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

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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

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

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This third edition cancels and replaces the second edition (ISO 2692:2006), of which subclauses 3.10, 4.1, 4.2.1 (rule D), 4.2.2 (rule G), 4.3.1 (rule K), 4.3.2 (rule N) and Annex A have been revised.

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Introduction

0.1. General

This International Standard 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 Masterplan given in ISO/TR 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 International Standard to the GPS matrix model, see Annex C.

This International Standard 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. Each requirement (MMR and LMR) combines two independent requirements into one collective requirement, 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 In ISO GPS standards, threaded features are often considered as features of size of type cylinder. However, no rules are defined in this International Standard for how to apply MMR, LMR and RPR to threaded features. Consequently, the tools defined in this International Standard cannot be used for threaded features.

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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 extracted features of size), and

b) the geometrical deviation of the (extracted) 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 at their maximum. 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 collective 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 is also characterized by a collective requirement for the size of a feature of size, the geometrical deviation of the feature of size (form deviations) and the location of its derived feature.

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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 International Standard have been updated to conform to GPS terminology, notably that in ISO 286-1, ISO 14405-1, ISO 14660-2:1999 and ISO 17450-1:2011.

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

1 Scope

This International Standard defines the maximum material requirement, the least material requirement and the reciprocity requirement. These requirements can only be applied to features of size.

These requirements are 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 are also used to fulfil other functional design requirements.

Considering this interdependence between size and geometry, the *principle of independency* defined in ISO 8015 does not apply when the maximum material requirement, least material requirement, or reciprocity requirement, are used.

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2 Normative references

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

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ISO 1101:2012, *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 14405-1:2010, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 1: Linear sizes*

ISO 14660-2:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 2: Extracted median line of a cylinder and a cone, extracted median surface, local size of an extracted feature*

ISO 17450-1:2011, *Geometrical product specifications (GPS) — General concepts — Part 1: Model for geometrical specification and verification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5459:2011, ISO 14405-1:2010, ISO 14660-2:1999, ISO 17450-1:2011 and the following apply.

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.

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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 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 feature, an associated feature, or an extracted feature. 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.

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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 cylinder surface, which is an integral feature. The axis of the nominal cylinder is a nominal derived feature.

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EXAMPLE 2 The median surface of two opposite parallel plane surfaces is a derived feature obtained from the two parallel plane surfaces, 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 International Standard 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 by default, or by several special definitions of the size of the extracted feature (see ISO 14405-1).

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

3.5
maximum material size
MMS
l_{MMS}
dimension defining the maximum material condition of a feature

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 14660-2).

Note 2 to entry: In this International Standard, 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.

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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 International Standard 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 14660-2).

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

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

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 14660-2).

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Note 2 to entry: In this International Standard, 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.

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Note 3 to entry: See Annex A.

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3.8
maximum material virtual size
MMVS
l_{MMVS}
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: 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.

Note 3 to entry: The MMVS for external features of size, $l_{\text{MMVS,e}}$, is given by Formula (1):

$$l_{\text{MMVS,e}} = l_{\text{MMS}} + \delta \qquad (1)$$

and the MMVS for internal features of size, $l_{\text{MMVS,i}}$, is given by Formula (2):

$$l_{\text{MMVS,i}} = l_{\text{MMS}} - \delta \qquad (2)$$

where

l_{MMS} is the maximum material size;

δ is the geometrical tolerance.

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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.

Note 2 to entry: Maximum material virtual condition, MMVC, includes an orientation constraint (in accordance with ISO 1101 and ISO 5459) of the associated feature 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-A.4, A.6. A.7 and A.10-A.13.

3.10
least material virtual size
LMVS
l_{LMVS}
size generated by the collective effect of the least material size, LMS, 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: 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: 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.

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Note 3 to entry: The LMVS for external features of size, $l_{LMVS,e}$, is given by Formula (3):

$$l_{LMVS,e} = l_{LMS} - \delta \quad (3)$$

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and the LMVS for internal features of size, $l_{LMVS,i}$, is given by Formula (4):

$$l_{LMVS,i} = l_{LMS} + \delta \quad (4)$$

where

l_{LMS} is the least material size;

δ is 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.

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 and A.9.

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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 assemblability 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 used as an 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

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

4.1 General

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. They create a combined requirement between the size of feature(s) of size and the geometry requirements (form, orientation or location) specified for its (their) derived feature(s).

