SLOVENSKI STANDARD
oSIST prEN ISO 2692:2019

01-julij-2019

Specifikacija geometrijskih veličin izdelka (GPS) - Toleriranje geometrijskih veličin - Zahteva po maksimalnem materialu, zahteva po minimalnem materialu in zahteva po usklajenosti materialov (ISO/DIS 2692:2019)

Geometrical product specifications (GPS) - Geometrical tolerancing - Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR) (ISO/DIS 2692:2019)

Geometrische Produktspezifikation (GPS) - Geometrische Tolerierung - Maximum-Material-Bedingung (MMR), Minimum-Material-Bedingung (LMR) und Reziprozitätsbedingung (RPR) (ISO/DIS 2692:2019)

Spécification géométrique des produits (GPS) - Tolérancement géométrique - Exigence du maximum de matière (MMR), exigence du minimum de matière (LMR) et exigence de réciprocité (RPR) (ISO/DIS 2692:2019)

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Geometrical product specifications (GPS) — Geometrical tolerancing — Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)

Spécification géométrique des produits (GPS) — Tolérancement géométrique — Exigence du maximum de matière (MMR), exigence du minimum de matière (LMR) et exigence de réciprocité (RPR)

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This fourth edition cancels and replaces the third edition (ISO 2692:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— direct indication of maximum material or least material virtual size has been added (see 4.1.3);

— the use of SZ or CZ symbols has been added (see 4.1.4);

— the use of SIM symbol has been added (see 4.1.5).

Introduction

0.1 General

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO/TR 14638). It influences the chain links 1, 2 and 3 of the chain of standards on size of linear "features of size" and form of a line (independent/dependent of a datum), form of a surface (independent/dependent of a datum), orientation and location of derived features based on "features of size" and datums also based on "features of size".

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

For more detailed information on the relation of this document to the GPS matrix model, see Annex E.

This document covers some frequently occurring workpiece functional cases in design and tolerancing. The "maximum material requirement", MMR, covers "assembleability" and the "least material requirement", LMR, covers, for example, "minimum wall thickness" of a part. MMR and LMR requirements allow for the combination of two independent requirements into one collective requirement or to directly define maximum material or least material virtual condition (see Annex C), which more accurately simulates the intended function of the workpiece. In some cases of both MMR and LMR, the "reciprocity requirement", RPR, can be added.

NOTE 1 In ISO GPS standards, threaded features are often considered as a type of cylindrical feature of size. However, no rules are defined in this document for how to apply MMR, LMR and RPR to threaded features. Consequently application of the tools defined in this document for threaded features is risky.

NOTE 2 Consideration of assembleability conditions using MMR or consideration of minimum wall thickness condition using LMR may lead the designer to choose a 0 tolerance value to avoid rejection of parts that can be assembled or have minimum wall thickness.

0.2 Information about maximum material requirement, MMR

The assembly of parts depends on the combined effect of

a) the size (of one or more features of size), and

b) the geometrical deviation of the features and their derived features, such as the pattern of bolt holes in two flanges and the bolts securing them.

The minimum assembly clearance occurs when each of the mating features of size is at its maximum material size (e.g. the largest bolt size and the smallest hole size) and when the geometrical deviations (e.g. the form, orientation and location deviations) of the features of size and their derived features (median line or median surface) are also are fully consuming their tolerances. Assembly clearance increases to a maximum when the sizes of the assembled features of size are furthest from their maximum material sizes (e.g. the smallest shaft size and the largest hole size) and when the geometrical deviations (e.g. the form, orientation and location deviations) of the features of size and their derived features are zero. It therefore follows that if the sizes of one mating part do not reach their maximum material size, the indicated geometrical tolerance of the features of size and their derived features may be increased without endangering the assembly to the other part.

This assembly function is controlled by the maximum material requirement. This requirement is indicated on drawings by the symbol Ⓜ.

0.3 Information about least material requirement, LMR

The least material requirement is designed to control, for example, the minimum wall thickness, thereby preventing breakout (due to pressure in a tube), the maximum width of a series of slots, etc. It is indicated on drawings by the symbol Ⓛ. The least material requirement can also be characterized

by a collective requirement for the size of a feature of size, the geometrical deviation of the feature of size (form deviations) or by direct definition of a least material virtual condition and the location of its derived feature.

0.4 Information about reciprocity requirement, RPR

The reciprocity requirement is an additional requirement, which may be used together with the maximum material requirement and the least material requirement in cases where it is permitted — taking into account the function of the toleranced feature(s) — to enlarge the size tolerance when the geometrical deviation on the actual workpiece does not take full advantage of, respectively, the maximum material virtual condition or the least material virtual condition.

