TECHNICAL SPECIFICATION

ISO/TS 8062-2

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Geometrical product specifications (GPS) — Dimensional and geometrical tolerances for moulded parts —

Part 2:
Rules

Spécification géométrique des produits (GPS) — Tolérances dimensionnelles et géométriques des pièces moulées —

Partie 2: Règles d'utilisation

Reference number
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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. www.iso.org/directives

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

ISO 8062 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Dimensional and geometrical tolerances for moulded parts*:

— *Part 1: Vocabulary*

— *Part 2: Rules* [Technical Specification]

— *Part 3: General dimensional and geometrical tolerances and machining allowances for castings*

The following part is under preparation:

— *Part 4: General tolerances for castings (according to the GPS rules)*

This corrected version of ISO 8062:2013 incorporates a change in 7.2.2, Figure 8.

Introduction

This part of ISO 8062 is to be regarded as a complementary process-specific tolerance geometrical production specification (GPS) standard (see ISO/TR 14638). It influences chain links 1, 2 and 3 of the chain of standards on mouldings.

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 about the relation of this part of ISO 8062 to other standards and the GPS matrix model, see Annex F.

This part of ISO 8062 takes into account experiences with the application of previous standards (e.g. ISO 8062:1994, ASME Y14-8M:1996, and ISO 1101).

The tolerancing methods in this part of ISO 8062 are not yet fully developed within the new approach of geometrical product specifications (GPS) according to ISO 17450. The requirements for castings (mainly due to the uncertainty in the calculation of the shrinking of the casting) remain incompatible with the GPS standards. Therefore, this Technical Specification has been issued in order to gather further experience in the tolerancing of castings.

It is intended that the next version of this document will include more realistic ways of calculating the nominal dimension d_C of the final moulded part by elaborating GPS-conformant ways of combining linear dimensions and tolerance zones.

This document is intended to cover all types of moulded parts. However, most of the examples refer to castings.

When the methods of this part of ISO 8062 are used in 3D models, provisions have to be made in order to distinguish between theoretically exact dimensions (TEDs) and linear and angular dimensions with plus/minus tolerances.

Geometrical product specifications (GPS) — Dimensional and geometrical tolerances for moulded parts —

Part 2: Rules

1 Scope

This part of ISO 8062 gives the rules for geometrical dimensioning and tolerancing of final moulded parts and parts machined out of moulded parts. It also gives rules and conventions for the indications of these requirements in technical product documentation and specifies the proportions and dimensions of the graphical symbols to be used.

This part of ISO 8062 provides symbols which may be used to identify the relative completeness of the moulded features and parts. These graphical symbols should not be confused with the graphical symbols for surface texture according to ISO 1302, which are notably larger.

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.

ISO 129-1, *Technical drawings — Indication of dimensions and tolerances — Part 1: General principles*

ISO 1101, *Geometrical product specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

ISO 1302, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

ISO 2692, *Geometrical product specifications (GPS) — Geometrical tolerancing — Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)*

ISO 5458, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Positional tolerancing*

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

ISO 7083, *Technical drawings — Symbols for geometrical tolerancing — Proportions and dimensions*

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

ISO 8062-1, *Geometrical product specifications (GPS) — Dimensional and geometrical tolerances for moulded parts — Part 1: Vocabulary*

ISO 8062-3:2007, *Geometrical product specifications (GPS) — Dimensional and geometrical tolerances for moulded parts — Part 3: General dimensional and geometrical tolerances and machining allowances for castings*

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

ISO 10579, *Geometrical product specifications (GPS) — Dimensioning and tolerancing — Non-rigid parts*

ISO 13715, *Technical drawings — Edges of undefined shape — Vocabulary and indications*

ISO 14405-2, *Geometrical product specifications (GPS) — Dimensional tolerancing — Part 2: Dimensions other than linear sizes*

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

ISO 81714-1, *Design of graphical symbols for use in the technical documentation of products — Part 1: Basic rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8062-1, ISO 1101, ISO 5459, ISO 17450-1 and the following apply.

3.1
moulded feature
<of a moulded part> feature which has not been machined on a moulded part

3.2
intermediate machined feature
<of a moulded part> feature of a moulded part which has undergone machining and which subsequently will be machined to its final condition

Note 1 to entry: An intermediate machined feature is typically a roughly machined *moulded feature* (3.1).

Note 2 to entry: An intermediate machined feature can be used as a datum for subsequent machining of the moulded part.

3.3
final machined feature
<of a moulded part> feature of a moulded part which has been machined to its final condition

3.4
final moulded part
moulded part after fettling (if any)

Note 1 to entry: A final moulded part only consists of features which are moulded and have not been finished except by fettling.

3.5
intermediate machined moulded part
moulded part which has undergone some machining and which subsequently will be machined further

Note 1 to entry: An intermediate machined moulded part consists of at least one *moulded feature* (3.1) to be subsequently machined or at least one *intermediate machined feature* (3.2). In addition, it consists of moulded features not to be machined (if any) and *final machined features* (3.3) (if any).

Note 2 to entry: An intermediate machined moulded part can be produced from a final moulded part or from another intermediate machined moulded part.

3.6
final machined moulded part
moulded part which has been machined to its final condition

Note 1 to entry: A final machined moulded part consists of *final machined features* (3.3) and can include *moulded features* (3.1) not to be machined. A final machined moulded part cannot include *intermediate machined moulded features*.

Note 2 to entry: A final machined moulded part can be produced from a *final moulded part* (3.4) or from an *intermediate machined moulded part* (3.5).

3.7
moulded-part condition
manufacturing stage of a moulded part

Note 1 to entry: Listed in chronological order of manufacturing, a moulded part can be in a *final moulded-part* (3.4) condition, *intermediate machined moulded-part* (3.5) condition or *final machined moulded-part* (3.6) condition.

Note 2 to entry: Only one final moulded-part condition exists.

Note 3 to entry: Various intermediate machined moulded-part conditions can exist.

Note 4 to entry: Only one final machined moulded-part condition can exist.

Note 5 to entry: A moulded part does not need to exist in an intermediate machined moulded-part condition before the final machined moulded-part condition.

Note 6 to entry: Heat treatment or straightening (correction of unintended distortion) can be carried out in any moulded-part condition.

3.8
single drawing
<of a moulded part> drawing of a moulded part giving requirements for one moulded-part condition only

3.9
combined drawing
<of a moulded part> drawing of a moulded part giving requirements for more than one moulded-part condition

4 Symbols

See Table 1 for the letter symbols and Table 2 for the graphical symbols used in this document.

Table 1 — Letter symbols

Term, quantity	Letter symbol
Required machining allowance	A_{RMA}
Nominal dimension of the final moulded part	d_C
Nominal dimension of the final machined moulded part	d_M
Dimensional or size tolerance	t_D
Machining tolerance	t_M
Dimensional tolerance for the final machined moulded part	t_{DMT}
Form tolerance	t_F
Form tolerance for the final machined moulded part	t_{FMT}
Form tolerance for the final moulded part Specific form tolerance of geometrical casting tolerance (GCT) for the final moulded part (casting) Casting form tolerance	t_{FCT}
Dimensional tolerance for the final moulded part (casting)	t_{DCT}
Geometrical tolerance for the final moulded part (casting)	t_{GCT}
Cutting depth for machining	c
Parallelism tolerance for the final moulded part (casting)	t_{PARC}
Flatness tolerance for the final moulded part (casting)	t_{FLAC}
Casting tolerance	t_C
Positional tolerance	t_{POS}
Orientation contribution value	c_{inclin}
Length of datum	l_d
Length of toleranced feature	l_t
Surface profile tolerance	t_{PROF}
Maximum material virtual size	S_{MMVS}
Least material virtual size	S_{LMVS}
Theoretical exact dimension	TED

Table 2 — Graphical symbols

Name of symbol	Graphical symbol	Clause	Reference document
Drawing identifier for final moulded part		6.2	ISO/TS 8062-2
Drawing identifier for intermediate machined moulded part		6.3	ISO/TS 8062-2
Drawing identifier for final machined moulded part		6.4	ISO/TS 8062-2
Identifier for machining by the supplier[a]		6.5	ISO/TS 8062-2
Part condition identifier for final moulded part		7.2	ISO/TS 8062-2
Part condition identifier for intermediate machined moulded part		7.2	ISO/TS 8062-2
Part condition identifier for final machined moulded part		7.2	ISO/TS 8062-2
Surface texture — removal of material not permitted		7.1.2	ISO 1302
Surface texture — removal of material required		7.1.3	ISO 1302

[a] When there is a change in the allocation of the supplier, a change of the documentation may be necessary to reflect this.

See Annex A for the proportions and dimensions of the graphical symbols referenced in this part of ISO 8062.

5 Designation on drawings

When drawing indications according to this part of ISO 8062 apply, the drawing shall be designated in or near the drawing title block:

ISO/TS 8062-2

However, this reference is not required if general tolerances or required machining allowances according to other parts of ISO 8062 are referenced.

6 Drawing type indicator

6.1 Single and combined drawings

The requirements for the three types of moulded-part conditions (final moulded, intermediate and final machined) can be specified on a combined drawing or separately on single drawings as appropriate.

If use of the symbology in this document makes a combined drawing difficult to read, use single drawings instead.

Information, as to which part condition or conditions the stated specifications on the drawing apply, shall be indicated on the drawing in accordance with the following clauses; therefore the drawing shall indicate which part condition(s) the stated specification applies to.

On combined drawings, only the outline of the most advanced part condition for which the drawing is valid shall be illustrated. Requirements for the most advanced condition and for the preceding moulded-part condition in question shall be stated.

6.2 Final moulded part drawings

If the drawing specifies requirements on a final moulded part, the graphical symbol given in Figure 1 shall be indicated in or near the drawing title block.

Figure 1 — Graphical symbol for a final moulded part drawing

6.3 Intermediate machined moulded part drawings

If the drawing specifies requirements on an intermediate machined moulded part, the graphical symbol given in Figure 2 shall be indicated in or near the drawing title block.

Figure 2 — Graphical symbol for an intermediate machined moulded part drawing

If more than one intermediate machined moulded-part condition exist on the drawing, they shall be numbered and indicated after the symbol (see Figure 3).

a) b) c)

Figure 3 — Examples of numbered intermediate machined moulded parts

If stating general tolerances on a single drawing of an intermediate machined moulded part, e.g. by referencing ISO 8062-3 or by stating particular general tolerances, these general tolerances apply to the moulded features in the intermediate machined moulded-part condition only.

6.4 Final machined moulded part drawings

If the drawing states requirements on a final machined moulded part, the graphical symbol given in Figure 4 shall be indicated in or near the title block.

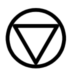


Figure 4 — Graphical symbol for final machined moulded part drawing

If stating general tolerances according to ISO 8062, e.g. by referencing ISO 8062-3 for castings, on a drawing of a final machined moulded part, these general tolerances apply to the moulded surfaces in the final machined moulded-part condition only.

6.5 Identifier for machining by the supplier

If there is, for some special reason, a need to identify which part condition specifications a supplier is expected to meet, this can be indicated by the symbol as shown in Figure 5 after the drawing type indicator (see Figure 6).

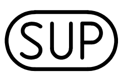
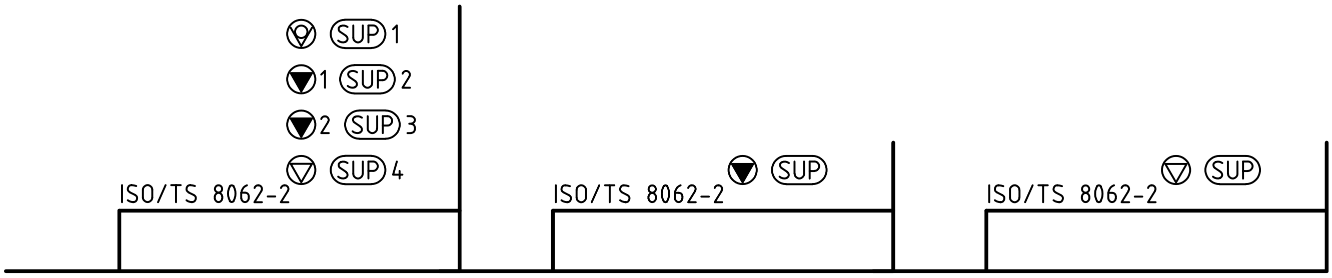


Figure 5 — Symbol for machining by the supplier



a) Combined drawing **b) Single drawing** **c) Single drawing**

Figure 6 — Example of SUP indication used together with the drawing type indicator near the drawing title block

In any case, the contract shall clearly state which part condition and which specification the supplier is expected to meet, irrespective of other part conditions and specifications appearing on the drawing.

7 Drawing indications

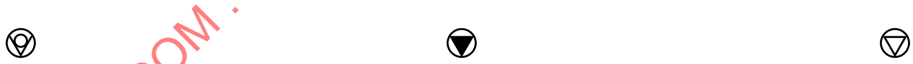
7.1 Surface texture symbols

On combined drawings, each surface shall be indicated with only one surface texture symbol according to the condition of the surface in question on the most advanced part condition stated on the drawing.

7.2 Part condition identifiers

7.2.1 General

Three part condition identifiers are used for identifying which part condition a specification applies to (see Figure 7).



for final moulded **for intermediate machined** **for final machined**

Figure 7 — Part condition identifiers

The part condition identifier may be omitted on single drawings.

The use of part condition identifiers is necessary on combined drawing to state requirements to different part conditions (final moulded, intermediate machined moulded, final machined moulded), see Figure E.7. More than one intermediate machined moulded-part condition may be specified. This being the case, the intermediate machined moulded-part condition is enumerated in consecutive sequence according to the manufacturing processes.

