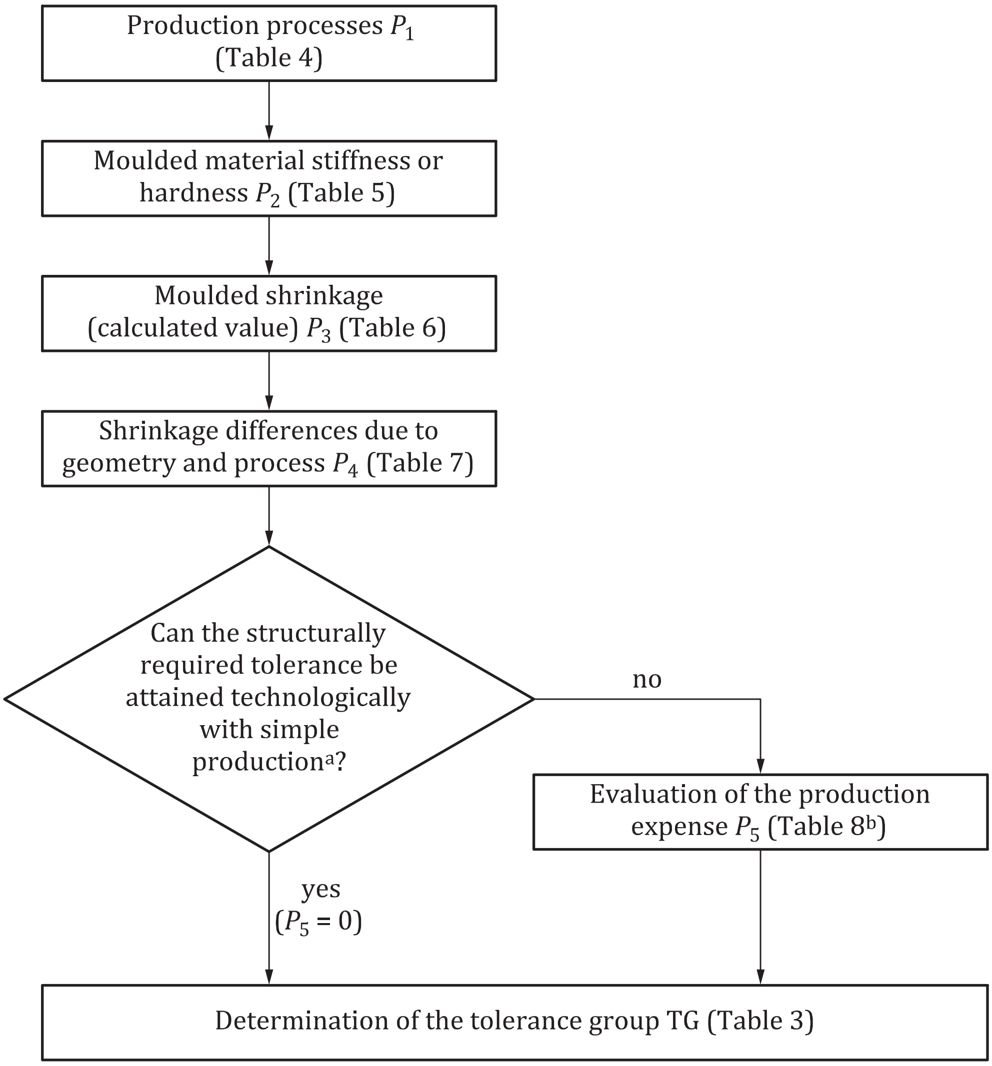
P_i is the point evaluation of the individual influences.

Table 3 — Point assignment of the tolerance grades

TG	**TG1**	**TG2**	**TG3**	**TG4**	**TG5**	**TG6**	**TG7**	**TG8**	**TG9**
$\boldsymbol{P_\mathrm{g}}$	1	2	3	4	5	6	7	8	≥9

In the process of determining, P_g, [as shown in Formula (5)] inputs from the moulded part manufacturer might be necessary.

Figure 4 shows an overview of the process to determine the tolerance grade.



[a] Simple production = Production realized with general tolerances. Dimensional stability requirements that do not form any special quality focus (see Table 8, Series 1).

[b] Exemplary selection criteria are listed in Annex C to assist the series assignment.

Figure 4 — Procedure to determine the tolerance grade TG

7.1.2.2 Evaluation of the production process and moulding compound properties (P_1 to P_4)

The point assignment is conducted with the following evaluation matrices (see Table 4, Table 5, Table 6 and Table 7), whereby the evaluation is at the user's discretion for limit ranges of the properties (P_2 to P_4).