NOTE 1 This edition of this International Standard only covers features of size of type cylinder and type two opposite parallel plane surfaces. Consequently, the only possible derived features are median lines and median surfaces.

NOTE 2 In ISO GPS standards, threaded features are often considered as features of size of type cylinder. However, no rules are defined in this International Standard for how to apply MMR, LMR and RPR to threaded features. Consequently, the tools defined in this International Standard cannot be used for threaded features.

When maximum material requirement, MMR, or least material requirement, LMR, is used, 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 International Standard relates to the surface(s) of the feature(s) of size(s).

NOTE 3 In the past, the maximum material requirement, MMR, was referred to as the maximum material principle, MMP.

When no modifiers (Ⓛ, Ⓜ, Ⓡ) are applied to the toleranced feature, the definitions of size of extracted feature in ISO 14405-1 and ISO 14660-2 apply.

When no modifiers (Ⓛ, Ⓜ) are applied to the datum, ISO 5459 applies. The modifier Ⓡ does not apply to datums.

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4.2 Maximum material requirement, MMR

4.2.1 Maximum material requirement for toleranced features

The maximum material requirement for toleranced features results in four independent requirements:

— a requirement for the upper limit of the local size [see Rules A 1) and A 2)];

— a requirement for the lower limit of the local size [see Rules B 1) and B 2)];

— a requirement for the surface non-violation of the MMVC (see Rule C);

— a requirement for when more than one feature is involved (see Rule D).

When the maximum material requirement, MMR, applies to the toleranced feature, it shall be indicated on drawings by the symbol Ⓜ placed after the geometrical tolerance of the derived feature of the feature of size (toleranced feature) in the tolerance indicator.

In this case, it specifies for the surface(s) (of the feature of size) the following rules.

a) **Rule A** The extracted local sizes of the toleranced feature shall be:

1) equal to or smaller than the maximum material size, MMS, for external features;

2) equal to or larger than the maximum material size, MMS, for internal features.

NOTE 1 This rule can be altered by the indication of reciprocity requirement, RPR, with the symbol Ⓡ after the symbol Ⓜ (see Clause 5 and Figure A.1).

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b) **Rule B** The extracted local sizes of the toleranced feature shall be:

1) equal to or larger than the least material size, LMS, for external features [see Figures A.2 a), A.3 a), A.4 a), A.6 a), A.7 a), A.10 and A.11];

2) equal to or smaller than the least material size, LMS, for internal features [see Figures A.2 b), A.3 b), A.4 b), A.6 b), A.7 b), A.10 and A.11].

c) **Rule C** The maximum material virtual condition, MMVC, of the toleranced feature shall not be violated by the extracted (integral) feature (see Figures A.2, A.3, A.4, A.6, A.7, A.10 and A.11).

NOTE 2 Use of the envelope requirement Ⓔ (previously also known as the Taylor Principle) usually leads to superfluous constraints regarding the function of the feature(s) (assembleability). Use of such constraints and size definitions reduces the technical and economic advantage of maximum material requirement, MMR.

NOTE 3 The indication 0 Ⓜ applied to a form specification has the same meaning as the envelope requirement Ⓔ applied to a size.

d) **Rule D** When the geometrical specification is an orientation or a location relative to a (primary) datum or a datum system, the maximum material virtual condition, MMVC, of the toleranced feature shall be in theoretically exact orientation or location relative to the datum or the datum system, in accordance with ISO 1101 and ISO 5459 (see 3.9 NOTE 2 and Figures A.3, A.4, A.6, and A.7). Moreover, in the case of several toleranced features controlled by the same tolerance indication, the maximum material virtual conditions, MMVCs, shall also be in theoretically exact orientation and location relative to each other [in addition to the possible constraints relative to the datum(s)] (see Figures A.1, A.10, A.11 and A.13).

NOTE 4 In the case of several toleranced features controlled by the same toleranced indication, the maximum material requirement, MMR, without any other modifier than Ⓜ has exactly the same meaning as the same requirement with both Ⓜ and CZ modifiers.

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To specify requirements that apply separately, the SZ[1)] modifier shall be used after the Ⓜ modifier.

4.2.2 Maximum material requirement for related datum features

The maximum material requirement for datum features results in three independent requirements:

— a requirement for the surface non-violation of the MMVC (see Rule E);

— a requirement for MMS when there is no geometrical specification or when there is only geometrical specifications whose tolerance value is not followed by the symbol Ⓜ (see Rule F);

— a requirement for MMS when there is a geometrical specification whose tolerance value is followed by the symbol Ⓜ and whose “datum” section (third and subsequent compartments) of the tolerance indicator meets a property defined in Rule G.

