BS 8888:2013

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Technical product documentation and specification

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Contents

List of tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 118, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 December 2013. It was prepared by Subcommittee TDW/4/8, *BS 8888 – Technical product specification*, under the authority of Technical Committee TDW/4, *Technical product realization*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 8888:2011, which is withdrawn.

Information about this document

This edition of the standard is a full revision. It introduces relevant international standards published since the 2011 edition. It also incorporates more fully than previous editions some of the fundamental requirements of the key international standards relevant to the preparation of technical product specifications, such as BS EN ISO 1101 and BS EN ISO 5459. It is hoped that UK industry will find this edition of BS 8888 more user-friendly than previous editions. It aims to help organizations better understand and implement the full complement of International Standards developed by ISO/TC 213, *Geometrical product specifications and verification*, and ISO/TC 10, *Technical product documentation*.

Relationship with other publications

The function of BS 8888 is to draw together, in an easily accessible manner, the full complement of international standards relevant to the preparation of technical product specifications. However, it is not the intention for BS 8888 to be a "stand-alone" standard. TDW/4 is responsible for a suite of related national standards, including the various parts of BS 8887, BS 8889[1)] and PD 68888, a new training document.

BS 8888 was taken up by the Ministry of Defence in 2006 as part of its DEF-STAN for defence project specification.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

In addition, information boxes provide additional informative material that might otherwise have appeared in informative annexes, but was felt to be best placed in the main body of text.

All dimensions shown in the figures in this British Standard are in millimetres.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1) In development.

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Section 1: Scope

1.1 Scope

This British Standard implements the ISO system for technical product documentation and specification.

The ISO system is defined in a large number of interlinked and related international standards which are referenced in this British Standard.

The purpose of this British Standard is to facilitate the use of the ISO system by providing:

- an index to the international standards which make up the ISO system, referencing them according to their area of application;
- key elements of the ISO standards to facilitate their application;
- references to additional British and European Standards where they provide information or guidance over and above that provided by ISO standards; and
- commentary and recommendations on the application of the standards where this is deemed useful.

The requirements refer to International and European Standards which have been implemented as British Standards, either in the BS EN, BS EN ISO, BS ISO series or as International Standards renumbered as British Standards.

Annex A (normative) contains a list of normative references, indispensable for the application of this British Standard.

Annex B (informative) contains a list of informative references.

Annex C (informative) gives examples of geometrical tolerances and requirements associated with them.

Annex D (normative) contains requirements for enhanced security.

1.2 Normative references

The documents listed in Annex A, 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.

1.3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN ISO 10209 and BS EN ISO 14660-1 apply, together with the following.

1.3.1 date of issue

point in time at which the technical product specification is officially released for its intended use

NOTE 1 The date of issue is important for legal reasons, e.g. patent rights, traceability.

*NOTE 2 For the implications of the date of issue, see **4.2**.*

1.3.2 ISO GPS system

geometrical product specification and verification system developed in ISO by ISO/TC 213

1.3.3 technical product documentation (TPD)
means of conveying all or part of a design definition or specification of a product

1.3.4 technical product specification (TPS)
technical product documentation comprising the complete design definition and specification of a product for manufacturing and verification purposes

NOTE A TPS, which might contain drawings, 3-D models, parts lists or other documents forming an integral part of the specification, in whatever format they might be presented, might consist of one or more TPDs.

Section 2: Standards underpinning BS 8888

2.1 General

The following documents shall be applied as "global" standards in support of BS 8888.

ISO/IEC Guide 98-3 *Guide to the expression of uncertainty in measurement (GUM)*

ISO/IEC Guide 99 *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

The principles in Section 3 shall always be applied where conformity with BS 8888 is claimed.

Section 3: Symbols and abbreviations

3.1 Symbols and abbreviations

3.1.1 General

Abbreviations (text equivalents) used in a TPS shall be the same in the singular and plural. Full stops shall not be used, except where the abbreviation forms a word (e.g. NO. as an abbreviation for "number").

*NOTE Where possible, abbreviations should be avoided (see **3.1.2**).*

Symbols used for physical quantities and units of measurement shall conform to the following standards, as appropriate.

BS EN ISO 80000-1	*Quantities and units – Part 1: General*
BS EN ISO 80000-2	*Quantities and units – Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*
BS EN ISO 80000-3	*Quantities and units – Part 3: Space and time*
BS EN ISO 80000-4	*Quantities and units – Part 4: Mechanics*
BS EN ISO 80000-5	*Quantities and units – Part 5: Thermodynamics*
BS EN ISO 80000-6	*Quantities and units – Part 6: Electromagnetism*
BS ISO 80000-7	*Quantities and units – Part 7: Light*
BS EN ISO 80000-8	*Quantities and units – Part 8: Acoustics*
BS EN ISO 80000-9	*Quantities and units – Part 9: Physical chemistry and molecular physics*
BS EN ISO 80000-10	*Quantities and units – Part 10: Atomic and nuclear physics*
BS EN ISO 80000-11	*Quantities and units – Part 11: Characteristic numbers*
BS EN ISO 80000-12	*Quantities and units – Part 12: Solid state physics*
BS EN 80000-13	*Quantities and units – Part 13: Information science and technology*
BS EN 80000-14	*Quantities and units – Part 14: Telebiometrics related to human physiology*

3.1.2 Standard symbols and abbreviations

*COMMENTARY ON **3.1.2***
In the existing environment of outsourcing across national borders, every effort is being made to make the use of GPS (geometrical product specification) independent of language through the adoption of standard symbology. It is for this reason that the continued use of abbreviations is deprecated.

Where particular specification requirements cannot be expressed using the available GPS system, full text description shall be employed.

NOTE 1 It is suggested that, where such a requirement occurs frequently, this be drawn to the attention of the relevant ISO committee through the appropriate BSI Technical Committee.

For diagrams used in technical applications, a library of harmonized graphical symbols has been developed with close cooperation between ISO and IEC. This is published in the following series of standards and these shall be applied wherever practicable to improve the universal applicability of the TPS.

BS ISO 14617-1 *Graphical symbols for diagrams – Part 1: General information and indexes*

BS ISO 14617-2 *Graphical symbols for diagrams – Part 2: Symbols having general application.*

BS ISO 14617-3 *Graphical symbols for diagrams – Part 3: Connections and related devices*

BS ISO 14617-4 *Graphical symbols for diagrams – Part 4: Actuators and related devices*

BS ISO 14617-5 *Graphical symbols for diagrams – Part 5: Measurement and control devices*

BS ISO 14617-6 *Graphical symbols for diagrams – Part 6: Measurement and control functions.*

BS ISO 14617-7 *Graphical symbols for diagrams – Part 7: Basic mechanical components*

BS ISO 14617-8 *Graphical symbols for diagrams – Part 8: Valves and dampers*

BS ISO 14617-9 *Graphical symbols for diagrams – Part 9: Pumps, compressors and fans*

BS ISO 14617-10 *Graphical symbols for diagrams – Part 10: Fluid power converters*

BS ISO 14617-11 *Graphical symbols for diagrams – Part 11: Devices for heat transfer and heat engines*

BS ISO 14617-12 *Graphical symbols for diagrams – Part 12: Devices for separating purification and mixing*

Symbols appropriate to TPS are provided and detailed throughout the suite of documents cross-referenced from this British Standard and these shall be used where appropriate.

NOTE 2 It is strongly recommended that abbreviations not be used.

Where, in particular technical fields, certain abbreviations are in common use and generally understood, it is accepted that these may continue to be used, but new abbreviations shall not be introduced.

NOTE 3 Former practice has resulted in certain abbreviations becoming accepted as symbols and these should not be considered to provide precedence for the proliferation of abbreviations.

Section 4: Principles of specification

4.1 General principles of specification

4.1.1 A TPS shall document the criteria that the manufactured product has to satisfy.

NOTE 1 The TPS might include requirements of individual manufactured components, where necessary.

NOTE 2 The TPS might include additional information required for the manufacture, verification, maintenance and disposal of the product.

NOTE 3 Criteria might include requirements relating to the appearance, transportation, storage, maintenance, assembly, disassembly, recycling and disposal of the product, as well as its performance and reliability in use.

Sizes, geometrical relationships and tolerances which are necessary for the correct functioning or location of a component or assembly shall be specified through the use of datums, dimensions and tolerances.

NOTE 4 Selection of datum features which are not related to the function or location of a component or assembly results in the need for tighter tolerances.

4.1.2 A TPS shall provide sufficient information to avoid ambiguity of interpretation.

NOTE A TPS is not complete if there is more than one possible interpretation of the specification.

4.1.3 A TPS shall provide sufficient information for the product to be manufactured, but shall not unnecessarily constrain manufacturing methods.

NOTE A particular manufacturing process which has been tested and approved for the production of a safety-critical component is an example of a situation where there is a requirement to specify the manufacturing method.

4.1.4 A TPS shall provide sufficient information for the verification of each element of the specification, but shall not unnecessarily constrain verification methods.

4.1.5 A TPS shall provide all the information necessary for the manufacture and verification of the product, or state where that information can be found.

NOTE 1 This might be achieved through the use of notes and references to other standards or documents.

NOTE 2 Requirements not specified in the TPS cannot be enforced.

4.1.6 Where a TPS includes requirements relating to several stages of completion of the product, it shall indicate which stage each indication refers to, unless it is the finished product.

4.2 Date of issue principle

A TPS shall always be interpreted according to those versions of standards which governed its interpretation on its date of issue.

NOTE What is not specified in a TPS at the date of issue cannot be required.

4.3 Reference condition principle

Unless otherwise stated, all geometrical properties and tolerances for a workpiece given in a TPS shall be considered to apply at 20 °C.

NOTE 1 See BS EN ISO 1.

Unless otherwise stated, the workpiece shall be considered to have infinite stiffness, and all geometrical properties and tolerances given in a TPS shall be

considered to apply in the absence of deformation from any external forces (including gravity).

*NOTE 2 This is of particular importance when aligning and/or measuring large and/or flexible constructions. See **5.3.2**.*

4.4 Interpretation

A TPS shall indicate which standards, or systems of standards, govern its interpretation.

When the presentation of data in a TPS conforms to the British and ISO standards identified in BS 8888, a reference to BS 8888 itself shall be sufficient to indicate that these standards apply to the specification. Such a reference shall take the following form.

CONFORMS TO BS 8888

NOTE 1 This note may be placed in the title block, in a drawing note, or elsewhere within the drawing frame.

NOTE 2 The phrase "presentation of data" refers to layout of drawing borders and title blocks, layout of views and projections, format of letters, numbers, dimensions and tolerances, use of different line types and thicknesses, etc.

When the geometry of a workpiece is defined according to the requirements of ISO GPS (see **7.1**), which are documented in standards such as BS EN ISO 5459 and BE EN ISO 1101, a reference to BS EN ISO 8015 is sufficient to indicate that all ISO GPS standards apply to the interpretation of that specification. Such a reference shall take the following form.

TOLERANCING ISO 8015

NOTE 3 This note may be placed in the title block, in a drawing note, or elsewhere within the drawing frame. This note is required in addition to any reference to BS 8888.

This marking is a BS 8888 requirement, and not a requirement of BS EN ISO 8015. This is necessary to avoid possible misinterpretation of which system of standards govern the interpretation of a TPS.

4.5 Decimal principle

Non-indicated decimals shall be taken as zeroes.

NOTE 1 0,2 is the same as 0,200 000 000 000 000 000 000 000 000 000 ... etc.

NOTE 2 10 is the same as 10,000 000 000 000 000 000 000 000 000 000 ... etc.

4.6 Rigid workpiece principle

By default, a workpiece shall be considered as having infinite stiffness and all GPS specifications shall apply in the free state, undeformed by any external forces, including the force of gravity. Any additional or other conditions that apply shall be defined in the drawing.

NOTE See, for example, BS ISO 10579.

4.7 Representation of features

Conventions used for the representation of features shall conform to the following standards, as appropriate.

BS EN ISO 4063 *Welding and allied processes – Nomenclature of processes and reference numbers*

BS EN ISO 5261 *Technical drawings – Simplified representation of bars and profile sections*

BS EN ISO 5845-1 *Technical drawings – Simplified representation of the assembly of parts with fasteners – Part 1: General principles*

BS EN ISO 6410-1 *Technical drawings – Screw threads and threaded parts – Part 1: General conventions*

BS EN ISO 6410-2 *Technical drawings – Screw threads and threaded parts – Part 2: Screw thread inserts*

BS EN ISO 6410-3 *Technical drawings – Screw threads and threaded parts – Part 3: Simplified representation*

BS EN ISO 6411 *Technical drawings – Simplified representation of centre holes*

BS EN ISO 6413 *Technical drawings – Representation of splines and serrations*

BS ISO 13715 *Technical drawings – Edges of unidentified shape – Vocabulary and indications*

BS EN ISO 15785 *Technical drawings – Symbolic presentation and indication of adhesive, fold and pressed joints*

BS EN 22553 *Welded, brazed and soldered joints – Symbolic representation on drawings*

NOTE The BS ISO 128 series of standards covers the general subject of feature representation.

Section 5: Fundamental concepts

5.1 Properties

A TPS defines various properties and requirements. Some properties or requirements may be defined for an entire workpiece (e.g. a material specification), some for part of a workpiece (e.g. a particular surface treatment), and some for individual features on a workpiece (e.g. a size requirement). Properties or requirements may also be defined for a process or procedure.

Properties which may be specified include:

- size;
- location;
- orientation;
- form;
- surface texture;
- surface imperfections;
- properties of edges;
- material;
- coatings and finishes;
- hardness;
- chemical composition;
- treatments which are to be applied to the workpiece;
- processing requirements;
- recycling requirements;
- packaging requirements;
- handling requirements.

Properties of size, location, orientation and form may be defined solely with toleranced dimensions (see Section 7), but this results in ambiguous specifications which are open to a wide range of interpretations.

For an unambiguous definition of the size, location, orientation and form of features on the workpiece, the ISO system of Geometrical Product Specification shall be used (see Section 7). This utilizes datums and geometrical tolerances to minimize ambiguity.

5.2 Features

A workpiece shall be considered as made up of a number of features limited by natural boundaries. By default, every specification requirement for a feature or relation between features shall apply to the entire feature and each specification requirement shall apply only to one feature or one relation between features.

NOTE This default can only be overridden by explicit indications on the drawing. The system for classifying features is outlined in the following information box.

Classification of features

ISO GPS defines several different types of feature. The main types of features are:

a) integral features: features which consist of, or represent, surfaces on the workpiece;

b) features of size: integral features which have a size characteristic and can consist of:

   1) two parallel opposed planes;

   2) a cylinder;

   3) a sphere;

   4) two non-parallel planes (a wedge);

   5) a cone; and

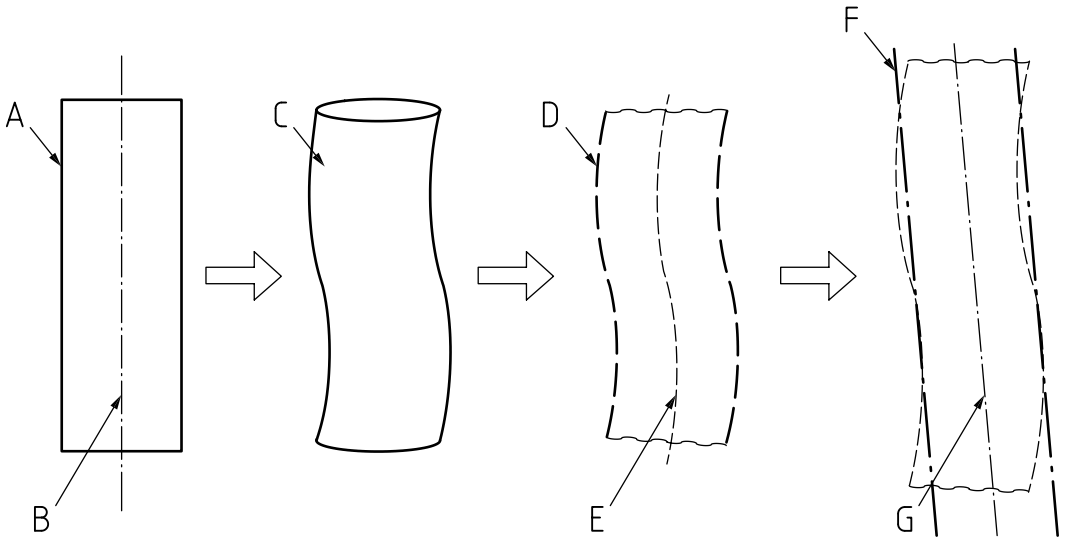
   6) a torus;

c) derived features: theoretical features, such as axes or median lines, which are derived from a feature of size (axis or median line, median plane or median surface, and centre points).

ISO GPS also defines a number of different "worlds" or "states" that features can exist in. In some "worlds" the features exist in an ideal form, such as in the specification, while in other states they exist in a non-ideal form, such as surfaces on the manufactured workpiece.

NOTE 1 See Figure 1.

Figure 1 **Interrelationship of the geometrical feature definitions**



Key

A Nominal integral feature
B Nominal derived feature
C Real feature
D Extracted integral feature
E Extracted derived feature
F Associated integral feature
G Associated derived feature

Nominal features

In the "world" of the specification, features are represented in an ideal state. These features have ideal form, and ideal relationships with each other. Features in this world are known as nominal features.

Real features

In the "world" of the manufactured workpiece (the physical world), features are non-ideal, and are known as real features.

Extracted features

In the "world" of verification, a feature is represented by a set of data obtained by sampling the workpiece with measuring instruments. This set of data represents the non-ideal real feature, and is known as an extracted feature.

NOTE 2 The extracted feature is used when determining whether a tolerance requirement has been met.

Associated features

In the "world" of verification, an ideal feature may be "fitted" to, or associated with, either the real feature or the extracted feature. This ideal feature is known as an associated feature.

NOTE 3 The associated feature is used when determining the orientation of size measurements, or when defining a datum. A range of different association methods may be used.

5.3 Interpretations of limits of size for a feature-of-size

5.3.1 General

BS EN ISO 14405-1 states that the default definition of a size tolerance is the "two-point" definition. This means that size limits only apply to any "two-point" size measurement of a feature. Therefore, the size limits do not control the form deviations of the feature. For example:

- the size limits on a cylindrical feature do not control its roundness or straightness;
- the size limits on a feature consisting of two parallel, opposed planes do not control the flatness of the two planes.

Form deviations can be controlled by:

- individually specified geometrical tolerances;
- general geometrical tolerances; or
- the use of the envelope requirement (where the maximum material limit of size defines an envelope of perfect form for the relevant surfaces, see BS EN ISO 14405-1).

Limits of size for an individual feature-of-size shall be interpreted according to the principles and rules defined in the following standards.

NOTE Figure 2 gives examples of how size limits could be interpreted where no form control is defined and the specification is incomplete.

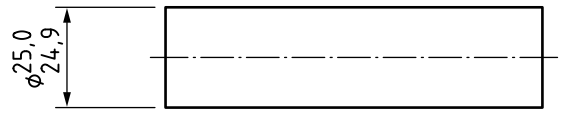
BS EN ISO 8015 *Geometrical product specifications (GPS) – Fundamentals – Concepts, principles and rules*

BS EN ISO 14405-1 *Geometrical product specifications (GPS) – Dimensional tolerancing – Part 1: Linear sizes (ISO 14405-1:2010)*

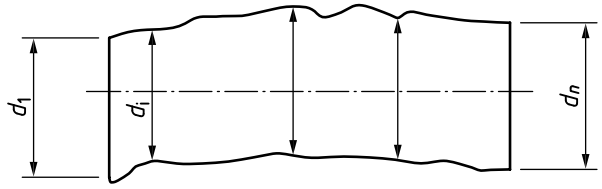
BS EN ISO 14660-1 *Geometrical product specifications (GPS) – Geometrical features – Part 1: General terms and definitions.*

BS EN ISO 14660-2 *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*

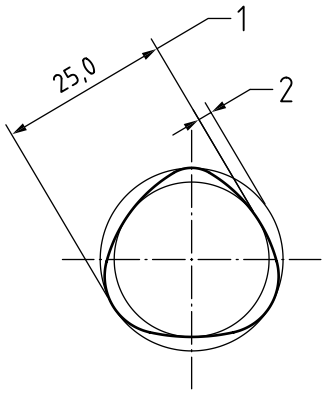
Figure 2 **Possible interpretations of size limits where no form control is defined and the specification is incomplete**



a) Drawing presentation



b) Size limit being met, but no control over the straightness of the feature



c) Size limit being met, but no adequate control over the roundness of the feature

NOTE For any cross section of the cylinder, there is no roundness control.

Key

1 Local size

2 Roundness deviation

5.3.2 Limits of size with mutual dependency of size and form

Some national standards apply, or have applied, the envelope requirement to all features-of-size by default. As the envelope requirement has been the default, they have not used a symbol to indicate this requirement; rather, they use a note to indicate when this is not required. This system of tolerancing is sometimes described as the principle of dependency, or the application of the Taylor Principle.

Standards which apply, or have applied, the envelope requirement by default include BS 308 and ASME Y14.5 [1] (the requirement that there is an envelope of perfect form corresponding to the Maximum Material Size of the feature is defined as Rule #1 in ASME Y14.5).

BS EN 22768-2 includes an option for marking drawings to indicate that the envelope requirement applies to all features of size on the drawing, but this marking is neither widely used nor well understood and is not recommended. Use of BS EN 22768-2 is in any case inadvisable.

BS EN ISO 14405-1 allows the default interpretation of size requirements to be changed for an TPS. A number of different possibilities are available, including the option of making the envelope requirement the default interpretation of size for the entire specification.

If the default interpretation of size is to be changed for a TPS, the following indication shall appear in or near the title block of each drawing.

SIZE ISO 14405

followed by the relevant modifier.

For example, if the envelope requirement is to be made the default interpretation of size requirements for the entire TPS, the indication shall be:

SIZE ISO 14405 Ⓔ

NOTE It is recommended that a note on the drawing be used in addition to the ISO 14405 reference, for clarity.

5.3.3 Implied dimensions

The following rules shall govern the use and interpretation of implied annotation on engineering drawings.

NOTE A dimension may be implied and not indicated on a drawing in the following circumstances, so long as there is no risk of misinterpretation.

a) Where two features are aligned, there is no requirement to indicate a linear dimension of 0 or an angular dimension of 0°.

b) Where two features are parallel to each other, there is no requirement to indicate an angular dimension of 0° or 180°.

c) Where two features are at 90° to each other, there is no requirement to indicate an angular dimension of 90°.

d) Where several features are equispaced around a pitch circle (see BS ISO 129-1), there is no requirement to indicate an angular dimension, although it might be advisable to do so. Terms such as "equispaced", "equally spaced", etc., shall not be used.

e) Where not otherwise indicated, holes are considered as through holes.

f) If the features concerned have their locations and/or orientations controlled through the use of geometrical tolerances, then the implied dimensions shall be taken as theoretically exact dimensions (TEDs; see BS EN ISO 1101).

g) If the features concerned have their locations and/or orientations controlled through the use of +/– or limit tolerances, then the implied dimensions shall also be toleranced. In the absence of other indications, they shall be subject to a general tolerance, or else the TPS would remain incomplete.

Tolerances shall never be implied, and shall always be indicated.

Datums shall never be implied, and shall always be indicated.

Section 6: Dimensioning

6.1 Dimensioning methods

6.1.1 Presentation rules

Dimensioning shall conform to BS ISO 129-1.

NOTE 1 The dimensioning of mechanical engineering drawings will be specified in BS ISO 129-2, which is currently in preparation, while the dimensioning of shipbuilding drawings is specified in BS ISO 129-4.

Only the dimensions which are necessary to unambiguously define the nominal geometry of the product shall be specified.

NOTE 2 The dimensions shown should be for the purposes of describing the function, production or verification of the product.

Each feature or relation between features shall be dimensioned only once.

Unless otherwise specified, dimensions shall be indicated for the finished state of the dimensioned feature. However, it might be necessary to give additional dimensions at intermediate stages of production if they are shown on the same drawing (e.g. the size of a feature prior to carburizing and finishing).

All dimensional information shall be complete and shown directly on a drawing, unless this information is specified in related associated documentation.

All dimensions, graphical symbols and annotations shall be indicated such that they can be read from the bottom or right-hand side (main reading directions) of the drawing.

Dimensions alone are not sufficient to define the requirements of a product. Dimension shall be used with other specification techniques as applicable, e.g. geometrical tolerancing or surface texture requirements.

Lettering on drawings shall be in accordance with BS EN ISO 3098.

There shall be only one lettering height for dimension and tolerance indication for a specific drawing.

A space shall separate the elements of the dimension indicator.

NOTE 2 The dimension value and the lower deviation should be at the same distance from the dimension line.

All dimensions shall be toleranced, either via a general tolerance or by direct indication of tolerance or limit indications, except the following cases:

a) MIN, see **6.1.7.4**;

b) MAX, see **6.1.7.4**;

c) auxiliary dimension, see **6.1.14**;

d) theoretically exact dimension (TED) (see BS EN ISO 1101).

When tolerance limits are indicated in a vertical orientation (e.g. limit deviations, dimension limit values) the decimal marker of the upper and lower shall be aligned. When a tolerance limit is not shown with a decimal marker, the remaining digits shall be aligned as if the decimal marker had been displayed, e.g.:

$$2\times 55^{+0,2}_{-0,15}$$

$$2\times 55^{\ 0}_{-0,15}$$

If two deviations relating to the same dimension have to be shown, both shall be expressed to the same number of decimal places (see Figure 3), except if one of

the deviations is zero. This shall also be applied if the limits of size are indicated (see Figure 4).

Figure 3 **Example: expression of two deviations to the same number of decimal places**

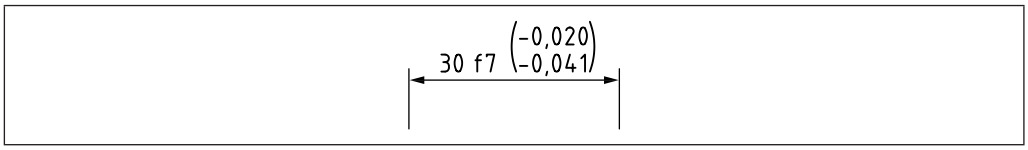
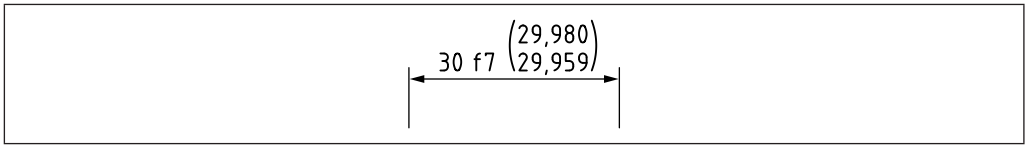
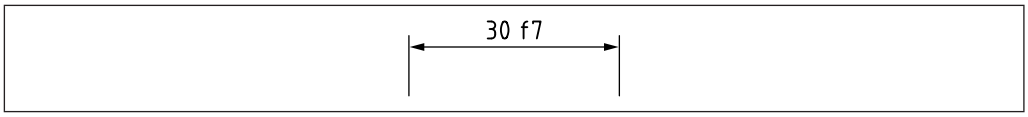


Figure 4 **Example: expression of two limits of size to the same number of decimal places**



NOTE 3 For dimensions displayed in accordance with BS EN ISO 286-1, it is not necessary to express the values of the deviations unless they are needed (see Figure 5).

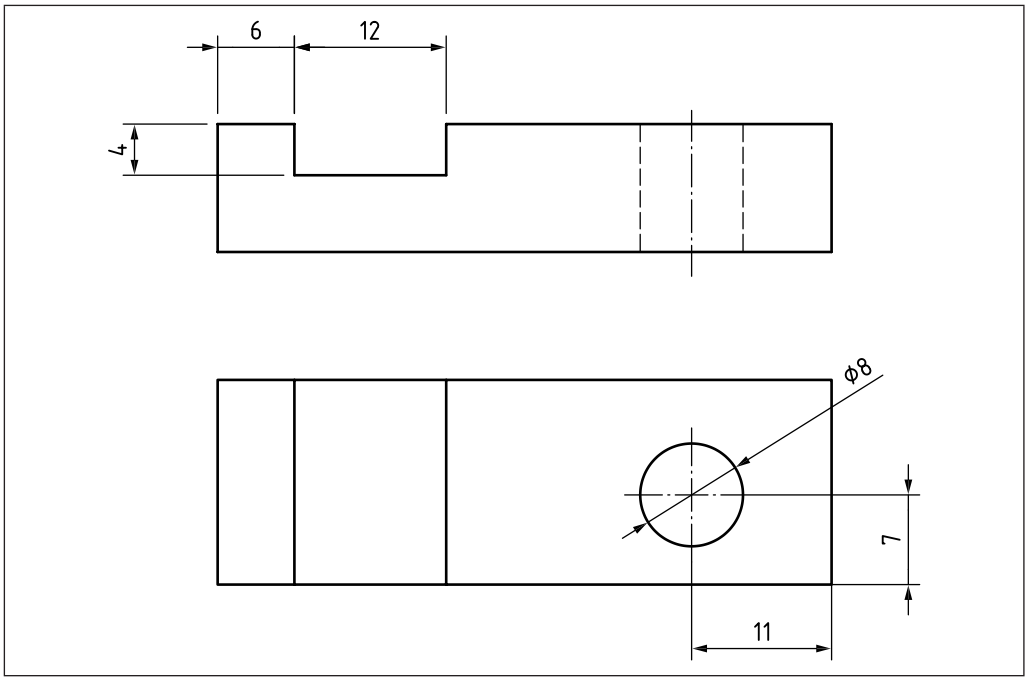
Figure 5 **Example: expression of deviations from dimensions displayed in accordance with BS EN ISO 286-1**



6.1.2 Positioning of dimensions

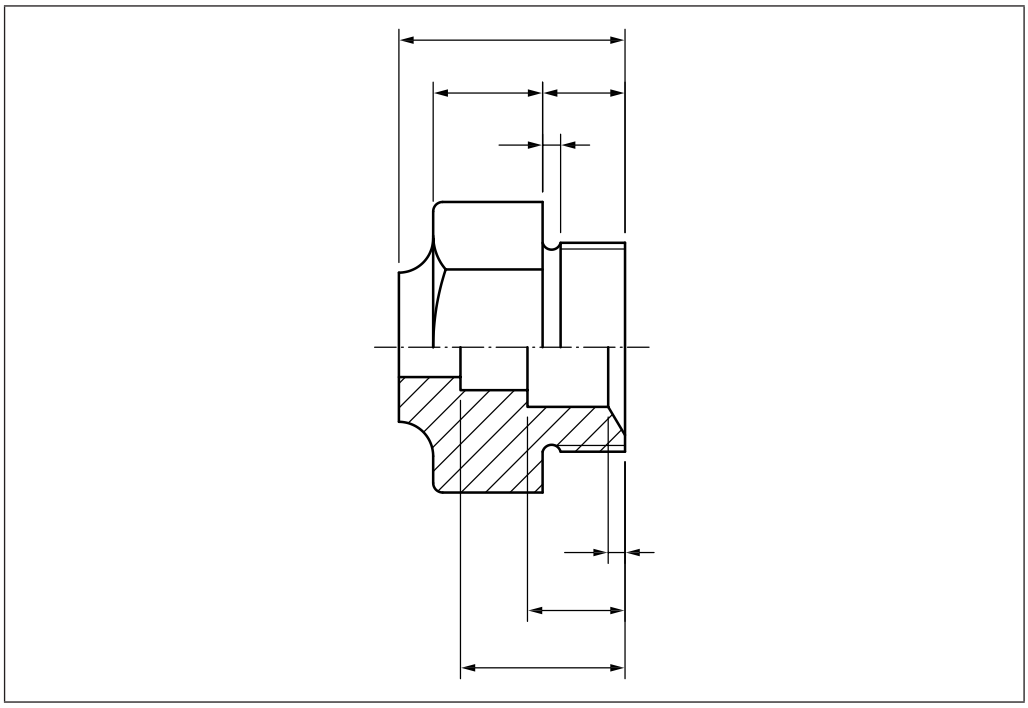
Dimensions shall be placed on that view or section which shows the relevant feature(s) most clearly (see Figure 6).

Figure 6 **Positioning of dimensions**



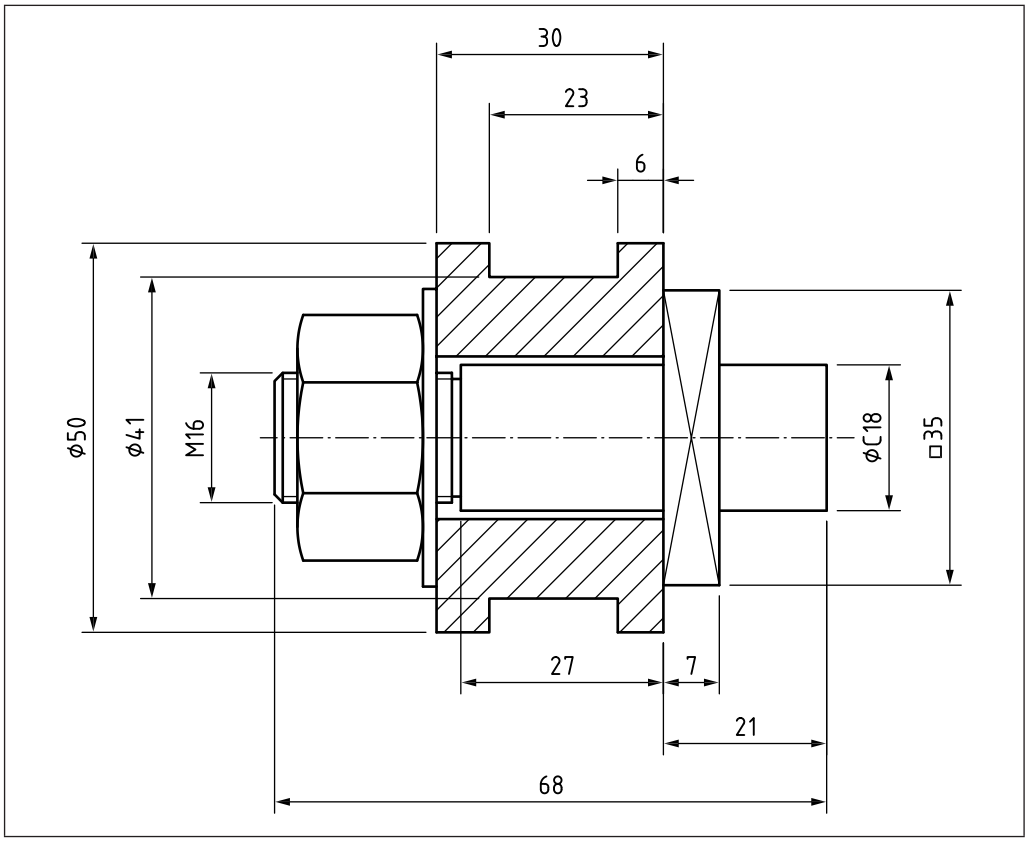
Dimensions for internal features and dimensions for external features shall, where possible, be arranged and indicated in separate groups of dimensions to improve readability (see Figure 7).

Figure 7 **Arrangement and indication of dimensions internal and external features**



Where several features or objects are depicted in close proximity, their relative dimensions shall be grouped together, separately, for ease of reading (see Figure 8).

Figure 8 **Grouping of relative dimensions of features or objects in close proximity**



Whenever possible, dimensions shall not be placed within the contour of the depicted item.

6.1.3 Units of dimensions

The units of a dimension shall be specified with the dimension. Typically, the predominant unit of measure on a drawing is specified in the drawing title block and the unit omitted from the individual dimensions. Any dimensions expressed in a different unit of measure shall indicate that unit of measure.

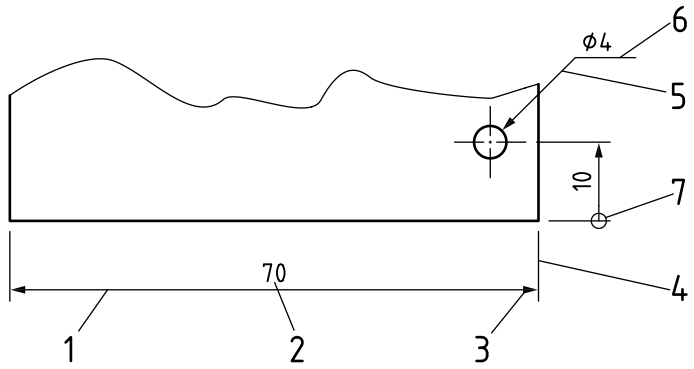
Limit deviations shall be expressed in the same unit as the dimensional value.

6.1.4 Elements of dimensioning: usage

6.1.4.1 General

The various elements of dimensioning shall be indicated as illustrated in Figure 9.

Figure 9 **Elements of dimensioning**



Key

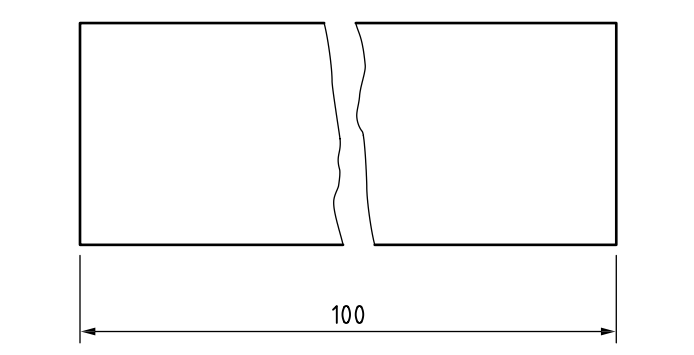
1 Dimension line
2 Dimensional value
3 Terminator (in this case, an arrowhead)
4 Extension line
5 Leader line
6 Reference line
7 Origin symbol

6.1.4.2 Dimension line

Dimension lines shall be indicated as continuous narrow lines in accordance with BS EN ISO 128-20.

Where the feature is shown broken, the corresponding dimension line shall be shown unbroken (see Figure 10).

Figure 10 **Dimension line of feature that is broken**

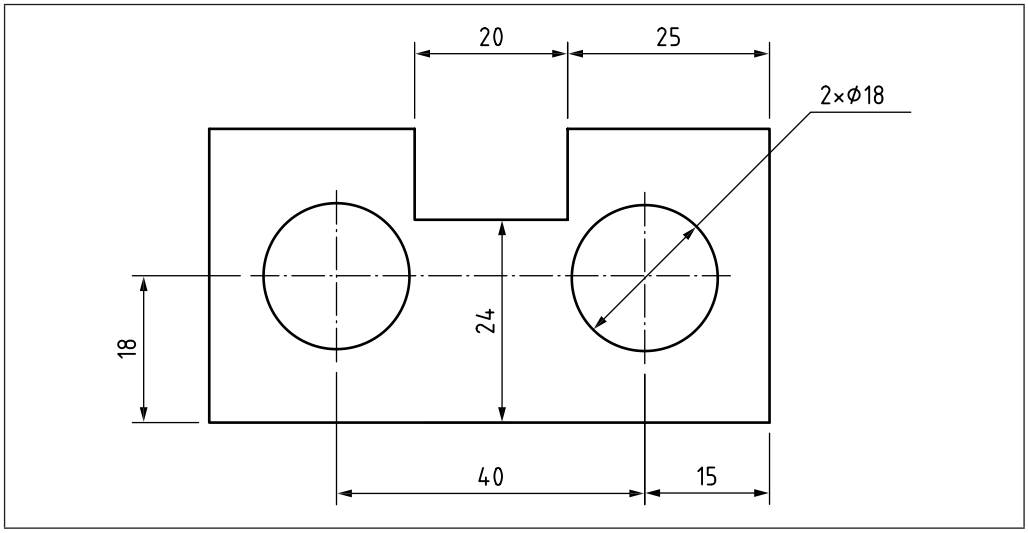


Dimension lines of holes may be indicated oblique through the centre of the hole (see Figure 11).

Intersection of dimension lines with any other line should be avoided, but where intersection is unavoidable they shall be shown unbroken (see Figure 8).

The centre line or outline of a feature or their extensions may be used in place of an extension line (see Figure 11). However, a centre line or the outline of a feature shall not be used as a dimension line.

Figure 11 **Dimension lines of holes**



6.1.4.3 Extension lines

Extension lines shall be drawn as continuous narrow lines in accordance with BS ISO 128-20.

Extension lines shall not be drawn between views and shall not be drawn parallel to the direction of hatching.

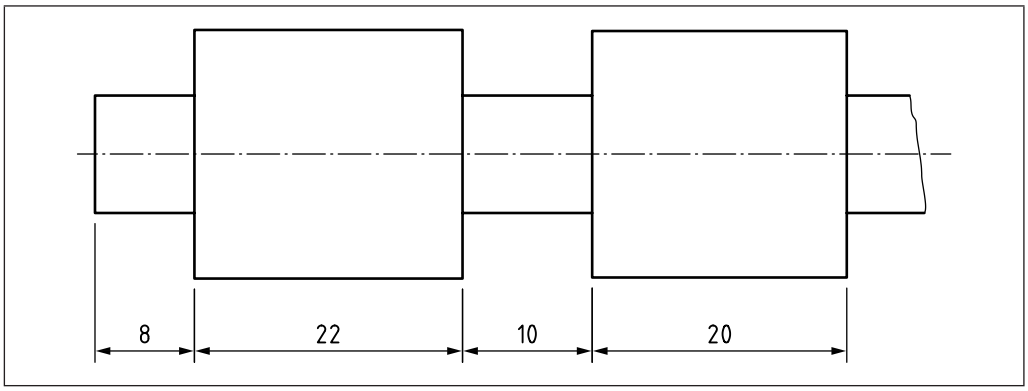
Extension lines shall extend approximately eight times the line width beyond their associated dimension line.