Table 4 — Evaluation matrices 1

Production process	P_1
Injection moulding, injection compression moulding, transfer moulding	1
Compression moulding, impact extrusion	2

Table 5 — Evaluation matrices 2

Moulded material stiffness or hardness[a]			P_2
Modulus of elasticity N/mm^2	**Shore D**	**Shore A; IRHD**	
above 1 200	above 75	—	1
above 30 to 1 200	above 35 to 75	—	2
3 to 30	—	50 to 90	3
below 3	—	below 50	4

[a] Modulus of elasticity: dry as moulded.

Table 6 — Evaluation matrices 3

Moulding shrinkage (calculated value)	P_3
below 0,5 %	0
0,5 % to 1 %	1
above 1 % to 2 %	2
above 2 %	3

The maximum shrinkage characteristic value is definitive for the assignment in the case of shrinkage anisotropy.

Table 7 — Evaluation matrices 4

Consideration of the shrinkage differences due to geometry and process	P_4
Precisely possible: Calculated values of the *VS* are known. (For example from experience, systematic measurements, computer simulations.) Shrinkage anisotropy is meaningless or can be considered sufficiently accurately in the relevant dimensional orientation. Possible deviations from the calculated value are max. ±10 %.	1
Precisely possible with limitations: Calculated values of the *VS* are known in ranges max. to ±20 %.	2
Only imprecisely possible: Calculated values of the *VS* are only known as rough guide values ranges. Shrinkage anisotropy cannot be considered or can only be considered inadequately. Practical experience for estimating relevant calculated values is not available. Possible deviations from the calculated value are above ±20 %.	3

In general, it is assumed that the shrinkage fluctuations due to variations in the processing conditions and differences in the moulding compound properties can be approximately ±30 % of the calculated value of the *VS*. The selection $P_4 = 3$ is to be made if no other information is available.

After determining P_1 to P_4 and their addition, it should be checked whether the structurally required tolerance can be attained technologically with series 1 (simple production). If this is fulfilled, all further considerations will be sufficient. The increase in the production expense contained in P_5 only has to be considered if the functionally required tolerance is not attained.

7.1.2.3 Evaluation of the production expense (P_5)

The expense necessary for the moulded part manufacturer for production and quality assurance is definitive for the level of the production accuracy. The differentiation is made by the application/utilization of the tolerance rows (see Table 8).

Table 8 — Evaluation of the production expense

Tolerance series	P_5
Series 1 (simple production) Production realized with general tolerances. Dimensional stability requirements that do not form any special quality focus.	0
Series 2 (accurate production) Production and quality assurance are oriented to higher dimensional stability requirements.	−1
Series 3 (precision production) Full alignment of production and quality assurance to the very high dimensional stability requirements.	−2
Series 4 (precision special production) As series 3, but with more intensive process monitoring.	−3
The tolerance Series 3 (precision production) and Series 4 (precision special production) are always subject to mandatory agreement.	

Exemplary selection criteria are listed in Annex C to assist the series assignment.

NOTE If a higher accuracy level (Series 2, Series 3 and Series 4) is necessary for directly toleranced dimensions, the rows assignment are to be performed after evaluation of the necessary fulfilment degree of the questions below:

— Are the moulded parts optimally designed and dimensioned in respect to dimensional stability?

— Are the moulds functionally reliable and consistent in respect to mechanical and thermal control?

— For complex or multi-cavity moldings, are fill patterns uniform throughout the mould or between cavities?

— Are adequate systems in place to monitor and document material handling, moulding, and quality control systems?

— Are operating and quality control personnel adequately trained to ensure quality assurance and conformance?

— Are corresponding terms of delivery agreed in respect to the dimensionally-relevant properties level of the moulding compounds, in particular the shrinkage fluctuations, and are these checked?

The actual effort to realizethe part by the moulded part manufacturer is derived from the required dimensional tolerances. Precision productions (Series 3 and Series 4) are special cases whose realization might require special agreements between the buyer and manufacturer of the moulded parts from an economic operational viewpoint (e.g. price surcharges) as well. It should therefore be expressly noted that unnecessarily high tolerance requirements lead to unnecessarily high moulded part costs.

7.2 Geometrical tolerancing

ISO 1101 and ISO 5458 in a datum system according to ISO 5459 apply for surface profile and line profile and position tolerances.

A component can have one or more datum systems. The furthest distance of the toleranced element to the origin of the datum system used for the position tolerance D_P shall be applied to determine the position tolerance. This does not have to correspond to the coordinate system of the component or from the assembly. The D_P dimension is the nominal dimension for determination of the position tolerance according to Table 9. The same also applies to profile form tolerances according to Table 10.