The reciprocity requirement is indicated on the drawing by the symbol Ⓡ.

0.5 General information about terminology and figures

The terminology and tolerancing concepts in this document have been updated to conform to GPS terminology, notably that in ISO 286-1, ISO 14405-1, ISO 17450-1 and ISO 17450-3.

Geometrical product specifications (GPS) — Geometrical tolerancing — Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)

1 Scope

This document defines the maximum material requirement, the least material requirement and the reciprocity requirement. These requirements can only be applied to linear features of size of cylindrical type or opposed planar type.

These requirements are often used to control specific functions of workpieces where size and geometry are interdependent, e.g. to fulfil the functions “assembly of parts” (for maximum material requirement) or “minimum wall thickness” (for least material requirement). However, the maximum material requirement and least material requirement can also be used to fulfil other functional design requirements.

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

ISO 5459:2011, *Geometrical product specifications (GPS) — Geometrical tolerancing — Datums and datum systems*

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 5459, ISO 14405-1, ISO 17450-1, ISO 17450-3 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
integral feature
geometrical feature belonging to the real surface of the workpiece or to a surface model

Note 1 to entry: An integral feature is intrinsically defined, e.g. skin of the workpiece.

Note 2 to entry: Adapted from ISO 17450-1:2011, definition 3.3.5.

3.2
feature of size
feature of linear size
geometrical feature, having one or more intrinsic characteristics, only one of which may be considered as variable parameter, that additionally is a member of a “one parameter family”, and obeys the monotonic containment property for that parameter

Note 1 to entry: Adapted from ISO 17450-1:2011, definition 3.3.1.5.1. See also ISO 22432:2011, definitions 3.2.5.1.1.1 and 3.2.5.1.1.2 for “one parameter family” and “monotonic containment property”.

EXAMPLE 1 A single cylindrical hole or shaft is a feature of linear size. Its linear size is its diameter.

EXAMPLE 2 Two opposite parallel plane surfaces are a feature of linear size. Its linear size is the distance between the two opposite parallel planes.

3.3
derived feature
geometrical feature, which does not exist physically on the real surface of the workpiece and which is not natively a nominal integral feature

Note 1 to entry: A derived feature can be established from a nominal integral surface, an associated integral surface, or an extracted integral surface. It is qualified respectively as a nominal derived feature, an associated derived feature, or an extracted derived feature.

Note 2 to entry: The centre point, the median line and the median surface defined from one or more integral features are types of derived features.

Note 3 to entry: Adapted from ISO 17450-1:2011, definition 3.3.6.

EXAMPLE 1 The median line of a cylinder is a derived feature obtained from the cylindrical surface, which is an integral feature. The axis of the nominal cylinder is a nominal derived feature.

EXAMPLE 2 The median surface of two opposite parallel planes is a derived feature obtained from the two opposite parallel planes, which constitute an integral feature. The median plane of the nominal two opposite parallel planes is a nominal derived feature.

3.4
maximum material condition
MMC
state of the considered extracted feature, where the feature of size is at that limit of size where the material of the feature is at its maximum everywhere, e.g. minimum hole diameter and maximum shaft diameter

Note 1 to entry: The term maximum material condition, MMC, is used in this document to indicate, at ideal or nominal feature level (see ISO 17450-1), which limit of the requirement (upper or lower) is concerned.

Note 2 to entry: The size of the extracted feature at maximum material condition, MMC, can be defined using the default definition of size, or by one of the special definitions of size given in ISO 14405-1.

Note 3 to entry: The maximum material condition, MMC, as defined in this document, can be used unambiguously with any definition of size of the extracted feature.

3.5
maximum material size
MMS
dimension defining the maximum material condition of a linear feature of size

Note 1 to entry: Maximum material size, MMS, can be defined by default or by one of several special definitions of the size of the extracted feature (see ISO 14405-1 and ISO 17450-3).

Note 2 to entry: In this document, maximum material size, MMS is used as a numerical value, therefore no specific definition of the extracted size is needed to permit unambiguous use of maximum material size, MMS.

Note 3 to entry: See Annex A.

3.6
least material condition
LMC
state of the considered extracted feature, where the feature of size is at that limit of size where the material of the feature is at its minimum everywhere, e.g. maximum hole diameter and minimum shaft diameter

Note 1 to entry: The term least material condition, LMC, is used in this document to indicate, at the ideal or nominal feature level (see ISO 17450-1), which limit of the requirement (upper or lower) is concerned.

Note 2 to entry: The size at least material condition, LMC, can be defined by default or by several special definitions of the size of extracted feature (see ISO 14405-1 and ISO 17450-3).

