
**Technical product documentation —
Digital product definition data practices**

Documentation technique de produits — Données de définition d'un produit

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16792 was prepared by Technical Committee ISO/TC 10, *Technical product documentation*.

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Introduction

Every effort was made during the preparation of this International Standard — adapted from ASME Y14.41:2003 — to apply existing requirements developed for two-dimensional (2-D) presentation equally to the output from three-dimensional (3-D) models. Where new Geometrical Product Specification (GPS) rules have proved essential, these have been drafted with a view to their being equally applicable to both 2-D and 3-D. Therefore, in order to maintain the integrity of a single system, these new rules are being incorporated in the relevant existing ISO standards for cross-reference. Application examples have been included where, due to the specific requirements of 3-D modelling, additional guidance was deemed beneficial.

It is recognised that there is a need to support drawings in conjunction with 3-D models now and for the foreseeable future. This need has been addressed in this International Standard through the definition of the two methods for documenting digital models and specification of requirements to ensure that the information in a data set is consistent between the model and the drawing.

The figures in this International Standard are intended only as illustrations to aid the user in understanding the practices elaborated in the text. In some cases, figures show a level of detail as needed for emphasis; in others, they are only complete enough to illustrate a concept or facet thereof. The absence of figures has no bearing on the applicability of the specified requirement or practice.

In order to comply with the requirements of this International Standard, actual data sets will need to meet the content requirements set forth in its text.

Most figures are illustrations of models in a 3-D environment. Figures illustrating drawings in digital format include a border.

Text in uppercase letters used in the figures are intended to appear in digital product definition data, or data sets; while that in lowercase letters is for information only and is not intended to appear in data sets.

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Technical product documentation — Digital product definition data practices

1 Scope

This International Standard specifies requirements for the preparation, revision and presentation of digital product definition data, hereafter referred to as data sets. It supports two methods of application: model-only, and model and drawing in digital format. Its structure presents requirements common to both methods followed by clauses providing for any essential, differing requirements for each method. Additionally, its use in conjunction with computer aided design (CAD) systems could assist in the progression towards improved modelling and annotation practices for CAD and engineering disciplines, as well as serving as a guideline for IT engineers.

The aspects specified in this International Standard refer mainly, but not exclusively, to requirements that differ or are additional to those provided in existing, related standards. Where no such requirements are identified, it is safe to assume that the appropriate existing ISO standards are instead applicable.

2 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.

ISO 31-0:1992, *Quantities and units — Part 0: General principles*

ISO 128 (all parts), *Technical drawings — General principles of presentation*

ISO 129-1:2004, *Technical drawings — Indication of dimensions and tolerances — Part 1: General principles*

ISO 286 (all parts), *ISO system of limits and fits*

ISO 406, *Technical drawings — Tolerancing of linear and angular dimensions*

ISO 1101:2004, *Geometrical Product Specifications (GPS) — Geometrical tolerancing — Tolerances of form, orientation, location and run-out*

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

ISO 2692, *Technical drawings — Geometrical tolerancing — Maximum material principle*

ISO 2768-1:1989, *General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

ISO 3098-0:1997, *Technical product documentation — Lettering — Part 0: General requirements*

ISO 3098-5:1997, *Technical product documentation — Lettering — Part 5: CAD lettering of the Latin alphabet, numerals and marks*

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ISO 5456 (all parts), *Technical drawings — Projection methods*

ISO 5457:1999, *Technical product documentation — Sizes and layout of drawing sheets*

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

ISO 5459:1981, *Technical drawings — Geometrical tolerancing — Datums and datum-systems for geometrical tolerances*

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

ISO 7200:2004, *Technical product documentation — Data fields in title blocks and document headers*

ISO 8015:1985, *Technical drawings — Fundamental tolerancing principles*

ISO 11442:2006, *Technical product documentation — Document management*

ISO 12944 (all parts), *Paints and varnishes — Corrosion protection of steel structures by protective paint systems*

ISO 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO 16016:2000, *Technical product documentation — Protection notices for restricting the use of documents and products*

ISO 82045-2:2004, *Document management — Part 2: Metadata elements and information reference model*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1 annotation
dimension(s), tolerance(s), note(s), text or symbol(s) visible without any manual or external manipulation

3.2 annotation plane
conceptual plane containing annotation

NOTE 1 It is desirable that annotation planes intersect or be coincident with a model feature.

NOTE 2 The plane is “conceptual” because it is not physically shown as geometry on the model but is provided to replace the drawing media.

3.3 assembly model
model in which the product described is an assembly of two or more items

3.4 associated entities
portion of a product definition to which annotation pertains

3.5 associated group
user-defined set of related digital elements

3.6**associativity**

established relationship between digital elements

3.7**attribute**

dimension, tolerance, note, text or symbol required to complete the product definition or model feature of the product that is not visible but available upon querying the model

3.8**data**

information represented in a formal manner suitable for communication, interpretation or processing by human beings or computers

3.9**datum system**

ordered list of two or three datums, which can be single or common

NOTE 1 See ISO 5459:1981.

NOTE 2 This can be considered as a partial or complete datum system.

3.10**design model**

portion of the data set that contains model and supplemental geometry

3.11**digital element**

geometric element, model feature, group of model features, annotation, associated group or attribute that exists in a data set

3.12**digital element identifier**

label or name used to specify a unique digital element

3.13**direction dependent tolerance**

tolerance that invokes a zone of parallel lines or curves

3.14**flagnote**

note that is located with the general notes but applies only at specific areas or points on the model or drawing

3.15**geometric element**

graphic entity used in a data set

EXAMPLE Representation of geometric feature as defined in ISO 14660-1, representation of models coordinate system, or representation of crosshatching.

3.16**hard copy**

printed or plotted copy of all or part of a data set

3.17**installation model**

model in which the product described is an installation, showing parts or assemblies and a partial or complete representation of the installation site

3.18

management data

data required for the release, control and storage of product definition data as well as other relevant engineering data

3.19

model

combination of design model, annotation and attributes that describes a product

3.20

model coordinate system

representation of a Cartesian coordinate system in a product definition data set

3.21

model geometry

geometric elements in product definition data which represent designed product

3.22

model feature

model geometry that represents a physical portion of a part

3.23

model value

numerical value derived by querying the model that quantifies the form and spatial relationships of the geometry composing a design model or assembly of models to the precision (number of decimal places) of the computer system

3.24

product definition data

data elements required to completely define a product

3.25

product definition data set

collection of one or more computer file(s) that discloses (directly or by reference), by means of graphic or textual presentations, or combinations of both, the physical and functional requirements of a product

3.26

screen dump

hard copy of a displayed image

3.27

query

means of interrogating a digital element or the relationship between digital elements

3.28

represented line element

supplemental geometry line or curve segment indicating the orientation of a direction-dependent tolerance

3.29

resolved dimension

model value that is rounded off to the number of decimal places required for the design

3.30

saved view

stored and retrievable specific orientation and a magnification factor of a model

3.31

special character

character not included in the set of letters A–Z, a–z, numerals and punctuation symbols

3.32**supplemental geometry**

geometric elements included in product definition data to communicate design requirements but not intended to represent a portion of the manufactured product

4 Data set identification and control**4.1 General**

Data sets for which compliance with this International Standard is claimed shall include a reference to this International Standard, ISO 16792, either in the data set itself or in a document referenced by the data set.

The current revision of the data and the computer application(s) and version(s) used to develop the data set shall be specified with other management data, see 5.4.

The data set identifier shall be unique and shall consist of numeric, alphabetic or special characters in any combination. Spaces are not permitted between any of the characters of the data set identifier.

The length of the data set identifier may be a direct function of the computer system and the operating system. When the part or identifying number is used as the data set identifier, the length shall be compatible with recognised limitations on number length in accordance with ISO 7200 and ISO 82045-2.

Special characters, such as hyphen (-), slash (/), or asterisk (*), shall be selected in a manner that does not hinder data set identification or have an adverse affect on the computer system operation.

A recognisable prefix or suffix may be included as part of the identifier to associate files and sets of related data.

See ISO 7200 and ISO 82045-2 for the description and use of drawings, drawing numbers, and identifying numbers.

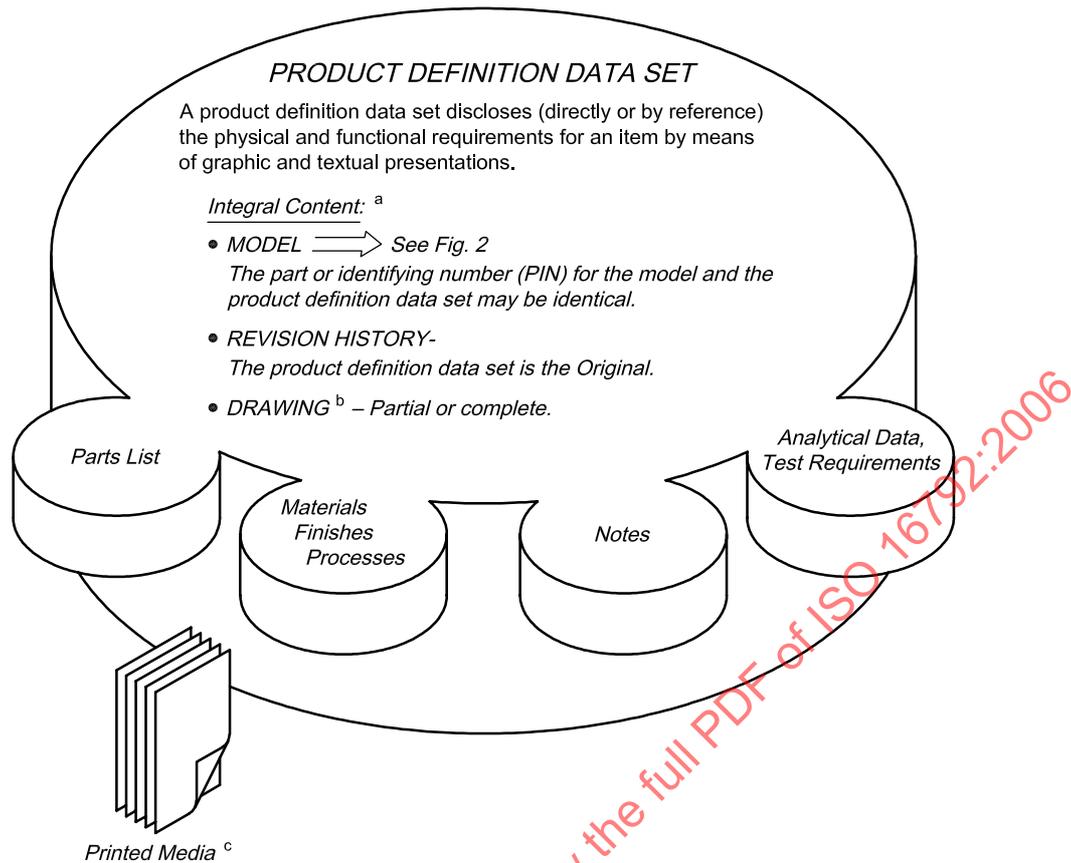
4.2 Related data

Related data shall be integral to, or referenced in, the data set. Related data consists of, but is not limited to, analytical data, parts lists, test requirements, material specifications, process and finish requirements in accordance with Figure 1.

4.3 Data management

The following specifies the structure and control requirements for data management:

- a) The data management system shall meet the requirements of ISO 11442, providing information to enable the control and tracking of data sets, throughout the life cycle of the product to which each relates. The system may include work in process, data review status, model checked status, release status, design tool and version, libraries, etc.
- b) Revision history information per ISO 11442 shall be contained in the data set.



Key

- ^a Related data (as applicable) required for complete definition may be integral to or referenced in the product definition data set. Data not integral to the product definition data set may be revised independently.
- ^b A drawing is not required for Model Only data sets.
- ^c Related data may be manually or computer generated.

Figure 1 — Content of a product definition data set

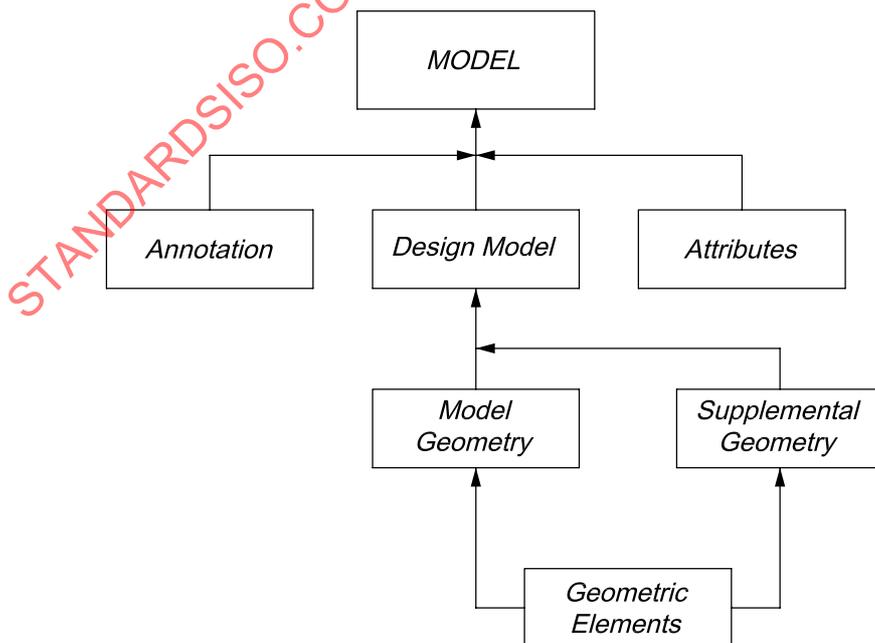


Figure 2 — Content of a model

5 Data set requirements

5.1 General

The data set shall provide complete product definition. For example, a design model, its annotation, and related documentation.

5.1.1 Fundamental requirements

The following are the fundamental requirements and other provisions applicable to both annotated models and drawings, specific to annotated models and specific to drawings.

a) Common to annotated models and drawings

- All model values and resolved dimensions shall be obtained from the model.
- Rounding requirements for resolved dimensions shall comply with 9.2.2.
- The ability to query the model shall be available, see 7.3.8.
- All angular values shall be queried from the model, see 9.3. Exceptions to this are model coordinate system(s), planes and axes in a datum system, and orthographic views.
- When query is required, a notation stating the requirement for query of the model or associated data shall be added to the drawing or in the general notes.
- When applying tolerances to features, alignment of the annotation plane to the nominal or theoretically exact profile is not required.
- Values obtained from the model for any feature(s) without any tolerance or datum target specifications assigned shall be auxiliary dimensions.
- Legibility requirements of ISO 3098-0 and ISO 3098-5 shall apply when the annotation is viewed perpendicular to the annotation plane.
- Annotation in any given annotation plane shall not overlap other annotation in the same annotation plane when the model is viewed perpendicular to the annotation plane.
- Annotation text within any given annotation plane shall not be placed over the design model when the model is viewed perpendicular to the annotation plane.

b) Applicable only to models

- All annotation shall be specified in one or more annotation planes. When CAD software does not support maintenance of annotation plane orientation relative to the model, the model-only method shall not be used, see 7.3.4.
- The associated entities, annotation, and attributes shall be in agreement, see 7.3.2.
- Resolved dimensions created from queried model values are considered the same as dimensions displayed on a model, see 9.2.1.
- Display of centrelines or centre planes for features of size is optional.
- To ensure that the annotation is readable — the text, for example, could be upside down or backwards following rotation of the model — one of the following techniques shall be used:
 - i) ensuring that the reading direction is updated after rotation of a model;

- ii) inclusion of means of determining the correct reading direction in each annotation plane applied to a model;
- iii) when using saved views, ensuring that the model is orientated in the intended view direction — for example, by including a means of determining the correct reading direction in the view.

— Dimensions and tolerances to internal features may be shown without the use of a section, see Figure 25 c).

c) Applicable only to drawings

- Annotation may be applied to orthographic or axonometric views.
- For axonometric views, the orientation of the annotation shall be parallel to, normal to or coincident with the surface to which it applies. An annotation shall not overlap another or the geometrical representation of the part.

5.1.2 Design model requirement

A design model is required and shall be in accordance with 5.2 and Clause 6.

5.2 General model requirements

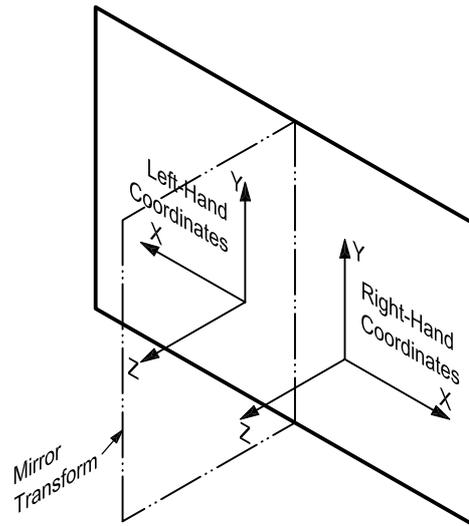
5.2.1 Associativity

The ability to associate digital elements shall be available and maintained. Associativity information shall be electronically accessible.

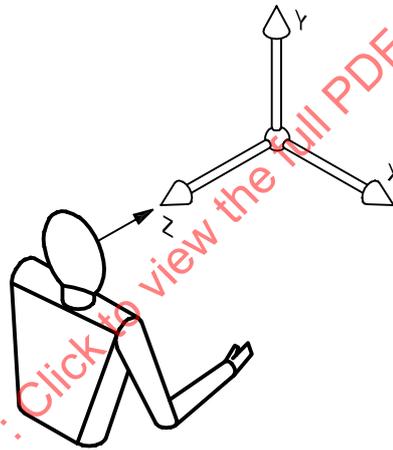
5.2.2 Model coordinate systems

A design model shall contain one or more model coordinate systems. A model coordinate system shall be depicted by three mutually perpendicular line segments with its origin located at the intersection of the three axes. Each axis shall be labelled and the positive direction shown. Model coordinate systems shall be right-handed unless otherwise specified, see Figure 3 b).

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a) Mirror-image relationship



NOTE When observed in the Z direction, with positive Y ascending, positive X is directed to the right-hand side of the observer.

b) Recognising the right-hand coordinate system

Figure 3 — Left- and right-hand model coordinate systems

5.2.3 Applications of supplemental geometry

When supplemental geometry is used, there shall be a clear distinction between the supplemental geometry and the design model geometry.

a) Represented line element

When a represented line element is used to indicate the direction of a geometric tolerance application, the leader line from the tolerance indicator shall terminate on the represented line element in an arrowhead, see Figure 41. The following geometric tolerances may use a represented line element to clarify the directionality of a two-dimensional tolerance zone of parallel lines:

- straightness applied to the line elements of a planar surface, see 11.3.2 and Figure 41;

- orientation tolerance applied on each line element on a surface, see 11.3.3 and Figure 46.
- profile any line, see 11.3.4 and Figure 55.

NOTE It may be necessary to carefully define the placement and orientation of the represented line element on the real workpiece.

b) Associativity

The represented line element, the tolerance indicator and, the toleranced model feature should be organized as an associated group, see Figures 41, 46, and 55.

5.2.4 Workpiece features not fully modelled

A conventional simplified representation of workpiece features such as threads, holes, fillets, rounds and drafts may be shown using partial geometry definition, annotations, attributes or a combination thereof, see Figure 10.

5.3 General method requirements

5.3.1 Data set methods

The following subclauses cover the product definition methods listed below. Each different method for specifying product definition is used in support of different industry processes and requirements. The data set is the original for all of the methods: any copy, no matter what the media of presentation, is subordinate.

5.3.2 Model-only

The following is applicable when there is complete product definition within a model.

- a) Product definition data, including but not limited to notes, parts lists, marking requirements, dimensions and, tolerances shall be contained or referenced in the data set.
- b) The data elements of a drawing format as defined in ISO 5457 and ISO 7200 are not required, except for the following, which shall be contained in the data set:
 - name and address of the company or design activity for the data set;
 - data set title;
 - data set number;
 - approval indicators and approval dates;
 - contract number when required;
 - originator's name and date.
- c) When working with a model, the first or third angle projection symbol (see ISO 5456-2) are not required.

5.3.3 Model and drawing

The following is applicable when there is complete product definition within a model and drawing.

- a) A complete definition of a product shall contain a model and a drawing that may contain orthographic views, axonometric views or a combination thereof. Annotation may be applied to the model, or on the drawing or, a combination thereof.

NOTE The development of a drawing that provides a complete product definition is allowed.

- b) Product definition data created or shown in the model and on the drawing shall not be in conflict.

- c) Product definition data created and shown on the drawing shall not conflict with product definition data in the model.
- d) The drawing shall contain a drawing border and title block information in accordance with ISO 5457 and ISO 7200.
- e) The drawing shall reference all models and data relevant to the product.
- f) Minimum drawing output capability shall be in accordance with ISO 128 (all parts, as appropriate), ISO 129-1, ISO 286-1, ISO 406, ISO 1101, ISO 1302, ISO 2692, ISO 5458, ISO 5459, ISO 5456 (all parts), ISO 5457, ISO 7083 and ISO 7200.
- g) Annotation displayed on the drawing shall be interpretable without the use of query.
- h) When complete product definition is not contained on the drawing, this shall be noted.
- i) When complete product definition is not contained in the model, this shall be noted.

5.4 Management data

5.4.1 General

Management data that is not placed on a drawing shall be placed on the model or in the data set separate from the model or drawing according to 5.4.2 and 5.4.3.

5.4.2 Management data in the data set

The following management data shall be contained in the data set:

- Application data;
- Approval;
- Data set identification;
- Design activity transfer;
- Revision history for the data set.

5.4.3 Management data on a model

Management data placed on a model shall be placed on a management data annotation plane or using an equivalent method. The annotation plane shall be available for display with the model. When displayed, the management data annotation plane shall not rotate with the model. Management data placed on a model shall include, but is not limited to

- ISO 16792,
- CAD maintained notation,
- design activity identification,
- duplicate original notation,
- item identification,
- unit of measurement, and
- navigation data.

5.5 Protection marking

5.5.1 General

Protection marking shall be placed in the file(s) or in the referenced document(s) to which it applies (see ISO 16016).

5.5.2 Location on models

Protection marking shall be placed on a protection-marking annotation plane, or equivalent, which shall be available for display with the model. Reproductions of technical data, or any portions thereof, subject to asserted restrictions shall also reproduce the asserted restrictions. When displayed, the protection-marking annotation plane does not rotate with the model.

NOTE Models containing company intellectual property could include notes to this effect, such as company proprietary notes and competition sensitive material. In addition, there could be requirement for the inclusion of other information such as government notices, statements and legends. Contractual requirements (copyright notices, distribution statements, export control notices and rights in data legends etc.) will determine precisely what is required.

5.6 Views on models

See ISO 128-30, ISO 128-34, ISO 128-40, ISO 128-44 and ISO 128-50 for sections and views. The following paragraphs describe exceptions or additions for views on models.

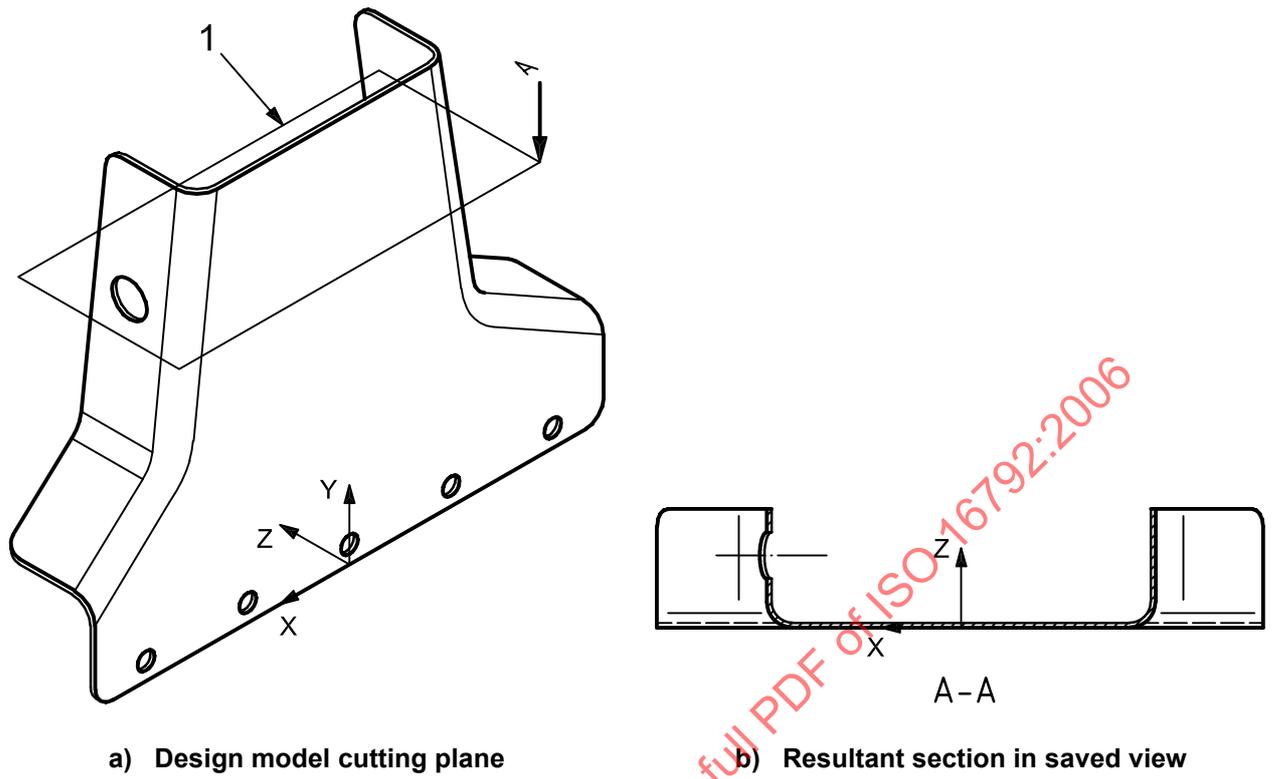
a) Saved views

Saved views of a design model may be defined to facilitate presentation of the model and its annotation. A saved view shall have an identifier, be retrievable on demand, contain a model coordinate system that denotes the direction of the view relative to the model and may contain one or more of the annotation plane(s), a selected set of annotation, or a selected set of geometry.

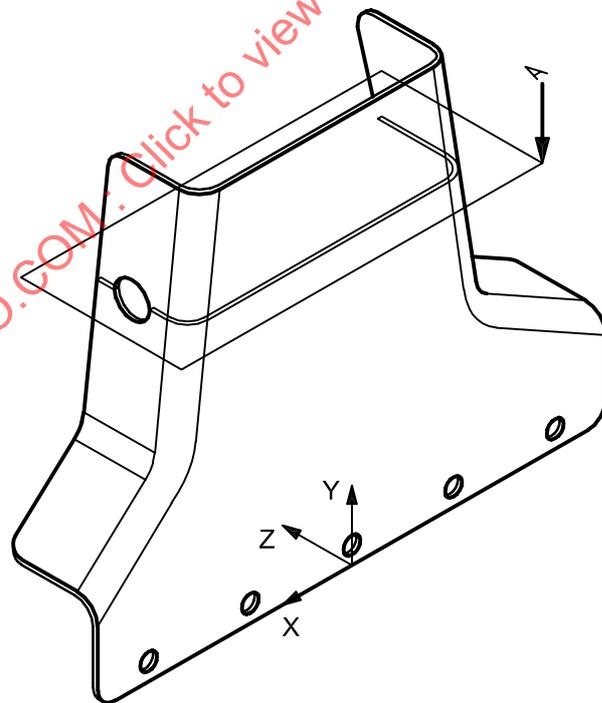
b) Sections

Saved views may be used to retain sections. All sections shall be the same scale as the design model.