Table 9 — Plastic moulded part tolerances for position tolerances

Dimensions in mllimetres

Tolerance grade		**Diameter of the cylindrical tolerance zones for the D_P nominal dimension ranges**															
		1 to 3	>3 to 6	>6 to 10	>10 to 18	>18 to 30	>30 to 50	>50 to 80	>80 to 120	>120 to 180	>180 to 250	>250 to 315	>315 to 400	>400 to 500	>500 to 630	>630 to 800	>800 to 1 000
TG1	W	⌀ 0,020	⌀ 0,034	⌀ 0,050	⌀ 0,062	⌀ 0,073	⌀ 0,087	⌀ 0,104	⌀ 0,123	—	—	—	—	—	—	—	—
	NW	⌀ 0,034	⌀ 0,050	⌀ 0,062	⌀ 0,073	⌀ 0,087	⌀ 0,104	⌀ 0,123	⌀ 0,154	—	—	—	—	—	—	—	—
TG2	W	⌀ 0,036	⌀ 0,053	⌀ 0,081	⌀ 0,098	⌀ 0,118	⌀ 0,140	⌀ 0,168	⌀ 0,252	⌀ 0,364	⌀ 0,420	⌀ 0,448	⌀ 0,504	⌀ 0,560	—	—	—
	NW	⌀ 0,053	⌀ 0,081	⌀ 0,098	⌀ 0,118	⌀ 0,140	⌀ 0,168	⌀ 0,252	⌀ 0,364	⌀ 0,420	⌀ 0,448	⌀ 0,504	⌀ 0,560	⌀ 0,616	—	—	—
TG3	W	⌀ 0,056	⌀ 0,084	⌀ 0,140	⌀ 0,168	⌀ 0,196	⌀ 0,224	⌀ 0,280	⌀ 0,420	⌀ 0,560	⌀ 0,644	⌀ 0,728	⌀ 0,812	⌀ 0,896	⌀ 0,980	⌀ 1,12	⌀ 1,26
	NW	⌀ 0,084	⌀ 0,140	⌀ 0,168	⌀ 0,196	⌀ 0,224	⌀ 0,280	⌀ 0,420	⌀ 0,560	⌀ 0,644	⌀ 0,728	⌀ 0,812	⌀ 0,896	⌀ 0,980	⌀ 1,12	⌀ 1,26	⌀ 1,48
TG4	W	⌀ 0,084	⌀ 0,140	⌀ 0,224	⌀ 0,252	⌀ 0,308	⌀ 0,364	⌀ 0,420	⌀ 0,644	⌀ 0,869	⌀ 0,980	⌀ 1,15	⌀ 1,26	⌀ 1,37	⌀ 1,54	⌀ 1,76	⌀ 1,96
	NW	⌀ 0,140	⌀ 0,224	⌀ 0,252	⌀ 0,308	⌀ 0,364	⌀ 0,420	⌀ 0,644	⌀ 0,896	⌀ 0,980	⌀ 1,15	⌀ 1,26	⌀ 1,37	⌀ 1,54	⌀ 1,76	⌀ 1,96	⌀ 2,32
TG5	W	⌀ 0,140	⌀ 0,224	⌀ 0,308	⌀ 0,392	⌀ 0,476	⌀ 0,560	⌀ 0,644	⌀ 1,01	⌀ 1,40	⌀ 1,62	⌀ 1,82	⌀ 1,96	⌀ 2,18	⌀ 2,46	⌀ 2,80	⌀ 3,22
	NW	⌀ 0,224	⌀ 0,308	⌀ 0,392	⌀ 0,476	⌀ 0,560	⌀ 0,644	⌀ 1,01	⌀ 1,40	⌀ 1,62	⌀ 1,82	⌀ 1,96	⌀ 2,18	⌀ 2,46	⌀ 2,80	⌀ 3,22	⌀ 3,64
TG6	W	⌀ 0,196	⌀ 0,336	⌀ 0,504	⌀ 0,616	⌀ 0,728	⌀ 0,868	⌀ 1,04	⌀ 1,60	⌀ 2,24	⌀ 2,60	⌀ 2,94	⌀ 3,22	⌀ 3,50	⌀ 3,92	⌀ 4,48	⌀ 5,04
	NW	⌀ 0,336	⌀ 0,504	⌀ 0,616	⌀ 0,728	⌀ 0,868	⌀ 1,04	⌀ 1,60	⌀ 2,24	⌀ 2,60	⌀ 2,94	⌀ 3,22	⌀ 3,50	⌀ 3,92	⌀ 4,48	⌀ 5,04	⌀ 5,88
TG7	W	⌀ 0,364	⌀ 0,560	⌀ 0,812	⌀ 0,980	⌀ 1,18	⌀ 1,40	⌀ 1,68	⌀ 2,52	⌀ 3,50	⌀ 4,06	⌀ 4,48	⌀ 5,04	⌀ 5,60	⌀ 6,16	⌀ 7,00	⌀ 7,84
	NW	⌀ 0,560	⌀ 0,812	⌀ 0,980	⌀ 1,18	⌀ 1,40	⌀ 1,68	⌀ 2,52	⌀ 3,50	⌀ 4,06	⌀ 4,48	⌀ 5,04	⌀ 5,60	⌀ 6,16	⌀ 7,00	⌀ 7,84	⌀ 9,24
TG8	W	⌀ 0,560	⌀ 0,840	⌀ 1,26	⌀ 1,54	⌀ 1,82	⌀ 2,24	⌀ 2,66	⌀ 3,92	⌀ 5,60	⌀ 6,44	⌀ 7,28	⌀ 7,98	⌀ 8,82	⌀ 9,80	⌀ 11,20	⌀ 12,60
	NW	⌀ 0,840	⌀ 1,26	⌀ 1,54	⌀ 1,82	⌀ 2,24	⌀ 2,66	⌀ 3,92	⌀ 5,60	⌀ 6,44	⌀ 7,28	⌀ 7,98	⌀ 8,82	⌀ 9,80	⌀ 11,20	⌀ 12,60	⌀ 14,84
TG9		⌀ 1,34	⌀ 2,10	⌀ 2,52	⌀ 2,94	⌀ 3,50	⌀ 4,20	⌀ 6,30	⌀ 8,82	⌀ 10,08	⌀ 11,34	⌀ 12,46	⌀ 13,72	⌀ 15,12	⌀ 17,36	⌀ 19,88	⌀ 23,80

