INTERNATIONAL STANDARD

ISO 20457

First edition
2018-09

Plastics moulded parts — Tolerances and acceptance conditions

Moulages plastiques — Tolérances et conditions de réception

Reference number
ISO 20457:2018(E)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

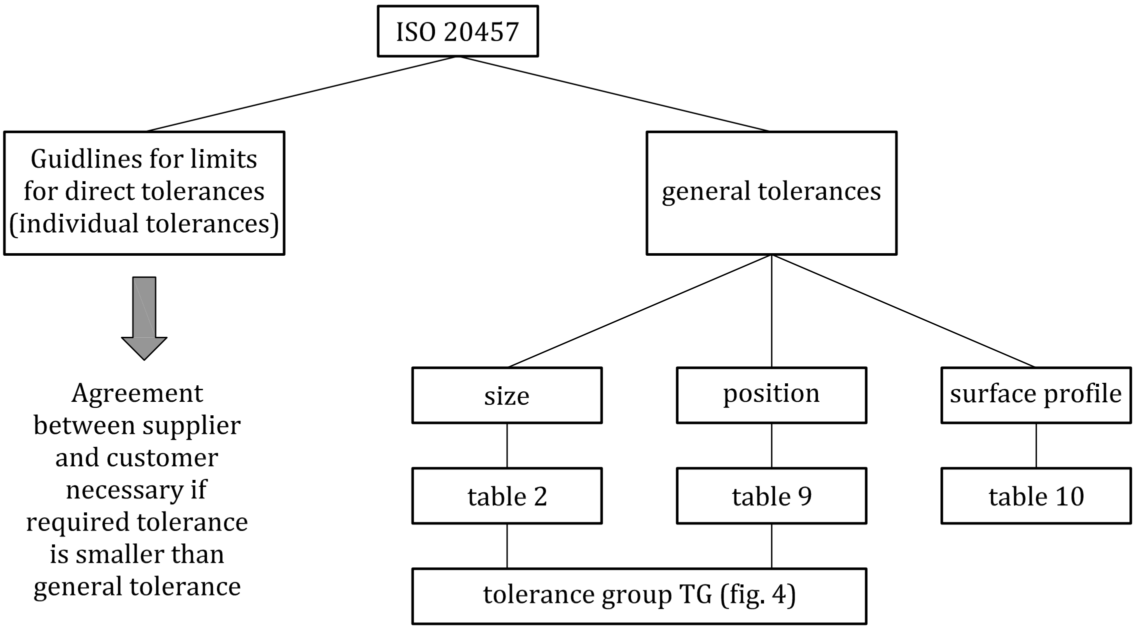

Figure 1 — Determination of tolerances for plastic moulded parts

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).

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

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.