- 1) A representation of a cutting plane shall be used to indicate the location and viewing direction of a section. The edges of the cutting plane shall be continuous or long-dashed dotted narrow lines, in accordance with ISO 128-40. A means of identifying all cutting planes in a model shall be available. A visible-view arrow or arrows shall be included to show the direction in which the section is viewed, see Figure 4. A capital letter or letters shall be used for the identification of the cutting plane as indicated in ISO 128-40.
- 2) The result of the section cut may be shown either by removing material from the part, see Figure 4 b), or by display of the curves overlaid on the model that result from intersecting the cutting plane with the part, see Figure 4 c).
- 3) Multiple connected cutting planes shall be used for offset sections, see Figure 5.
- 4) Aligned sections, removed sections and revolved sections shall not be used on design models.
- 5) Broken-out sections shall be accomplished as offset sections, see also 2), above.
- 6) Foreshortened and aligned features as well as rotation of features shall not be used on design models.
- 7) Section views shall be derived from the design model. Changes to the design model shall cause section views to be updated accordingly.



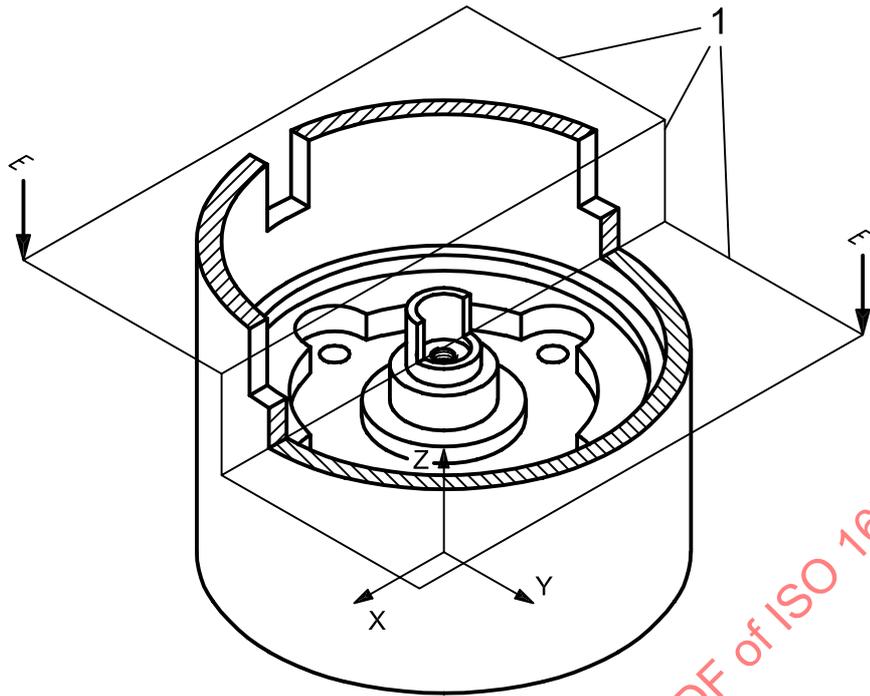
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Key

1 an identified cutting plane

Figure 4 — Design cutting model plane



Key

- 1 multiple connected cutting planes

Figure 5 — Design model with offset section

6 Design model requirements

6.1 General

Design models represent a product in ideal geometric form at a specified dimensional condition, for example minimum, maximum or mean. The dimensional condition shall be specified as a general note.

6.2 Geometric scale, units and precision

Design models shall be modelled using a scale of 1:1.

The design model precision indicates the numeric accuracy required in the production of the workpiece in order for it to fulfil the design intent. The number of significant digits of the design model shall be specified in the data set. The number of decimal places required for the design cannot exceed the precision of the design model.

NOTE If the number of decimal places for a model is changed, this can cause dimensional values or tolerances to change because rounding is applied. See 9.2.2.

6.3 Model completeness

The model shall contain geometry, attributes and annotation as required to provide a complete definition of the part. The model shall be constructed so as to provide a complete definition of the workpiece (geometry, attributes and annotation). In the event that this facility is not used,

- models not fully modelled shall be identified as such, e.g. a partially modelled symmetrical part,
- features that are not fully modelled shall be identified as such, e.g. threaded holes that are only shown as holes, and
- thin parts for which the thickness has not been fully modelled shall be shown as indicated in ISO 129-1. See Figure 6.

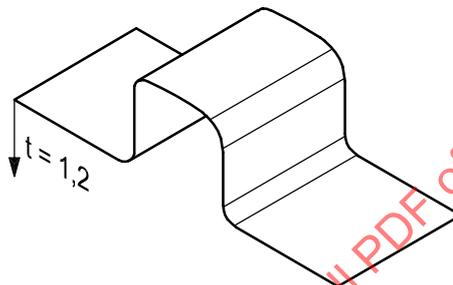


Figure 6 — Thickness indicator for non-modelled thin parts

6.4 Assembly model completeness

Assembly model completeness shall be in accordance with 6.3. Workpiece and sub-assembly models shown in the assembly model need only have sufficient detail shown to ensure correct identification, orientation and placement. The assembly model may be shown in an exploded, partially assembled or completely assembled state. Location and orientation of parts and assemblies may be shown by geometric definition, annotation, or a combination of both.

6.5 Installation model completeness

Installation model completeness shall be in accordance with 6.3 and 6.4. Workpiece and assembly models shown in the installation model need only be sufficiently detailed to provide installation and space requirements. The maximum envelope for parts and assemblies may be shown using supplemental geometry, annotation or a combination of both. Location and orientation of parts and assemblies may be shown by geometric definition, annotation, or a combination of both.

7 Common requirements for product definition data

7.1 General

This clause establishes the common requirements for the application, display management and query of product definition data. Specific requirements for particular types of product definition data are given in Clauses 8 to 11.

7.2 Common requirements

7.2.1 Display management

Display management shall include the facility to enable or disable the display of annotation completely, by type or selectively, see Figure 7.

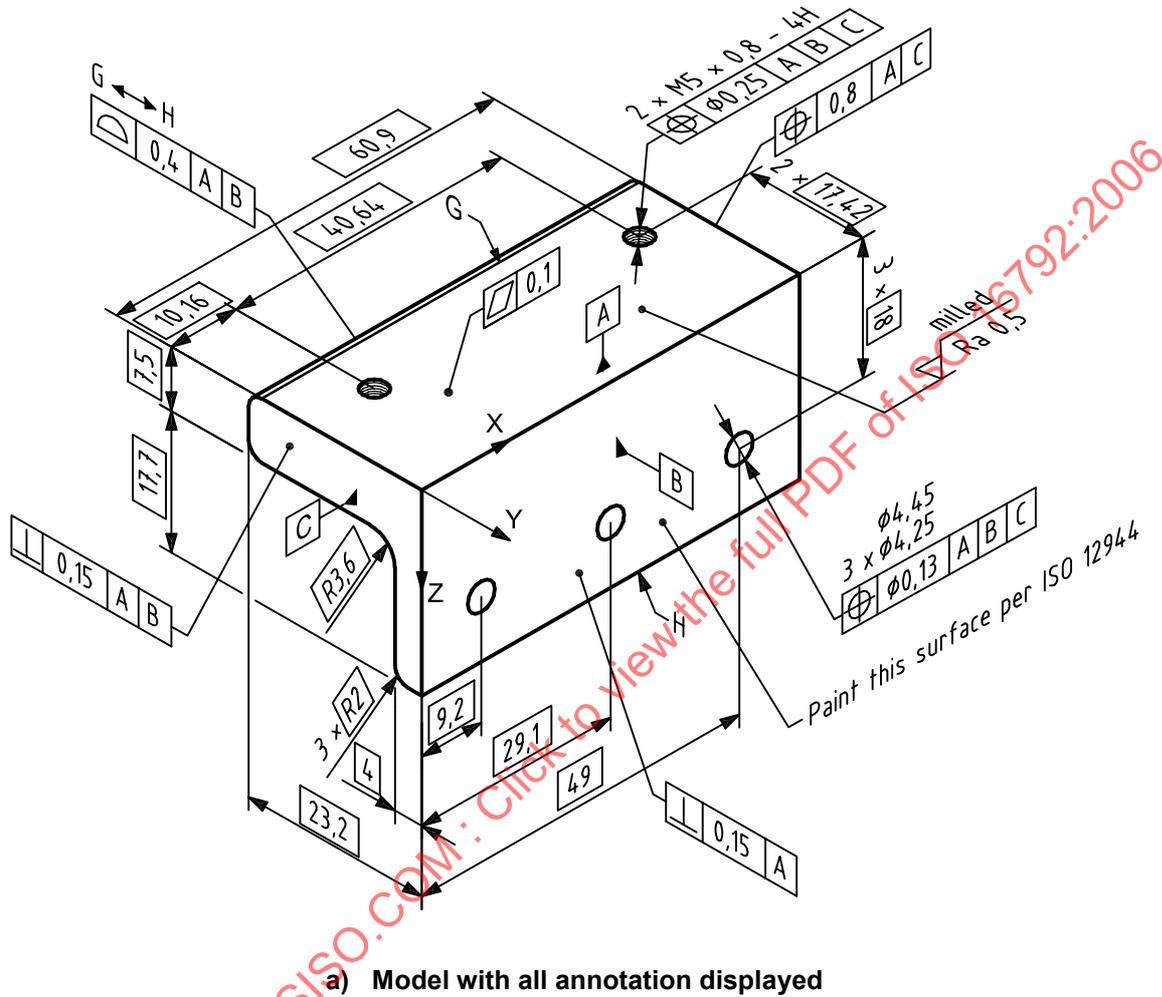
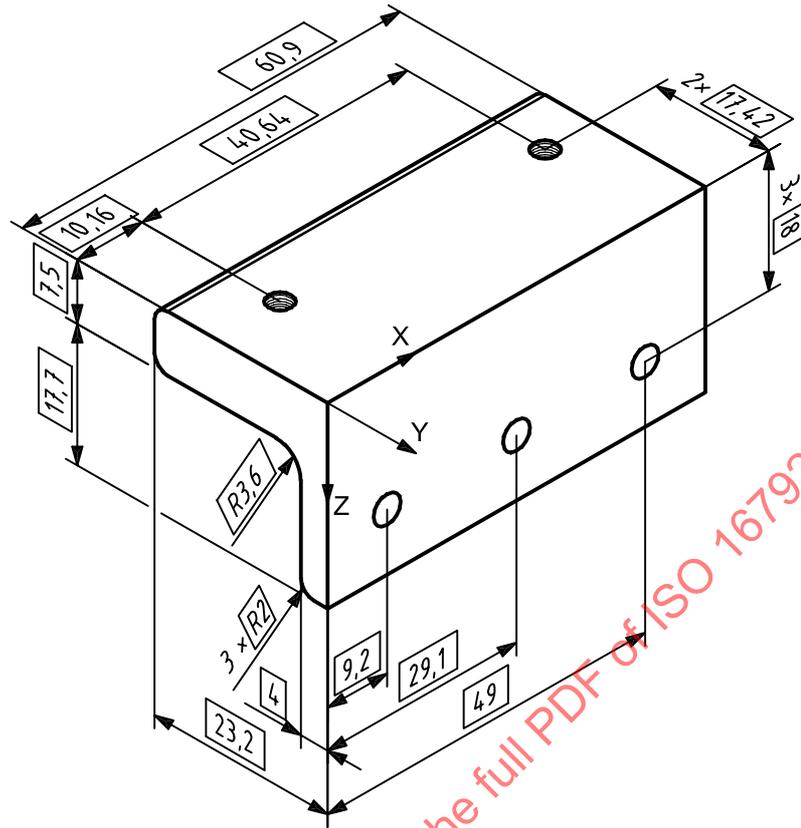
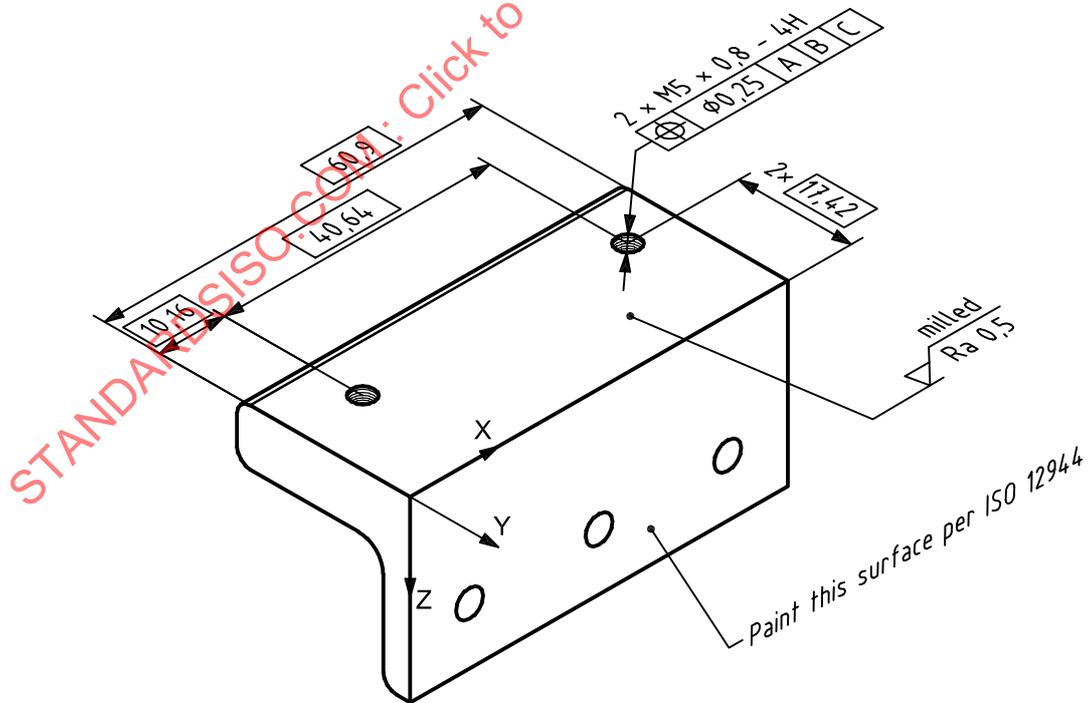


Figure 7 — Display management



b) Model with one type of annotation displayed



c) Model with selected annotation displayed

Figure 7 (continued)

7.2.2 Screen dump

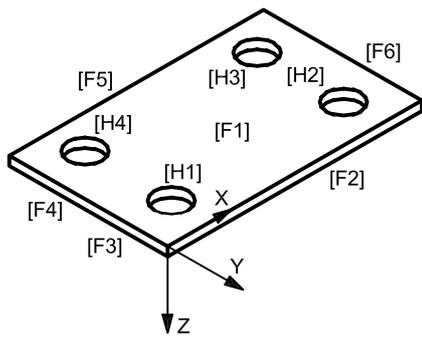
A hard copy of any given visual display shall be available on demand. When a hard copy is intended to be used as an engineering drawing it shall meet applicable drawing standards.

7.3 Model requirements

7.3.1 General

The following subclauses give requirements for annotation applied to a design model. These are general requirements, which apply to all types of annotation. Specific requirements for particular types of annotation are addressed in Clauses 8 to 11, see Figure 8 for a diagram showing the relationship between annotation and model geometry.

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Model Geometry:

Annotation:

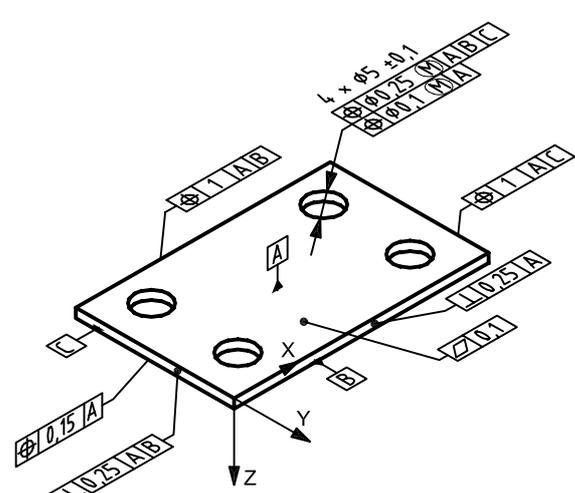
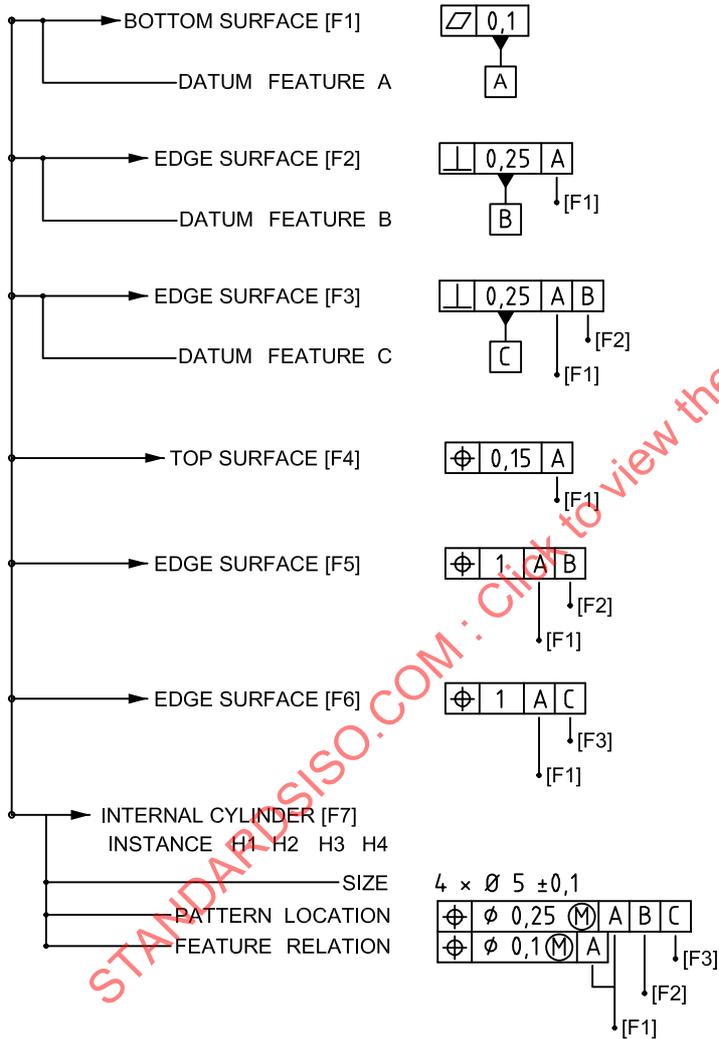


Figure 8 — Annotation and model geometry relationship

7.3.2 Associativity

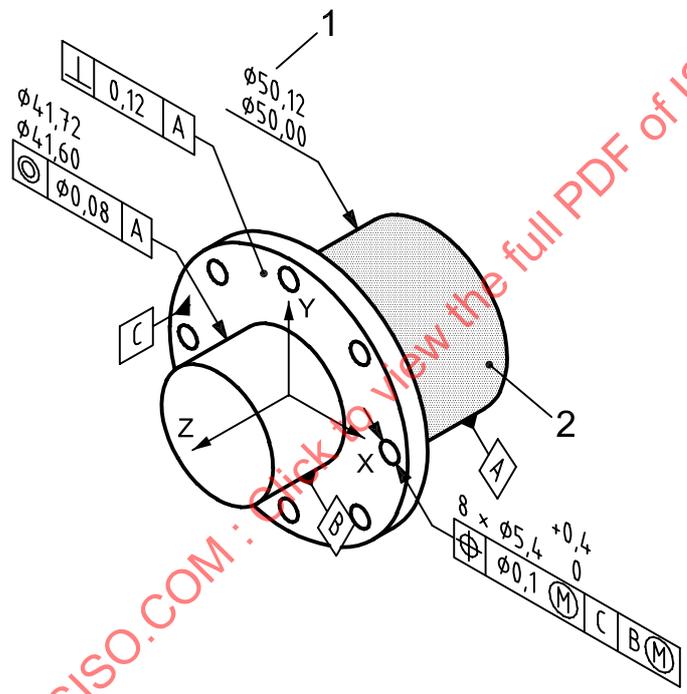
The following are general provisions for defining an associative relationship between digital elements.

- Annotation may be associated to a model feature, a group of model features, or a portion of an applicable model feature. For an example of the associated entities for a dimension, see Figure 9.
- Annotation, model geometry, and supplemental geometry may be placed into associated groups to indicate their relationships.

EXAMPLE 1 Supplemental geometry used to define location, orientation, or further clarify the application of annotation to a model.

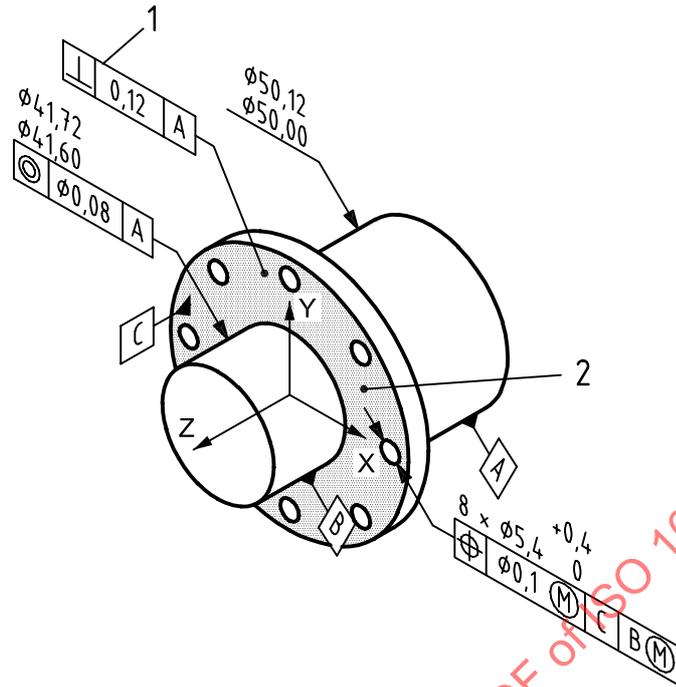
EXAMPLE 2 A model coordinate system for datum systems.

EXAMPLE 3 Other annotation. This could include qualifying notes and size limit indications.

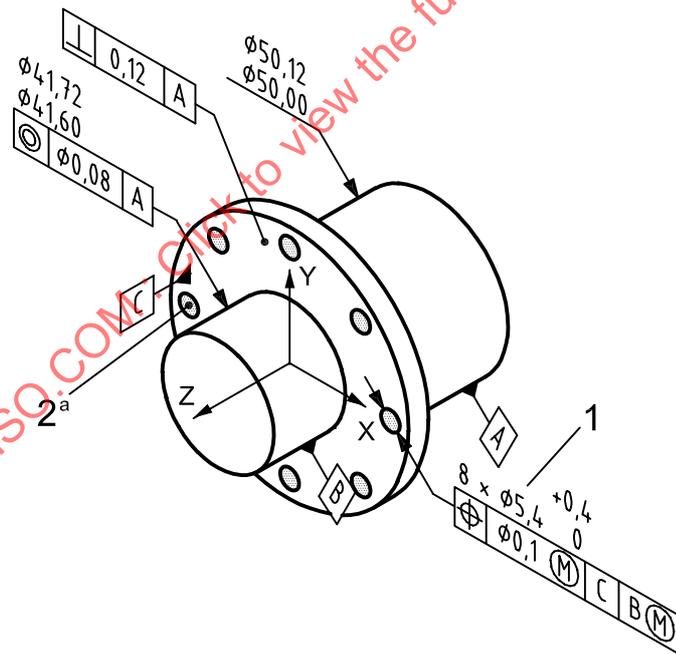


a) Size tolerance query

Figure 9 — Tolerance query associativity



b) Geometric tolerance query



c) Pattern of features query

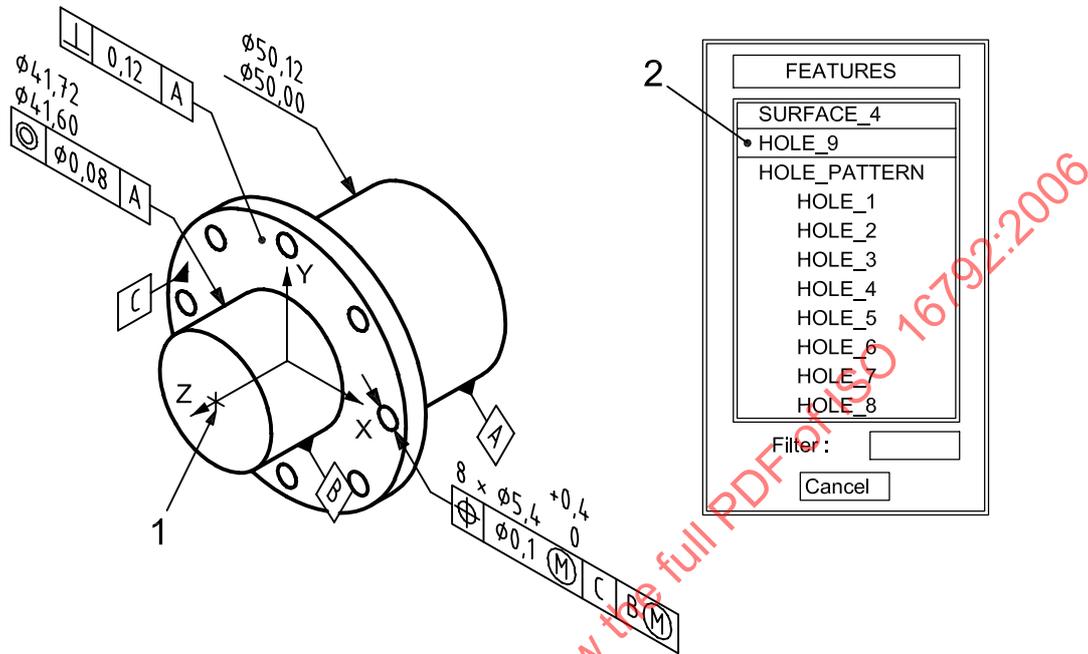
Key

- 1 query
- 2 visual response
- a All eight associative features.