NOTE 1 W: Tool-specific dimensions; NW: Non-tool-specific dimensions.

NOTE 2 The differentiation of tool-specific and non-tool-specific dimension is not necessary for TG9.

NOTE 3 Dimensions under 1 mm and above 1 000 mm are subject to mandatory agreement.

NOTE 4 For validation of machine and process capability, see Annex D.

The prerequisites $P_2 = 1$ and $P_3 + P_4 \leq 3$ should apply for the toleraces “profile any line” and “profile any surface” (see Table 5, 6 and 7) for consideration of the moulded part properties.

The empirical tolerance values, t, from Table 10 in relation to the nominal dimension, D_P, shall only be used for general tolerances for surface profile tolerances specified in the drawing.

Table 10 — General tolerances for surface profiles

Dimensions in millimetres

Nominal dimension D_P	≤30	>30 to 100	>100 to 250	>250 to 400	>400 to 1 000
Tolerance value t	0,5	1	2	4	6

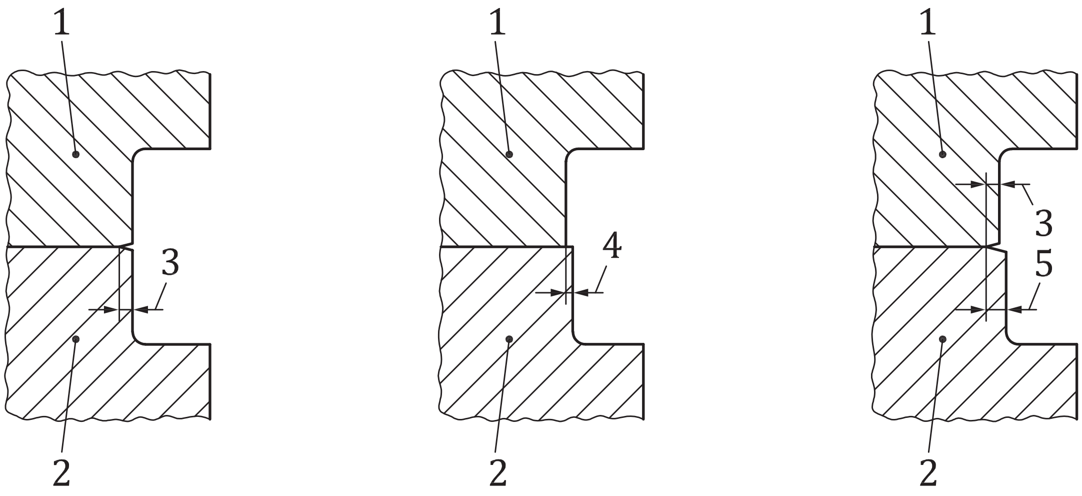
7.3 Parting line/Tool offset

Visible parting lines are unavoidable in the production of plastic parts in the original moulding process. The location of the parting lines shall be agreed upon between the producer and costumer. A distinction shall be made between a parting line and a parting offset. See Figure 5.

