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Production and General Engineering Department		http://www.bis.org.in Email pgd@bis.org,in

प्रलेख प्रेषण संज्ञापन/DOCUMENT DESPATCH ADVICE

संदर्भ /Ref. पीजीडी/PGD 24/T-24(1570) दिनांक/Date 02/12/2014

तकनीकी समिति/TECHNICAL COMMITTEE: आरेखण विषय समिति, पीजीडी 24 Drawing Sectional Committee, PGD 24

सभी सदस्य /

1. कउत्पादन एवं सामान्य इंजीनियरिंग विभागीय परिषद (Production and General Engineering Division Council

ख (आरेखण विषय समिति, पीजीडी 24 Drawing Sectional Committee, PGD 24

2. रूचि रखने वाले अन्य सदस्य Other Interested Members

Dear Sir(s),

कृपया आरेखण विषय समिति, पीजीडी 24 द्वारा तैयार किये गये निम्नलिखित संलग्न प्रलेख प्राप्त करें/Please find enclosed the following documents prepared by the Metal Drawing Sectional Committee, PGD 24:

प्रलेख संख्या/DOCUMENT NO.	शीर्षक/TITLE
पीजीडी/PGD 24(1570)	**राष्ट्रीय ड्राइंग संहिता NATIONAL DRAWING CODE** ENGINEERING DRAWING PRACTICES FOR EDUCATIONAL/ INDUSTRIAL PURPOSES (Guidelines for preparing Drawings) (Second Revision of SP 46:2003)

कृपया इन प्रलेखों का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजें कि अंततयदि यह : मानक के रूप में प्रकाशित हो जाए तो इस पर अमल करने में आपके व्यवसाय अथवा कारोबार में क्या कठिनाईयाँ आ सकती हैं/Kindly examine the draft standards and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

सम्मतियाँ भेजने की अंतिम तिथि/Last date for comments: **15.02.2015**

यदि आपकी कोई सम्मति हो तो कृपया दिये गये प्रारूप में अद्योहस्ताक्षरी को उपरोक्त पते पर भेजें/Comments, if any, may please be made in the format as given in overleaf and mailed to the undersigned at the above address.

यदि आपकी कोई सम्मतियाँ प्राप्त नहीं होती हैं या केवल सम्पादकीय सम्मतियाँ प्राप्त होती हैं तो हमें उपरोक्त प्रस्ताव को भारतीय मानक के अंतमित रूप से अधिग्रहण करने की आपकी सहमति मान लेने की अनुमति दें। परंतु यदि हमें तकनीकी सम्मतियाँ प्राप्त होती हैं तब या तो वे विषय समिति के अध्यक्ष से परामर्श पश्चात भारतीय मानक के अंतमित रूप में पारित कर अधिग्रहित किया जाएगा अथवा उनकी इच्छानुसार आवश्यक कार्यवाही हेतु विशय समिति के विचारार्थ भेजा जाएगा /In case, no comments are received or comments received are of editorial nature, you will kindly permit us to presume your approval for the above document as finalized for adoption as Indian Standard. However, in case of comments of technical in nature are received then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee.

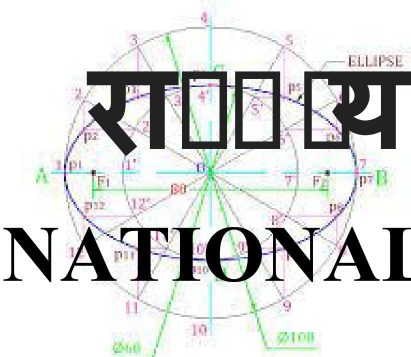
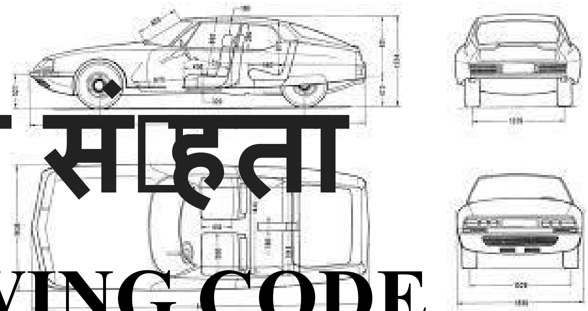
धन्यवाद/Thanking you

भवदीय/Yours faithfully,

sd/02.12.2014

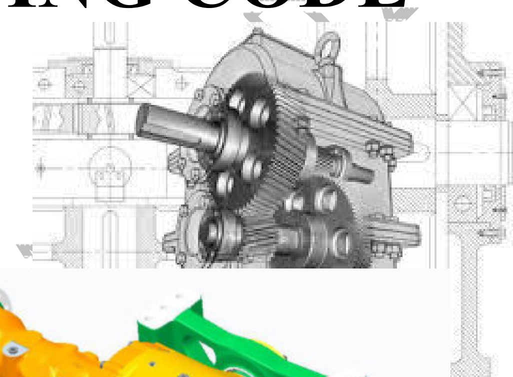
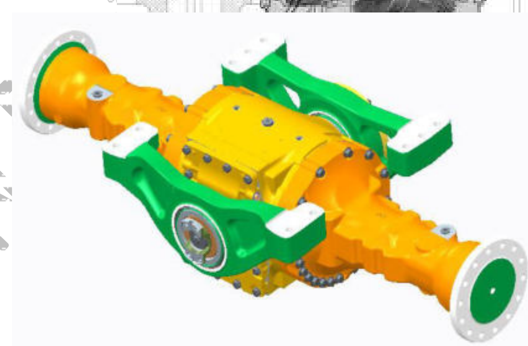
संलग्न/Encls.: उपरोक्त/As above.

(**राजपाल RAJPAL**)
प्रमुख /Head (पीजीडी/PGD)
Email: hpgd@bis.org.in
Telefax: 011-23234819

राष्ट्रीय ड्राइंग संहिता

NATIONAL DRAWING CODE

मानकः पथप्रदर्शकः

भारतीय मानक ब्यूरो

BUREAU of INDIAN STANDARDS

ENGINEERING DRAWING PRACTICES FOR EDUCATIONAL/INDUSTRIAL PURPOSES

(Guidelines for preparing Drawings)

SP 46
(Second Revision)

Bureau of Indian Standards

CONTENTS

Drawing Sectional Committee, PGD 24

FOREWORD

This Indian Standard (second revision) will be adopted by the Bureau of Indian Standards, after the draft finalized by the Drawing Sectional Committee and approved by the Production and General Engineering Division Council**.**

In all the three types of exchange like exchange of goods, exchange of services and exchange of information, technical drawings form an essential component. Exchange of goods of technical nature in national and international trade nearly always need to be accompanied by service diagrams, or other technical drawings illustrating the components, their assembly and their use.

Exchange of services may involve, for example, consultancy work or the design of an assembly in one unit for construction in another. In such cases, the technical drawing is an important way of communicating instructions or advice. In exchange of information, especially where different languages are involved, the technical drawings can clarify ambiguities or help to resolve problems in communicating by spoken or written word across languages barriers.

This standard specifies the drawing codes to be used in the Engineering Drawing and will base in preparing any kind of engineering drawing.

This Indian Standard was first published in 1988 and revised in 2003. This revision has been take up to incorporate feedback gained through experience and other developments taken at national and international level in this field.

This publication is not intended to be a replacement for the complete standards on technical drawings and any parts omitted from this publication should not be considered as less important to the engineering profession than those included. It is expected that educational institutions will have complete set of Indian Standards accessible in technical drawing classes. Where there are no corresponding Indian Standards for the International Standards referred on this Special Publication, reference to the relevant International Standards maybe made.

The composition of the Committee responsible for the formulation of this special publication is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ꞉Rules for rounding off numerical values (*revised*)˘. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Drawing Sectional Committee, PGD 24

Organization	*Representative(s)*
Indian Institute of Technology, Delhi	DR S. R. KALE (***Chairman***)
Bharat Heavy Electricals Limited, Bhopal	SH S. G. BOKADE
	SH A. DEOTA (*Alternate*)
Bosch Limited, Bangalore	SH MURTHY
	SH SUBHRAMANAYAM (*Alternate*)
Directorate of Quality Assurance (E), CQAE, Pune	SH N. SARVANA
Engineers India Limited, New Delhi	SH A. T. DHARMIK
Institution of Engineers (India), New Delhi	SH R. C. BAIRATHI
	SH D. GILL (*Alternate*)
Ministry of Defence, R & DE(Engineers), Pune	SH R. G. GABHALE
	SH B. N. BORADE (*Alternate*)
RITES Limited	SMT A. D. KAUL
	SH R. K. DAYAL (*Alternate*)
John Deere India Pvt Ltd	SH N. BAULASKAR
National Institute of Technology, Tiruchirappally	DR S. KUMANAN
In personal Capacity – Tiruchirapalli	DR R. VASUDEVAN
BIS Directorate General	SHRI RAJPAL, Scientist 'F' and Head (PGD) [Representing Director General (*Ex-officio*)]

Member Secretary
SHRI TILAK RAJ
Scientist 'D' (PGD), BIS

The Panel for the Revision of SP 46

Organization	*Representative(s)*
Indian Institute of Technology, Delhi	DR S. R. KALE (***Convenor***)
In personal Capacity – Tiruchirapalli	DR R. VASUDEVAN
Bosch Limited, Bangalore	SH MURTHY
John Deere India Pvt Ltd	SH N. BAULASKAR
Bureau of Indian Standards	SHRI TILAK RAJ Scientist 'D' (PGD), BIS

SECTION 1 SIZES AND LAYOUT OF DRAWING SHEETS

[Based on IS 10711: 2014/1S0 5457:1999 and IS11665: 2014/1S0 7200:2004]

1.1 Scope

This section specifies sizes of pre-printed (*pre-printed implies templates used by Software or individual drawing sheets*) drawing sheets and drawings made *with CAD or other Drawing Software's* for use with all technical drawings in any field of engineering viz Products/Services covered by Medical/Mechanical/Aeronautical/ Marine/Architectural /Structural/ Electrical/Civil / Agricultural etc or any Engineered Components/Systems/Assembly/Sub-assembly.