Figure 9 (continued)

7.3.3 Attributes

Attributes are used to capture additional information that is not shown using geometry or in the model annotation. Attributes shall be available on demand. Attributes may be presented using text description, forms or other techniques, see Figure 10 for an example of how the attributes of a hole could be represented. Applications of attributes include, but are not limited to, coatings, knurling, threaded holes, and pins.



a) Simplified feature query

FEATURE DEFINITION	
Existing feature.	
ID :	HOLE_9
Comment :	mach_center
Type :	Single
Class :	Right Conical
Diameter	3±0,1
No sub-feature.	
Feature Geometry	
HOLE_9 *PT340	

b) Feature attributes

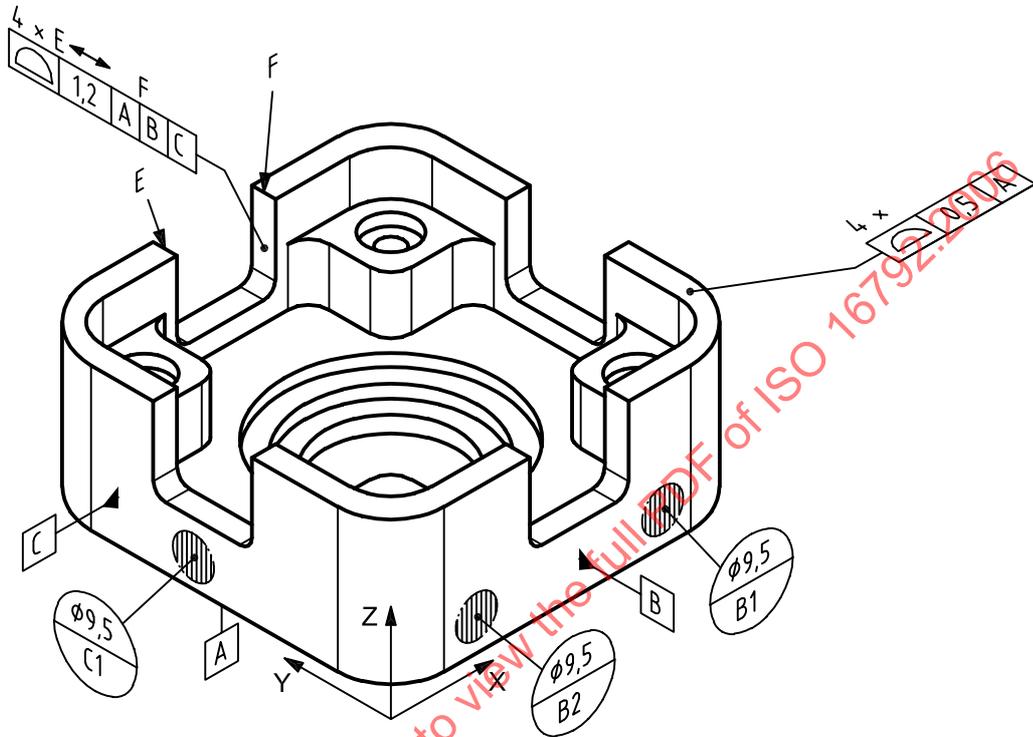
Key

- 1 query
- 2 response

Figure 10 — Simplified feature representation and attributes

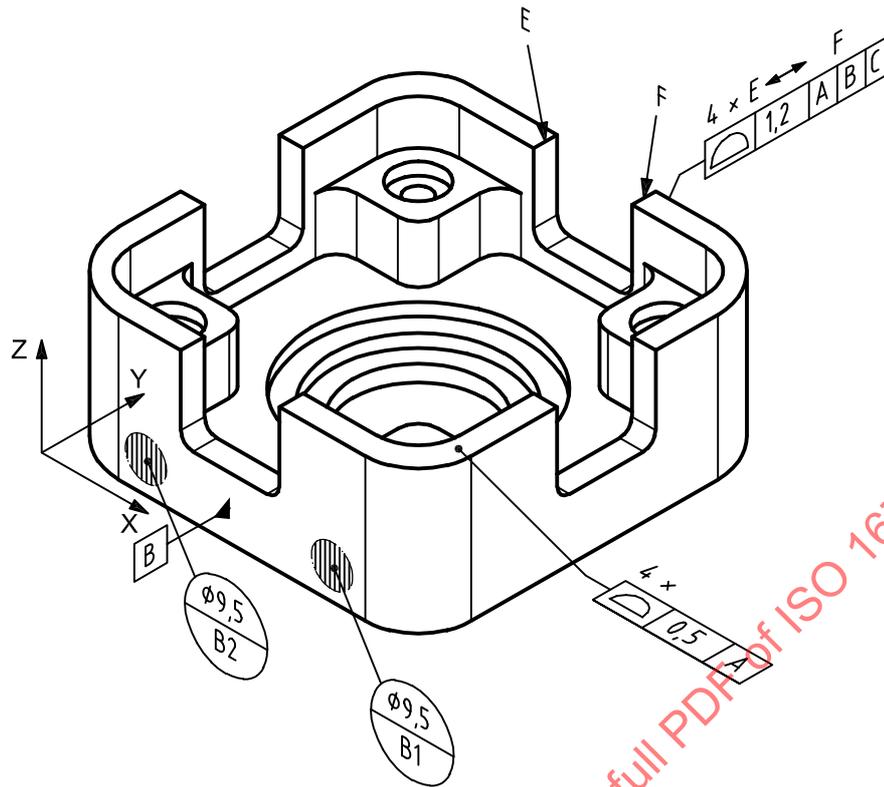
7.3.4 Annotation planes

The orientation of the annotation plane shall be maintained relative to the model geometry as the model is manipulated in 3-D. For example, as the geometry is rotated the text rotates correspondingly, see Figure 11. When a CAD system does not support maintenance of annotation plane orientation relative to the model, annotation planes shall not be used.



a) Initial attitude of model geometry and annotation

Figure 11 — Annotation planes relative to model geometry



b) Related 90° about the Z axis

Figure 11 (continued)

7.3.5 Leader lines

Leader lines directed to represented line elements shall terminate with an arrowhead, see Figure 55. When an indicated element is a surface, the leader line shall terminate with a dot within the bounds of the surface. Leader lines may terminate on the rim or edge of a feature of size when doing so provides a clearer understanding of the intention of the annotation. A continuous leader line shall be used to indicate all datum targets in a design model, see 5.1.1 b). Leader lines shall be directed to an associated entity.

7.3.6 Direction dependent tolerances

When a direction dependent tolerance (e.g. straightness) is applied to a design model, the direction shall be explicitly defined as follows.

- Supplemental geometry is added to the model to show the direction of application. The model geometry to which the tolerance applies shall be the associated geometry for the annotation, see Figures 41, 46 and 55, and 5.2.3 a).
- Direction dependent tolerances may use a model coordinate system vector to define the direction of application. The model coordinate system vector, associated entity and tolerance shall be organized as an associated group, see Figures 42, 47 and 56.
- As indicated in ISO 1101.
- When the lay for a surface texture indication is direction dependent, the direction of the lay may be indicated using either supplemental geometry or association to a model coordinate system vector. See Figure 55.

7.3.7 Indicating limited application of a tolerance

Limited length, area and location indicators may consist of, but are not limited to, supplemental geometry and associative annotation. When supplemental geometry is used, it shall be located on the model geometry, see Figures 29.

7.3.8 Query types

The model shall contain information sufficient to satisfy the following query types.

a) Model values

b) Relationship between model geometry and annotation in either direction, including the following.

- Graphic display of associated entities: the associated entities for a piece of annotation shall be highlighted, or otherwise distinguished from other entities on the display, on demand, see Figures 9 and 36.
- Graphic display of associated annotation: all annotations associated with selected geometry or model features shall be highlighted, or otherwise distinguished from other entities, on demand, see Figures 12 b) and 40 c).

c) Digital element identifiers, see Figure 13.

d) Model geometry and model features

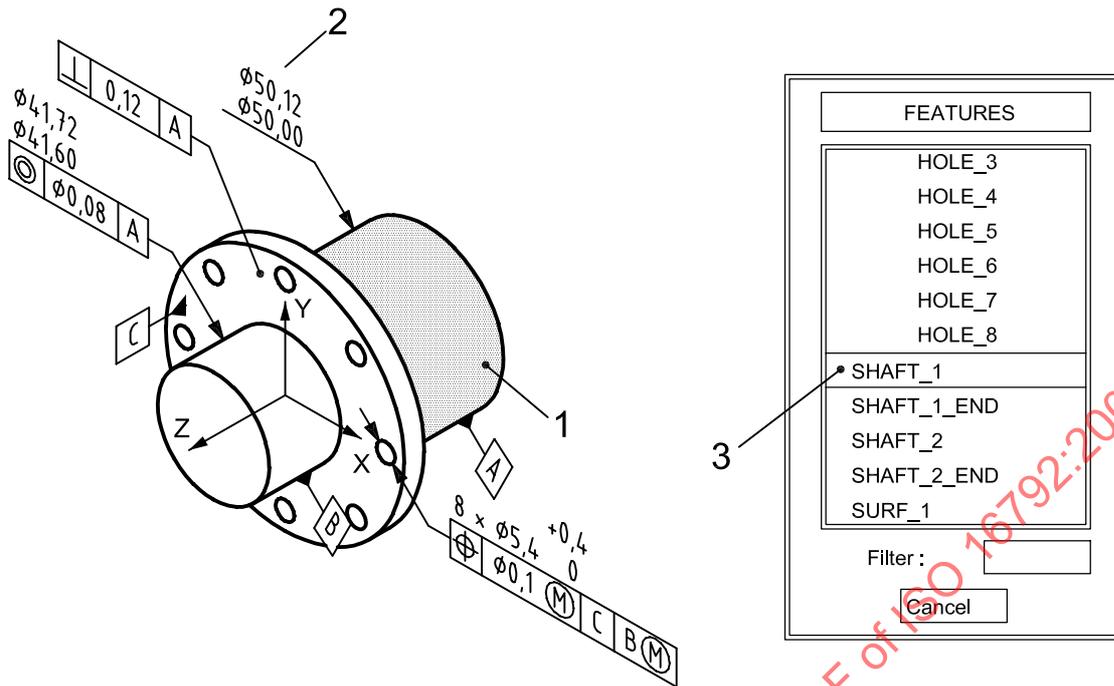
- Model features shall be identifiable by selecting a geometric element of the model feature.
- All geometric elements in an associated group of model features shall be identifiable by selecting any geometric element within the group.
- All model features in a group of model features shall be identifiable by selecting one of the model features.

e) Tolerance indicators, datum indicators and datum target indicators

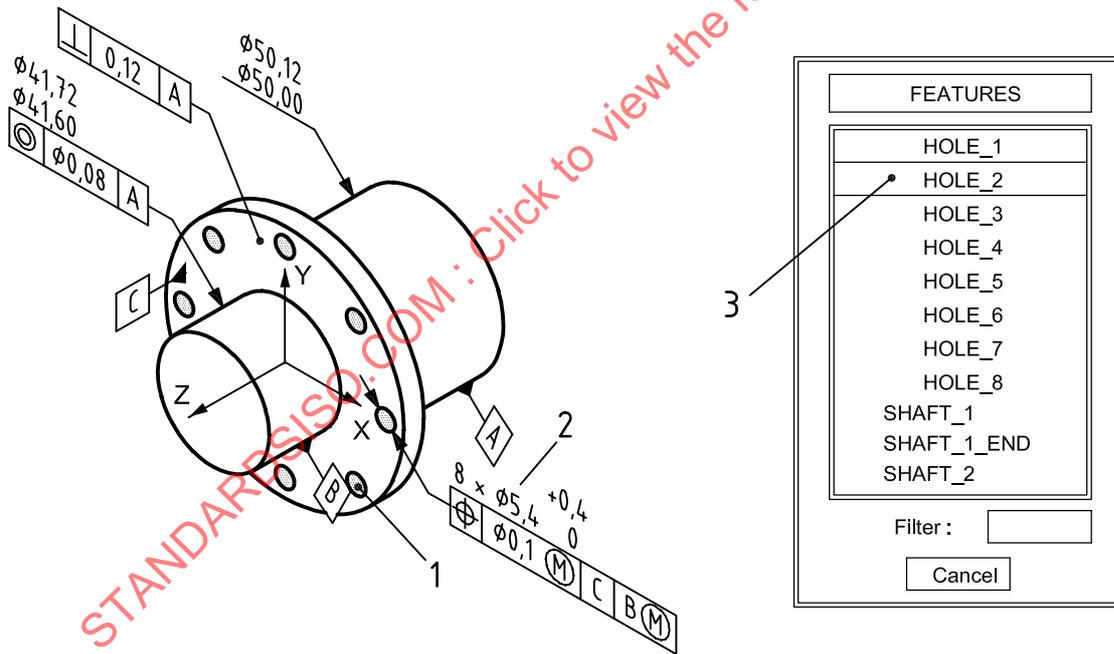
- Upon selection of a tolerance indicator, the datum indicators and datum target indicators that correspond to the datum references shall be highlighted or otherwise distinguished from other entities on the display, see Figure 14.
- Upon selection of a datum target indicator, all datum target indicators sharing the same letter shall be highlighted or otherwise distinguished from other entities on the display, see Figure 15.
- Upon selection of a datum indicator, the datum target indicators which have the same datum letter shall be highlighted or otherwise distinguished from other entities on the display, see Figure 16.

f) Supplemental geometry used in the definition of annotations, appropriately highlighted or otherwise distinguished from other entities on the display.

g) Identification of all elements of an associated group, appropriately highlighted or otherwise distinguished from other entities on the display, through the selection of any one element.

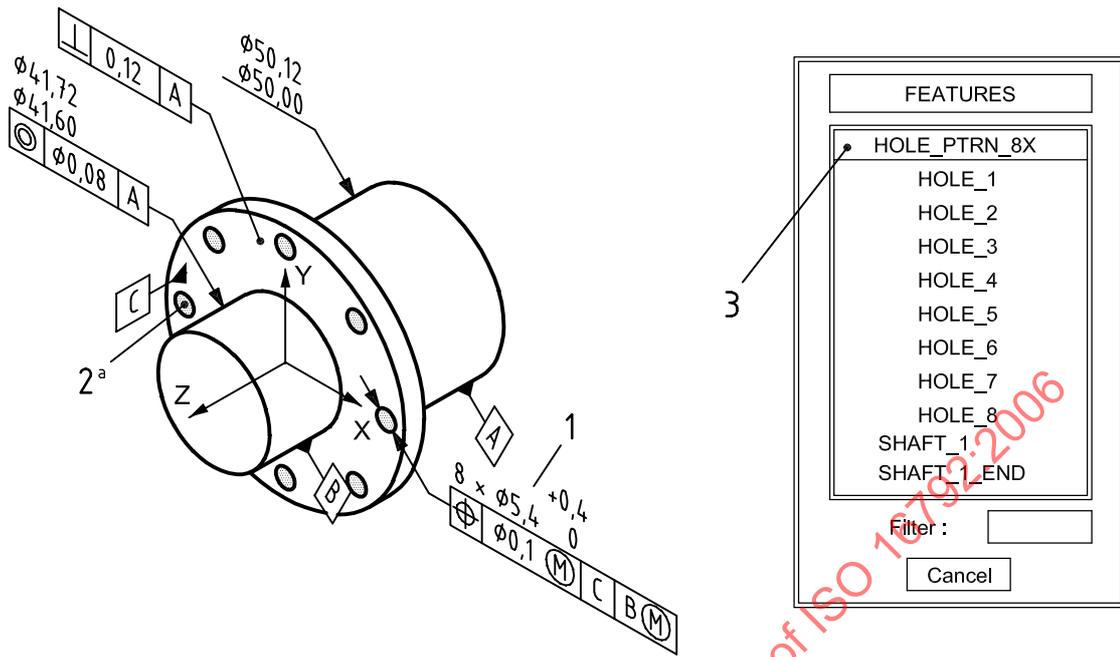


a) Individual feature



b) One feature of a pattern

Figure 12 — Graphic display of associated annotation



c) Pattern of features

Key

- 1 query
- 2 visual response
- 3 attribute response
- a All eight associative features.

Figure 12 (continued)

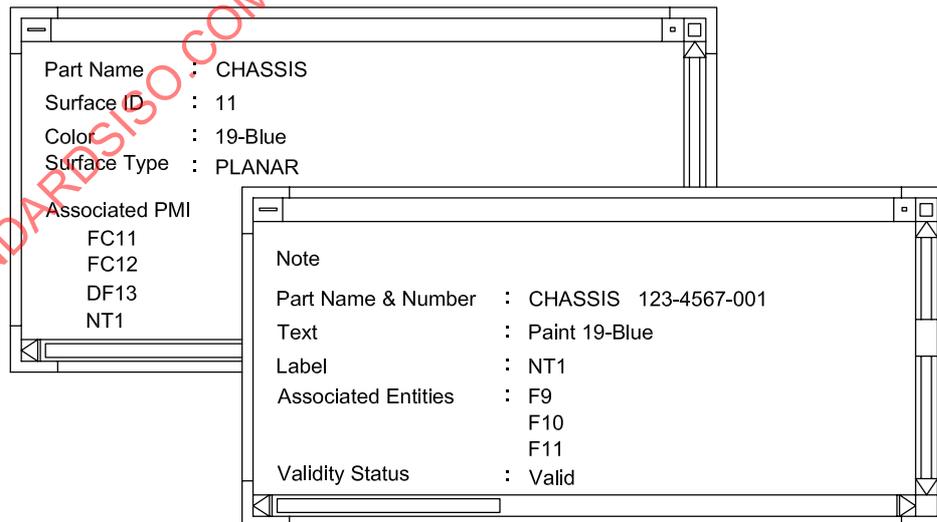
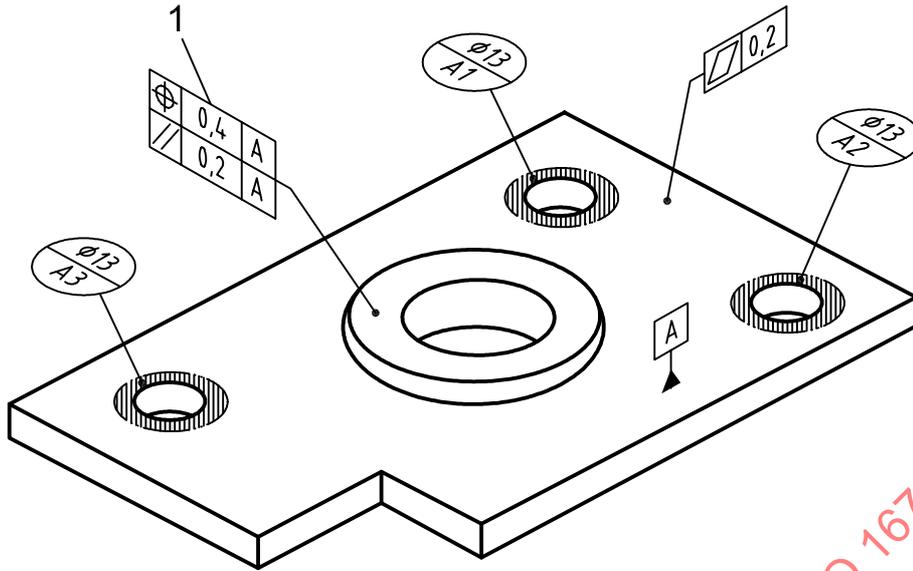


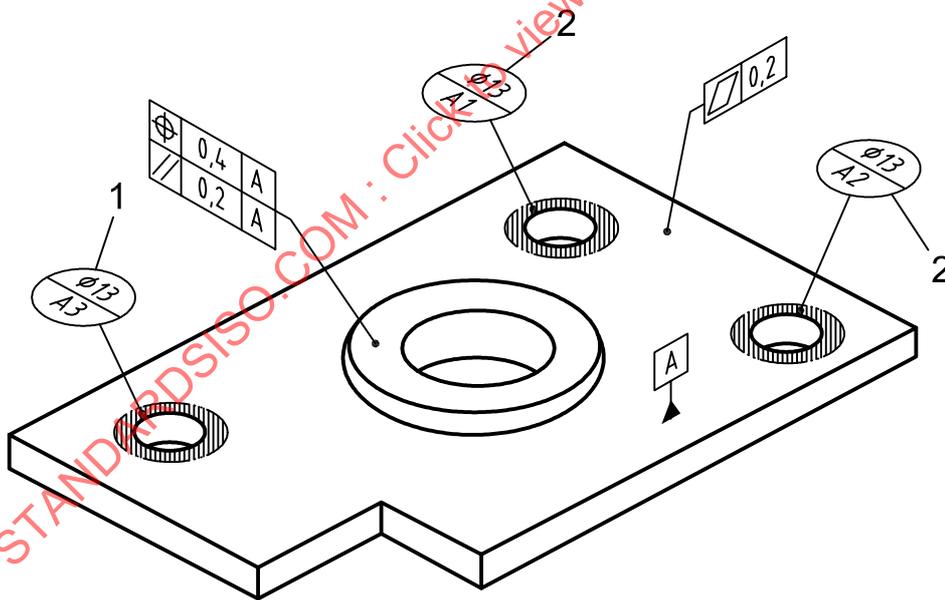
Figure 13 — Listing of digital elements identifiers



Key
1 query

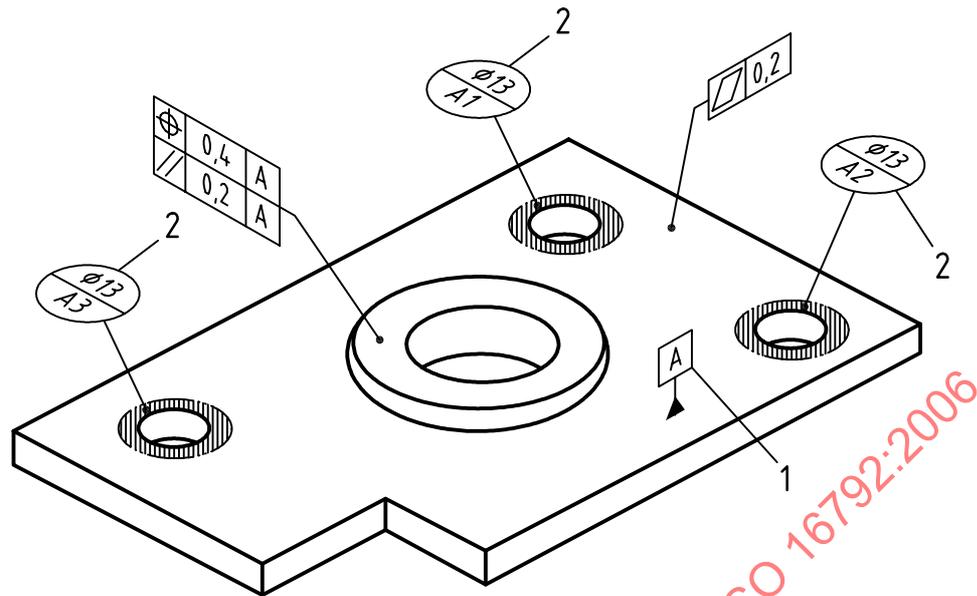
NOTE Visual response: all datum feature symbols and datum target symbols respond.

Figure 14 — Queries of datum indicators and datum target indicators



Key
1 query
2 visual response

Figure 15 — Queries for datum targets

**Key**

- 1 query
- 2 visual response

Figure 16 — Queries for supplemental geometry

7.4 Drawing requirements

7.4.1 General

See ISO 128-30, ISO 128-34, ISO 128-40, ISO 128-44 for sections and views. The following subclauses describe exceptions or additions for views on drawings. The following subclauses also describe general requirements for axonometric views on fully or partially defined drawings. Specific requirements for particular types of annotation are addressed in Clauses 8 to 11. The relationship between a model and a drawing are illustrated in Figures 17 and 18.

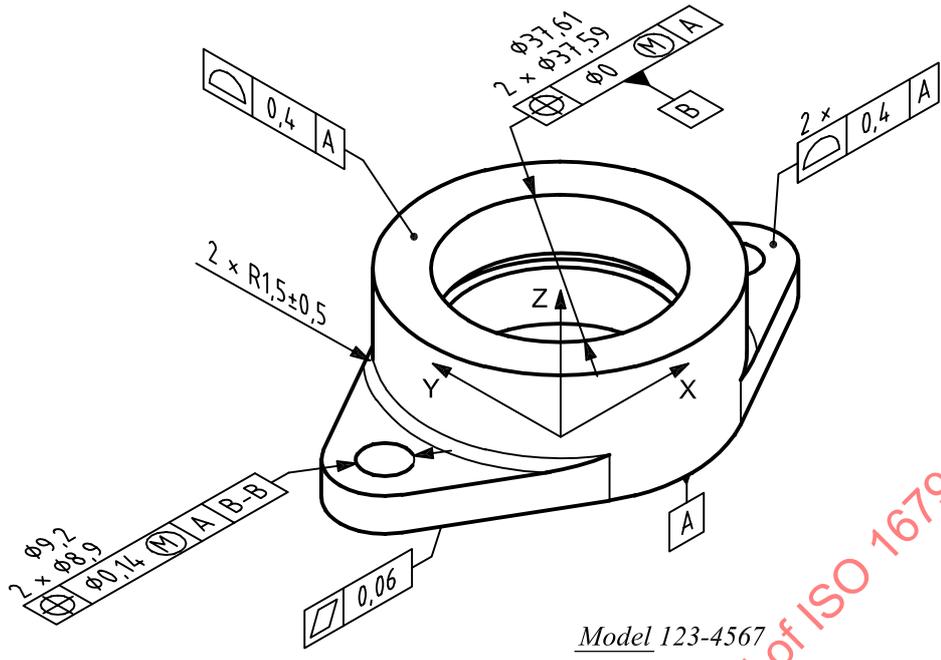
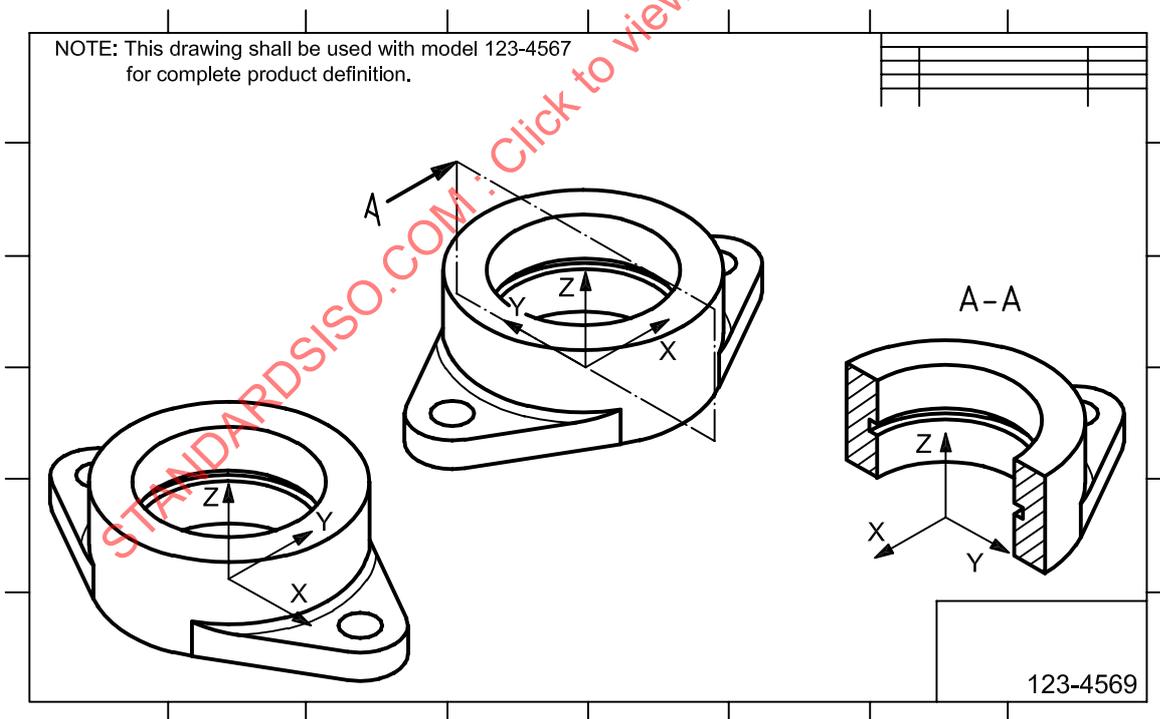


Figure 17 — Annotated model

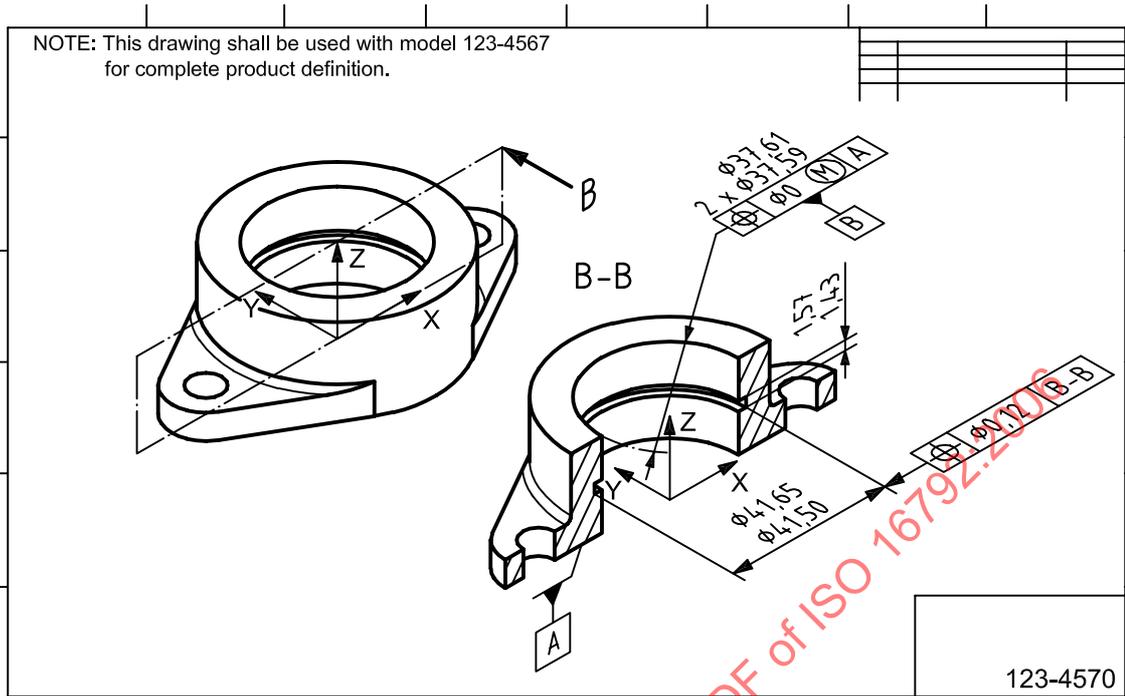
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- A representation of a cutting plane shall be used to indicate the location and viewing direction of a section. The edges of the cutting plane shall be continuous or long dashed double-short dashed lines. A visible viewing arrow or arrows shall be included to show the direction in which the section is viewed, see Figure 19. The cutting plane and the cuts and sections shall be indicated according to ISO 128-40 and ISO 128-44.
- The result of the section cut may be shown either by removing material from the part, see Figures 19 a) and 19 b), or by display of the curves overlaid on the view that result from intersecting the cutting plane with the part, see Figure 19 c).
- Sections taken from axonometric views may be presented in the same orientation as the parent view or rotated to present the section in the viewing plane of the drawing.
- The use of a stepped or offset cutting line is supported in axonometric views. The resulting section cut geometry may be shown in its true position on the design model or drawn as if the offsets were in one plane.
- The use of a cutting plane line containing angular changes is supported in axonometric views. The resulting section may show all features in their true position on the design model or be drawn as if the bent cutting plane and features were rotated into a plane perpendicular to the line of sight of the sectional view.
- Features may be shown in their actual position, without foreshortening or alignment, when the section is made from an axonometric view.
- Features may be shown in their actual location when shown in a section view cut from an axonometric view.