The essential influencing factors for the parting line are:

- mould quality of the design;
- viscosity of the plastics in the processing state;
- processing parameters (essentially melt temperature, tool contour temperature, injection speed, tool inside pressure, tool retaining force and location of the changeover point);
- quality of the mould release in the tool (accuracy of the mechanical processing, hardness of the contour-giving component parts, service life of the tool).

In contrast, the dimension of the visible mould offset is affected by the precision during production of the tools and the centering precision of the processing machine.



a) Parting line **b) Offset** **c) Combination**

Key

1	tool element 1
2	tool element 2
3	parting line
4	offset
5	parting line + offset

Figure 5 — Parting line/Tool offset

Generally, combinations of both parting faults occur [see Figure 5 c)].

A distinction shall be made into functional and non-functional relevant areas here.

As a rule, the required mould parting conditions shall be defined in size and location for functional and subordinate areas. ISO 10135 shall be used for the applicable symbols.

7.4 Tolerancing of angular dimensions

Directly toleranced angles and edges are subject to mandatory agreement.

All angles and edges not directly toleranced are negligible for verification.

8 Acceptance conditions for moulded part production (ABF)

The test dimensions are regarded as acceptance values for normative acceptance conditions, if the moulded parts are stored according to ISO 291:2008, Table 1, unless otherwise specified by contract or the relevant ISO-material specification after production until acceptance as well as tested no earlier than 16 h and no later than 72 h after production.

NOTE Reference conditions: 23 °C and 50 %RH.

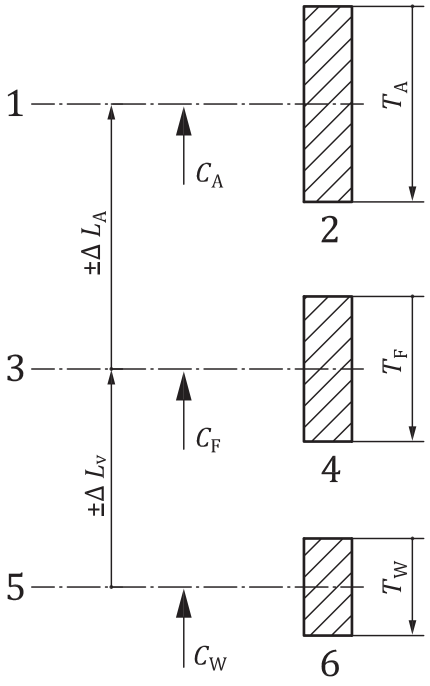
If deviations from the above acceptance conditions are accepted by the parts producer, the acceptance parameters shall be agreed separately between the producer and costumer, and documented (e.g. in or on the labelling field with the note: Tolerancing ISO 8015 AD – “Agreement document number xxx”). Exemplary feasible acceptance parameters are listed in Annex G.

Annex A
(informative)

Dimensional reference levels for application and production of the moulded parts

A.1 Sizes and dimensional relations

Dimensional reference levels for application and production of the moulded parts for identification of the position (tolerance mean dimension, C), the shift (dimensional shift, ΔL) and the distribution (tolerance, T) for the dimensional levels are illustrated in Figure A.1.



Key

1	parts application (application conditon)
2	moulded part application tolerance (total tolerance)
3	parts production (ABF)
4	moulded part production tolerance
5	tool production (ABW)
6	tool contour production tolerance

Figure A.1 — Dimensional reference levels for application and production of the moulded parts

A.2 Application conditions

Application conditions are all utilization and storage conditions of the parts during the application time period after production, insofar as they effect the dimensional stability and functional performance of the products.

Application-induced dimensional shifts, ΔL_A, result from the application conditions as situation-dependent overlapping of various individual influences with variations in time. Anisotropy effects can be of major significance in this respect.

The types and orientation of action are defined as follows:

— thermal expansion (+) or contraction (-): Dimensional change caused by temperature change, which ensues with little time delay to the temperature change of the parts and hence should always be considered.

