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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 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 213, *Dimensional and geometrical product specifications and verification*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 290, *Dimensional and geometrical product specification and verification*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

The main changes 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).

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

0.1 General

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences the chain links A, B and C of the chain of standards on size, form, orientation and location.

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 deals with some frequently occurring workpiece functional cases in design and tolerancing. The "maximum material requirement" (MMR) can cover, for example, "assemblability" and the "least material requirement" (LMR) can cover, for example, "minimum wall thickness" of a part. MMR and LMR requirements can accurately simulate the intended function of the workpiece by allowing the combination of two independent requirements into one collective requirement or to directly define maximum material virtual condition (MMVC) or least material virtual condition (LMVC) (see Annex C). In some cases of both MMR and LMR, the "reciprocity requirement" (RPR) can be added.

NOTE 1 In 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 A geometrical tolerance value of 0 (0Ⓜ or 0Ⓛ) can be used to avoid non-conformity of parts that can be assembled, in the case of MMR, or have minimum wall thickness, in the case of LMR.

0.2 Information about 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 (MMS) (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 fully consuming their tolerances. Assembly clearance increases to a maximum when the sizes of the assembled features of size are furthest from their MMSs (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 to manage the assemblability, the effect of the dimensional and geometrical variation can be dealt with by a specification using the maximum material concept. This requirement is indicated on the drawing by the symbol Ⓜ.

Furthermore, it can be useful to add Ⓜ to the datum indicator in the datum section when the datum is a feature of linear size and the clearance between the datum and the counterpart is favourable to the assembly of the part.

0.3 Information about LMR

The LMR is designed to control, for example, the minimum wall thickness, thereby preventing burst (due to pressure in a tube), or the maximum width of a series of slots. To manage the material strength function, the effect of the dimensional and geometrical variation can be dealt with by a specification using the minimum material concept. This requirement is indicated on drawings by the symbol Ⓛ.

0.4 Information about RPR

The RPR is an additional modifier, which may be used together with the MMR or with the LMR 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 MMVC or the LMVC.

The RPR is indicated on drawings 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 (MMR), the least material requirement (LMR) and the reciprocity requirement (RPR). These requirements can only be applied to linear features of size of cylindrical type or two parallel opposite planes type.

These requirements are often used to control specific functions of workpieces where size and geometry are interdependent, for example to fulfil the functions "assembly of parts" (for MMR) or "minimum wall thickness" (for LMR). However, the MMR and LMR 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 1101:2017, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 5458, *Geometrical product specifications (GPS) — Geometrical tolerancing — Pattern and combined geometrical specification*

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*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5459, ISO 14405-1, ISO 17450-1 and 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, for example skin of the workpiece.