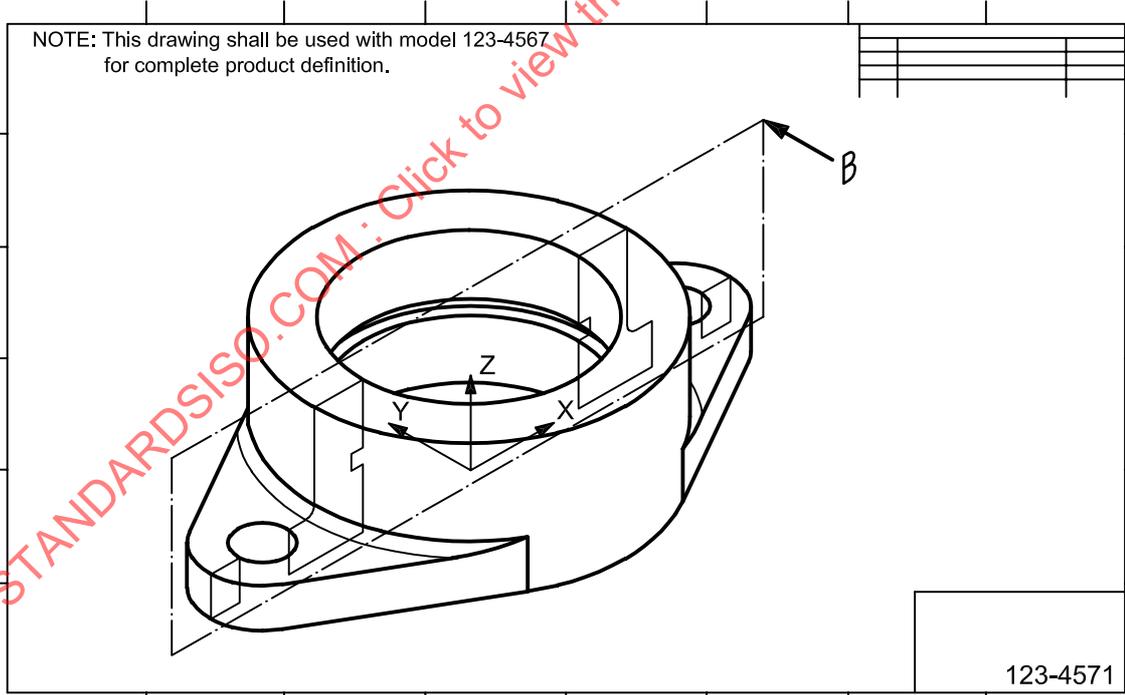


a) Drawing with axonometric view

Figure 19 — Axonometric views



b) Axonometric section view



c) Section curves shown in an axonometric view

Figure 19 (continued)

8 Notes and special notations

8.1 Common requirements

There are no common requirements for notes and special notations.

8.2 Model requirements

A flagnote shall have a unique identifier and be identified with a flagnote symbol as shown in Figure 55 a) and b).

The flagnote symbol shall be shown at each point of application.

The flagnote symbol is placed around the identifier in the notes area to indicate that it applies at specific areas on the model or drawing.

When general notes, flagnotes and special notations are placed in a model, they shall be placed on a single annotation plane that does not rotate with the model. This annotation plane shall be available for display with the annotated model.

General notes do not require associativity. General notes may include general tolerance(s) for the entire model. Local notes shall be associative to the applicable digital elements in the model. When a flagnote is placed in a model, the following shall apply.

- The flagnote symbol, note number, and text shall be placed on the notes area annotation plane.
- The flagnote symbol, note number and text shall be associative to the digital elements to which it applies.
- The flagnote symbol and note number shall be shown adjacent to the applicable digital elements in the model.
- The flagnote symbol and note number shown adjacent to the digital elements in the model shall rotate with the model.

When special notations are placed in a model, the following shall apply.

- When the special notations are applicable to the entire model, the notation shall be placed on the notes area annotation plane.
- When the special notations are applicable only to a portion of a model, the special notations symbol and its associated text shall be placed on the notes area annotation plane in accordance with 8.2. The special notations symbol shall be shown adjacent to the applicable digital elements in the model. The special notation symbol shall be associative to the digital elements to which it applies.

8.3 Drawing requirements

In axonometric views, leader lines shall be used to associate each local note to its related model feature.

9 Model values and dimensions

9.1 General

This clause establishes the requirements for model value query, and resolved theoretically exact, and radial dimensions, linear and angular distance, size, and limits of dimensions in a data set. It also contains the common requirements for associativity and dimensions on a model or drawing.

9.2 Common requirements

9.2.1 Model value queries

The following model value queries shall always be conducted in relation to the absolute or a user-defined model coordinate system of the design model:

- determination of location and orientation of surfaces;
- determination of distance or angle between two surfaces;
- determination of position (location and orientation) of features of size (as per ISO 14660-1);
- determination of feature relation (hole-to-hole spacing and orientation) dimensions within a pattern of features of size.

Direct query of the model surface or model feature of size is usually conducted for

- determining the shape (curvature) of surfaces, and
- determining the size value for a feature of size or a pattern of features of size.

9.2.2 Resolved dimensions

Dimensions displayed on a model are resolved dimensions. For examples of resolving model values to displayed dimensions, see Table 1. The requirements for resolved dimensions follow.

- a) To obtain a resolved dimension, a model value shall be rounded to the number of decimal places required for the design.
- b) All resolved dimensions shall be absolute values in accordance with ISO 129-1 and ISO 1101.
- c) Rounding shall be in accordance with ISO 31-0.
- d) Resolved dimension preservation and association: a direct and permanent association to the originating model value shall be established and maintained for every resolved dimension.
- e) Utilisation of model or resolved dimensions: the use of model values or resolved dimensions for analyses and other processes shall be defined in appropriate documentation.

9.2.3 Plus and minus tolerances

One or more general notes defining plus and minus tolerances may be specified, such as a general tolerance.

Table 1 — Resolved dimension examples

(Applicable International Standard)	ISO 16792		
	Model value ^a	Resolved dimension ^a	Application example
Linear theoretically exact dimension line (linear TED)^b (ISO 1101)	88,4100000 ...	88,4	
Angular theoretically exact dimension (angular TED) (ISO 1101)	28,5918273 ...	28,6	
Size^c (ISO 406, ISO 8015)	7,0000000 ...	7,0	
Size (ISO 286)	45,700000	45,7	45,7h7
Linear distance	19,6666666 ...	19,67	
Radial distance (ISO/TR 14638)	3,1500000 ...	3,2	
Angular dimension	28,5918273 ...	28,6	
Unilateral limit^b	12,0000000 ...	12	12 min.
Auxiliary dimension^b (ISO 129-1)	21,6018043 ...	21,6	

^a The values shown are examples. Actual values will reflect the defined precision of the model and the rounding requirements of each particular application.

^b Linear, radial, angular, diametrical or spherical diameter.

^c Linear, diametrical or spherical diameter.

9.3 Model requirements

9.3.1 General

Requirements for attaching and displaying theoretically exact dimensions, size values and plus and minus tolerances on a model are defined in the following subclauses.

9.3.2 Theoretically exact and nominal dimensions

Queried model values for features fully constrained by geometrical tolerances shall be interpreted as theoretically exact dimensions, per ISO 1101. In all other circumstances, queried model values not defined by a specific tolerance, or identified as an auxiliary [see 5.1.1 a)], shall be interpreted as a nominal dimension, i.e. covered by a general tolerance.

NOTE ISO 2768-1 does not apply to nominal dimensions obtained by querying values from a model.

- a) Querying of the model for the profile, location, and orientation of a feature shall occur within the appropriate model coordinate system, see 9.2 and 10.3.1.
- b) The display of theoretically exact dimensions may be necessary in defining some model relationships. This is applicable to an inclined datum feature, and features that can appear to be 90° but for which the actual model angle is other than this. Displayed theoretically exact dimensions shall be enclosed in a frame in accordance with ISO 1101.
- c) Theoretically exact dimensions should be placed in annotation planes that are parallel with one of the planes of the absolute or a user-defined model coordinate system. An exception is the 3 × 6,35 theoretically exact dimension shown in the example of Figure 20.
- d) Theoretically exact dimensions defining surface curvature or extent, such as fillets, rounds or chamfers, shall be directed to the model feature surface by a leader line, see Figure 20.
- e) Theoretically exact dimensions defining linear distance or angular relation are shown using dimension and extension lines, see Figure 20.

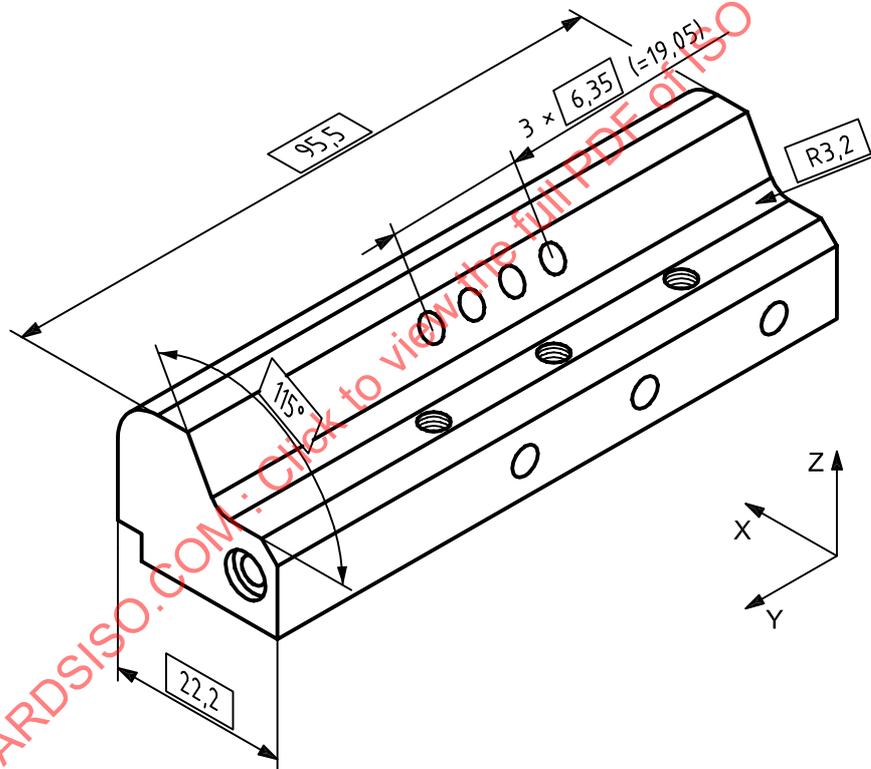


Figure 20 — Placement and attachment for theoretically exact dimensions

9.3.3 Size values

A size value shall not conflict with the queried model value for the same feature when the model value is rounded to the same number of decimal places. This agreement shall meet one of the following requirements, depending on the tolerance expression used.

For bilateral or unilateral tolerances, the displayed size value shall equal the resolved model value.

For size values, the placement and attachment methods for size values are as follows.

- Spherical surface: the size value, dimension, and extension lines shall be placed on an annotation plane containing the model feature centre-point.

- Cylindrical surface: the size value, dimension, and extension lines shall be placed on an annotation plane perpendicular to the model feature axis or containing the model feature axis.
- Set of two opposed parallel surfaces (a width): the size value, dimension, and extension lines shall be placed on an annotation plane perpendicular to, or containing, the model feature centre plane; the extension lines shall clearly indicate the surfaces comprising the width, see Figure 21 for examples.

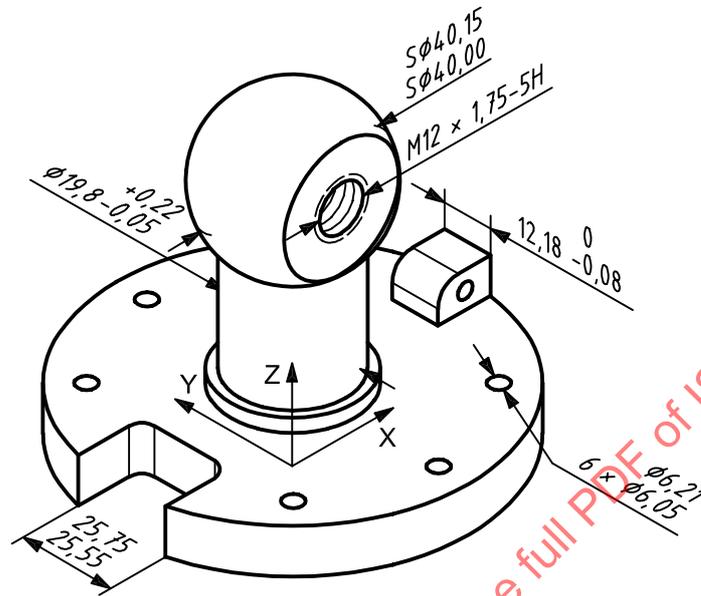


Figure 21 — Placement and attachment for linear dimensions

9.3.4 Coded size tolerances

Size tolerances may be specified using the ISO system of coded size tolerances as specified in ISO 286. When this type of tolerance specification is used, ISO 286 shall be cited in the general notes on the model.

9.3.5 General applications of plus and minus tolerances

Guidance with regard to the application of plus and minus tolerances to linear, angular and radial dimensions is given in Table 2.

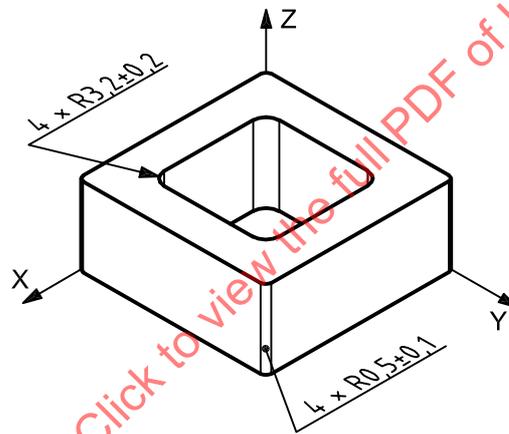
The attachment method believed to be most commonly used is shown.

9.3.6 Chamfers

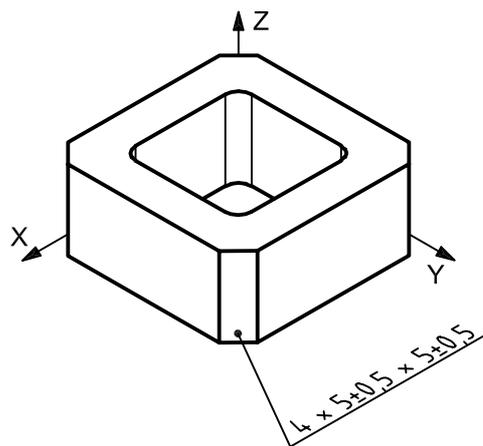
Attachment for 90° surface intersections with an equally disposed chamfer is indicated in Table 2. Oblique surface intersections, unequally disposed extents, or chamfers defined using a linear and angular dimension require the use of dimension and extension lines, see Figures 22 d) and 22 e). The value shall be located and oriented in a manner that is clear.

Table 2 — Examples of plus and minus tolerance applications

General application	Attachment technique			Figure
	Dimension indication	Directed leader line	Extension lines	
Fillets, round, chamfers		X		22
Reliefs, step surface			X	23
Countersinks	X			24a
Oblique surfaces			X	24b
Entry depth	X			25a
Spotface	X			25b
Remaining thickness			X	25c
Notches, flats and pin height			X	26

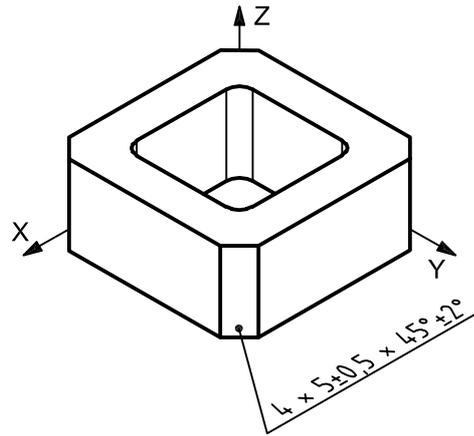


a) Fillets and rounds

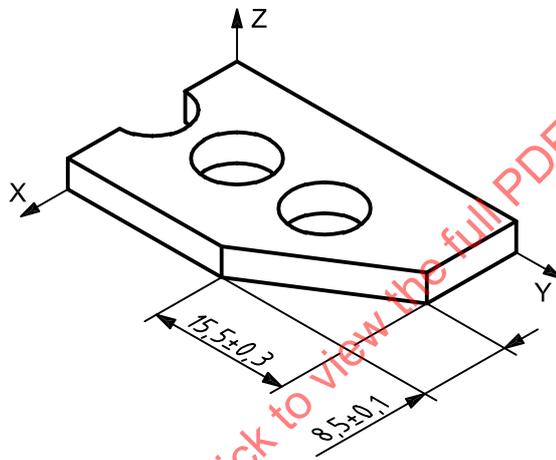


b) Chamfer — Equal offsets

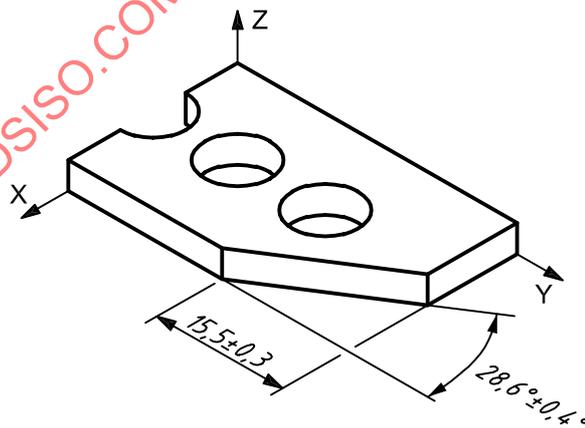
Figure 22 — Attachment techniques — Fillets, rounds and chamfers



c) Chamfer — Offset and 45° angle



d) Chamfer — Unequal offsets



e) Chamfer — Offset and angle

Figure 22 (continued)

9.3.7 Depth specification

When a feature depth is governed by a remaining thickness tolerance, the feature tolerance and the remaining thickness requirement should be an associated group, see 25 c).

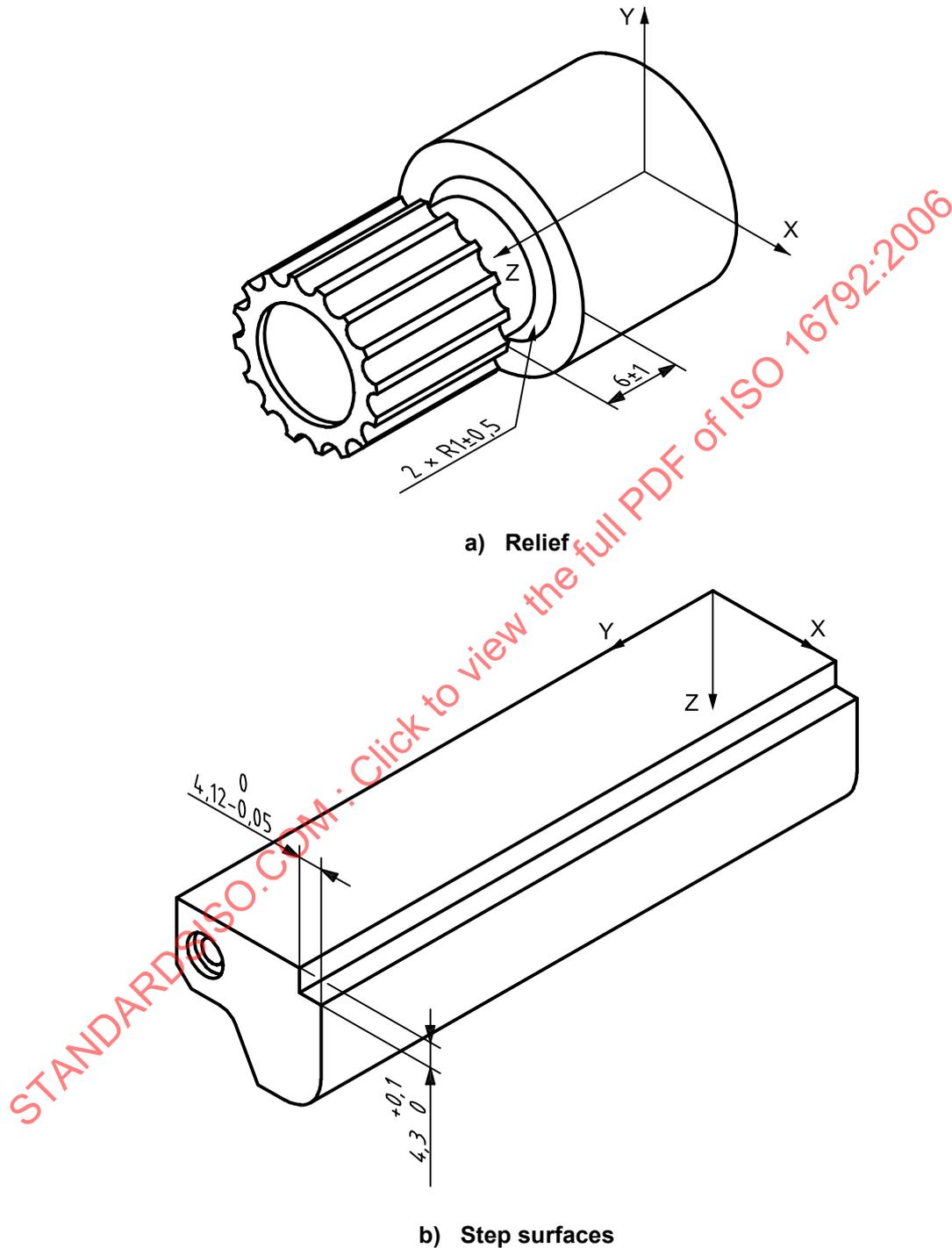
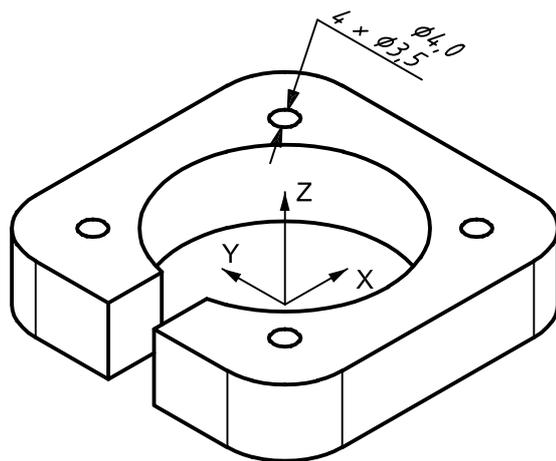
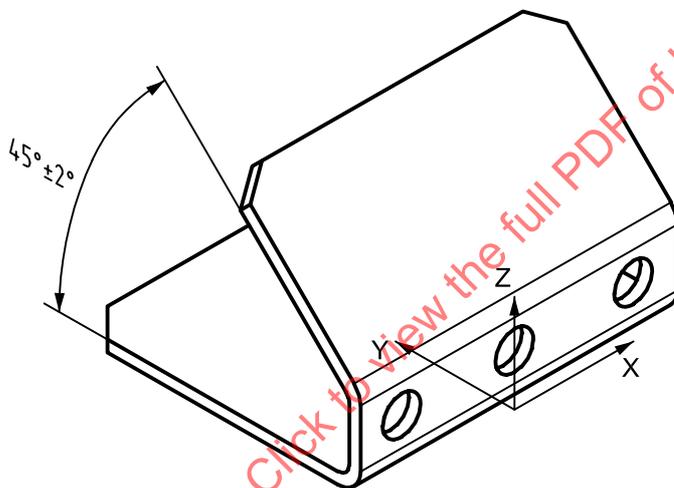


Figure 23 — Attachment techniques — Reliefs and step surfaces

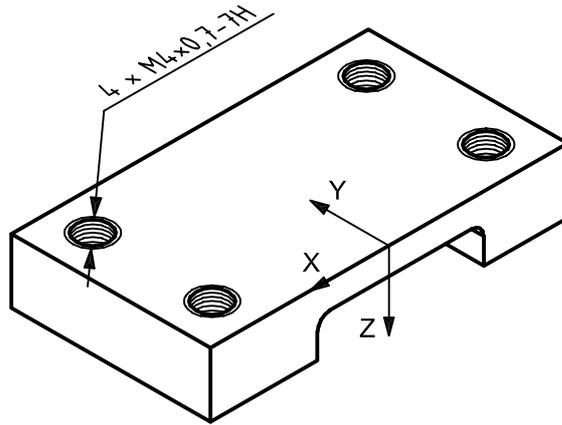


a) Countersinks

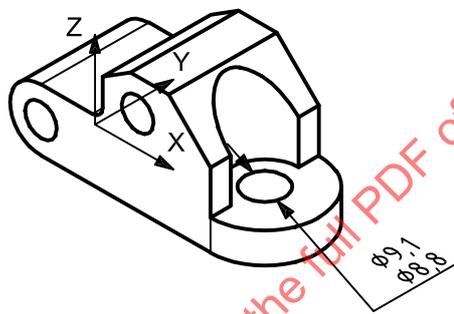


b) Oblique surfaces

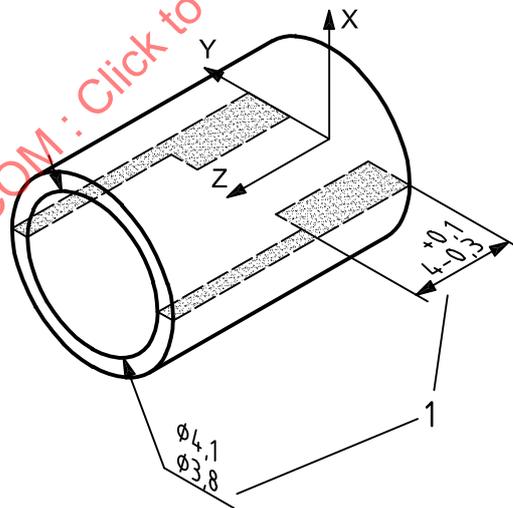
Figure 24 — Attachment techniques — Countersinks and oblique surfaces



a) Entry depth



b) Spotface

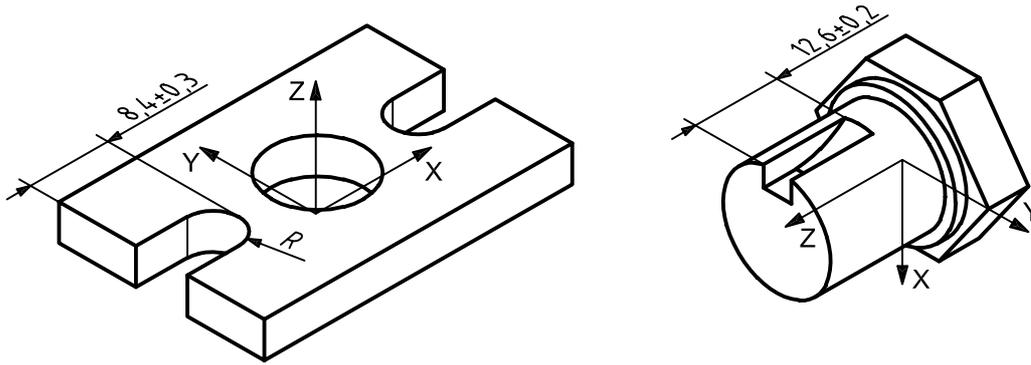


c) Remaining thickness

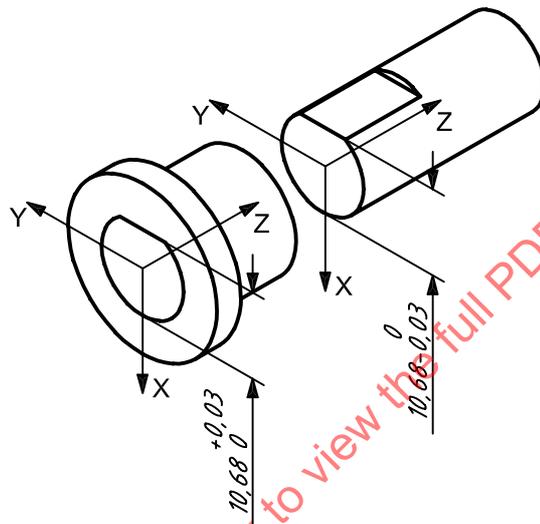
Key

- 1 an associative group

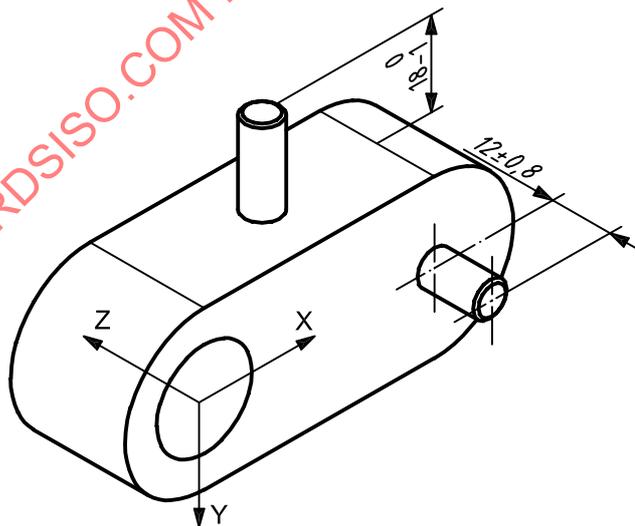
Figure 25 — Attachment techniques — Depth, spotface, remaining thickness



a) Notches



b) Flats on cylinders



c) Pin heights

Figure 26 — Attachment techniques — Notches, flats and pin heights

9.4 Drawing requirements

Theoretically exact dimensions not displayed on a drawing shall be obtained by querying the model. Requirements for dimensions on axonometric views of a drawing are as follows.