Note 3 to entry: The least material condition, LMC, as defined in this document, can be used unambiguously with any definition of size of the extracted feature.

3.7
least material size
LMS
dimension defining the least material condition of a feature of size

Note 1 to entry: Least material size, LMS, can be defined by default or by one of several special definitions of the size of the extracted feature (see ISO 14405-1 and ISO 17450-3).

Note 2 to entry: In this document, least material size, LMS, is used as a numerical value, therefore no specific definition of the extracted size is needed to permit unambiguous use of least material size, LMS.

Note 3 to entry: See Annex A.

3.8
maximum material virtual size
MMVS

directly indicated size (see 4.1.3) or size generated by the collective effect of the maximum material size, MMS, of a feature of size and the geometrical tolerance (form, orientation or location) given for the derived feature of the same feature of size

Note 1 to entry: Maximum material virtual size, MMVS, is a parameter for size used as a numerical value connected to maximum material virtual condition, MMVC.

Note 2 to entry: If it is not directly indicated on the drawing then for external features, MMVS is the sum of MMS and the geometrical tolerance, whereas for internal features, it is the difference between MMS and the geometrical tolerance.

3.9
maximum material virtual condition
MMVC
state of associated feature of maximum material virtual size, MMVS

Note 1 to entry: Maximum material virtual condition, MMVC, is a perfect form condition of the feature of size.

Note 2 to entry: Maximum material virtual condition, MMVC, includes an orientation constraint (in accordance with ISO 1101 and ISO 5459) when the geometrical specification is an orientation specification (see Figure A.3). Maximum material virtual condition, MMVC, includes a location constraint (in accordance with ISO 1101 and ISO 5459) of the associated feature when the geometrical specification is a location specification (see Figure A.4).

Note 3 to entry: See Figures A.1 to A.4, A.6, A.7, A.10 to A.19.

3.10
least material virtual size
LMVS
directly indicated size (see 4.1.3) or size generated by the collective effect of the least material size, LMS, of a feature of linear size and the geometrical tolerance (form, orientation or location) given for the derived feature of the same feature of size

Note 1 to entry: Least material virtual size, LMVS, is a parameter for size used as a numerical value connected to least material virtual condition, LMVC.

Note 2 to entry: If it is not directly indicated then for external features, LMVS is the difference between LMS and the geometrical tolerance, whereas for internal features, it is the sum of LMS and the geometrical tolerance.

3.11
least material virtual condition
LMVC
state of associated feature of least material virtual size, LMVS

Note 1 to entry: Least material virtual condition, LMVC, is a perfect form condition of the feature of size.

Note 2 to entry: Least material virtual condition, LMVC, includes an orientation constraint (in accordance with ISO 1101 and ISO 5459) of the associated feature when the geometrical specification is an orientation specification. Least material virtual condition, LMVC, includes a location constraint (in accordance with ISO 1101 and ISO 5459) of the associated feature when the geometrical specification is a location specification (see Figure A.5).

Note 3 to entry: See Figures A.5, A.8, A.9, A.14, A.15.

3.12
maximum material requirement
MMR
requirement for a feature of size, defining a geometrical feature of the same type and of perfect form, with a given value for the intrinsic characteristic (dimension) equal to MMVS, which limits the non-ideal feature on the outside of the material

Note 1 to entry: Maximum material requirement, MMR, is used to control the assembleability of a workpiece.

Note 2 to entry: See also 4.2.

3.13
least material requirement
LMR
requirement for a feature of size, defining a geometrical feature of the same type and of perfect form, with a given value for the intrinsic characteristic (dimension) equal to LMVS, which limits the non-ideal feature on the inside of the material

Note 1 to entry: Least material requirements, LMR, are used in pairs, e.g. to control the minimum wall thickness between two symmetrical or coaxially located similar features of size.

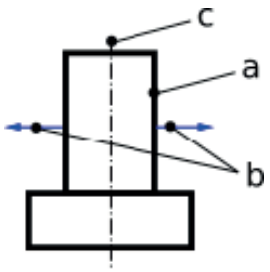
Note 2 to entry: See also 4.3.

3.14
reciprocity requirement
RPR
additional requirement for a feature of size indicated in addition to the maximum material requirement, MMR, or the least material requirement, LMR to indicate that the size tolerance is increased by the difference between the geometrical tolerance and the actual geometrical deviation

3.15
external feature of size
feature of linear size where vectors normal to the surface are directed outward from the material in a direction opposite to the median feature

Note 1 to entry: The cylindrical surface of a shaft is considered to be an external cylindrical feature.

Note 2 to entry: See Figure 1.