— swelling (+) and/or post-moulding shrinkage (-): Dimensional change caused by molecular and micro-morphological structural processes as well as by diffusion and migration processes, which ensues with large time delay to the change of the relevant active factors and should hence be considered as a complex variable in relation to situation and time. After-shrinkage results from molecular short-range order effects (e.g. post-crystallization, readjustment of molecular orientations), chemical reactions (e.g. post curing), dissipation of volatile components or drying out (e.g. water, condensation products, solvents and thinners, plasticisers), migration of liquid and solid components (e.g. plasticiser migration, chalking) as well as by relaxation (compensation) of elastic tensions. Swelling is caused by media absorption, in particular also water absorption.

— wear of internal dimensions (+) or external dimensions (-): Dimensional change caused by material abrasion, which is to be considered in relation to the type, size duration of the wear load (friction, cavitation, erosion).

— mechanical deformation as expansion (+) or compression (-): Part deformation caused by external forces and/or moments.

A.3 Moulding-induced dimensional shift, ΔL_V

Moulding-induced dimension shift, ΔL_V, results from dimensional decrease (-) due to the moulding shrinkage and possibly from partial dimensional increase (+) as a result of dimensional corrections for dead compression areas (crushing areas), loose enclosures and jaws. The designation contour allowance is also normal for ΔL_V.

Annex B
(informative)

Causes and influential factors on the moulding shrinkage of non-porous plastics

The causes and influential factors on the moulding shrinkage of non-porous plastics are shown in Table B.1.

Table B.1 — Causes and influential factors on the moulding shrinkage of non-porous plastics

Causes	Effect on the moulding shrinkage	
	reducing	increasing
Density increase as a result of thermal contraction due to cooling from demoulding temperature to room temperature and the compression due to the effects of pressure	— High effective pressure on moulding compound until demoulding and contour until demoulding (after-pressure) — Low demoulding temperature (long cooling time and/or low contour temperature) — Low coefficient of thermal expansion (hard-elastic polymers)	— Low or premature withdrawn after-pressure until demoulding — High demoulding temperature (short cooling time and/or high contour temperature) — High coefficient of thermal expansion (soft-elastic or rubber-elastic polymers)
Density increase as a result of thermodynamically induced structural arrangement processes (crystallization; gelation)	— Amorphous polymers — Low degree of crystallinity of semi-crystalline polymers due to rapid solidification (supercooling due to low contour temperature and/or thin-walled parts) — High degree of gelation of polymers containing plasticisers	— Semi-crystalline polymers — High degree of crystallinity due to slow solidification (high contour temperature and/or thick-walled parts) as well as by improved nucleation (nucleation additives) — Low degree of gelation of polymers containing plasticisers
Density increase as a result of molecular structural and cross-linking processes (curing; vulcanization; polyreaction)	— High degree of cross-linking and hence lower coefficient of thermal expansion (long curing or vulcanisation time and/or high mass temperature) — Moulding compounds essentially preformed or cross-linked materially (e.g. prepolymers)	— Low degree of cross-linking and hence higher coefficient of thermal expansion (short curing or vulcanisation time and/or low mass temperature) — Non-cross-linked preproducts (oligomers) or monomers as moulding compounds

Causes	Effect on the moulding shrinkage	
	reducing	**increasing**
Stiffness or curing change due to additives (e.g. filling and strengthening agents; plasticisers)	— Additives with low coefficient of thermal expansion (e.g. inorganic filling and strengthening agents) — No or low plasticiser additives	— Additives with high coefficient of thermal expansion (e.g. organic filling and strengthening agents) — Plasticiser additives

Annex C

(informative)

Evaluation of the production expense

The evaluation criteria listed in Table C.1 for the production expense for classification of the tolerance series are to be understood as an orientation aid. According to the current experience of the user, they can be supplemented and weighted differently.

Table C.1 — Differentiation options or required expense

Criterion	Simple production	Accurate production	Precision production	Precision special production
Injection moulding machine/ machinery	Standard injection moulding machines without monitoring of the process parameters.	Standard injection moulding machine with monitoring of the process parameters.	Production on controlled injection moulding machines with extended monitoring options for additional pressure sensors or temperature sensors or thermographic camera control or weight control or similar.	
			Increased special monitoring expense of the machines (calibration).	
			Machines with especially stiff structure.	
	Production without stationary machine assignment possible.		Production on specified machines with stationary machine assignment.	
Infrastructure/ Periphery	Injection parts can be produced off-tool.		Tempering media – flow temperature controlled (±1 K). Controlled tempering ΔT flow – return max. (1,5 to 2,5) K.	
			Forced circulation without bridging.	
			Sufficiently accurate monitoring of the mass temperature (hot runner).	
			Handling devices for insertion of insertion parts for the removal of the injection parts.	
			Dry-air dryer for hydrophilic moulding compounds.	
			Defined cooling sections for the injection parts until removal.	
Environmental conditions	Production in simple workshop environment conditions.		Production with restricted room climate conditions or in air-conditioned rooms. Injection moulding machines possibly specially insulated (e.g. plasticisation).	
Tool	Tools with change inserts permissible.	Tools with few change inserts permissible.	Tools without change inserts. No family tools (grade tools).	
			The production method for the tool contour for the directly toleranced geometry elements should enable the required accuracy. (For example, the accuracy of a ground contour cannot be attained with erosion.)	
		The number of cavities and the complexity of the geometry affect the tolerances that can be complied with over all cavities.	The number of cavities and the complexity of the geometry affect the tolerances that can be complied with over all cavities.	
			Balanced thermal conditions in the tool.	
			Demoulding with low mechanical stress of the injection parts. Sufficiently precise and stiff guidance of the moving tool components.	
	Production accuracy simple	Production accuracy average	Production accuracy very high.	
Moulded part design	Plastic compatible design		Plastic compatible design with filling simulation and deformation calculation.	
			Moulded part design should enable homogenous tempering.	
			Only few closely toleranced dimensions.	