Extension lines should be drawn perpendicular to the corresponding physical length (see Figure 12, Figure 13 and Figure 16).

For circular features the extension line shall be drawn as a continuation of the feature shape (see Figure 55).

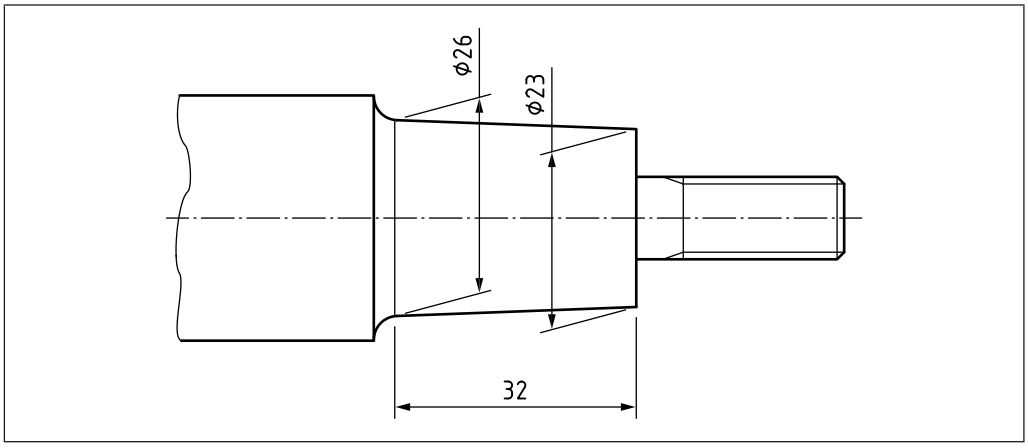
*NOTE It is advisable to have a gap between the feature and the beginning of the extension line (see the information box in **6.2.1**).*

Figure 12 **Extension lines**



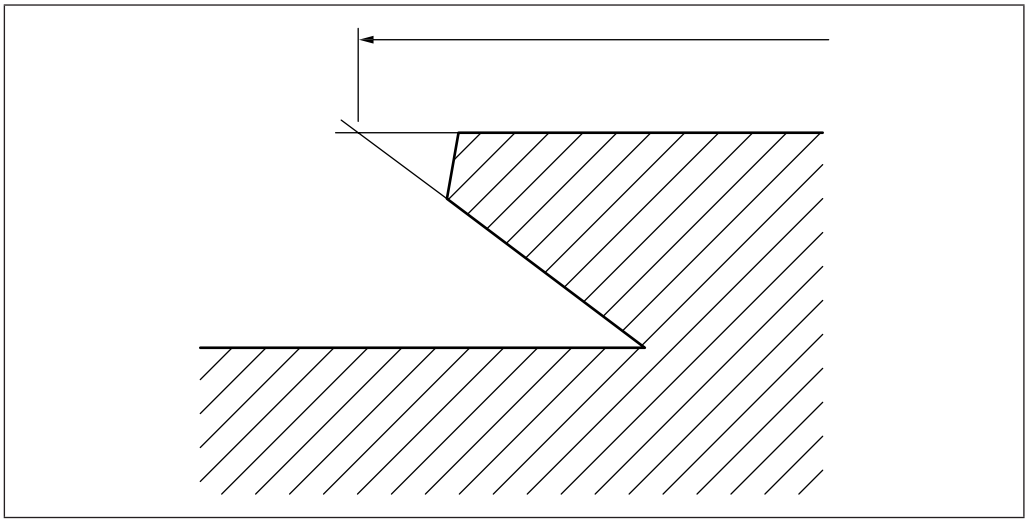
The extension lines may be drawn oblique to the feature but shall be parallel to each other (see Figure 13).

Figure 13 **Oblique extension lines**



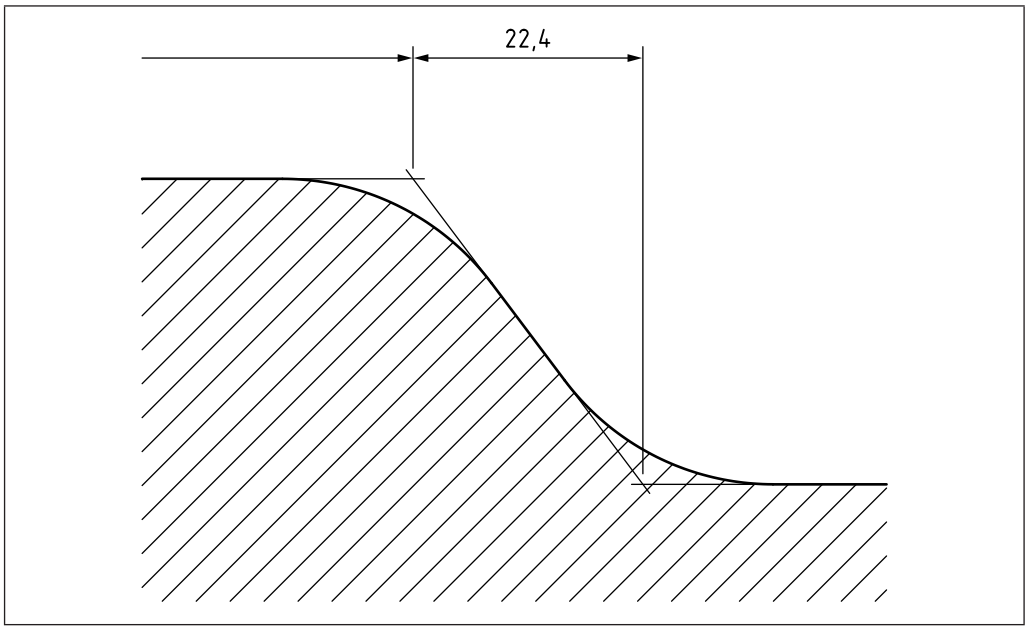
Intersecting projected contours of outlines shall extend approximately eight times the line width beyond the point of intersection (see Figure 14).

Figure 14 **Intersection of projected contours of outlines**



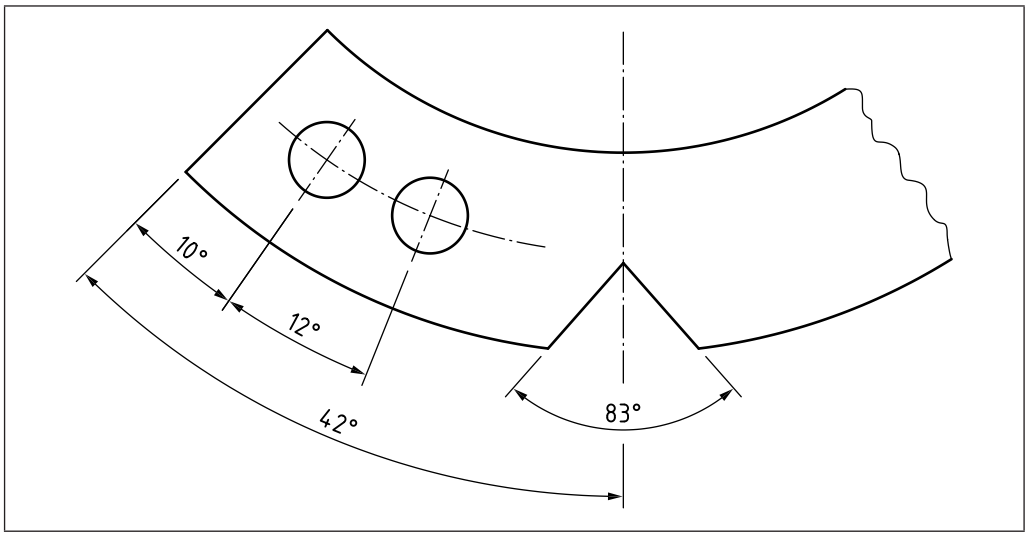
In the case of projected contours of transitions and similar features, the extension lines shall apply at the point of intersection of the projection lines (see Figure 15).

Figure 15 **Intersection of projected contours of transitions and similar features**



In the case of angular dimensions, the extension lines shall be the extensions of the angle legs (see Figure 16).

Figure 16 **Extension lines of angular dimensions**



6.1.5 Leader line

Leader lines shall be drawn in accordance with BS ISO 128-22.

6.1.6 Dimensional values

6.1.6.1 Indication

Dimensional values shall be indicated on drawings in characters of sufficient size to ensure complete legibility on the original drawing, as well as on reproductions made from microfilms (see BS EN ISO 6428).

NOTE Lettering ISO 3098-BVL (Type B, Vertical, Latin) is recommended.

6.1.6.2 Positions of dimensional values

Dimensional values shall be placed parallel to their dimension line and near the middle of and slightly above that line (see Figure 17 and Figure 18).

Dimensional values shall be placed in such a way that they are not crossed or separated by any line.

Figure 17 **Position of dimensional values**

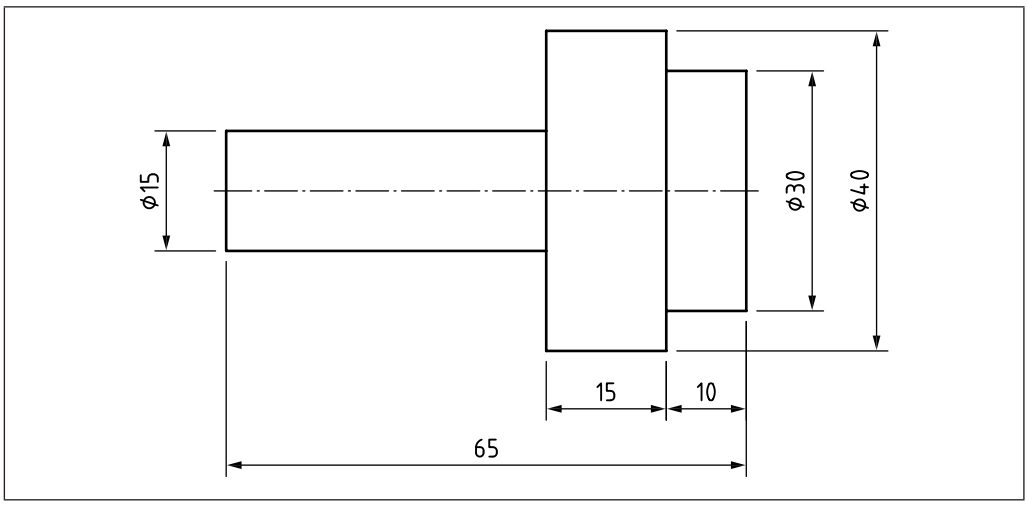
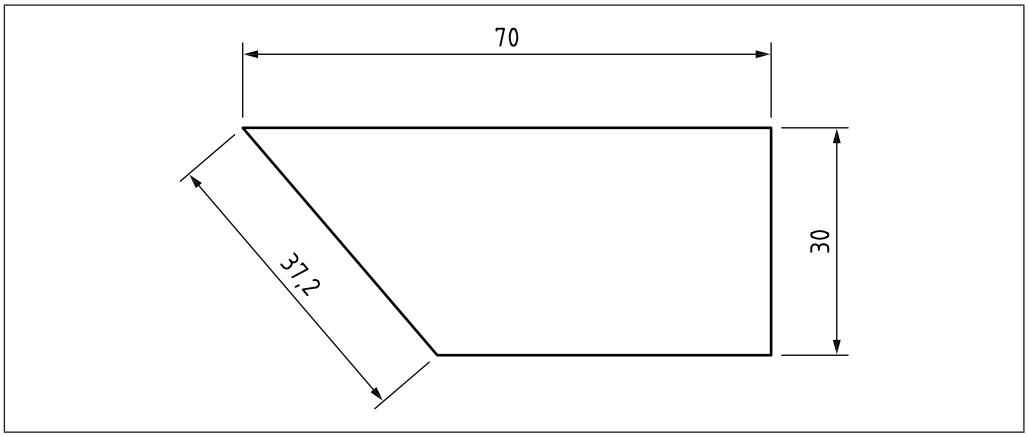


Figure 18 **Position of dimensional values**



Values of linear dimensions on oblique dimension lines shall be oriented as shown in Figure 19. The values shall be indicated so that they can be read from the bottom or right-hand side of the drawing.

Values of angular dimensions shall be oriented as shown in Figure 20. Angular dimensions shall be placed on top of the dimension line and follow the same rule as linear dimensions (see Figure 19).

Figure 19 **Orientation of linear dimensions**

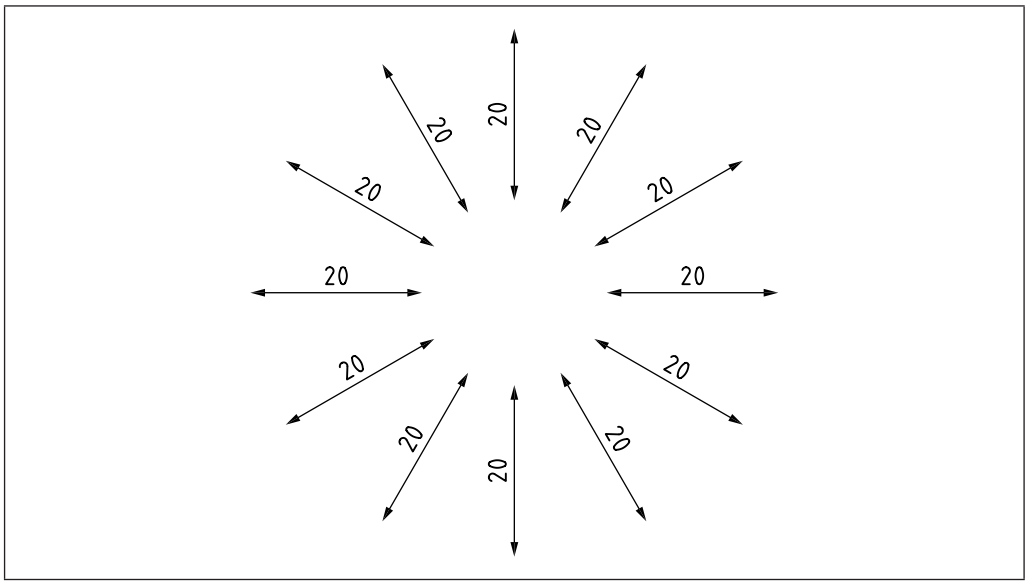
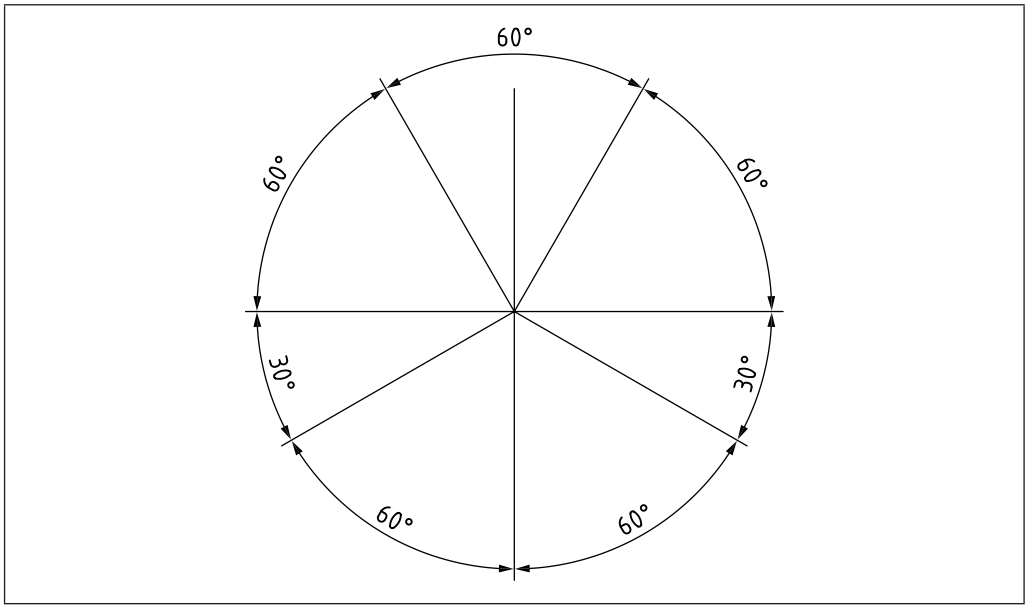


Figure 20 **Orientation of angular dimensions**



6.1.7 Indication of tolerances

6.1.7.1 General

Dimensional tolerancing for mechanical engineering shall be in accordance with BS EN ISO 14405. BS EN ISO 14405 may also be applied to fields other than mechanical engineering. Some of these rules are summarized here for information.

Depending on the field of application, the tolerances of dimensions may be indicated by:

- general tolerances (see **6.1.7.2**);
- limit deviations (see **6.1.7.3**);
- limits of dimension (see **6.1.7.4**).

All tolerances shall apply to the represented state of the feature in the technical drawing.

6.1.7.2 General tolerances

When general tolerances are controlled by another document or method, the reference shall be indicated on the drawing.

6.1.7.3 Limit deviations

The components of a toleranced dimension shall be indicated in the following order (see Figure 21 to Figure 29):

a) the dimensional value;

b) the limit deviations.

A space shall separate the dimensional values and the tolerance indication, e.g.:

- 55 ±0,2;
- 30 min;
- ø10 h7.

Limit deviations shall be indicated by indicating the upper deviation above the lower deviation (see Figure 21 and Figure 22).

If one of the two limit deviations is zero, this shall be expressed explicitly by the digit zero shown without sign (see Figure 22).

If the tolerance is symmetrical in relation to the dimensional value, the limit deviation shall be indicated only once, preceded by the plus-minus sign (±) (see Figure 23).

Figure 21 **Components of a toleranced dimension**

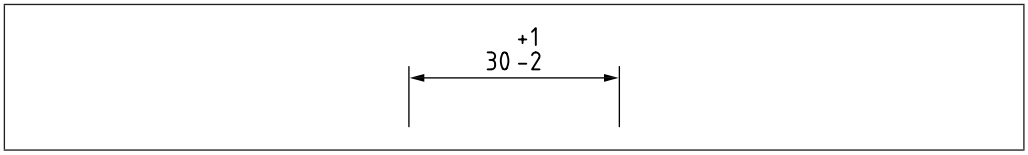


Figure 22 **Components of a toleranced dimension**

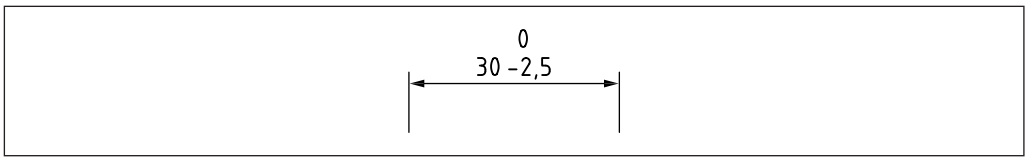
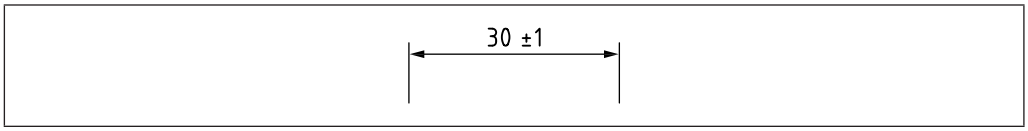


Figure 23 **Components of a toleranced dimension**

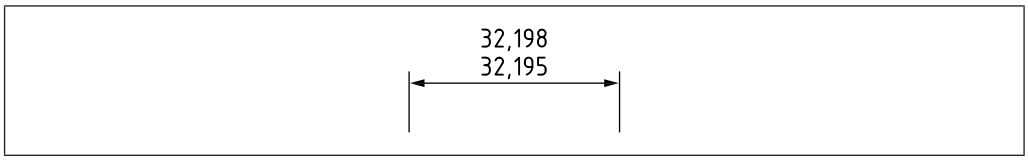


6.1.7.4 Limit dimensioning

6.1.7.4.1 Maximum and minimum limit dimensions

The limits of dimensions shall be indicated by a maximum and a minimum dimension (see Figure 24). The larger dimension shall be placed above the smaller dimension.

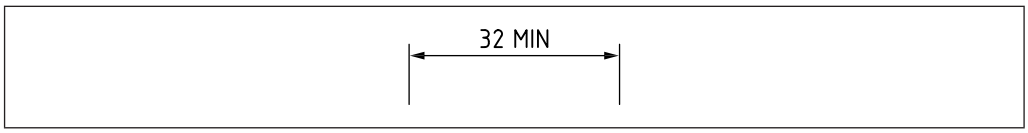
Figure 24 **Limits of dimensions**



6.1.7.4.2 Single limit dimensions

To limit the dimension in one direction only, the word "MIN" or "MAX" shall be added after the dimensional value (see Figure 25).

Figure 25 **Single limit dimension**



6.1.8 Indications of special dimensions: Arrangement of graphical and letter symbols with dimensional values

The following symbols shall be used with dimensions to identify the feature characteristics. The following symbols shall directly precede the dimensional value without space (see Figure 26 to Figure 30).

- ⌀ Diameter
- R Radius
- □ Square
- S⌀ Spherical diameter
- SR Spherical radius
- ⌒ Arc length
- t= Thickness of thin objects
- ↧ Depth
- ⌴ Cylindrical counterbore
- ⌵ Countersink

Figure 26 **Indications of special dimensions: Radius**

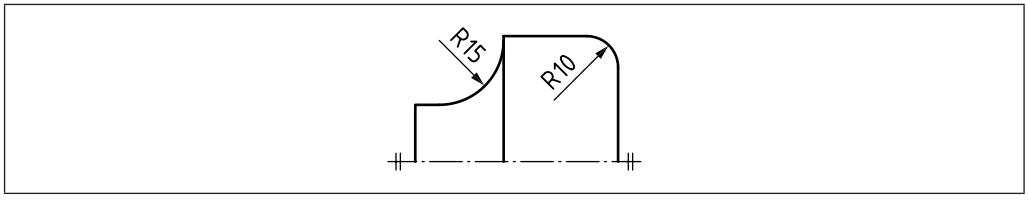


Figure 27 **Indications of special dimensions: Square**

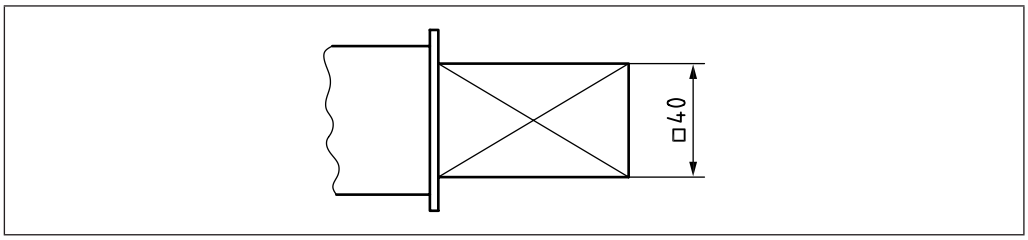


Figure 28 **Indications of special dimensions: Spherical diameter**

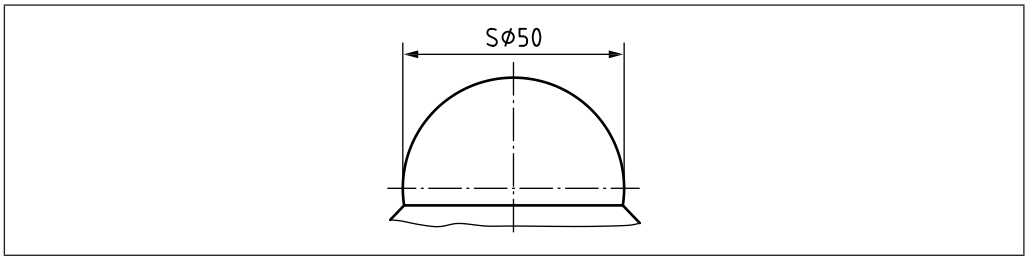


Figure 29 **Indications of special dimensions: Spherical radius**

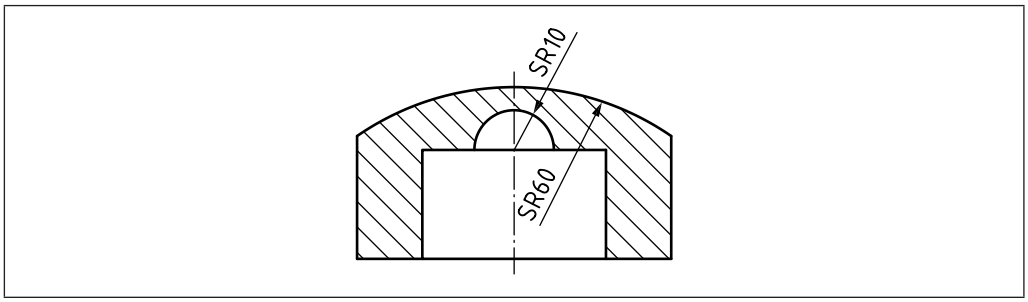
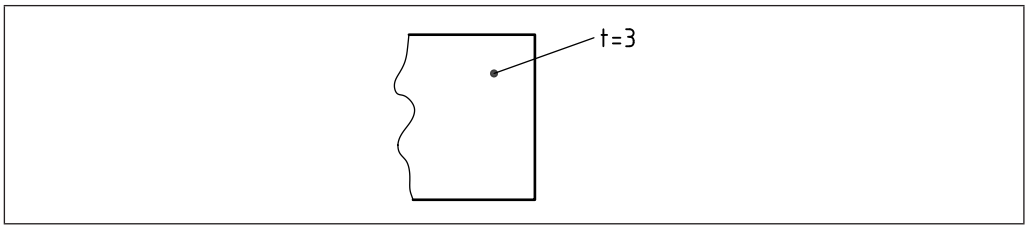
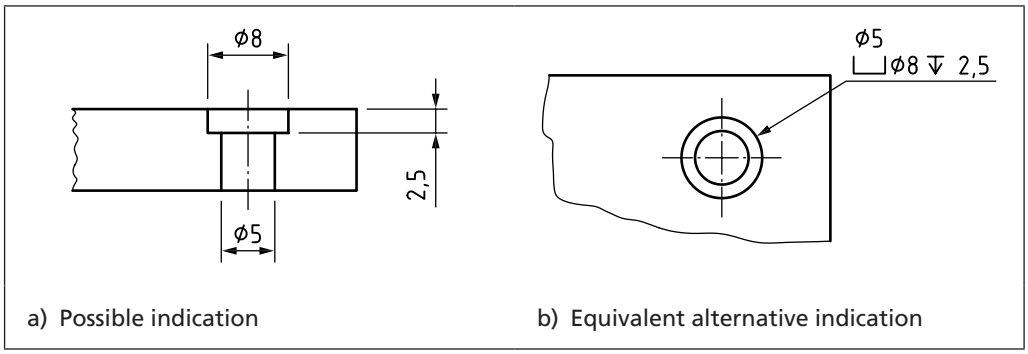


Figure 30 **Indications of special dimensions: Thickness**



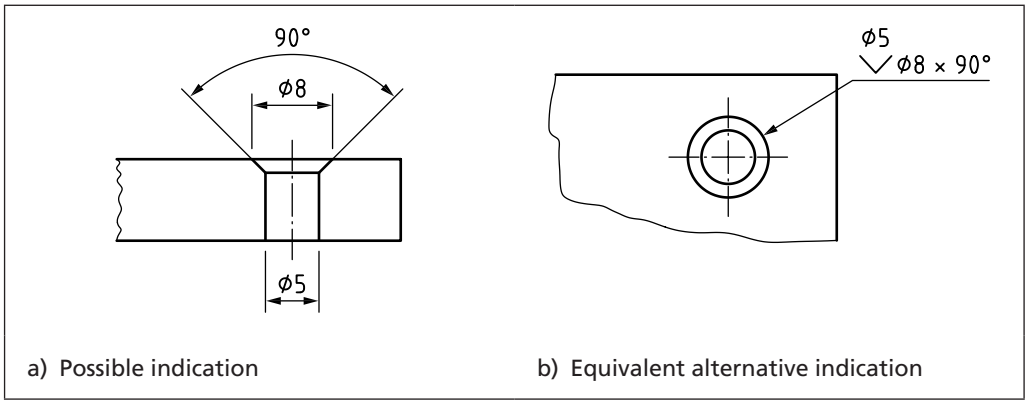
When counterbore is indicated, the diameter, and depth if needed, of the counterbore shall be specified below the dimension value of the hole (see Figure 31). When countersink is indicated, the size and inclusive angle of the countersink shall be specified below the dimensional value of the hole (see Figure 32).

Figure 31 **Diameter and depth of counterbore**



a) Possible indication b) Equivalent alternative indication

Figure 32 **Size and angle of countersink**



a) Possible indication b) Equivalent alternative indication

6.1.9 Equally-spaced and repeated features

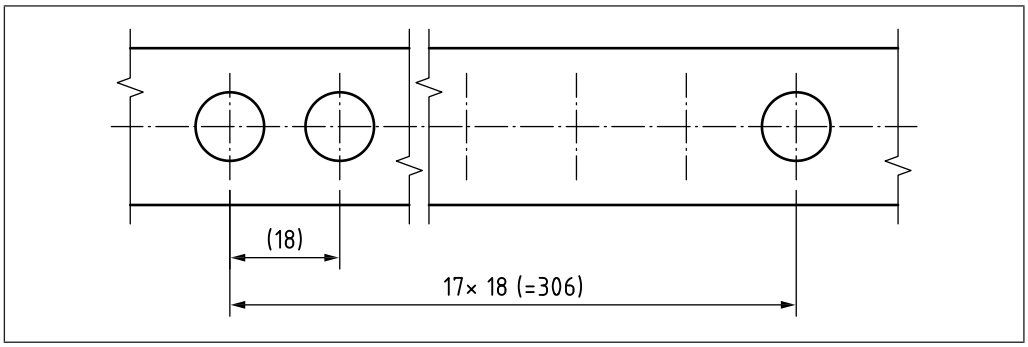
6.1.9.1 Equally-spaced features

Where features have the same spacing and are uniformly arranged, their dimensioning shall, where appropriate, be simplified as follows.

a) Repeated linear and angular spacing can be indicated with the number of spacings and their dimensional value separated by the symbol "×". The number of features shall directly precede the symbol "×" without a space and the dimensional value shall be preceded by a space, e.g. 17× 18. If there is any risk of confusion between the length of the space and the number of spacings, one space may additionally be dimensioned (see Figure 33).

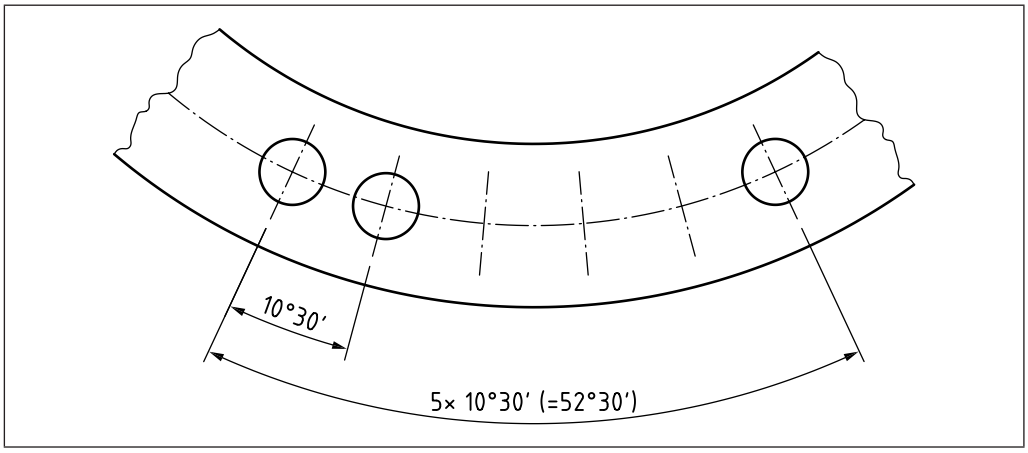
b) The sum of the linear or angular spacing of the indicated features is an auxiliary dimension (see **6.1.14** and Figure 33 and Figure 34). The total representation shall be indicated as the number of spacings times the dimensional value of the spacings, and the sum given in parenthesis preceded by the equal sign.

Figure 33 **Number of equally-spaced features and the dimensional value**



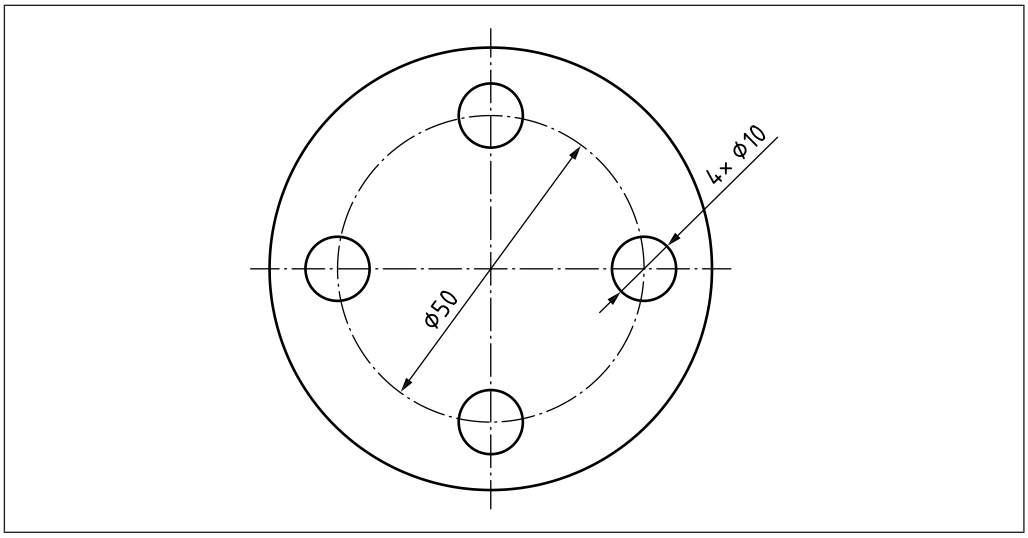
c) Angular spacing cab be dimensioned as shown in Figure 34.

Figure 34 **Dimensioning of angular spacing**



d) The angles of the spacings can be omitted where spacings are self-evident and the indication does not lead to confusion (see Figure 35).

Figure 35 **Angles of spacings**



6.1.9.2 Repeated features

Where clarity is not impaired, features having the same dimensional value shall be indicated by that value preceded by the number of features and the symbol "×" (see Figure 36 and Figure 37).

Figure 36 **Indication of features having the same dimensional value**

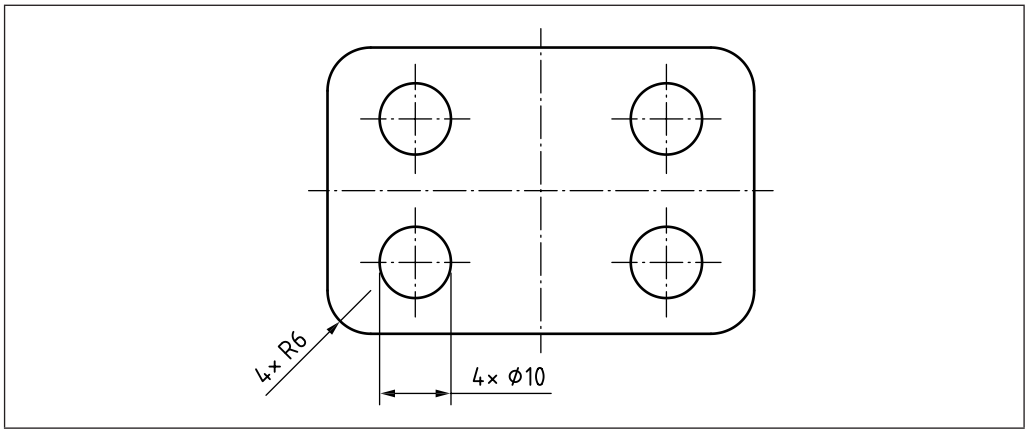
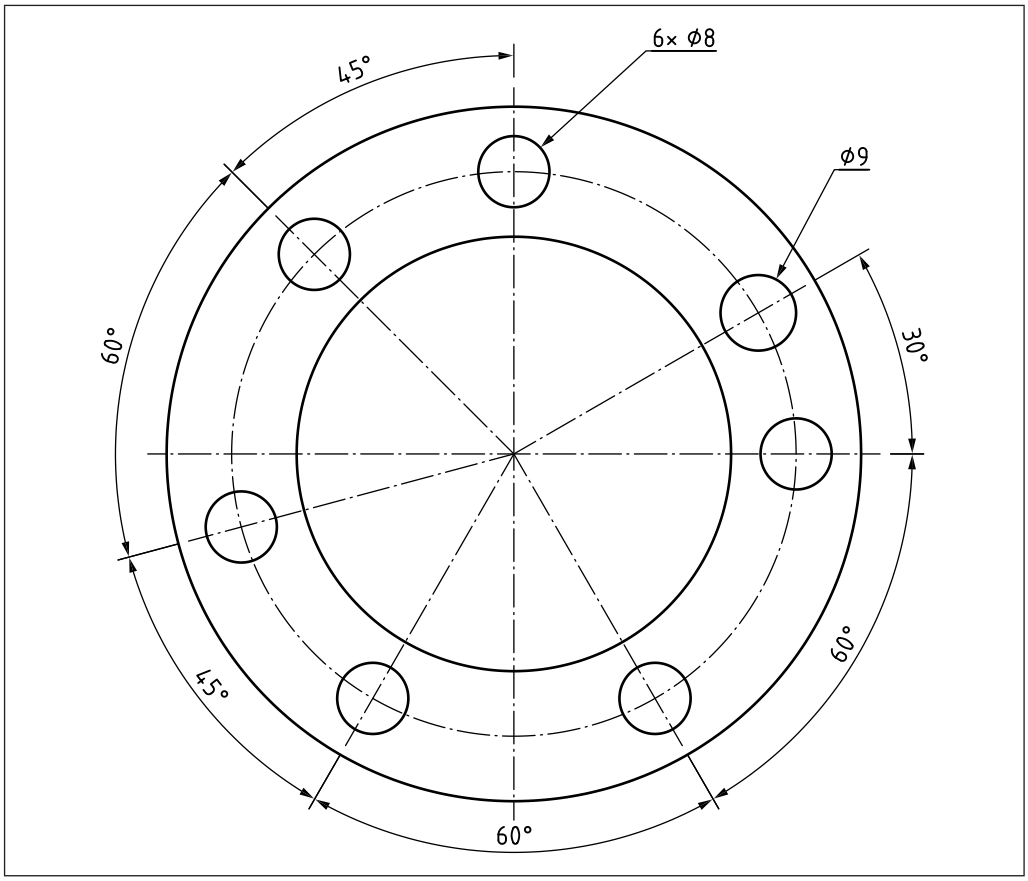


Figure 37 **Indication of features having the same dimensional value**

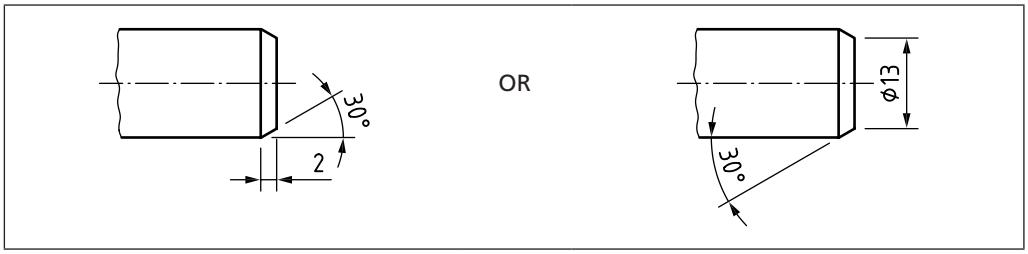


6.1.10 Chamfers

6.1.10.1 External chamfer

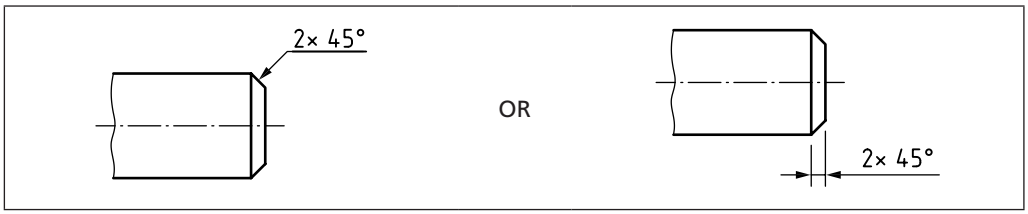
An external chamfer shall be dimensioned conventionally if the angle of the chamfer is not equal to 45° (see Figure 38).

Figure 38 **Dimension of external chamfer not equal to 45°**



If the chamfer angle is 45°, the indication can be simplified (see Figure 39).