- Displayed dimensions in views are true dimensions. Dimensions shown in an axonometric view shall be actual values (not out-of-scale).
- Displayed theoretically exact dimensions shall be enclosed in a frame in accordance with ISO 1101.
- Leader lines shall be used to relate a dimension to a cylindrical model feature. The leader line shall be directed to the intersection of the cylindrical model feature and a surface. Leader lines shall terminate with an arrowhead.
- The existing drawing standards for plus and minus tolerances shall be used. These shall include those according to ISO 129-1, ISO 406 and ISO 8015.
- When limits and fits dimensions are used on drawings, ISO 286 shall be applied.

10 Datum applications

10.1 General

This clause establishes practices for organizing, attaching, and displaying datum indicators, datum target indicators and related information associative with models. Requirements and recommendations for correlating datum features to the coordinate axes of the model space are given.

10.2 Common requirements

There are no common exceptions or additions between models and drawings.

10.3 Model requirements

10.3.1 Datum systems and model coordinate systems

The following requirements apply to the relationship between the datum systems on the model and the model coordinate systems.

a) Datum system and coordinate system correspondence

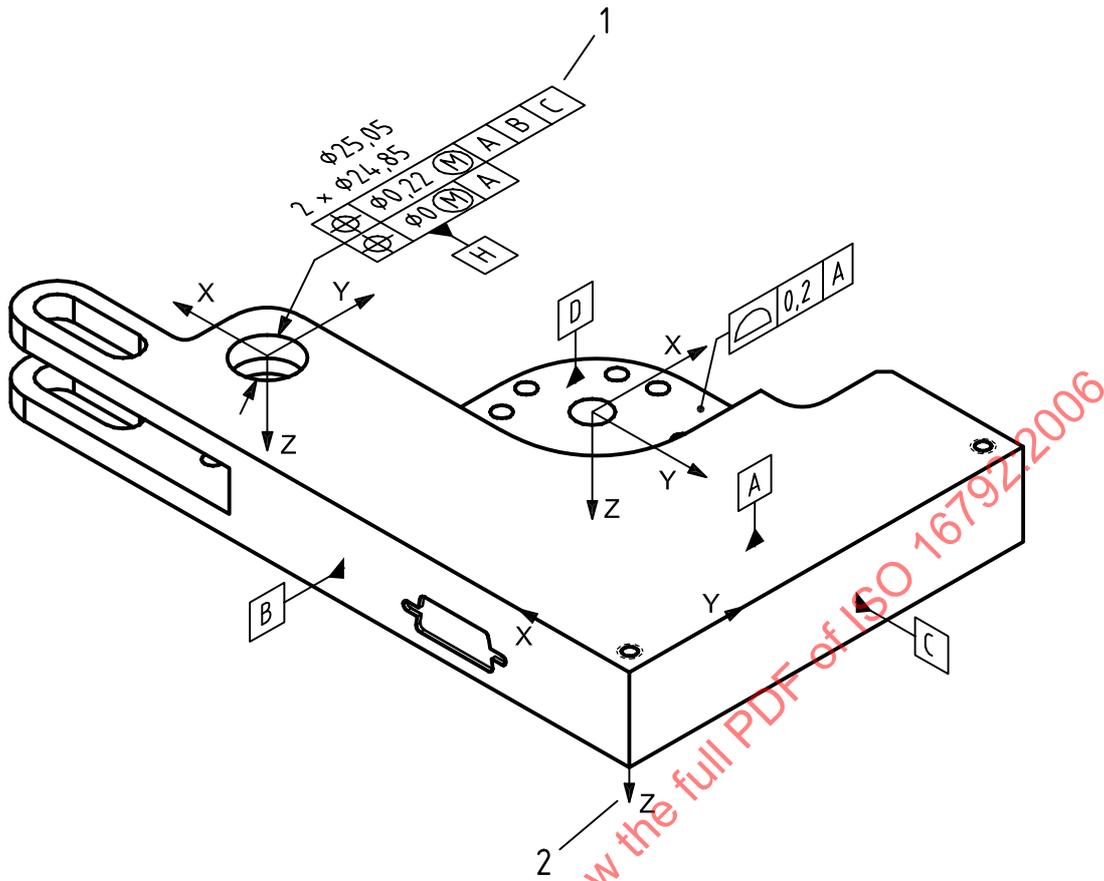
Each datum system shall be associated to a corresponding model coordinate system.

b) Datum system and coordinate system associativity

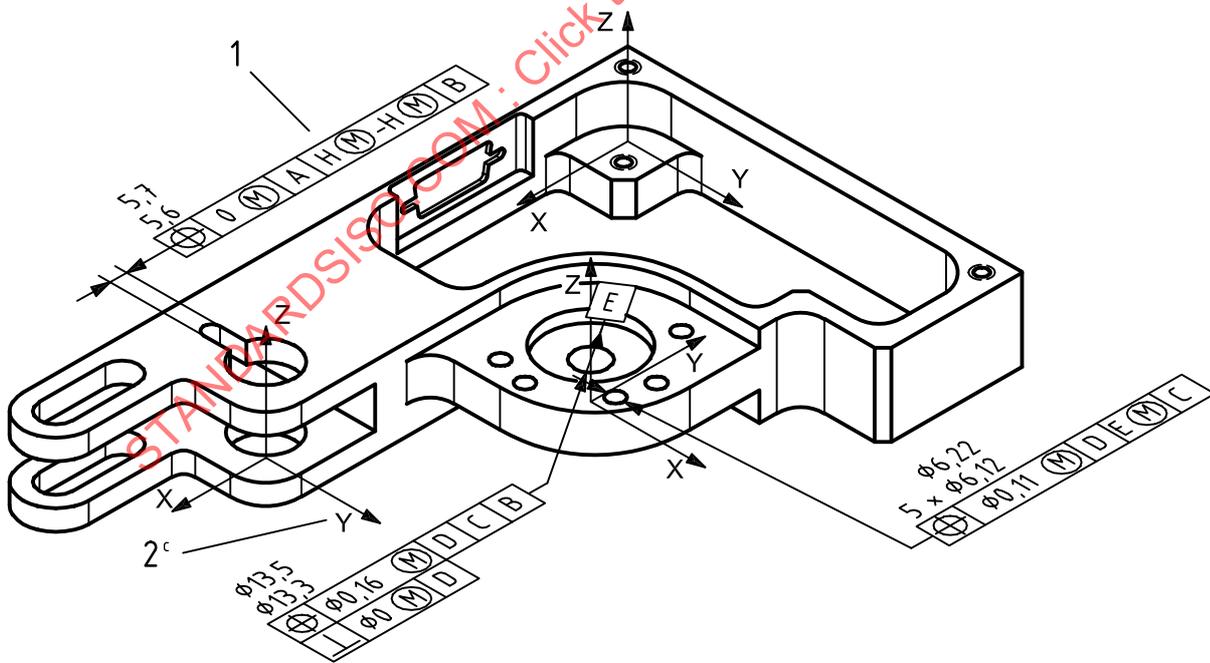
A definite visual relationship between any datum system and the corresponding coordinate system shall be preserved throughout navigation and query of the presented design data.

c) Multiple datum system and coordinate systems relationship

When more than one datum system is imposed upon a model, each datum system-to-coordinate system relationship shall be clearly presented and maintained, see Figures 27 a), 27 b), and 27 c) for an example of multiple datum systems and coordinate systems organized in a single design presentation.

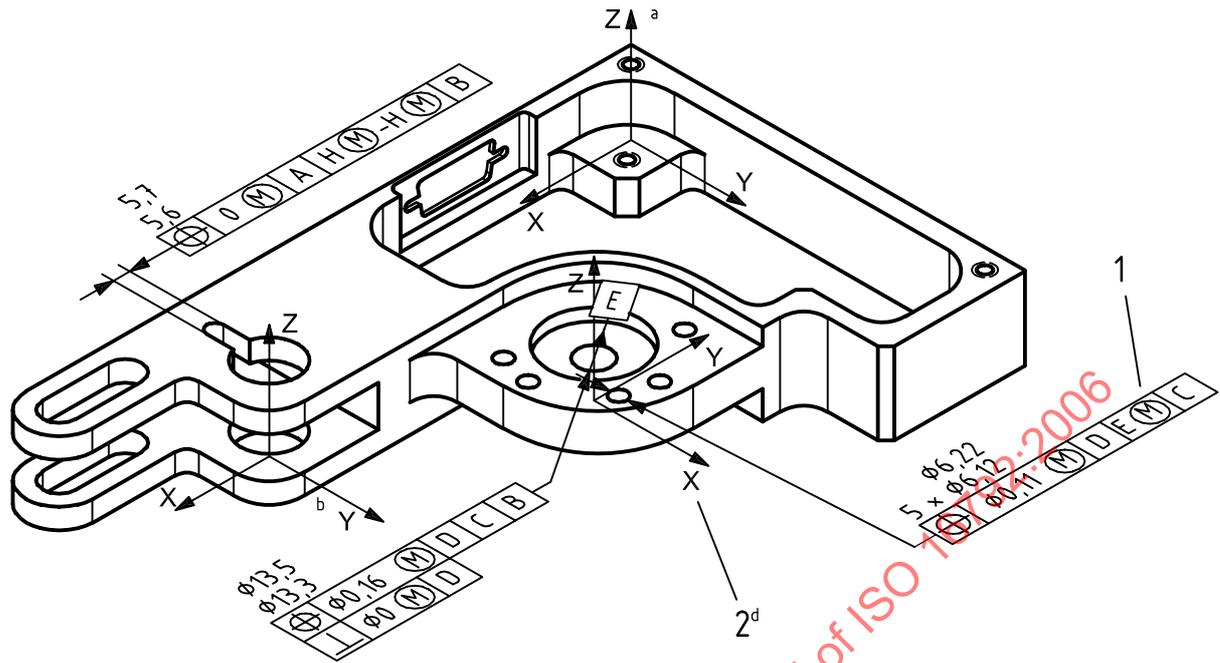


a) Absolute coordinates corresponding to a datum system



b) User-defined coordinates corresponding to a datum system

Figure 27 — Datum systems and coordinates relationship



c) Multiple user-defined coordinate systems

Key

- 1 datum reference query
 2 visual response
- a Absolutes.
 b User-defined.
- c User-defined coordinate system is the only result of this query.
 d User-defined coordinate systems are the only result of this query.

Figure 27 (continued)

10.3.2 Identification of datums

Figure 28 demonstrates symbol attachment methods for identifying datums on a model. The datum indicator should be attached to the surface representing the datum feature. Single extension lines of model feature outlines should not be used for attachment of datum indicators. Particular requirements and the preferred attachment methods for datum indicators are as follows.

a) Identification of planar integral feature

Place the datum indicator on an annotation plane perpendicular to the integral feature, see datum A in Figure 28 a).

b) Identification of spherical integral feature

- Identification of a surface as a datum: attach the datum indicator to a reference line and using a leader line terminated with a dot to the surface.
- Identification of a centre point as a datum: attach the datum indicator with two opposing arrowheads as shown in Figure 28 a). The datum indicator may also be attached to the tolerance indicator as shown in Figure 28 b).

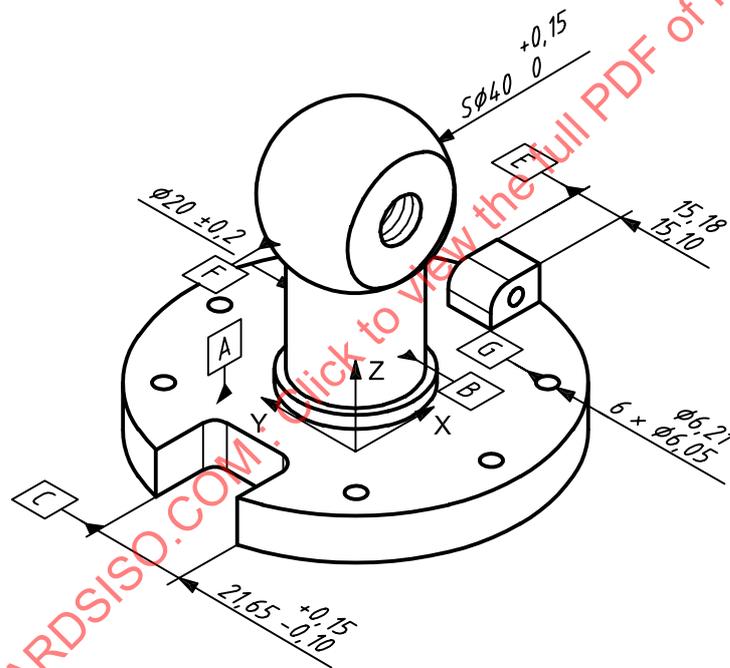
c) Identification of cylindrical integral feature

- Identification of a line on a surface as a datum: attach the datum indicator to a reference line and using a leader line terminated with a dot to the surface.
- Identification of an axis as a datum: attach the datum indicator with two opposing arrowheads or to the leader line of a dimension as shown in Figure 28 a). The datum indicator may also be attached to the tolerance indicator as shown in Figure 28 b).

d) Identification of a set of two opposed, parallel planes (a width)

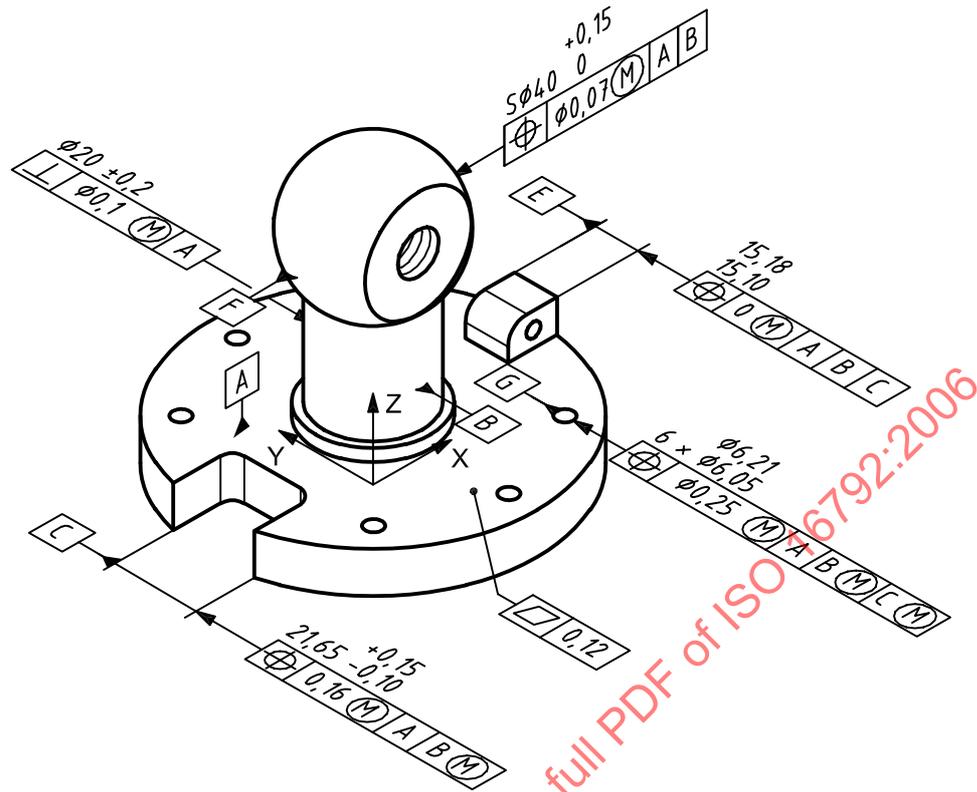
Place the datum indicator and the dimension and extension lines on an annotation plane perpendicular to the width centre-plane. The size limits shall be organized and displayed similarly as shown.

- Identification of a surface as a datum: attach the datum indicator using a leader line terminated with a dot to the surface.
- Identification of a median plane as a datum: attach the datum indicator as an extension of the dimension line as shown in Figure 28 a) or to the tolerance indicator as shown in Figure 28 b).



a) Direct attachment

Figure 28 — Datum indicator attachments



b) Feature control frames

Figure 28 (continued)

e) Identification of restricted area application

When the surface containing a datum feature also contains an area of limited application of a geometric tolerance, represent the restricted area of application on the model using supplemental geometry, see Figure 29.

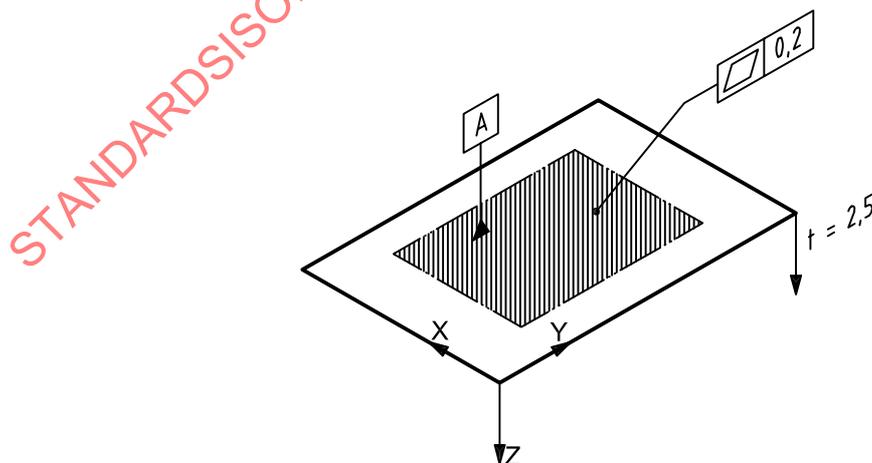


Figure 29 — Partial surface as a datum feature

10.3.3 Associativity of datum features and design data

A query of any datum feature shall permit access to all relevant information for the datum feature. This includes the datum indicator, the size limits (if applicable), any applied geometric tolerance, and the relevant coordinate system.

10.3.4 Datum target identification and attachment

The following gives the requirements and other provisions for attaching, associating, and displaying datum target indicators on models.

- a) When establishing a datum axis from a single internal cylindrical surface, datum targets may be used, for example as shown in Figure 31.
- b) When establishing a datum axis from two external cylindrical surfaces, datum targets from the two surfaces may be used, for example as shown in Figure 32.
- c) Datum target areas shall be shown using shading or crosshatching.

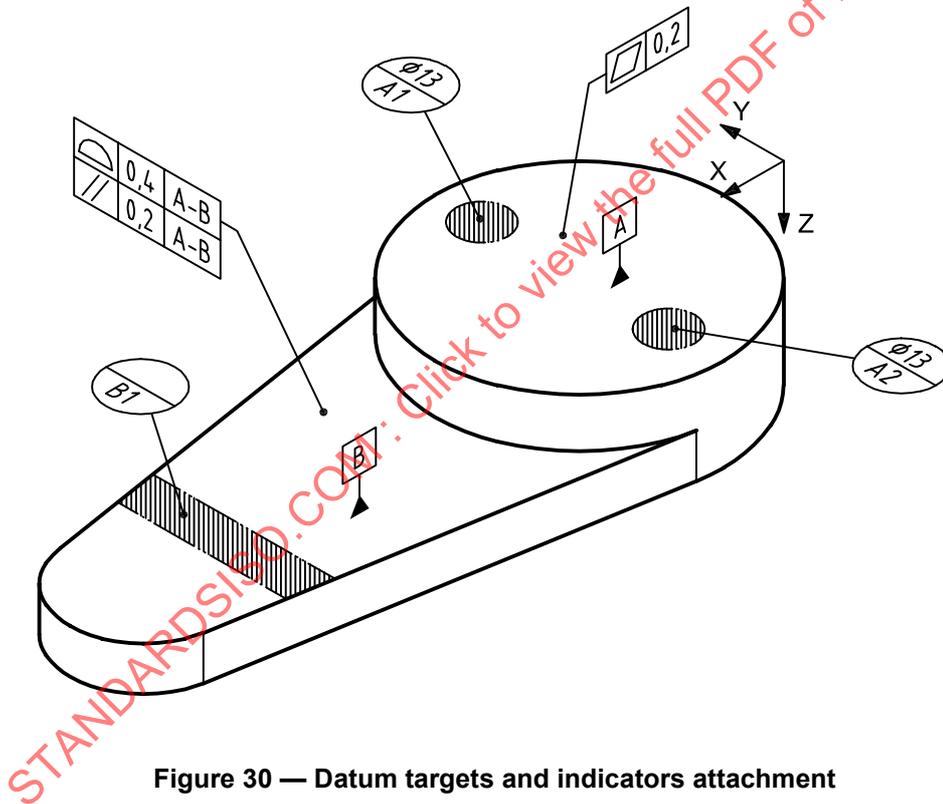


Figure 30 — Datum targets and indicators attachment

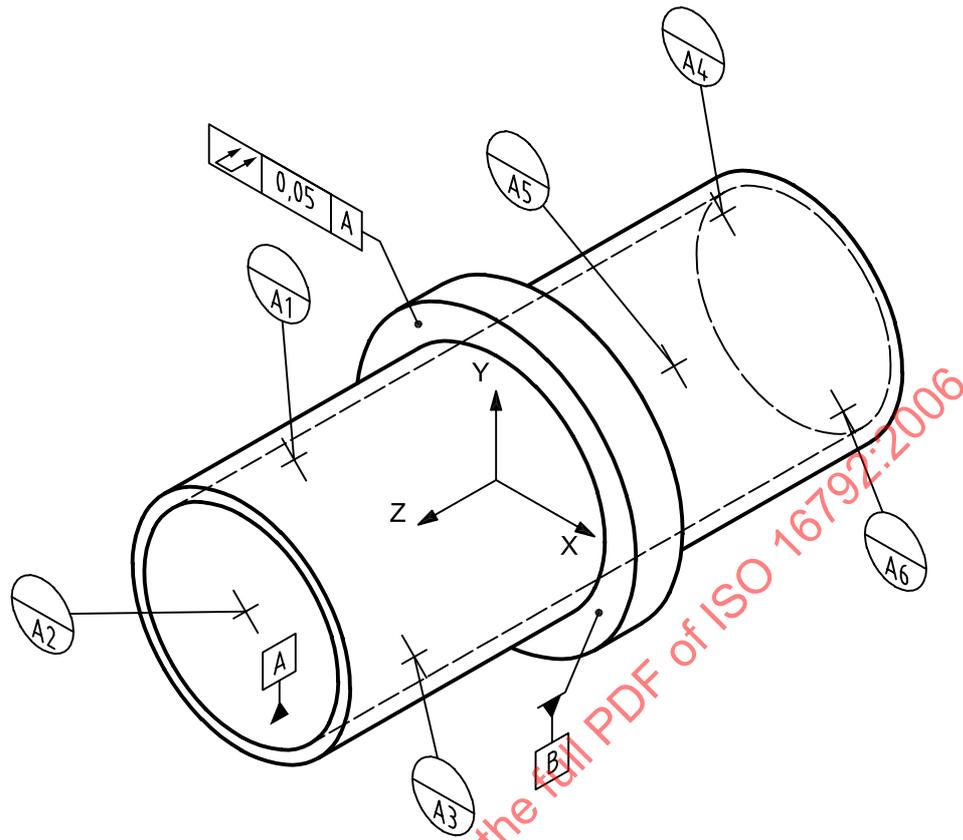
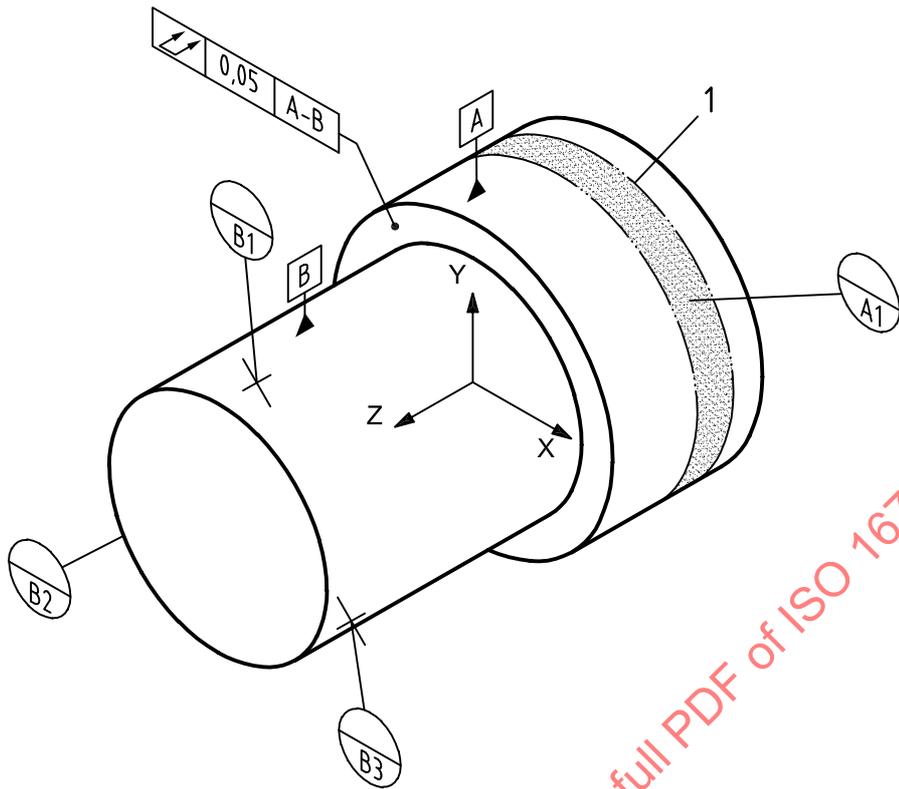