When a specification is given without a part condition identifier, this specification applies to all part conditions stated on the drawing.

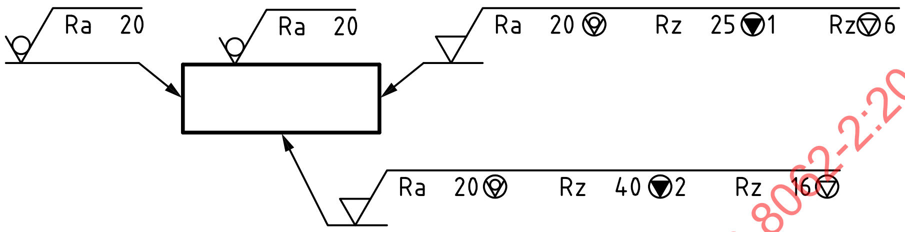
On combined drawings, requirements on features that remain as moulded in the most advanced part condition according to the drawing may also be given. If not otherwise specified, this type of specification applies to all part conditions according to the drawing, see Figure 8.

When a specification is given with an intermediate part condition, this specification applies for all subsequent part conditions if not otherwise specified.

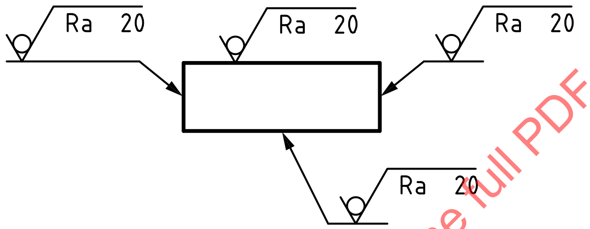
7.2.2 Surface texture

On combined drawings, surface texture requirements shall be indicated for each part condition using the symbols as shown in Figure 8.

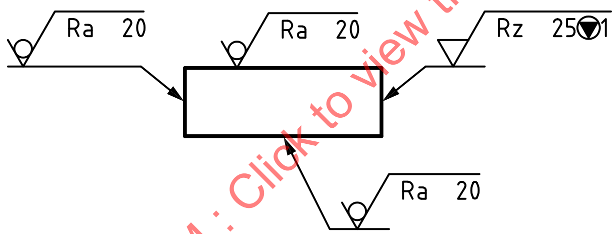
Drawing indication:



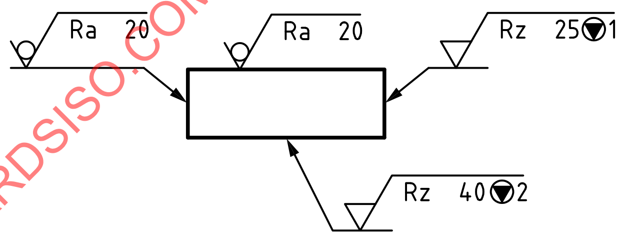
Meaning **condition**



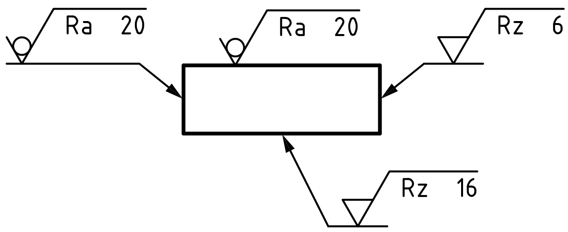
final moulded



intermediate machined 1



intermediate machined 2

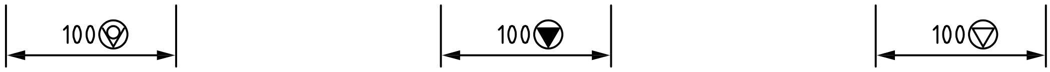


final machined

Figure 8 — Example of a surface texture indication on a combined drawing and its interpretation

7.2.3 Linear dimensions

The part condition to which the linear dimension applies shall be indicated by a part condition identifier as shown in Figure 9, if necessary.



a) **Final moulded part**

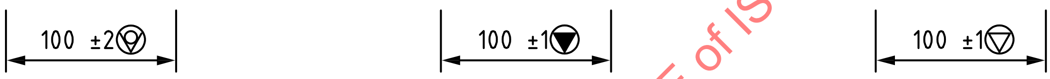
b) **Intermediate machined moulded part**

c) **Final machined moulded part**

Figure 9 — Examples of nominal dimensions

7.2.4 Linear dimensions and individually indicated dimensional tolerances

The part condition to which the linear dimension with its tolerance applies shall be indicated by a part condition identifier as shown in Figure 10, if necessary.



a) **Final moulded part**

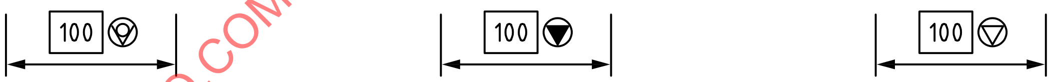
b) **Intermediate machined moulded part**

c) **Final machined moulded part**

Figure 10 — Examples of nominal dimensions with individual tolerances

7.2.5 Theoretically exact dimensions

The part condition to which the theoretically exact dimension applies shall be indicated by a part condition identifier as shown in Figure 11, if necessary.



a) **Final moulded part**

b) **Intermediate machined moulded part**

c) **Final machined moulded part**

Figure 11 — Examples of theoretically exact dimensions

7.2.6 Geometrical tolerances and datums

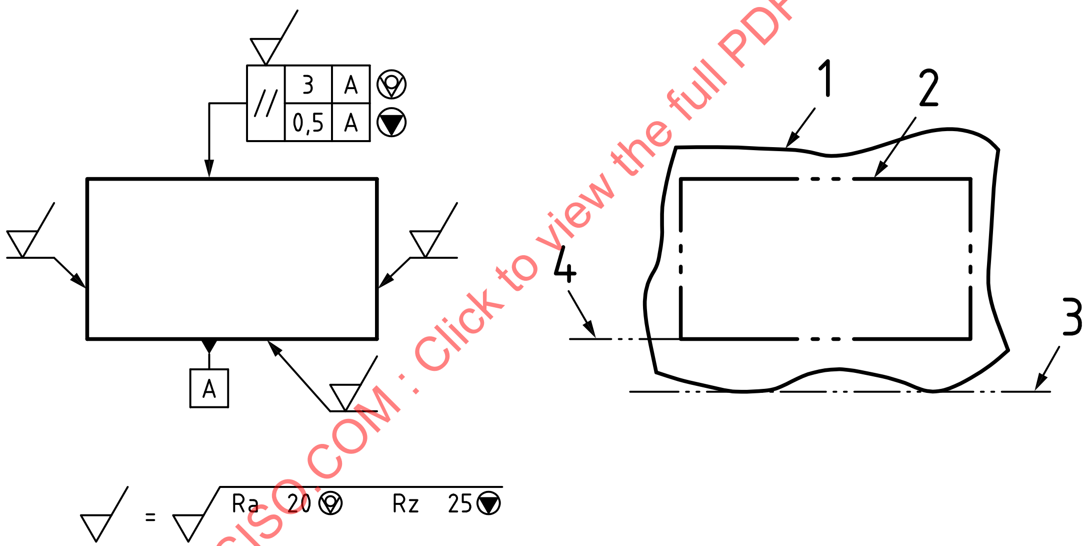
The part condition to which the geometrical tolerance applies, shall be indicated by a part condition identifier as shown in Figure 12, if necessary.

a) Final moulded part **b) Final machined moulded part** **c) Final machined moulded part** **d) Intermediate machined moulded part**

Figure 12 — Examples of geometrical tolerances with datum references

The part condition identifier shall be indicated after the tolerance frame. If the datum exists in different part conditions than those specified by the surface texture symbol, the datum applies in that part condition stated together with the tolerance value (see Figures 13 and 14).

If the datum is specified to a planar feature in the final moulded-part condition and the feature has a taper, the datum applies without the taper, i.e. the actual taper shall be removed mechanically or virtually. If possible, planar surfaces with tapers should not be used as datums.



Key

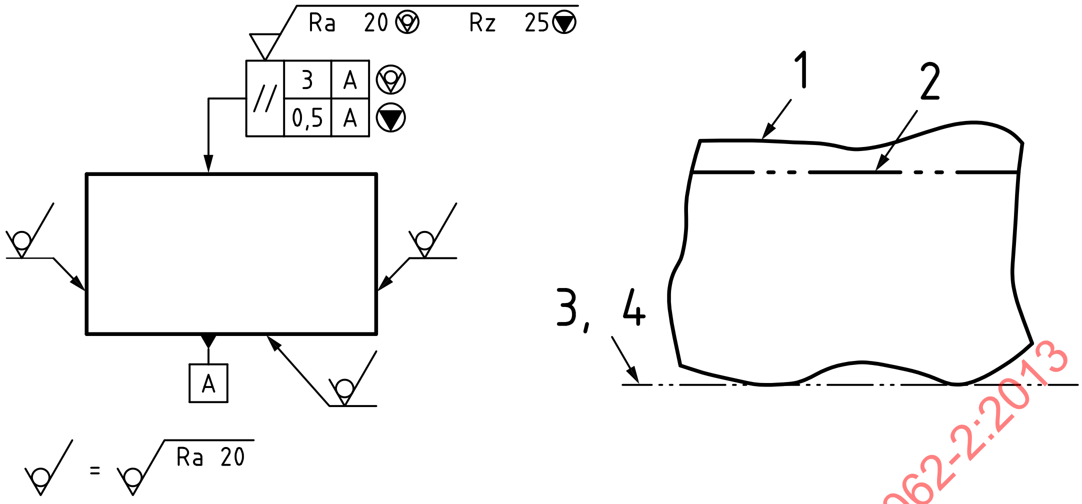
1 final moulded part

2 intermediate machined moulded part

3 datum A of final moulded part

4 datum A of intermediate machined moulded part

Figure 13 — Example of a datum indication in different part conditions with different datums



Key

1 final moulded part

2 intermediate machined moulded part

3 datum A of final moulded part

4 datum A of intermediate machined moulded part

Figure 14 — Example of a datum indication in different part conditions with same datum

When a geometrical tolerance specification is given without a part condition identifier, this specification applies to all part conditions stated on the drawing.

7.3 Required machining allowance, RMA

7.3.1 General

All required machining allowance values, A_{RMA}, are nominal values, and have no tolerance.

7.3.2 General required machining allowance

If a general required machining allowance is to apply to all surfaces to be machined on the final moulded part, it shall be stated in or near the drawing title block according to ISO 8062-3, e.g.

General tolerances ISO 8062-3 RMA 6 (RMAG H)

Only one value is specified for all surfaces to be machined, and this value shall be selected from the appropriate dimension range according to the largest overall dimension of the final moulded part. ISO 8062-3 contains standardized required machining allowances.

7.3.3 Individual required machining allowance

If a special required machining allowance is to apply to an individual surface, it shall be indicated individually before the surface texture symbol according to ISO 1302 (see Figure 15).

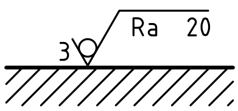


Figure 15 — Individual required machining allowance

An individual required machining allowance overrules a general required machining allowance.

In sand casting, top surfaces sometimes need more machining allowance than other features. For these surfaces, coarser required-machining-allowance grades can be selected and then indicated individually.

8 Indication of general tolerances

8.1 General tolerances according to ISO 8062-3

On drawings, the callout of general tolerances, e.g. according to ISO 8062-3, applies only to those part conditions stated by the drawing type indicator.

On combined drawings where the drawing type indicator for final moulded is stated and the general tolerance according to ISO 8062-3 is referenced, all non-individually indicated dimensions on the final moulded-part condition are to be calculated according to the accumulation method, see Annex B.

General tolerances for moulded parts shall be indicated in or near the drawing title block, if applicable. See Figures E.3, E.4, E.5.

8.2 General surface profile tolerance

See Figure 16.

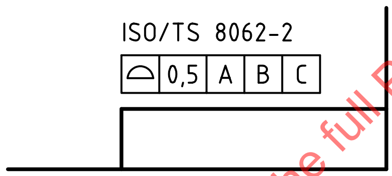


Figure 16 — Example of the indication of general surface profile tolerance

The general surface profile tolerance applies to all surfaces which are not explicitly dimensioned with linear and angular dimensions with plus/minus tolerance.

The geometry of all the surfaces to which the general surface profile tolerance applies shall be specified with the theoretically exact dimension (TED) in its entirety, and shall be considered as a single pattern.

NOTE When using a general surface profile tolerance for the final moulded part, the reference to the general tolerances according to ISO 8062-3 for the same part condition cannot be used because of a contradiction.

9 Types of specifications

9.1 General

The geometry of the part in its different conditions shall be specified completely. This can be done by using the following specification methods.

9.2 Specification of final moulded-part condition

9.2.1 The final moulded-part condition can be specified directly on a single final moulded part drawing according to ISO 10135. This method shall be used if the final moulded part is not to be machined.

If the final moulded part is to be machined, the specification of the final moulded part can be given on a combined drawing

— indirectly, by using the accumulation method, or

— directly, by using the multiple tolerancing method.

9.2.2 When using the accumulation method, the final moulded part is specified indirectly on the drawing in the following way:

— the machined moulded part is specified directly in total;

— appropriate dimensional tolerance grade (DCTG) according to ISO 8062-3 is specified;

— appropriate geometrical tolerance grade (GCTG) according to ISO 8062-3 is specified;

— appropriate required machining allowance grade (RMAG) according to ISO 8062-3 is specified;

— drawing type indicator for final moulded part is indicated;

— drawing type indicator for final machined moulded part is indicated.