1.2 Basic Principles

The basic principles involved in arriving at the sizes of the rectangle of sides x and y are:

a) x : y = 1 : Ŧ2
b) y/2 : x = 1 : Ŧ2
c) xy = 1 sq metre which gives x = 0.841 m and y = 1.189 m

(this sizes are for trimmed sheet only)

1.3 Designation of Sizes

1.3.1 *Sizes Series* lSO-A The preferred sizes of the trimmed sheets as selected from the main ISO-A Series are given in Table 1.1.

Table 1.1 Sizes Series ISO-A
(*Clauses* 1.3.1 and 1.4)
All dimensions are in millimetres

Designation	Figure	Trimmed Sheet (T)		Drawing Space		Untrimmed Sheet (U)	
		a1	b1	a2	b2	a3	b3
A0	1.4	841	1189	821	1159	880	1230
A1	1.4	594	841	574	811	625	880
A2	1.4	420	594	400	564	450	625
A3	1.4	297	420	277	390	330	450
A4	1.4	210	297	190	267	240	330
A4	1.5	210	297	180	277	240	330

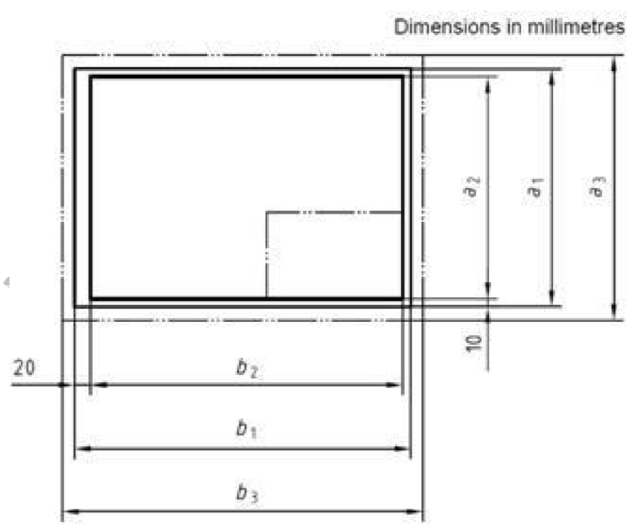


FIG 1.1 Size A4 to A0
(positioned horizontally)

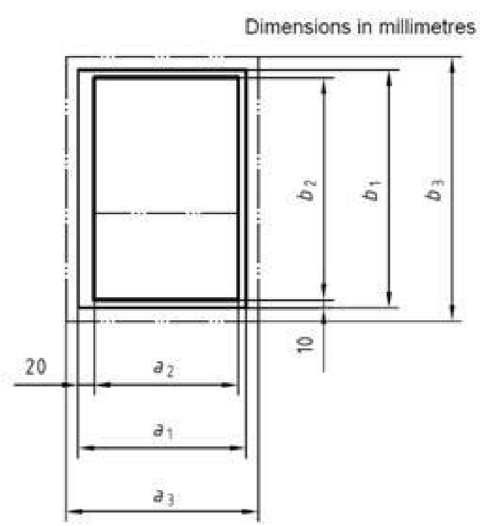


FIG 1.2 Size A4
(positioned vertically)

1.3.2 *Elongated Sizes*

Elongated sizes should be avoided. In case elongated sizes are needed, these are formed by combination of the dimensions of the short side of an A-size with the dimensions of the long side of another larger A-size.
for examples size A3.1 in Fig 1.3 denotes vertical dimension of A3 size and width of A1 size; the result is a new size with the abbreviation A3.1.

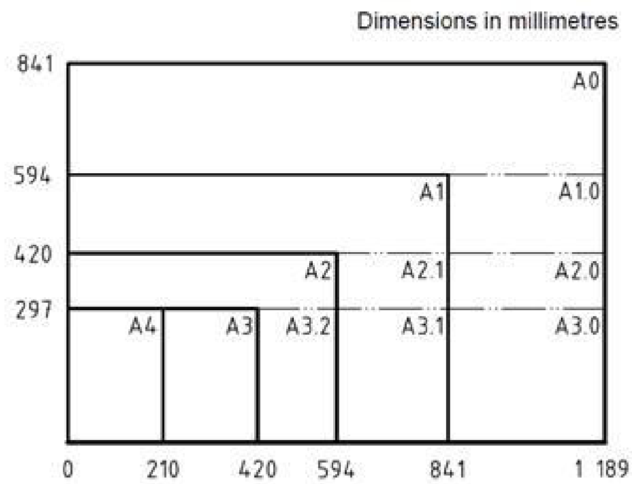


FIG 1.3 Size Sytem overview

1.4 Selection of Sizes

The original drawing should be made on the smallest sheet permitting the necessary clarity and resolution. The choice of sizes of the original drawing and its reproduction shall be made from the series shown in Tables 1.1. All Drawing sheets shall be used with their longer sides positioned horizontally (see Fig. 1.1) only; Except A-4 size may be used Positioned Vertically also (See Fig 1.2). The general features of a drawing sheet is as shown in Fig. 1.3.

1.5 Title Block

The Title Block information is important information about the ownership/Intellectual Property /design /processes /material and other related information including propertier/patented information

1.5.1 *Terms and definitions*

1.5.1.1 *Classification*
Method of structuring a defined type of item (objects or documents) into classes and subclasses in accordance with their characteristics

1.5.1.2 *Data Field*
Bounded area used for a specific category of data

1.5.1.3 *Data Transfer*
Moving of data from one computer process to another in an ordered form

1.5.1.4 *Segment*
Fixed portion of a document, sharing the identification number with the other portions, but individually presented and stored

1.5.1.5 *Sheet*
Segment of a technical drawing

1.5.1.6 *Page*
Portion in a low-level physical substructure of a document, providing a presentation-dependent division of the document content (primarily applied in the context of a text-based document)

1.6 Data fields in the title block

1.6.1 *Identifying data fields* – The data field identification as per the 1.6.1.1 to 1.6.1.8

1.6.1.1 *General*
The identifying data fields in the title block shall be in accordance with Table 1.2 and below sub clauses.

Table 1.2 — Identifying data fields in the title block
(Clause No. 1.6.1.1)

Subclause	Field name	Language-dependent	Recommended number of characters	Obligation
1.6.1.2	Legal owner	-	Unspecified	M
1.6.1.3	Identification/drawing/part	No	16	M
	number	No		
1.6.1.4	Revision index	No	2	M
1.6.1.5	Date of issue	No	10	M
1.6.1.6	Segment/sheet number	No	4	M
1.6.1.7	Number of segments/sheets	No	4	O
1.6 .1.8	Language code	No	4 per language	O
M Mandatory O Optional				

1.6.1.2 *Legal owner*
The name of the legal owner of the document, e.g. firm, company, enterprise. It could be the official owner˘s name, an abridged trade name or a logotype for the presentation.

1.6.1.3 *Identification/Drawing/Part number*
The document identification number is used as the reference to the document. The identification number shall be unique ˊ at least within the organization of the legal owner.

1.6.1.4 *Revision index*
The revision index identifies the revision status of the document. Different versions are numbered in consecutive order by means of, e.g. a letter or letter combination A to Z, then AA, AB, AC ... or Figures 1, 2, 3 ... The letters I and O should be avoided because they are easily confused with the digits 1 and 0. Alternatively, the date of issue field only may be used. In marking the revision index, the revision date and person effecting the change should also be indicated.

1.6.1.5 *Date of issue*
The date of issue is the date on which the document is officially released for the first time, and that of every subsequent released version. It is when the document is made available for its intended use. The date of issue is important for legal reasons, e.g. patent rights, traceability.

1.6.1.6 *Segment/sheet number*
The segment/sheet number identifies the segment or sheet.

NOTE – As needed, the contents of a document can be divided into fixed portions, called segments. In the case of technical drawings, these segments are called sheets.

1.6.1.7 *Number of segments/sheets*
This is the total number of segments or sheets of which the document consists.