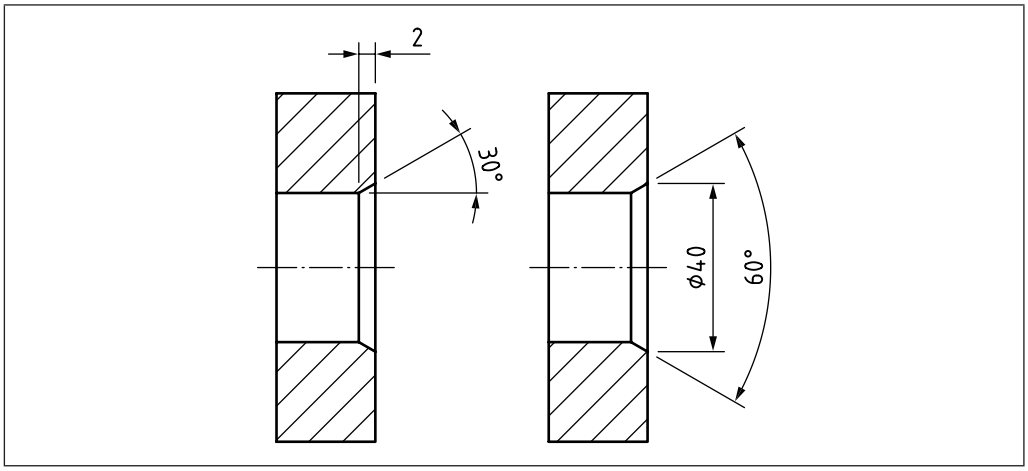
Figure 39 **Dimension of external chamfer equal to 45°**



6.1.10.2 Internal chamfer

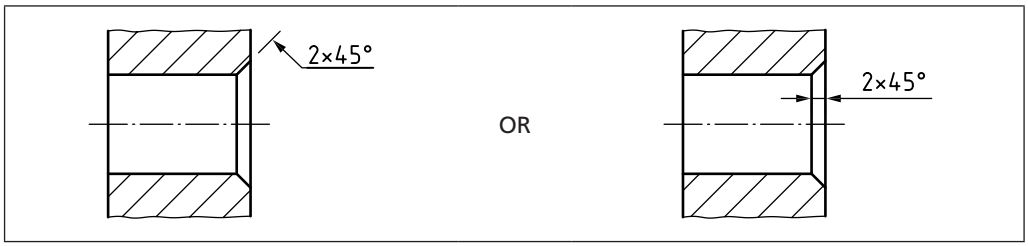
An internal chamfer shall be dimensioned conventionally if the angle of the chamfer is not equal to 45° (see Figure 40).

Figure 40 **Dimension of internal chamfer not equal to 45°**



If the chamfer angle is 45° the indication can be simplified (see Figure 41).

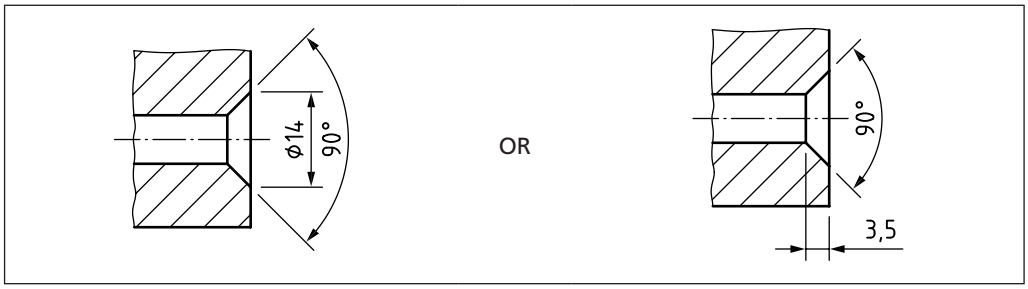
Figure 41 **Dimension of internal chamfer equal to 45°**



6.1.11 Countersink

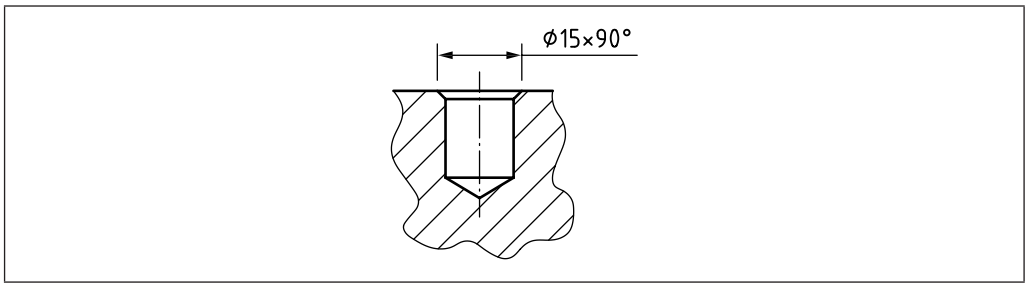
A countersink shall be dimensioned by showing either the required diametrical dimension at the surface and the included angle, or the depth and the included angle (see Figure 42).

Figure 42 **Dimension of countersink**



If the included angle is 90°, the indication may be simplified in accordance with BS ISO 15786 (see Figure 43).

Figure 43 **Dimension of countersink: simplification**



6.1.12 Symmetrical parts

The dimensions of symmetrical arranged features shall be indicated once only (see Figure 44 to Figure 46). The dimension shall indicate the total number of features which occur in the part.

Usually, the line of symmetry of features shall not be dimensioned (see Figure 44 to Figure 46).

In the case of half or quarter representations and if also required in the case of full representations, a symmetry symbol (see BS ISO 128-30) shall be indicated at both ends of the line of symmetry (see Figure 44 to Figure 46).

In the case of half or quarter representations, the dimension lines that need to cross the line of symmetry shall extend past the axis of symmetry; the second termination shall then be omitted (see Figure 44 to Figure 46).

Figure 44 **Symmetrical parts**

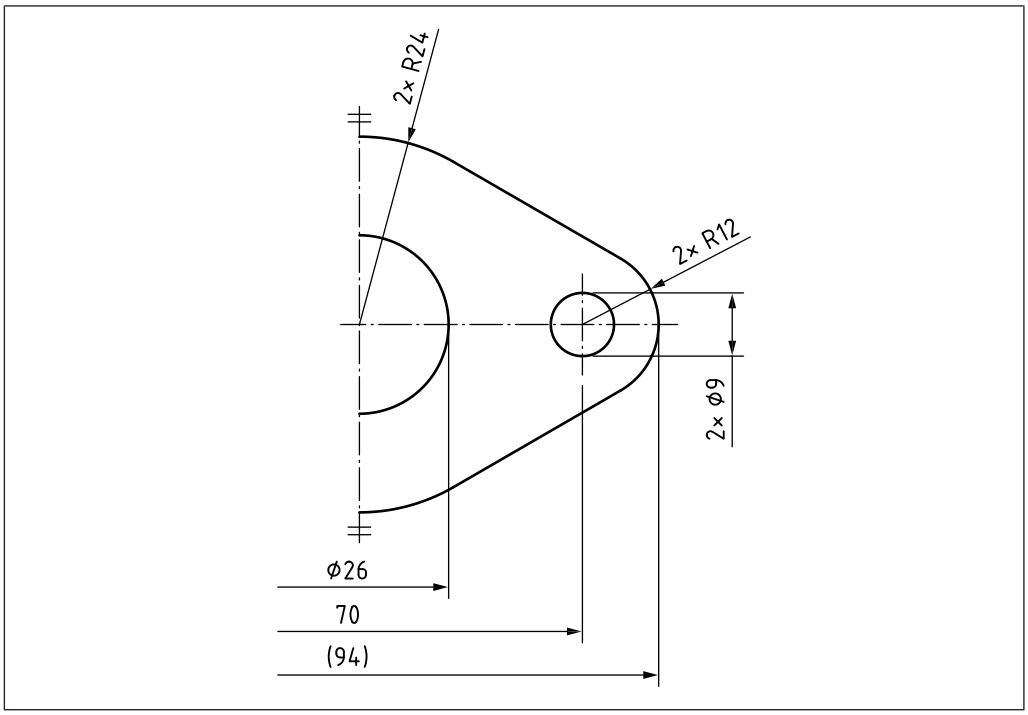


Figure 45 **Symmetrical parts**

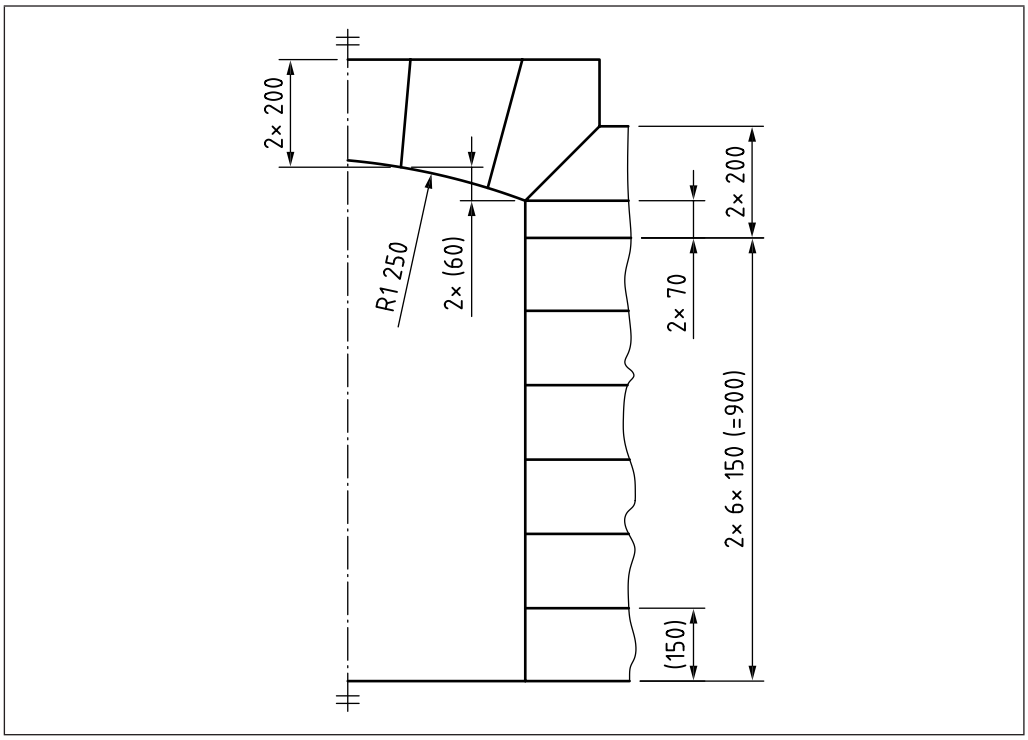
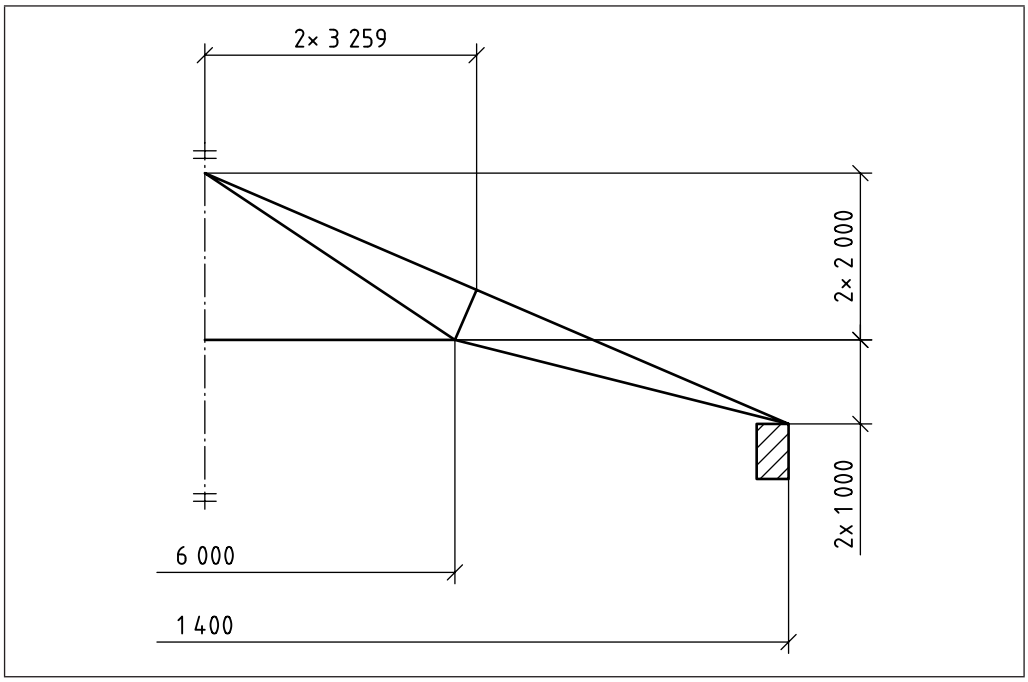


Figure 46 **Symmetrical parts**



6.1.13 Indication of levels

Levels on vertical views, sections and cuts shall be indicated by an open 90° arrowhead connected with a vertical line and horizontal line above which the numerical value of level is placed (see Figure 47).

Levels for specified points on horizontal (planes) views and sections shall be indicated by a numerical value of the level placed above a line connected to the point indicated by "X" (see Figure 48).

Figure 47 **Indication of level on vertical view**

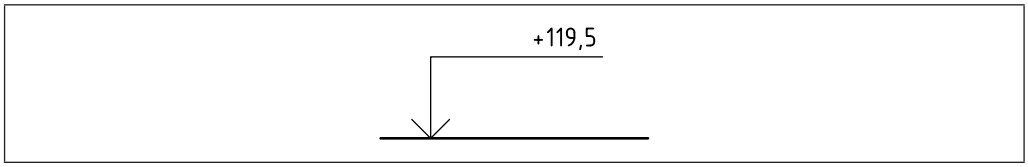
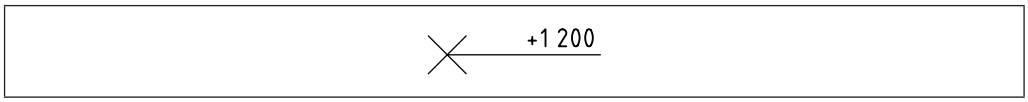


Figure 48 **Indication of level on horizontal view or section**



6.1.14 Auxiliary dimensions

Auxiliary dimensions in drawings are for information only and not for manufacturing and verification purposes. They shall be indicated within parentheses and do not constitute an integral part of the specification or requirement (see Figure 33 and Figure 34).

NOTE Auxiliary dimensions should have limited use.

6.1.15 Dimensioning of curved features

6.1.15.1 Curved feature defined by radii

Where appropriate, a curved feature shall be defined by radii, as shown in Figure 49 and Figure 50).

Figure 49 **Example of curved feature defined by radii**

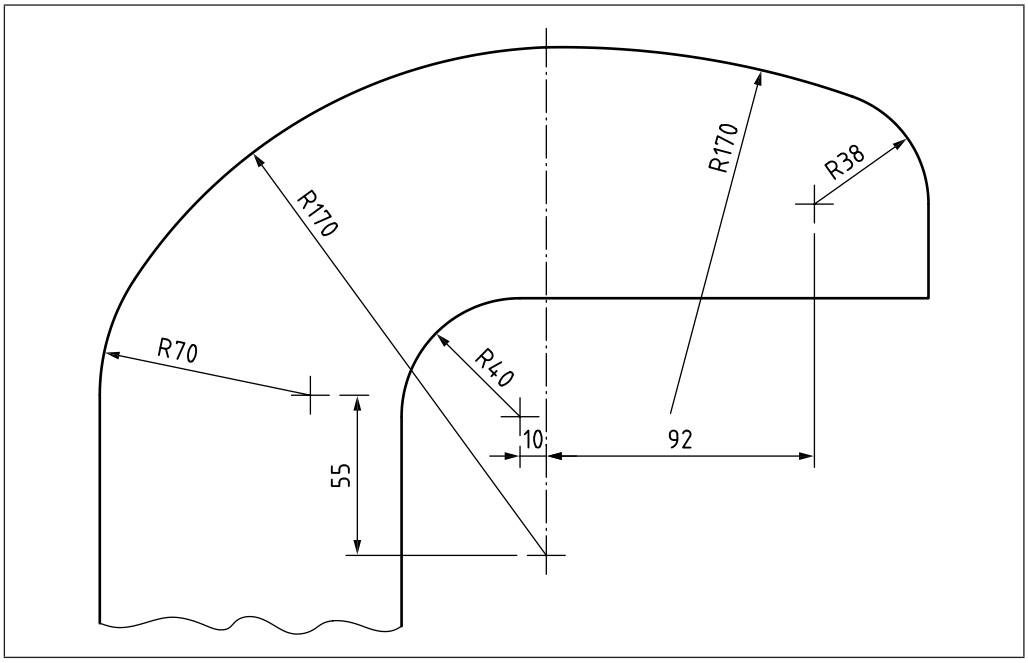
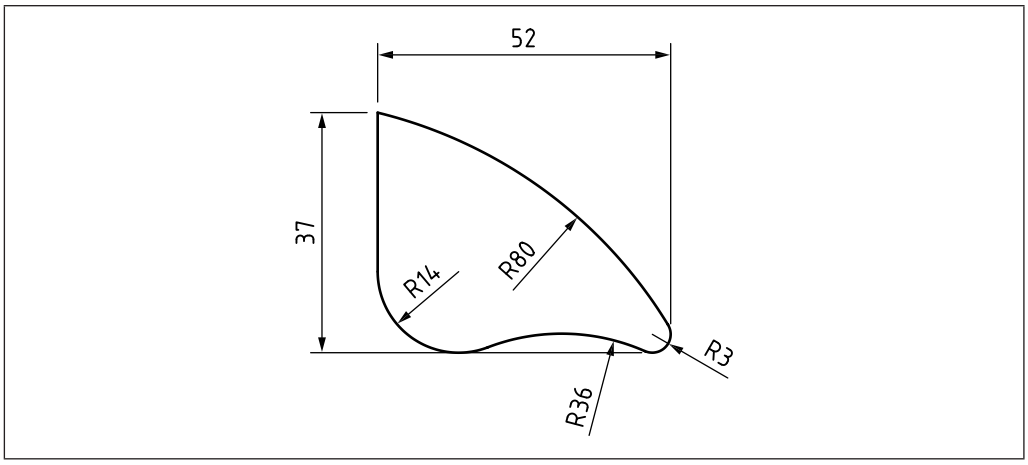


Figure 50 **Example of curved feature defined by radii**



6.1.15.2 Curved feature defined by coordinate dimensions

Dimensioning of curved features using linear or polar coordinates shall be indicated by dimensions to points on the profile (see Figure 51 and Figure 52).

Figure 51 **Curved feature defined by coordinate dimensions**

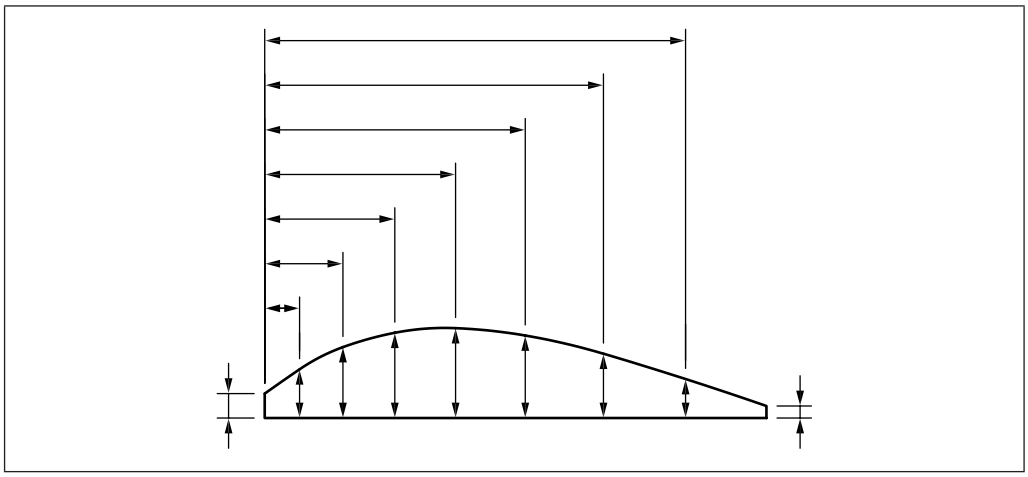
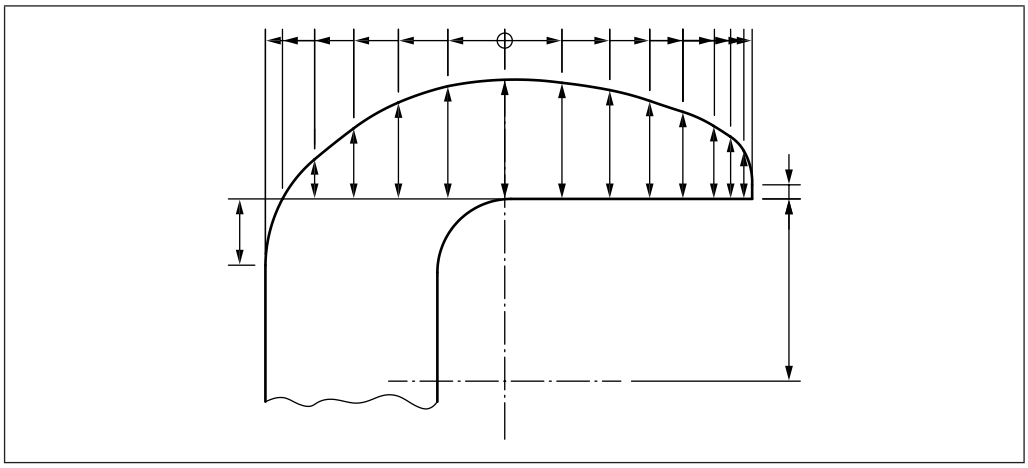


Figure 52 **Curved features defined by coordinate dimensions**



6.1.16 Arrangements of dimensions

6.1.16.1 General

Dimensional values indicated in decimal notation shall use a comma as the decimal marker.

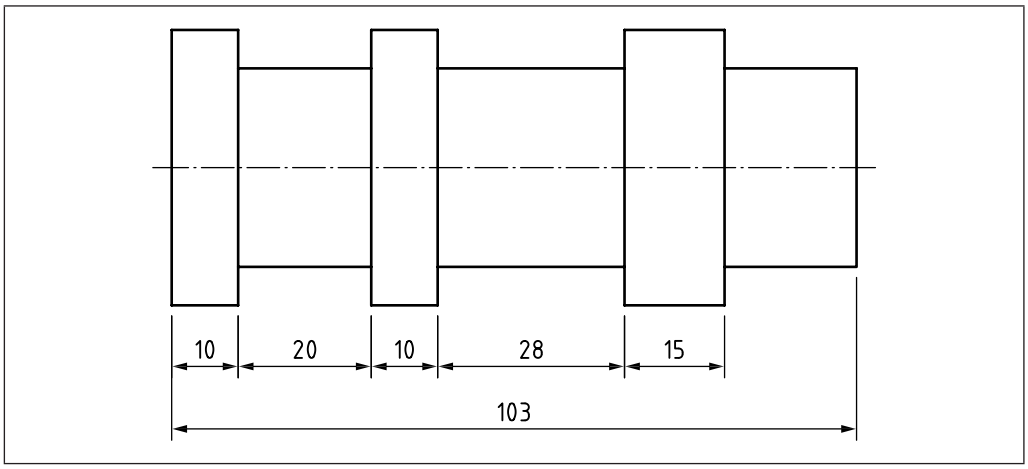
Dimension lines shall be arranged as parallel, chain or running dimensioning, or in combination.

6.1.16.2 Chain dimensioning

Using chain dimensioning, chains of single dimensions shall be arranged in a row (see Figure 53).

Chains of single dimensions shall be used only where the possible accumulation of tolerances does not impinge on the functional requirements of the workpiece.

Figure 53 **Example of chain dimensioning**



6.1.16.3 Parallel dimensioning

The dimension lines shall be drawn parallel in one, two or three orthogonal directions, or concentrically (see Figure 54 and Figure 55).

Figure 54 **Example of parallel dimensioning**

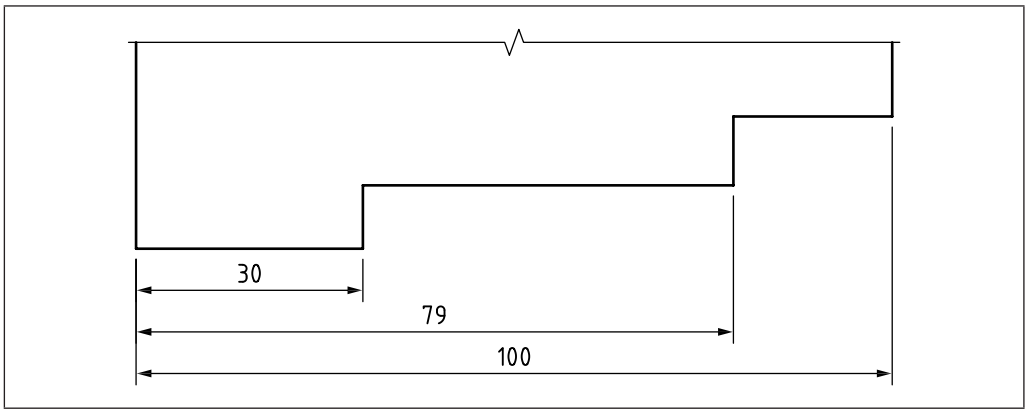
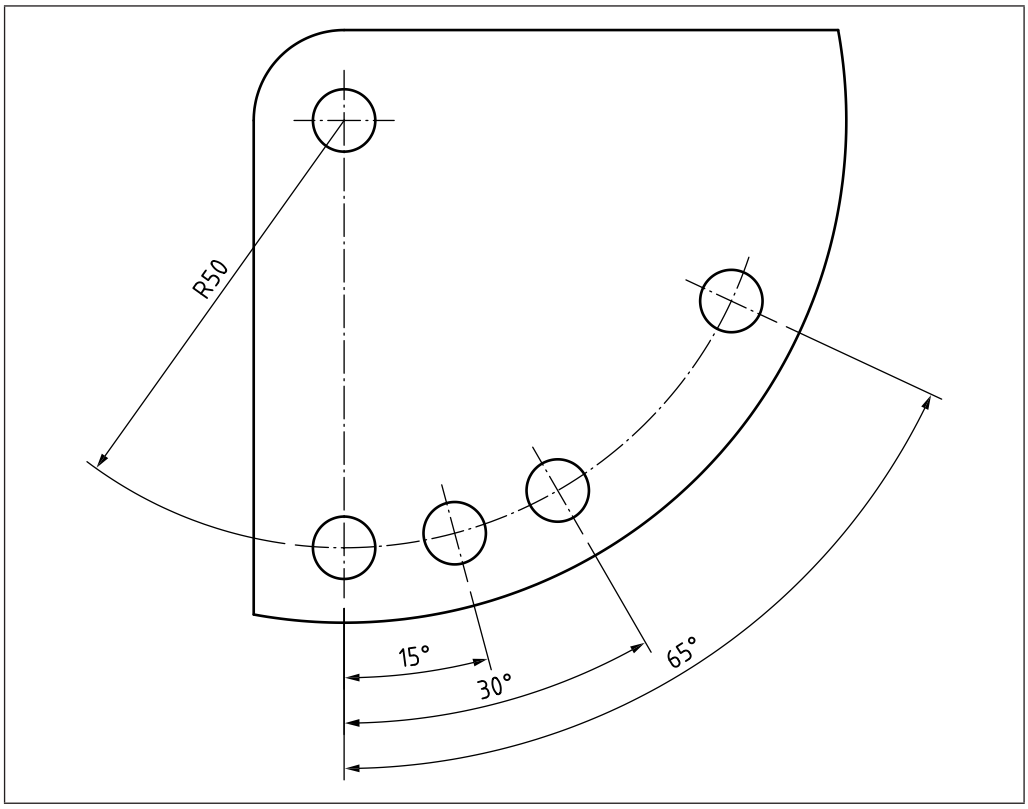


Figure 55 **Example of parallel dimensioning**



6.1.17 Running dimensioning

6.1.17.1 General

Running dimensioning is simplified parallel dimensioning. The origin(s) of the dimension line(s) shall be indicated in accordance with **6.1.4.1** (see Figure 9).

Dimensional values shall be placed near the terminator, remote from the origin, and may be either:

- in line with the corresponding extension line (see Figure 56); or
- above and clear of the dimension line (see Figure 57).

An alternate representation of running dimensions can be used where:

- the origin of the dimension(s) is shown in an appropriate location to indicate where the dimensions are measured from;
- the dimension values are shown on abbreviated dimension lines, where only one arrow is used, directed to the feature to which the dimension value applies (see Figure 56).

6.1.17.2 Running dimensioning in two directions

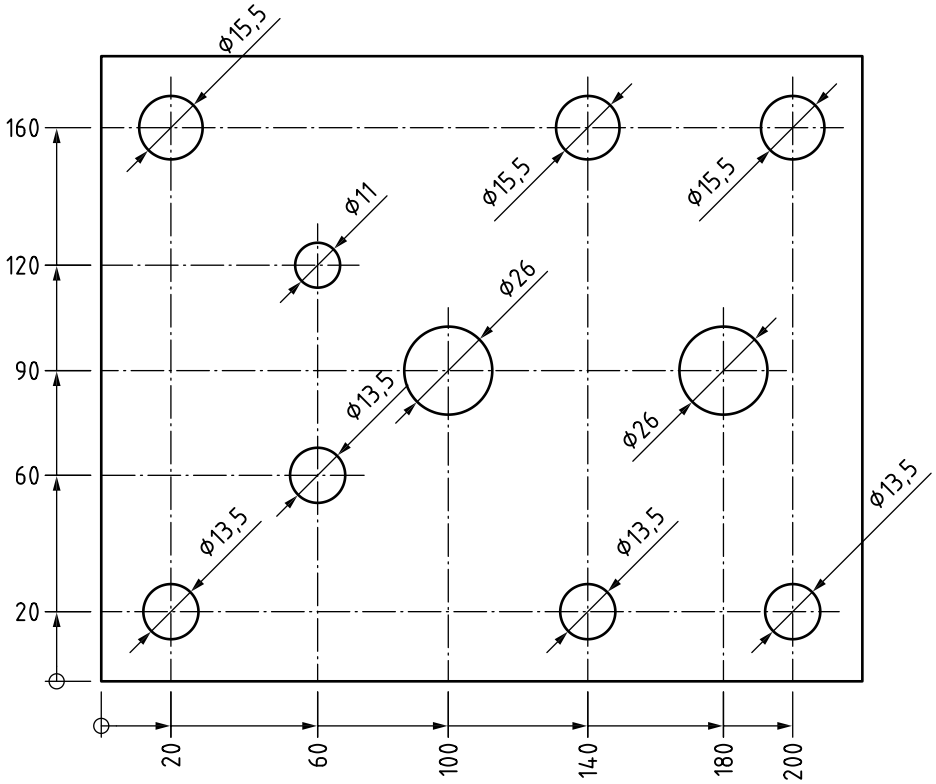
Running dimensioning in two directions shall utilize either:

- one continuous dimension line and one origin; or
- two dimension lines, inclined to each other, and two origins (see Figure 56).

In the case of two directions that are rectangular to each other, the running dimension shall be indicated by two origin symbols.

NOTE Figure 56 shows the running dimension values on the same line as the corresponding origin symbol.

Figure 56 **Two dimension lines, inclined to each other, and two origins**

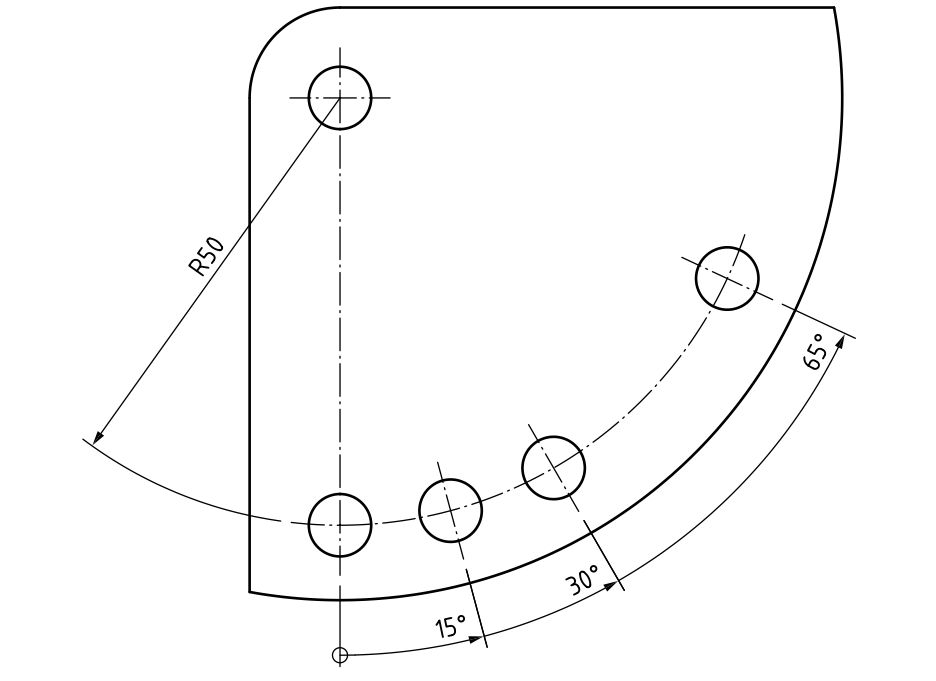


NOTE It is permissible to indicate only one dimension in the case of running dimensions in two directions.

6.1.17.3 Running dimensioning of angles

Running dimensioning of angles shall be indicated by one origin symbol and arrowheads to the extension lines of the feature (see Figure 57).

Figure 57 **Running dimensioning of angles**



6.1.18 Cartesian coordinate dimensioning

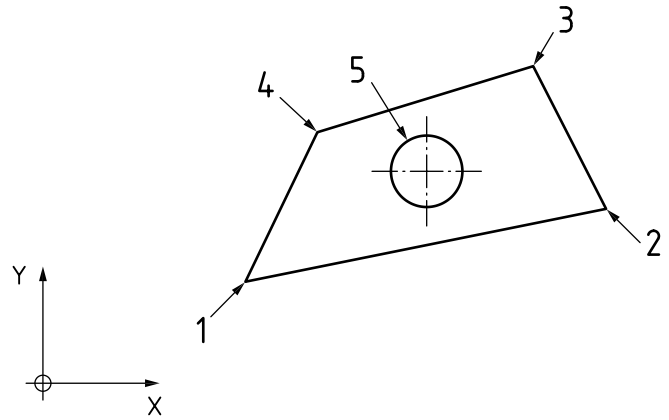
NOTE Cartesian coordinates are defined starting from the origin by linear dimensions in orthogonal directions (see Figure 58 and Figure 59). Neither dimension lines nor extension lines are drawn.

The dimensional values indicated in the negative directions shall have negative signs.

The origin used for coordinate dimensioning shall be indicated (see Figure 58).

The coordinates can be indicated by a reference letter(s) or number which appears in a table together with the value of the coordinate, or by the direct indication of the coordinates. The reference letter(s) or number or the coordinate value can be placed adjacent to the coordinate location or indicated using a leader line.

Figure 58 **Cartesian coordinate dimensioning**

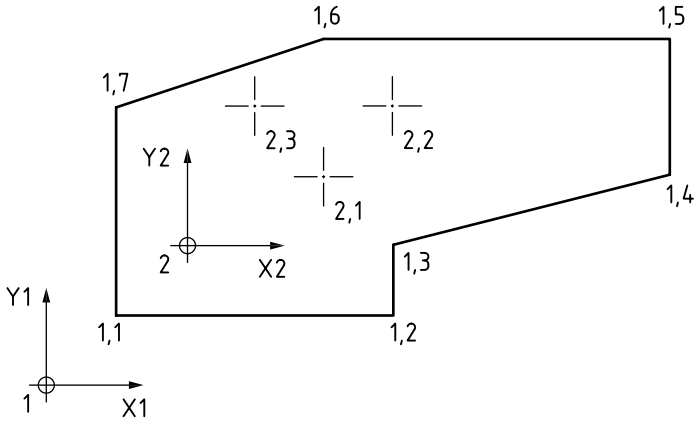


Position	X	Y	*d*
1	10	10	—
2	60	20	—
3	50	40	—
4	20	30	—
5	35	25	ø10

NOTE Designations for position may be numerical or alphanumerical.

The main coordinate system may have subsystems. If this is the case, the origin of the coordinate systems and the specific positions within the coordinate systems shall be numbered continuously by arabic numbers. A point shall be used as a separation symbol (see Figure 59).

Figure 59 **Cartesian coordinate dimensioning**



Coordinate origin	**Position**	X1, X2	Y1, Y2	*d*
1	1	0	0	—
1	1,1	10	10	—
1	1,2	50	10	—
1	1,3	50	20	—
1	1,4	80	30	—
1	1,5	80	50	—
1	1,6	30	50	—
1	1,7	10	40	—
1	2	20	20	ø10
2	2,1	20	10	ø5
2	2,2	30	20	ø10
2	2,3	10	20	ø5

6.2 Dimensioning common features

6.2.1 General

It is the practice in the UK to leave a small gap between the extension line and the feature. In BS ISO 129-1:2004 the illustrated examples do not show a gap, but **5.3** includes the text, "in certain technical fields, a gap between the feature and the beginning of the extension line is acceptable". The UK has always held to the view that, for reasons of clarity, a gap is preferable and, given that in the revised standard the gap is permissible, it is intended that the current UK practice should be maintained.

Dimensioning and tolerancing shall conform to the following standards, as appropriate.

BS ISO 129-1	*Technical drawings – Indications of dimensions and tolerances – Part 1: General principles*
BS EN ISO 14405-2	*Geometrical product specifications (GPS) – Dimensional tolerancing – Dimensions other than linear sizes*
BS EN ISO 1119	*Geometrical product specifications (GPS) – Series of conical tapers and taper angles*
BS EN ISO 1660	*Technical drawings – Dimensioning and tolerancing of profiles*
BS 1916-1	*Limits and fits for engineering – Part 1: Limits and tolerances*
BS 1916-2	*Limits and fits for engineering – Part 2: Guide to the selection of fits in BS 1916-1*
BS 1916-3	*Limits and fits for engineering – Part 3: Recommendations for tolerances, limits and fits for large diameters*
BS EN ISO 3040	*Geometrical product specifications (GPS) – Dimensioning and tolerancing – Cones*
BS 3734-1	*Rubber – Tolerances for products – Part 1: Dimensional tolerances*
BS 4500	*Limits and fits – Guidance for system of cone (taper) fits and tolerances for cones from C = 1:3 to 1:500, lengths from 6 mm to 630 mm and diameters up to 500 mm*
BS EN ISO 5458	*Geometrical product specifications (GPS) – Geometrical tolerancing – Positional tolerancing*
BS EN ISO 6410-1	*Technical drawings – Screw threads and threaded parts – Part 1: General conventions*
BS 6615 [2)]	*Specification for dimensional tolerances for metal and metal alloy castings*
BS 7010	*Code of practice for a system of tolerances for the dimensions of plastic mouldings*
BS EN ISO 7083	*Technical drawings – Symbols for geometrical tolerancing – Proportions and dimensions*
BS EN ISO 8015	*Geometrical product specifications (GPS) – Fundamentals – Concepts, principles and rules*
BS ISO 10579	*Geometrical product specifications (GPS) – Dimensioning and tolerancing – Non-rigid parts*
BS EN ISO 13920	*Welding – General tolerances for welded constructions – Dimensions for lengths and angles – Shape and position*
BS EN ISO 286-1	*Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 1: Basis of tolerances, deviations and fits*
BS EN ISO 286-2	*Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

[2)] Due to be superseded by ISO 8062.

6.2.2 Presentation of decimals

6.2.2.1 General

Each group of three digits, counting from the decimal marker to the left and to the right, shall be separated from other digits by a small space (e.g. 12 345,067 8).

NOTE The use of a comma or a point for this purpose is deprecated, i.e. it is further recommended that separation of items in lists be effected by the use of a semicolon.

6.2.2.2 Decimal marker

The decimal marker shall be a comma.

6.2.2.3 Non-indicated decimals in tolerances

Non-indicated decimals in a tolerance indication shall be taken as zeroes, e.g. 0,2 is the same as 0,20000000000 . . .

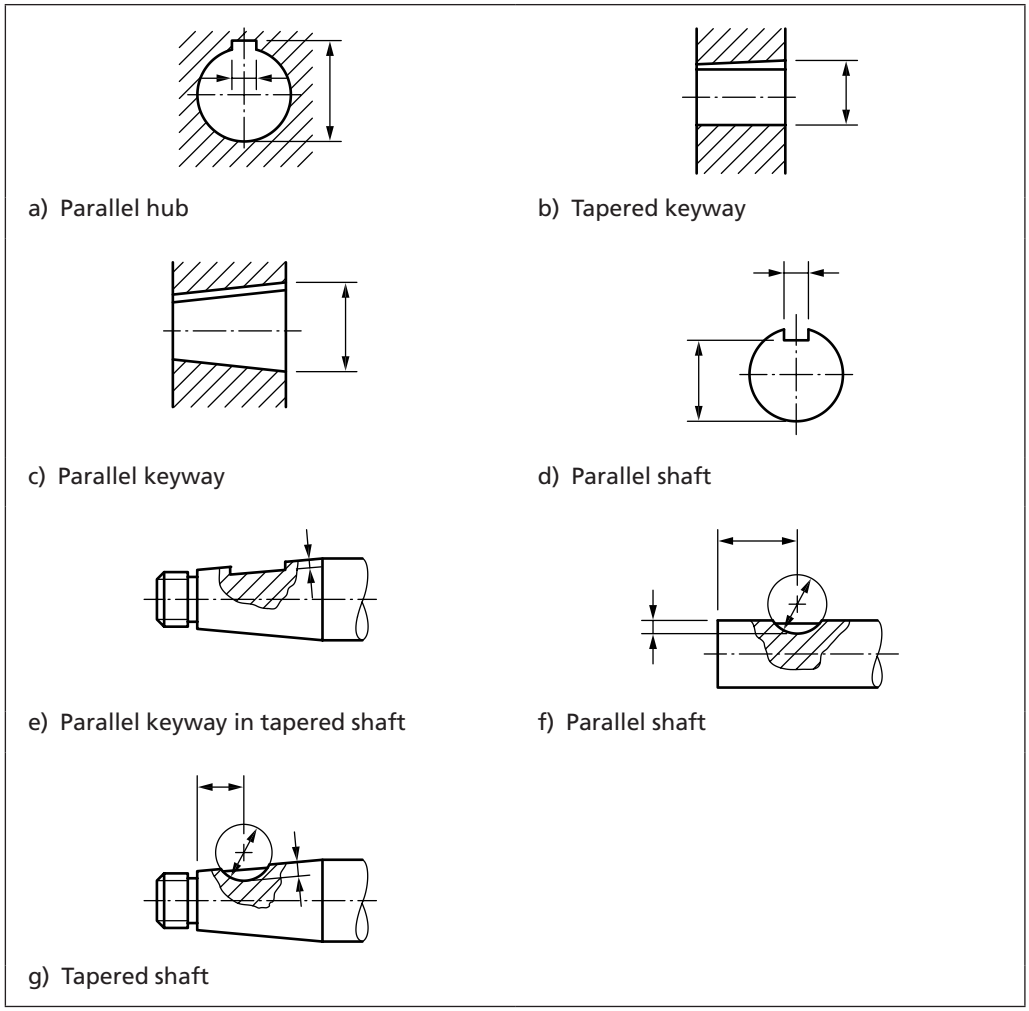
6.2.3 Keyways

Keyways in hubs or shafts shall be dimensioned by one of the methods shown in Figure 60.