As a result, the drawing is a combined drawing indirectly giving the specifications on the final moulded part. In this case, unless otherwise specified, the linear dimensions, which are not individually indicated on the final moulded part drawing, are to be calculated. The dimensional and the geometrical tolerances which are not individually indicated on the final moulded part drawing are given by ISO 8062-3.

This specification method can lead to large excess material, but simplifies the specification of the final moulded part.

9.2.3 When using the multiple tolerancing method, the final moulded part is specified directly on the drawing in the following way:

— the most advanced machined moulded part, illustrated on the drawing, is specified in total;

— the final moulded part is specified directly in total;

— drawing type indicator for final moulded part is stated.

The specification of the final moulded part and the machined moulded parts should mainly be done by using appropriate geometrical tolerances according to ISO 1101. For sizes (e.g. diameters, widths of slots, tabs), wall thicknesses, fillets and chamfers, dimensional tolerancing (+/− tolerancing) may be used instead.

9.2.4 The tolerances according to ISO 1101 may be specified as general tolerances (with or without individual tolerances) or as individual tolerances only.

ISO 8062-3 may be used as a guidance to select appropriate individual tolerance values.

This specification method can lead to smaller excess material than the accumulation method, but needs complete specification of the final moulded part directly on the drawing.

9.2.5 Surface profile (profile of any surface) tolerances may be used

— either for all surfaces, or

— for all surfaces except those belonging to features of size (diameters and widths), fillets and chamfers. Features of size may be toleranced by dimensional tolerances together with positional tolerances and, if appropriate, with maximum material requirement Ⓜ or least material requirement Ⓛ (see ISO 2692). Fillets and chamfers may be toleranced with linear dimensions.

9.3 Specification of intermediate machined moulded-part conditions

The specification of the intermediate machined moulded part can be given on a single drawing of the intermediate machined moulded part only or on a combined drawing which includes this intermediate machined moulded part and the final moulded-part condition or other intermediate moulded parts or the final machined moulded-part condition.

The intermediate machined moulded part is specified directly on the drawing in the following way:

— the most advanced intermediate machined moulded part, illustrated on the drawing, is specified in total;

— drawing type indicator for intermediate machined moulded part is stated.

The intermediate machined surfaces with their theoretically exact dimensions and their surface profile (profile of any surface) tolerances relative to the datum or datum system should be specified either with a general surface profile tolerance or, if more appropriate, with individual tolerances. For sizes (e.g. diameters, widths of slots, tabs), wall thicknesses, fillets and chamfers, dimensional tolerancing (+/− tolerancing) may be used instead.

Surface profile (profile of any surface) tolerances may be used

— either for all surfaces, or

— for all surfaces except those belonging to features of size (diameters and widths). Features of size may be toleranced by dimensional tolerances together with positional tolerances and, if appropriate, with material modifiers requirement Ⓜ or least material requirement Ⓛ (see ISO 2692).

All moulded surfaces remaining as moulded shall be specified according to ISO 10135.

NOTE A former common practice indicated the nominal linear and angular dimensions together with a minimum and maximum machining allowance on the intermediate machined moulded part for the final machining. This created ambiguities in the interpretation of the permissible dimensional and geometrical deviations of the intermediate machined moulded part. The method described in this Technical Specification uses appropriate GPS symbols and rules and avoids these ambiguities.

9.4 Specification of final machined moulded-part condition

The specification of the final machined moulded part can be given on a single drawing of the final machined moulded part only or on a combined drawing which includes the final machined moulded part and the final moulded-part condition and/or any intermediate machined moulded-part condition.

The final machined moulded part is specified directly on the drawing in the following way:

— the final machined moulded part, illustrated on the drawing, is specified in total;

— the drawing type indicator for final machined moulded part is stated.

The final machined surfaces with their theoretically exact dimensions and their surface profile tolerances relative to the datum or datum system should be specified either with a general surface profile tolerance or, if more appropriate, with individual tolerances. For sizes (e.g. diameters, widths of slots, tabs), wall thicknesses, fillets and chamfers, dimensional tolerancing (+/− tolerancing) may be used instead.

Surface profile tolerances may be used

— either for all surfaces, or

— for all surfaces except those belonging to features of size (diameters and widths). Features of size may be toleranced by dimensional tolerances together with positional tolerances and, if appropriate, with material modifiers requirement Ⓜ or least material requirement Ⓛ (see ISO 2692).

All moulded surfaces remaining as moulded shall be specified according to ISO 10135.

All intermediate machined moulded surfaces shall be specified.

10 Tolerancing

10.1 General

For the tolerance indication, ISO 129-1, ISO 1101, ISO 2692, ISO 5458, ISO 5459, ISO 8015, ISO 10135, ISO 10579, ISO 14405-2 and this document apply.

For the tolerance indication, there is also the possibility to simplify the presentation by using general tolerances, e.g. according to ISO 8062-3, or by using particular general tolerances indicated on the drawing. For the identification of the part condition to which the general tolerances apply, the specification identifier shall be used when necessary.

Tolerancing of moulded parts in various types of conditions (final moulded, intermediate machined moulded, final machined moulded) can be performed as described in the following.

10.2 Tolerancing of final moulded parts

10.2.1 Recommendations

Particular general tolerances for moulded parts and individual tolerances for moulded parts may be specified as

— dimensional tolerances for features of size, and, if appropriate, the envelope requirement Ⓔ (see ISO 8015),

— positional tolerances for the location of features of size, and, if appropriate, the maximum material requirement Ⓜ or the least material requirement Ⓛ (see ISO 2692),

— dimensional tolerances for wall thicknesses, fillets and chamfers,

— surface profile tolerances and, if appropriate, positional tolerances, according to ISO 1101 for distances and step dimensions, see ISO 1101, ISO 1660 and ISO 5458.

If datums established from surfaces remaining as moulded are necessary, the use of datum targets is recommended, see ISO 5459.

When dimensional tolerances (general or individual) are applied to distances, step dimensions and profiles, it is difficult to assess which is the largest ideal part that can be achieved from the final moulded part. The reason for this is that tolerances for size, distances, step dimensions and geometrical characteristics are independent of each other. Therefore, it is recommended to use the tolerancing methods according to ISO 1101 as described in this Technical Specification.

10.2.2 Draft

Draft can be indicated according to ISO 10135. Unless otherwise specified, drafts are additional material (TP).

However, for a feature of size to which the maximum material requirement or the envelope requirement applies, drafts are subtracted material (TM).

10.3 Tolerancing of intermediate machined moulded parts

The drawing, whether single or combined, shall specify the moulded part in the intermediate machined condition.

The intermediate machined surfaces are identified by the machined surface texture symbol, and, if necessary, by the part condition identifier. The intermediate machined surfaces, are toleranced by surface profile tolerances (according to ISO 1101) related to a datum or datum system.

The datum or datum system may be established from intermediate machined surfaces or from final moulded surfaces by using the surfaces or datum targets.

10.4 Tolerancing of final machined moulded part

10.4.1 General

There are two calculation methods for deriving the dimensions and the tolerances of the surfaces to be machined on a final moulded part:

— accumulation method;

— multiple tolerancing method.

For calculations using the accumulation method, it is assumed that the relevant tolerances (dimensional tolerance, form tolerance of the moulded part and the machined moulded part) accumulate according to a “worst case” concept. Consequently, this will often lead to an (unnecessarily) large amount of material being removed. Therefore, smaller tolerances for the moulded part may be agreed upon by the supplier and the purchaser. These smaller tolerances shall be indicated individually on the drawing.

For calculations using the multiple tolerancing method, the following needs to be taken into account: the boundary of the maximum material condition of the final machined moulded part fits into the boundary of the least material condition of the final moulded part, including the necessary required machining allowance. This method offers the possibility of choosing tolerances which can lead to smaller quantities of material being removed compared to those removed using the accumulation method.

10.4.2 Accumulation method

10.4.2.1 General

The purchaser provides a drawing of the final machined moulded part where machined surfaces are indicated.

Where no individual tolerances or particular general tolerances are indicated for the moulded part, and for surfaces remaining in the as final moulded condition, the general tolerances for moulded parts, e.g. according to ISO 8062-3 for castings, apply and shall be indicated accordingly.

For surfaces to be machined by the purchaser (the drawing defines the final machined moulded part only), the following rules apply.

a) The dimensional and geometrical deviations of the final moulded part shall allow the final machined moulded part to be achieved (primordial requirement for moulded surfaces to be machined while removing certain layers of the surface, at least the required machining allowance).

b) The nominal dimensions d_C of the moulded part that relate to surfaces to be machined shall be calculated from the nominal dimensions d_M of the final machined moulded part, taking into account the miscellaneous influences.

There is not yet a clearly defined way to apply rule b) in the context of the future system of GPS standards. As a first step, it is therefore assumed in this part of ISO 8062 that for the calculation of the moulded part nominal dimension d_C from the final machined moulded part nominal dimension d_M, the contributions of size, form and required machining allowance (excluding taper) have to be added linearly, i.e. the accumulation of the extremes.

The formulae for these calculations are deduced from the geometrical relationships between the final moulded part and the final machined moulded part.

10.4.2.2 Features of size

When calculating the final moulded part nominal dimension d_C from the respective final machined moulded part nominal dimension d_M, external and internal features of size and the cases with and without envelope requirements have to be distinguished. This results in the set of four formulae deduced in Annex B (for castings) under the assumption of symmetrically disposed tolerances for the moulded part.

With the envelope requirement for the final machined feature of size, the final moulded part nominal dimension d_C of a feature of size to be machined is calculated according to Formula (1) or (2):

External size: $$d_C = d_{M\max} + 2A_{RMA} + t_{FCT} + \frac{t_{DCT}}{2} \quad (1)$$

Internal size: $$d_C = d_{M\min} - 2A_{RMA} - t_{FCT} - \frac{t_{DCT}}{2} \quad (2)$$

Without the envelope requirement for the final machined feature of size, the final moulded part nominal dimension d_C of a feature of size to be machined is calculated according to Formula (3) or (4):

External size: $$d_C = d_{M\max} + 2A_{RMA} + t_{FCT} + \frac{t_{DCT}}{2} + t_{FMT} \quad (3)$$

Internal size: $$d_C = d_{M\min} - 2A_{RMA} - t_{FCT} - \frac{t_{DCT}}{2} - t_{FMT} \quad (4)$$

In order to determine the correct values of the dimensional casting tolerance t_{DCT} and the form tolerances t_{FCT} of the GCT in Formulae (1) to (4), the final value of d_C has to be known. Since this value is not known when starting the calculation, the nominal value of the machined feature of size may be taken as a first step. If the result does not match the anticipated range for t_{DCT} or t_{GCT}, a second step with the use of the result of the first calculation will lead to the final value of d_C. An example is given in C.2 to illustrate this calculation procedure.

For internal features, in the unlikely event of a loop, the larger value of t_{DCT} or t_{GCT} shall be used, leading to the smaller value of d_C. An example is given to illustrate this calculation procedure.

For cylindrical features, the sum of the parallelism and the roundness tolerance applies for the form tolerance (cylindricity tolerance) for both the final moulded part and the final machined moulded part.

For features of size established by two opposite plane surfaces, the larger of the two flatness tolerances applies for both the final moulded part and the final machined moulded part.

For other distributions of the tolerance for the moulded part (other than symmetrically disposed), the formulae given above have to be modified accordingly.

The minimum thickness of material to be removed is the required machining allowance.

The maximum thickness of material to be removed is the sum of A_{RMA}, t_{DCT}, t_{FCT}, and t_{FMT}. If there is taper (draft), the corresponding material shall also be removed.

Additionally, when the location of a feature of size is involved, defined by linear dimension or by a locational tolerance and a theoretically exact dimension, the respective tolerance for the moulded part of the distance shall also be taken into account.

— In the case of a linear dimension, the maximum thickness of the material to be removed (cutting depth) increases then by half of the tolerance of the linear dimension for the moulded part, e.g. $t_{DCT}/2$ for castings. The moulded part nominal dimension d_C increases with external dimensions and decreases with internal dimensions by the half of the tolerance of the linear dimension for the moulded part, e.g. $t_{DCT}/2$ for castings.

— In the case of a locational tolerance, the maximum thickness of the material to be removed (cutting depth) increases then by the locational tolerance for the moulded part. The moulded part nominal dimension d_C increases with external dimensions and decreases with internal dimensions by the locational tolerance for the moulded part.

Furthermore, when chain dimensioning is involved, the thickness of the material to be removed increases theoretically according to the dimensional tolerance accumulation. In practice, a provision for less material may be sufficient to meet the primordial requirement that the final machined moulded part can be achieved.

10.4.2.3 Step dimensions

The final moulded part nominal dimension d_C of a step dimension between surfaces to be machined is calculated according to Formula (5).

$$d_C = d_M - t_{FLAC} + \frac{t_{DMT}}{2} + t_{PARC} + \frac{t_{DCT}}{2} \quad (5)$$

The thickness of material to be removed from the reference surface is:

$$c = A_{RMA} + t_{FLAC} \quad (6)$$

The thickness of material to be removed from the other surface is:

minimum: $$c = A_{RMA} + t_{PARC} \quad (7)$$

maximum: $$c = A_{RMA} + t_{PARC} + t_{DCT} \quad (8)$$

If there is taper (draft), the corresponding material shall also be removed.

10.4.2.4 Drafts

If not otherwise specified (see ISO 10135), drafts are additional material (TP), i.e. they are in addition to the dimensional and geometrical tolerances. However, when the maximum material requirement (MMR) is specified, TM (taper minus) applies to the feature of size to which the MMR is allocated.