1.6.1.8 *Language code*
The language code is used to indicate the language in which the language-dependent parts of the document are presented. It controls the print-out of the document and administration of the different language versions when required. Whenever possible, documents should be presented in single-language versions. However, in a multilingual document, the language codes shall be separated with an appropriate sign.

1.6.2 *Descriptive data fields* – The data field description given from 1.6.2.1 to 1.6.2.3

1.6.2.1 *General*
The descriptive data fields in the title block shall be in accordance with Table 1.3 and 1.6.2.2 and 1.6.2.3.

Table 1.3 — Descriptive data fields in the title block
(*Clause 1.6.2.1*)

Subclause	Field name	Language-dependent	Recommended number of characters	Obligation
1.6.2.2	Title	Yes	25/30[a]	M
1.6.2.3	Supplementary title	Yes	2x25/30 [a]	O
M Mandatory O Optional				
[a] 30 to support two-byte-character languages such as Japanese or Chinese.				

1.6.2.2 *Title*
The title refers to the content of the document. More detailed information, e.g. regarding origin, adaptation to market, standard or environmental conditions, or information on erection direction or position, may be given in the supplementary title (*see* 5.2.3). Titles that limit a part to a particular use or application should be avoided.

The title should be chosen from established terms, such as those given in international or national standards, company standards, or according to practice within the area of application. Consistent descriptions facilitate efficient searching and retrieval using the title field. Abbreviations should be avoided.

Example `Apparatus plate_.

1.6.2.3 *Supplementary Title*
The supplementary title field may be used to give further information on the object, when needed. When indicating information in this field, it shall be taken into consideration that in some cases only the title field is to be presented. Abbreviations should be avoided.

Example `Complete with brackets_.

1.6.3 *Administrative data fields*

1.6.3.1 *General*

The administrative data fields in the title block shall be in accordance with Table 1.4 and 1.6.3.2 to 1.6.3.11. For administrative reasons, in product data management systems (PDM) etc., data fields such as creator and approval person may be shown in a separate document part, e.g. description of revision.

Table 1.4 — Administrative data fields in the title block

(Clause no 1.6.3.1)

Subclause	Field name	Language-dependent	Recommended number of characters	Obligation
1.6.3.2	Responsible department	No/Yes [a]	10	O
1.6.3.3	Technical reference	No/Yes [a]	20	O
1.6.3.4	Approval person	No/Yes [a]	20	M
1.6.3.5	Creator	No/Yes [a]	20	M
1.6.3.6	Document type	Yes	30	O
1.6.3.7	Classification/key words	No/Yes [a]	Unspecified	O
1.6.3.8	Document status	Yes	20	O
1.6.3.9	Page number	No	4	O
1.6.3.10	0 Number of pages	No	4	O
1.6.3.11	Paper size	No	4	O
M Mandatory O Optional				
[a] `Yes_ to support presentation in different types of alphabet.				

1.6.3.2 *Responsible department*

The name or code for the organizational unit responsible for the contents and maintenance of the document at the date of release.

1.6.3.3 *Technical reference*

The name of the person having sufficient knowledge of the technical contents of the document to be named as the contact person and who will answer, coordinate and act on queries. Even if a consultant prepares the document, the technical reference shall be a person within the legal owners organization. The name of the technical reference may be kept up to date without formal rules for revision.

1.6.3.4 *Approval person*

The name of the person who approved the document. The document might have been checked by a number of different specialists in accordance with the local rules for that type of document, specific project etc. The names of such specialists may be indicated in the title block or in a separate document part.

1.6.3.5 *Creator*

The creator/Originator is the person who has prepared the drawing for the first time.

1.6.3.6 *Document type*

The document type field indicates the role of the document with respect to its content of information and representation format. It is one of the main ways in which searches for documents can be made.

1.6.3.7 *Classification/key words*

The text or code to categorize the contents of the document used for retrieval.

1.6.3.8 *Document status*

The document status indicates where the document is in its life cycle. The status is indicated by means of terms such as `In preparation_, `Under approval_, `Released_ and `Withdrawn_.

1.6.3.9 *Page number*
The page number is usually generated by the presentation system.

1.6.3.10 *Number of pages*
The number of pages is dependent on the presentation format used, e.g. text font, paper size and character size.

1.6.3.11 *Paper size*
The size of the form for the original document, e.g. A4.

1.7 Title block arrangement

For examples of title block arrangements for use on drawings as well as text documents, *see* Fig 1.4 and 1.5. The total width is 180 mm to fit an A4 sheet, with the left margin being 20 mm and the right margin 10 mm. The same title block is used for all paper sizes.

<table>
<tr><td>Responsible Dept.
ABC 2</td><td>Technical Reference
Tilak Raj</td><td colspan="2">Document Type
Sub-assembly drawing</td><td colspan="4">Document status
Released</td></tr>
<tr><td rowspan="2">Legal owner</td><td>Created by
Narender Kumar</td><td rowspan="2">Title Supplementary Title
Apparatus plate complete with brackets</td><td colspan="5">BISABC229092014-5</td></tr>
<tr><td>Approved by
Rajpal</td><td colspan="2">Rev.
A</td><td>Date o f Issue
02.10.2014</td><td>Lang.
En.</td><td>Sheet
1/5</td></tr>
</table>

180 mm

FIG 1.4 ´ Title block in compact form ´ Provides maximum space for factual content of document

<table>
<tr><td>Responsible Dept.
ABC 2</td><td>Technical Reference
Tilak Raj</td><td>Created by
Narender Kumar</td><td colspan="3">Approved by
Rajpal</td><td colspan="3"></td></tr>
<tr><td colspan="2" rowspan="3">Legal owner</td><td colspan="2">Document Type
Sub-assembly drawing</td><td colspan="5">Document status
Released</td></tr>
<tr><td colspan="2" rowspan="2">Title Supplementary Title
Apparatus plate complete with brackets</td><td colspan="5">BISABC229092014-5</td></tr>
<tr><td>Rev.
A</td><td colspan="2">Date o f Issue
02.10.2014</td><td>Lang.
En.</td><td>Sheet
1/5</td></tr>
</table>

180 mm

FIG 1.5 ´ Title block with person name fields on additional line ´ Provides larger space for legal owner field and free area in upper right-hand corner for classification, key words, etc.

1.8 Centring marks

In order to facilitate positioning of the drawing when reproduced or microfilmed, four centring marks shall be provided. These marks are placed at the ends of the two axes of symmetry of the trimmed sheet with a symmetry tolerance of 1 mm. The form of the centring marks may be chosen freely. It is recommended to indicate them by continuous lines of 0.7 mm width, starting at the grid reference border and extending 10 mm beyond the drawing frame (*see* Fig. 1.6). Sizes greater than A0 require additional centring marks at the mid-point of each section to be filmed.

1.9 Grid References

1.9.1 *Grid reference system*
The sheets shall be divided into fields in order to permit easy location of details, additions, revisions, etc. on the drawing (*see* Fig 1.6).
The individual fields should be referenced from the top downwards with capital letters (I and O shall not be used) and from left to right with numerals figuring on both sides of the sheet. For the size A4, they are located only at the top and the right side. The size of letters and characters is 3.5 mm. The length of the grid shall be 50 mm, starting at the axes of symmetry of the trimmed size (centring marks). The number of fields depends on the size (*see* Table 1.5). The differences resulting from the division are added to the fields at the corners.
The letters and numerals shall be placed in the grid reference border, and are to be written in vertical characters according to ISO 3098-1. The grid reference system lines shall be executed with continuous lines of 0.35 mm width.

Table 1.5 — Number of fields
(Clause 1.9.1*)*

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

1.10 Trimming marks

In order to facilitate trimming of the sheets either by hand or automatically, trimming marks shall be provided in the borders of the four edges of the trimmed sheet. These marks are in the form of two overlapping rectangles with the dimensions 10 mm ´ 5 mm (*see* Fig 1.7).

1.11 Designation

The designation of a preprinted drawing sheet /software template shall consist of the following elements in the given order and this information may be printed typically at the outside of the border:

a) the description block (i.e. "Drawing sheet");
b) the number of the Indian Standard (i.e. IS 10711);
c) the designation of size (A4 to A0) as specified in Table 1.1 or Fig 1.4;
d) trimmed (T) or untrimmed (U) as specified in Table 1.1;
e) type of material:

- ¾ tracing paper (TP) 92,5 g/m2 or 112,5 g/m2, according to ISO 9961,
- ¾ opaque paper (OP) 60 g/m2 to 120 g/m2,
- ¾ draughting film with polyester base (PE) of thickness Ä 50 ≂m, according to ISO 9958-1,

f) printed frontside (F) or reverseside (R);
g) title block according to a pattern (TBL), if applicable.

Example
A preprinted drawing sheet according to IS 10711, of size A1, trimmed on tracing paper, with a mass per unit area of 112,5 g/m2, printed on the An abbreviated title block, containing only the identification zone, may be used for all sheets after the first sheet.