NOTE 1 Limit tolerances and/or geometrical tolerances are also required.

NOTE 2 Further information on keys and keyways is given in BS 4235-1 and BS 4235-2.

Figure 60 **Dimensioning of keyways**



6.2.4 Screw threads

The following standards provide the definition for metric ISO screw threads.	
BS 3643-1	*ISO metric screw threads – Part 1: Principles and basic data*
BS 3643-2	*ISO metric screw threads – Part 2: Specification for selected limits of size*
BS 4827	*Specification for ISO miniature screw threads – Metric series*
BS ISO 261	*ISO general purpose metric screw threads – General plan*
BS ISO 262	*ISO general purpose metric screw threads – Selected sizes for screws, bolts and nuts*
BS ISO 965-1	*ISO general purpose metric screw threads – Tolerances – Part 1: Principles and basic data*

Screw threads shall be specified according to functional requirement.

6.2.5 Methods of specifying tolerances

The necessary tolerances shall be specified in one or more of the following ways.

a) Separate indication on the drawing.

b) Reference to general tolerances noted on the drawing.

c) Reference to a standard containing general tolerances.

d) Reference to other documents.

6.3 Tolerance dimensions

6.3.1 General

*COMMENTARY ON **6.3.1***
All features on component parts always have a size and a geometrical shape. For the deviation of size and for the deviations of the geometrical characteristics (form, orientation and location) the function of the part requires limitations which, when exceeded, impair this function.

The tolerancing on the drawing shall be complete to ensure that the elements of size and geometry of all features are controlled, i.e. nothing shall be implied or left to judgement in the workshop or in the inspection department.

NOTE 1 The use of general tolerances for size and geometry simplifies the task of ensuring that the prerequisites are met.

NOTE 2 See BS EN 22768 for more information on general tolerances.

6.3.2 General tolerances for linear dimensions

When use is made of BS EN 22768-1 for general tolerances, tolerances for dimensions shall be as given in Table 1, Table 2 and Table 3.

Table 1 **Permissible deviations for linear dimensions except for broken edges**

Tolerance class		Permissible deviations for basic size range							
Designation	**Description**	**0,5 [A] up to 3**	**over 3 up to 6**	**over 6 up to 30**	**over 30 up to 120**	**over 120 up to 400**	**over 400 up to 1000**	**over 1000 up to 2000**	**over 2000 up to 4000**
f	fine	±0,05	±0,05	±0,1	±0,15	±0,2	±0,3	±0,5	—
m	medium	±0,1	±0,1	±0,2	±0,3	±0,5	±0,8	±1,2	±2
c	coarse	±0,2	±0,3	±0,5	±0,8	±1,2	±2	±3	±4
v	very coarse	—	±0,5	±1	±1,5	±2,5	±4	±6	±8

[A] For nominal sizes below 0,5 mm, the deviations shall be indicated adjacent to the relevant nominal size(s).

NOTE Values in millimetres.

Table 2 **Permissible deviations for broken edges (external radii and chamfer heights)**

Tolerance class		Permissible deviations for basic size range		
Designation	**Description**	**0,5 [A] up to 3**	**over 3 up to 6**	**over 6**
f m	fine medium	±0,2	±0,5	±1
c v	coarse very coarse	±0,4	±1	±2

[A] For nominal sizes below 0,5 mm, the deviations shall be indicated adjacent to the relevant nominal size(s).

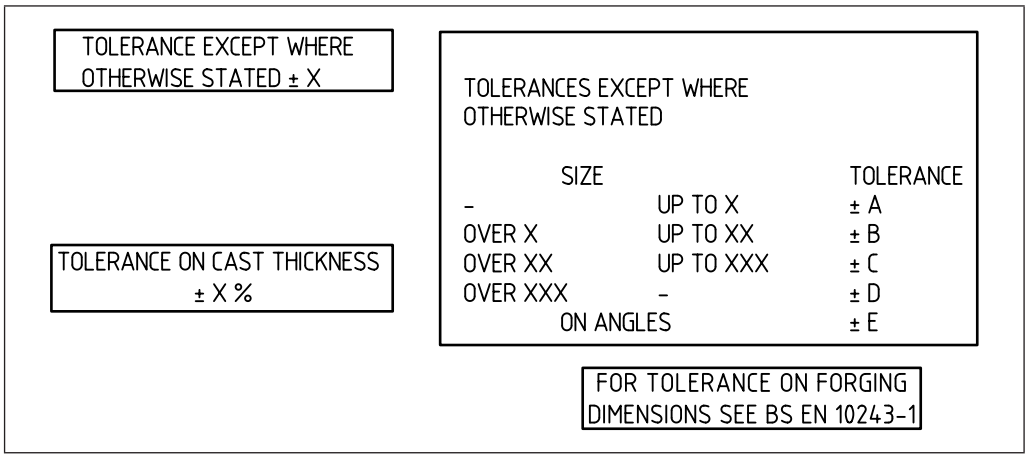
NOTE Values in millimetres.

Table 3 **Permissible deviations of angular dimensions**

Tolerance class		Permissible deviations for ranges of lengths, in millimetres, of the shorter side of the angle concerned				
Designation	**Description**	**up to 10**	**over 10 up to 50**	**over 50 up to 120**	**over 120 up to 400**	**over 400**
f m	fine medium	±1°	±0°30′	±0°20′	±0°10′	±0°5′
c	coarse	±1°30′	±1°	±0°30′	±0°15′	±0°10′
v	very coarse	±3°	±2°	±1°	±0°30′	±0°20′

NOTE Due to the inherent risk of unintentionally over-specifying form and orientation controls that can result from the use of general geometrical tolerances, reference to BS EN 22768-2 is inadvisable. In such cases, general tolerance notes could be used to apply a common tolerance to many of the features on a drawing. The example shown in Figure 61 illustrates the wide field of application of this system.

Figure 61 **Use of general tolerance notes**



6.3.3 Unspecified features of the 3-D CAD model

Where no datum system is specified then the 3-D CAD model coordinate system shall be the default for the position (location and orientation) of all unspecified features.

Where no general tolerance is stated, all dimensions shall be considered auxiliary.

Where a general tolerance is stated, that general tolerance shall be applicable for the nominal dimensions of:

a) features of size;

b) location and orientation of features of size (in accordance with BS EN ISO 14660-1);

c) location and orientation of other features, e.g. planes and surfaces.

Care shall be taken to ensure that ambiguities between 2-D and 3-D are avoided as any such ambiguities could render the specification incomplete (see **4.1**)

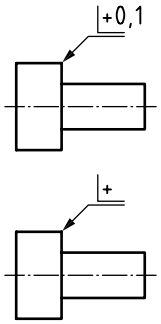
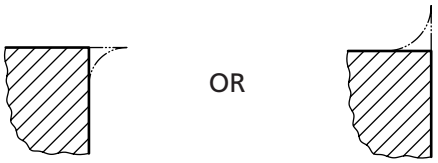
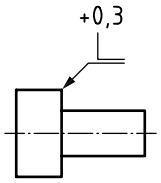
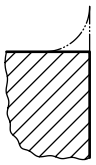
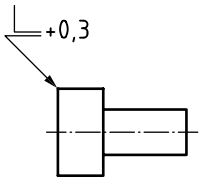
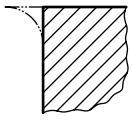
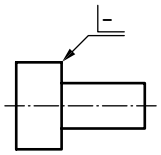
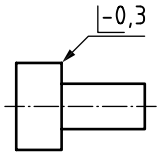
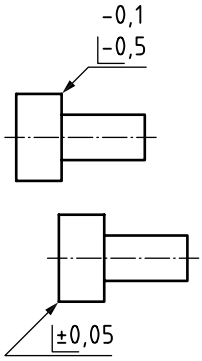
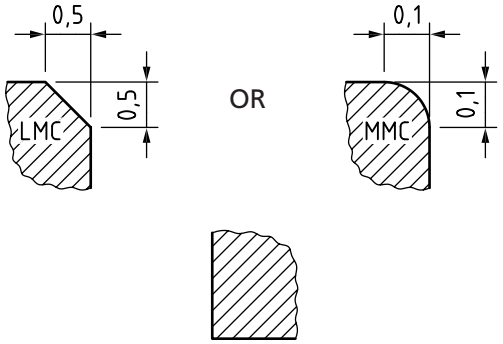
NOTE BS EN 22768-1 does not apply to nominal dimensions of a 3-D CAD model.

6.4 Edges specification

Edges shall be specified in accordance with BS ISO 13715.

NOTE Examples of how edges can be specified are given in Table 4. For full details, though, see BS ISO 13715.

Table 4 **Examples of indication of edges**

Indication	Meaning	Explanation
		External edge with burr permitted up to 0,1mm; burr direction undefined. External edge with permitted burr; size and direction of burr undefined.
		External edge with burr acceptable up to 0,3 mm; burr direction defined.
		
		External edge without burr; undercut permitted, size undefined.
		External edge without burr; undercut up to 0,3 mm.
		External edge without burr; undercut in the zone from 0,1 mm to 0,5 mm. External edge with burr permitted up to 0,05 mm or undercut down to 0,05 mm (sharp edge); burr direction undefined.

Abbreviations: LMC = least material condition; MMC = maximum material condition.

Section 7: Geometrical product specification

7.1 Interpretation and invocation principle

If a TPS is to be interpreted according to the rules of ISO GPS, the following statement shall be included in the title block, in a note, or somewhere else reasonably prominent within the drawing frame.

"TOLERANCING ISO 8015"

NOTE 1 This marking is a BS 8888 requirement, and not a requirement of BS EN ISO 8015. This is necessary to avoid possible misinterpretation of which system of standards govern the interpretation of a TPS.

Once a portion of the ISO GPS system is invoked on a mechanical engineering product specification, the entire ISO GPS system shall be invoked, unless otherwise indicated on the specification e.g. by reference to a relevant document.

"Unless otherwise indicated on the specification" means that it is indicated on the specification that this has been prepared in accordance with a certain standard. That standard and not the ISO GPS system shall be used to interpret those elements of the specification which are covered by that standard.

NOTE 2 The ISO GPS system is defined in a hierarchy of standards that includes the following types of standards in the given order.

- *Fundamental GPS standards.*
- *General GPS standards.*
- *Complementary GPS standards.*

See ISO/TR 14638 for further details.

The "entire ISO GPS system shall be invoked" means that fundamental and general GPS standards shall apply and, consequently, that the reference temperature given in BS EN ISO 1 and the decision rules given in BS EN ISO 14253-1 shall apply, unless otherwise indicated.

NOTE 3 The purpose of the invocation principle is to provide the formal traceability for these GPS standards and rules.

The rules given in standards at a higher level in the hierarchy shall apply in all cases, unless rules in standards at lower levels in the hierarchy specifically give other rules.

All rules given in fundamental GPS standards shall apply, in addition to those specifically given in general GPS standards, e.g. BS EN ISO 1101, except where the rules in the general GPS standard are explicitly different from the rules given in fundamental GPS standards and unless the rules in a specific complementary GPS standard give other rules that apply within its scope.

All rules given in fundamental and general GPS standards shall apply in addition to the rules specifically given in complementary GPS standards, e.g. BS EN 22768-1, except in the cases where the rules in the complementary GPS standard are explicitly different from the rules given in fundamental, and general GPS standards.

7.2 Independency principle

By default, every GPS requirement for a feature or relation between features shall be fulfilled independently of other requirements, except when it is stated in a standard or by special indication (e.g. Ⓜ modifiers according to BS EN ISO 2692 or CZ) as part of the actual specification.

7.3 Feature principle

A workpiece shall be considered as made up of a number of features limited by natural boundaries. By default, every GPS specification for a feature or relation between features shall apply to the entire feature and each GPS specification shall apply only to one feature or one relation between features.

NOTE This default can only be overridden by explicit indications on the drawing.

7.4 Default principle

A complete specification operator shall be indicated by using ISO basic GPS specifications.

NOTE The ISO basic GPS specification indicates that the requirement is based on the default specification operator.

7.5 Reference condition principle

By default, all GPS specifications shall apply at reference conditions, including the standard temperature of 20 °C defined in BS EN ISO 1 and the workpiece's freedom from contaminants.

Any additional or other conditions that apply, e.g. humidity conditions, shall be defined on the drawing.

7.6 Rigid workpiece principle

By default, a workpiece shall be considered as having infinite stiffness and all GPS specifications shall apply in the free state, undeformed by any external forces, including the force of gravity. Any additional or other conditions that apply shall be defined in the drawing.

NOTE See, for example, BS ISO 10579.

7.7 Datums and datum systems

*COMMENTARY ON **7.7***
This subclause describes some of the main definitions, principles and rules of working with datums and datum features. A more extensive description of datums and datum systems is give in in BS EN ISO 5459. This subclause is not intended to replace BS EN ISO 5459; it is only intended to make some of the key content more accessible.

7.7.1 General

A datum is an ideal (theoretically perfect) geometrical reference, which is used when defining the location or orientation of other features.

A datum is based on one or more non-ideal, manufactured surfaces, which are known as datum features.

Two or three datums can be used together when defining the geometry of a workpiece. Two or three datums working together are known as a datum system.

Datums shall be used to avoid or minimize ambiguity in specifications.

Definitions and explanations

Datum

A datum is a geometrically ideal feature, which can be used to define the location or orientation of a tolerance zone.

A datum can be:

a) a point;

b) a straight line;

c) a flat plane;

d) a combination of a), b) and c).

A datum consists of the situation feature(s) (see definition below) of a datum feature.

The concept of six degrees of freedom is very useful in understanding the way in which datums work.

Datum feature

The datum feature is a real integral feature or part of a real integral feature. The datum feature is a manufactured surface, and is non-ideal.

Common datum

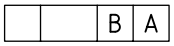
A common datum is a datum based on the situation features of more than one datum feature.

Datum system

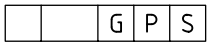
A datum system is a set of two or three datums which are used together in a specified order to define a frame of reference for locating or orientating the tolerance zones for other features on a workpiece (see Figure 62). This is achieved by defining the theoretically exact location or the theoretically exact orientation of the tolerance zone relative to the datum system.

A datum system is defined in a tolerance frame, where two or three datum references are listed, so each geometrical tolerance contains within it the datum system required to fully define or evaluate that requirement. Not all geometrical tolerances require datum systems.

Figure 62 **Tolerance defining a datum system**



a) Consisting of two datums



b) Consisting of three datums

Primary datum

The primary datum is the datum listed first in the tolerance frame. This datum is not influenced by constraints from other datums.

Secondary datum

The secondary datum is the datum listed second in the tolerance frame. In a datum system, the secondary datum is perfectly oriented or aligned with the primary datum.

NOTE 1 A secondary datum is not always required. Datum features should be derived according to functional requirements.

Tertiary datum

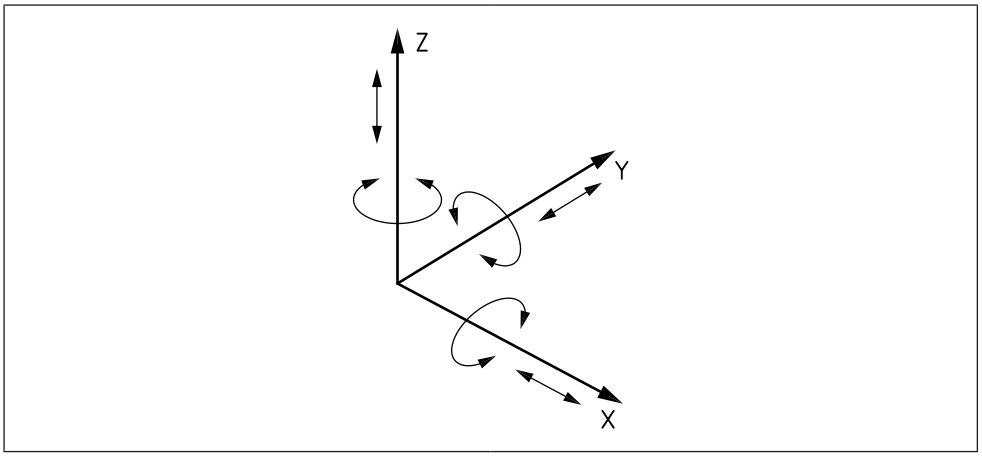
The tertiary datum is the datum listed third in the tolerance frame. In a datum system, the tertiary datum is perfectly oriented or aligned with the primary and secondary datums.

NOTE 2 A tertiary datum is not always required. Datum features should be derived according to functional requirements.

Six degrees of freedom

A rigid body is said to have six degrees of freedom (see Figure 63). These can be considered as the freedom to translate, or move, along each of the three axes of a Cartesian coordinate system, and also to rotate around each of these axes. Thus, a rigid body has three translational degrees of freedom, and three rotational degrees of freedom.

Figure 63 **Degrees of freedom**



Some or all of these degrees of freedom can be locked by constraining the rigid body in various ways.

Situation feature

A situation feature is one of the ideal geometrical elements used when defining the location or orientation of a surface.

A situation feature can be:

a) a point;

b) a straight line;

c) a flat plane.

For example, the situation feature for a planar surface is a flat plane, the situation feature for a cylinder is a straight line (the axis of the cylinder), and the situation feature for a sphere is a point (the centre point of the sphere).

Locking the location or orientation of a situation feature causes some of the degrees of freedom of the surface to be locked.

Some types of surface have more than one situation feature. A cone has two situation features, an axis and a point (where the taper of the cone intersects the axis of the cone, or a point on the axis where a section through the cone has a particular diameter).

The situation features for any non-ideal, manufactured surface are based on the associated feature (the associated feature is an ideal feature which is fitted to the real feature, or to data extracted from the real feature: see BS EN ISO 17450-1 and BS EN ISO 5459).

7.7.2 Deriving datums from datum features

NOTE The datum, by default[3], is based on an ideal feature, in contact with the datum feature (non-ideal feature), remaining outside the datum feature, such that the deviation of the datum from any point on the datum feature is minimized.

7.7.2.1 Datum based on a planar datum feature

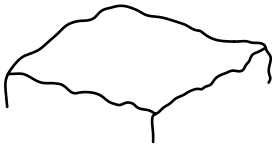
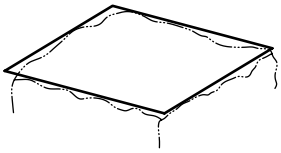
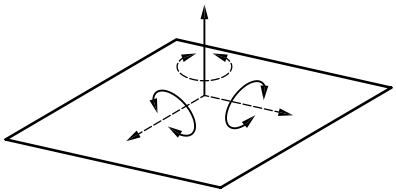
The datum feature consists of a non-ideal plane (see Figure 64).

A primary datum based on the datum feature in Figure 64 shall be a tangent plane, in contact with the surface but outside the material of the datum feature, such that the distance *d* is minimized.

A secondary datum based on the datum feature in Figure 64 shall be a tangent plane, in contact with the surface but outside the material of the datum feature, which is perfectly oriented or aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 64 shall be a tangent plane, in contact with the surface but outside the material of the datum feature, which is perfectly oriented or aligned with the primary and secondary datum.

Figure 64 **Datum based on a planar datum feature**

Datum feature (non-ideal surface)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Plane	b) Associated plane	c) One translation and two rotations Translation along an axis perpendicular to the plane. Rotation about two perpendicular axes aligned with the plane.

7.7.2.2 Datum based on two parallel, opposed planes (external)

NOTE 1 An external feature consisting of two parallel, opposed planes would be a feature such as a flange.

The datum feature consists of two non-ideal planes (see Figure 65).

A primary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is minimized.

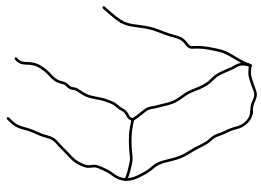
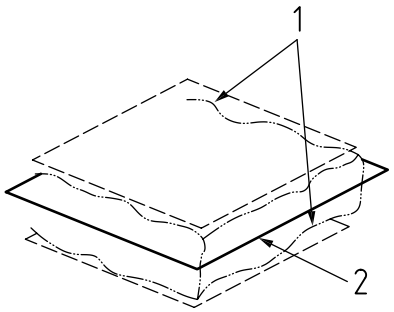
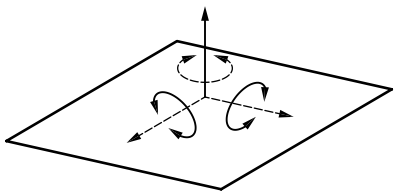
NOTE 2 This pair of contacting planes is sometimes described as the minimum circumscribing feature.

A secondary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is minimized while they are perfectly oriented or aligned with the primary datum.

[3] Other association methods may be specified.

A tertiary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is minimized while they are perfectly oriented or aligned with the primary and secondary datum.

Figure 65 **Datum based on two parallel, opposed planes (external)**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Two parallel opposed planes	b) Median plane of associated feature	c) One translation and two rotations Translation along an axis perpendicular to the median plane. Rotation about two perpendicular axes aligned with the median plane.

Key

1 Associated feature

2 Median plane

7.7.2.3 Datum based on two parallel, opposed planes (internal)

NOTE An internal feature consisting of two parallel, opposed planes would be a feature such as a slot with two parallel sides.

*For an internal feature, the same definitions apply as for an external feature (**7.7.2.2**). In this case, the two contacting planes used to define the datum consist of what is sometimes described as the maximum inscribing feature.*

The datum feature consists of two non-ideal planes.

A primary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is maximized.

A secondary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is maximized while they are perfectly oriented or aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 65 shall be a median plane, constructed from two parallel planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation is maximized while they are perfectly oriented or aligned with the primary and secondary datum.

7.7.2.4 Cylindrical feature (external)

NOTE An external cylindrical feature would be a shaft.

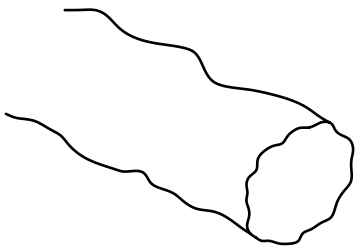
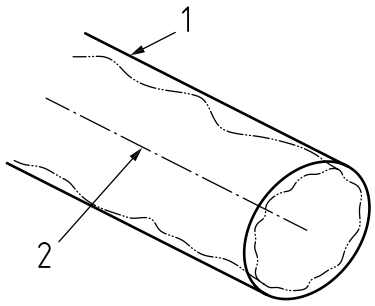
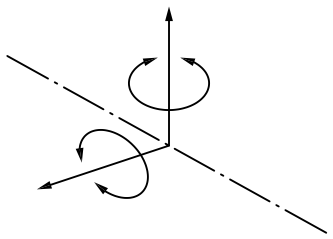
The datum feature consists of a non-ideal cylinder (see Figure 66).

A primary datum based on the datum feature in Figure 66 shall be an axis, constructed from the minimum circumscribing cylinder which can be constructed around the datum feature.

A secondary datum based on the datum feature in Figure 66 shall be an axis, constructed from the minimum circumscribing cylinder which can be constructed around the datum feature, whilst perfectly oriented or aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 66 shall be an axis, constructed from the minimum circumscribing cylinder which can be constructed around the datum feature, whilst perfectly oriented or aligned with the primary and secondary datum.

Figure 66 **Datum feature consisting of a non-ideal cylinder (external)**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Cylinder	b) Axis of associated feature	c) Two translations and two rotations Translation along two perpendicular axes which are also perpendicular to the axis of the associated feature. Rotation about two perpendicular axes which are also perpendicular to the axis of the associated feature.

Key

1 Associated feature

2 Axis

7.7.2.5 Cylindrical feature (internal)

NOTE An internal cylindrical feature would be a cylindrical hole or bore.

The datum feature consists of a non-ideal cylinder.

A primary datum based on the datum feature in Figure 66 shall be an axis, constructed from the maximum inscribing cylinder which can be constructed around the datum feature.

A secondary datum based on the datum feature in Figure 66 shall be an axis, constructed from the maximum inscribing cylinder which can be constructed around the datum feature, whilst perfectly oriented or aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 66 shall be an axis, constructed from the maximum inscribing cylinder which can be constructed around the datum feature, whilst perfectly oriented or aligned with the primary and secondary datum.

7.7.2.6 Spherical feature (external)

NOTE An external spherical feature would be a feature, such as the ball in a ball and socket joint.

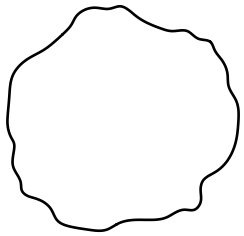
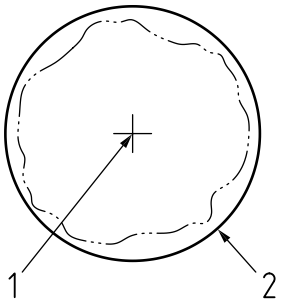
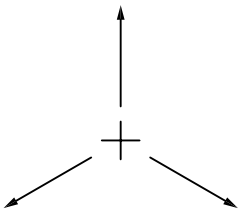
The datum feature consists of a non-ideal sphere (see Figure 67).

A primary datum based on the datum feature in Figure 67 shall be a point, constructed from the minimum circumscribing sphere which can be constructed around the datum feature.

A secondary datum based on the datum feature in Figure 67 shall be a point, constructed from the minimum circumscribing sphere which can be constructed around the datum feature, whilst perfectly aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 67 shall be a point, constructed from the minimum circumscribing sphere which can be constructed around the datum feature, whilst perfectly aligned with the primary and secondary datum.

Figure 67 **Datum feature consisting of a non-ideal sphere (external)**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Sphere	b) Centre point of associated feature	c) Three translations Translation along each of three mutually perpendicular axes which have their origin located at the centre point of the associated feature.

Key

1 Centre point

2 Associated feature

7.7.2.7 Spherical feature (internal)

NOTE An internal spherical feature would be a feature such as the socket in a ball and socket joint.

The datum feature consists of a non-ideal sphere.

A primary datum based on the datum feature in Figure 67 shall be a point, constructed from the maximum inscribing sphere which can be constructed around the datum feature.

A secondary datum based on the datum feature in Figure 67 shall be a point, constructed from the maximum inscribing sphere which can be constructed around the datum feature, whilst perfectly aligned with the primary datum.

A tertiary datum based on the datum feature in Figure 67 shall be a point, constructed from the maximum inscribing sphere which can be constructed around the datum feature, whilst perfectly aligned with the primary and secondary datum.

7.7.2.8 Wedge

The datum feature consists of a non-ideal wedge (see Figure 68).

A secondary datum based on the datum feature in Figure 68 shall consist of a median plane and an axis. The median plane shall be constructed from two angled planes, which are in contact with the two surfaces of the datum feature but outside the material of the datum feature, such that their separation from the surfaces of the datum feature is minimized and the median plane is perfectly oriented or aligned with the primary datum. The axis shall be an axis that lies in the median plane, either at the intersection of the two angled planes of the associated feature or in a specified position parallel to that intersection.

A tertiary datum based on the datum feature in Figure 68 shall consist of a median plane and an axis. The median plane shall be constructed from two angled planes, which are in contact with the two surfaces of the datum feature, but outside the material of the datum feature, such that their separation from the surfaces of the datum feature is minimized and the median plane is perfectly oriented or aligned with the primary and secondary datum. The axis shall be an axis that lies in the median plane, either at the intersection of the two angled planes of the associated feature or in a specified position parallel to that intersection.

NOTE If the wedge is defined with a theoretically exact angle, then the angle between the planes of the associated feature is fixed at the same angle. If the wedge is defined with a toleranced value for the angle, then the angle between the planes of the associated feature is variable.

7.7.2.9 Cone

The datum feature consists of a non-ideal cone (see Figure 69).

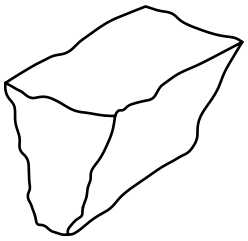
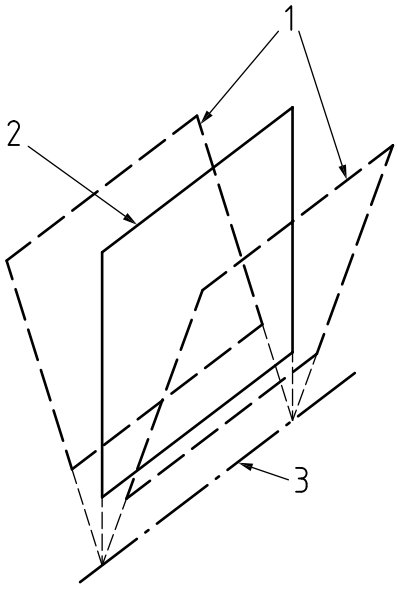
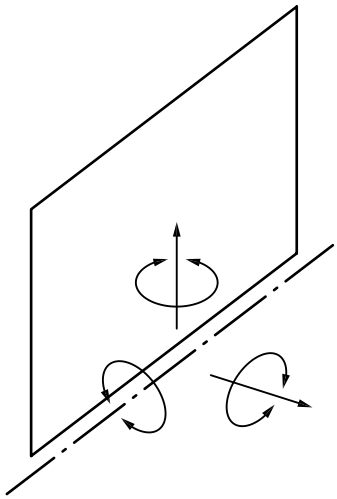
A primary datum based on the datum feature in Figure 69 shall consist of an axis and a point. The axis shall be the axis of an ideal cone, in contact with the surface of the datum feature, but outside the material of the datum feature, such that its separation from the surface of the datum feature is minimized. The point shall be a point that lies on the axis. The position of the point can be taken either at the apex of the cone or at another specified position along the axis.

A secondary datum based on the datum feature in Figure 69 shall consist of an axis and a point. The axis shall be the axis of an ideal cone, in contact with the surface of the datum feature, but outside the material of the datum feature, such that its separation from the surface of the datum feature is minimized and the axis is perfectly oriented or aligned with the primary datum. The position of the point can be taken either at the apex of the cone, or at another specified position along the axis.

A tertiary datum based on the datum feature in Figure 69 shall consist of an axis and a point. The axis shall be the axis of an ideal cone, in contact with the surface of the datum feature, but outside the material of the datum feature, such that its separation from the surface of the datum feature is minimized and the axis is perfectly oriented or aligned with the primary and secondary datum. The position of the point can be taken either at the apex of the cone, or at another specified position along the axis.

NOTE If the cone is defined with a theoretically exact angle, then the angle of the associated feature is fixed at the same angle. If the cone is defined with a toleranced value for the angle, then the angle of the associated feature is variable.

Figure 68 **Datum feature consisting of a non-ideal wedge**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Wedge	b) Median plane and axis of associated feature	c) Two translations and three rotations Translation along an axis perpendicular to the median plane, and translation along an axis parallel to the situation feature axis. Rotation about all three axes.

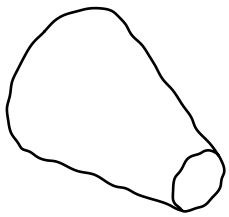
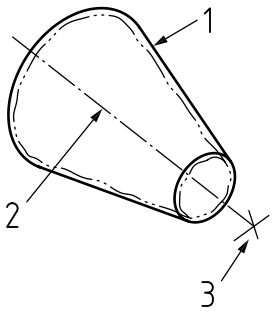
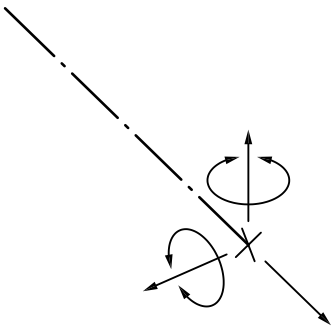
Key

1 Associated feature

2 Median plane

3 Axis

Figure 69 **Datum feature consisting of a non-ideal cone**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Cone	b) Axis and point of associated feature	c) Three translations and two rotations Translation along all three axes. Rotation about two perpendicular axes which are also perpendicular to the axis of the associated feature.

Key

1 Associated feature

2 Axis

3 Point

7.7.2.10 Complex surface

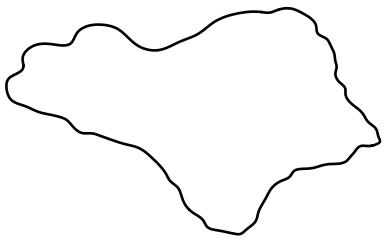
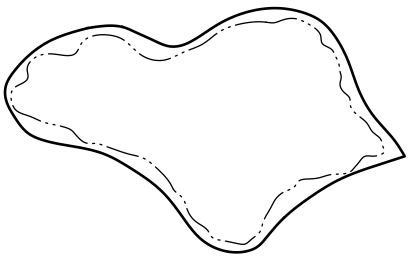
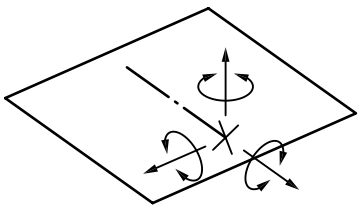
The datum feature consists of a non-ideal surface (see Figure 70).

A primary datum based on this datum feature shall be equivalent to a plane, an axis and a point.

a) A complex surface can be used in its entirety as a datum feature. The associated feature would be an ideal version of the surface, adjusted by varying the surface normal vectors so that it is in contact with the surface, but outside the surface, such that the distance from the surface is minimized. This results in a single datum which is the equivalent of three situation features, a surface, a line and a point, which can lock all six degrees of freedom. This is similar to offering the datum feature up to a fixture containing a negative impression of the feature. While the datum feature is in contact with the fixture, the workpiece is immobilized (all six degrees of freedom locked).

b) Not all inspection systems are capable of working with complex datum features in this way. Datum targets provide an alternative way of defining datums based on complex surfaces.

Figure 70 **Datum feature consisting of a non-ideal complex surface**

Datum feature (non-ideal surfaces)	**Datum (situation feature)**	**Degrees of freedom that can be controlled**
		
a) Complex surface	b) The associated surface provides the equivalent of a plane, axis and point	c) Three translations and three rotations Translation along all three axes. Rotation about all three axes.

7.7.3 Identifying datum features: Placement of the datum feature indicator

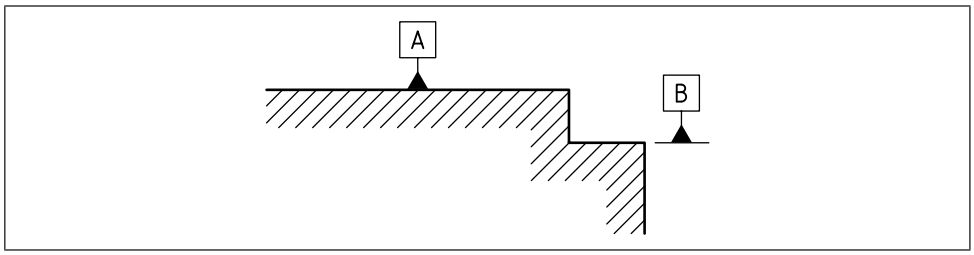
7.7.3.1 General

Where a datum is based on a single datum feature, the datum feature shall be identified with a datum feature indicator.

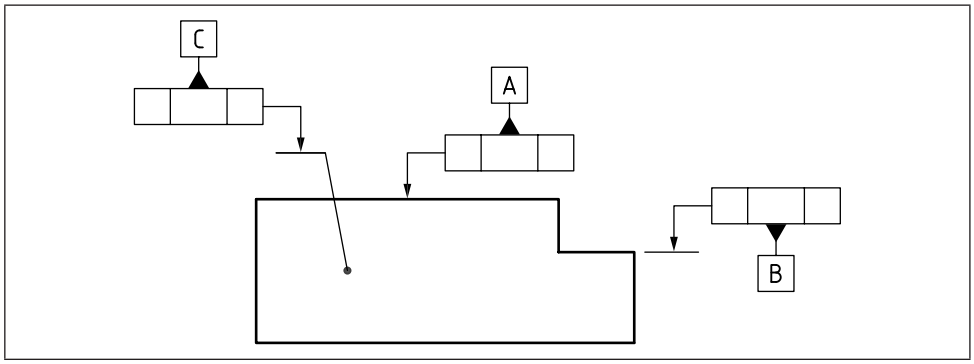
*NOTE The datum is based on the entire surface of the datum feature, unless otherwise indicated (if the datum is based on part of the datum feature, datum targets are used (see **7.7.5**).*

If the feature is not a feature of size, the datum feature indicator shall be placed in one of the following positions.

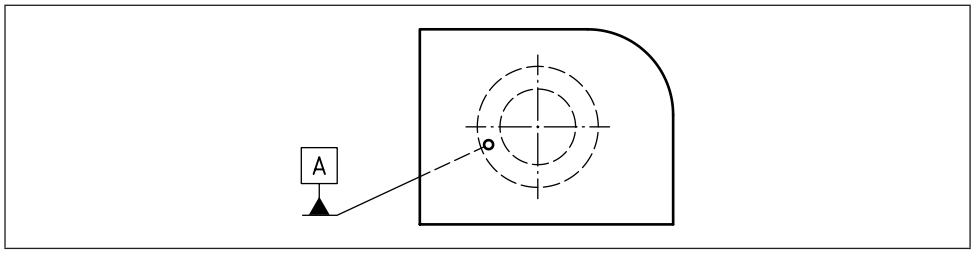
a) Attached to an outline, or an extension line from an outline, representing the feature in profile.



b) Attached to a tolerance frame which is attached to the feature.

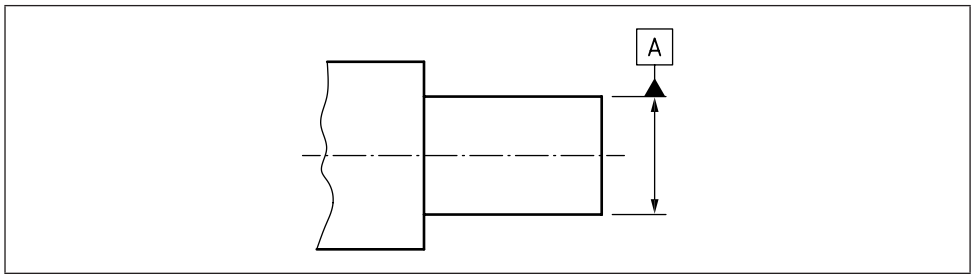


c) Attached to a visible surface with a leader line ending in a filled dot on the surface.

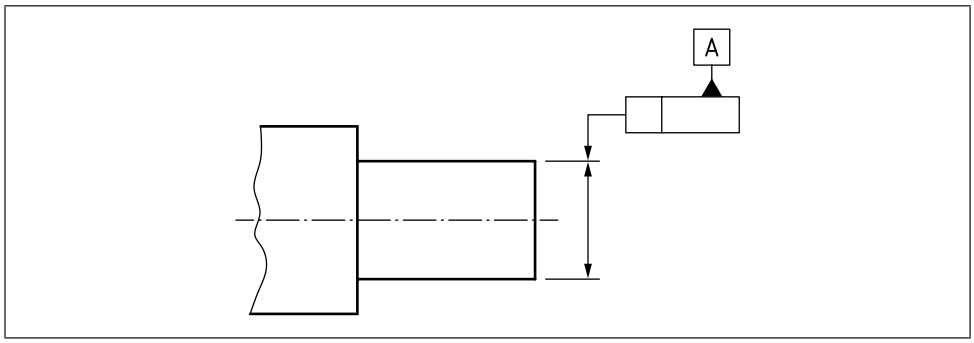


If the datum feature is a feature of size, the datum feature indicator shall be placed in one of the following positions.

1) In line with the dimension line for the size dimension of the feature.



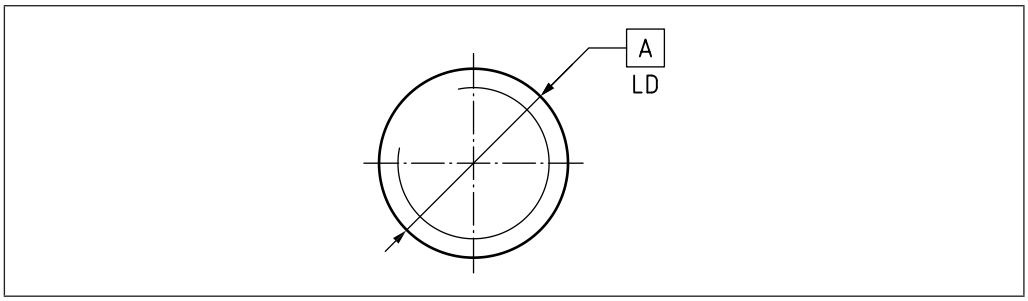
2) Attached to a tolerance frame which has its leader line-in-line with the dimension line for the size dimension of the feature.



3) Attached to a tolerance frame which is attached to the dimension line for the size dimension of the feature.

7.7.3.2 Datums based on threaded features, gears or splines

If the datum feature is a threaded feature, then it shall be treated like a cylindrical feature of size. The datum feature indicator shall be placed in line with the thread dimension, or attached to a tolerance frame which is attached in line with the thread dimension. By default, the datum is a datum axis based on the pitch cylinder of the thread. The datum definition can be altered by placing the MD (major diameter) or LD (minor diameter) modifier adjacent to the datum feature indicator (see BS EN ISO 1101).