10.4.3 Multiple tolerancing method

The purchaser provides a combined drawing or two single drawings specifying both the tolerances for the final moulded part and the tolerances for the final machined moulded part. Therefore, for surfaces to be machined, both the tolerance of the final machined moulded part and the tolerance of the final moulded part shall be indicated.

The dimensional and geometrical tolerances of the final moulded part shall permit the final machined moulded part dimensions, form, orientation and location to be achieved (supreme requirement for surfaces to be machined while removing certain layers of the surface, at least the required machining allowance). This shall be taken into account when calculating the final moulded part nominal dimensions.

Tolerances for the final moulded part applied to surfaces to be machined do not include the required machining allowance. (The required machining allowance is an additional material and, contrary to the material in the tolerance zones, this material always exists on the moulded part.)

When the tolerance or the datum refers to the final moulded-part condition, the required machining allowance shall be included when calculating the nominal dimension of the final moulded part.

For sizes (diameters, widths),

— the least material virtual size of an external feature of size of the final moulded part shall be larger than the maximum material virtual size of the final machined moulded part by the required machining allowance;

— the least material virtual size of an internal feature of size of the final moulded part shall be smaller than the maximum material virtual size of the final machined moulded part by the required machining allowance.

For features of size to be machined, it is recommended to use, according to ISO 2692, “0 Ⓛ tolerancing” for the final moulded part and “0 Ⓜ tolerancing” for the final machined moulded part. When there are no features of size, profile tolerancing according to ISO 1101 is recommended.

For wall thicknesses, fillets and chamfers, dimensional tolerancing (+/− tolerancing) is recommended, and is to be indicated generally or individually.

For distances, step dimensions and profiles excluding fillets and chamfers, profile and positional tolerancing according to ISO 1101, ISO 1660 and ISO 5458 is recommended, and is generally or individually to be indicated.

If not otherwise specified (see ISO 10135), drafts are additional material. However, for features of size to which the maximum material requirement applies, the draft is subtracted (TM). In these cases, the considered feature must not exceed its maximum material virtual condition of perfect form.

Annex A
(normative)

Proportions and dimensions of graphical symbols

A.1 General requirements

In order to harmonize the size of the symbols specified in this part of ISO 8062 with those of other inscriptions on technical drawings (dimensions, geometrical tolerances, etc.), the rules given in ISO 81714-1 shall be applied.

A.2 Application

The graphical symbols given in ISO 1302, ISO 7083 and ISO 13715 shall be used.

A.3 Proportions

The graphical symbols and the additional indications in the area “a” shall be draughted in accordance with Figure A.1.

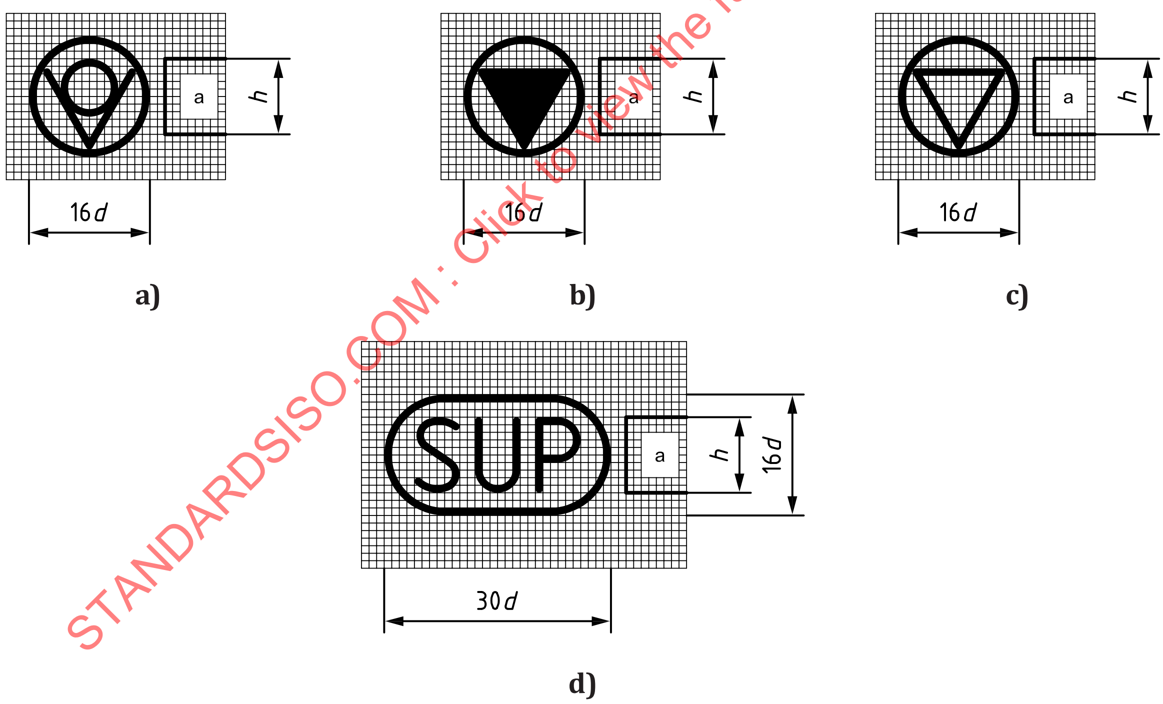


Figure A.1

A.4 Dimensions

The dimensional requirements of the graphical symbols and the additional indications are specified in Table A.1.

Table A.1 — Dimensions

Dimensions in millimetres

Lettering height *h*	2,5	3,5	5	7	10	14
Line thickness for symbols and lettering *d*	0,25	0,35	0,5	0,7	1	1,4

Annex B
(informative)

Accumulation method, relationship between moulded part and machined moulded part

B.1 General

The final machined moulded part must be achievable.

In order to calculate the moulded part dimensions from the machined moulded part dimension, the accumulation method combines two different tolerancing systems: linear dimensional tolerancing and tolerancing by zones according to ISO 1101.

NOTE The accumulation method is not applicable for features that are totally defined by geometrical tolerances according to ISO 1101.

B.2 Factors of influence

The following influences require additional material for the casting to be removed to achieve the final machined moulded part.

— Required machining allowance RMA (see e.g. ISO 8062-3:2007, Table 7).

— Casting tolerance t_C: the casting tolerance required by the manufacturing process is mainly influenced by shrinking variations (difference between actual shrinking and assumed shrinking), which mainly depend on the distance between the considered features (see ISO 8062-3:2007, Table 2).

— Geometrical tolerance (e.g. straightness, flatness, roundness, parallelism, perpendicularity, coaxiality, symmetry): the geometrical tolerance required by the manufacturing process is mainly influenced by the length of the considered feature (see ISO 8062-3:2007, Tables 3 to 6).

NOTE The orientation tolerances (parallelism, perpendicularity) include the form tolerances (straightness, flatness, roundness), see ISO 1101. Therefore, when taking into account orientation tolerances, the form tolerances need not be taken into account as well.

— Taper, if applicable.

B.3 Calculation formulae

B.3.1 The following shows the geometrical dependencies between the final machined moulded part and the final moulded part.

The moulded part nominal dimension, d_C, of a feature to be machined, with symmetrically disposed casting tolerance, is calculated as shown in B.3.2 and B.3.6.

B.3.2 For external features with the envelope requirement for the machined feature, see Formula (B.1):

$$d_C = d_{M\max} + 2A_{RMA} + t_{FCT} + \frac{t_{DCT}}{2} \tag{B.1}$$

where

d_C is the nominal size of the final moulded part;

$d_{M\max}$ is the maximum size of the final machined moulded part;

A_{RMA} is the required machining allowance;

t_{FCT} is the casting form tolerance;

t_{DCT} is the casting dimensional tolerance.

B.3.3 For external features without the envelope requirement for the machined feature, see Formula (B.2):

$$d_C = d_{M\max} + 2A_{RMA} + t_{FCT} + \frac{t_{DCT}}{2} + t_{FMT} \tag{B.2}$$

where

d_C is the nominal size of the final moulded part;

$d_{M\max}$ is the maximum size of the final machined moulded part;

A_{RMA} is the required machining allowance;

t_{FCT} is the casting form tolerance;

t_{DCT} is the casting dimensional tolerance.

t_{FMT} is the machining form tolerance.

See Figure B.1.

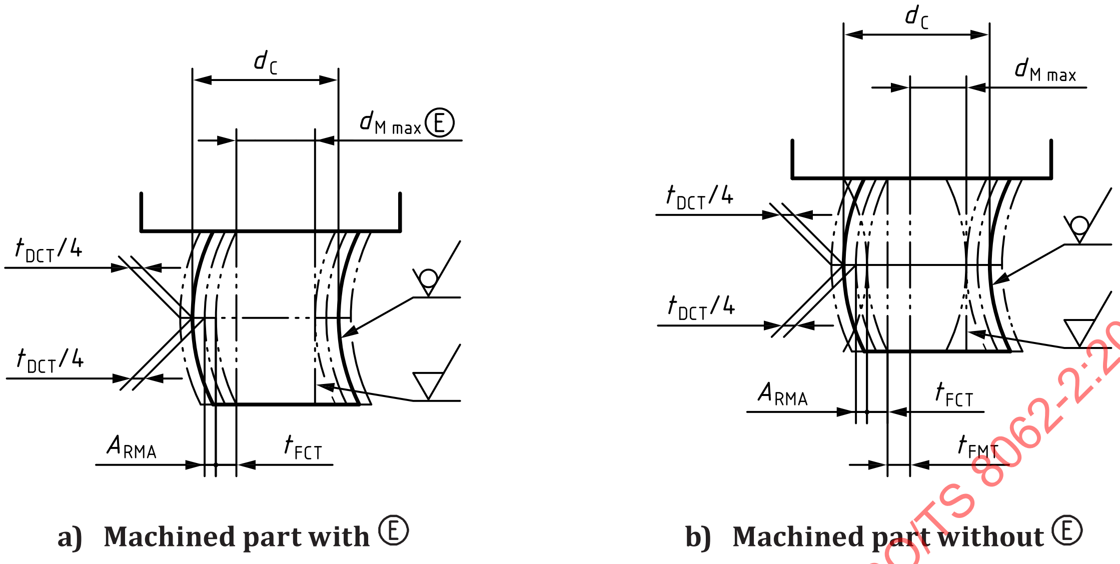


Figure B.1 — Moulded part nominal dimension, d_C, and machined moulded part nominal dimension, d_M, of an external feature

B.3.4 For internal features with the envelope requirement for the machined feature, see Formula (B.3):

$$d_C = d_{M\min} - 2A_{RMA} - t_{FCT} - \frac{t_{DCT}}{2} \qquad \text{(B.3)}$$

where

d_C is the nominal size of the final moulded part;

$d_{M\min}$ is the minimum size of the final machined moulded part;

A_{RMA} is the required machining allowance;

t_{FCT} is the casting form tolerance;

t_{DCT} is the casting dimensional tolerance.

B.3.5 For internal features without the envelope requirement for the machined feature, see Formula (B.4):

$$d_C = d_{M\min} - 2A_{RMA} - t_{FCT} - \frac{t_{DCT}}{2} - t_{FMT} \quad \text{(B.4)}$$

where

d_C is the nominal size of the final moulded part;

$d_{M\min}$ is the minimum size of the final machined moulded part;

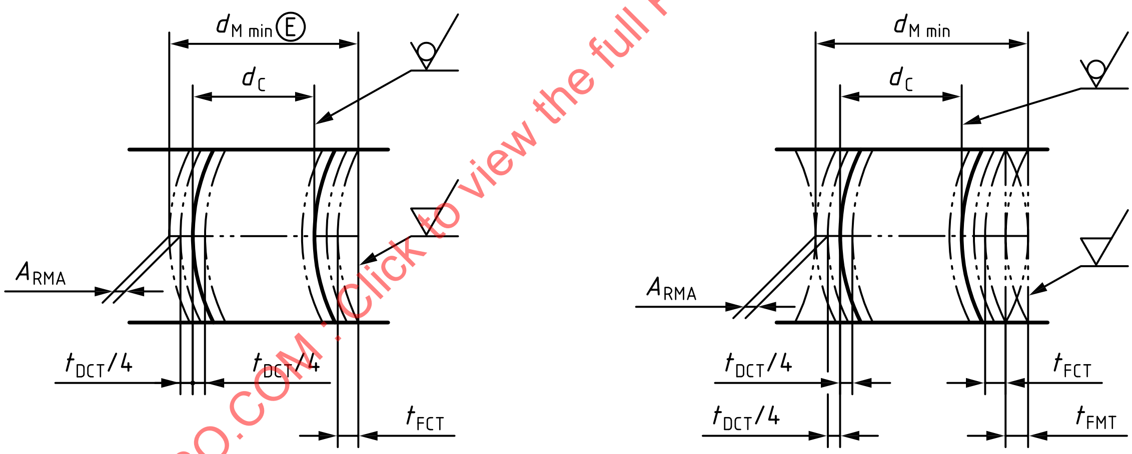
A_{RMA} is the required machining allowance;

t_{FCT} is the casting form tolerance;

t_{DCT} is the casting dimensional tolerance.

t_{FMT} is the machining form tolerance.

See Figure B.2.



a) Machined part with Ⓔ

b) Machined part without Ⓔ

Figure B.2 — Moulded part nominal dimension, d_C, and machined moulded part nominal dimension, d_M, of an internal feature

B.3.6 For step dimensions, see Formula (B.5):

$$d_C = d_{M\min} - t_{FLAC} + \frac{t_{DMT}}{2} + t_{PARC} + \frac{t_{DCT}}{2} \qquad \text{(B.5)}$$

where

d_C is the nominal size of the final moulded part;

$d_{M\min}$ is the minimum dimension of the final machined moulded part;

t_{FLAC} is the casting flatness tolerance;

t_{DMT} is the machining dimensional tolerance;

t_{PARC} is the casting parallelism tolerance;

t_{DCT} is the casting dimensional tolerance.