Drawing sheet IS 10711 - A1T - TP112,5 - R - TBL

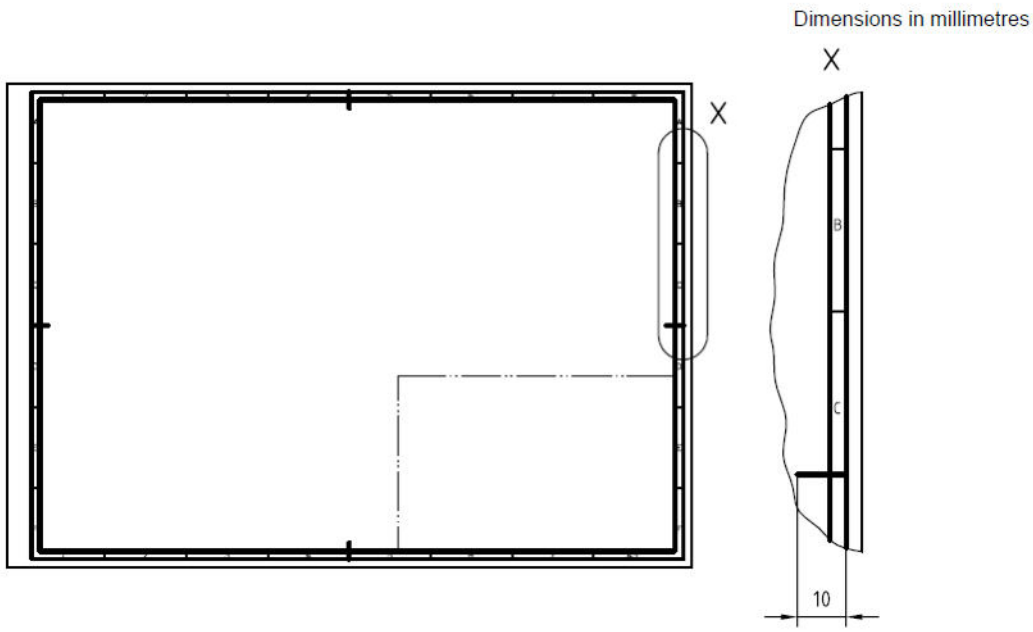


FIG 1.6 Grid reference system and centring marks

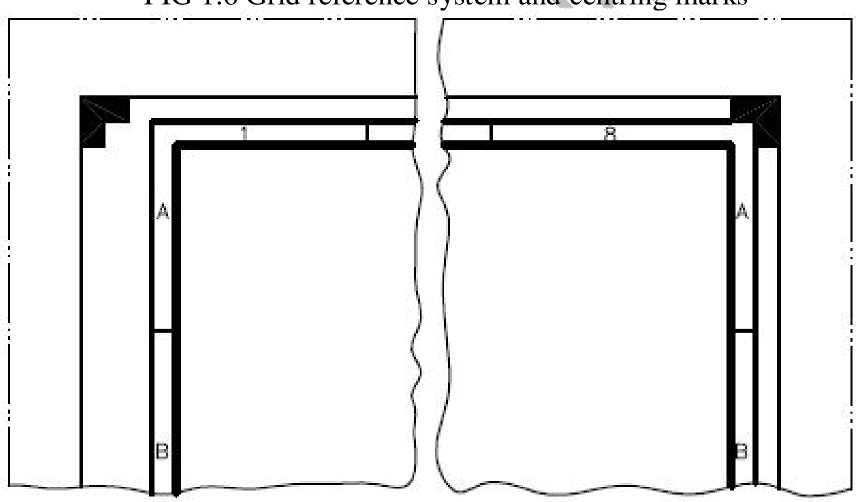


FIG 1.7 Trimming marks

EXAMPLE OF THE DRAWING SHEET

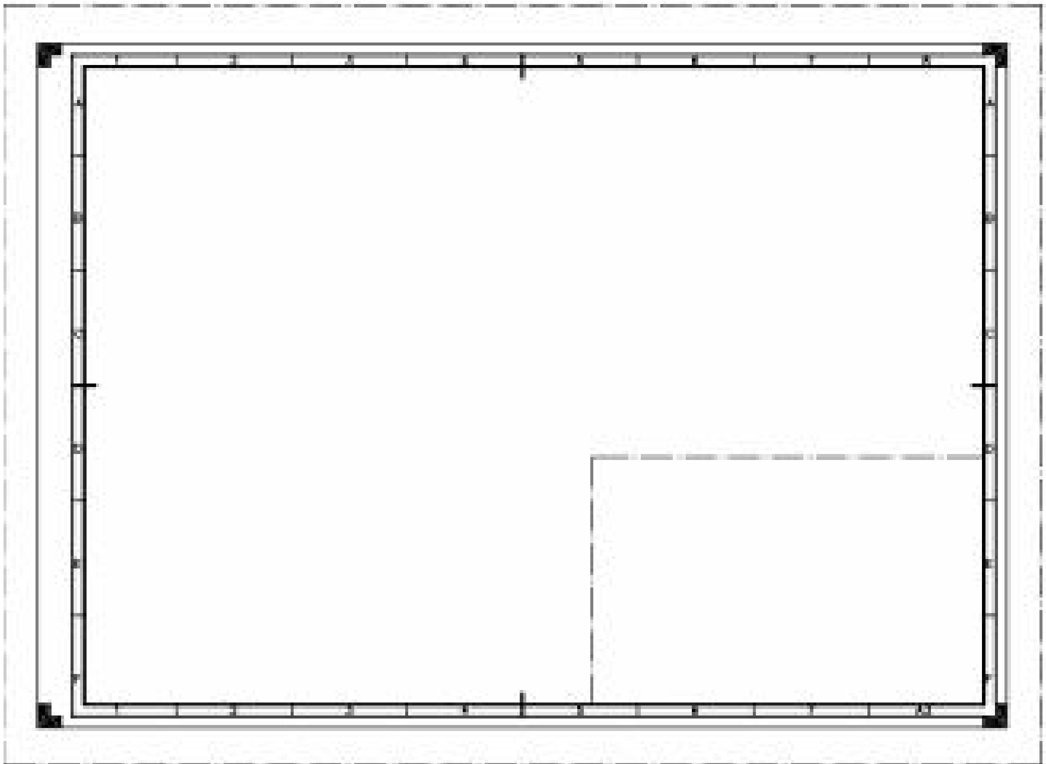


FIG. 1.8

SECTION 2
ITEM REFERENCES ON DRAWINGS AND ITEM LISTS
[Based on IS 10712: 2014/ISO 6433:2012 and IS 11666:2014/ISO 7573: 2008]

2.1 Scope

This section gives guidance and recommendations for the presentation of part references in assembly representations, e.g. on assembly drawings, in order to identify the constituent parts in a related parts list.

Further this section provides minimum requirements for parts lists to provide necessary information, e.g. for the production, procurement or maintenance of the parts. This International Standard covers manuals well as computer-generated parts lists

2.2 Part/List References

It is recommended that part references be assigned in sequential order. Identical parts shown in an assembly shall have the same part reference. Each complete sub‑assembly incorporated in the superior assembly is identified by a single part reference. All part references shall be shown in a parts list giving the appropriate information on the parts concerned.

The parts lists specify all constituents of an assembled part by part reference number, quantity, part number, technical data, etc. The association between the part on a parts list and its graphical representation on the drawing is given by an identification reference. This reference can be given by a part reference or the constituent part number.

2.3 Presentation

2.3.1 Preferably part references should consist of numerals only. If necessary, they may be augmented by the use of capital letters.
2.3.2 The design, dimensions and spacing of the characters shall comply with IS 9609 (Part 0).
2.3.3 It is recommended that the part reference number contain a maximum of three characters

2.4 Appearance

All part references on the same drawing shall be of the same type and have the same height of lettering. Either of the styles referred in Fig 2.1, 2.2 and 2.3 may be used.

They shall be clearly distinguishable from all other indications. This can be achieved for example by:

a) encircling the characters of each part reference (*see* Fig 2.1); in this case, the circles shall have the same diameter and be drawn with continuous narrow lines;
a) using characters of a larger height, for example twice the height as used for dimensioning, and similar indications (*see* Fig. 2.2 and 2.3).