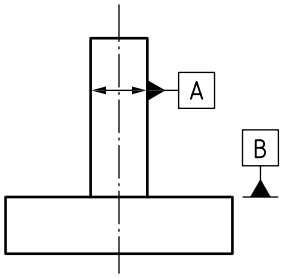
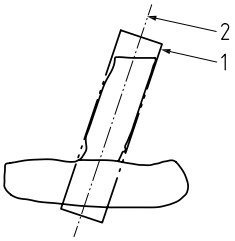
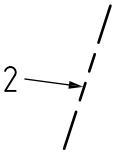
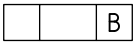
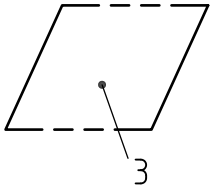
If the datum feature is a cylindrical gear form or a splined cylindrical feature, then it shall be treated like a cylindrical feature of size. The datum feature indicator shall be placed in line with the size dimension, or attached to a tolerance frame which is attached in line with the size dimension for the feature.

The size dimension can be the diameter dimension for the pitch diameter, major diameter or minor diameter of the feature.

There is no default definition of the datum axis based on a gear form or spline. The datum definition shall be completed by placing the PD (pitch diameter), MD (major diameter) or LD (minor diameter) modifier adjacent to the datum feature indicator (see BS EN ISO 1101).

NOTE An example of a datum based on a single datum feature is given in Table 5.

Table 5 **Example: single datum**

Indication of datum feature	Indication of datum in tolerance frame	Illustration of the meaning	Datum
			
			

Key

1 Associated feature (without orientation constraint)

2 Straight line which is the situation feature of the associated cylinder (its axis)

3 Plane which is the situation feature of the associated plane (the associated plane itself)

NOTE Association for single datums is described in BS EN ISO 5459:2011, Annex A.

7.7.4 Datum systems

7.7.4.1 Common datum

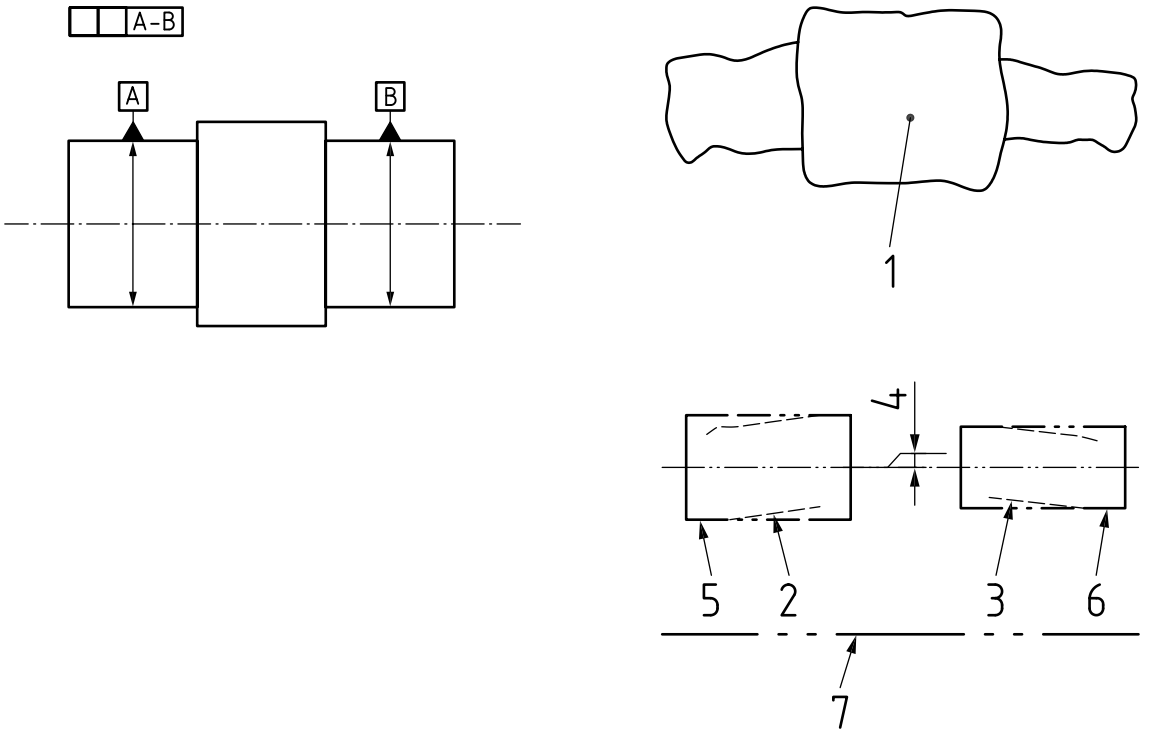
A common datum is a single datum based on more than one datum feature.

This is most often used to define a datum axis based on two or more coaxial features, but BE EN ISO 5459 also illustrates other possibilities.

The individual datum features being used to define the common datum are identified with datum feature identifiers. The common datum is defined in a tolerance frame, by a reference in a single compartment, consisting of each relevant datum feature name separated by hyphens.

Figure 71 illustrates the process used to establish a common datum from two surfaces nominally cylindrical and coaxial.

Figure 71 **Common datum established from two coaxial cylinders**



a) Indication

b) Meaning of common datum A-B

Key

1 Real workpiece
2 Non-ideal surface for datum feature A
3 Non-ideal surface for datum feature B
4 Defined (tolerance) relationship between the datum features used
5 Datum axis A-B is the axis of the minimum circumscribing feature for datum feature A
6 and the minimum circumscribing feature for datum B, constructed so that the two minimum
7 circumscribing features are perfectly coaxial with each other

7.7.4.2 Datum systems and the six degrees of freedom

In a datum system, the datums shall be used to lock some or all of the six degrees of freedom available to the tolerance zone. The effect of datums can be modified with the "orientation only" symbol (see **7.7.6**):

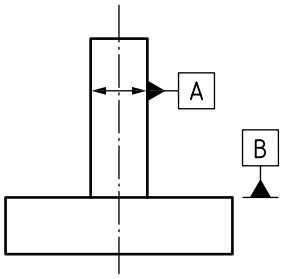
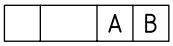
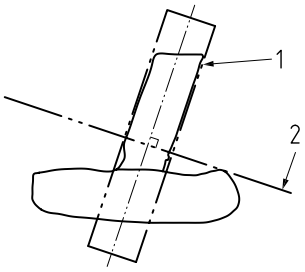
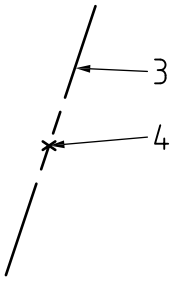
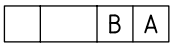
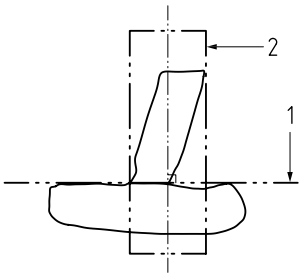
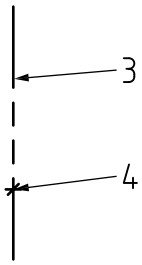
a) the primary datum locks, whichever degrees of freedom it can lock;

b) the secondary datum locks, whichever degrees of freedom it can lock, and which have not already been locked by the primary datum;

c) the tertiary datum locks, whichever degrees of freedom it can lock, and which have not already been locked by the primary and secondary datum.

NOTE Table 6 and Table 7 give examples of datum systems.

Table 6 **Examples: datum systems**

Indication of datum feature	Indication of datum in tolerance frame	Meaning on workpiece	Resulting common datum or datum system
			
			

Key

1 First associated feature without orientation constraint

2 Second associated feature with orientation constraint from the first associated feature

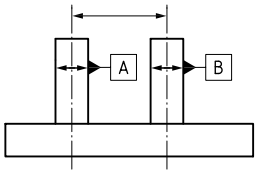
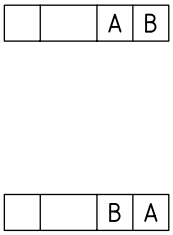
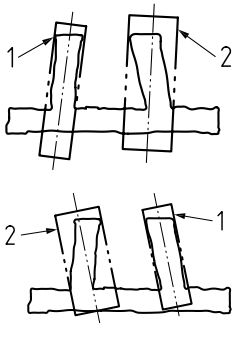
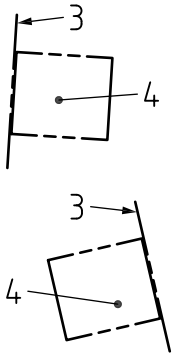
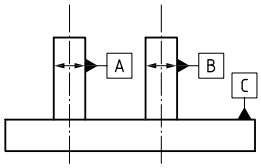
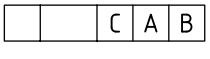
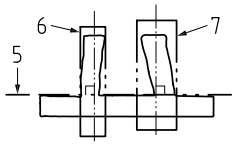
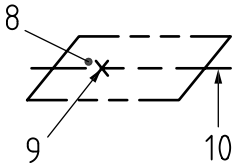
3 Straight line which is the situation feature of the associated cylinder (its axis)

4 Point of intersection between the straight line and the plane

NOTE 1 The orientation and location of datums are different, depending on the datum indications in the tolerance frame.

NOTE 2 Association for single datums is described in BS EN ISO 5459:2011, Annex A.

Table 7 **Examples: datum systems**

Indication of datum feature	Indication of datum in tolerance frame	Meaning on workpiece	Resulting common datum or datum system	Degrees of freedom that can be locked
				Five degrees of freedom locked. Translation along the axis (item 3) not locked.
				All six degrees of freedom locked

Key

1 First associated cylinder without constraint

2 Second associated cylinder with parallelism constraint from the first associated feature

3 Straight line which is the axis of the first associated cylinder

4 Plane including the axes of the two associated cylinders

5 First associated feature without a constraint

6 Second associated feature with a perpendicularlity constraint from the first associated feature

7 Third associated feature with a perpendicularlity constraint from the first associated feature (and parallelism constraint from the second feature)

8 Plane which is the first associated feature

9 Point of intersection between the plane and the axis of the second associated feature

10 Straight line which is the intersection between the associated plane and the plane containing the two axes

NOTE 1 The orientation and location of datums are different depending on the datum indication in the tolerance frame. Not all possibilities for establishing the datums are covered.

NOTE 2 Association for single datums is described in BS EN ISO 5459:2011, Annex A.

7.7.5 Datum targets

7.7.5.1 General

When a datum is based on part of a datum feature, then datum targets shall be used to identify the part of the datum feature to be used.

Datum targets shall be used for the following purposes, as appropriate.

a) To simulate the interface between the workpiece and other components of an assembly.

b) To simulate the interface between the workpiece and a fixture (frequently used with cast or forged components, which are held in fixtures for machining operations).

c) To identify probing points to be used when inspecting the workpiece with a coordinate measuring machine (CMM) or an articulated arm.

A datum target can take the form of:

1) a point;
2) a line; or
3) an area.

A datum target shall be indicated by a datum target indicator constructed from a datum target frame, a datum target symbol and a leader line linking the two symbols (directly or through a reference line).

Where necessary, the same datum target shall be indicated on several appropriate views in order to provide an unambiguous definition (see Figure 72 and Figure 73; see also Figure 84 and Figure 85).

Figure 72 **Application of datum targets**

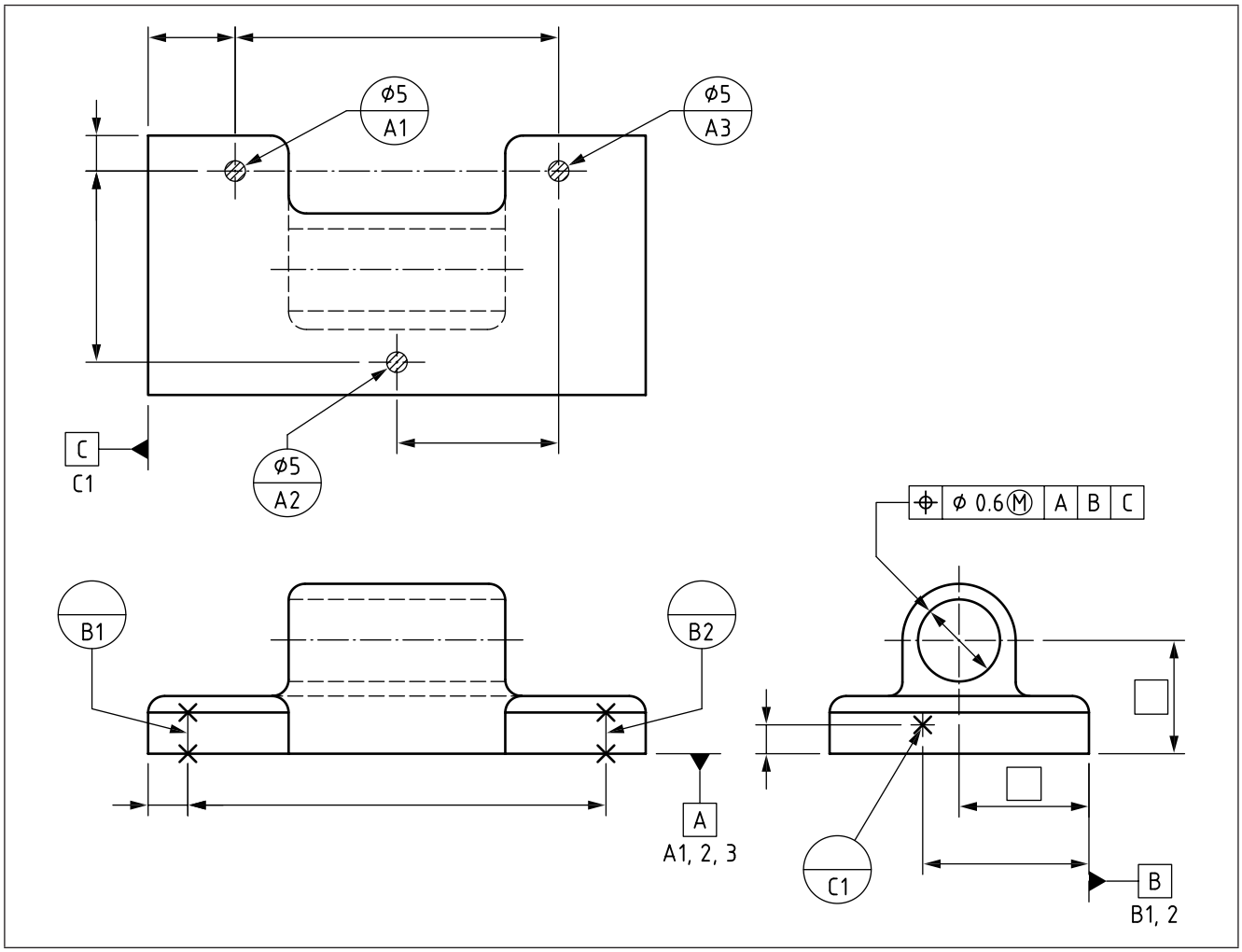
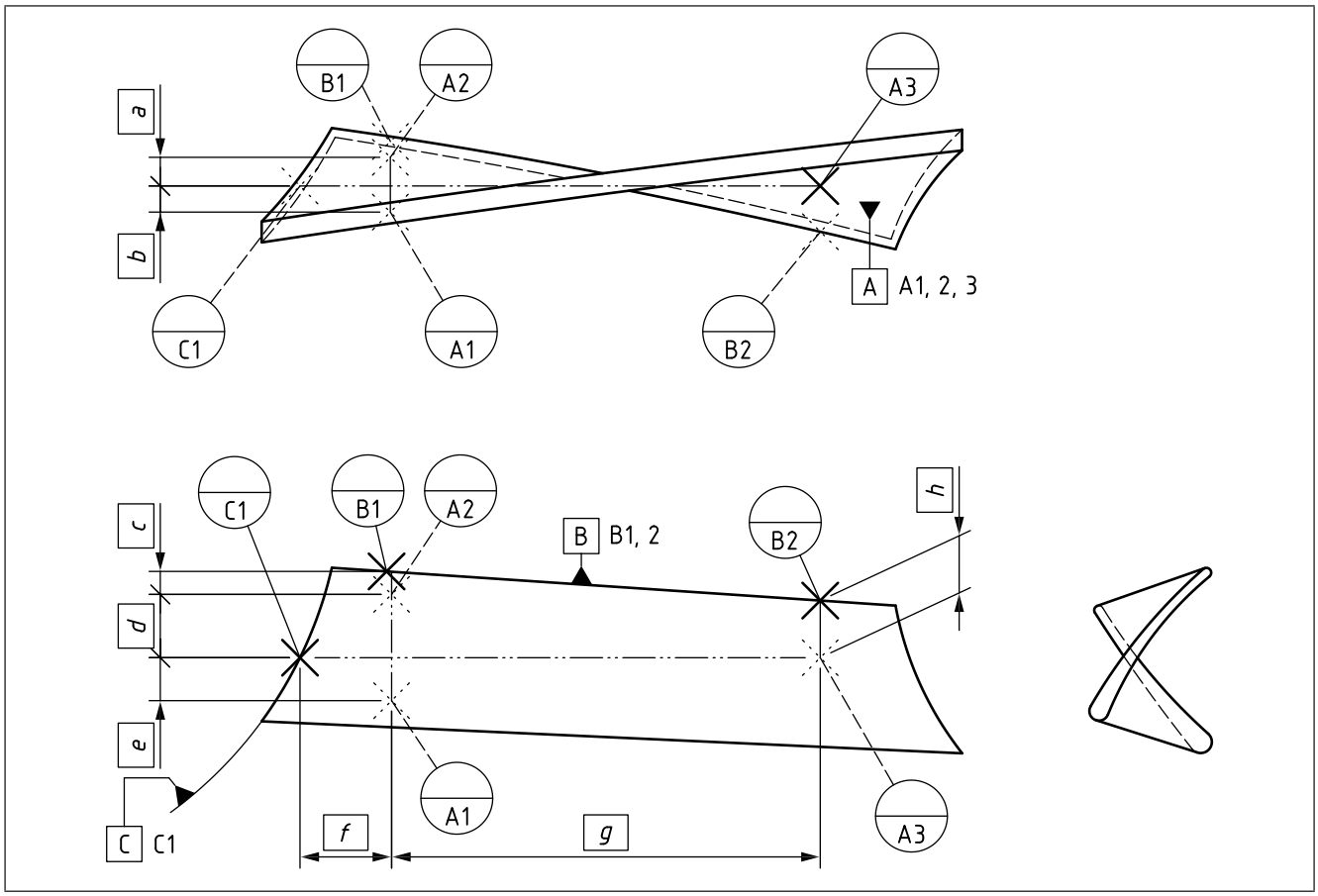


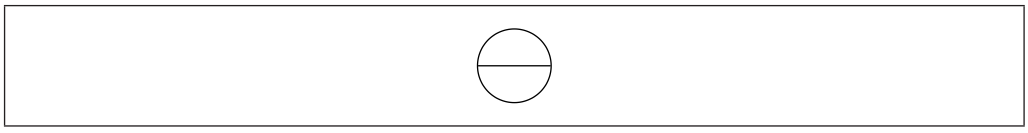
Figure 73 **Application of datum targets**



7.7.5.2 Datum target frame

The datum target frame shall be a circle, divided into two compartments by a horizontal line (see Figure 74). The lower compartment is reserved for the datum feature identifier followed by a digit (from 1 to n), corresponding to the datum target number. The upper compartment shall be reserved for additional information, such as dimensions of the target area.

Figure 74 **Single datum target frame**

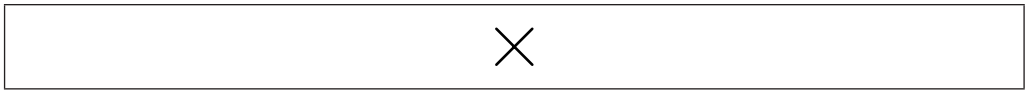


7.7.5.3 Datum target symbol

The datum target symbol indicates the type of datum target.

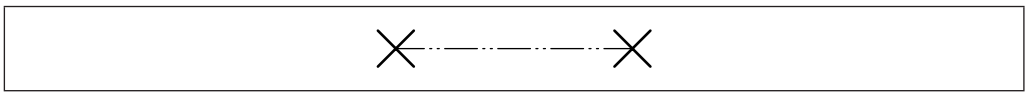
A datum target point shall be identified with a cross (see Figure 75).

Figure 75 **Datum target point**



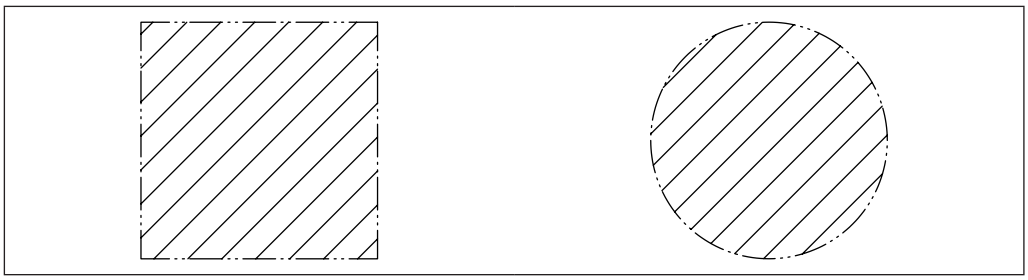
A datum target line shall be indicated by a long-dashed double-dotted narrow line (type 05.1 of BS ISO 128-24:1999). If the line is open, each end shall be terminated by a cross (see Figure 76). This line may be straight, circular or a line of any shape.

Figure 76 **Open datum target line**



A datum target area shall be indicated with an outline using a long-dashed double-dotted narrow line (type 05.1 of BS ISO 128-24:1999), and cross-hatched (see Figure 77).

Figure 77 **Datum target area**



7.7.5.4 Leader line

The datum target frame shall be connected directly, or through a reference line, to the datum target symbol by a leader line terminated with or without an arrow or a dot (see Figure 78, Figure 79 and Figure 80).

Figure 78 **Indicator for single datum target point**

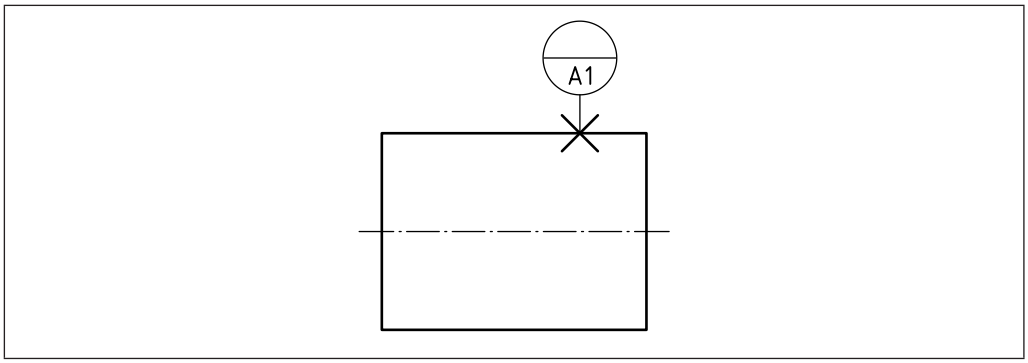


Figure 79 **Indicator for single datum target line**

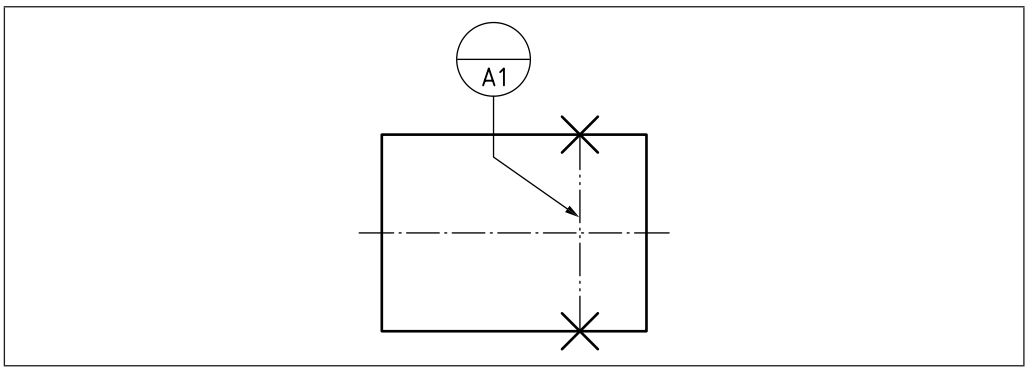
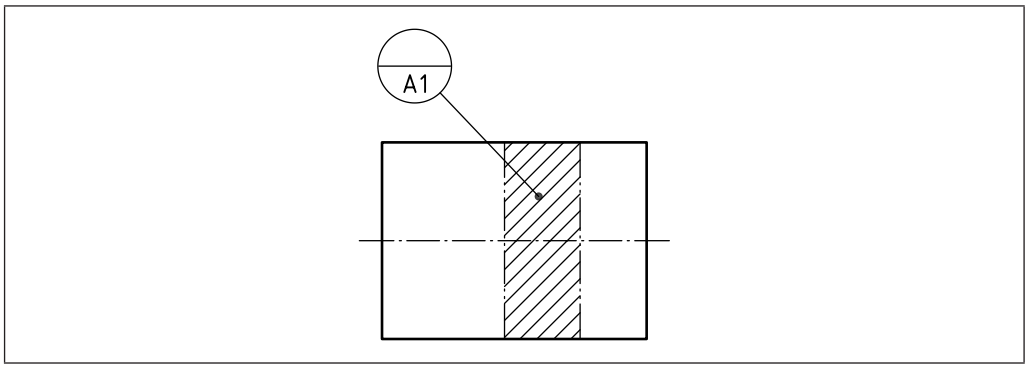


Figure 80 **Indicator for single datum target surface**

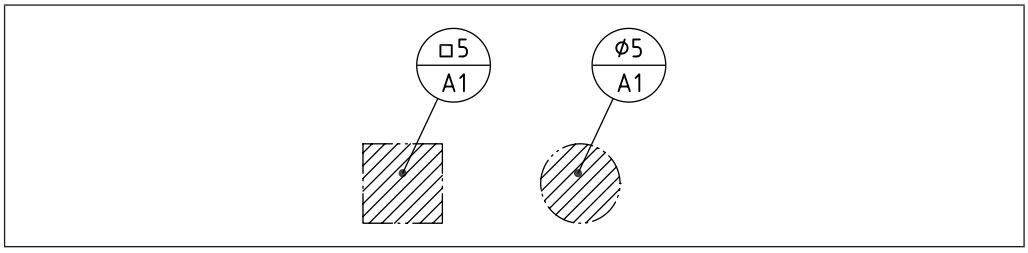


NOTE The orientation of the leader line connecting the frame with the datum target symbol is unimportant.

7.7.5.5 Datum target areas

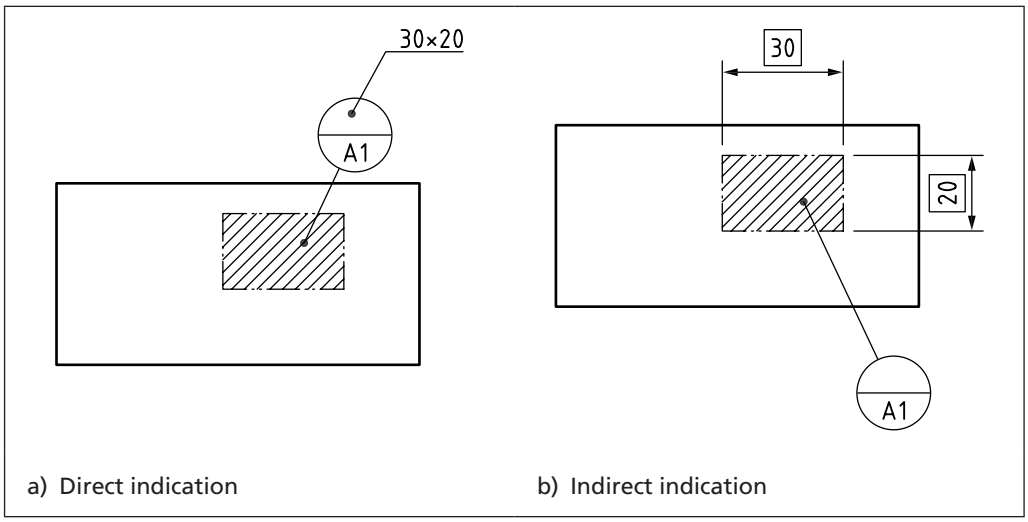
The upper compartment of the datum target frame shall only be used when defining a datum target area (see Figure 81).

Figure 81 **Indicator for single datum target point**



The size of the area can be indicated in the upper compartment, or using dimensions elsewhere on the specification (in which case the upper compartment remains blank) (see Figure 82).

Figure 82 **Indicator for single datum target point**

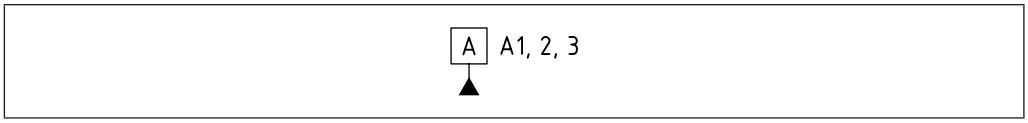


NOTE The dimensions defining the size of the datum target area are theoretically exact.

7.7.5.6 Datum feature indicators used with datum targets

If a single datum feature is established from one or more datum targets belonging to only one surface, then the datum feature identifier identifying the surface shall be repeated close to the datum indicator, followed by the list of numbers (separated by commas) identifying the targets (see Figure 83). Each individual datum target shall be identified by a datum target indicator, indicating the datum feature identifier, the number of the datum target and, if applicable, the dimensions of the datum target.

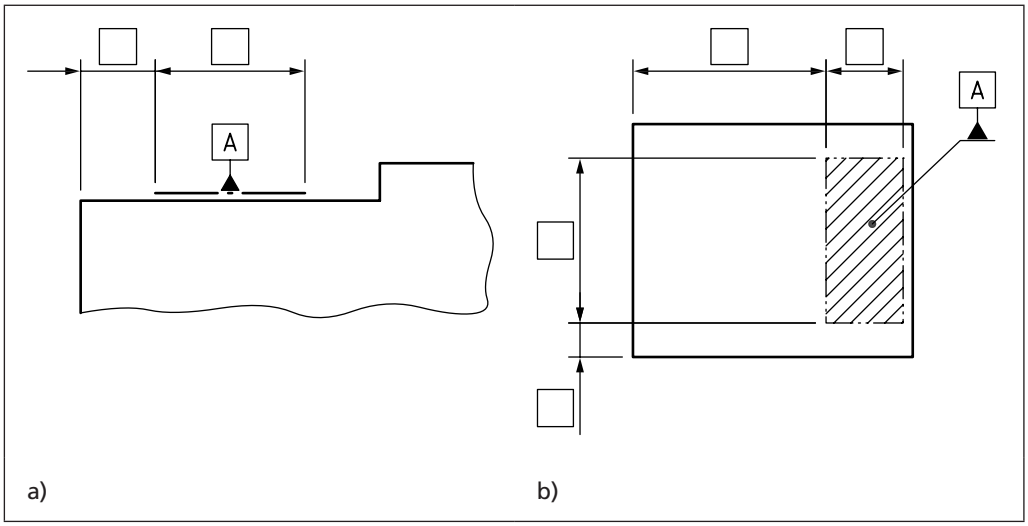
Figure 83 **Indication of datums established from datum targets**



In the case of a large number of datum targets (e.g. when defining a datum for a large, flexible panel), an abbreviated indication, such as "A1-20", is acceptable.

If there is only one datum target, the drawing indication may be simplified by placing the datum indicator as shown in Figure 84.

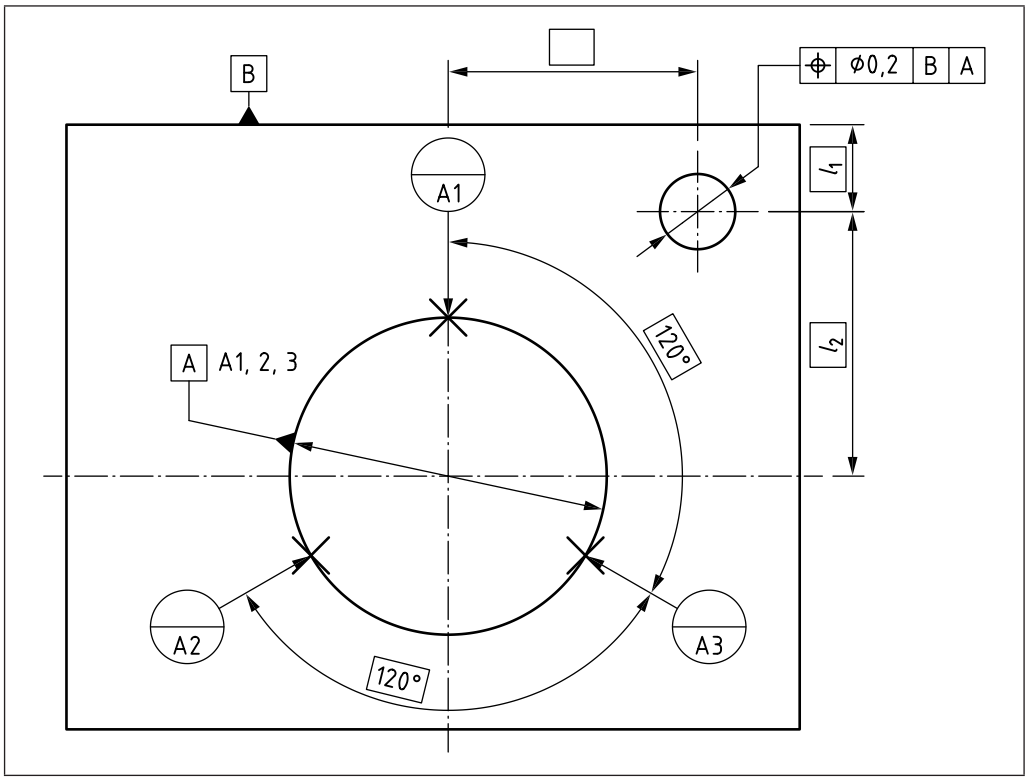
Figure 84 **Simplification of drawing indication when there is only one datum target area**



7.7.5.7 Datums based on more than one datum target

If a single datum is based on more than one datum target, the relationships between the datum targets shall as necessary be defined with theoretically exact dimensions (see Figure 85).

Figure 85 **Datums based on more than one datum target**



In this case the TEDs can be used without any corresponding geometrical tolerance. The tolerance on the location of the datum targets is not part of the definition of the workpiece geometry, so does not need to be defined on the design specification. The tolerance on the location of the datum targets is a contributory factor to the measurement uncertainty when verifying the requirement, and shall be considered as part of the verification process. The tolerance value is a function of the verification process.

7.7.6 Modifying the effects of datums

NOTE The effect of a datum can be modified in several ways.

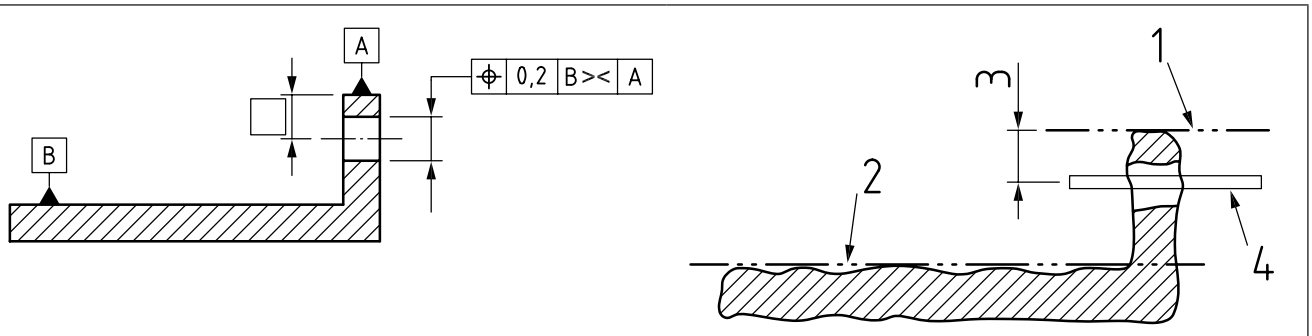
7.7.6.1 "Orientation only" modifier

In some instances, a datum might be required only to control the orientation of a tolerance zone, and not its location. In order to prevent the datum controlling the location of the tolerance zone, the "orientation only" modifier shall be used in the datum reference compartment of the tolerance frame (see Figure 86).

The "orientation only" modifier consists of two angle brackets used in the following arrangement, "><".

If the datum reference can only control the orientation of the tolerance zone in any case, the "><" modifier is redundant and shall be omitted.

Figure 86 **Application of "orientation-only" modifier**



a) Indication

b) Meaning

Key

1 Associated plane with outside material constraint and with orientation constraint from datum B

2 Associated plane with outside material constraint (datum B)

3 Distance relative to the location

4 Tolerance zone with orientation constraint from datum B and location constraint from datum A

7.7.6.2 Situation feature modifiers

NOTE A datum can be based on a set of more than one situation feature. In some instances, the full effect of all the situation features defining the datum may prevent the tolerance requirement from being correctly defined. The tolerance requirement might need to utilize the effect of only a subset of the situation features.

Individual situation features shall be invoked, as appropriate, by using the following modifiers (see Figure 87).

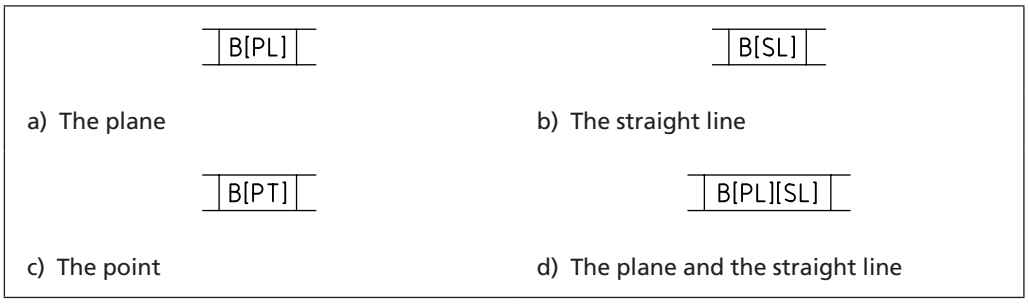
a) If the situation feature to be utilized is a plane, the [PL] modifier shall be used.

b) If the situation feature to be utilized is a straight line, the [SL] modifier shall be used.

c) If the situation feature to be utilized is a point, the [PT] modifier shall be used.

More than one of these modifiers can be used with a single datum reference.

Figure 87 **Indication of which modifier is need in the set of situation features**



a) The plane

b) The straight line

c) The point

d) The plane and the straight line

7.8 Geometric tolerances

7.8.1 General

Geometrical tolerancing shall conform to the following standards, as appropriate.

BS EN ISO 1101	*Geometrical product specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out*
BS EN ISO 2692	*Geometrical product specifications (GPS) – Geometrical tolerancing – Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)*
BS EN ISO 5458	*Geometrical product specifications (GPS) – Geometrical tolerancing – Positional tolerancing*
BS EN ISO 5459	*Geometrical product specifications (GPS) – Geometrical tolerancing – Datums and datum-systems for geometrical tolerances*
BS EN ISO 7083	*Technical drawings – Symbols for geometrical tolerancing – Proportions and dimensions*
BS EN ISO 12180-1	*GPS – Cylindricity – Part 1: Vocabulary and parameters of cylindrical form*
BS EN ISO 12180-2	*GPS – Cylindricity – Part 2: Specification operators*
BS EN ISO 12181-1	*GPS – Roundness – Part 1: Vocabulary and parameters of roundness*
BS EN ISO 12181-2	*GPS – Roundness – Part 2: Specification operators*
BS EN ISO 12780-1	*GPS – Straightness – Part 1: Vocabulary and parameters of straightness*
BS EN ISO 12780-2	*GPS – Straightness – Part 2: Specification operators*
BS EN ISO 12781-1	*GPS – Flatness – Part 1: Vocabulary and parameters of flatness*
BS EN ISO 12781-2	*GPS – Flatness – Part 2: Specification operators*

7.8.2 Basic concepts

Geometrical tolerances shall be specified in accordance with functional requirements.

NOTE 1 Manufacturing and inspection requirements can also influence geometrical tolerancing.

NOTE 2 Indicating geometrical tolerances on a drawing does not necessarily imply the use of any particular method of production, measurement or gauging.

NOTE 3 Annex C gives examples of geometrical tolerances and requirements associated with them.

A geometrical tolerance applied to a feature defines the tolerance zone within which that feature shall be contained.

NOTE 4 A feature is a specific portion of the workpiece, such as a point, a line or a surface; these features can be integral features (e.g. the external surface of a cylinder) or derived (e.g. a median line or median surface). See BS EN ISO 14660-1.

According to the characteristic to be toleranced and the manner in which it is dimensioned, the tolerance zone shall be one of the following:

- the space within a circle;
- the space between two concentric circles;

- the space between two equidistant lines or two parallel straight lines;
- the space within a cylinder;
- the space between two coaxial cylinders;
- the space between two equidistant surfaces or two parallel planes; or
- the space within a sphere.

Unless a more restrictive indication is required, for example by an explanatory note, the toleranced feature shall be of any form or orientation within this tolerance zone.

The tolerance shall apply to the whole extent of the considered feature, unless otherwise specified as in **7.8.9** and **7.8.10**.

NOTE 5 Geometrical tolerances which are assigned to features related to a datum do not limit the form deviations of the datum feature itself. It might be necessary to specify tolerances of form for the datum feature(s).