When the maximum material requirement, MMR, applies to the datum feature, it shall be indicated on drawings by the symbol Ⓜ placed after the datum letter(s) in the tolerance indicator.

NOTE 1 The use of Ⓜ after the datum letter is only possible if the datum is obtained from a feature of size.

NOTE 2 When maximum or least material requirement applies to all elements of the collection of surfaces of a common datum, the corresponding sequence of letters identifying the common datum are indicated within parentheses (see Figure A.13 and ISO 5459:2011, Rule 9) and maximum material virtual conditions, MMVCs, are by default constrained in location and orientation relative to each other (see ISO 5459:2011, Rule 7). When maximum or least material requirement applies only to one surface of the collection of features involved in a common datum, the sequence of letters identifying the common datum is not indicated within parentheses, and the requirement applies only to the feature identified by the letter placed just before the modifier.

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In this case, it specifies for the surface(s) (of the feature of size) the following rules.

a) **Rule E** The maximum material virtual condition, MMVC, of the related datum feature shall not be violated by the extracted (integral) datum feature from which the datum is derived (see Figures A.6 and A.7).

b) **Rule F** The size of the maximum material virtual condition, MMVC, of the related datum feature shall be the maximum material size, MMS, when the related datum feature has no geometrical specification (see Figure A.6), or has only geometrical specifications whose tolerance value is not followed by the symbol Ⓜ, or has no geometrical specification complying with Rule G.

   NOTE 3 In these cases, the MMVS for external and internal features of size, l_{MMVS}, is given by Formula (5):

   $$l_{MMVS} = l_{MMS} \pm 0 = l_{MMS} \quad (5)$$

   where l_{MMS} is the maximum material size.

c) **Rule G** The size of the maximum material virtual condition, MMVC, of the related datum feature shall be the maximum material size, MMS, plus (for external features of size) or minus (for internal features of size) the geometrical tolerance, when the datum feature is controlled by a geometrical specification with the following properties:

   1) its tolerance value is followed by the symbol Ⓜ, and

      i) it is a form specification and the related datum corresponds to the primary datum of the tolerance indicator where the Ⓜ symbol is indicated next to the datum letter (see Figure A.7), or

      ii) it is an orientation/location specification whose datum or datum system contains exactly the same datum(s) in the same order as the one(s) called before the related datum in

1) SZ will be incorporated in the revision of ISO 1101:2012.

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the tolerance indicator where the Ⓜ symbol is indicated next to the datum letter (see Figure A.12 and Figure A.13).

NOTE 4 In this case, the MMVS for external features of size is as given in Formula (1), and the MMVS for internal features of size is as given in Formula (2). See 3.8, Note 3.

NOTE 5 When above properties are not observed, Rule F applies.

In the case of Rule G, the datum feature indicator shall be directly connected to that geometrical tolerance indicator from which maximum material virtual condition, MMVC, of the datum feature is controlled (see ISO 5459:2011, Rule 1, dash 2).

4.3 Least material requirement, LMR

4.3.1 Least material requirement for toleranced features

When the least material requirement, LMR, applies to the toleranced feature, it shall be indicated on the drawing by the symbol Ⓛ placed after the geometrical tolerance of the derived feature of the feature of size (toleranced feature) in the tolerance indicator.

EXAMPLE To fully control the minimum wall thickness, the symbol Ⓛ is applied to the tolerancing of the features on both sides of the wall. Least material requirement, LMR can be implemented in two different ways, as follows.

— The location requirements for the two different sides of the wall can refer to the same datum axis or datum system (see Figure A.8). In this case, Ⓛ applies to the two toleranced features.

— The location requirement of the derived feature for one of the sides of the wall can refer to the derived feature of the other as the datum. In this case, the tolerance for the toleranced feature and the datum letter are followed by the symbol Ⓛ (see Figure A.9).

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NOTE 1 This possibility only applies if the features on the two sides are features of size.

When the least material requirement, LMR, applies to the toleranced feature, it specifies for the surface(s) (of the feature of size) the following rules.

a) **Rule H** The extracted local sizes of the toleranced feature shall be:

1) equal to or larger than the least material size, LMS, for external features;

2) equal to or smaller than the least material size, LMS, for internal features.