2.5 Identical parts

Part references of identical parts should only be identified once, provided that there is no risk of ambiguity. For exceptions, see below:

The number of parts is specified in the parts list and should be avoided in connection to the part reference number on the drawing. For clarity, the same part reference number may need to be repeated at different locations. The number of parts at each location may also be needed. The part reference number shall then be encircled according to method a) in 4.2 and the indication of number of parts should follow general drawing rules. The number of parts shall be indicated along with the symbol `×_ in accordance *See* Fig. 2.4

When the number of parts is indicated for several part references using a common leader line, method as per clause 2.7 shall be used. *See* Fig. 2.5

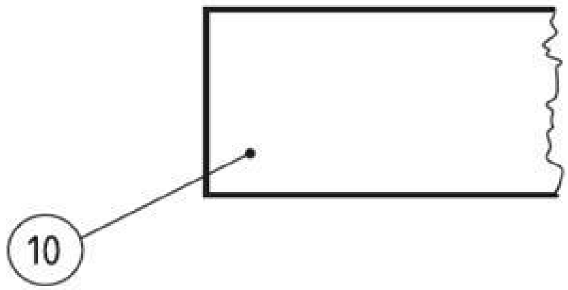


FIG 2.1 ˉ Encircled part reference number
(the dot(.) represents the leader line attached to the surface of the parts)

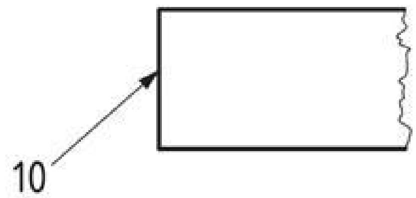


FIG 2.2 ˉ Part reference number written with larger character height
(the arrow represents the leader line attached to the edge of the parts)

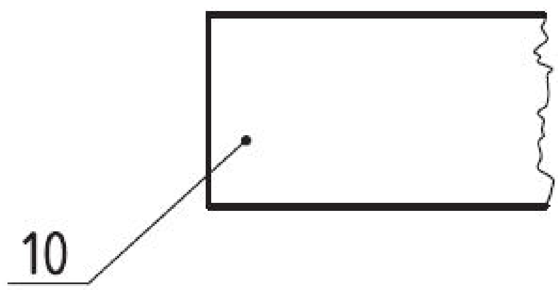


FIG 2.3 Alternative method of indication
(the dot(.) represents the leader line attached to the surface of the parts)

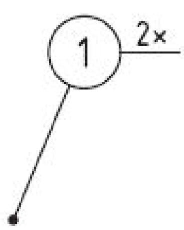


FIG 2.4 Part reference shown with number of parts
(2x implies 2 parts)

Example 1 Example 2

FIG 2.5 ‑ Indication of number of parts for several part references with common leader line

2.6 Location

Part references shall be placed outside the outlines of the parts concerned. The part reference should be connected to its associated part by a leader line (*see* Fig 2.1, 2.2 and 2.3), the termination of which shall comply with 10714 (Part 22). Leader lines shall not intersect. They should be kept as short as practicable and should preferably be drawn at an angle to the part reference. In the case of encircled-part references, the leader Iine shall be directed towards the centre of the circle.

2.7 Positioning

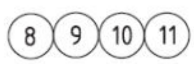
For the sake of clarity and legibility of a drawing, part references should preferably be arranged in horizontal rows and/or vertical columns (*see* Fig 2.6). When several part references use a common leader line, they may be arranged horizontally according to one of following methods illustrating four part references (8, 9, 10 and 11).

NOTE Method a) can also be arranged vertically.

Methods:

a) 8 9 10 11 (Circling each number)
b) 8 ‑ 9 - 10 - 11

a)



b) 8-9-10-11

The parts list may be included on the drawing itself or be a separate document (*see* Annex A). When issuing the parts list as a separate document, the title block may be located in the lower or the upper margin of the document. If the parts list is a separate document, the sheet sizes shall be chosen in accordance with IS 10711 : 2001.

The reading direction of the parts list shall correspond to that of the title block. The list may be in conjunction with the title block *(see* IS 11665 : 2009) or be placed elsewhere. Its outlines shall be drawn with continuous lines.

When the parts list is located in conjunction with the title block, the parts list table header shall be in direct connection with the title block (*see* Fig 2.7). When the parts list table is located elsewhere on the document, the table header may be placed in the top or in the bottom of the table (*see* IS 10714 (Part 20) : 1996).

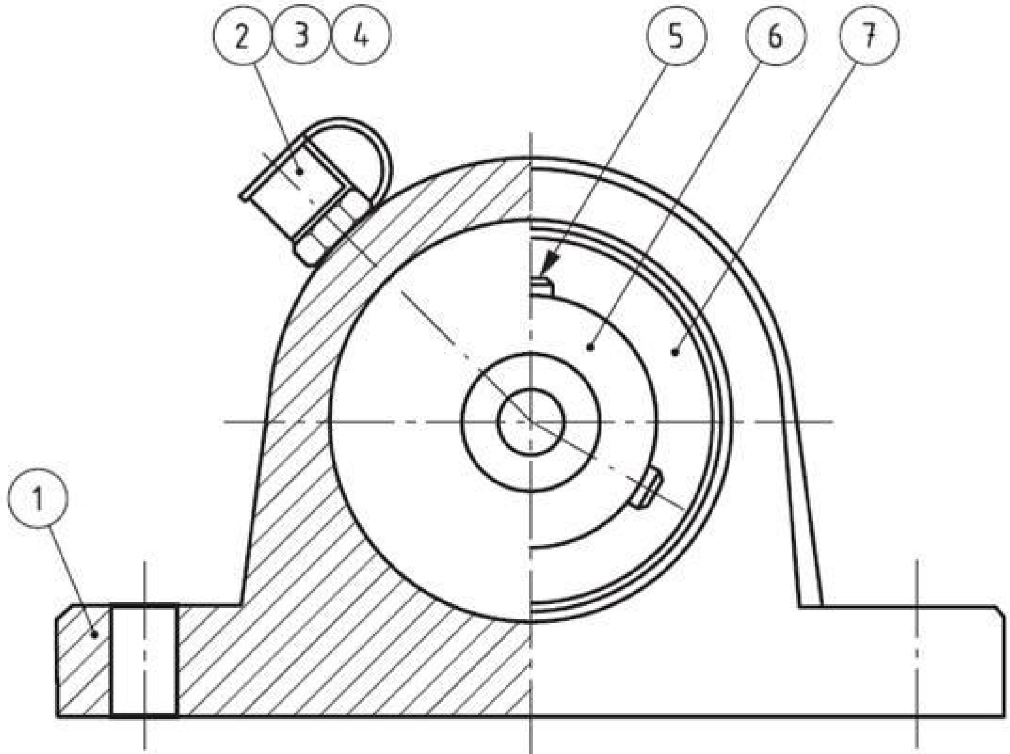


FIG 2.6 Use of part references on an assembly drawing

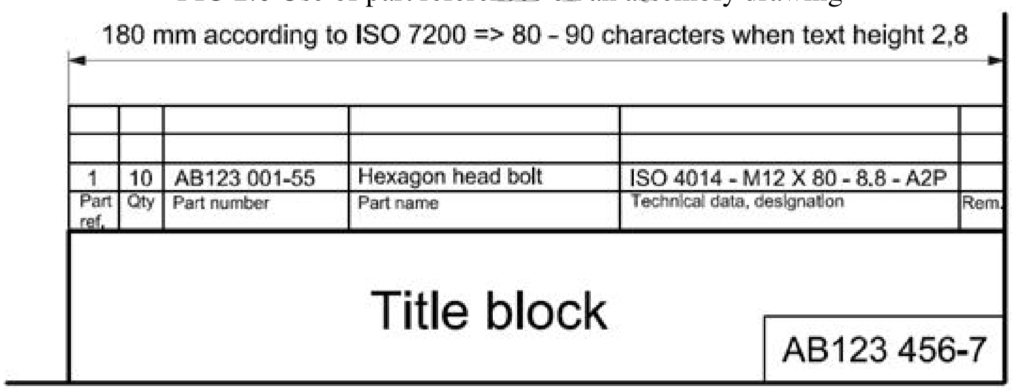


FIG 2.7 Part lists combined with a title block which is located at the lower margin of the document

2.8 Related parts

Part references of related parts, e.g. screw, washer and nut, may be identified by a common leader Iine (*see* Fig 2.6, parts 2.2, 2.3 and 2.6).

2.9 Numbering sequence

A distinct sequence for numbering should be adopted:

- according to the possible order of assembly;
- according to the importance of the component parts (sub-assemblies, major parts, minor parts, etc.);
- according to any other logical sequence.

2.10 Data fields for parts lists

2.10.1 *General*

The parts list data fields specified below are intended to cover the general use of parts lists.
The parts list shall be arranged in columns by means of continuous lines to allow information to be entered
under the following headings:

- part reference;
- quantity;
- unit;
- reference designation;
- part number;
- part name;
- technical data, designation;
- remarks.

The sequence of the columns is optional.

Part ref.	Qty	Unit	Reference designation	Part number	Part name	Technical data, designation	Remarks
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

FIG 2.8 ‾ Example of arrangement of columns in the part list

The data fields are optional, but at least one identifying element is needed.

NOTE -- When additional data fields are required for special needs within a company, it is possible to add or replace columns.

2.10.2 *Part reference*
Part references are assigned to component parts or material of assemblies. The purpose of the part references is to link the parts on the drawing to the parts in the parts list. Identical parts on a drawing are required to have the same part reference. If no part references are used on the drawing, this field can be left blank or the column can be omitted.

2.10.3 *Quantity*
The quantity expresses the number of parts or the amount of material necessary for one specific assembly. The number entered in this column shall denote pieces, volume, length, or other quantities required. When this number applies to quantities other than pieces, enter the unit of measure in the unit column or in the combined column for quantity and unit.

When the exact amount of an item is not known, one of the following methods may be used:

a) enter `AR_ (as required) with no expression of amount;

b) enter the numerical amount with `EST_ (estimated) in the unit column or in the combined column forquantity and unit.