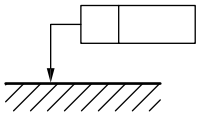
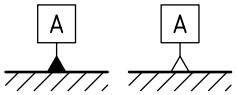
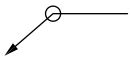
7.8.3 Symbols

Symbols for geometrical characteristics shall be as indicated in Table 8 and Table 9 and as indicated in BS EN ISO 1101.

Table 8 **Symbols for geometrical characteristics**

Tolerances	Characteristics	Symbol	Datum needed
Form	Straightness	—	no
	Flatness	▱	no
	Roundness	○	no
	Cylindricity	⌭	no
	Profile any line	⌒	no
	Profile any surface	⌓	no
Orientation	Parallelism	//	yes
	Perpendicularity	⊥	yes
	Angularity	∠	yes
	Profile any line	⌒	yes
	Profile any surface	⌓	yes
Location	Position	⌖	yes or no
	Concentricity (for centre points)	◎	yes
	Coaxiality (for axes)	◎	yes
	Symmetry	⌯	yes
	Profile any line	⌒	yes
	Profile any surface	⌓	yes
Run-out	Circular run-out	↗	yes
	Total run-out	⌰	yes

Table 9 **Additional symbols**

Description	Symbol
Toleranced feature indication	
Datum feature indication	
Datum target indication	
Theoretically exact dimensions	50
Projected tolerance zone	Ⓟ
Maximum material requirement	Ⓜ
Least material requirement	Ⓛ
Free state condition (non-rigid parts)	Ⓕ
All around (profile)	
Envelope requirement	Ⓔ
Common zone	CZ
Minor diameter	LD
Major diameter	MD
Pitch diameter	PD
Line element	LE
Not convex	NC
Any cross section	ACS

NOTE Further symbols and modifiers are standardized in BS EN ISO 1101 and other standards.

7.8.4 Tolerance frame

The requirements shall be shown in a rectangular frame which is divided into two or more compartments, in accordance with BS EN ISO 1101. These compartments shall contain, from left to right, in the following order.

- The symbol for the geometrical characteristic; the tolerance value in the unit used for linear dimensions.
- This value shall be preceded by the symbol "Ø" if the tolerance zone is circular or cylindrical or by "SØ" if the tolerance zone is spherical.
- If applicable, the letter or letters identifying the datum or common datum or datum system.

When a tolerance applies to more than one feature this shall be indicated above the tolerance frame by the number of features followed by the symbol "×" (see Figure 88).

If required, indications qualifying the form of the feature within the tolerance zone shall be written near the tolerance frame (see example of Figure 89).

NOTE 1 If it is necessary to specify more than one geometrical characteristic for a feature, the requirements may be given in tolerance frames one under the other for convenience (see example of Figure 90).

NOTE 2 Annex C gives examples of geometrical tolerances and requirements associated with them.

Figure 88 **Tolerance applying to more than one feature**

Figure 89 **Indications qualifying the form of the feature within the tolerance zone**

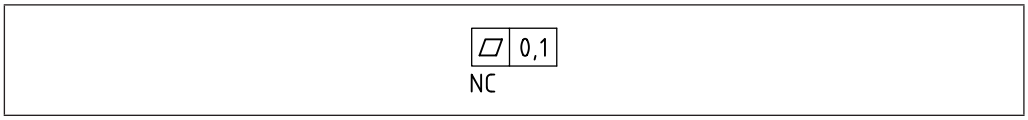
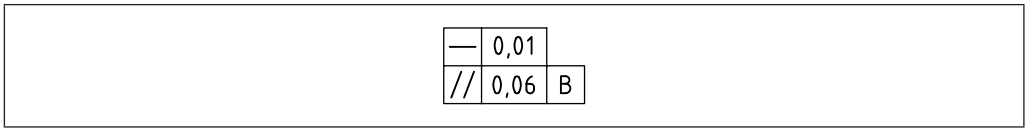


Figure 90 **Requirements given in tolerance frames one under the other**



7.8.5 Toleranced features

As specified by BS EN ISO 1101, the tolerance frame shall be connected to the toleranced feature by a leader line starting from either side of the frame and terminating with an arrowhead in one of the following ways.

- On the outline of the feature or an extension of the outline (but clearly separated from the dimension line) when the tolerance refers to the line or surface itself [see Figure 91a) and 91b)].

  NOTE 1 The arrowhead could be placed on a reference line using a leader line to point to the surface [see example of Figure 91c)].

- As an extension of the dimension line when the tolerance refers to the median line or median surface or a point defined by the feature so dimensioned (see Figure 92).

If needed, an indication specifying the form of the feature (line instead of a surface) shall be written near the tolerance frame.

NOTE 2 When the toleranced feature is a line, a further indication might be needed to control the orientation.

Figure 91 **Arrowhead terminating on the outline of the feature or as an extension**

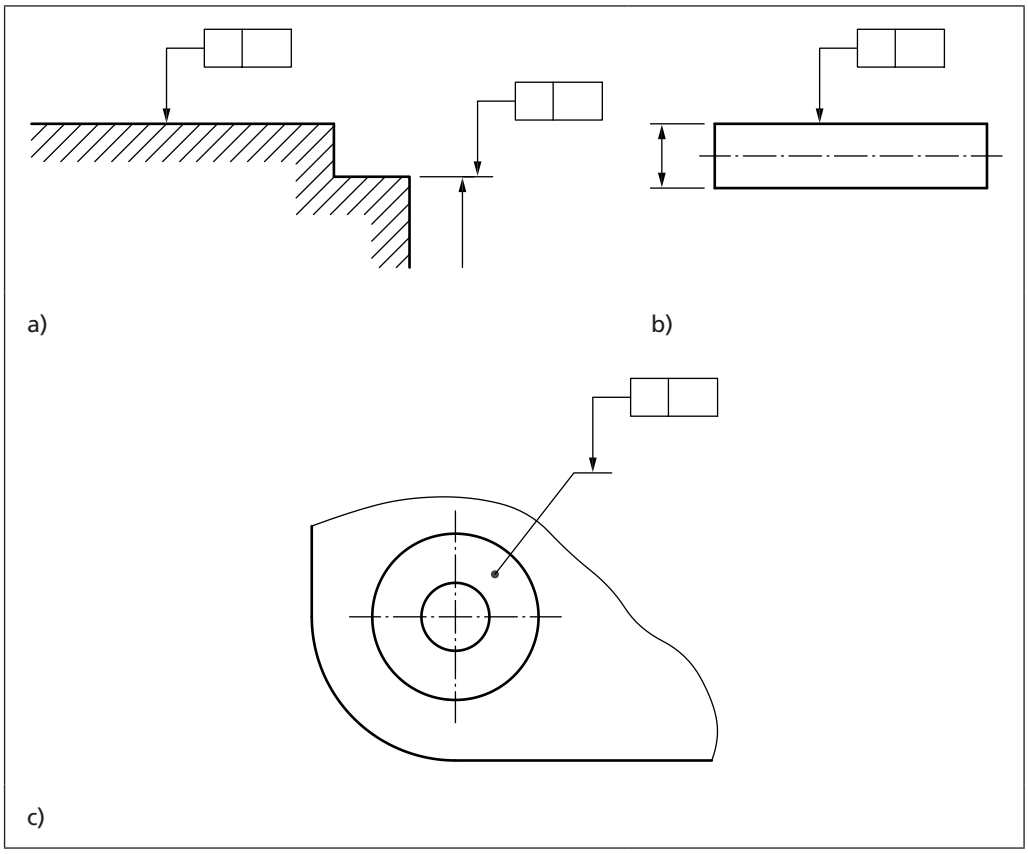
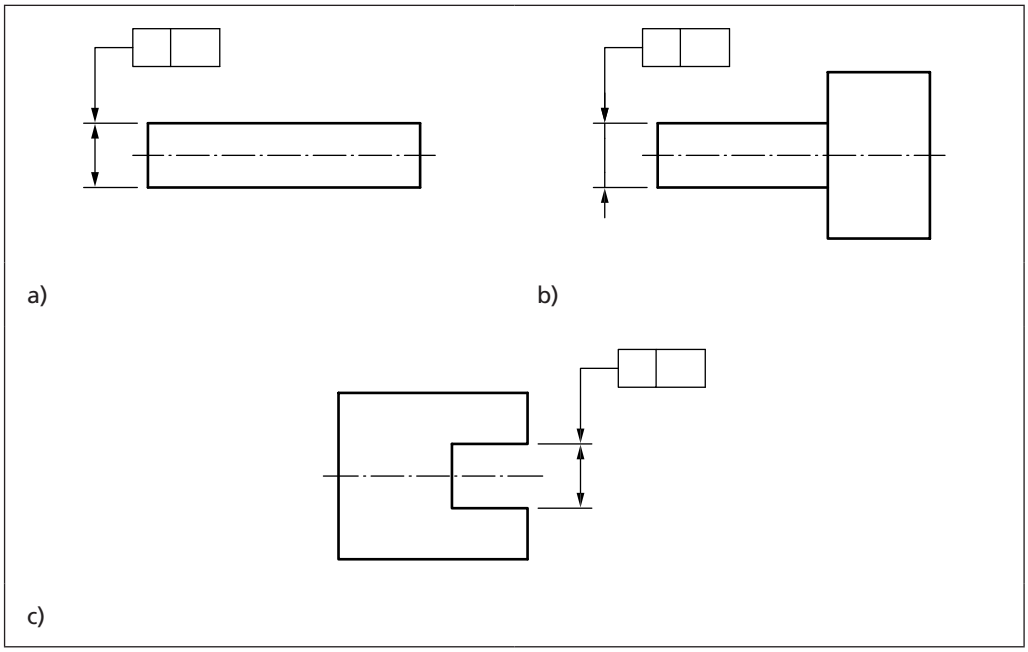


Figure 92 **Arrowhead terminating as an extension of the dimension line**

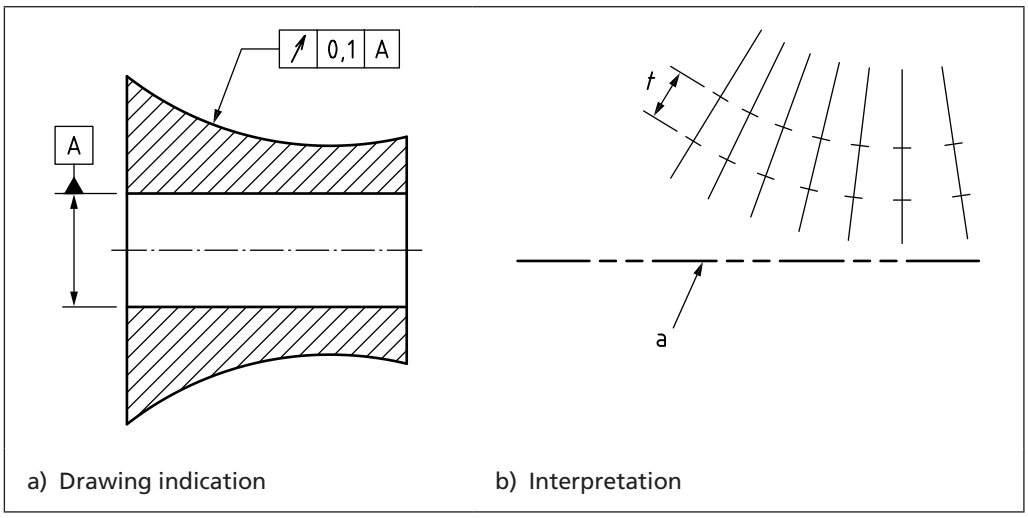


7.8.6 Tolerance zones

The width of the tolerance zone shall apply normal to the specified geometry (see Figure 93) unless otherwise indicated (see Figure 94).

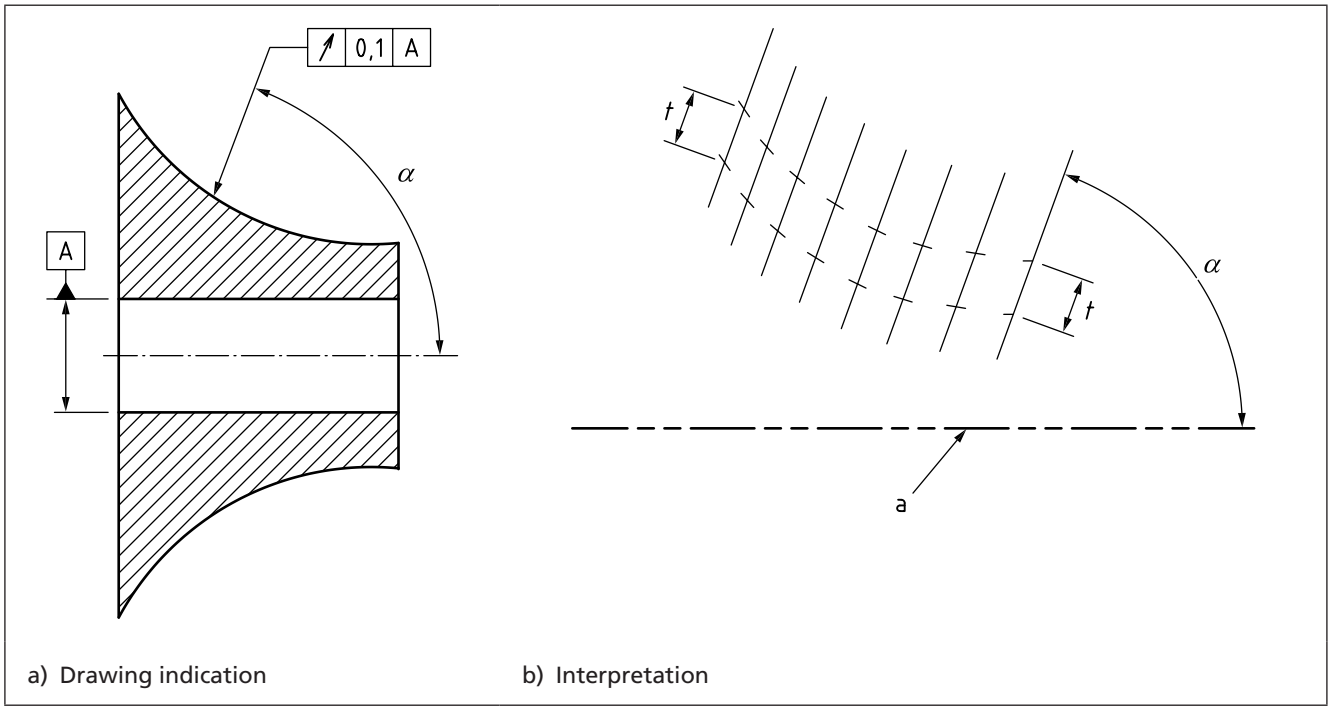
NOTE 1 The orientation alone of the leader line does not influence the definition of the tolerance.

Figure 93 **Width of tolerance zone applying to the specified geometry**



a) Drawing indication b) Interpretation

Figure 94 **With of tolerance zone, otherwise indicated**



a) Drawing indication b) Interpretation

The angle α shown in Figure 94a) shall be indicated, even if it is equal to 90°.

In the case of roundness, the width of the tolerance zone shall always apply in a plane perpendicular to the nominal axis.

In the case of a centre point or median line or median surface toleranced in one direction:

- the orientation of the width of a positional tolerance zone shall be based on the pattern of the theoretically exact dimensions (TED) and shall be at 0° or 90° as indicated by the direction of the arrowhead of the leader line, unless otherwise indicated (see Figure 95);
- the orientation of the width of an orientation tolerance zone shall be at 0° or 90° relative to the datum as indicated by the direction of the arrowhead of the leader line, unless otherwise indicated (see Figure 96 and Figure 97);
- when two tolerances are stated, they shall be perpendicular to each other, unless otherwise specified (see Figure 96 and Figure 97).

Figure 95 **Orientation of the width of a positional tolerance zone**

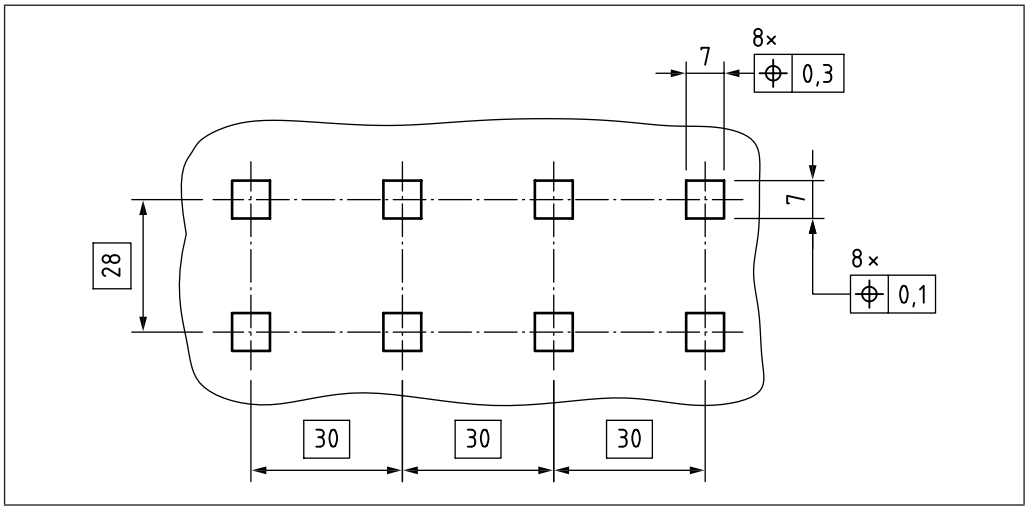


Figure 96 **Orientation of the width of an orientation tolerance zone**

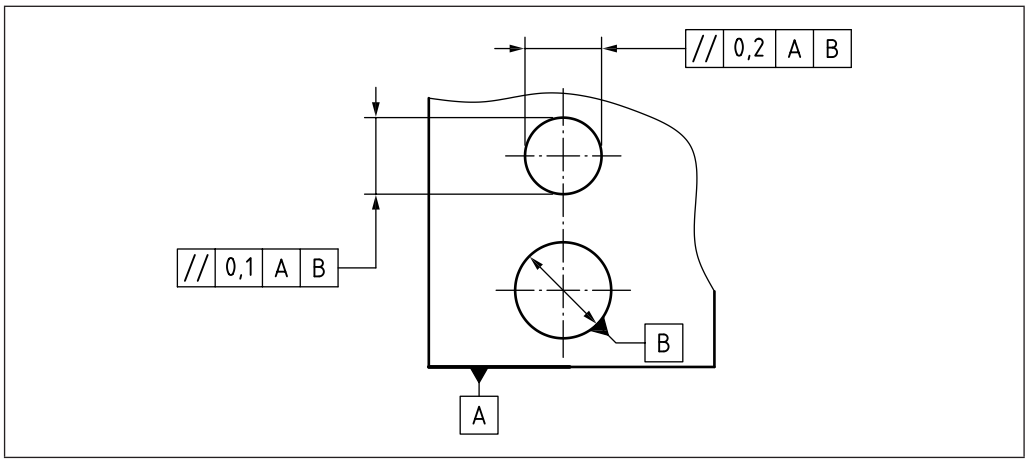
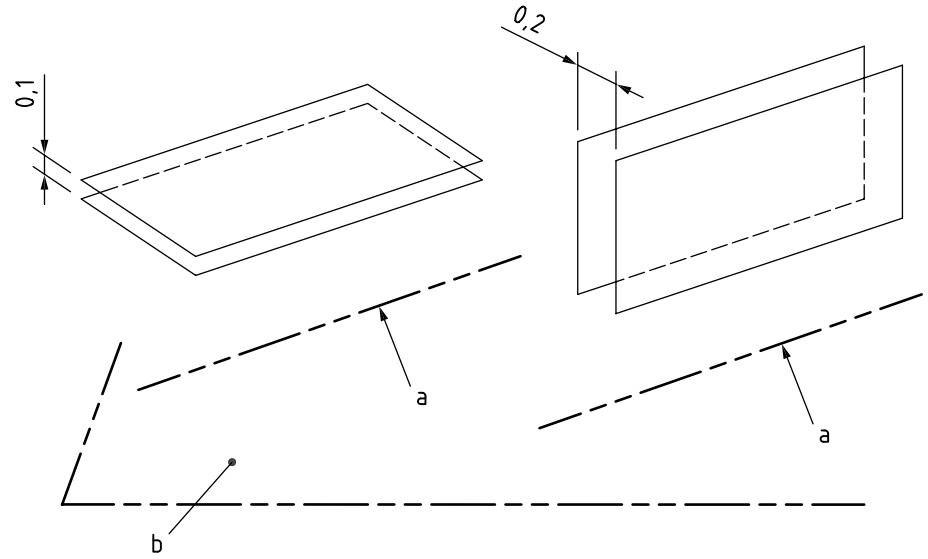


Figure 97 **Tolerances perpendicular to each other**



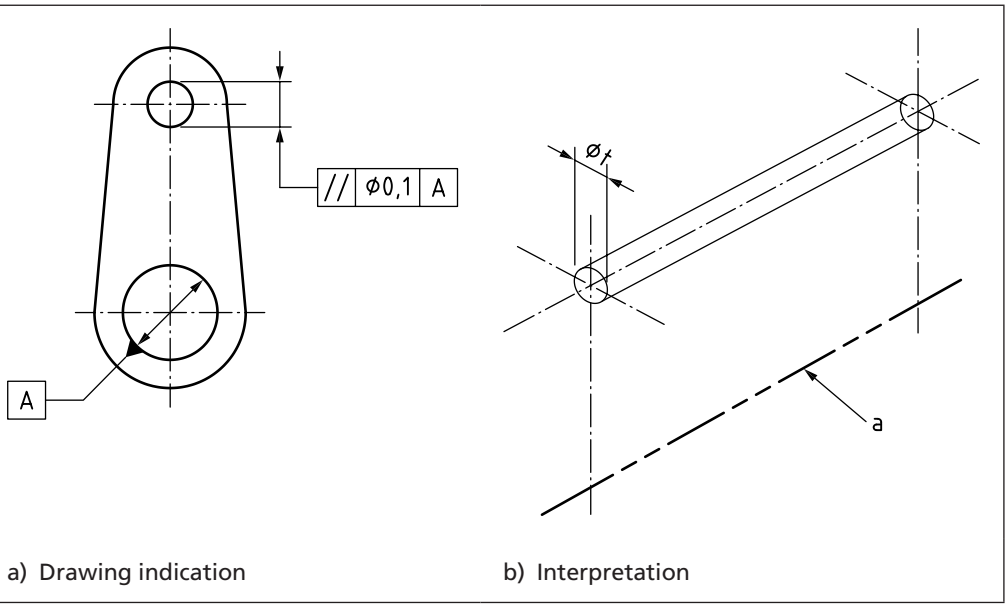
Key

a Datum A

b Datum B

The tolerance zone shall be cylindrical (see Figure 98) or circular if the tolerance value is preceded by the symbol "Ø" or spherical if it is preceded by the symbol "SØ".

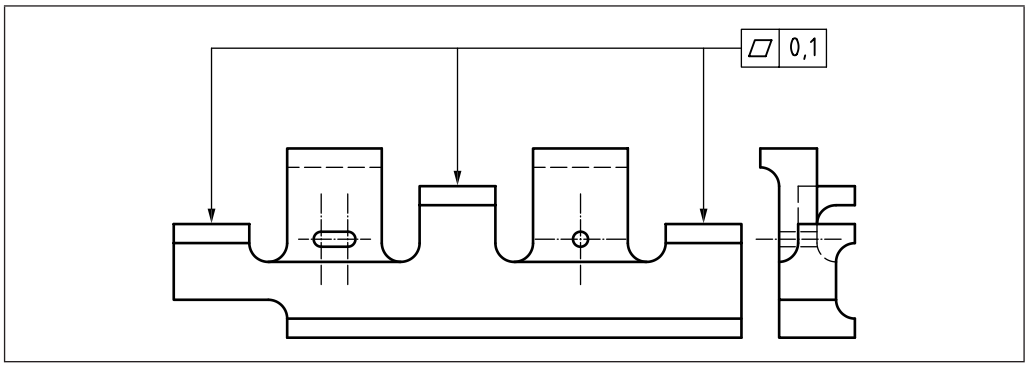
Figure 98 **Cylindrical and circular tolerance zones**



a) Drawing indication b) Interpretation

NOTE 2 Individual tolerance zones of the same value applied to several separate features can be specified (see Figure 99).

Figure 99 **Tolerance zones applied to separate features**

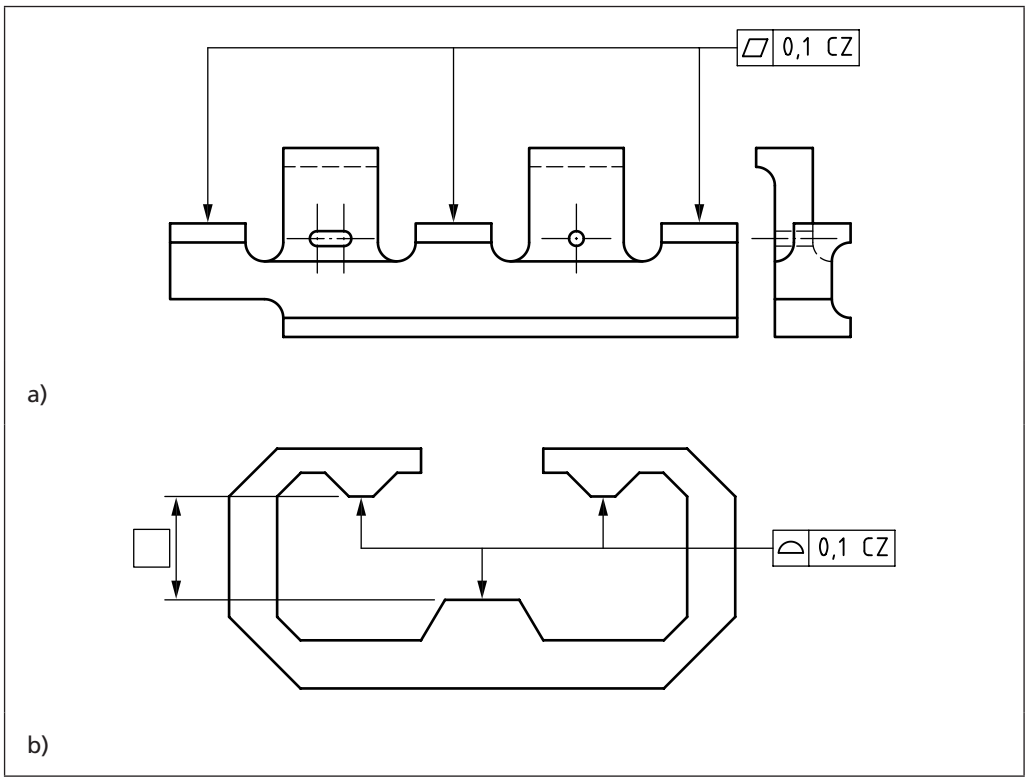


Where a common tolerance zone is applied to several separate features, this common requirement shall be indicated by the symbol "CZ" for common zone following the tolerance in the tolerance frame [see the example in Figure 100a)].

Where several tolerance zones (controlled by the same tolerance frame) are applied simultaneously to several separate features (not independently), to create a combined zone, the requirement shall be indicated by the symbol "CZ" for common zone following the tolerance in the tolerance frame [see the example in Figure 100b)] and an indication that the specification applies to several features, e.g. using "3×" over the tolerance frame or using three leader lines attached to the tolerance frame.

Where indicated in the tolerance frame, all the related individual tolerance zones shall be constrained in location and in orientation amongst themselves using either implicit (0 mm, 0°, 90°, etc.) or explicit theoretically exact dimensions (TED).

Figure 100 **Single tolerance zone applied to separate features**

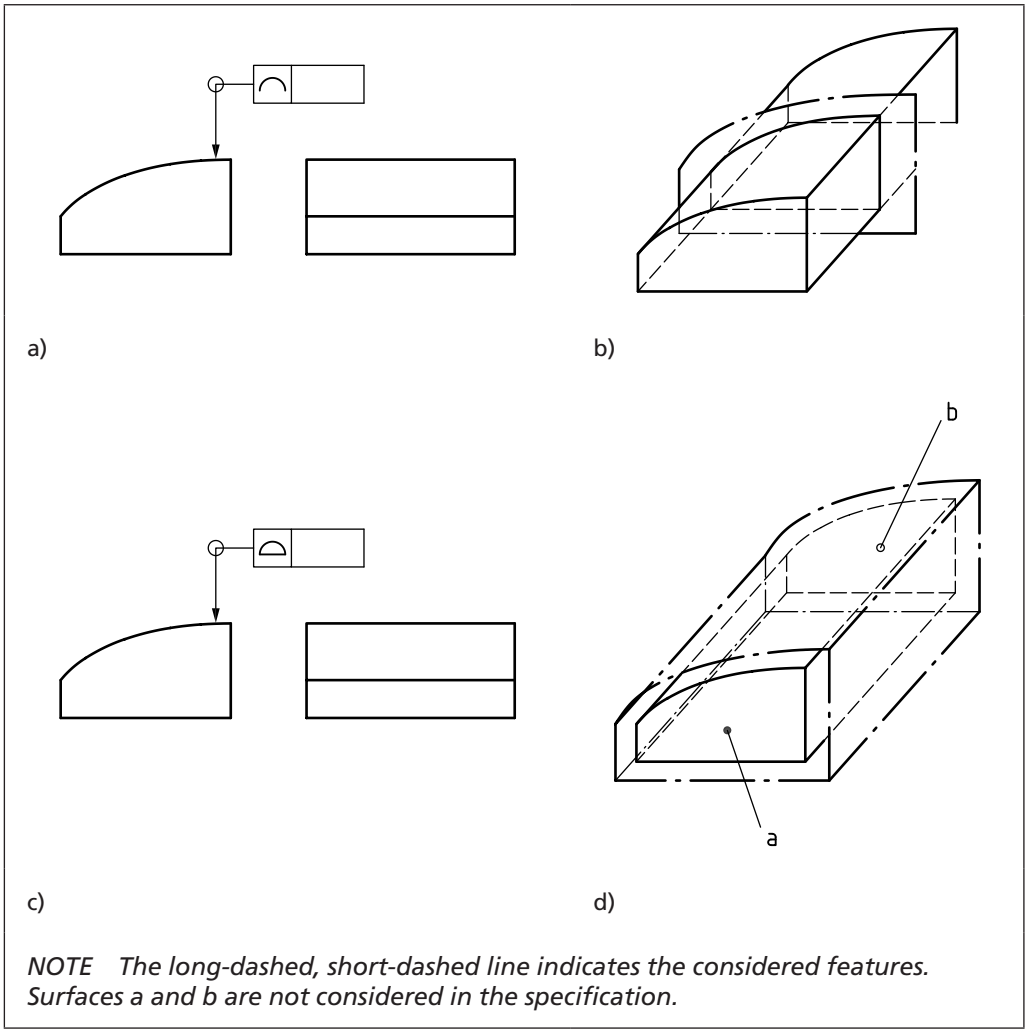


7.8.7 Supplementary indications

If a profile characteristic is applied to the entire outline of the cross sections or, if it is applied to the entire surface represented by the outline, it shall be indicated using the symbol "all around".

NOTE The all around symbol does not involve the entire workpiece, but only the surfaces represented by the outline and identified by the tolerance indication (see Figure 101).

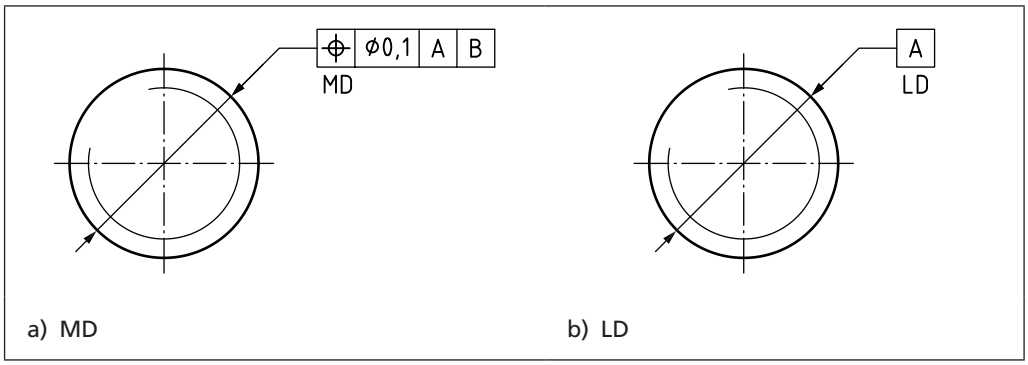
Figure 101 **Examples of the use of the "all around" symbol**



NOTE The long-dashed, short-dashed line indicates the considered features. Surfaces a and b are not considered in the specification.

Tolerances and datums specified for screw threads shall apply to the axis derived from the pitch cylinder, unless otherwise specified, e.g. "MD" for major diameter and "LD" for minor diameter (see example of Figure 102). Tolerances and datums specified for gears and splines shall designate the specific feature to which they apply, i.e. "PD" for pitch diameter, "MD" for major diameter or "LD" for minor diameter.

Figure 102 **Examples of "MD" and "LD"**



7.8.8 Theoretically exact dimensions (TED)

*COMMENTARY ON **7.8.8***
A theoretically exact dimension (TED) is a dimension which has the dimension value enclosed in a frame.

No tolerance shall be applied directly to the value of a TED.

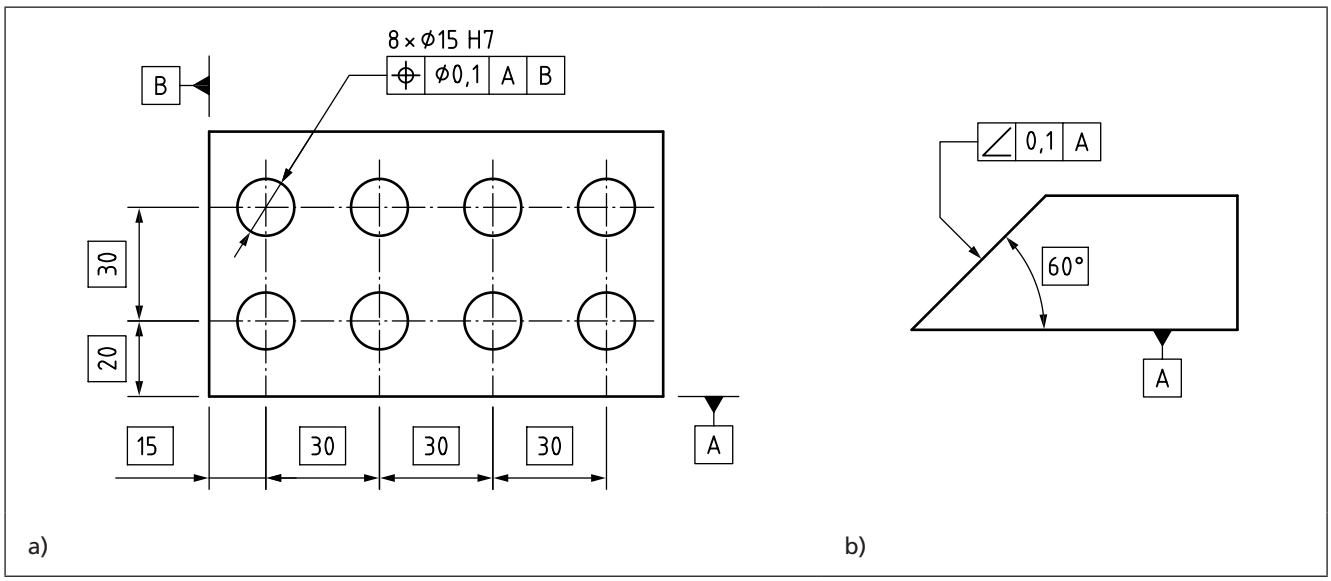
When a geometrical tolerance is used to tolerance the location of a feature (or group of features), the theoretically exact location of the feature(s) shall be defined with TEDs [see Figure 103a)].

When a geometrical tolerance is used to tolerance the orientation of a feature (or group of features), the theoretically exact orientation of the feature(s) shall be defined with TEDs [see Figure 103b)].

NOTE Examples are given in Annex C.

When a profile tolerance is applied to a feature (or group of features), the theoretically exact profile or surface shall be defined with TEDs.

Figure 103 **Use of theoretically exact dimensions (TEDs)**

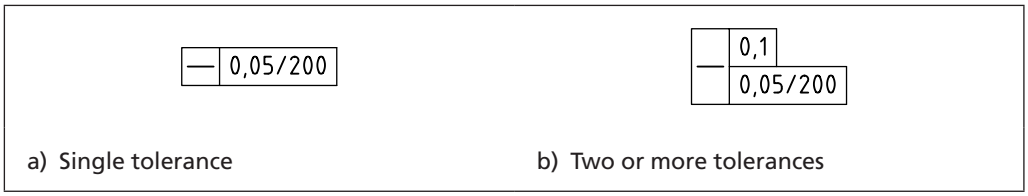


7.8.9 Restrictive specifications

If a tolerance of the same characteristic is applied to a restricted length, lying anywhere within the total extent of the feature, the value of the restricted length shall be added after the tolerance value and separated from it by an oblique stroke [see Figure 104a)].

NOTE 1 If two or more tolerances of the same characteristic are to be indicated, they could be combined as shown in Figure 104b).

Figure 104 **Examples of tolerances of the same characteristic**

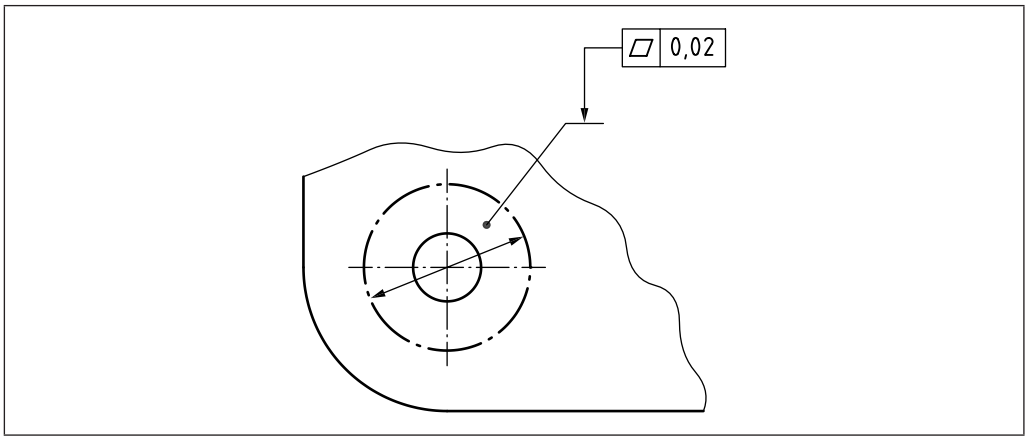


a) Single tolerance b) Two or more tolerances

If a tolerance is applied to a restricted part of a feature only, this restriction shall be shown as a wide, long, dashed-dotted line and dimensioned (see Figure 105).

NOTE 2 See BS ISO 128-24:1999, Table 2.

Figure 105 **Tolerance applied to a restricted part of a feature**



*NOTE 3 For information about the restricted part of a datum see BS EN ISO 1101:2013, **9.4**.*

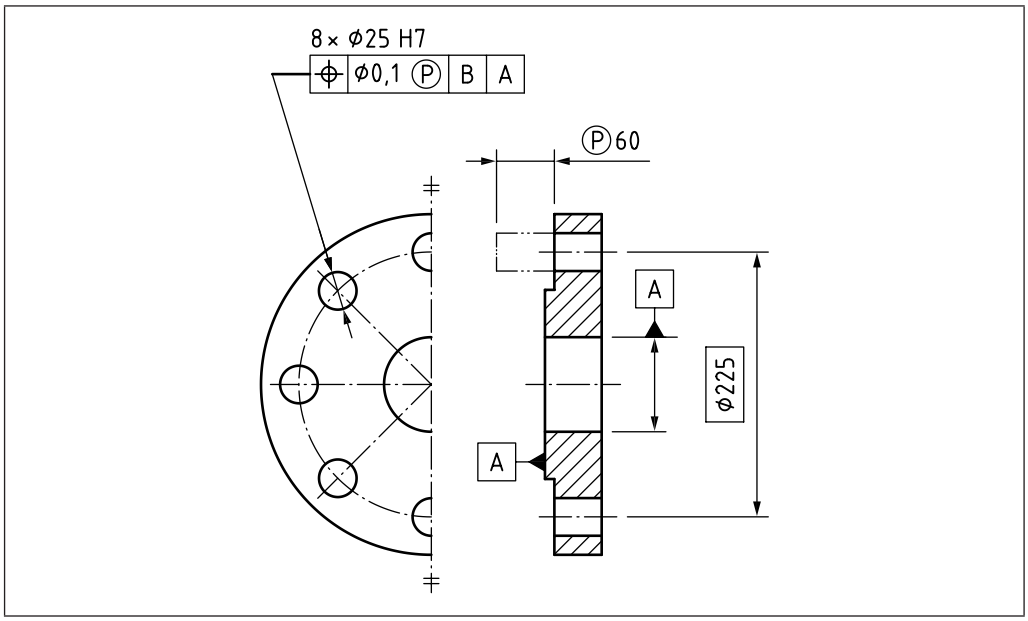
*NOTE 4 Restrictions to the form of a feature within the tolerance zone are given in **6.2** and BS EN ISO 1101:2013, Clause **7**.*

7.8.10 Projected tolerance zone

Projected tolerance zones shall be indicated by the specification modifier symbol Ⓟ (see example of Figure 106).

NOTE See BS EN ISO 1101 for additional information.