The required machining allowance, A_{RMA}, as shown in Figure B.3, shall not be taken into account when calculating the final machined moulded part minimum dimension, d_M, since the required machining allowance is to be removed on both surfaces.

Furthermore, the machining parallelism tolerance, t_{PARM}, shall not be taken into account since the final machined moulded part minimum dimension, d_M, applies to the point that is most outward of the material.

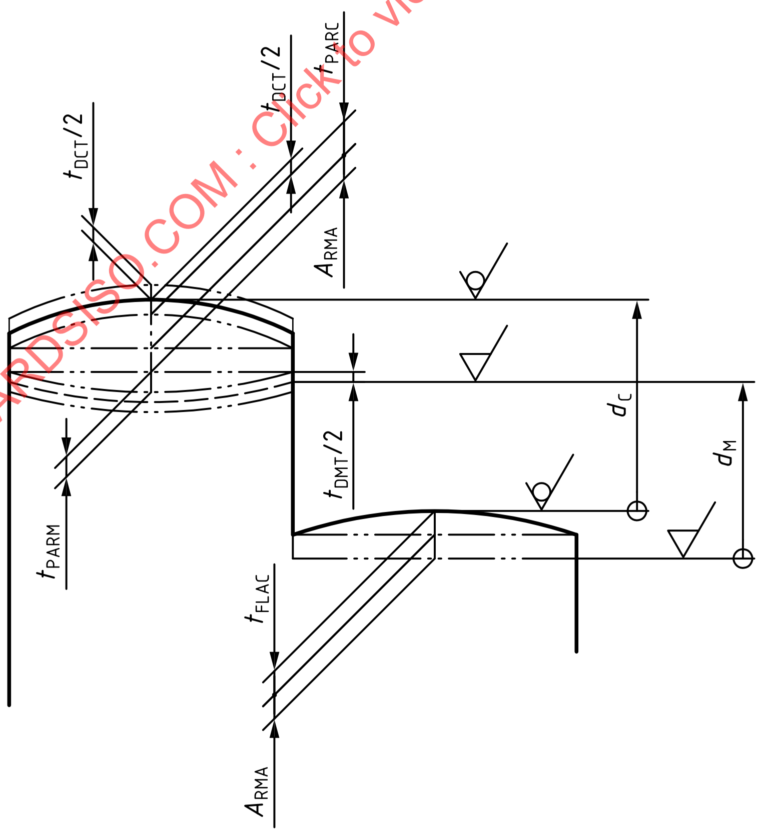


Figure B.3 — Moulded part nominal dimension, d_C, and machined moulded part nominal dimension, d_M, of a step dimension

Annex C
(informative)

Calculation of moulded part nominal dimensions of features to be machined

C.1 External features

Examples are given for calculating – according to the accumulation method – the moulded part nominal dimension of external features to be machined with envelope requirement for the machined feature.

As a starting point, assume a grey-iron casting (sand cast, machine moulded). In addition, assume the largest overall dimension of the moulded part to be 900 mm which leads, together with an agreed RMAG of d_M (intermediate value, ISO 8062-3:2007,Table B.1), to a value of 3,5 mm for the A_{RMA} (ISO 8062-3:2007, Table 7). Assume, furthermore, an agreed DCTG of 10 (intermediate value, ISO 8062-3:2007, Table A.1) and the agreed GCTG (ISO 8062-3:2007, Table A.3) to be 6. Then, consider an external feature of size with parallel plane surfaces 78 mm apart which are to be machined. Starting with the assumption of the moulded part nominal dimension to be 78 mm as well, t_{DCT} amounts to 3,2 mm (ISO 8062-3:2007, Table 2), and the t_{GCT} amounts to 1,4 mm according to ISO 8062-3:2007, Table 4.

With these numbers, Formula (C.1) gives the following value for the moulded part nominal dimension:

$$d_C = 78\text{ mm} + 2\times 3{,}5\text{ mm} + 1{,}4\text{ mm} + \frac{1}{2}\times 3{,}2\text{ mm} = 88{,}0\text{ mm} \tag{C.1}$$

This value of d_C does not change the range to be chosen in ISO 8062-3:2007, Tables 2 and 4. So, d_C = 88,0 mm is the final result.

If the nominal distance of the two parallel machined planes is 94 mm, start the calculation of d_C with the same values for t_{DCT} and t_{GCT}:

$$d_C = 94\text{ mm} + 2\times 3{,}5\text{ mm} + 1{,}4\text{ mm} + \frac{1}{2}\times 3{,}2\text{ mm} = 104{,}0\text{ mm} \tag{C.2}$$

Since this result is larger than 100 mm, the value for t_{DCT} shall be chosen as 3,6 mm, and the new value for t_{GCT} is 2,0 mm. So, the final value for d_C is calculated as:

$$d_C = 94\text{ mm} + 2\times 3{,}5\text{ mm} + 2{,}0\text{ mm} + \frac{1}{2}\times 3{,}6\text{ mm} = 104{,}8\text{ mm} \tag{C.3}$$

If on the same casting the external feature of size was meant without envelope requirement, the machining flatness tolerance would have to be taken into account (i.e. added) in accordance with Formula (B.2). However, the flatness tolerance for the final machined moulded part will be substantially smaller than the flatness tolerance for the final moulded part. It is up to the designer of the final moulded-part condition to decide whether or not these smaller tolerances can be neglected.

C.2 Internal features

As an example for calculating the nominal dimension of a moulded part internal feature of size with envelope requirement, the casting is chosen with the same dimensions as the latter of the two cases described above, the only difference being that an internal feature of size is considered.

For d_{Mmin} = 94 mm, Formula (B.3) gives:

$$d_C = 94\ \text{mm} - 2 \times 3{,}5\ \text{mm} - 1{,}4\ \text{mm} - \frac{1}{2} \times 3{,}2\ \text{mm} = 84{,}0\ \text{mm} \tag{C.4}$$

Since this value of d_C does not change the range to be chosen in ISO 8062-3:2007, Tables 2 and 4, d_C = 84,0 mm is the final result.

The situation is completely different if d_{Mmin} = 110,5 mm. ISO 8062-3:2007, Tables 2 and 4 give t_{DCT} = 3,6 mm and t_{GCT} = 2,0 mm. As a first step, Formula (B.3) leads to:

$$d_C = 110{,}5\ \text{mm} - 2 \times 3{,}5\ \text{mm} - 2{,}0\ \text{mm} - \frac{1}{2} \times 3{,}6\ \text{mm} = 99{,}7\ \text{mm} \tag{C.5}$$

This value of d_C changes the range to be chosen in ISO 8062-3:2007, Tables 2 and 4. The new values are t_{DCT} = 3,2 mm and t_{GCT} = 1,4 mm. For the moulded part nominal dimension, Formula (B.3) gives:

$$d_C = 110{,}5\ \text{mm} - 2 \times 3{,}5\ \text{mm} - 1{,}4\ \text{mm} - \frac{1}{2} \times 3{,}2\ \text{mm} = 100{,}5\ \text{mm} \tag{C.6}$$

According to this result, the larger values for t_{DCT} and t_{GCT} would have to be chosen. So, under these special conditions, we are locked in a loop. This is solved by defining that, in the event of a loop, the larger values for t_{DCT} and t_{GCT} are to be chosen, which in the case of the example described above means d_C = 99,7 mm.

Again, the examples do not differ significantly if an internal feature of size without envelope requirement is considered: the flatness tolerance for the final machined moulded part shall be taken into account (i.e. subtracted) as well, but its value is in most cases much smaller than the flatness tolerance for the final moulded part. It is up to the designer of the final moulded-part condition to decide whether or not these smaller tolerances can be neglected.

Annex D
(informative)

Examples for the multiple tolerancing method

D.1 General

The purpose of this annex is to give examples of:

a) the design of the final moulded part specification on the basis of information on:

    1) the functional requirements of the final machined moulded part,

    2) the information on manufacturing process ability;

b) the interpretation of a combined drawing with multiple tolerancing.

These examples show the relationship between the tolerances in the various part conditions. In practice the tolerances for the final machined moulded-part condition may be much smaller than the tolerances for the final moulded-part condition. It is up to the designer of the final moulded-part condition to decide whether or not these smaller tolerances can be neglected.

D.2 Feature of size (hole) relative to a plane datum

D.2.1 Design of the final moulded part

D.2.1.1 Information

In accordance with the functional requirement for the final machined moulded part [see Figure D.1 a)]:

— the maximum material requirement for the hole (datum B) applies at a distance of 60 mm from datum surface A;

— the diameter requirement for the hole (datum B) is ⌀ (30,3 ± 0,1) mm;

— the flatness tolerance for the surface (datum A) is 0,1 mm.

Assuming that, according to the production planning, it is decided to have an intermediate machining of the part, where the surface (datum A) is machined.

As a consequence of the process ability of the intermediate machining:

— the surface profile tolerance (location) of datum feature A in relation to datum feature B is 0,2 mm.

As a consequence of the process ability from the foundry [see Figure D.1 c)]:

— A_{RMA} = 1,5 mm;

— the diameter tolerance for the hole (datum B) is ± 1 mm;

— the flatness tolerance of the surface (datum A) is 1 mm.

From this information, the tolerancing shown in Figure D.2 is derived. The part condition identifiers (intermediate machined and final machined) determine the sequence of manufacturing, i.e. the surface (datum A) is machined before the hole (datum B).

Dimensions in millimetres

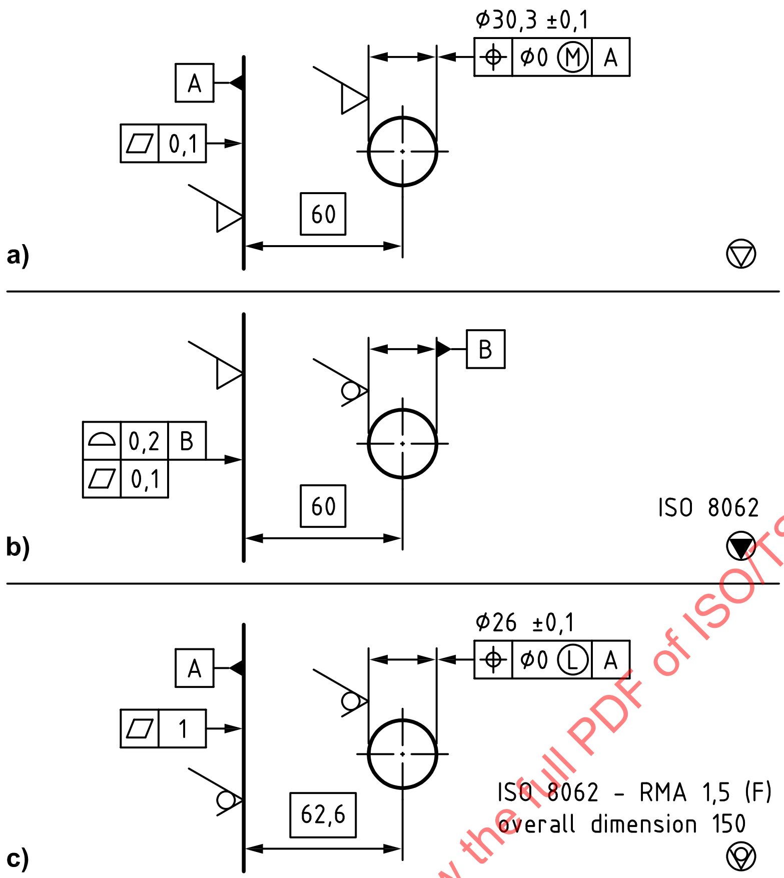


Figure D.1 — Feature of size (hole) relative to a plane datum, requirements

D.2.1.2 Design process

The contour in the machined condition (the plane and the internal cylinder, 60 mm apart) perfect in form and orientation at maximum material virtual size ϕ 30,2 mm must be achievable.

D.2.1.3 Requirement for the intermediate part condition

The theoretically exact dimension (TED) for the surface profile tolerance (location) of 0,2 mm, given by the process ability for the intermediate part condition, remains the same as for the final machined moulded-part condition, since datum surface A is not to be machined at the final machining.

The flatness tolerance of 0,1 mm for the final machined moulded part on datum surface A shall be respected, since this intermediate machining actually is the final machining of datum surface A. Therefore, the flatness tolerance of the intermediate moulded part is identical to the flatness tolerance of the final machined moulded part.

D.2.1.4 Requirement for the final moulded part

D.2.1.4.1 Calculation of the location of the hole (datum B)

Start with the location of the hole (datum B) of the final machined moulded part of a theoretically exact dimension of 60 mm from the machined datum surface A.

Taking into account half of the surface profile tolerance for location of datum surface A on the intermediate machined moulded part, i.e. 0,2 mm/2 = 0,1 mm, the location of the hole in the moulded-part condition is to be 60,1 mm.

Taking into account the required machining allowance, i.e. A_{RMA} = 1,5 mm, the location of the hole in the moulded-part condition is to be 61,6 mm.

Taking into account the flatness tolerance of the final moulded part for the surface (datum A), i.e. t_{FLAC} = 1 mm, the location of the hole in the moulded-part condition ends up being 62,6 mm.