NOTE -- If needed, the abbreviations can be explained on the parts list.

2.10.4 *Unit*
The unit is an entity adopted as the basis or standard of measurement. If the unit is `piece_, this field can beleft blank.

2.10.5 *Reference designation*
The reference designation is a unique constituent identifier of each occurrence of a part or material.

NOTE -- Consequently, if several identical parts are used, they will have different reference designations.

2.10.6 *Part number*
The part number is a unique identification of a part or material for a particular organization. If the part number is international, national, etc., it should be included in the column `technical data, designation_. A part shall be identified in the parts list by `part number_, `technical data, designation_ or a combination of these two fields. If the reference designation is used, this shall also be included as an identifier.

2.10.7 *Part name*
The part name is a text designation of a part or a material.

2.10.8 *Technical data, designation*
The technical data and/or designation is an indication by word(s) or sign(s). This can include dimensions, material, performance figures or other characteristics, manufacturer designation or designation according to any applicable standard.

A part shall be identified in the parts list by `part number_, `technical data, designation_, or a combination of these two fields. If the reference designation is used, this shall also be included as an identifier.

2.10.9 *Remarks*
The remarks can provide any additional information that may be required. If the column does not have enough space for this information, a reference to a note may be entered in the column. The note is then given elsewhere on the parts list or the drawing (when the parts list is included on the drawing).

2.11 EXAMPLES

2.11.1 *Example of the Part reference*

An example of the application of part references for an assembly is given in Fig. 2.6.

2.11.2 *An example of a parts list in connection with the title block*

In Fig 2.7, the character height 2,8 mm has been used for the factual content.

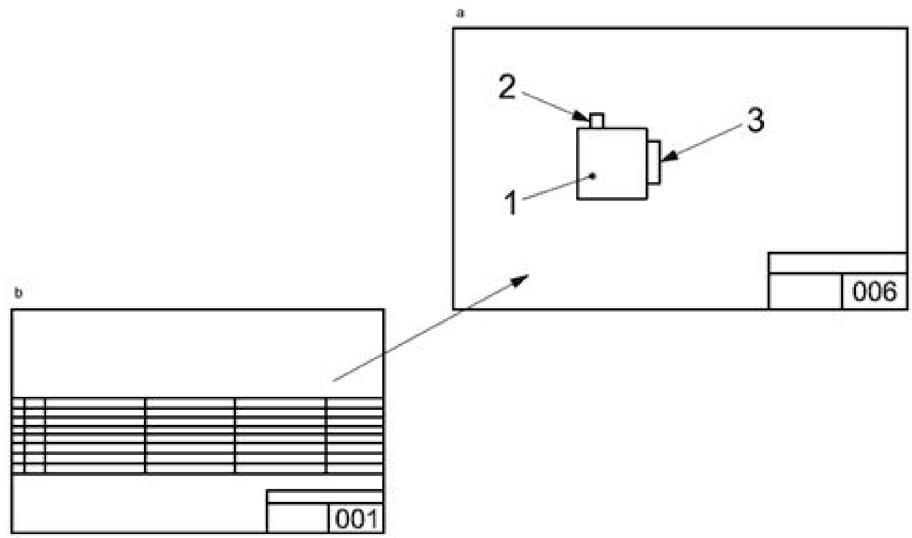
2.11.3 *An example of the column layout in a parts list*
See Fig 2.9

Part ref.	Qty	Unit	Reference designation	Part number	Part name	Technical data, designation	Remarks
1	1			AB123 001-55	Apparaturs plate		
2	1			AB123 001-56	Front plate		
3	2			AB123 001-57	Side plate	ISO 14583 - M5 x 16 - 8,8 - A2F	
4	6			AB123 009-68	Torx pan head screw	ISO 4017 - M8 x 25 - 8.8 - A2F	
5	2			AB123 009-52	Hexagon head screw	ISO 4032 - M8 - 8 - AF	
6	2			AB123 009-27	Hexagon nut		
7	1			AB123 009-95	Label		Marked: AB123 456-1

FIG 2.9 Parts list header with example of use

2.11.4 *An example of a parts list and an assembly drawing as separate documents*

In this example, the assembly drawing is free for cross-use and for re-use for future similar variants (see Fig 2.10).



a Assembly drawing.
b Parts list.

FIG 2.10 Parts list and assembly drawing as seprate documents

2.11.5 *Examples of a parts list and an assembly drawing as one document*

2.11.5.1 *Presented on several drawing sheets*

See Fig 2.11.

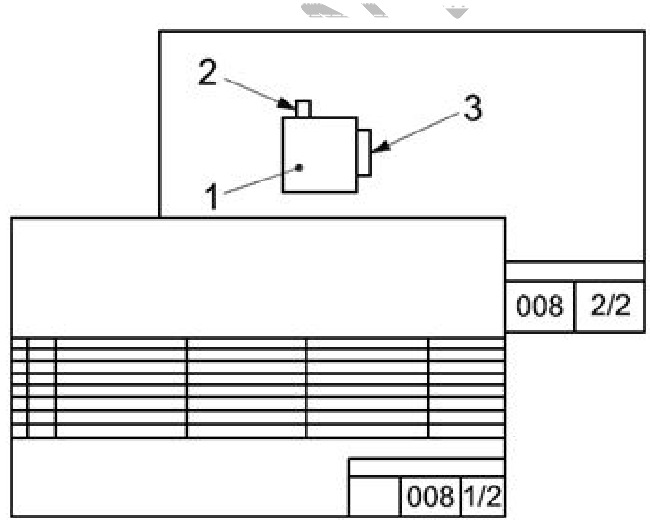


FIG 2.11 Parts lists and assembly drawing as one document, but different sheets

2.11.5.2 *Presented on one drawing sheet*
See Figure 2.12.

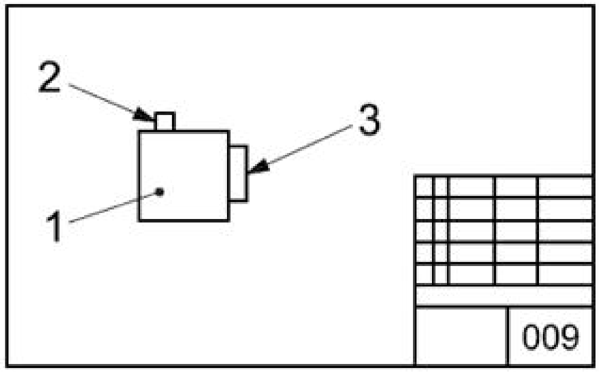


FIG 2.12 Parts list and assembly drawing as one sheet document

SECTION 3 PLANNING OF ASSEMBLY DRAWINGS

3.1 Scope

This section covers the requirements of planning of assembly drawings.

3.2 Where a number of drawings are required to detail a complete design, an assembly drawing is necessary. Such a drawing will show the design to a convenient scale, and the drawing or part numbers which are the constituents of the particular assembly are listed in a tabular form as shown in Fig. 2.1 and Table 2.1

3.3 A method, applicable to general engineering drawings and also structural drawings is to include on each individual drawing sheet of a series of drawings, a small key plan or elevation or both, conveniently placed near the title block, indicating part of the whole work in continuous wide lines to which the particular drawing sheet refers (see Fig. 3.1).

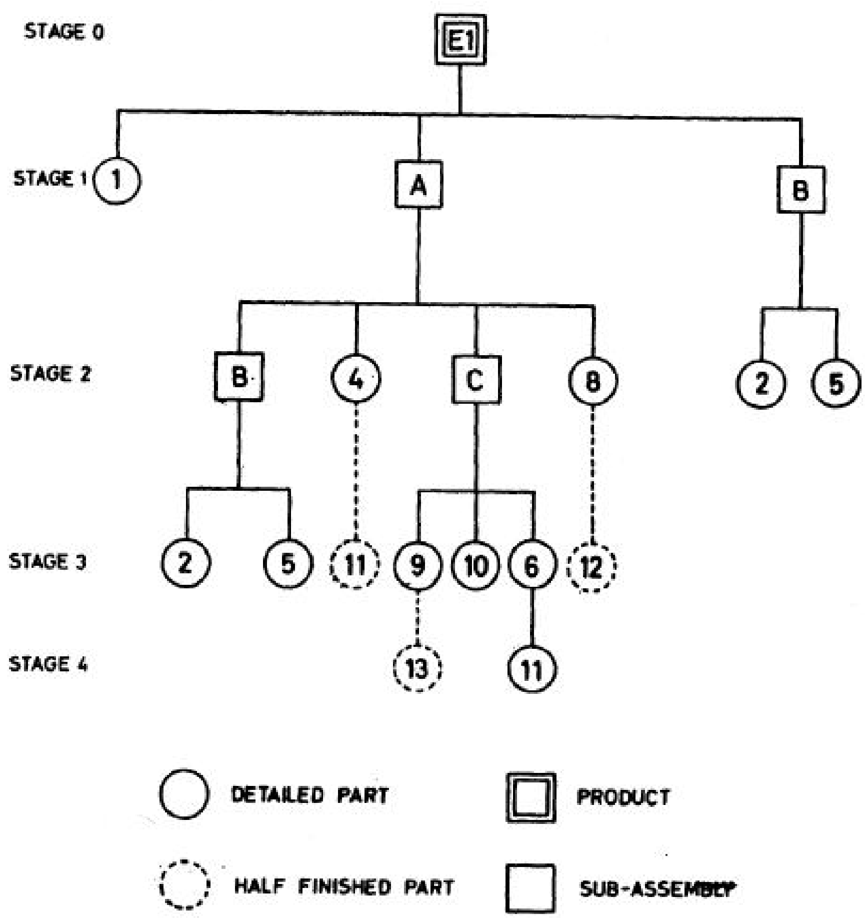


FIG. 3.1

3.4 The general assembly drawing rnay be broken into further sub-assemblies and parts, determined mainly by. .production requirements. A typical chart showing the breakdown of such assembly drawing is shown in Fig. *3.2.*