Key

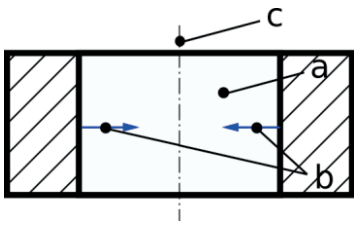
a external cylindrical feature
b normal vectors directed outward from the material
c median feature (cylinder axis)

Figure 1 — Example of external cylindrical feature

3.16
internal feature of size
feature of linear size where vectors normal to the surface are directed outward from the material in a direction toward the median feature

Note 1 to entry: The cylindrical surface of a hole is considered to be an internal cylindrical feature.

Note 2 to entry: See Figure 2.



Key

a internal cylindrical feature
b normal vectors directed outward material
c median feature (cylinder axis)

Figure 2 — Example of internal cylindrical feature

4 Maximum material requirement, MMR and least material requirement, LMR

4.1 General

4.1.1 Maximum material virtual size or least material virtual size specification

The maximum material requirement, MMR, and the least material requirement, LMR, can be applied to a set of one or more feature(s) of size as toleranced feature(s), or datum(s), or both. The maximum material virtual size (MMVS) or the least material virtual size (LMVS) shall be specified by one of the two following options:

a) a maximum material requirement without direct indication of maximum material virtual size (MMVS) or a least material requirement without direct indication of least material virtual size (LMVS) but with a size specification for the considered feature. This option is referred to as indirect determination of virtual size in this document.

b) a maximum material requirement with direct indication of maximum material virtual size (MMVS) between brackets in the tolerance indicator or a least material requirement with direct indication of least material virtual size (LMVS) between brackets in the tolerance indicator as explained in this document. This option is referred to as direct indication of virtual size.

The rules in this document shall not be applied to threaded features even if threaded features are often considered as cylindrical features in ISO GPS standards.

The possible combinations of geometrical characteristic symbols and MMR or LMR are illustrated in Annex D.

4.1.2 Indirect determination of virtual size

When indirect determination of virtual size is selected option a) above, then the maximum material or least material requirement together with the corresponding size specification create a combined requirement between the size of feature(s) of size and the geometrical requirements (form, orientation or location) specified for its (their) derived feature(s).

NOTE Due to the scope definition, the only derived features considered in this document are median lines and median surfaces.

When maximum material requirement, MMR, or least material requirement, LMR, is used together with indirect determination of virtual size, the two specifications (size specification and geometrical specification) are transformed into one collective requirements specification. The collective specification concerns only the integral feature, which in this document relates to the surface(s) of the feature(s) of size(s).

When indirect determination of virtual size is used then the maximum material virtual size or the least material virtual size shall be the result of the computations described hereafter.

For external features of size the maximum material virtual size (MMVS) is given by Formula (1):

$$MMVS = MMS + \delta \quad (1)$$

For internal features of size the maximum material virtual size (MMVS) is given by Formula (2):

$$MMVS = MMS - \delta \quad (2)$$

For external features of size the least material virtual size (LMVS) is given by Formula (3):

$$LMVS = LMS - \delta \quad (3)$$

For internal features of size the least material virtual size (LMVS) is given by Formula (4):

$$LMVS = LMS + \delta \quad (4)$$

where

MMS is the maximum material size;

LMS is the least material size;

δ is the geometrical tolerance.

4.1.3 Direct indication of maximum material or least material virtual size

When direct indication of virtual size is selected option b) above, then the maximum virtual size or the least material virtual size shall be indicated between brackets in the tolerance indicator and the virtual size is equal to this value as stated in the rules of this document. If a size is also specified for the considered feature, it shall be considered as an independent specification according to ISO 14405-1. No collective requirement is created between the two specifications (size specification and geometrical specification) in the case of direct indication of maximum material or least material virtual size.

NOTE It is the responsibility of the designer to select compatible values for the size of the feature and the maximum material virtual size or least material virtual size when they can conflict.

4.1.4 Maximum material or least material requirement applied to several toleranced features

When a maximum material or least material requirement applies to several toleranced features the symbols CZ or SZ shall be indicated in the zone section of the tolerance indicator following the sequence order specified in ISO 1101.

NOTE See Annex B for former practice.

4.1.5 Maximum material or least material requirement with same datum indication containing maximum material or least material requirement

When a simultaneous requirement is needed, the SIM symbol possibly followed by an identification number (SIMi) without space shall be indicated in the adjacent indication area of each related geometrical specification (see ISO 5458).

The use of the SIM modifier transforms a set of more than one geometrical specification with maximum material or least material requirement into a combined specification. The corresponding MMVC or LMVC are locked together with location and orientation constraints according to the rules of this document. The datum system is also constrained to be the same for each specification in the same SIM group.