D.2.1.4.2 Calculation of the dimension of the hole (datum B)

Starting with the diameter ⌀ (30,3 ± 0,1) mm with maximum material condition on the location of the hole, the actual machined surface must not exceed a cylinder of ⌀ 30,2 mm.

Taking into account the variation in the location of the surface (datum A) in the intermediate part condition in relation to the hole (datum B), i.e. 0,2 mm, the diameter of the hole is ⌀ 30 mm.

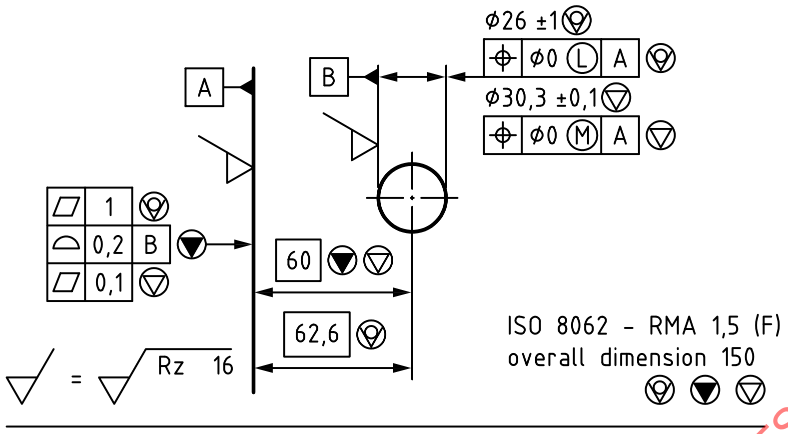
It is not necessary to take the flatness tolerance of 0,1 mm of the intermediate and the final machined moulded part for datum surface A into account, since it is already included in the surface profile tolerance (location) of the intermediate machined moulded part for datum surface A in relation to the hole (datum B).

Taking into account the A_{RMA} two times (2 × 1,5 mm = 3 mm), the diameter of the hole is to be ⌀ 27 mm.

Taking into account the dimensional ability of the moulding process, i.e. dimensional tolerance ± 1 mm, the diameter of the hole ends up being ⌀ (26 ± 1) mm.

Dimensions in millimetres

Drawing indication:



Meaning:

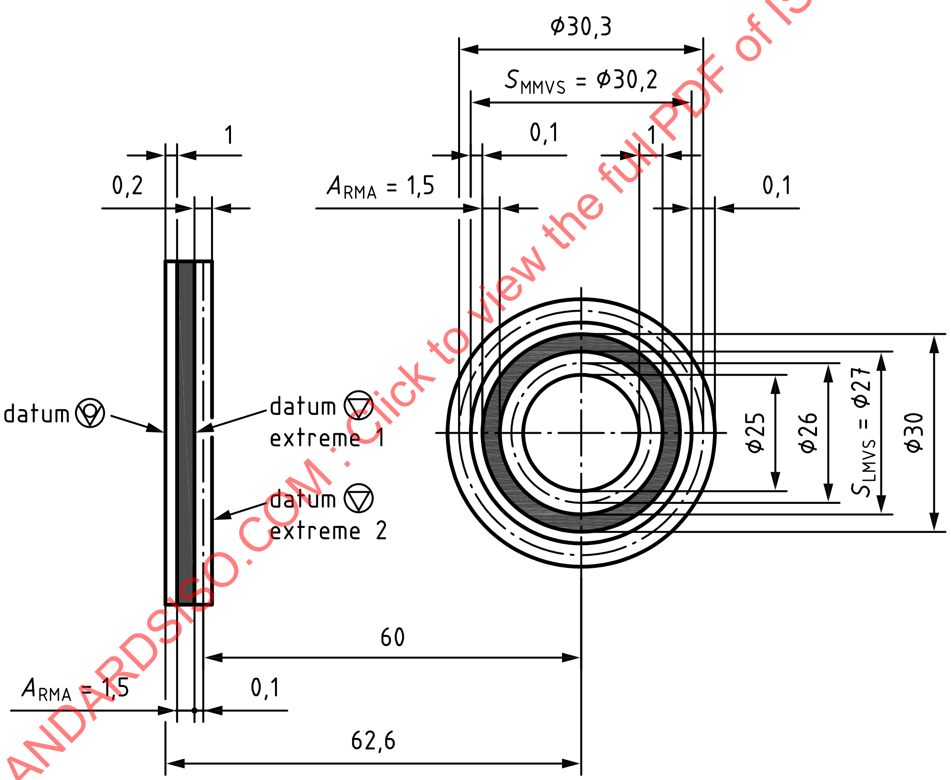


Figure D.2 — Feature of size (hole) relative to a plane datum

D.2.2 Interpretation of the drawing for intermediate machining

In order to machine the final moulded part as shown in Figure D.1 a), the thickness of the material to be removed (cutting depth c) by the intermediate machining at datum feature A is:

minimum: $$c = A_{\text{RMA}} + t_{\text{F}} = (1{,}5 + 1)\ \text{mm} \qquad \text{(D.1)}$$

maximum: $$c = A_{RMA} + t_F + t_{PROF} = (1{,}5 + 1 + 0{,}2)\ \text{mm} \quad \text{(D.2)}$$

If there is taper (draft), the corresponding material shall also be removed.

D.2.3 Interpretation of the drawing for final machining

In order to machine the final machined moulded part as shown in Figure D.1 a), the thickness of the material to be removed (cutting depth c) by the final machining at the toleranced hole (datum feature B) is:

minimum: $$c = A_{RMA} + \frac{t_{PROF}}{2} = (1{,}5 + 0{,}1)\ \text{mm} \quad \text{(D.3)}$$

maximum: $$c = A_{RMA} + \frac{t_{PROF}}{2} + t_{DCT} = (1{,}5 + 0{,}1 + 1)\ \text{mm} \quad \text{(D.4)}$$

If there is taper (draft), the corresponding material shall also be removed.

D.3 Feature of size (hole) relative to a derived datum axis

D.3.1 Design of the final moulded part

D.3.1.1 Information

In accordance with the functional requirement for the final machined moulded part [see Figure D.3 a)]:

— the maximum material requirement indicated on the hole datum B applies to both holes relative to each other with a distance of 95 mm;

— the diameter requirement for the hole (datum B) is ⌀ (30,3 ± 0,1) mm;

— the diameter requirement for the hole (datum A) is ⌀ (40,2 ± 0,2) mm.

Assuming that, according to the production planning, it is decided to have an intermediate machining of the part, where the hole (datum surface A) is machined.

As a consequence of the process ability of the intermediate machining [see Figure D.3. b)]:

— the positional tolerance (location) of datum feature B in relation to datum feature A is ⌀ 0,2 mm.

As a consequence of the process ability from the foundry [see Figure D.3 c)]:

— A_{RMA} = 1,5 mm;

— the diameter tolerance for the hole (datum B) t_D = ± 1 mm;

— the diameter tolerance for the hole (datum A) t_D = ± 1 mm.

The tolerancing shown in Figure D.4 is derived from this information. The part condition identifiers, intermediate machined and final machined, determine the sequence of manufacturing, i.e. the hole (datum A) is machined before the hole (datum B).

Dimensions in millimetres

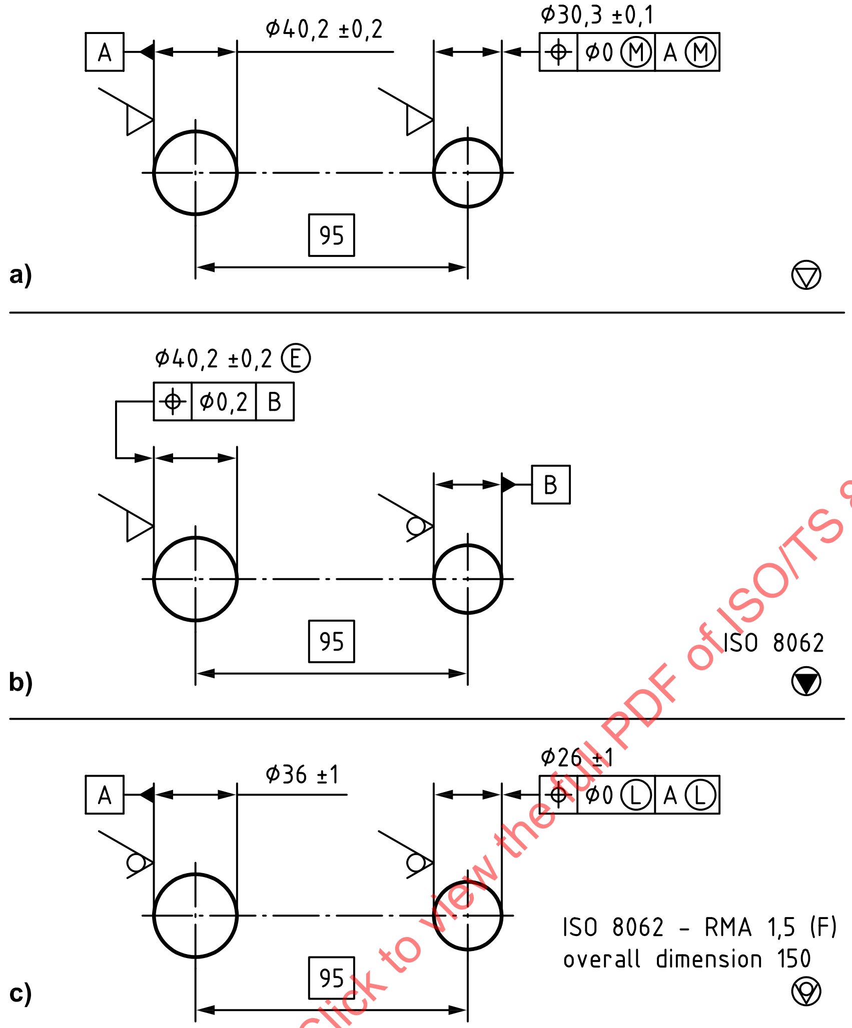


Figure D.3 — Feature of size (hole) relative to a cylindrical datum feature, requirements; a) final machined, b) intermediate machined, c) final moulded

D.3.1.2 Design process

The contour in the machined condition (two holes, 95 mm apart) perfect in form and orientation at maximum material virtual size ⌀(30,2) mm and maximum material virtual size ⌀(40) mm must be achievable.

D.3.1.3 Requirement for the intermediate part condition

The TED between the two holes (datum feature B and datum feature A) will remain the same for all three part conditions since the material to be added in order to calculate the dimension of the final moulded part can only be made by diminishing the diameter of the two holes.

In order to calculate the dimension of the final moulded part, material shall be added. The only way to do this is to add material to the two holes by diminishing the diameters of the holes.

In the intermediate part condition, only datum feature A is to be machined. Therefore, on the drawing for the intermediate part condition, only the requirement for the intermediate machined surface is stated.

The size of the hole (datum feature A) and its tolerance for the intermediate moulded-part condition are derived from the final machined moulded-part condition as follows.

Start with the size of the hole (datum A) of the final machined moulded part with a dimension of ϕ (40,2 ± 0,2) mm.

In order to meet the maximum material requirement on the datum A indicated on the positional tolerance for datum feature B of the final machined moulded-part condition, the envelope requirement is added.

The positional tolerance for this hole in relation to datum feature B is given by the ability of the intermediate machining process.

D.3.1.4 Size of the two holes for the final moulded-part condition

D.3.1.4.1 For datum feature A

Start with the size of the hole (datum A) in the intermediate machined moulded-part condition with a nominal dimension of ϕ (40,2) mm.

Taking into account half of the size tolerance of the hole (datum A) for the intermediate machined moulded-part condition, i.e. 0,4 mm/2 = 0,2 mm, the nominal size of the hole is ϕ 40 mm.

NOTE For the limiting deviations of ± 0,2 mm, the tolerance is 0,4 mm according to ISO 286-1.

Taking into account the required machining allowance two times (2 × 1,5 mm = 3 mm), the diameter of the hole is to be ϕ 37 mm.

Taking into account half of the size tolerance of the hole (datum A) for the final moulded-part condition, i.e. 2 mm/2 = 1 mm, the nominal size of the hole is ϕ 36 mm.

D.3.1.4.2 For datum feature B

Start with the size of the hole (datum B) in the final machined moulded-part condition with a nominal dimension of ϕ 30,3 mm.

Taking into account half of the size tolerance of the hole (datum B) for the final machined moulded-part condition, i.e. 0,2 mm/2 = 0,1 mm, the nominal size of the hole is ϕ 30,2 mm.

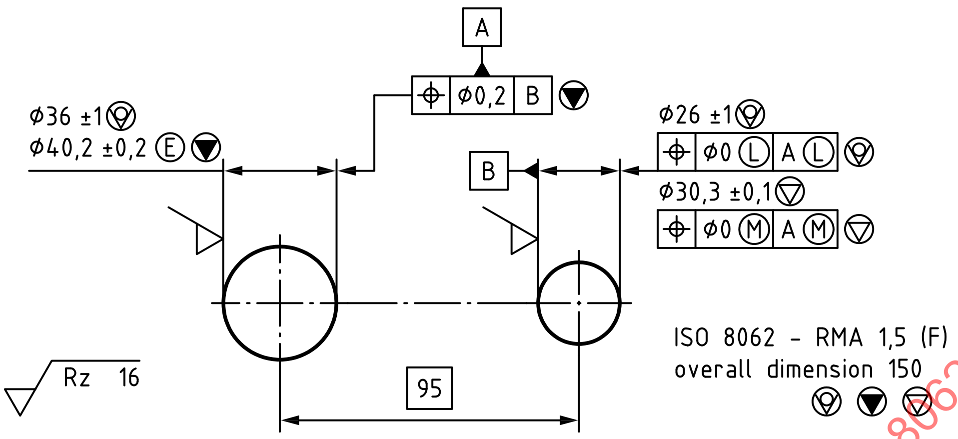
Taking into account the positional tolerance of the hole (datum A) in the intermediate machined moulded-part condition, i.e. 0,2 mm, the nominal size of the hole is ϕ 30 mm.