Figure 31 — Target points establishing a datum axis on an internal cylindrical surface



Key

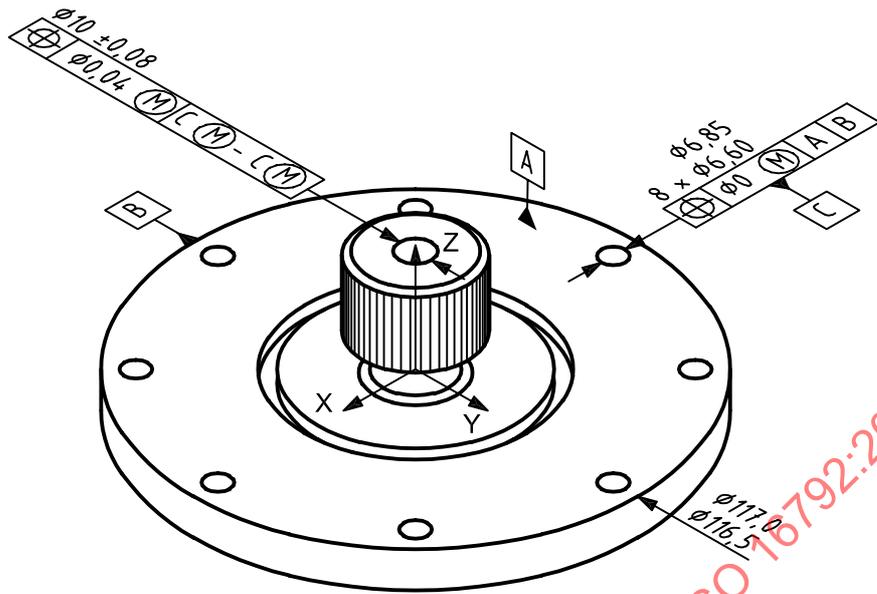
- 1 cylindrical target datum line

Figure 32 — Two cylindrical features establish a datum axis

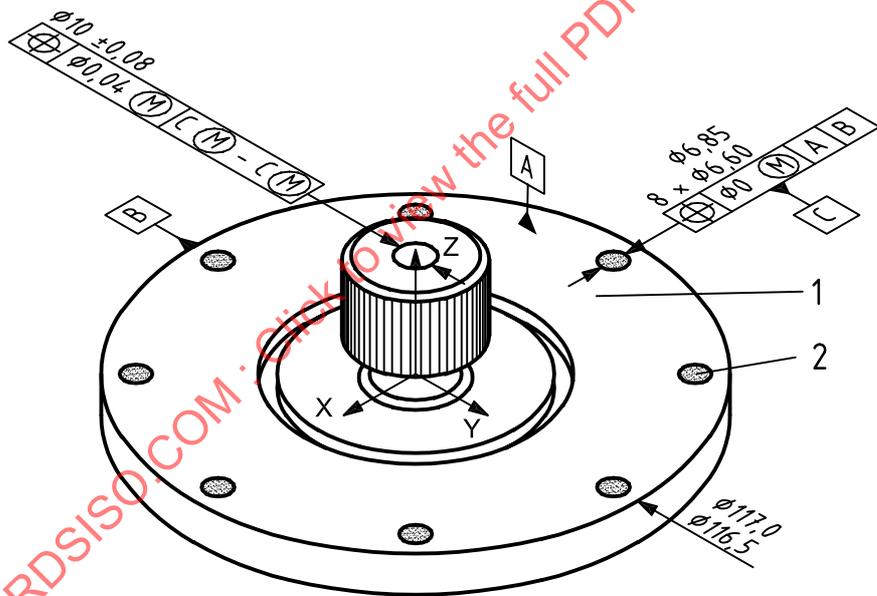
10.3.5 Multiple features establishing a datum

When two or more features are combined to establish a datum, associativity shall be established in the design presentation. For several common instances, the following display and associativity requirements apply.

- a) When a pattern of features of size is used to establish a datum axis, the involved model features and any applied tolerance for these model features shall be organized as an associated group, see Figure 33.
- b) When two or more coaxial and cylindrical datum features are used to establish a single, common datum axis, the involved model features and any applied tolerance for these model features shall be organized as an associated group, see Figure 34.
- c) When two or more co-planar surface features are used to establish a datum plane, the involved model surfaces and any applied tolerance for these surfaces shall be organized as an associated group, see Figure 35. When an intervening feature separates the surfaces being tolerated, the profile tolerance shall be attached to one of the surfaces but not both, see Figure 36.



a) Placement and attachment



b) Datum feature indicator associativity

Key

- 1 query
- 2 visual response

Figure 33 — Pattern of features establish a datum axis

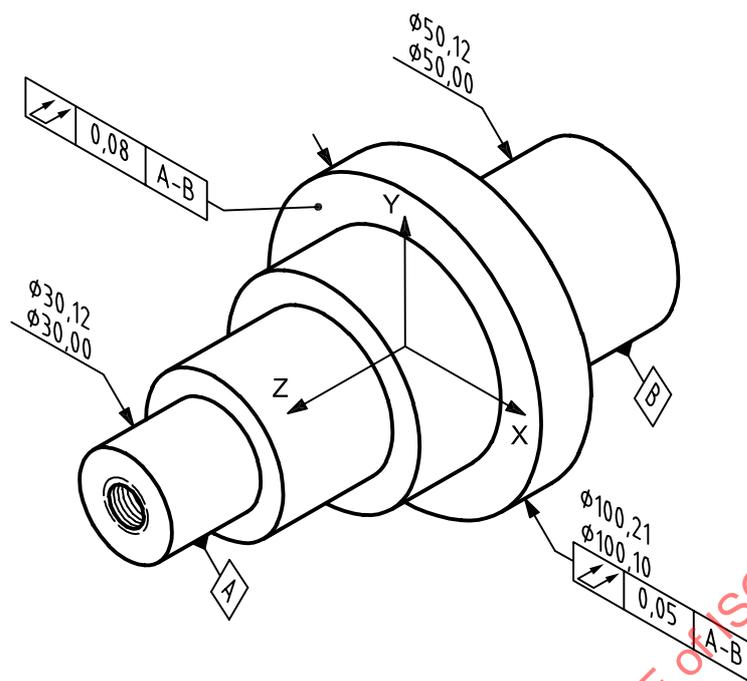
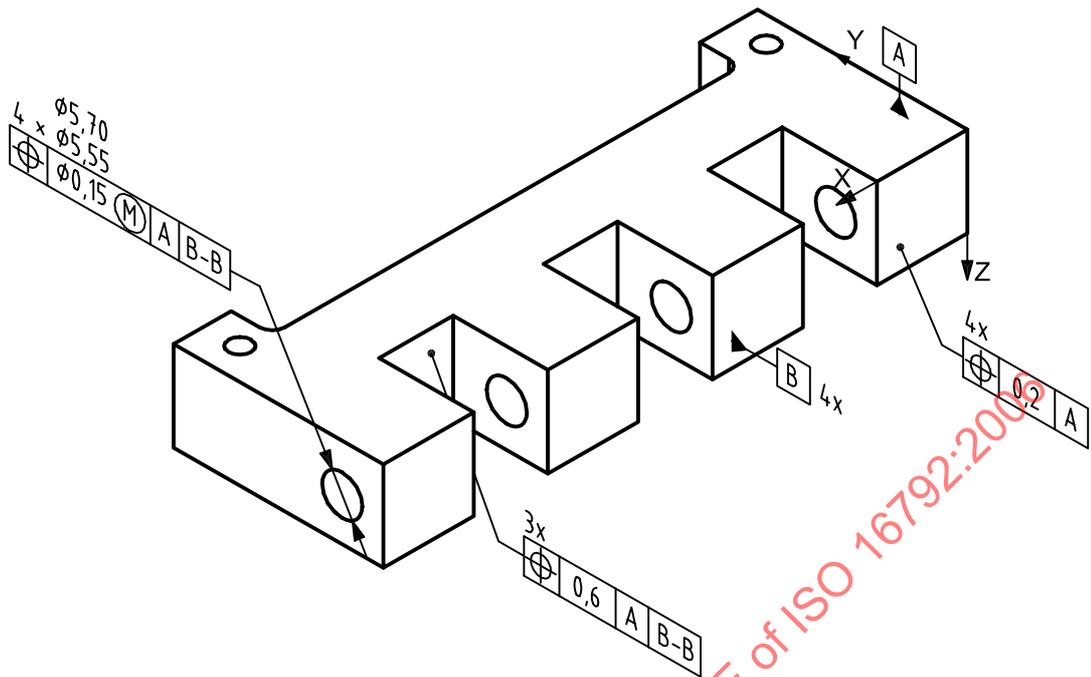
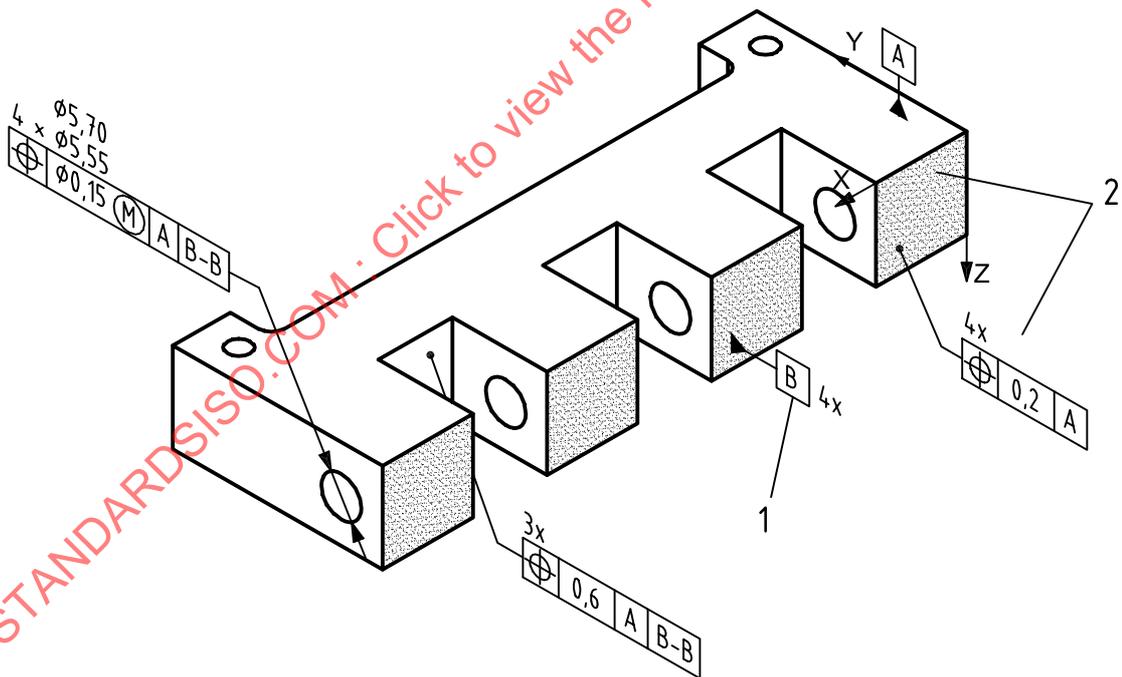


Figure 34 — Two coaxial features establish a datum axis

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a) Placement and attachment

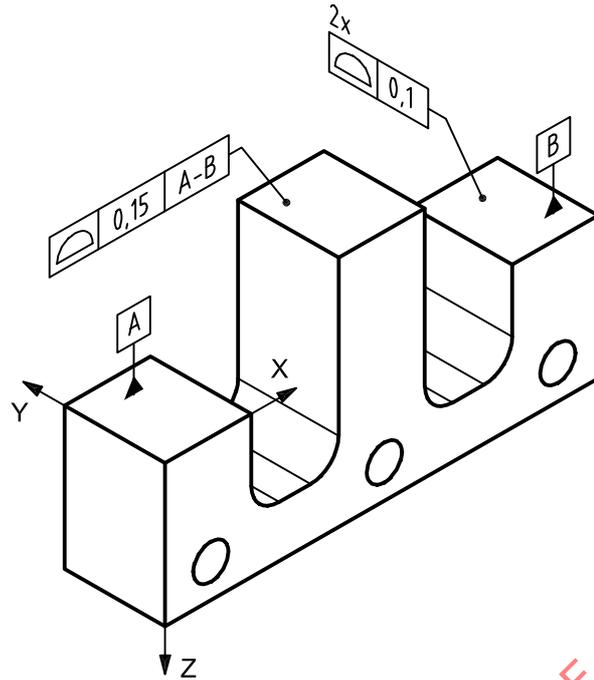


b) Datum feature indicator associativity

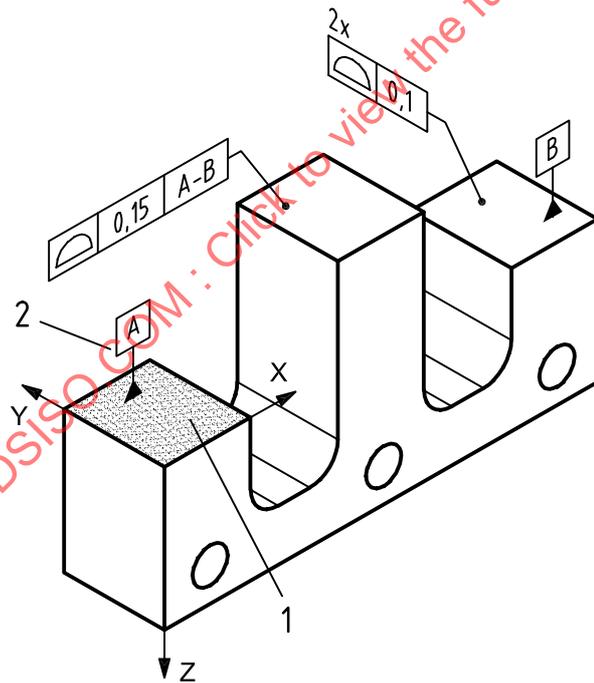
Key

- 1 query
- 2 visual response

Figure 35 — Co-planar surfaces establish a datum plane

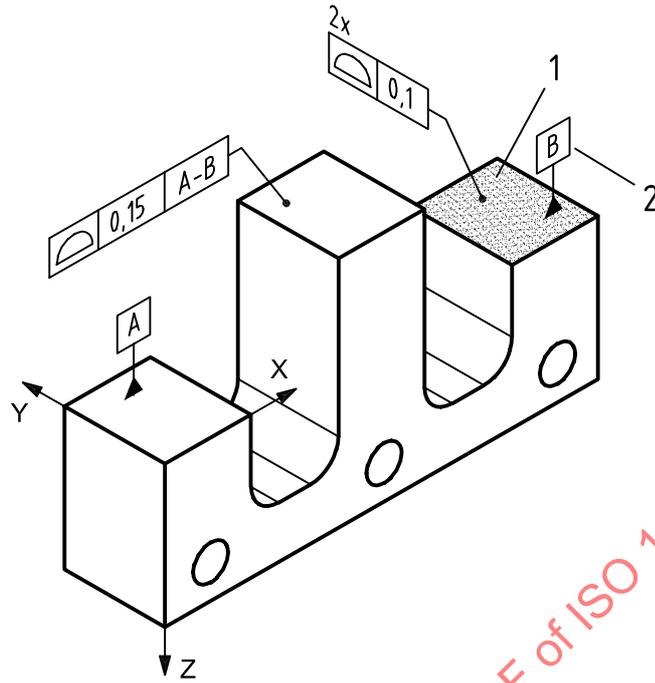


a) Placement and attachment

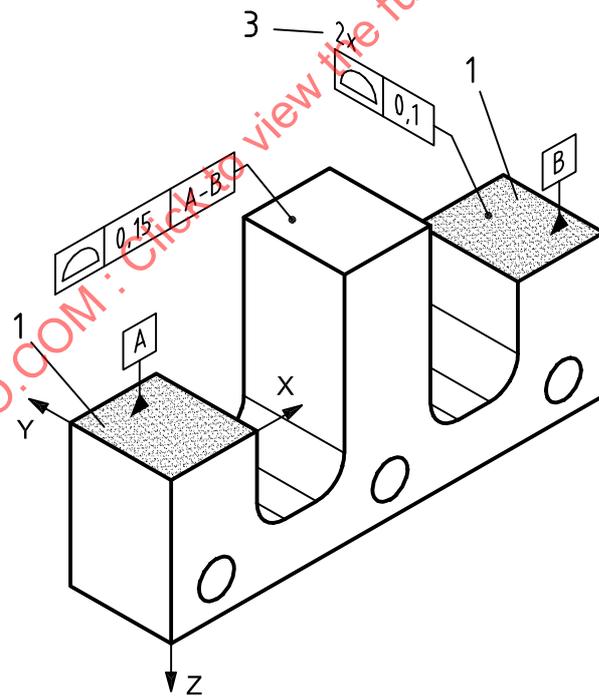


b) Datum feature indicator associativity

Figure 36 — Separated surfaces establish a datum plane

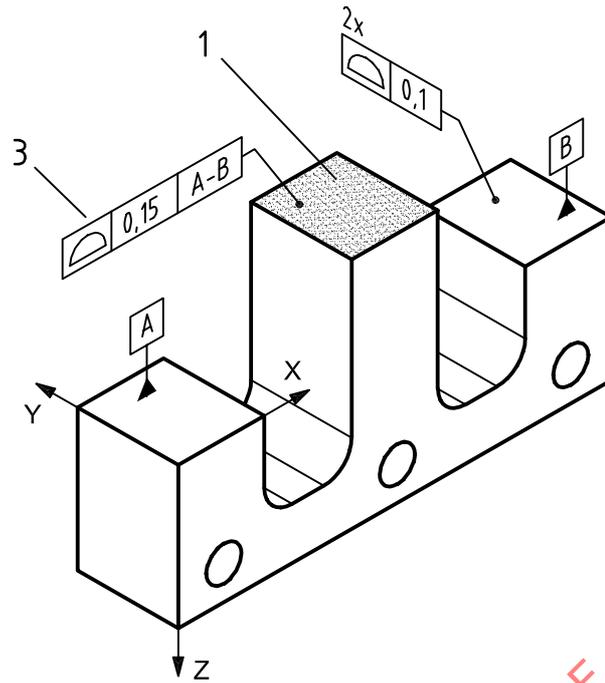


c) Datum feature indicator associativity

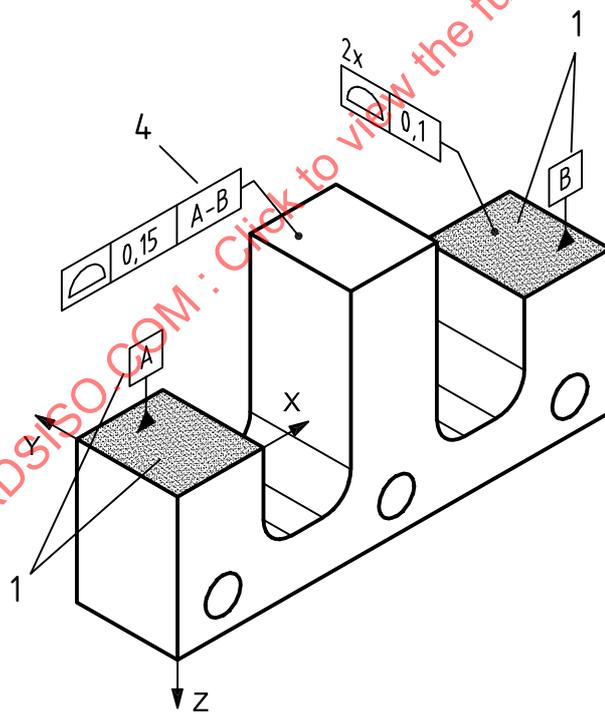


d) Tolerance indicator associativity

Figure 36 (continued)



e) Tolerance indicator associativity



f) Datum reference associativity

Key

- 1 visual response
- 2 datum indicator query
- 3 tolerance indicator query
- 4 datum reference query

Figure 36 (continued)

10.4 Drawing requirements

The following are requirements and other provisions for datum features in axonometric views.

- a) The corresponding model coordinate system shall be displayed in each axonometric view in which a datum system is cited.
 - The datum indicator should be attached to the surface of the represented object. A single extension line of a model feature outline should not be used for attachment of datum indicators in an axonometric view.
 - Datum indicators may be attached to the dimension for features of size when the feature is used to define a datum, see Figure 28.
- b) Identification of datum features in axonometric views

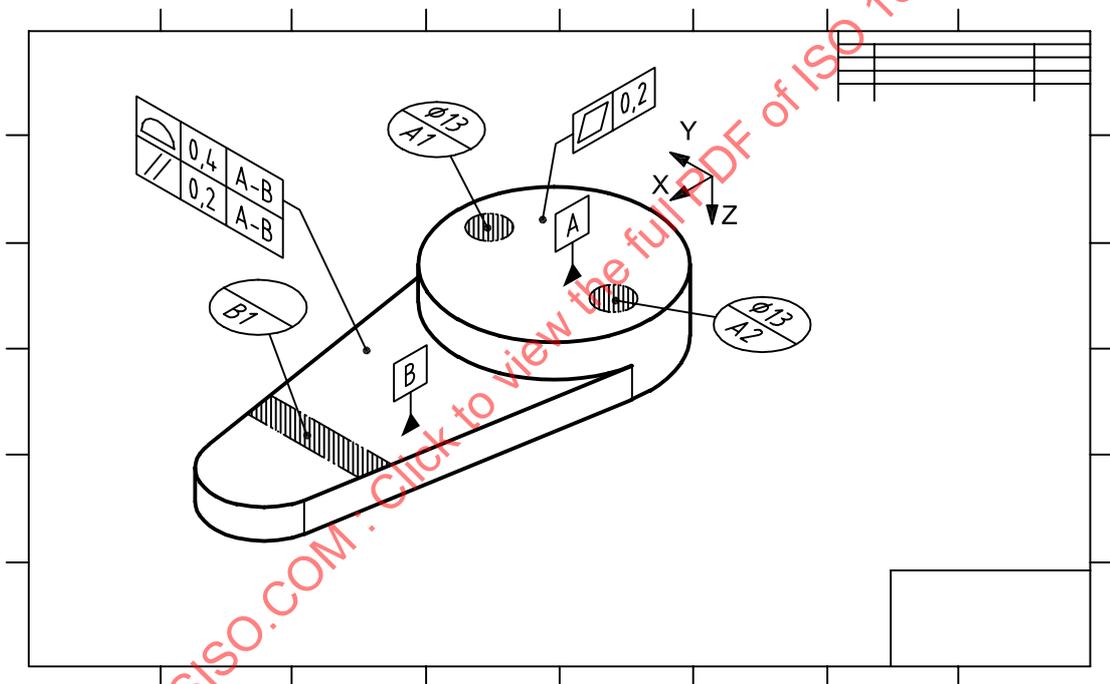


Figure 37 — Datum targets and indicators in an axonometric view

11 Geometric tolerances

11.1 General

This clause establishes the placement, attachment, and display requirements and other provisions for geometric tolerances.

11.2 Common requirements

A general note defining a geometric tolerance may be specified. More than one tolerance may be specified.

11.3 Model requirements

11.3.1 General

The following subclauses address the placement, attachment, and display requirements and other provisions for geometric tolerances associated with model features.

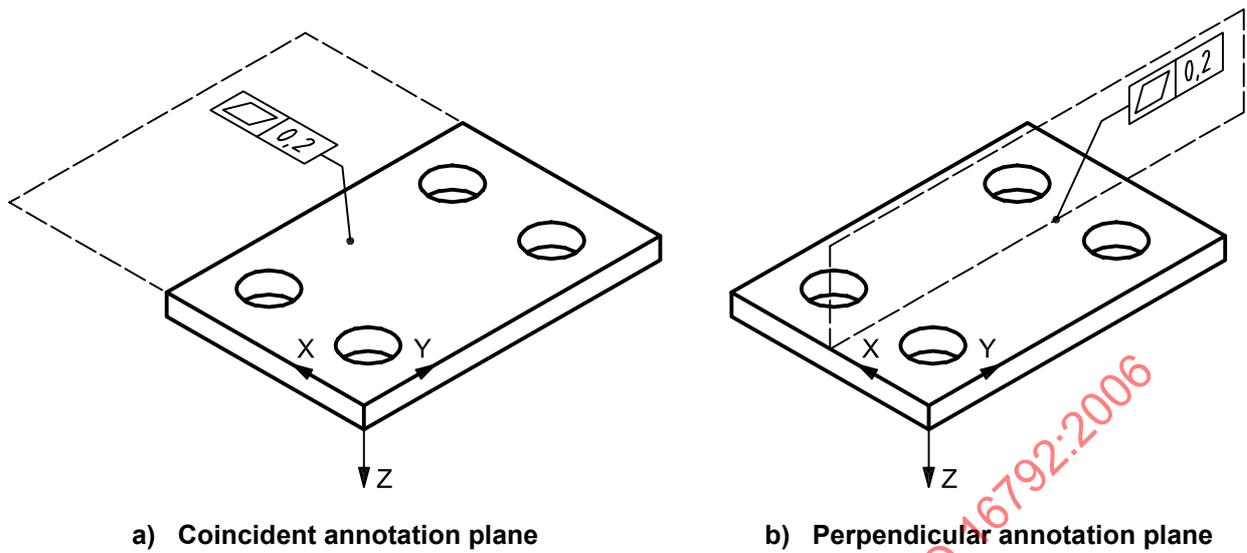
11.3.2 Form tolerances

The tolerance indicator shall be placed on an annotation plane parallel to, perpendicular to, or coincident with, the surface to which it applies using the attachment methods given in Table 3, see Figure 38.

- a) Show flatness tolerance applicable to a restricted feature using supplemental geometry on the model to indicate the area. Direct a leader line from the flatness tolerance indicator to the represented area. See Figure 29.
- b) When a roundness tolerance is applied to a sphere, cylinder, cone or surface of revolution, the tolerance indicator shall be placed on an annotation plane perpendicular to the model feature axis, or containing the centre point of a sphere, see Figure 39.
- c) When a straightness tolerance is applied to the line elements of a cylindrical or conical surface, the tolerance indicator shall be placed on an annotation plane containing the axis of the model feature surface, see Figure 43.

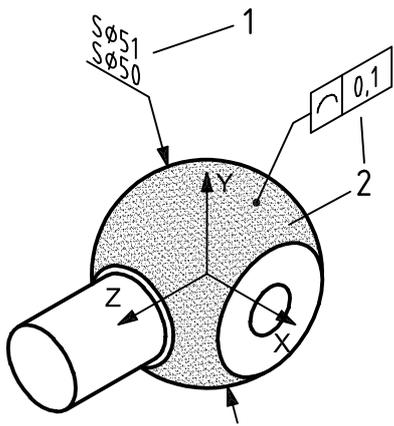
Table 3 — Form tolerances

General application		Attachment technique		Figure
		Size	Directed leader line	
	Planar surface		X	38
	Restricted area		X	29
	Sphere	X		39 a)
			X	39 b)
	Cylinder	X		39 c)
			X	39 d)
			X	39 e)
Surface of revolution		X	39 f)	
	Cylinder	X		40 a)
			X	40 b)
	Planar surface		X	41
			X	42
	Cylindrical or conical surface		X	43
	Median line or surface	X		44

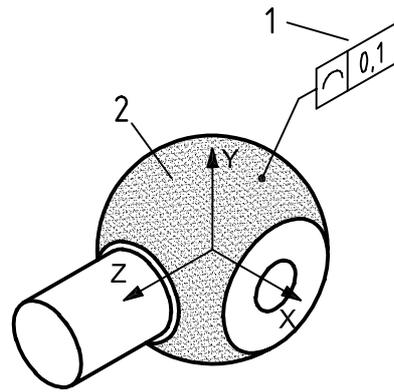


NOTE The annotation planes shown here as dashed lines are for clarification only and are not part of an actual presentation.