Figure 106 **Projected tolerance zone**

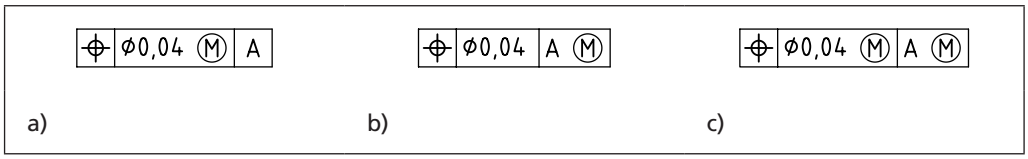


7.8.11 Maximum material requirement

The maximum material requirement shall be indicated by the specification modifier symbol Ⓜ. The symbol shall be placed after the specified tolerance value, datum letter or both as appropriate (see Figure 107).

NOTE See BS EN ISO 2692 for detailed rules.

Figure 107 **Indication of the maximum material requirement**

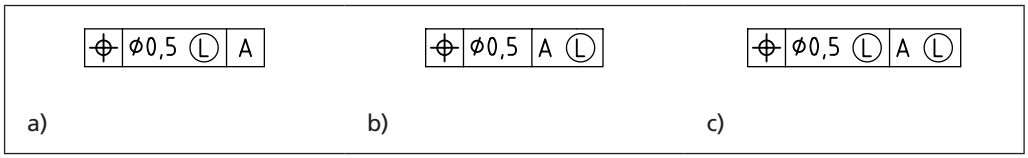


7.8.12 Least material requirement

The least material requirement shall be indicated by the specification modifier symbol Ⓛ. The symbol shall be placed after the specified tolerance value, datum letter or both as appropriate (see Figure 108).

NOTE See BS EN ISO 2692 for additional information.

Figure 108 **Indication of the least material requirement**

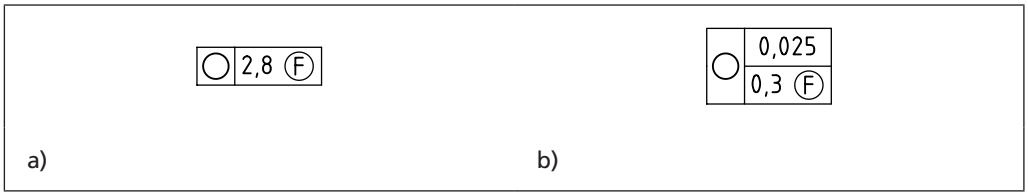


7.8.13 Free state condition

The free state condition for non-rigid parts shall be indicated by the specification modifier symbol Ⓕ placed after the specified tolerance value (see Figure 109).

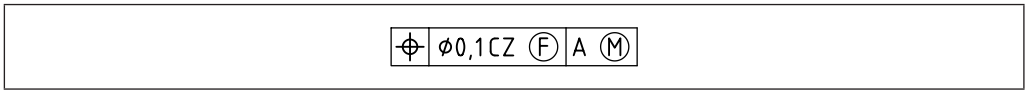
NOTE 1 See BS ISO 10579 and BS EN ISO 1101 for additional information.

Figure 109 **Free state condition**



NOTE 2 Several specification modifiers, e.g. Ⓟ, Ⓜ, Ⓛ, Ⓕ, CZ and ∠ Ø ⌓ could be used simultaneously in the same tolerance frame (see Figure 110).

Figure 110 **Use of several specification modifiers**



7.8.14 Interrelationship of geometrical tolerances

*COMMENTARY ON **7.8.14***
For functional reasons, one or more characteristics can be toleranced to define the geometrical deviations of a feature. Certain types of tolerances, which limit the geometrical deviations of a feature, can also limit other types of deviations for the same feature.

Location tolerances of a feature shall control location deviation, orientation deviation and form deviation of this feature.

Orientation tolerances of a feature shall control orientation and form deviations of this feature.

Form tolerances of a feature shall only control form deviations of this feature.

Section 8: Surface texture specification

*COMMENTARY ON SECTION **8***
BS 1134 offers an excellent introduction to surface texture specification.

Indication of surface texture shall conform to the following standards, as appropriate.

BS 1134	*Assessment of surface texture – Guidance and general information*
BS EN ISO 1302	*Geometrical product specifications (GPS) – Indication of surface texture in technical product documentation*

NOTE 1 The correct application of BS EN ISO 1302 requires the use of the following standards.

NOTE 2 Although it is not usual practice to make secondary references such as these, BS EN ISO 1302 itself is of such significance that it is considered appropriate to ensure their inclusion in the BS 8888 kits in this way.

BS EN ISO 8785	*Geometrical product specification (GPS) – Surface imperfections – Terms definitions and parameters*
BS EN ISO 3274	*Geometrical product specifications (GPS) – Surface texture: profile method – Nominal characteristics of contact (stylus) instruments*
BS EN ISO 4287	*Geometrical product specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*
BS EN ISO 4288	*Geometrical product specification (GPS) – Surface texture – Profile method: Rules and procedures for the assessment of surface texture*
BS EN ISO 10135	*Geometrical product specifications (GPS) – Drawing indications for moulded parts in technical product documentation (TPD)*
BS EN ISO 16610-21	*Geometrical product specifications (GPS) – Filtration – Part 21: Linear profile filters: Gaussian filters*
BS EN ISO 12085	*Geometrical product specifications (GPS) – Surface texture: Profile method – Motif parameters*
BS EN ISO 13565-1	*Geometric product specifications (GPS) – Surface texture: Profile method – Surfaces having stratified functional properties – Part 1: Filtering and general measurement conditions*
BS EN ISO 13565-2	*Geometrical product specifications (GPS) – Surface texture: Profile method – Part 2: Height characterization using the linear material ratio curve*
BS EN ISO 13565-3	*Geometrical product specifications (GPS) – Surface texture: Profile method – Part 3: Height characterization using the material probability curve*
BS EN ISO 14253-1	*Geometrical product specifications (GPS) – Inspection by measurement of workpieces and measuring equipment – Part 1: Decision rules for proving conformance or non-conformance with specifications*
BS EN ISO 14660-1	*Geometrical product specifications (GPS) – Geometrical features – Part 1: General terms and definitions*

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

NOTE 3 The following documents detail different aspects of filtering which could be utilized to process surface texture readings.

DD ISO/TS 16610-1 *GPS – Filtration – Part 1: Overview and basic concepts*

DD ISO/TS 16610-20 *GPS – Filtration – Part 20: Linear profile filters: Basic concepts*

DD ISO/TS 16610-22 *GPS – Filtration – Part 22: Linear profile filters: Spline filters*

DD ISO/TS 16610-29 *GPS – Filtration – Part 29: Linear profile filters: Spline wavelets*

DD ISO/TS 16610-40 *GPS – Filtration – Part 40: Morphological profile filters: Basic concepts*

DD ISO/TS 16610-41 *GPS – Filtration – Part 41: Morphological profile filters: Disk and horizontal line-segment filters*

DD ISO/TS 16610-49 *GPS – Filtration – Part 49: Morphological profile filters: Scale space techniques*

Section 9: Technical product documentation

A technical product document may consist of a 3-D document (e.g. a CAD model), a 2-D document (e.g. an engineering drawing), or a combination of these.

9.1 Graphical representation and annotation of 3-D data (3-D modelling output)

Graphical representation and annotation of 3-D models shall conform to the following standard.

BS ISO 16792, *Technical product documentation – Digital product definition data practices*

9.2 Drawing sheets

9.2.1 Sizes

As required by BS EN ISO 5457, the original drawing shall be made on the smallest sheet permitting the necessary clarity and resolution.

NOTE 1 The preferred sizes of the trimmed and untrimmed sheets, as well as the drawing space of the main ISO-A series (see BS EN ISO 216), are given in Table 10.

NOTE 2 See BS EN ISO 5457 for more information about drawing sheets.

*NOTE 3 The range of sheet sizes chosen could be rationalized through the use of a variety of new scales. See **9.4**.*

Table 10 **Sizes of trimmed and untrimmed sheets and the drawing space** [A)]

Designation	Trimmed sheet (T)		Drawing space		Untrimmed sheet (U)	
	a_1 [B)]	b_1 [B)]	a_2 ±0.5	b_2 ±0.5	a_5 ±2	b_5 ±2
A0 [C)]	841	1 189	821	1 159	880	1 230
A1	594	841	574	811	625	880
A2	420	594	400	564	450	625
A3	297	420	277	390	330	450
A4	210	297	180	277	240	330

[A)] Dimensions in millimetres.

[B)] For tolerances, see BS EN ISO 216.

[C)] For sizes >A0, see BS EN ISO 216.

9.2.2 Graphical features

9.2.2.1 Title block

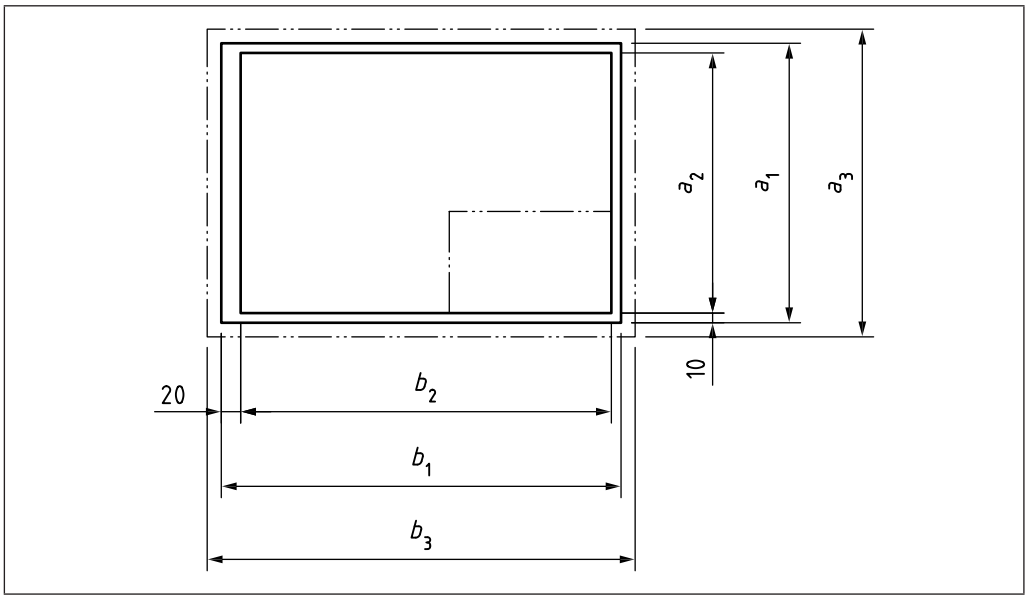
NOTE 1 For the dimensions and layout of title blocks, see BS EN ISO 7200.

Sizes A0 to A3 shall be used in landscape orientation only (Figure 111) and the location of the title block shall be situated in the bottom right-hand corner of the drawing space.

NOTE 2 A4 sheets may be used in landscape or portrait orientation.

For the size A4, the title block shall be situated in the bottom right-hand corner when used in landscape orientation, or the shorter (bottom) part of the drawing space when used in portrait orientation.

Figure 111 **Size A4 to A0**



9.2.2.2 Borders and frame

Borders enclosed by the edges of the trimmed sheet and the frame limiting the drawing space shall be provided with all sizes. The border shall be 20 mm wide on the left edge, including the frame, and it can be used as a filing margin. All other borders shall be 10 mm wide.

The frame for limiting the drawing space shall be executed with continuous wide lines.

9.2.2.3 Grid reference system

The sheets shall be divided into fields in order to permit easy location of details, additions, revisions, etc., on the drawing. The individual fields shall be referenced from the top downwards with capital letters (I and O shall not be used) and from left to right with numerals. For the size A4, they shall be located only at the top and the right side.

The size of letters and characters shall be 3.5 mm. The length of the fields shall be 50 mm, starting at the axes of symmetry of the trimmed size (centring marks).

NOTE The number of fields depends on the size (see Table 11).

The differences resulting from the division shall be added to the fields at the corners. The letters and numerals shall be placed in the grid reference border, and shall be written in vertical characters in accordance with BS EN ISO 3098-2.

The grid reference system lines shall be executed with continuous narrow lines.

Table 11 **Number of fields**

Designation	A0	A1	A2	A3	A4
Long side	24	16	12	8	6
Short side	16	12	8	6	4

9.3 Line types and line widths

9.3.1 Types of line

*COMMENTARY ON **9.3.1***
See BS EN ISO 128-20 for more information on lines.

Lines shall conform to BS EN ISO 128-20. Examples of common line types are given in Table 12.

Table 12 **Basic types**

No.	Representation	Description
01	————————————————	continuous line
02	— — — — — — — — — — — — —	dashed line
03	—— —— —— —— —— ——	dashed spaced line
04	——— · ——— · ——— · ——— · ——— · ———	long-dashed dotted line
05	——— · · ——— · · ——— · · ——— · · ———	long-dashed double-dotted line
06	——— · · · ——— · · · ——— · · · ——— · · · ———	long-dashed triplicate-dotted line
07	- -	dotted line
08	——— – ——— – ——— – ——— – ——— – ———	long-dashed short-dashed line
09	——— – – ——— – – ——— – – ——— – – ———	long-dashed double short-dashed line
10	— · — · — · — · — · — · — · — · — · —	dashed dotted line
11	— — · — — · — — · — — · — — · —	double-dashed dotted line
12	— · · — · · — · · — · · — · · — · · —	dashed double-dotted line
13	— — · · — — · · — — · · — — · · —	double-dashed double-dotted line
14	— · · · — · · · — · · · — · · · — · · · —	dashed triplicate-dotted line
15	— — · · · — — · · · — — · · · — — · · · —	double-dashed triplicate-dotted line

9.3.2 Line width

In accordance with BS EN ISO 128-20, the width, *d*, of all types of line shall be one of the following depending on the type and size of drawing.

0,13 mm, 0,18 mm, 0,25 mm, 0,35 mm, 0,5 mm, 0,7 mm, 1 mm, 1,4 mm, 2 mm.

NOTE 1 The widths of extra wide, wide and narrow lines are in the ratio 4:2:1.

NOTE 2 For mechanical engineering drawings, four line types – continuous, dashed, chain (long-dashed dotted) and phantom (long-dashed double-dotted) – in two line thicknesses (typically 0,35 mm and 0,7 mm) are sufficient for most purposes.

The line width of any one line shall be constant throughout the whole line.

9.3.3 Colours

According to the requirements of BS EN ISO 128-20, lines shall be drawn black or white depending on the background. Other standardized colours may also be used for drawing standardized lines and, in this case, the meaning of the colours shall be explained.

9.4 Scales

The recommended scales for use on technical drawings shall be as specified in Table 13.

Table 13 **Scales**

Category	Recommended scales		
Enlargement scales	50:1	20:1	10:1
	5:1	2:1	
Full size			
Reduction scales	1:2	1:5	1:10
	1:20	1:50	1:100
	1:200	1:500	1:1 000
	1:2 000	1:5 000	1:10 000

The scale for a drawing shall be chosen according to the complexity of the object to be depicted and the purpose of the representation. In all cases, the selected scale shall be large enough to permit easy and clear interpretation of the information depicted. The scale and the size of the object, in turn, shall determine the size of the drawing.

Details that are too small for complete dimensioning in the main representation shall be shown adjacent to the main representation in a separate detail view (or section) which is drawn to a larger scale.

NOTE 1 It is recommended that the scales in Table 13 are used wherever possible. However, with the advent of CAD systems and the ability to view drawings electronically at any size, the importance of using a standard range of scales has diminished. Where the recommended scales cannot be applied, intermediate scales may be selected.

3-D models produced on CAD systems shall always be produced at 1:1.

NOTE 2 For more information on scales, see BS EN ISO 5455.

9.5 Lines

9.5.1 Lines and terminators

Lines shall conform to the following standards, as appropriate.

BS EN ISO 128-20 *Technical drawings – General principles of presentation – Part 20: Basic conventions for lines*

BS EN ISO 128-21 *Technical drawings – General principles of presentation – Part 21: Preparation of lines by CAD systems*

BS ISO 128-22 *Technical drawings – General principles of presentation – Part 22: Basic conventions and applications for leader lines and reference lines*

BS ISO 128-23 *Technical drawings – General principles of presentation – Part 23: Lines on construction drawings*

BS ISO 128-24 *Technical drawings – General principles of presentation – Part 24: Lines on mechanical engineering drawings*

BS ISO 128-25 *Technical drawings – General principles of presentation – Part 25: Lines on shipbuilding drawings*

9.5.2 Lines, terminators and origin indicators

Arrows and terminators composed of lines shall conform to the following standard.

BS ISO 129-1 *Technical drawings – Indications of dimensions and tolerances – Part 1: General principles*

9.6 Lettering

9.6.1 General

Lettering shall conform to the following standards, as appropriate.

BS EN ISO 3098-0 *Technical product documentation – Lettering – Part 0: General requirements*

BS EN ISO 3098-2 *Technical product documentation – Lettering – Part 2: Latin alphabet, numerals and marks*

BS EN ISO 3098-3 *Technical product documentation – Lettering – Part 3: Greek alphabet*

BS EN ISO 3098-4 *Technical product documentation – Lettering – Part 4: Diacritical and particular marks for the Latin alphabet*

BS EN ISO 3098-5 *Technical product documentation – Lettering – Part 5: CAD lettering of the Latin alphabet, numerals and marks*

BS EN ISO 3098-6 *Technical product documentation – Lettering – Part 6: Cyrillic alphabet*

9.6.2 Notes

When a landscape-format drawing sheet is used in its normal orientation, with the title block at the bottom right-hand corner, notes shall be written with the text parallel to the long side of the sheet. When a landscape-format drawing sheet is used in portrait orientation, the title block shall be located at the left-hand side and notes shall be written with the text parallel to the short side of the sheet.

NOTE 1 Notes of a general nature should, wherever practicable, be grouped together and not distributed over the drawing. Notes relating to specific details should appear near the relevant feature, but not so near as to crowd the view.

NOTE 2 Underlining of notes is not recommended. Where emphasis is required, larger characters should be used.

NOTE 3 It is recommended that capital lettering is used wherever possible.

9.7 Projections

9.7.1 General

Projections shall conform to one of the following standards.

BS EN ISO 5456-2 *Technical drawings – Projection methods – Part 2: Orthographic representations*

BS EN ISO 5456-3 *Technical drawings – Projection methods – Part 3: Axonometric representations*

BS ISO 5456-4 *Technical drawings – Projection methods – Part 4: Central projection*

BS EN ISO 10209 *Technical product documentation – Vocabulary – Terms relating to technical drawings, product definition and related documentation*

NOTE BS EN ISO 5456-1 contains a survey of the various projection methods.

9.7.2 Conventions for arrangement of views on a TPD

9.7.2.1 General

Three main conventions shall be used for arranging the views on a TPD:

a) labelled views (see **9.7.2.3**);

b) first angle orthographic projection (see **9.7.2.4**);

c) third angle orthographic projection (see **9.7.2.5**).

NOTE 1 The order of this list is not meant to indicate a preference.

NOTE 2 Other projection methods exist. See BS EN ISO 5456 (all parts).

9.7.2.2 Choice of views

When views (including sections and sectional views) are needed, these shall be selected according to the following principles.

a) The number of views (and sections and sectional views) shall be limited to the minimum necessary, but shall be sufficient to fully delineate the object without ambiguity.

b) The need for hidden outlines and edges shall be avoided.

c) The unnecessary repetition of a detail shall be avoided.

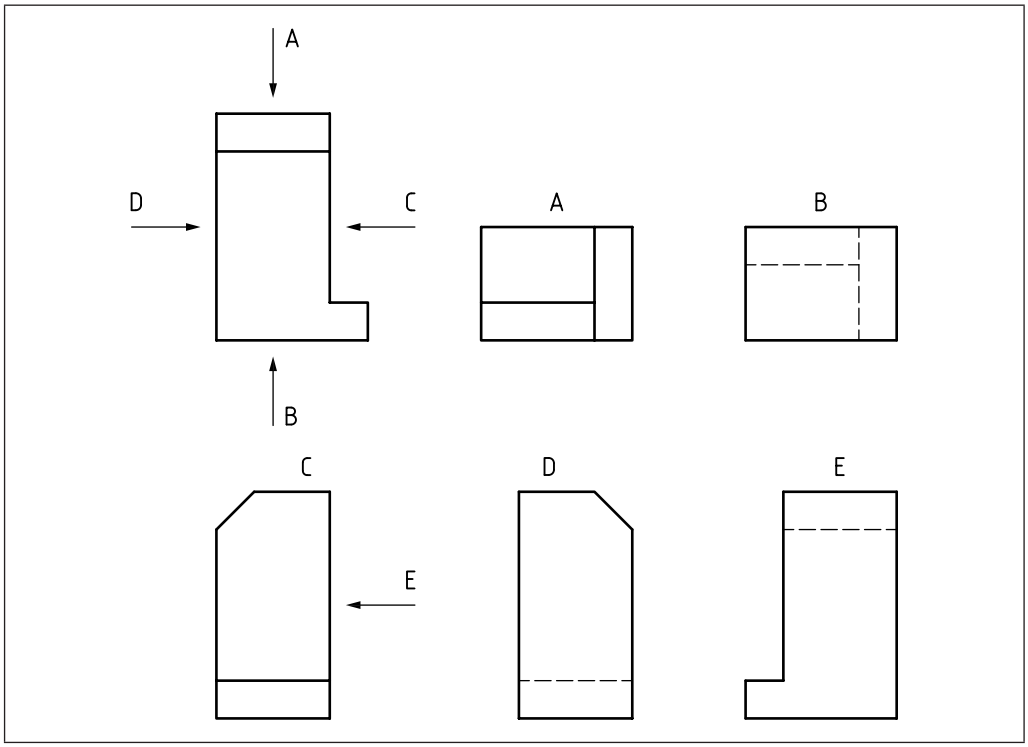
9.7.2.3 Labelled view method

As required by BS ISO 128-30, the most informative view of an object shall be used as the front or principal figure, taking into consideration, for example, its functioning position, position of manufacturing or mounting. Each view, with the exception of the front or principal figure (view, plan, principal figure), shall be

given clear identification with a capital letter, repeated near the reference arrow needed to indicate the direction of the viewing for the relevant view. Whatever the direction of viewing, the capital letter shall always be positioned in normal relation to the direction of reading, and be indicated either above or on the right side of the reference arrow.

The capital letters identifying the referenced views shall be placed immediately above the relevant views (see Figure 112).

Figure 112 **Labelled view method**



9.7.2.4 First angle projection method

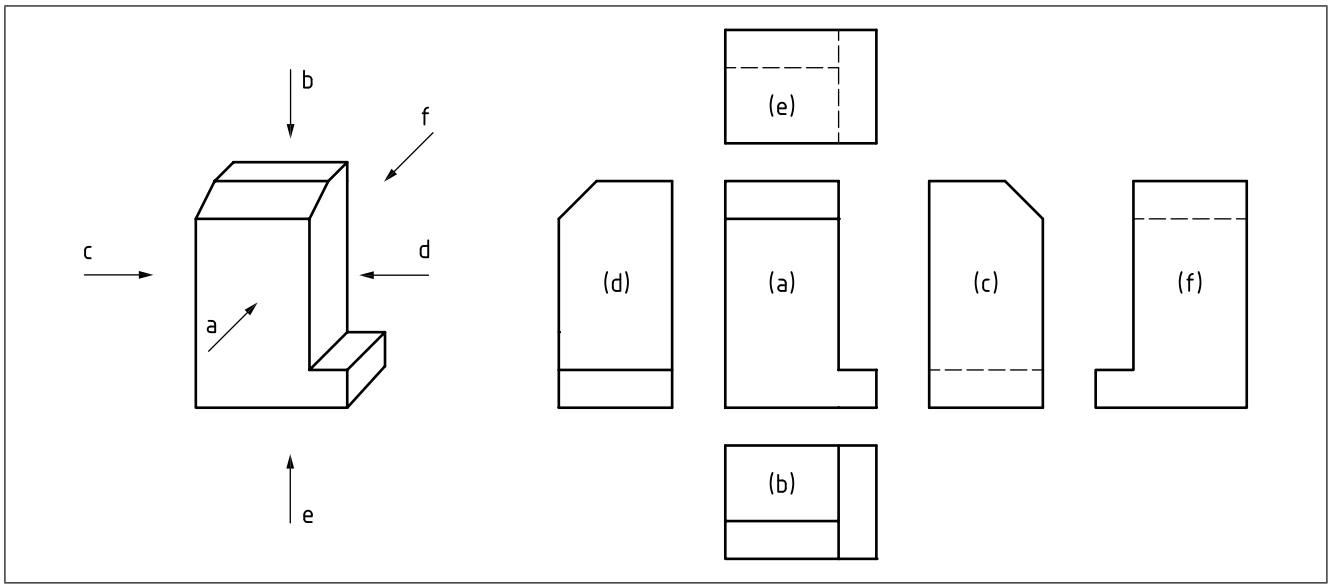
9.7.2.4.1 General

NOTE A more detailed description of the first angle projection method is to be found in BS ISO 128-30 and BS EN ISO 5456-2.

With reference to the front view (a), the other views shall be arranged as follows (see Figure 113).

- The view from above (b) shall be placed underneath.
- The view from below (e) shall be placed above.
- The view from the left (c) shall be placed on the right.
- The view from the right (d) shall be placed on the left.
- The view from the rear (f) shall be placed on the left or right, as convenient.

Figure 113 **First angle projection method**

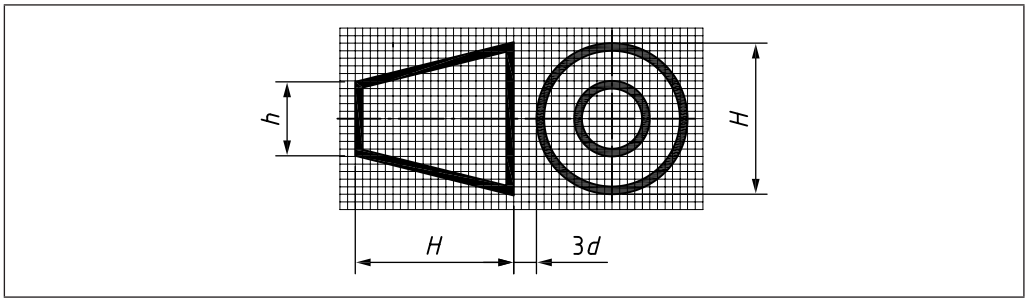


9.7.2.4.2 First angle projection method – Graphical symbol

As specified by BS ISO 128-30, the graphical symbol for the first angle projection method shall be as shown in Figure 114.

The proportions and dimensions of this graphical symbol shall be as specified in BS ISO 128-30.

Figure 114 **First angle projection method: Graphical symbol**



9.7.2.5 Third angle projection method

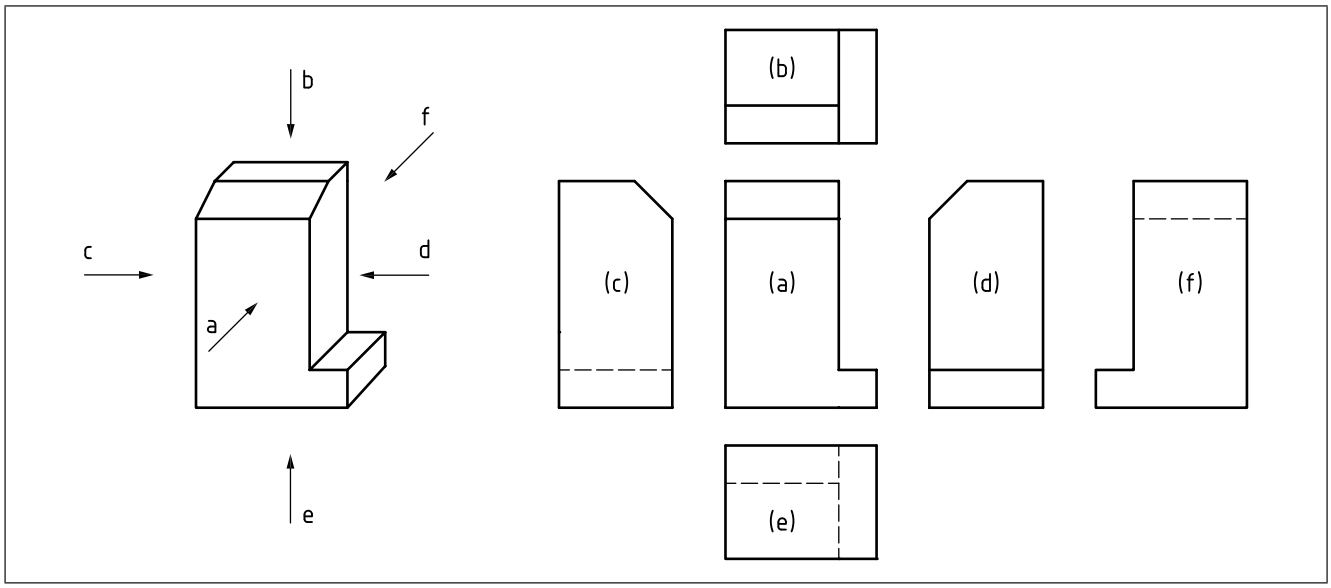
NOTE A more detailed description of the third angle projection method is to be found in BS ISO 128-30 and in BS EN ISO 5456-2.

9.7.2.5.1 General

With reference to the front view (a), the other views shall be arranged as follows (see Figure 115).

- The view from above (b) shall be placed above.
- The view from below (e) shall be placed underneath.
- The view from the left (c) shall be placed on the left.
- The view from the right (d) shall be placed on the right.
- The view from the rear (f) shall be placed on the left or right, as convenient.

Figure 115 **Third angle projection method**

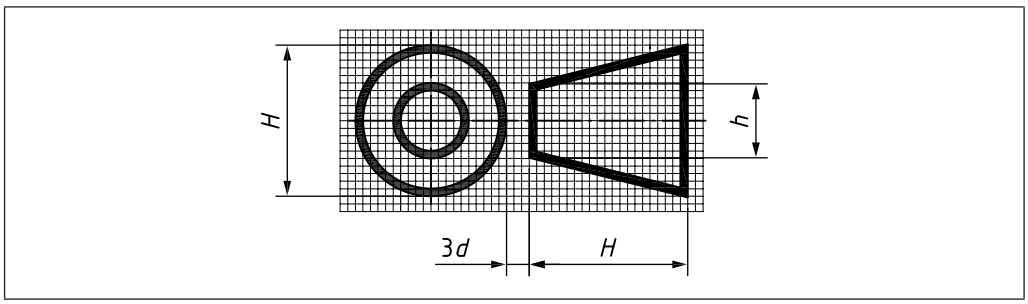


9.7.2.5.2 Third angle projection method – Graphical symbol

As specified by BS ISO 128-30, the graphical symbol for the third angle projection method shall be as shown in Figure 116.

The proportions and dimensions of this graphical symbol shall be as specified in BS ISO 128-30.

Figure 116 **Third angle projection method: Graphical symbol**



9.8 Views

9.8.1 General

Views shall conform to the following standards.

BS ISO 128-30 *Technical drawings – General principles of presentation – Part 30: Basic conventions for views*

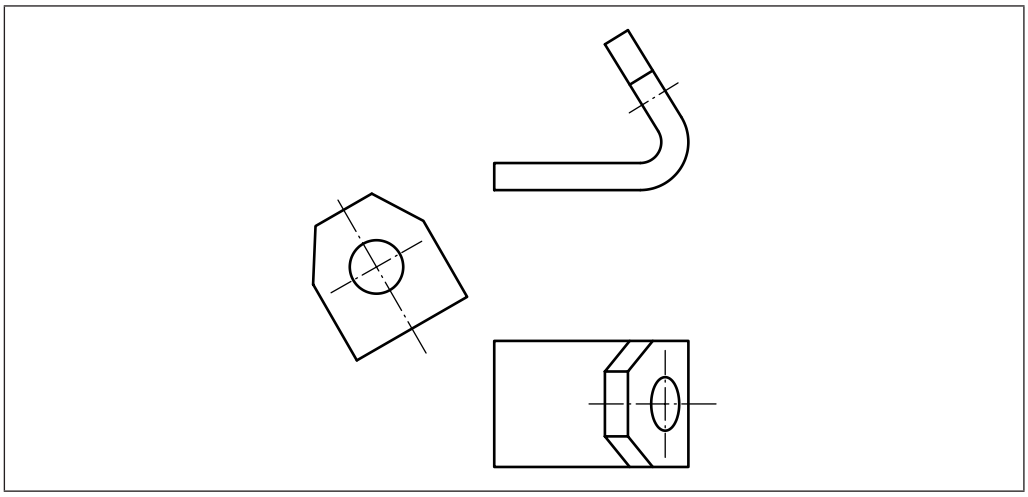
BS ISO 128-34 *Technical drawings – General principles of presentation – Part 34: Views on mechanical engineering drawings*

9.8.2 Auxiliary views

Where true representation of features is necessary, but cannot be achieved on the orthographic views, the features shall be shown in projected auxiliary views.

NOTE An example is shown in Figure 117.

Figure 117 **Auxiliary view showing true shape of inclined surface**



9.9 Sections

9.9.1 General

Sections shall conform to the following standards.

BS ISO 128-40 *Technical drawings – General principles of presentation – Part 40: Basic conventions for cuts and sections*

BS ISO 128-44 *Technical drawings – General principles of presentation – Part 44: Sections on mechanical engineering drawings*

BS ISO 128-50 *Technical drawings – General principles of presentation – Part 50: Basic conventions for representing areas on cuts and sections*

NOTE BS ISO 128-44 and BS ISO 128-50 contain presentational defects in some figures (e.g. line types, line thickness, terminators and letter heights). It is stressed that the text of these standards is technically correct and users should, therefore, regard the figures as illustrations only.

9.9.2 Mechanical engineering drawings

9.9.2.1 General

As specified by BS ISO 128-44, ribs, fasteners, shafts, spokes of wheels and the like shall not be cut in longitudinal sections, and shall therefore not be represented as sections.

NOTE 1 Like views, sections might be shown in a position other than that indicated by the arrows for the direction of their viewing.

NOTE 2 A section in one plane is shown in Figure 118.

NOTE 3 A section in two parallel planes is shown in Figure 119.

NOTE 4 A section in three contiguous planes is shown in Figure 120.

Figure 118 **Auxiliary view showing true shape of inclined surface**

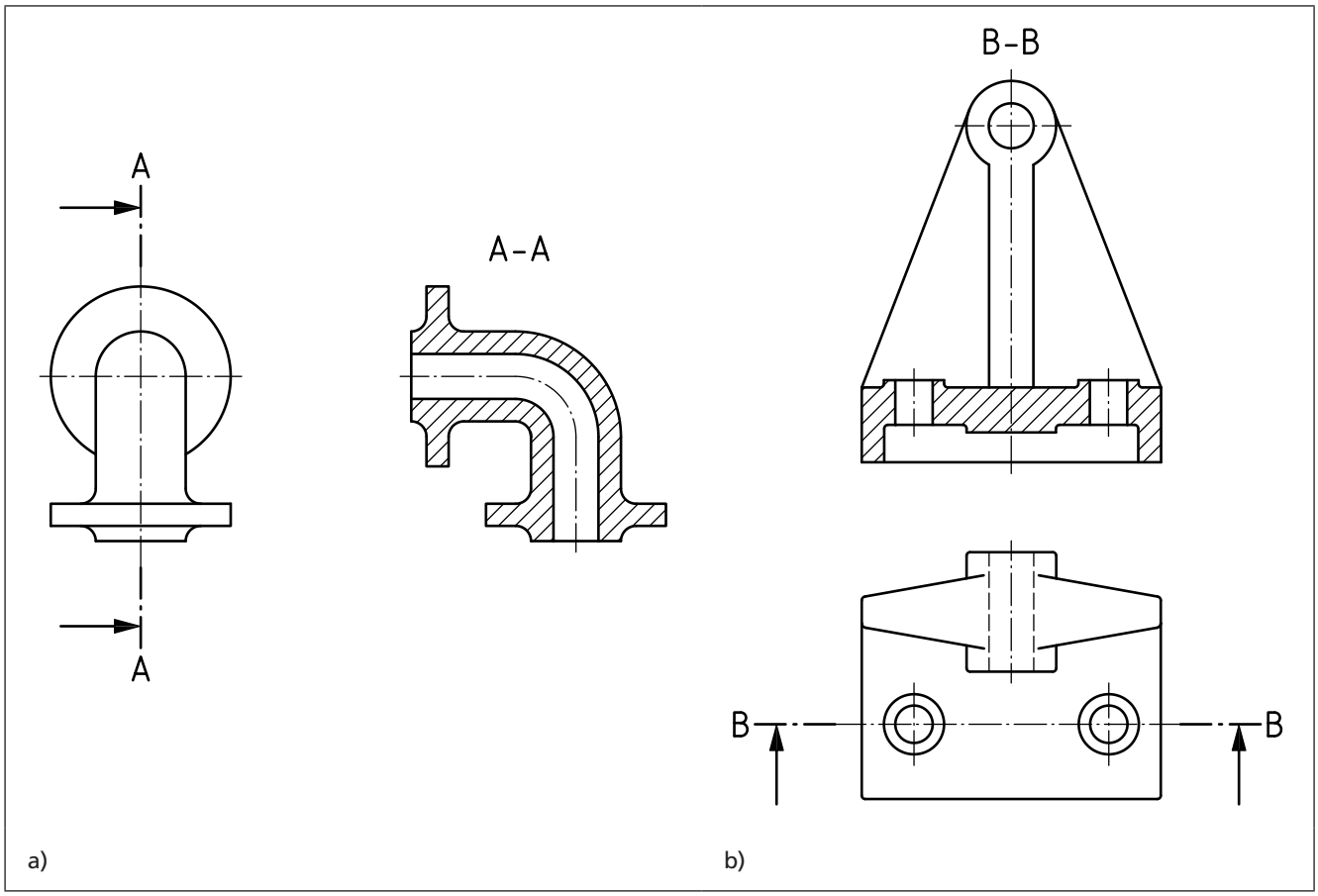


Figure 119 **Auxiliary view showing true shape of inclined surface**

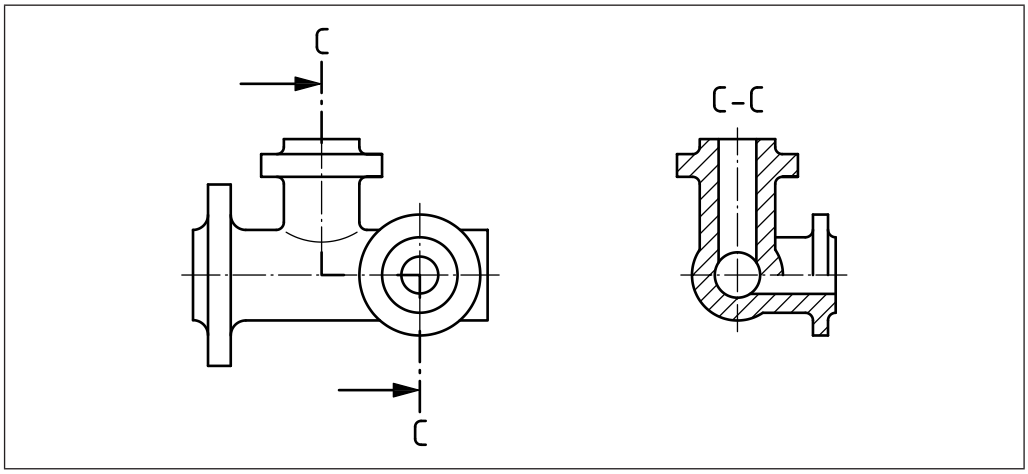
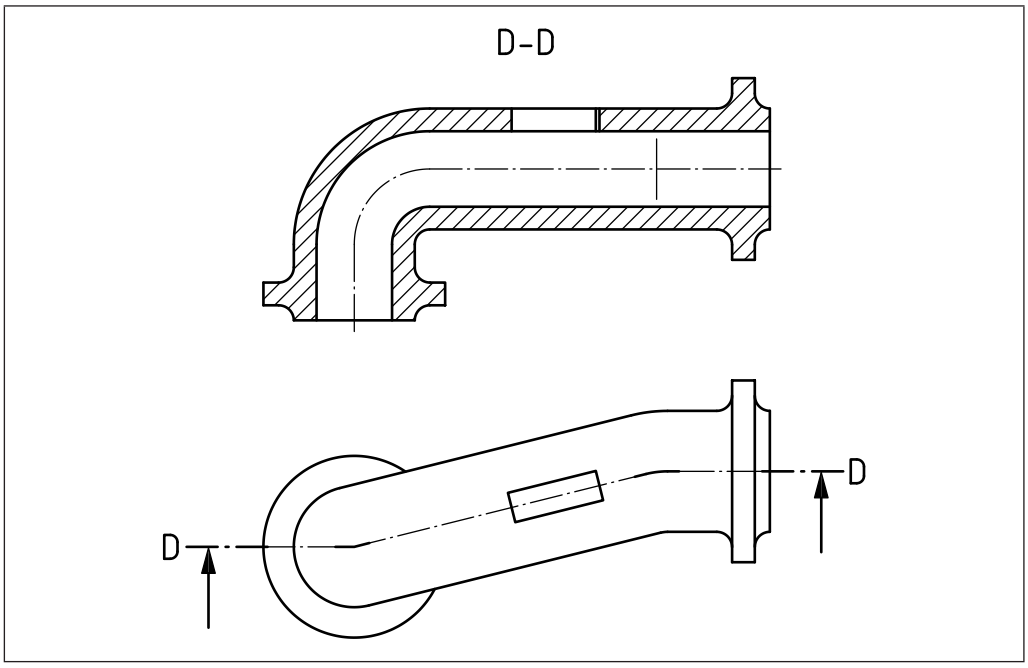


Figure 120 **Auxiliary view showing true shape of inclined surface**



9.10 Representation of features

Conventions used for the representation of features shall conform to the following standards, as appropriate.