Taking into account the required machining allowance two times (2 × 1,5 mm = 3 mm), the diameter of the hole is to be ϕ 27 mm.

Taking into account half of the size tolerance of the hole (datum B) for the final moulded-part condition, i.e. 2 mm/2 = 1 mm, the nominal size of the hole ends up being ϕ 26 mm.

Dimensions in millimetres

Drawing indication:



Meaning:

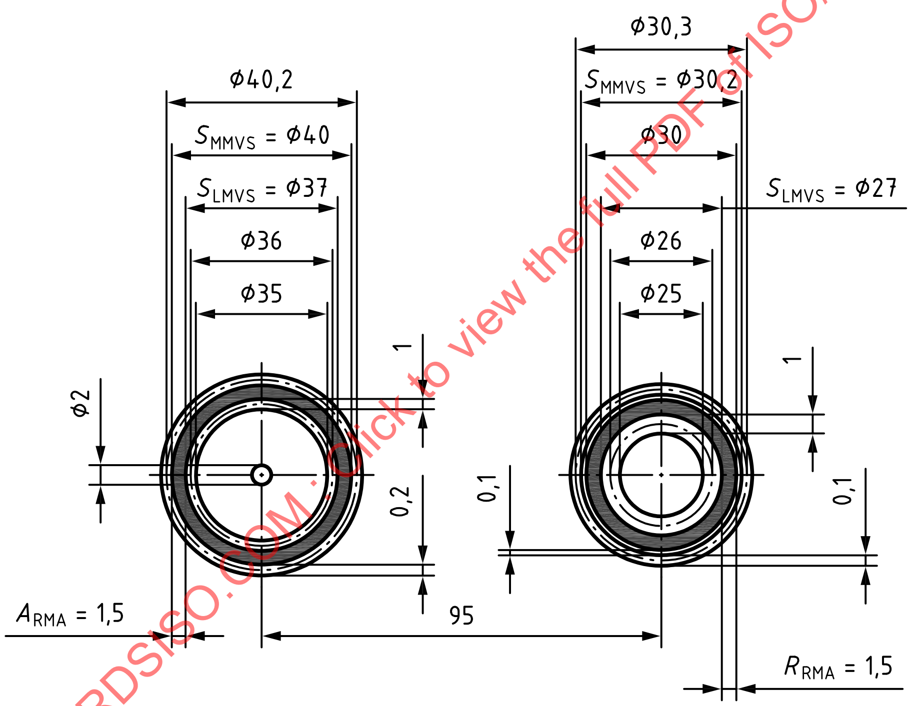


Figure D.4 — Feature of size (hole) relative to a cylindrical datum feature, combined drawing

D.3.2 Interpretation of the drawing for intermediate machining

In order to machine the final moulded part as shown in Figure D.3 a), the thickness of the material to be removed (cutting depth c, on the surface of a cylinder) by the intermediate machining at datum feature A is:

minimum: $$c = A_{RMA} = 1{,}5 \text{ mm} \tag{D.5}$$

maximum: $$c = A_{RMA} + \frac{t_{DCT}}{2} + \frac{t_{DMT}}{2} = (1{,}5 + 1 + 0{,}2) \text{ mm} \tag{D.6}$$

If there is taper (draft), the corresponding material shall also be removed.

D.3.3 Interpretation of the drawing for final machining

In order to machine the final machined moulded part as shown in Figure D.3 a), the material to be removed (cutting depth *c*, on the surface of a cylinder) by the final machining at the toleranced feature (datum B) is:

minimum: $$c = A_{\text{RMA}} + \frac{t_{\text{POSI}}}{2} = (1{,}5 + 0{,}1)\ \text{mm} \qquad \text{(D.7)}$$

maximum: $$c = A_{\text{RMA}} + \frac{t_{\text{POSI}}}{2} + \frac{t_{\text{DCT}}}{2} + \frac{t_{\text{DMT}}}{2} = (1{,}5 + 0{,}1 + 1 + 0{,}1)\ \text{mm} \qquad \text{(D.8)}$$

If there is taper (draft), the corresponding material shall also be removed.

D.4 Plane relative to a plane datum (step dimension)

D.4.1 Design of the final moulded part

D.4.1.1 Information

In accordance with the functional requirement for the final machined moulded part [see Figure D.5 a)]:

— the flatness tolerance of datum feature B is 0,1 mm;

— the surface profile tolerance (location) of the surface (datum feature A) shall be 0,1 mm in relation to datum B with a distance of 60,25 mm.

Assuming that, according to the production planning, it is decided to have an intermediate machining of the part, where datum surface B is machined.

As a consequence of the process ability of the intermediate machining [see Figure D.5. b)]:

— the surface profile tolerance (location) of datum surface B in relation to datum surface A is 0,2 mm.

As a consequence of the process ability from the foundry [see Figure D.5 c)]:

— A_{RMA} = 1,5 mm;

— the surface profile tolerance (location) of datum surface B in relation to datum surface A is 2 mm;

— the flatness tolerance of datum surface A is 1 mm.

From this information, the tolerancing shown in Figure D.5 is derived. The part condition identifiers (intermediate machined and final machined) determine the sequence of manufacturing.

Dimensions in millimetres

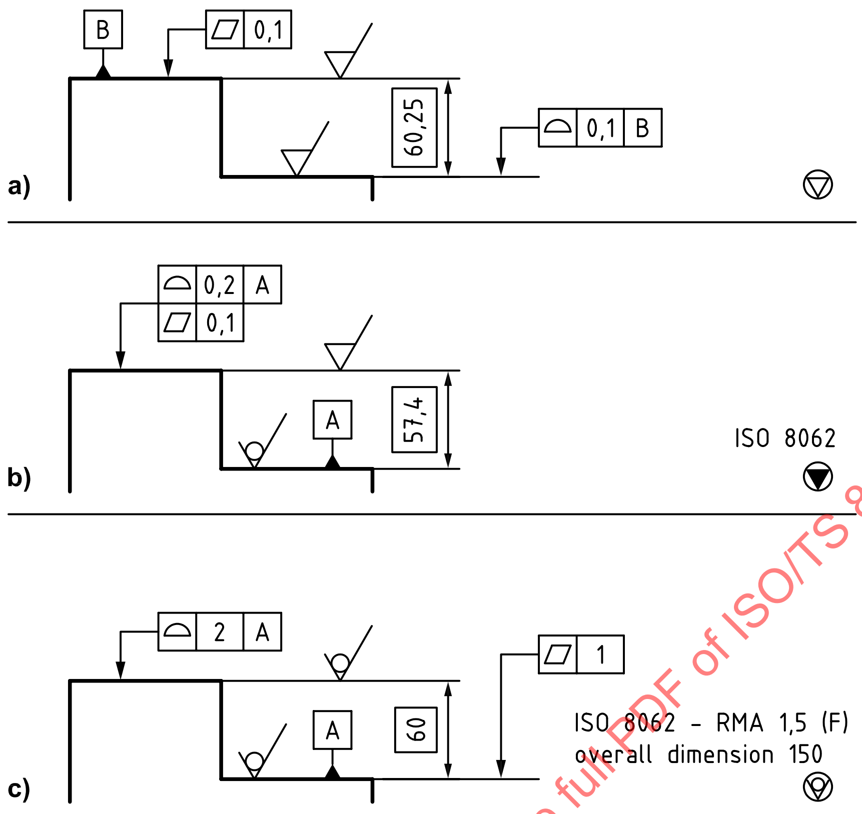


Figure D.5 — Plane relative to a plane datum (step dimension), requirements; a) final machined, b) intermediate machined, c) final moulded

D.4.1.2 Design process

The contour in the machined condition (plane datum surface A and plane datum surface B, 60,25 mm apart) must be achievable.

The theoretically exact dimension (TED) for the intermediate moulded-part condition is calculated as follows.

Start with the theoretically exact dimension of 60,25 mm from machined datum surface B to the surface (datum A).

Taking into account half of the surface profile tolerance for location of surface (datum A) on the final machined moulded part, i.e. 0,1 mm/2 = 0,05 mm, the TED in the intermediate moulded-part condition becomes 60,20 mm.

Taking into account the required machining allowance on datum surface A, i.e. 1,5 mm, the TED in the intermediate moulded-part condition becomes 58,7 mm.

Taking into account the surface flatness tolerance of the final moulded part for the surface (datum A), i.e. One mm, the TED in the intermediate moulded-part condition becomes 57,7 mm.

Taking into account the possible inclination of the intermediate machined surface (datum B), i.e. 0,2 mm × 40/40 = 0,2 mm (calculation of the extreme situation – worst case), the TED in the intermediate moulded-part condition becomes 57,5 mm.

NOTE The shown inclination pertains to the worst case. The other extreme, which is inclination in the opposite direction, leads to smaller values and to less material being removed.

Taking into account the surface profile tolerance (location) of the final machined moulded part for datum surface B in relation to datum A, i.e. 0,2 mm/2 = 0,1 mm, the TED in the intermediate moulded-part condition ends up being 57,4 mm.

It is not necessary to take the flatness tolerance of 0,1 mm of the final machined moulded part for datum surface B into account, since it is already included in the surface profile tolerance (location) of the final machined moulded part for datum surface B in relation to datum A. However, the intermediate machining shall respect the flatness tolerance requirement.

D.4.1.3 Calculation of the theoretically exact dimension (TED) for the moulded-part condition

Start with the theoretically exact dimension of 57,4 mm from intermediate machined datum surface B to the surface (datum A).

Taking into account half of the surface profile tolerance (location) of datum surface B on the intermediate machined moulded part, i.e. 0,2 mm/2 = 0,1 mm, the TED in the final moulded-part condition becomes 57,5 mm.

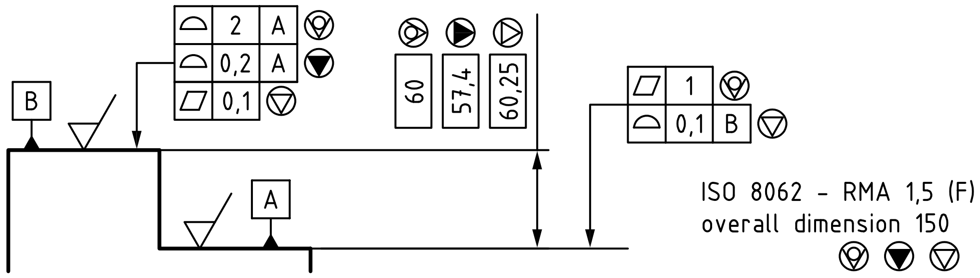
Taking into account the required machining allowance on datum surface B, i.e. 1,5 mm, the TED in the final moulded-part condition becomes 59 mm.

Taking into account half of the surface profile tolerance (location) of moulded datum surface B in relation to datum A, i.e. Two mm/2 = 1 mm, the TED in the final moulded-part condition ends up being 60 mm.

See Figure D.6.

Dimensions in millimetres

Drawing indication:



Meaning:

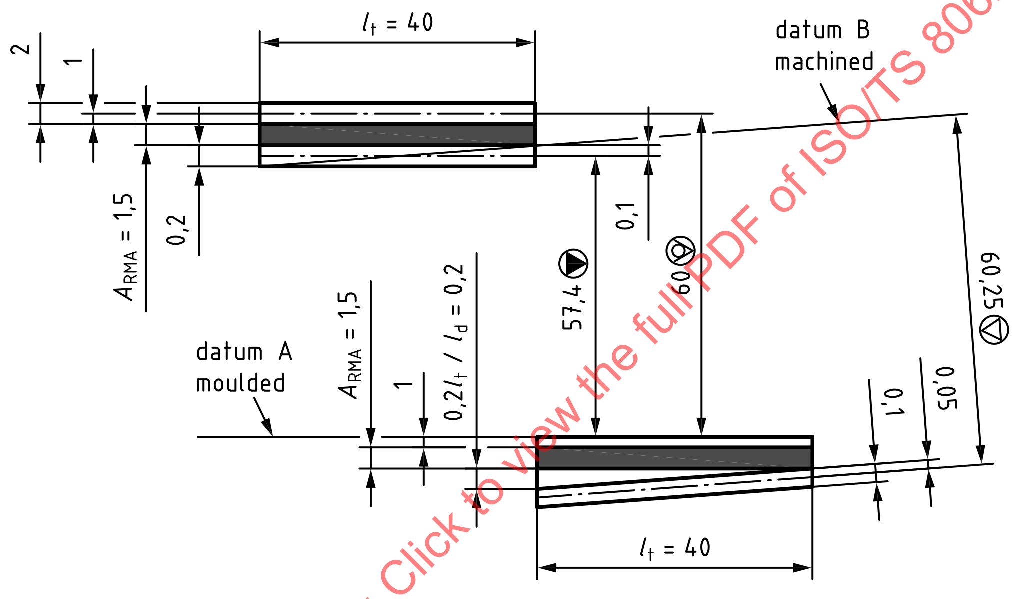


Figure D.6 — Plane relative to a plane datum (step dimension), combined drawing

D.4.2 Interpretation of the drawing for intermediate machining

In order to machine the final moulded part as shown in Figure D.5 a), the material to be removed (cutting depth c) by the intermediate machining at datum feature B is:

minimum: $c = A_{RMA} = 1{,}5$ mm (D.9)

maximum: $c = A_{RMA} + t_{PROFC} + t_{PROFI} = (1{,}5 + 2 + 0{,}2)$ mm (D.10)

If there is taper (draft), the corresponding material shall also be removed.