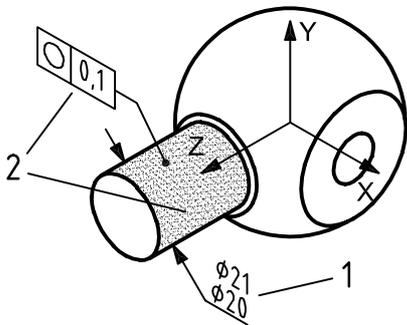
Figure 38 — General application of geometric tolerances' coincident or perpendicular annotation plane



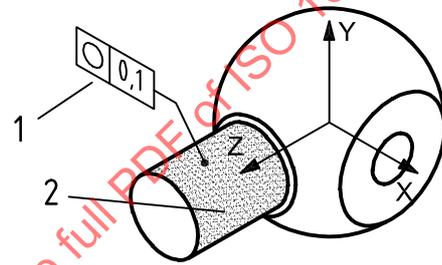
a) Sphere — Size attachment



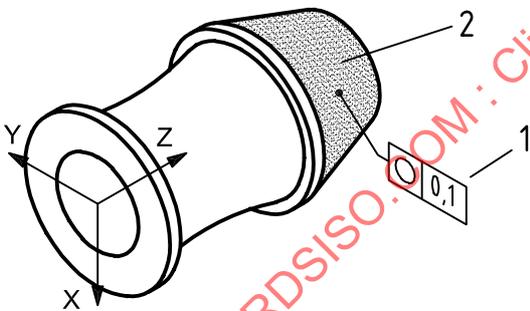
b) Sphere — Leader attachment



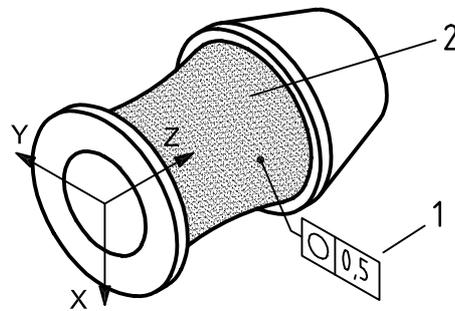
c) Cylinder — Size attachment



d) Cylinder — Leader attachment



e) Conical surface

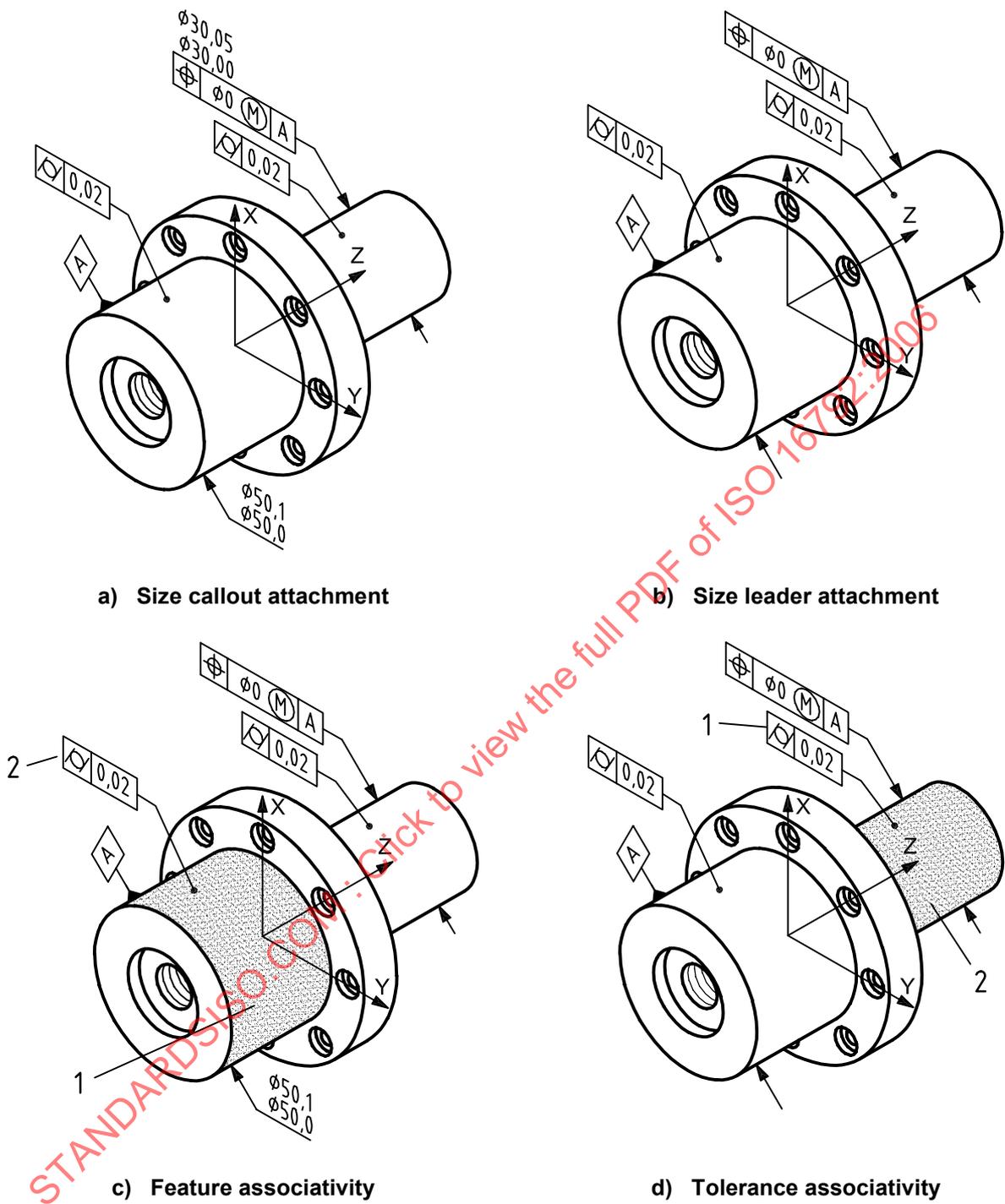


f) Surface of revolution

Key

- 1 query
- 2 visual response

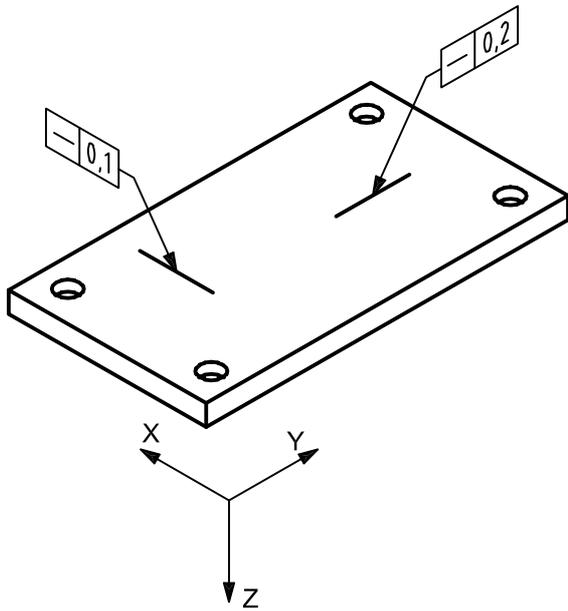
Figure 39 — Roundness — Sphere, cylinder, conical or revolved surface



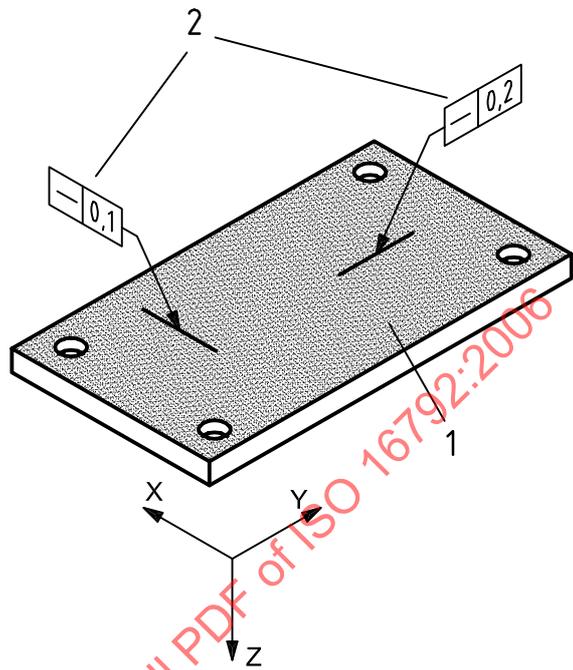
Key

- 1 query
- 2 visual response

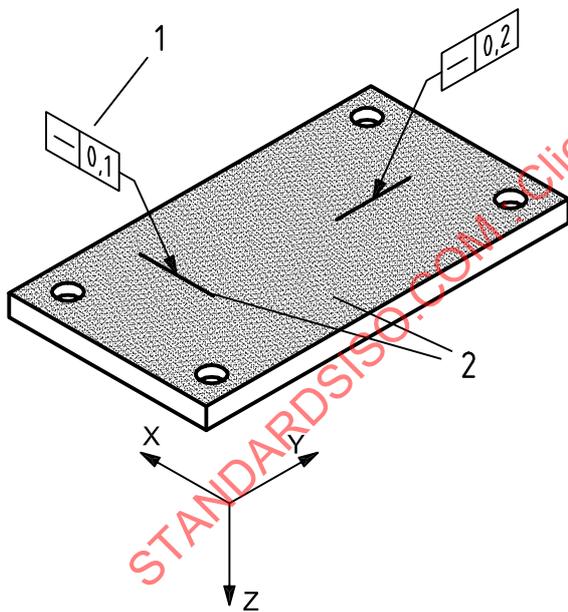
Figure 40 — Cylindricity



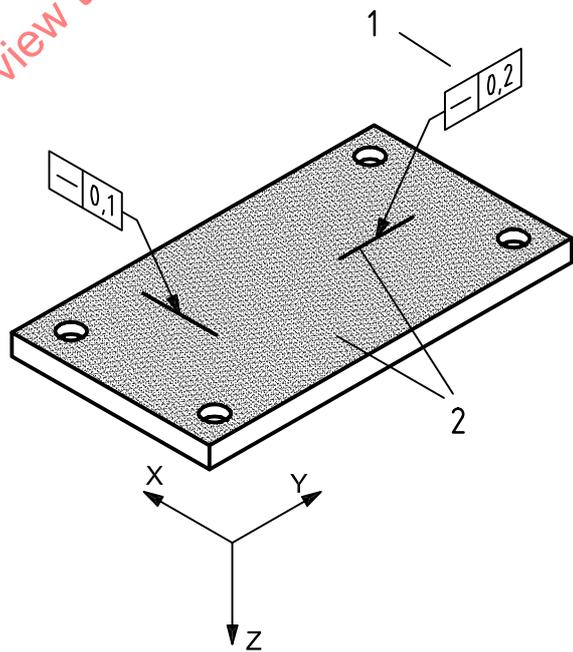
a) Placement and attachment



b) Feature associativity



c) Tolerance direction associativity



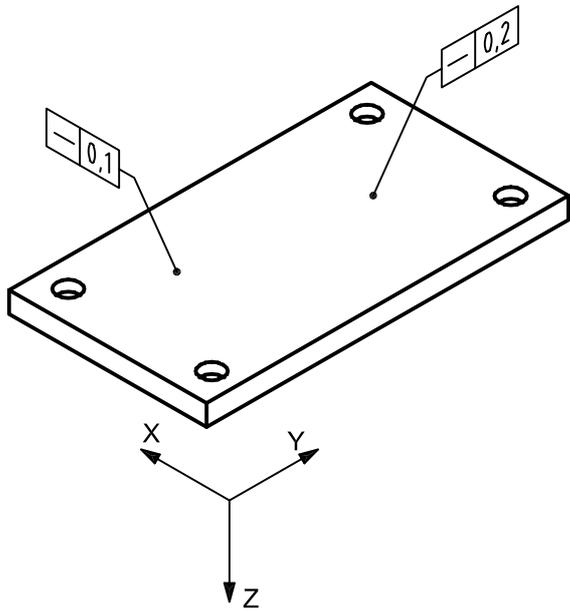
d) Tolerance direction associativity

Key

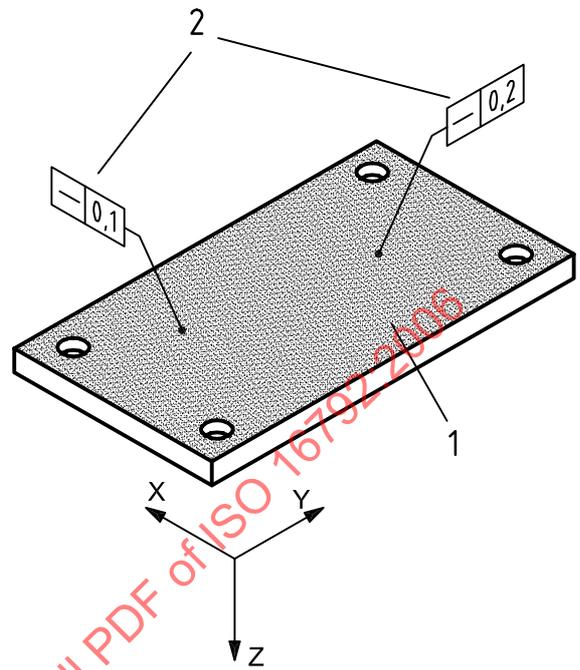
- 1 query
- 2 visual response

See also 5.2.3 a)

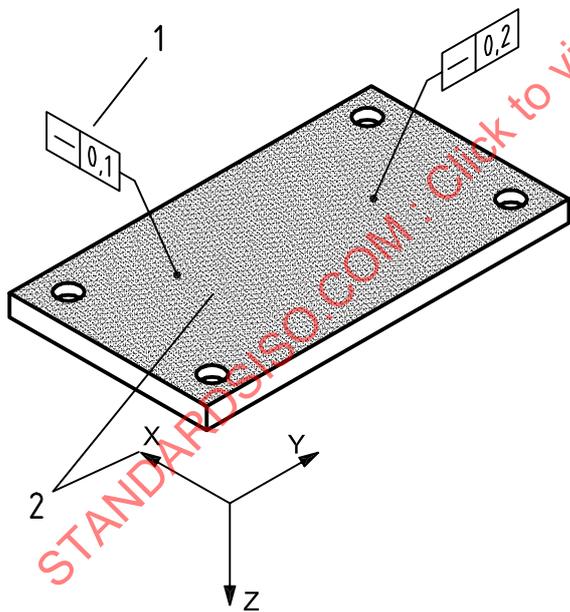
Figure 41 — Straightness — Directed by line element



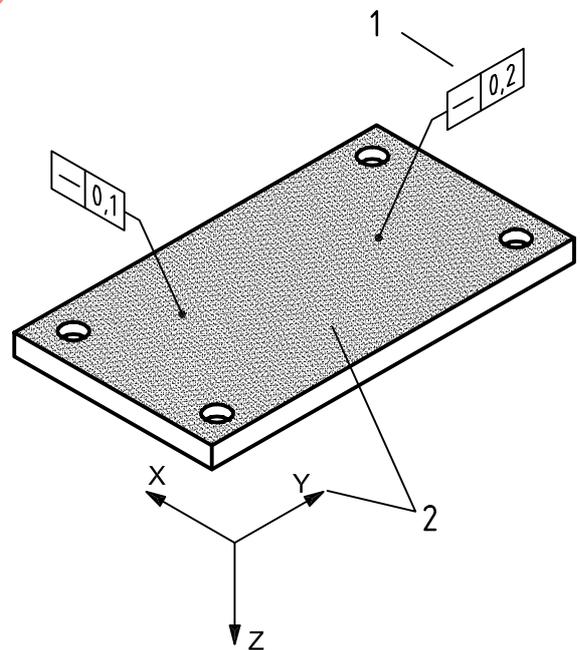
a) Placement and attachment



b) Feature associativity



c) Tolerance direction associativity



d) Tolerance direction associativity

Key

- 1 query
- 2 visual response

Figure 42 — Straightness — Directed by ordinate axis

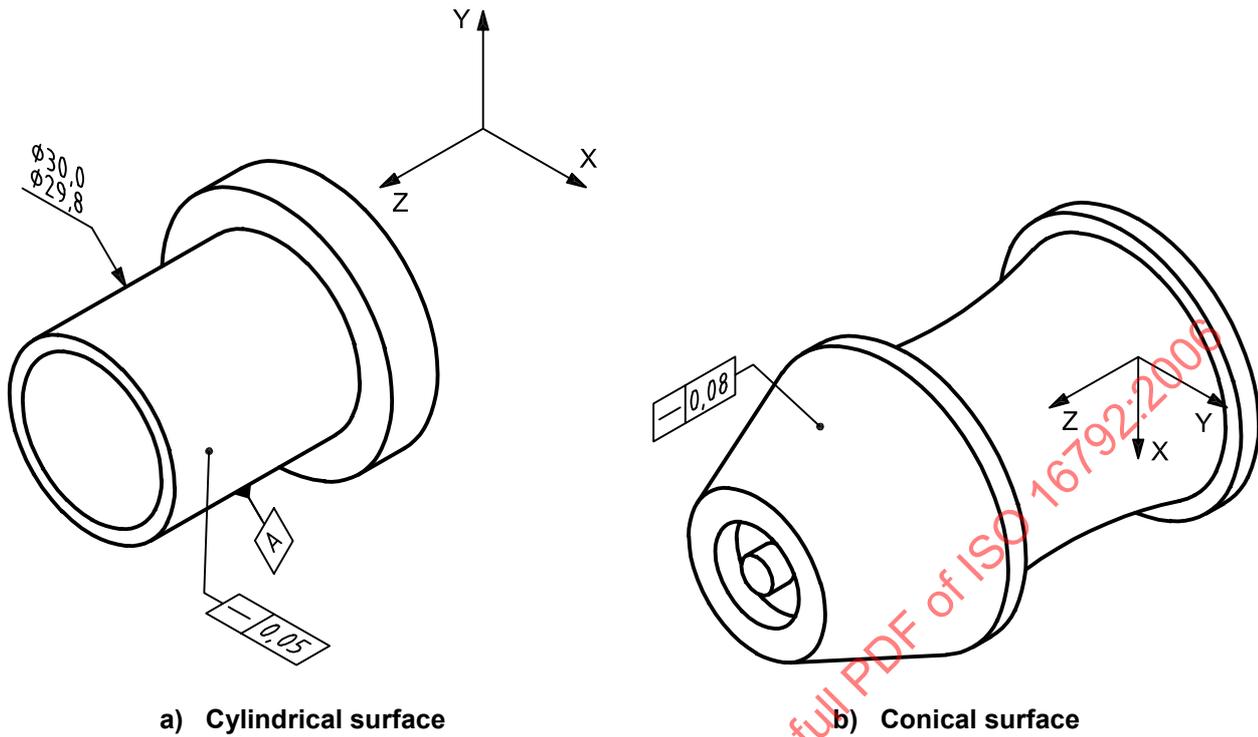


Figure 43 — Straightness — Cylindrical or conical surface

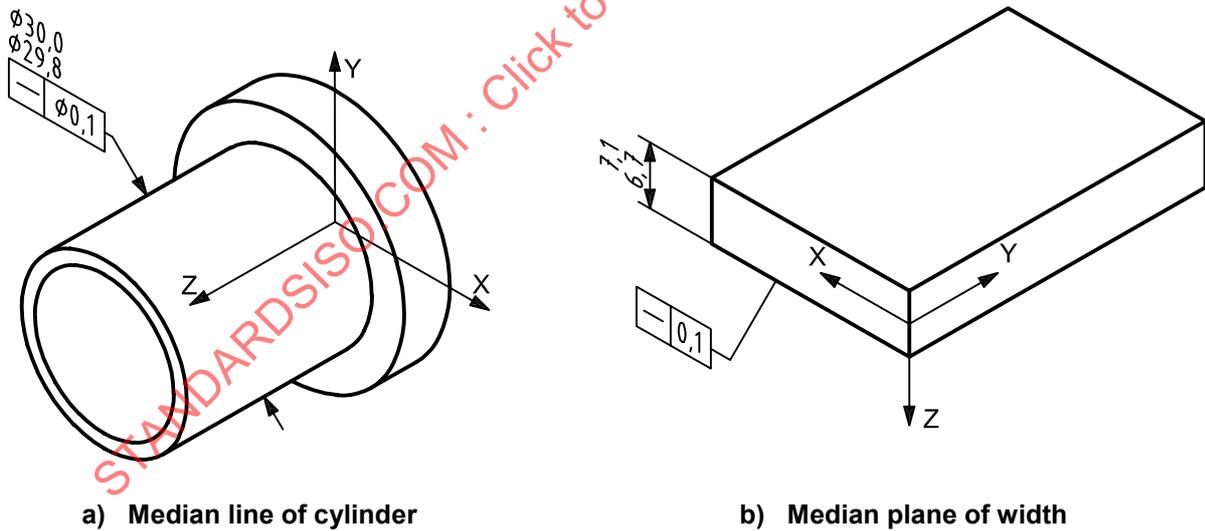


Figure 44 — Straightness — Median line or plane

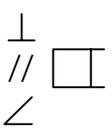
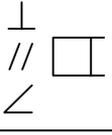
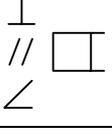
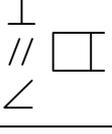
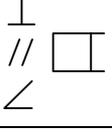
11.3.3 Orientation tolerances

The orientation tolerance indicator shall be placed on an annotation plane parallel with, or perpendicular to, the referenced datum or primary datum using the attachment methods given in Table 4.

- a) When each line element on a surface is directed by ordinate axis, the orientation tolerance indicator and the appropriate modifier shall be placed on an annotation plane parallel with, and perpendicular, to the absolute coordinate system or an established user defined coordinate system, see Figure 47.

- b) When using multiple datum references, the orientation tolerance indicator and the appropriate modifier shall be placed on an annotation plane containing the represented line element indicating the direction of application, see Figure 46.
- c) When orienting a median line of a cylinder within a parallel planes tolerance zone, the orientation tolerance indicator shall be attached to the diametral size and any other geometric tolerance requirement. The orientation of the extension lines defines the orientation of the tolerance zone, see Figure 50.

Table 4 — Orientation tolerances

General application	Attachment technique			Figure
	Size	Directed leader line	Extension lines	
 Two flat surfaces		X		45
 Straight line on a flat surface		X		46 47
 Inclined flat surface		X		48
 Generating line of cylinder		X		49b
 Median line of cylinder	X			49 a)
 Median surface of two opposed parallel surfaces	X			49 c)
			X	49 d)
 Median line — Within parallel plane's tolerance zone	X			50 a)
			X	50 b)

NOTE All three symbols are shown for applications that apply equally to perpendicularity, parallelism and angularity.

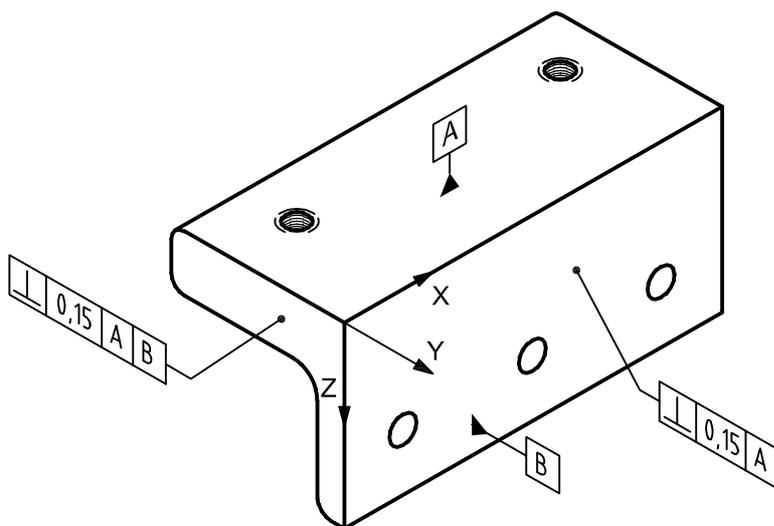
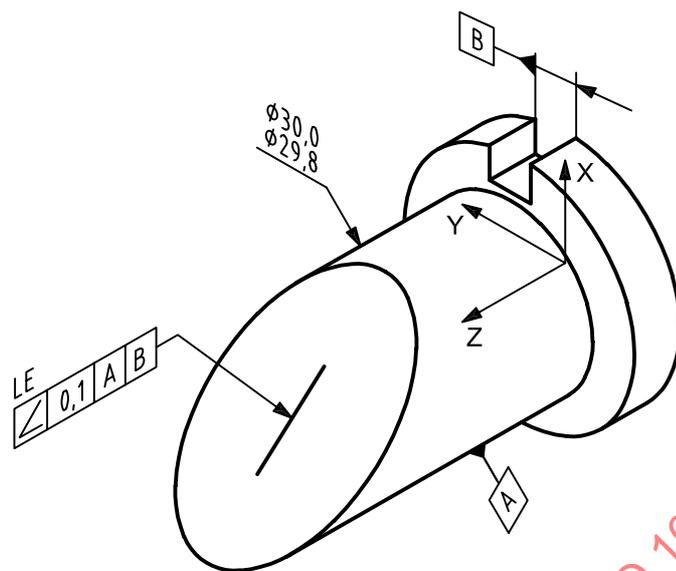
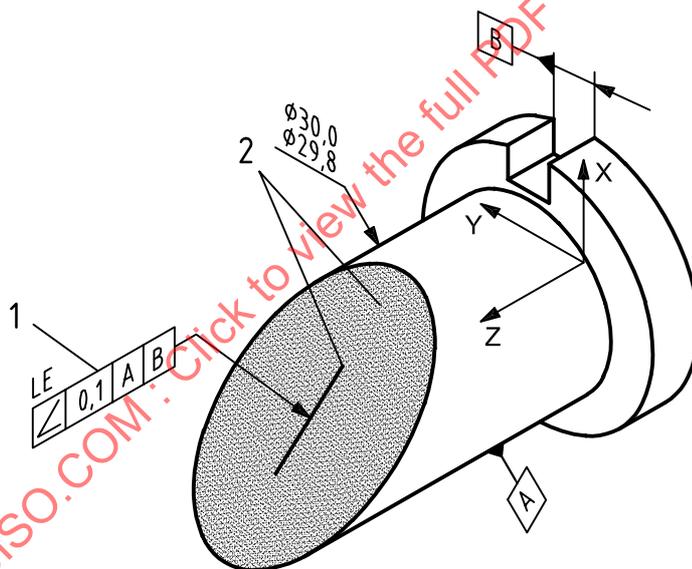