Table C.1 *(continued)*

Criterion	Simple production	Accurate production	Precision production	Precision special production
Moulding compound	Recyclate can be used	Recyclate definitely useable	Check wear of the tool contours in case of abrasive additives.	
			Moulding compounds only type ware.	Moulding compounds only type ware with restricted supply tolerances (specified moulding compound).
Insertion parts	Purchased parts with standard tolerances.		Purchased parts with reduced tolerances.	
			If necessary, 100 % check of especially closely toleranced and important dimensions/characteristics.	
			Handling devices for insertion of insertion parts.	
Personnel	Trained personnel	Specifically trained technical personnel.	Trained and qualified personnel with more detailed knowledge or process optimization.	
Quality monitoring	Startup and concluding inspection	Startup and concluding inspection with specified interim tests.	Startup and concluding inspection with closely meshed quality tests.	Startup and concluding inspection with process-monitored closely-meshed quality tests of the specially toleranced dimensions through to equipment for the 100 % inspection of these dimensions.
			3D measuring system	3D measuring system of higher accuracy class.
Process documentation	Present		Present with batch management	
Parts packaging	After agreement		Special packaging adapted to the part.	Special packaging adapted to the part, if necessary individual packaging in trays/layers/palletisation.
				Depending on material, specially defined transport and storage conditions.

Annex D
(informative)

Validation of machine or process capability

The production tolerances indicated in this document are to be regarded as minimum possible tolerances. No additional scopes for the validation of machine or process capability are calculated in these tolerances. Many different factors have an effect on the dimensioning, with the result that a process control in the actual sense of control card systems is not normally possible. Rather, control cards are used for monitoring and documentation of the injection process, for example. If machine or process capability validations are required, a broadening of the tolerances is necessary so that sufficient scope from the tolerance limits to the mean value is established in which the process can move.

In addition to the machine and process capability validations, validation of the measuring instrumentation capability is often required. The validation of the measuring instrumentation capacity according to the ANOVA model cannot be applied to the injection moulding process, as the entire process width cannot be simulated in the injection process and hence the process distribution in relation to the measuring instrumentation distribution is too low.

Annex E
(informative)

Main causes for dimension, form and location deviations in moulded part production

The main causes for corresponding dimensional deviations are:

- moulding compound and moulding-induced distribution of the moulding shrinkage;
- uncertainties when determining calculated values of the moulding shrinkage for the tool contour calculation, in particular in case of large shrinkage values and for shrinkage anisotropy;
- different elastic recovery capacity of the parts after demoulding, depending on moulding compound stiffness or hardness;
- tool contour wear;
- production-induced dimensional distribution of the tool contours including deformation due to hardening and surface coating;
- deformation of tool parts as a result of pressure loads.

Form, location and angle deviations created due to deformation of the moulded parts as a result of shrinkage anisotropy and possibly due to the compensation of elastic tensions after demoulding in interaction with the moulded part design.