D.4.3 Interpretation of the drawing for final machining

In order to machine the final machined moulded part as shown in Figure D.5 a) the thickness of the material to be removed (cutting depth c) by the final machining at datum feature A is:

minimum: $c = A_{RMA} + t_{FLAC} + c_{inclin} = (1{,}5 + 1 + 0{,}2)$ mm (D.11) maximum: $$c = A_{\mathrm{RMA}} + t_{\mathrm{FLAC}} + t_{\mathrm{PROFM}} + c_{\mathrm{inclin}} = (1{,}5 + 1 + 0{,}1 + 0{,}2)\ \mathrm{mm} \quad \text{(D.12)}$$

If there is taper (draft), the corresponding material shall also be removed.

Annex E
(informative)

Drawing examples

Drawing examples are given in Figures E.1 to E.10.

Dimensions in millimetres

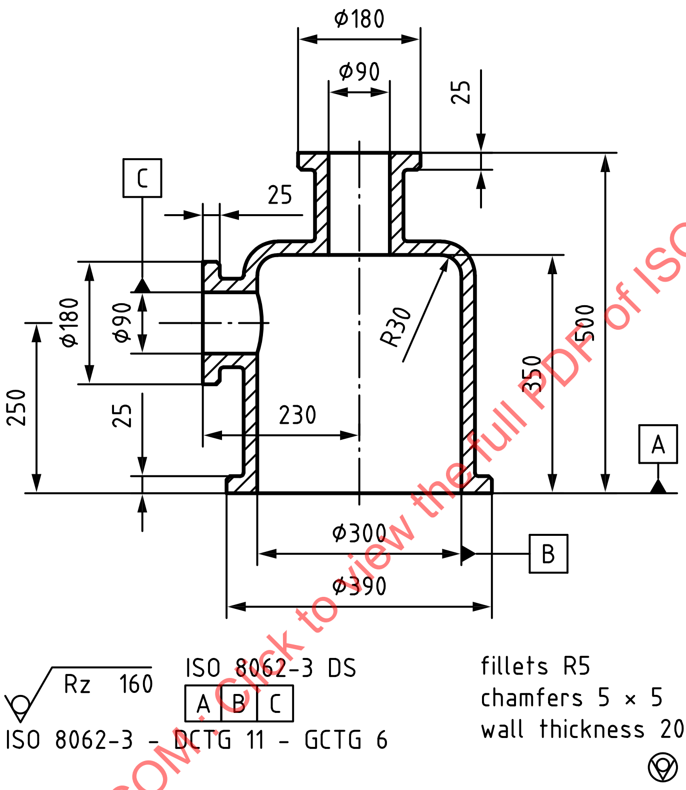


Figure E.1 — Final moulded part, ± tolerances

Meaning: The dimensional and geometrical tolerances according to ISO 8062-3 — DCTG 11 — GCTG 6 apply independent of each other.

This type of tolerancing is not recommended because of large specification ambiguities.

Dimensions in millimetres

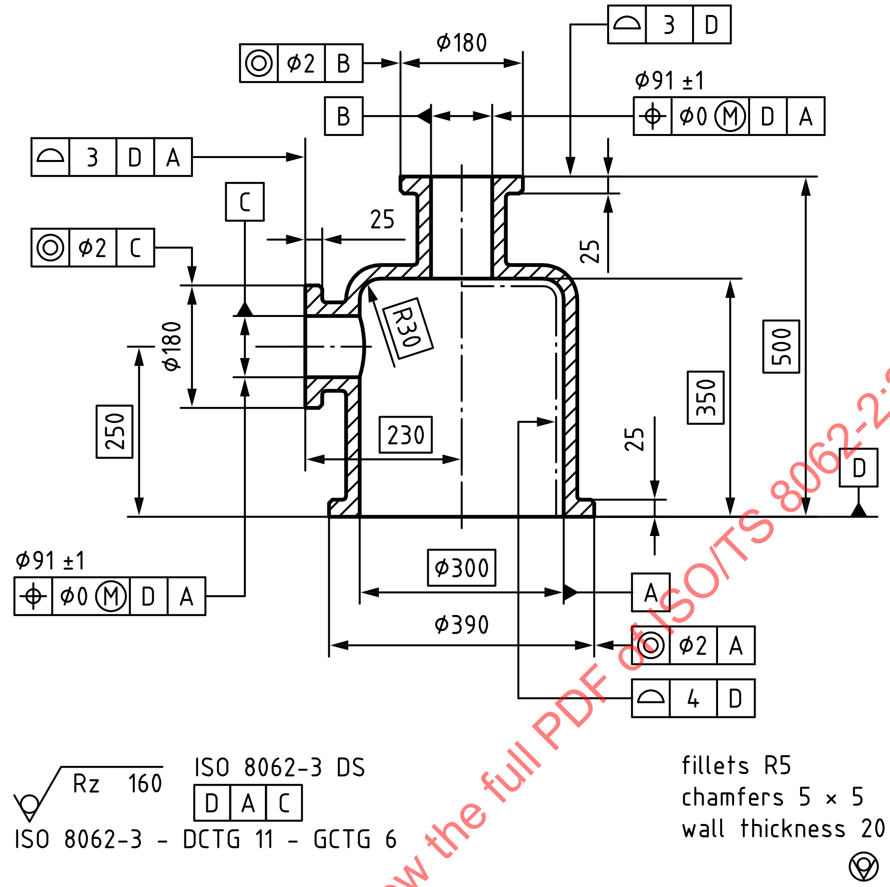


Figure E.2 — Final moulded part, general tolerances ISO 8062-3 and individual tolerances

Meaning: The indicated tolerances apply. For the remaining characteristics, the general tolerances apply (ISO 8062-3).

Dimensions in millimetres

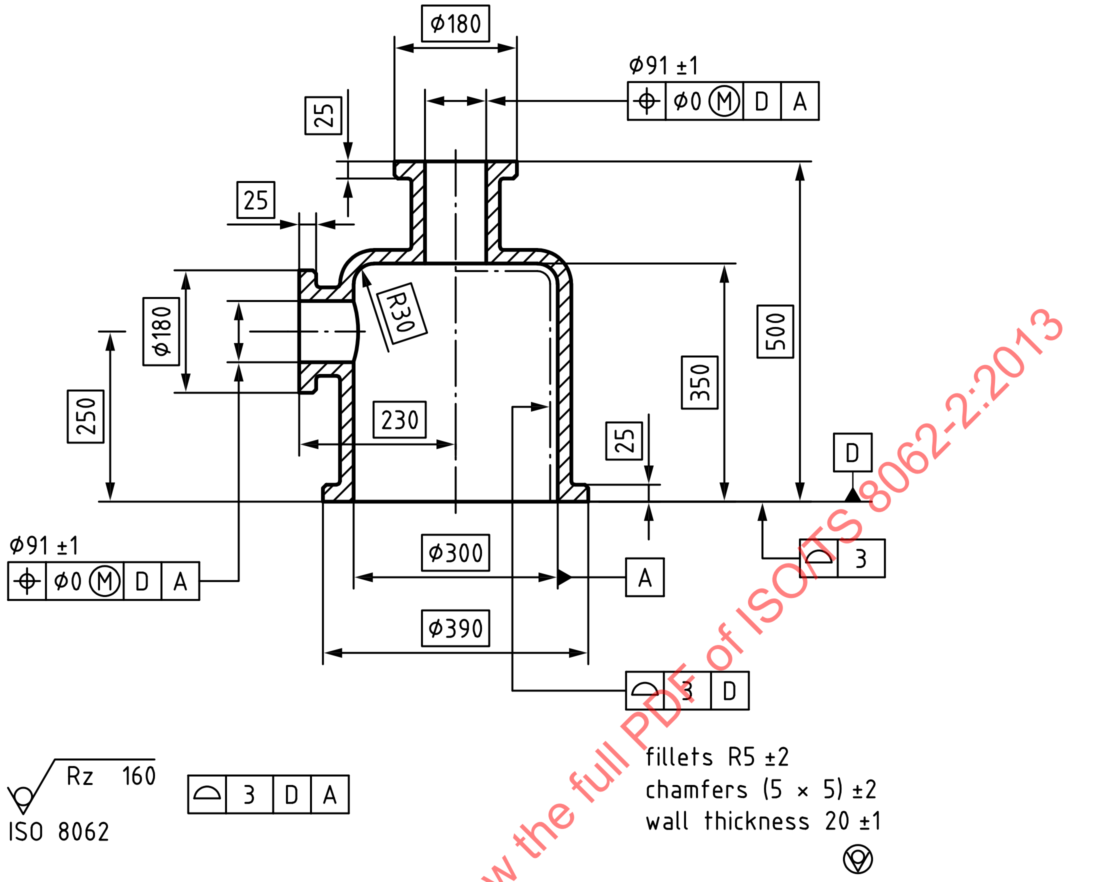


Figure E.3 — Final moulded part, particular general tolerances and individual tolerances

The general surface profile tolerance and the individual tolerances define the geometry practically without uncertainty. The general surface profile tolerance 3 mm does not apply to Ø 91 mm because there is no TED.

This type of tolerancing is recommended.

Dimensions in millimetres

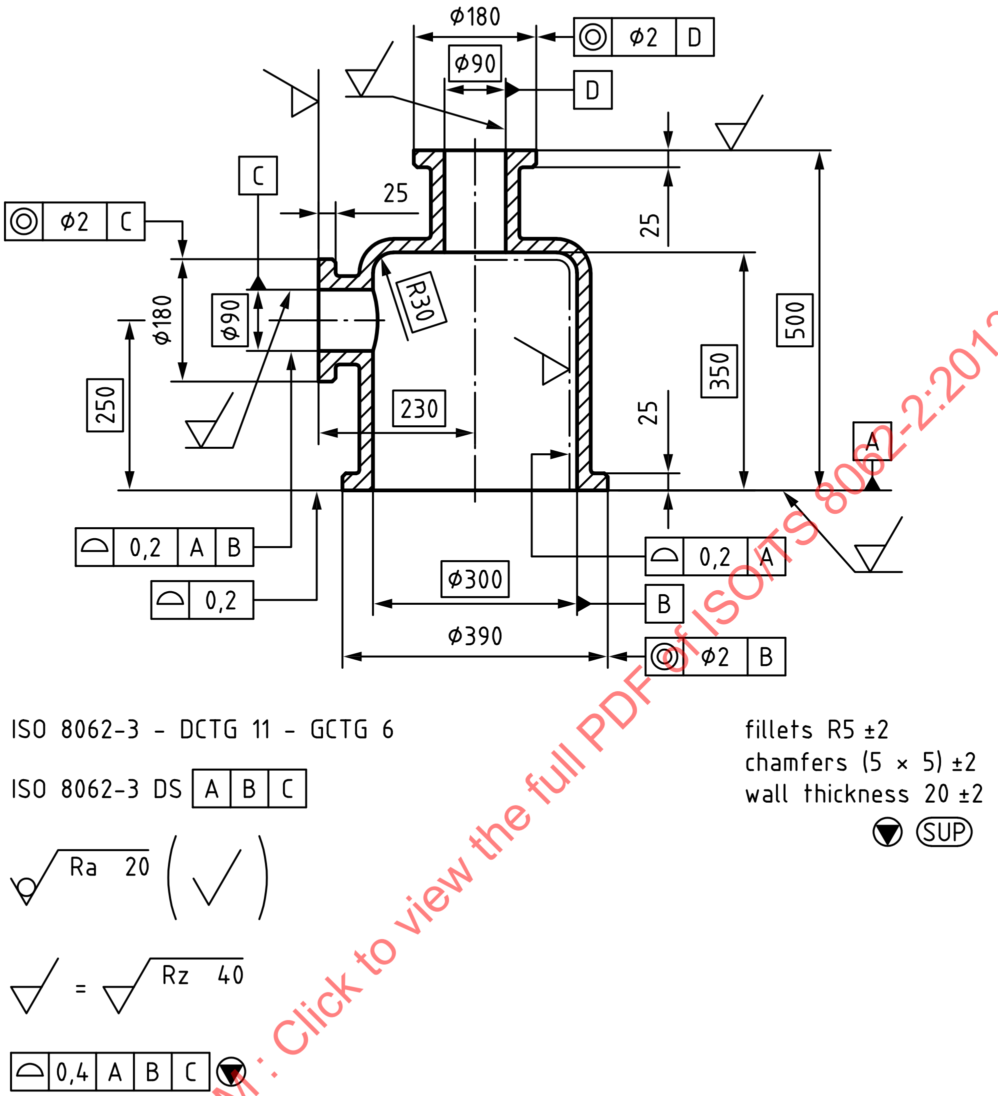


Figure E.4 — Intermediate machined moulded part SUP, general tolerances ISO 8062-3 for moulded surfaces

Meaning: Profile tolerances define tolerance zones and thereby a perfect shape of least material of the following dimensions: ⌀ 300,2 mm, R 30,2 mm, 350 mm, ⌀ 90,4 mm, ⌀ 90,4 mm, 249,8 mm, 229,8 mm, 499,6 mm. [For the calculation, it is assumed that at the datum surfaces 0,2 mm (= profile tolerance) will be finally removed.]

The final machined moulded part with all deviations and with an additional material layer of the final machining allowance must fit into the material of this shape.

Wall thicknesses (20 ± 2) mm.

Dimensions ⌀ 390 mm, ⌀ 180 mm, and thickness 25 mm within ISO 8062-3 — DCTG 11.