Figure 45 — Orientation — Planar surfaces



a) Placement and attachment

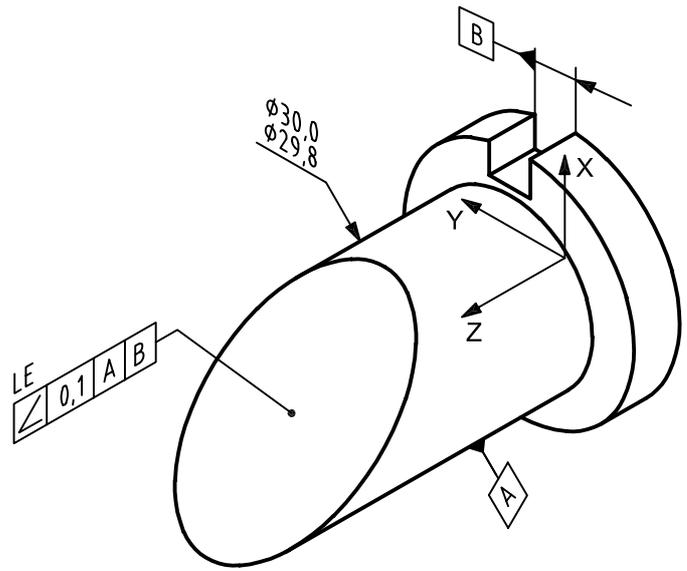


b) Toleranced lines associativity

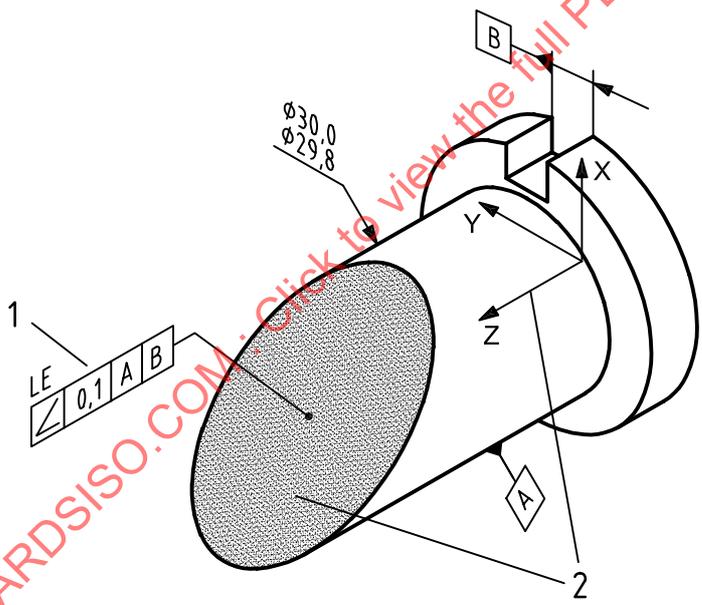
Key

- 1 query
- 2 visual response

Figure 46 — Orientation of each line element on a surface — Directed by line element



a) Placement and attachment

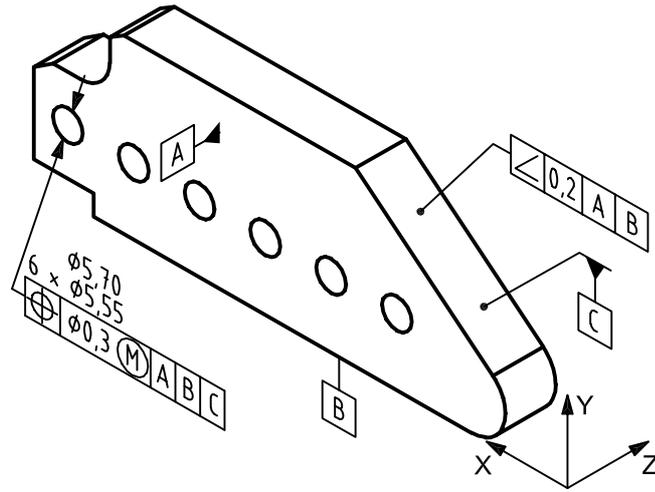


b) Toleranced lines associativity

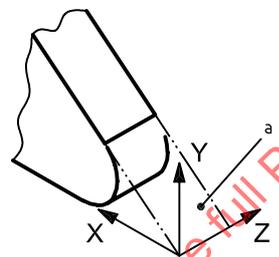
Key

- 1 query
- 2 visual response

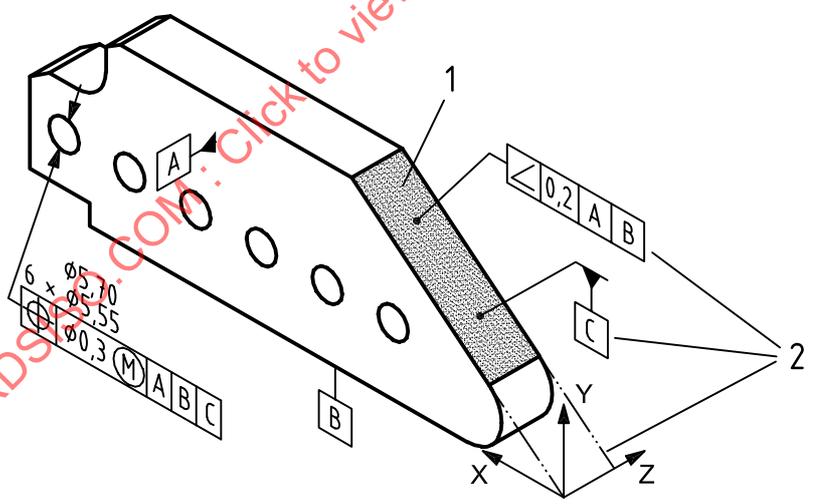
Figure 47 — Orientation of each line element on a surface — Directed by ordinate axes



a) Placement and attachment



b) Counterpart representation

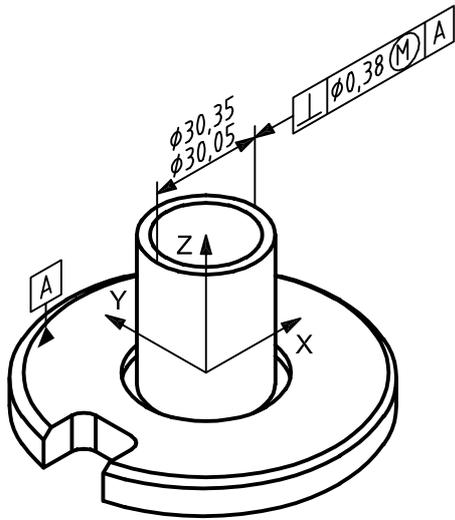


c) Counterpart associativity

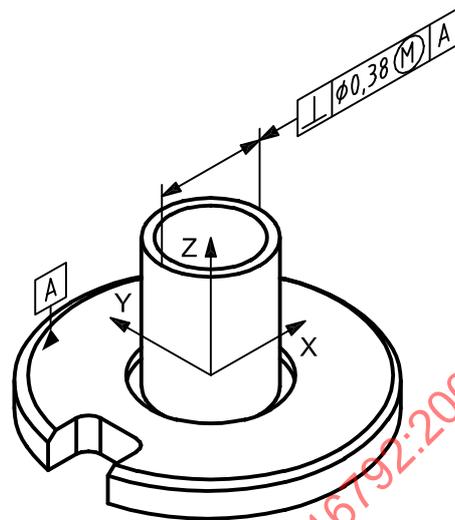
Key

- 1 query
- 2 visual response
- a Supplemental geometry used to represent the theoretically exact counterpart.

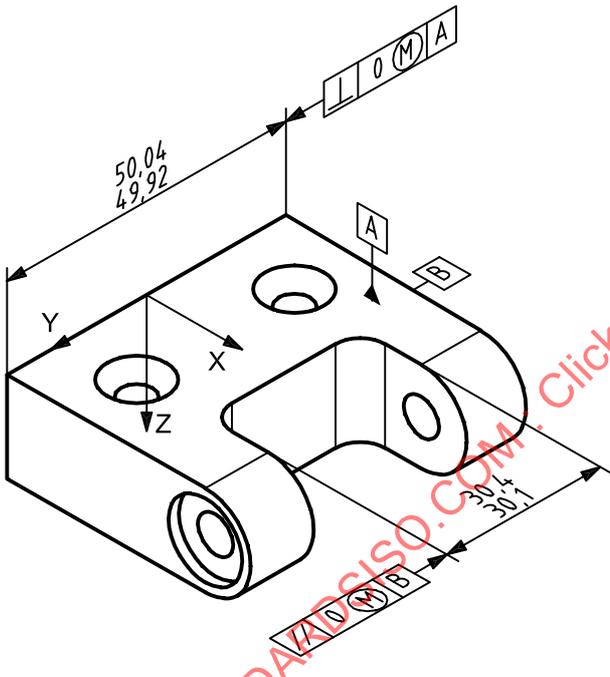
Figure 48 — Orientation — Inclined surface



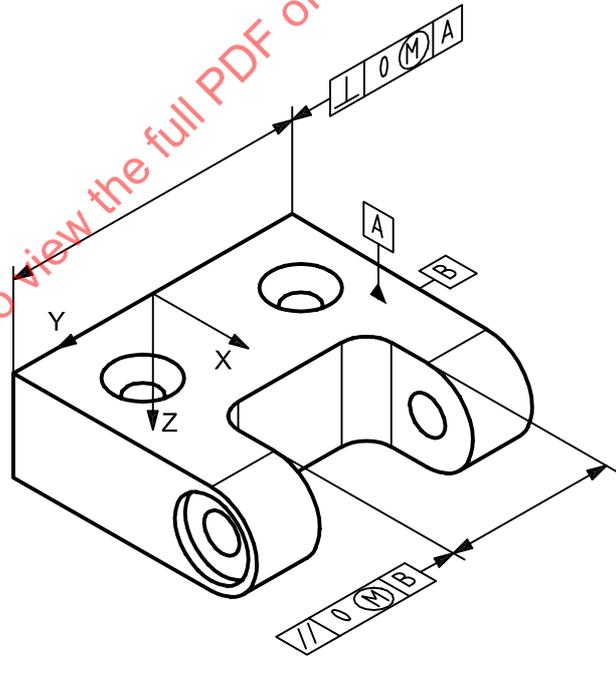
a) Cylinder — Size attachment



b) Cylinder — Leader attachment

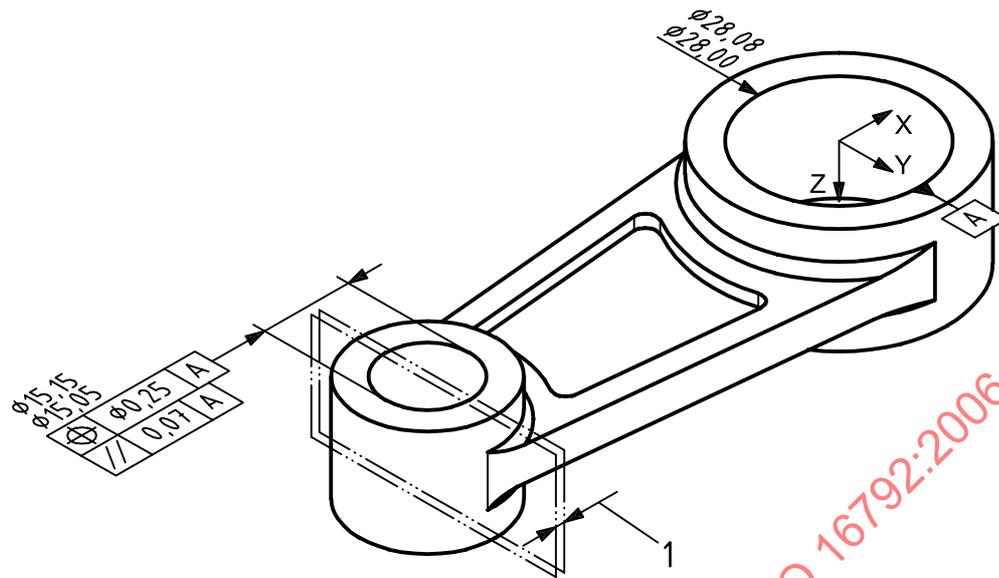


c) Width — Size attachment

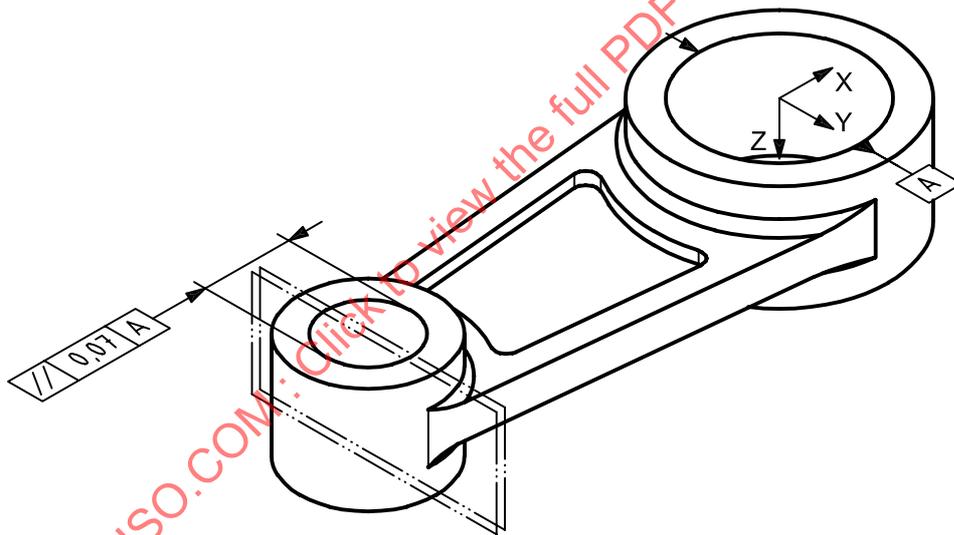


d) Width — Extension lines attachment

Figure 49 — Orientation — Cylinder or set of opposed parallel surfaces



a) Size attachment



b) Extension lines attachment

Key

1 parallel plane's tolerance zone

^a The orientation of direction lines defines the direction of application.

NOTE The tolerance zones shown here are for clarification only and are not part of an actual presentation.

Figure 50 — Orientation of axis with parallel plane's tolerance zone

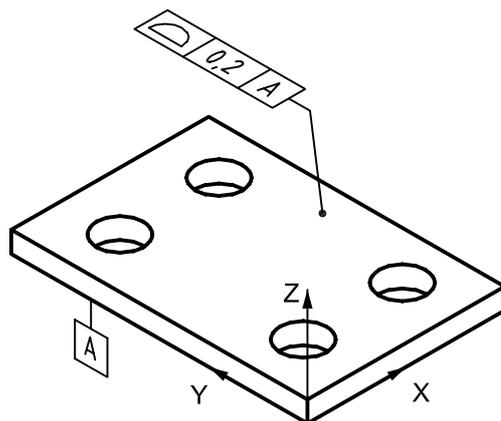
11.3.4 Profile tolerances

When an individual profile requirement is specified, it shall be attached by a directed leader line using the attachment techniques given in Table 5.

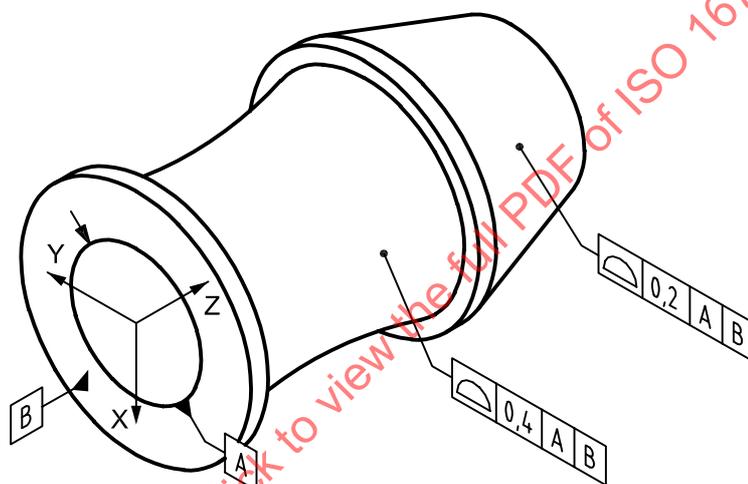
- a) When a tolerance applies to a conical surface or a surface of revolution, the tolerance indicator shall be placed on an annotation plane perpendicular to, or containing, the model feature axis, see Figure 51 b).
- b) When a profile tolerance applies to multiple co-planar surfaces, the model features shall be combined into an associated group. The tolerance indicator shall be placed on an annotation plane parallel with, or perpendicular to, the referenced primary datum, see Figure 52.
- c) When the associated geometry is not sufficient to indicate the application, labelled supplemental geometry may be added to indicate the boundary of application. The *between* symbol may be used to clarify the requirement, see Figure 53.
- d) When the *all-around* symbol is used, query shall be used to identify the controlled surfaces, see Figure 54.
- e) When a profile of a line is directed by a line element, the tolerance indicator shall be placed on an annotation plane containing the represented line element, parallel with, and perpendicular to, the absolute coordinate system or an established user-defined coordinate system, see Figure 55.
- f) When a profile of a line is directed by ordinate axis, the tolerance indicator shall be placed on an annotation plane parallel with, and perpendicular to, the absolute coordinate system or an established user-defined coordinate system, see Figure 56.

Table 5 — Profile tolerances

General application		Attachment technique Directed leader line	Figure
	Planar surface	X	51
	Conical surface Revolved surface	X	51
	Multiple or co-planar surfaces	X	52
	Between basis	X	53
	All around basis	X	54
	Lines in surfaces	X	55
			56

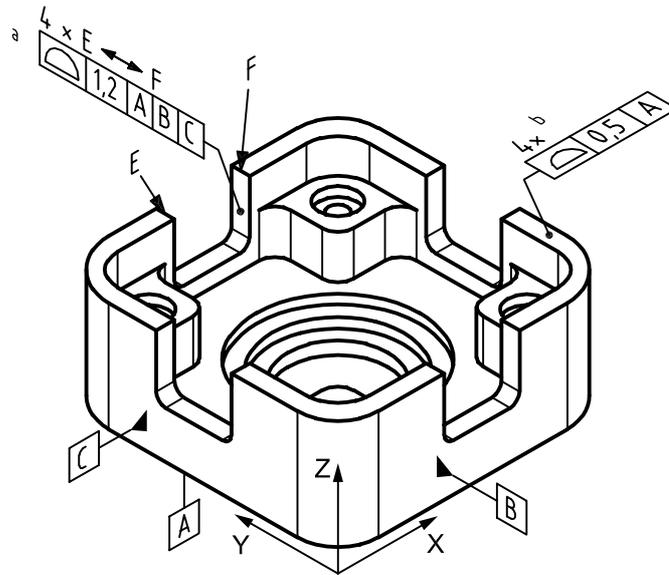


a) Planar surface

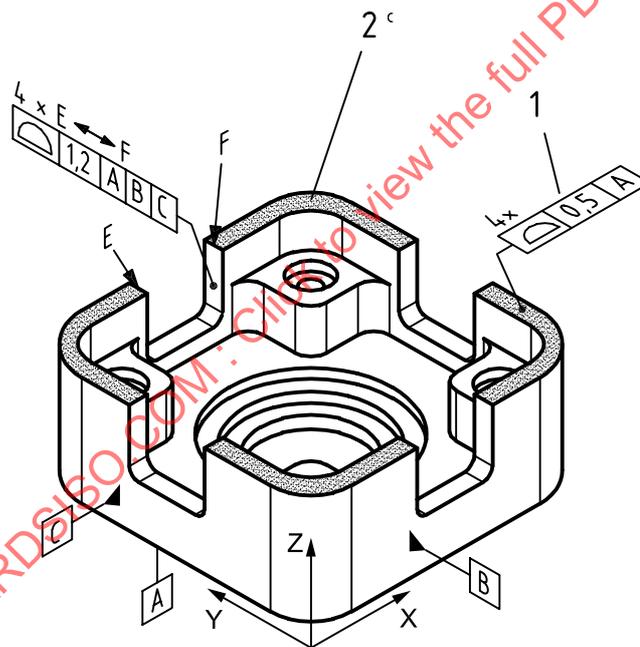


b) Conical or revolved surface

Figure 51 — Profile — Planar, conical or revolved surface

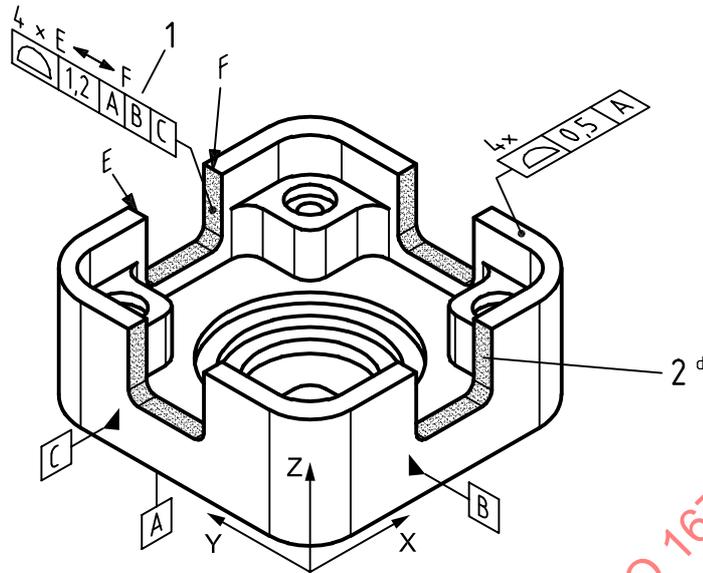


a) Placement and attachment



b) Counterpart representation

Figure 52 — Profile — Multiple or co-planar surfaces



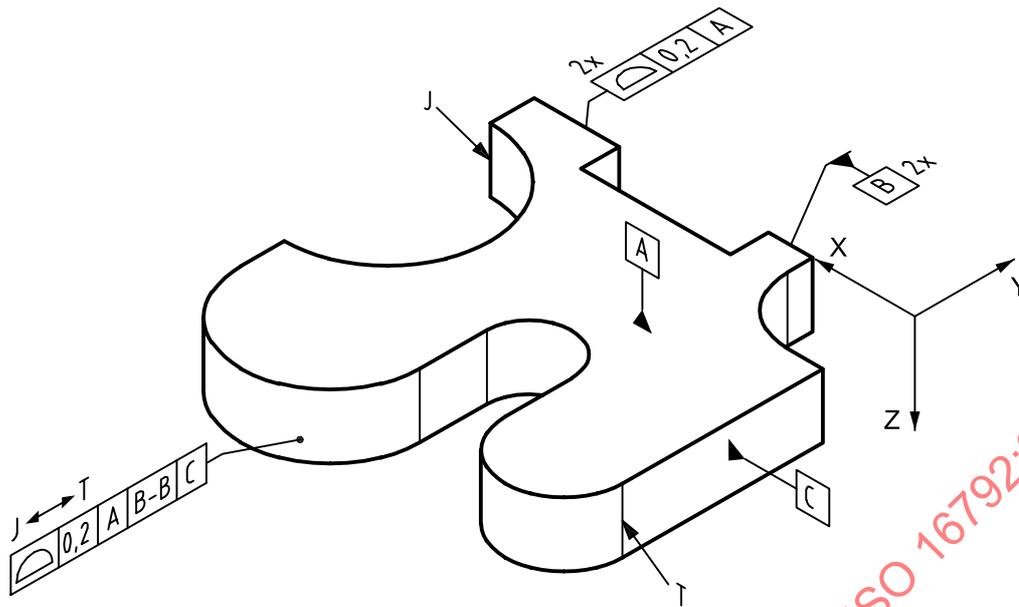
c) Counterpart associativity

Key

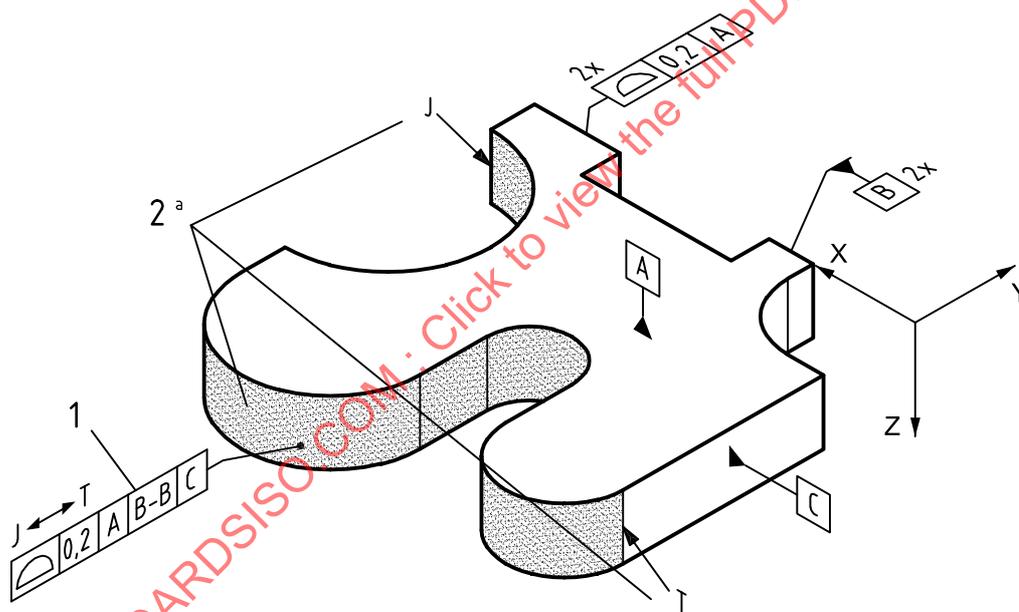
- 1 query
- 2 visual response
- a Multiple surfaces.
- b Co-planar surfaces.
- c All four coplanar surfaces.
- d All four recesses.

Figure 52 (continued)

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a) Placement and attachment



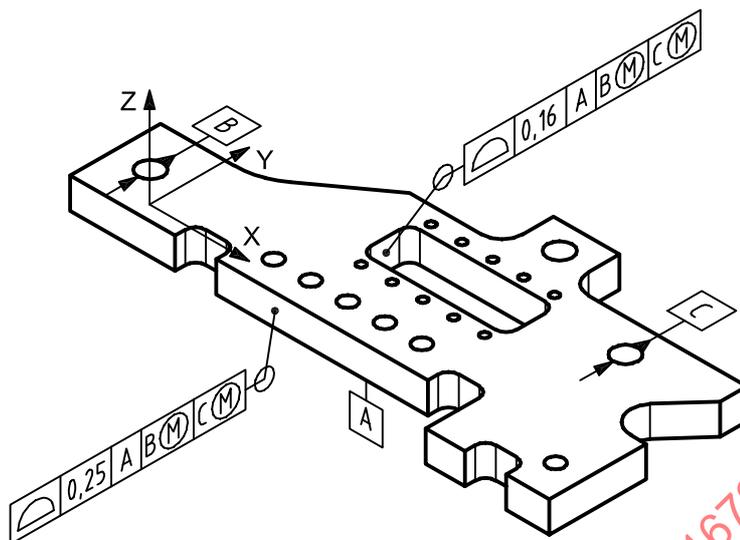
b) Tolerance associativity

Key

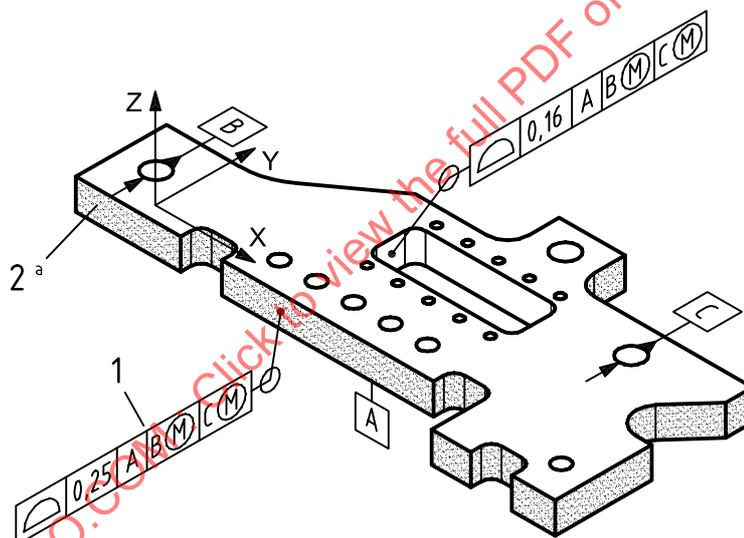
- 1 query
- 2 visual response

^a All surfaces residing between lines J and T.

Figure 53 — Profile — Between basis



a) Placement and attachment



b) Tolerance associativity

Figure 54 — Profile — All-around application