BS EN ISO 4063 *Welding and allied processes – Nomenclature of processes and reference numbers*

BS EN ISO 5261 *Technical drawings – Simplified representation of bars and profile sections*

BS EN ISO 5845-1 *Technical drawings – Simplified representation of the assembly of parts with fasteners – Part 1: General principles*

BS EN ISO 6410-1 *Technical drawings – Screw threads and threaded parts – Part 1: General conventions*

BS EN ISO 6410-2 *Technical drawings – Screw threads and threaded parts – Part 2: Screw thread inserts*

BS EN ISO 6410-3 *Technical drawings – Screw threads and threaded parts – Part 3: Simplified representation*

BS EN ISO 6411 *Technical drawings – Simplified representation of centre holes*

BS EN ISO 6413 *Technical drawings – Representation of splines and serrations*

BS ISO 13715 *Technical drawings – Edges of unidentified shape – Vocabulary and indications*

BS EN ISO 15785 *Technical drawings – Symbolic presentation and indication of adhesive, fold and pressed joints*

BS EN 22553 *Welded, brazed and soldered joints – Symbolic representation on drawings*

NOTE The BS ISO 128 series of standards covers the general subject of feature representation.

9.11 Representation of components

9.11.1 General

Conventions used for the representation of components shall conform to the following standards, as appropriate.

BS EN ISO 2162-1 *Technical product documentation – Springs – Part 1: Simplified representation*

BS EN ISO 2162-2 *Technical product documentation – Springs – Part 2: Presentation of data for cylindrical helical compression springs*

BS EN ISO 26909 *Springs – Vocabulary*

BS EN ISO 2203 *Technical drawings – Conventional representation of gears*

BS ISO 1219-1 *Fluid power systems and components – Graphical symbols and circuit diagrams – Part 1: Graphical symbols for conventional use and data-processing applications*

BS 3238-1 *Graphical symbols for components of servo-mechanisms – Part 1: Transductors and magnetic amplifiers*

BS 3238-2 *Graphical symbols for components of servo-mechanisms – Part 2: General servo-mechanisms*

BS EN ISO 5845-1 *Technical drawings – Simplified representation of the assembly of parts with fasteners – Part 1: General principles*

BS EN ISO 6410-1 *Technical drawings – Screw threads and threaded parts – Part 1: General conventions*

BS EN ISO 6410-2 *Technical drawings – Screw threads and threaded parts – Part 2: Screw thread inserts*

BS EN ISO 6410-3 *Technical drawings – Screw threads and threaded parts – Part 3: Simplified representation*

BS EN ISO 6412-1 *Technical drawings – Simplified representation of pipelines – Part 1: General rules and orthogonal representation*

BS EN ISO 6412-2 *Technical drawings – Simplified representation of pipelines – Part 2: Isometric projection*

BS EN ISO 6412-3 *Technical drawings – Simplified representation of pipelines – Part 3: Terminal features of ventilation and drainage systems*

BS EN ISO 8826-1 *Technical drawings – Roller bearings – Part 1: General simplified representation*

BS EN ISO 8826-2 *Technical drawings – Roller bearings – Part 2: Detailed simplified representation*

BS EN ISO 9222-1 *Technical drawings – Seals for dynamic application – Part 1: General simplified representation*

BS EN ISO 9222-2 *Technical drawings – Seals for dynamic application – Part 2: Detailed simplified representation*

NOTE The BS ISO 128 series of standards covers the general subject of component representation.

9.11.2 Representation of moulded, cast and forged components

*COMMENTARY ON **9.11.2***
It is recommended that tolerances for the dimensions of plastics mouldings be applied in accordance with the system provided in BS 7010.

Dimensional tolerancing for metal and metal alloy castings shall conform to the following standards, as appropriate.

BS EN ISO 10135 *Geometrical product specifications (GPS) – Drawing indications for moulded parts in technical product documentation (TPD)*

BS EN ISO 8062-1 *Geometrical product specification (GPS) – Dimensional and geometrical tolerances for moulded parts – Part 1: Vocabulary*

ISO/TS 8062-2 *Geometrical product specification (GPS) – Dimensional and geometrical tolerances for moulded parts – Part 2: Rules*

BS EN ISO 8062-3 *GPS – Dimensional and geometrical tolerances for moulded parts – Part 3: General dimensional and geometrical tolerances and machine allowances for casting*

Section 10: Document handling

10.1 Types of documentation

10.1.1 General

*COMMENTARY ON **10.1.1***
The careful targeting of TPD to known or intended users can greatly assist the accuracy with which the specification is converted into the final product.

While precision and avoidance of ambiguity are always paramount, the means employed to convey this information shall be seen to match the capability, or potential capability, of the available or achievable manufacturing facility.

NOTE Specification beyond this level is unlikely to produce satisfactory results and can often prove expensive, both in terms of the cost of the over-specification itself and in terms of inadequate or unacceptable product.

10.1.2 Presentation media

10.1.2.1 General

The presentation of the drawings shall conform to the following standards, as appropriate.

BS EN ISO 5457 *Technical product documentation – Sizes and layout of drawing sheets*

BS EN ISO 7200 *Technical product documentation – Data fields in title blocks and document headers*

BS ISO 7573 *Technical drawings – Parts lists*

10.1.2.2 Format

Drawing sheets and other documents shall be presented in one of the following formats.

a) Landscape: intended to be viewed with the longest side of the sheet horizontal.

b) Portrait: intended to be viewed with the longest side of the sheet vertical.

NOTE Contrary to BS EN ISO 5457, A4 sheets may be used in landscape or portrait mode.

10.2 Security

10.2.1 Introduction

Many TPSs have minimal requirements for security, other than that provided by general handling and storage procedures. However, where specific need for a general level of security is identified, the requirements in **10.2.2**, **10.2.3** and **10.2.4** shall be met.

10.2.2 General security

Procedures for ensuring the security of TPDs and TPSs shall conform to the following standard.

BS EN ISO 11442 *Technical product documentation*

10.2.3 Enhanced security

Where enhanced security is claimed, the requirements of Annex D shall be met, in addition to those in **10.2.4**.

10.2.4 Security level identification

The level of security attributed to any given TPS shall be clearly identified by the relevant marking placed adjacent to the title or title block of every TPD making up that TPS.

10.3 Storage

Methods for storage and retrieval of the document shall conform to the following standards, as appropriate.

BS EN ISO 6428 *Technical drawings – Requirements for microcopying*

BS EN ISO 11442 *Technical product documentation*

10.4 Marking

10.4.1 General

Technical product documents shall be marked to indicate which standards, or system of standards, are to govern their interpretation in a prominent location.[4)]

Technical product documents prepared in accordance with this British Standard shall be prepared in accordance with the ISO system.

*NOTE The marking of a TPD or TPS with the number of this standard constitutes a claim that the appropriate requirements of all relevant cross-referenced standards, in addition to the requirements directly stated in this British Standard, have been met. Attention is drawn to the date of issue principle (**4.2**).*

10.4.2 Enhanced security

TPDs conforming to Annex D, shall be marked in a prominent location with the number of this standard, followed by the suffix "/D", i.e.:

CONFORMS TO BS 8888/D

10.4.3 Tolerancing system

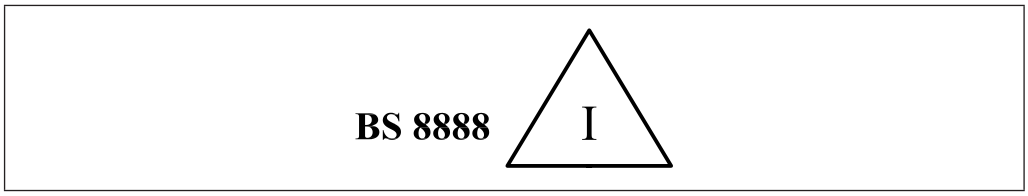
*COMMENTARY ON **10.4.3***
It was former practice to mark a TPS with the indication "BS 8888", supplemented by the letter "I" contained within an equilateral triangle (see Figure 121) or the letter "D" contained within an equilateral triangle (see Figure 122).

---

4) Marking BS 8888:2013 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

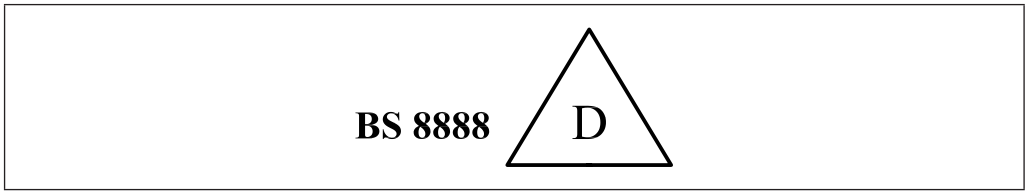
The triangle "I" symbol was taken to indicate that the principle of independency was to be used to govern the interpretation of size and form requirements. While this had the same meaning as "TOLERANCING ISO 8015", its meaning might not be apparent to an interpreter who was familiar with ISO standards, but not BS 8888, so its use is no longer recommended.

Figure 121 **BS 8888 independency system symbol – No longer recommended**



The triangle "D" symbol (see Figure 122) was taken to indicate that the principle of dependency was to be used to govern the interpretation of size and form requirements. While this was included to maintain consistency with earlier versions of BS 8888 and BS 308, the interpretation of the principle of dependency as a general requirement is not fully defined within the ISO system, so there might be ambiguities in its interpretation. In view of such possible ambiguities, and the fact that the symbol might not be understood by interpreters who were familiar with the ISO system but not BS 8888, the use of this symbol is no longer recommended.

Figure 122 **BS 8888 dependency system symbol – No longer recommended**



Where the TPD or TPS has been prepared using the ISO system for the interpretation of size and form, the drawing shall carry the following statement in, or close to, the title block.

TOLERANCING ISO 8015

10.5 Protection notices

Where appropriate to place restrictions on the use of TPD, the following standard shall be applied.

BS ISO 16016 *Technical product documentation – Protection notices for restricting the use of documents and products*

Annex A (normative) Normative references

The following referenced documents are indispensable for the application 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.

BS 1134, *Assessment of surface texture – Guidance and general information*

BS 1916-1, *Limits and fits for engineering – Part 1: Guide to limits and tolerances*

BS 1916-2, *Limits and fits for engineering – Part 2: Guide to the selection of fits in BS 1916-1*

BS 1916-3, *Limits and fits for engineering – Part 3: Recommendations for tolerances, limits and fits for large diameters*

BS 3238-1, *Graphical symbols for components of servo-mechanisms – Part 1: Transductors and magnetic amplifiers*

BS 3238-2, *Graphical symbols for components of servo-mechanisms – Part 2: General servo-mechanisms*

BS 3734-1, *Rubber – Tolerances for products – Part 1: Dimensional tolerances*

BS 4500, *Limits and fits – Guidance for system of cone (taper) fits and tolerances for cones from C = 1:3 to 1:500, lengths from 6 mm to 630 mm and diameters up to 500 mm*

BS 6615, *Specification for dimensional tolerances for metal and metal alloy castings*

BS 7010, *Code of practice for a system of tolerances for the dimensions of plastic mouldings*

BS EN 22553, *Welded, brazed and soldered joints – Symbolic representation on drawings*

BS EN 80000-13, *Quantities and units – Part 13: Information science and technology*

BS EN 80000-14, *Quantities and units – Part 14: Telebiometrics related to human physiology*

BS EN ISO 1, *Geometrical product specifications (GPS) – Standard reference temperature for geometrical product specification and verification*

BS EN ISO 128-20, *Technical drawings – General principles of presentation – Part 20: Basic conventions for lines*

BS EN ISO 128-21, *Technical drawings – General principles of presentation – Part 21: Preparation of lines by CAD systems*

BS EN ISO 286-1, *Geometrical product specifications (GPS) – ISO code system for tolerances on linear sizes – Part 1: Basis of tolerances, deviations and fits*

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BS EN ISO 1119, *Geometrical product specifications (GPS) – Series of conical tapers and taper angles*

BS EN ISO 1302, *Geometrical product specifications (GPS) – Indication of surface texture in technical product documentation*

BS EN ISO 1660, *Technical drawings – Dimensioning and tolerancing of profiles*

BS EN ISO 2162-1, *Technical product documentation – Springs – Part 1: Simplified representation*

BS EN ISO 2162-2, *Technical product documentation – Springs – Part 2: Presentation of data for cylindrical helical compression springs*

BS EN ISO 2203, *Technical drawings – Conventional representation of gears*

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

BS EN ISO 3040, *Geometrical product specifications (GPS) – Dimensioning and tolerancing – Cones*

BS EN ISO 3098-0, *Technical product documentation – Lettering – Part 0: General requirements*

BS EN ISO 3098-2, *Technical product documentation – Lettering – Part 2: Latin alphabet, numerals and marks*

BS EN ISO 3098-3, *Technical product documentation – Lettering – Part 3: Greek alphabet*

BS EN ISO 3098-4, *Technical product documentation – Lettering – Part 4: Diacritical and particular marks for the Latin alphabet*

BS EN ISO 3098-5, *Technical product documentation – Lettering – Part 5: CAD lettering of the Latin alphabet, numerals and marks*

BS EN ISO 3098-6, *Technical product documentation – Lettering – Part 6: Cyrillic alphabet*

BS EN ISO 3274, *Geometrical product specifications (GPS) – Surface texture: profile method – Nominal characteristics of contact (stylus) instruments*

BS EN ISO 4063, *Welding and allied processes – Nomenclature of processes and reference numbers*

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BS EN ISO 5261, *Technical drawings – Simplified representation of bars and profile sections*

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BS EN ISO 5456-3, *Technical drawings – Projection methods – Part 3: Axonometric representations*

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BS EN ISO 5458, *Geometrical product specifications (GPS) – Geometrical tolerancing – Positional tolerancing*

BS EN ISO 5459:2011, *Geometrical product specification (GPS) – Geometrical tolerancing – Datums and datum-systems*

BS EN ISO 5845-1, *Technical drawings – Simplified representation of the assembly of parts with fasteners – Part 1: General principles*

BS EN ISO 6410-1, *Technical drawings – Screw threads and threaded parts – Part 1: General conventions*

BS EN ISO 6410-2, *Technical drawings – Screw threads and threaded parts – Part 2: Screw thread inserts*

BS EN ISO 6410-3, *Technical drawings – Screw threads and threaded parts – Part 3: Simplified representation*

BS EN ISO 6411, *Technical drawings – Simplified representation of centre holes*

BS EN ISO 6412-1, *Technical drawings – Simplified representation of pipelines – Part 1: General rules and orthogonal representation*

BS EN ISO 6412-2, *Technical drawings – Simplified representation of pipelines – Part 2: Isometric projection*

BS EN ISO 6412-3, *Technical drawings – Simplified representation of pipelines – Part 3: Terminal features of ventilation and drainage systems*

BS EN ISO 6413, *Technical drawings – Representation of splines and serrations*

BS EN ISO 6428, *Technical drawings – Requirements for microcopying*

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BS EN ISO 8785, *Geometrical product specification (GPS) – Surface imperfections – Terms definitions and parameters*

BS EN ISO 8826-1, *Technical drawings – Roller bearings – Part 1: General simplified representation*

BS EN ISO 8826-2, *Technical drawings – Roller bearings – Part 2: Detailed simplified representation*

BS EN ISO 9222-1, *Technical drawings – Seals for dynamic application – Part 1: General simplified representation*

BS EN ISO 9222-2, *Technical drawings – Seals for dynamic application – Part 2: Detailed simplified representation*

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

BS EN ISO 10209, *Technical product documentation – Vocabulary – Terms relating to technical drawings, product definition and related documentation*

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BS EN ISO 12085, *Geometrical product specifications (GPS) – Surface texture: Profile method – Motif parameters*

BS EN ISO 12180-1, *GPS – Cylindricity – Part 1: Vocabulary and parameters of cylindrical form*

BS EN ISO 12180-2, *GPS – Cylindricity – Part 2: Specification operators*

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BS EN ISO 12181-2, *GPS – Roundness – Part 2: Specification operators*

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BS EN ISO 14253-1, *Geometrical product specifications (GPS) – Inspection by measurement of workpieces and measuring equipment – Part 1: Decision rules for proving conformity or non-conformity with specifications*

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BS EN ISO 14660-1, *Geometrical product specifications (GPS) – Geometrical features – Part 1: General terms and definitions*

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BS EN ISO 16610-21, *Geometrical product specifications (GPS) – Filtration – Part 21: Linear profile filters: Gaussian filters*

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BS EN ISO 80000-1, *Quantities and units – Part 1: General*

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BS EN ISO 80000-4, *Quantities and units – Part 4: Mechanics*

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BS EN ISO 80000-6, *Quantities and units – Part 6: Electromagnetism*

BS EN ISO 80000-8, *Quantities and units – Part 8: Acoustics*

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BS EN ISO 80000-12, *Quantities and units – Part 12: Solid state physics*

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

BS ISO 128-22, *Technical drawings – General principles of presentation – Part 22: Basic conventions and applications for leader lines and reference lines*

BS ISO 128-23, *Technical drawings – General principles of presentation – Part 23: Lines on construction drawings*

BS ISO 128-24:1999, *Technical drawings – General principles of presentation – Part 24: Lines on mechanical engineering drawings*

BS ISO 128-25, *Technical drawings – General principles of presentation – Part 25: Lines on shipbuilding drawings*

BS ISO 128-30, *Technical drawings – General principles of presentation – Part 30: Basic conventions for views*

BS ISO 128-34, *Technical drawings – General principles of presentation – Part 34: Views on mechanical engineering drawings*

BS ISO 128-40, *Technical drawings – General principles of presentation – Part 40: Basic conventions for cuts and sections*

BS ISO 128-44, *Technical drawings – General principles of presentation – Part 44: Sections on mechanical engineering drawings*

BS ISO 128-50, *Technical drawings – General principles of presentation – Part 50: Basic conventions for representing areas on cuts and sections*

BS ISO 129-1:2004, *Technical drawings – Indications of dimensions and tolerances – Part 1: General principles*

BS ISO 1219-1, *Fluid power systems and components – Graphical symbols and circuit diagrams – Part 1: Graphical symbols for conventional use and data-processing applications*

BS ISO 5456-4, *Technical drawings – Projection methods – Part 4: Central projection*

BS ISO 7573, *Technical product documentation – Parts lists*

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

BS ISO 13715, *Technical drawings – Edges of unidentified shape – Vocabulary and indications*

BS ISO 14617-1, *Graphical symbols for diagrams – Part 1: General information and indexes*

BS ISO 14617-2, *Graphical symbols for diagrams – Part 2: Symbols having general application*

BS ISO 14617-3, *Graphical symbols for diagrams – Part 3: Connections and related devices*

BS ISO 14617-4, *Graphical symbols for diagrams – Part 4: Actuators and related devices*

BS ISO 14617-5, *Graphical symbols for diagrams – Part 5: Measurement and control devices*

BS ISO 14617-6, *Graphical symbols for diagrams – Part 6: Measurement and control functions*

BS ISO 14617-7, *Graphical symbols for diagrams – Part 7: Basic mechanical components*

BS ISO 14617-8, *Graphical symbols for diagrams – Part 8: Valves and dampers*

BS ISO 14617-9, *Graphical symbols for diagrams – Part 9: Pumps, compressors and fans*

BS ISO 14617-10, *Graphical symbols for diagrams – Part 10: Fluid power converters*

BS ISO 14617-11, *Graphical symbols for diagrams – Part 11: Devices for heat transfer and heat engines*

BS ISO 14617-12, *Graphical symbols for diagrams – Part 12: Devices for separating, purification and mixing*

BS ISO 15786, *Technical drawings – Simplified representation and dimensioning of holes*

BS ISO 16016, *Technical product documentation – Protection notices for restricting the use of documents and products*

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BS ISO 80000-7, *Quantities and units – Part 7: Light*

ISO/TS 8062-2, *Geometrical product specifications (GPS) – Dimensional and geometrical tolerances for moulded parts – Part 2: Rules*

DD ISO/TS 16610-1, *GPS – Filtration – Part 1: Overview and basic concepts*

DD ISO/TS 16610-20, *GPS – Filtration – Part 20: Linear profile filters: Basic concepts*

DD ISO/TS 16610-22, *GPS – Filtration – Part 22: Linear profile filters: Spline filters*

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DD ISO/TS 16610-40, *GPS – Filtration – Part 40: Morphological profile filters: Basic concepts*

DD ISO/TS 16610-41, *GPS – Filtration – Part 41: Morphological profile filters: Disk and horizontal line-segment filters*

DD ISO/TS 16610-49, *GPS – Filtration – Part 49: Morphological profile filters: Scale space techniques*

ISO/IEC Guide 98-3, *Guide to the expression of uncertainty in measurement (GUM)*

ISO/IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

Annex B (informative)

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 308, *Engineering drawing practice* (withdrawn)

BS 3643-1, *ISO metric screw threads – Part 1: Principles and basic data*

BS 3643-2, *ISO metric screw threads – Part 2: Specification for selected limits of size*

BS 4235-1, *Specification for metric keys and keyways – Part 1: Parallel and taper keys*

BS 4235-2, *Specification for metric keys and keyways – Part 2: Woodruff keys and keyways*

BS 4827, *Specification for ISO miniature screw threads – Metric series*

BS 8887 (all parts), *Design for manufacture, assembly, disassembly and end-of-life processing (MADE)*

BS 8889, *Technical product verification – Inspection of size, form and surface texture in relation to function – Specification* (in preparation)

BS EN 10243-1, *Steel die forgings – Tolerances on dimensions – Part 1: Drop and vertical press forgings*

BS EN 22768-1, *General tolerances – Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

BS EN 22768-2, *General tolerances – Part 2: Geometrical tolerances for features without individual tolerance indications*

BS EN ISO 216, *Writing paper and certain classes of printed matter – Trimmed sizes – A and B series, and indication of machine direction*

BS EN ISO 5455, *Technical drawings – Scales*

BS EN ISO 5456-1, *Technical drawing – Projection methods – Part 1: Synopsis*

BS EN ISO 17450-1, *Geometrical product specification (GPS) – Part 1: Model for geometrical specification and verification*

BS ISO 129-2, *Technical product documentation – Indication of dimensions and tolerances – Part 2: Dimensioning of mechanical engineering drawing* (in preparation)

BS ISO 129-4, *Technical product documentation (TPD) – Indication of dimensions and tolerances – Part 4: Dimensioning of shipbuilding drawings*

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ISO/TR 14638, *Geometrical product specification (GPS) – Masterplan* [5)]

PD 68888, *Objectives and learning outcomes for BS 8888 training*

BIP 2155, *The essential guide to technical product specification – Engineering drawing*

Other publications

[1] AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME). *Dimensioning and tolerancing (Y14.5)*. New York: ASME, 2009

[5)] Withdrawn.

Annex C (informative) Geometrical tolerancing

C.1 General

NOTE Examples of geometrical tolerances and requirements associated with them (according to BIP 2155) are shown in Table C.1.

Table C.1 **Examples of geometrical tolerancing**

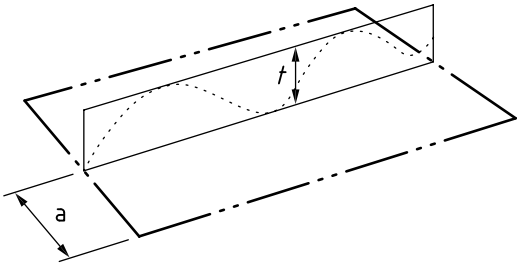
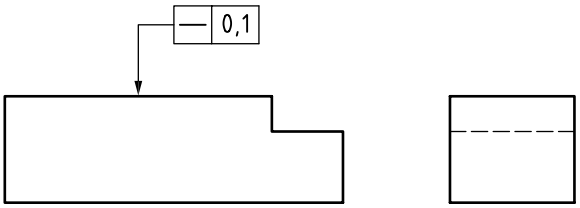
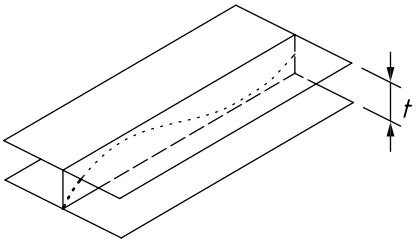
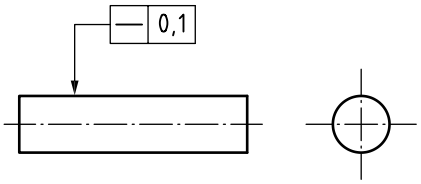
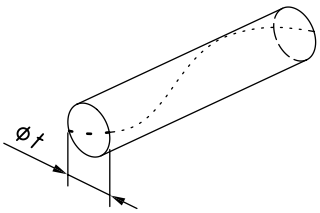
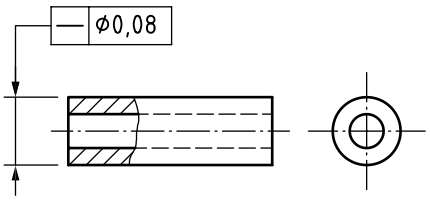
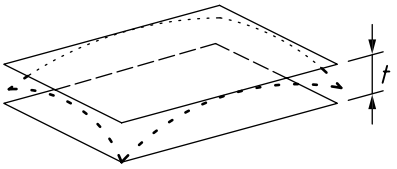
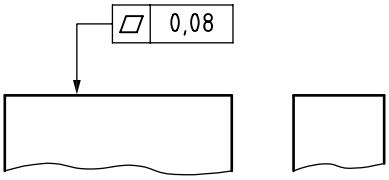
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Straightness tolerance	
—	The tolerance zone, in the considered plane, shall be limited by two parallel straight lines a distance *t* apart and in the specified direction only (*a* = any distance). 	Any extracted (actual) line on the upper surface, parallel to the plane of projection in which the indication is shown, shall be contained between two parallel straight lines 0,1 apart. 
—	The tolerance zone shall be limited by two parallel planes a distance *t* apart. 	Any extracted (actual) generating line on the cylindrical surface shall be contained between two parallel planes 0,1 apart. 
—	The tolerance zone shall be limited by a cylinder of diameter *t*, if the tolerance value is preceded by the symbol Ø. 	The extracted (actual) median line of the cylinder to which the tolerance applies shall be contained within a cylindrical zone of diameter 0,08. 
	Flatness tolerance	
▱	The tolerance zone shall be limited by two parallel planes a distance *t* apart. 	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

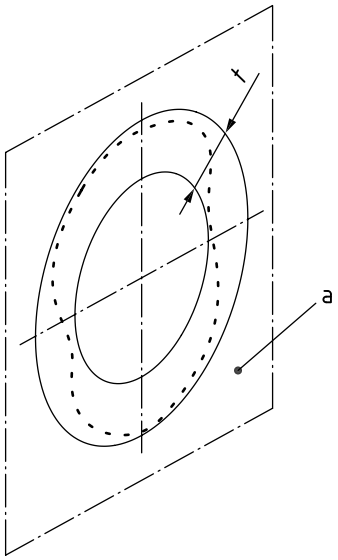
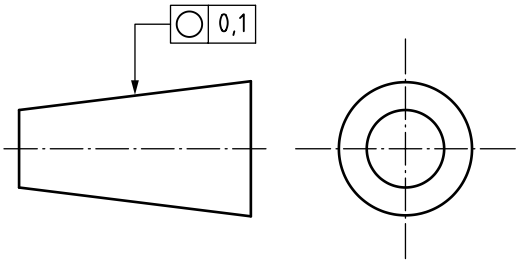
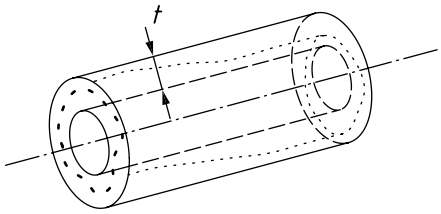
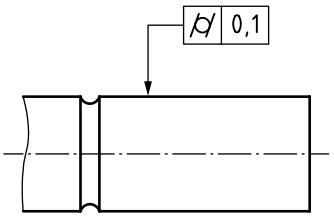
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Roundness tolerance	
○	The tolerance zone, in the considered cross section, shall be limited by two concentric circles with a difference in radii of *t* (*a* = any cross section). 	The extracted (actual) circumferential line in any cross section of the conical surface, shall be contained between two coplanar concentric circles with a difference in radii of 0,1. 
	Cylindricity tolerance	
⌭	The tolerance zone shall be limited by two coaxial cylinders with a difference in radii of *t*. 	The extracted (actual) cylindrical surface shall be contained between two coaxial cylinders with a difference in radii of 0,1. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

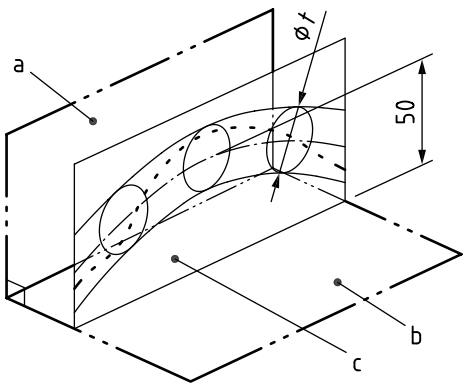
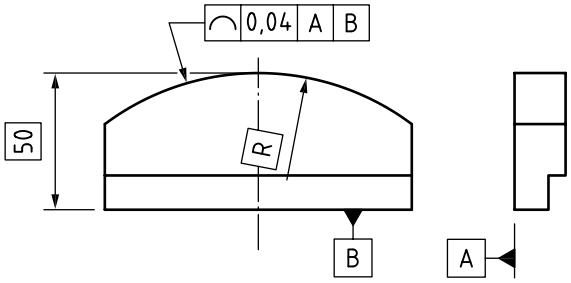
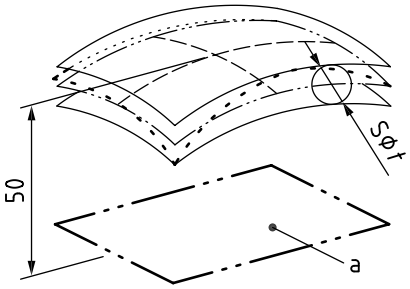
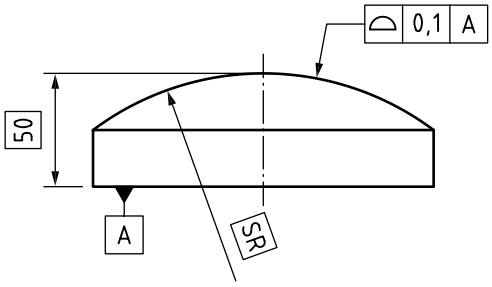
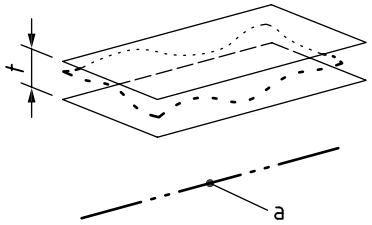
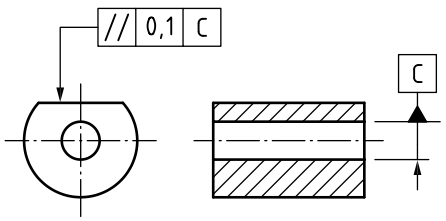
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Profile tolerance of a line related to a datum system	
⌒	The tolerance zone shall be limited by two lines enveloping circles of diameter t, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B.  *NOTE a = datum A; b = datum B; c = plane parallel to datum A.*	In each section, parallel to the plane of projection in which the indication is shown, the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0,04, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B. 
	Profile tolerance of a surface related to a datum	
⌓	The tolerance zone shall be limited by two surfaces enveloping spheres of diameter *t*, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A (a = datum A).  	The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of diameter 0,1, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A. 
	Parallelism tolerance of a surface related to a datum line	
//	The tolerance zone shall be limited by two parallel planes a distance *t* apart and parallel to the datum (a = datum C).  	The extracted (actual) surface shall be contained between two parallel planes 0,1 apart which are parallel to the datum axis C. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

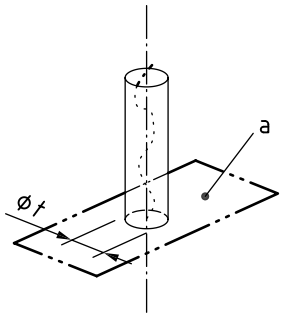
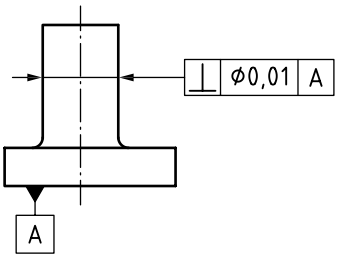
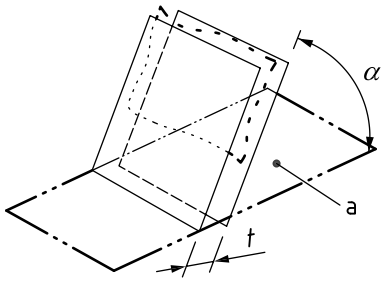
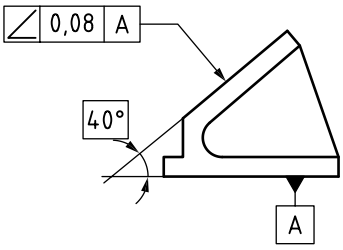
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Perpendicularity tolerance of a line related to a datum surface	
⊥	The tolerance zone shall be limited by a cylinder of diameter *t* perpendicular to the datum if the tolerance value is preceded by the symbol Ø (a = datum A). 	The extracted (actual) median line of the cylinder shall be within a cylindrical zone of diameter 0,01 perpendicular to datum plane A. 
	Angularity tolerance of a surface related to a datum surface	
∠	The tolerance zone shall be limited by two parallel planes a distance *t* apart and inclined at the specified angle to the datum (a = datum A). 	The extracted (actual) surface shall be contained between two parallel planes 0,08 apart that are inclined at a theoretically exact angle of 40° to datum plane A. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

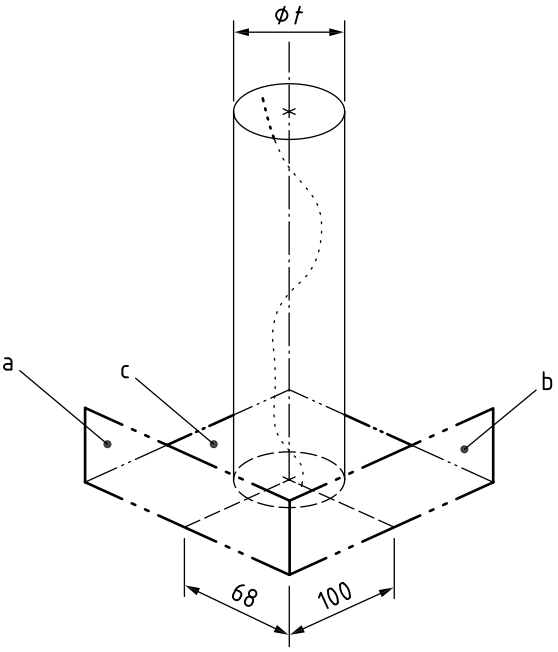
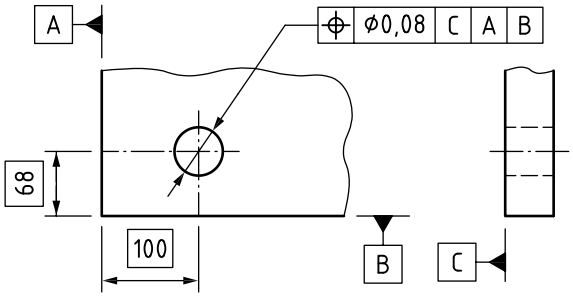
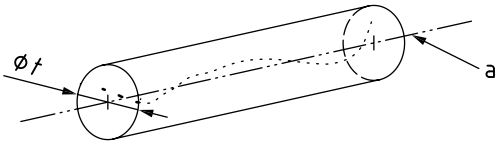
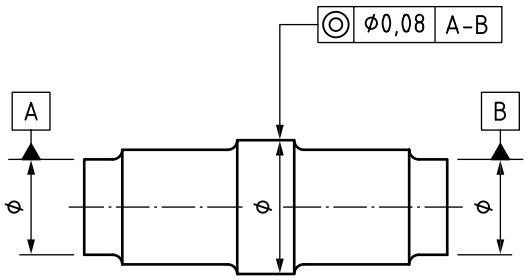
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Positional tolerance of a line	
⌖	The tolerance zone shall be limited by a cylinder of diameter *t* if the tolerance value s preceded by the symbol Ø. The axis of the tolerance cylinder shall be fixed by theoretically exact dimensions with respect to the datums C, A and B.  *NOTE a = datum A; b = datum B; c = datum C.*	The extracted (actual) median line shall be within a cylindrical zone of diameter 0,08, the axis of which coincides with the theoretically exact position of the considered hole, with respect to datum planes C, A and B. 
	Coaxiality tolerance of an axis	
◎	The tolerance zone shall be limited by a cylinder of diameter *t*; the tolerance value shall be preceded by the symbol Ø. The axis of the cylindrical tolerance zone coincides with the datum (a = datum A–B). 	The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0,08 the axis of which is the common datum straight line A–B. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

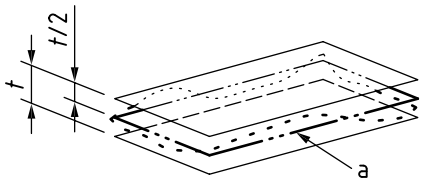
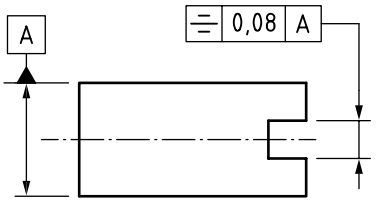
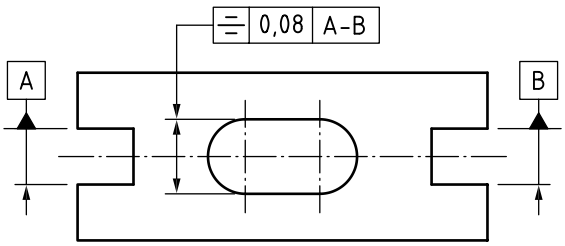
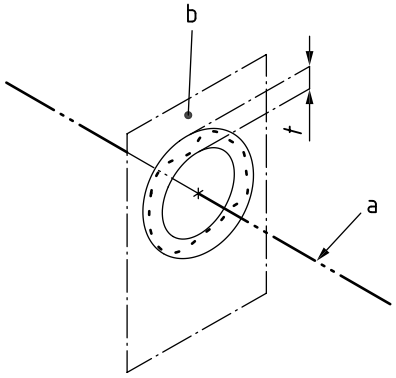
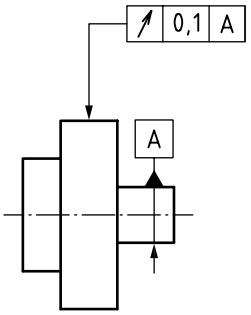
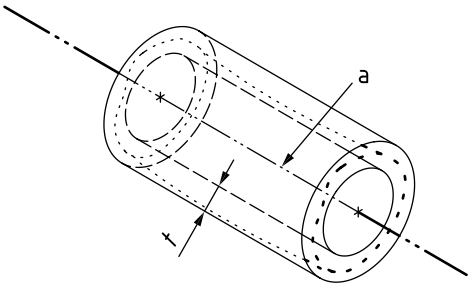
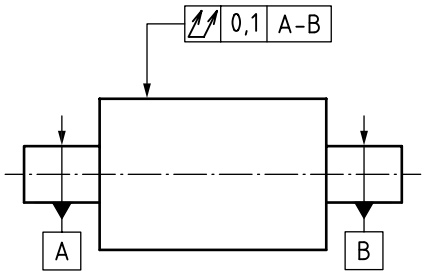
Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Symmetry tolerance of a median plane	
	The tolerance zone shall be limited by two parallel planes a distance *t* apart, symmetrically disposed about the median plane, with respect to the datum (a = datum). 	The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart which are symmetrically disposed about the datum median plane A. 
⌯		The extracted (actual) median surface shall be contained between two parallel planes 0,08 apart and symmetrically disposed about the common datum plane A–B. 
	Circular run-out tolerance – Radial	
↗	The tolerance zone shall be limited within any cross section perpendicular to the datum axis by two concentric circles with a difference in radii of *t*, the centres of which coincide with the datum.  *NOTE a = datum; b = cross section plane.*	The extracted (actual) line in any cross section plane perpendicular to datum axis A shall be contained between two coplanar concentric circles with a difference in radii of 0,1. 

Table C.1 **Examples of geometrical tolerancing** *(continued)*

Symbol	Definition of the tolerance zone	Indication and explanation in 2-D
	Total radial run-out tolerance	
	The tolerance zone shall be limited by two coaxial cylinders with a difference in radii of *t*, the axes of which coincide with the datum (a = datum A–B). 	The extracted (actual) surface shall be contained between two coaxial cylinders with a difference in radii of 0,1 and the axes coincident with the common datum straight line A–B. 

Annex D (normative) Document security – Enhanced

D.1 Enhanced security

Where requirements for enhanced security are known to exist, the procedures identified in this annex shall be applied in addition to those specified in **10.2.4**.

D.2 Identification of security classification

Any required security classification and/or caveat, shall be inserted in the TPS, immediately after classified information is incorporated.

Each sheet shall be classified according to its content.

The security classification shall always appear at the top and bottom of A4 sheets and at the top left and bottom right hand corners of sheets larger than A4.

The security classification shall either be:

a) larger than the largest text used in the TPS; or

b) bolder and the same size as the largest text used in the TPS.

D.3 Marking for enhanced security

Technical product document sets prepared in accordance with **D.1** and **D.2** shall be identified by the addition of the suffix "/D" to the number of this standard, i.e. "BS 8888/D", in a prominent location.

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