Annex F
(informative)

Example for determining the D_{P} dimension for application of Table 9

Dimensions in millimetres

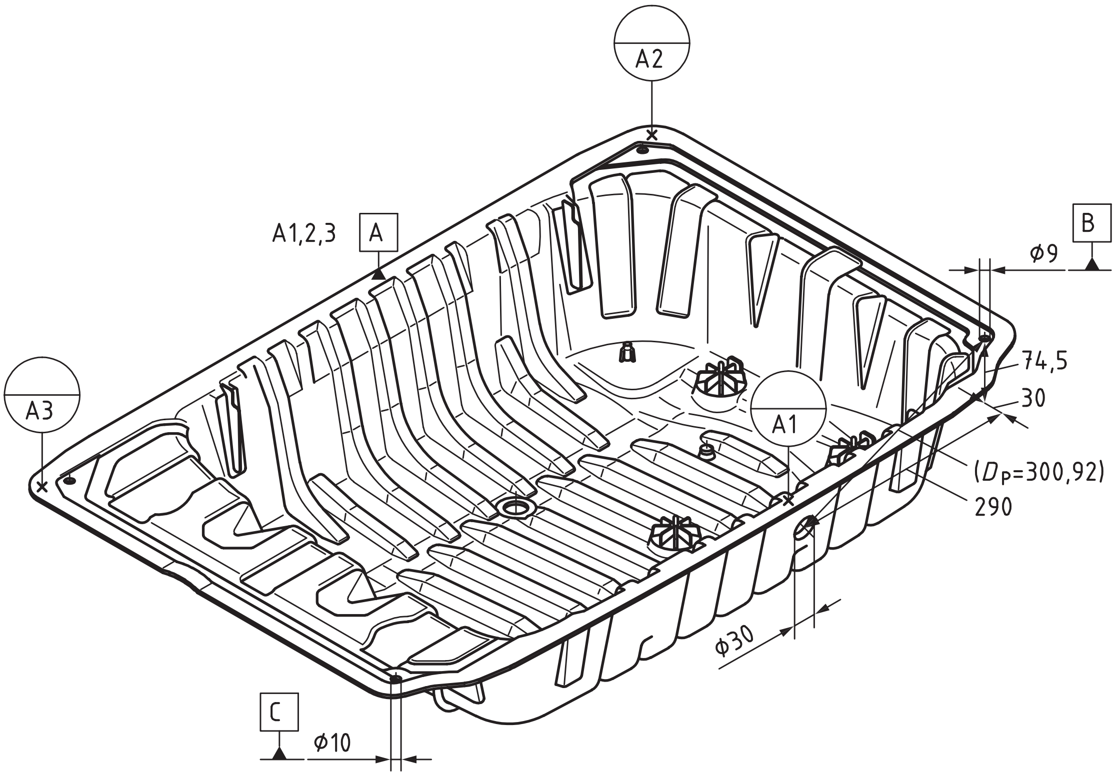


Figure F.1 — Example diagram for determination of the D_{P} dimension

The D_{P} dimension is determined according to 7.2 as the furthest distance in the space between the element to be toleranced and the origin of the datum system used for this position tolerance.

The origin of the datum system is the intersection between the datum plane A and the centre line of datum B. The slot C is only the rotational stop.

This distance is D_{P} = 300,92 mm here. The technologically tenable position tolerance is ⌀ 1,26 mm for TG 4 according to Table 9 (not tool specific).

NOTE If a dimensional tolerance is selected as a length dimension for the dimensioning of the semi shells instead of the geometrical tolerancing, Table 2 is consulted and the tolerance for the length dimension 30 mm determined there used for determination of the tolerance for the dimension 30 mm with D_{P} = 300,92 mm. When indicating ISO 20457 – TG4 NW, the dimension 30 mm receives the tolerance ±0,45 mm in the above example.

Annex G
(informative)

Feasible acceptance parameters

Feasible acceptance for separate agreements between manufacturer and buyer can be:

- dimensional location and dimensional deviations (if necessary, after testing);
- dimensional inspection method;
- minimum and maximum time period of the dimensional inspection after the parts production;
- storage and test conditions until parts acceptance (room air temperature, relative air humidity, if necessary a special storage regulation).

Such deviations from the usual acceptance conditions can be:

- follow-up operations at the parts manufacturer with material application (painting, coating) or material removal (cutting, grinding, polishing);
- parts aftertreatment by tempering (preliminary removal of the after-shrinkage, compensation of inner tensions, after-hardening) or follow-up operations with significant thermal load (painting, solder wire treatment, etc.);
- parts aftertreatment by conditioning, e.g. by soaking (preliminary removal of the swelling, increasing toughness);
- low dimensional stability of structure and state of mould material for ABF. Examples are structural changes to the crystalline phase of semi-crystalline polymers (e.g. PB-1) and swelling as well as plasticisation as a result of water absorption of thin-walled moulded parts (below 2 mm) made from hydrophilic polymers (e.g. PA6, PA66, PA46; biopolymers).

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

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

[19] ISO 17450-3, *Geometrical product specifications (GPS) — General concepts — Part 3: Toleranced features*

[20] ISO 18064, *Thermoplastic elastomers — Nomenclature and abbreviated terms*

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