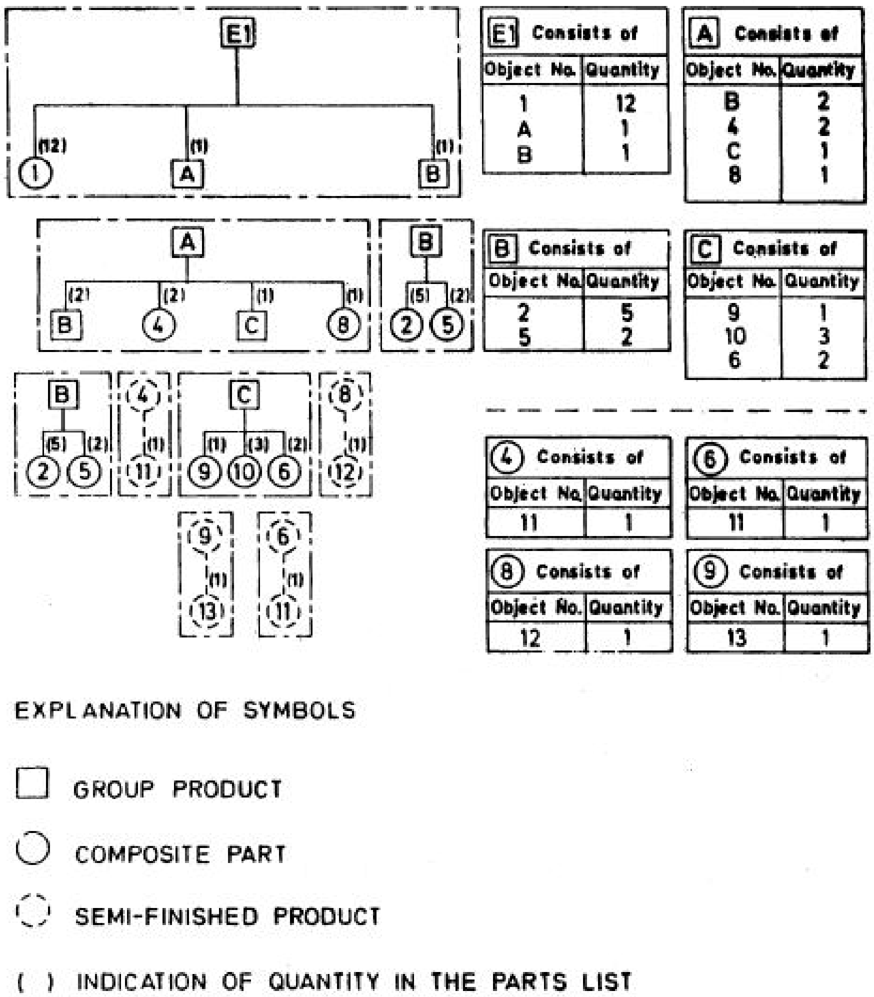


FIG. 3.2

3.5 In general, the detailed view shown in, an assembly drawing should have the same orientation as that shown in the main assembly view.

SECTION 4 FOLDING DRAWING PRINTS SAVING OF CAD/CAM DRAWINGS

[Based on IS 11664: 1986]

4.1 Scope
This section covers two methods of folding of drawing prints in Hard Copy Formats. The section also covers the way to save and retrieve the CAD/CAM documents/drawings (finalized) in soft formats also.

4.1.1 The first method is intended for drawing prints to be filed or bound, while the second method is intended for prints to be kept individually in filing cabinet.

4.2 Basic Principles The basic principles in each of the above methods are to ensure that:

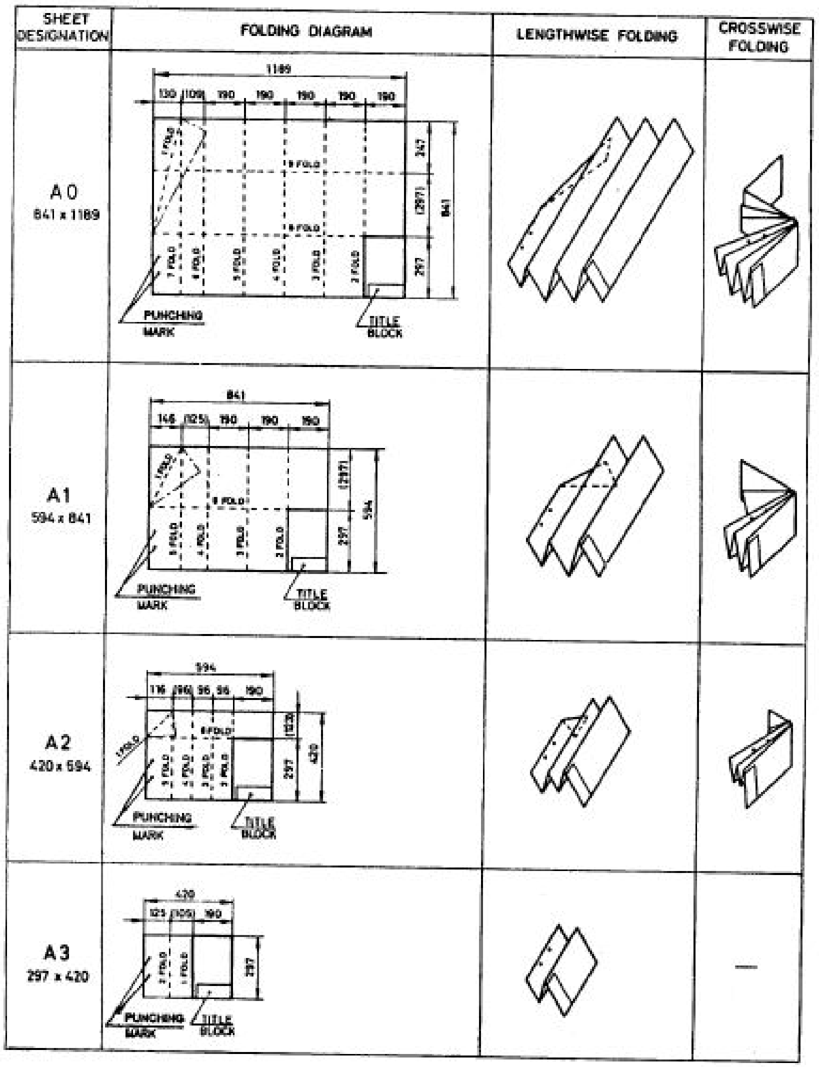
a) all large prints of sizes higher than A4 are folded to A4 sizes;
b) the title blocks of all the folded prints appear in topmost position; and
c) the bottom right corner shall be outermost visible section and shall have a width not less than 190 mm.

4.3 Depending on the method of folding adopted, suitable folding marks are to be introduced in the tracing sheets as guide.