NOTE 2 This rule can be altered by the indication of reciprocity requirement, RPR, with the symbol Ⓡ after the symbol Ⓛ [see 5.3, Figure A.5 e) and Figure A.5 f)].

b) **Rule I** The extracted local sizes of the toleranced feature shall be:

1) equal to or smaller than the maximum material size, MMS, for external features [see Figures A.5 a), A.8 and A.9];

2) equal to or larger than the maximum material size, MMS, for internal features [see Figures A.5 b) and A.8].

c) **Rule J** The least material virtual condition, LMVC, of the toleranced feature shall not be violated by the extracted (integral) feature (see Figures A.5, A.8 and A.9).

NOTE 3 Use of the envelope requirement Ⓔ (previously also known as the Taylor Principle) usually leads to superfluous constraints regarding the function of the feature(s) (minimum wall thickness). Use of such constraints and size definitions for size reduces the technical and economic advantage of LMR.

d) **Rule K** When the geometrical specification is an orientation or a location relative to a (primary) datum or a datum system, the least material virtual condition, LMVC, of the toleranced feature

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shall be in theoretically exact orientation or location relative to the datum or the datum system, in accordance with ISO 1101 and ISO 5459 (see 3.11 NOTE 2 and Figures A.5, A.8, and A.9). Moreover, in the case of several toleranced features controlled by the same tolerance indication, the least material virtual conditions, LMVCs, shall also be in theoretically exact orientation and location relative to each other [in addition to the possible constraints relative to the datum(s)].

NOTE 4 In the case of several toleranced features controlled by the same toleranced indication, the least material requirement, LMR, without any other modifier than Ⓛ has exactly the same meaning as the same requirement with both Ⓛ and CZ modifiers.

To specify requirements that apply separately, the SZ[2)] modifier shall be used after the Ⓛ modifier.

4.3.2 Least material requirement for related datum features

When the least material requirement, LMR, applies to the datum feature, it shall be indicated on the drawing by the symbol Ⓛ placed after the datum letter in the tolerance indicator.

NOTE 1 The use of Ⓛ after the datum letter is only possible if the datum is obtained from a feature of size.

NOTE 2 When maximum or least material requirement applies to all elements of the collection of surfaces of a common datum, the corresponding sequence of letters identifying the common datum are indicated within parentheses (see Figure A.13 and ISO 5459:2011, Rule 9) and maximum material virtual conditions, MMVCs, are by default constrained in location and orientation relative to each other (see ISO 5459:2011, Rule 7). When maximum or least material requirement applies only to one surface of the collection of features involved in a common datum, the sequence of letters identifying the common datum is not indicated within parentheses, and the requirement applies only to the feature identified by the letter placed just before the modifier.

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In this case, it specifies for the surface(s) (of the feature of size) the following rules.

a) **Rule L** The least material virtual condition, LMVC, of the related datum feature shall not be violated by the extracted (integral) datum feature from which the datum is derived (see Figure A.9).

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b) **Rule M** The size of the least material virtual condition, LMVC, of the related datum feature shall be the least material size, LMS, when the related datum feature has no geometrical specification (see Figure A.9), or has only geometrical specifications whose tolerance value is not followed by the symbol Ⓛ, or has no geometrical specification complying with Rule N.

NOTE 3 In these cases, the LMVS for external and internal features of size, l_{LMVS}, is given by Formula (6):

$$l_{LMVS} = l_{LMS} \pm 0 = l_{LMS} \qquad (6)$$

where l_{LMS} is the least material size.

c) **Rule N** The size of the least material virtual condition, LMVC, of the related datum feature shall be the least material size, LMS, minus (for external features of size) or plus (for internal features of size) the geometrical tolerance, when the datum feature is controlled by a geometrical specification with the following properties:

1) its tolerance value is followed by the symbol Ⓛ, and

i) it is a form specification and the related datum corresponds to the primary datum of the tolerance indicator where the Ⓛ symbol is indicated next to the datum letter, or

ii) It is an orientation/location specification whose datum or datum system contains exactly the same datum(s) in the same order as the one(s) called before the related datum in the tolerance indicator where the Ⓛ symbol is indicated next to the datum letter.

NOTE 4 In this case, the LMVS for external features of size is as given in Formula (3), and the LMVS for internal features of size is as given in Formula (4). See 3.10, Note 3.

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2) SZ will be incorporated in the revision of ISO 1101:2012.

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