4.4 Method of Folding of Drawing Prints
The methods recommended for folding are indicated`in Fig. 4.1 and 4.2

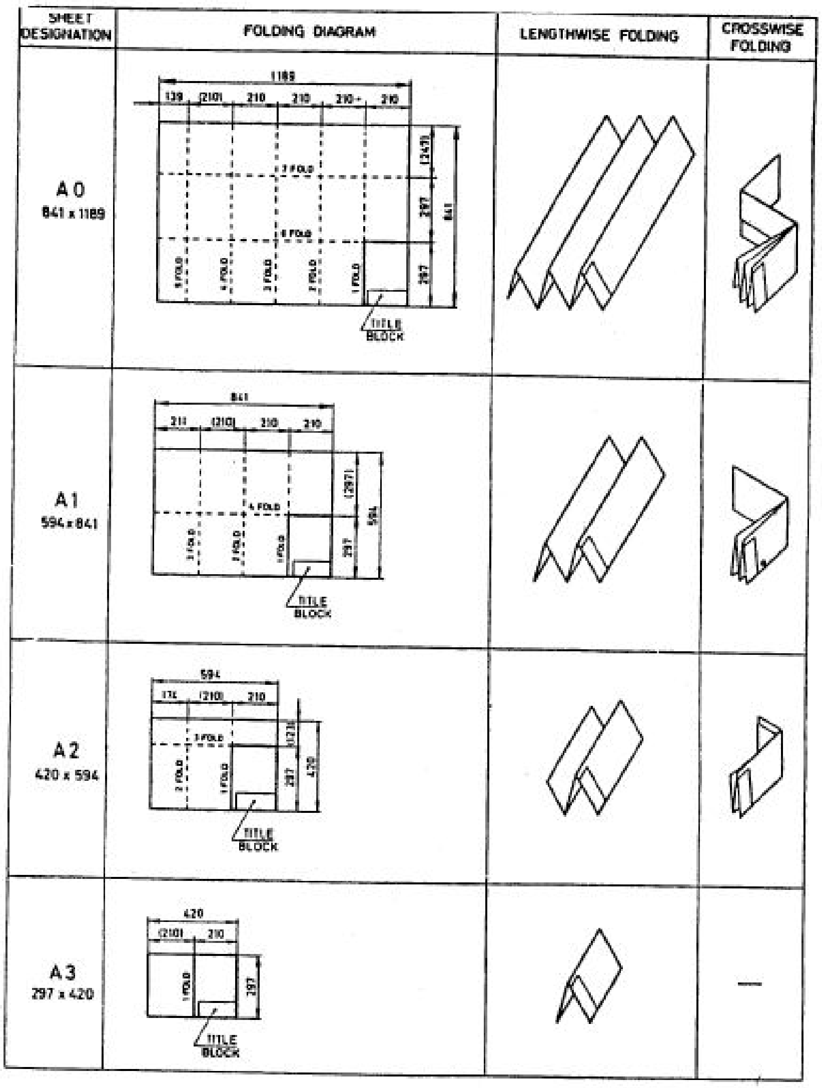
4.4 Saving the CAD/CAM Drawing in Soft Formats
In the present scenario the drawings are being produced in soft copies format also. The drawings made in CAD/CAM or other compatible software after finalization shall be securely saved in soft formats. The drawings/documents saved shall be non editable format and if the editing is required same may be save with new name duly incorporate the revision number. It is preferable the drawings made shall be duly secured and the soft format finalized drawing may be save in Cloud technology or external hard disc or available media as desired by the company/organization.
The format of file name shall be as per the requirement of the creator or company.
However, by default the file name may be saved as Company Name with place (initials)/Creator(initials) /Approval (initials) /date of drawing (yyyymmdd or ddmmyyyy format)/ Revision Number, if any.
for example The drawing of ABC Corporation India Limited at Pune created on 21 September 2014 by Mr Arun Kapoor approved by Mr Brijesh Singh may represented as:

ACILPNAKBS2014092100.XXX



All dimensions in millimetres.

FIG. 4.1 FOLDING OF PRINTS FOR FILING OR BINDING



All dimensions in millimetres.

FIG. 4.2 FOLDING OF PRINTS FOR STORING IN FILING CABINET

SECTION 5 SCALES
[Based on IS 10713: 1983/1S0 5455: 1979]

5.1 Scope
This section specifies recommended scales and their designation for use on all technical drawings in any field of engineering.

5.2 Definitions
5.2.1 *Scale*
Ratio of the linear dimension of an element of an object as represented in the original drawing to the real linear dimension of the same element of the object itself.

NOTE ´ The scale of a print may be different from that of the original drawing,

5.2.2 *Full Size*
A scale with the ratio 1:1.

5.2.3 *Enlargement Scale*
A scale where the ratio is larger than 1:1. It is said to be larger as its ratio increases.

5.2.4 Reduction *Scale*
A scale where ratio is smaller than 1:1. It is said to be smaller as its ratio decreases.

5.3 Designation
The complete designation of a scale shall consist of the word `SCALE˘(or its equivalent in the language used on the drawing) followed by the indication of its ratio, us follows:

SCALE 1: 1 for full size;
SCALE X :1 for enlargement scales;
SCALE 1: X for reduction scales.

If there is no likelihood of misunderstanding, the word SCALE may be omitted.

5.4 Scales for Use on Technical Drawings

Category	*Recommended Scales*		
Enlargement	50:1	20:1	10:1
Scales	5:1	2:1	
Full size			1:1
	1:2	1:5	1:10
Reduction	1:20	1:50	1:100
Scales	1:200	1:500	1:1000
	1:2000	1:5000	1:10000

NOTE ´ In exceptional cases where for functional reasons the recommended scales cannot be applied, intermediate scales maybe chosen.

5.4.1 The scale to be chosen for a drawing will depend upon the complexity of the object to be depicted and the purpose of the representation.

5.4.2 In all cases, the selected scale shall be large enough to permit easy and clear interpretation of the information depicted.

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

5.4.4 It is recommended that, for information a full size view be added to the large scale representation of a small object. In this case the full size view may be simplified by showing the outlines of the object only.

SECTION 6 LINES

[Based on IS 10714 (Part 20): 2001/ISO 128-20:1996, IS 10714 (Part 21): 2001/ ISO 128-21 :1997, ISO 128-22 : 1999, ISO 128-23 : 1999 and ISO 128-24 : 2014]

6.1 Scope

This section establishes types of lines, their designations and configurations and general rules for draughting of lines used in

- Technical drawings (for example, Diagrams, Plans and Maps)
- Lines by CAD systems or other softwares
- Leader lines, reference lines and their components
- Lines used in various drawings

6.2 Definitions

6.2.1 *Line*

Geometrical object, the length of which is more than half of the line width and which connects an origin with an end in any way, for example, straight, curved, without or with interruptions.

NOTES ‒ 1. The origin and the end may coincide with one another, *for example*, in the case of a line forming a circle.
2. A line, the length of which is less than or equal to half of the line width, is called a dot..
3. A test should be made in order to check the appearance of drawings intended to be microcopied or transferred by fax.

6.2.1 Line Element

Single part of a non-continuous line, for example, dots, dashes, which vary in length, and gaps.

6.2.2 Line Segment

Group of two or more different line elements which form a non-continuous line, for example, long dash/gap/dot/ gap/dot/gap.

6.3 Types of Lines

6.3.1 Basic Types (*see* Table 6.1)

6.3.2 Variations of the Basic Types of Lines Possible variations of the basic types of lines in accordance with Table 6.1 are given in Table 6.2.

6.3.3 Combinations of Lines with the Same Length

6.3.3.1 Arrangement of two or more lines parallel to each other

For examples *see* Fig. 6.1.

Table 6.1 Basic Types of Lines
(Clause 6.3.1)

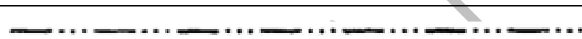
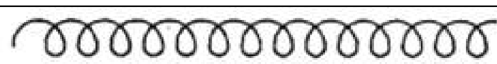
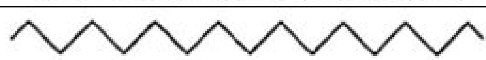
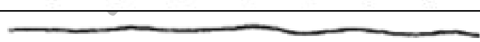
No.	Representation	Description
01		Continuous Line
02		Dashed Line
03		Dashes Space Line
04		Long Dashed Dotted Line
05		Long Dashed Double-dotted Line
06		Long Dashed Triple-dotted Line
07		Dotted Line
08		Long Dashed Short Dashed Line
09		Long Dashed Short Dashed Line
10		Dashed Dotted Line
11		Double Dashed Dotted Line
12		Dashed Double Dotted Line
13		Double Dashed Double Dotted Line
14		Dashed Triplicate Dotted Line
15		Double Dashed Triplicate Dotted Line

Table 6.2 Variations of the Basic Types of Lines
(Clause 6.3.2*)*

Representation	Description
	Uniform wavy Continuous Line
	Uniform Spiral Continuous Line
	Uniform Zigzag Continuous Line
	Freehand Continuous Line

NOTE ´ Table contains only variations of the basic type of line No. 01. Variations of the basic types Nos. 02 to 15 are possible and are presented in the same way.

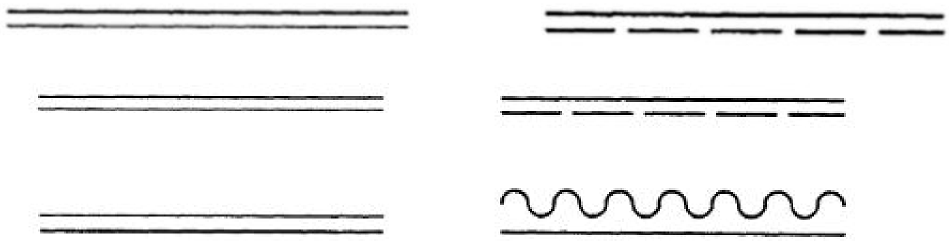


FIG. 6.1

FIG. 6.2

FIG. 6.3

FIG. 6.4

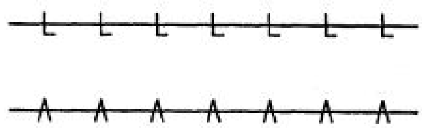


FIG. 6.5

Arrangement of two different types of lines

a) With different line widths superimposed.
See Fig. 6.2 (a) and (b) for examples; [Fig. 6.2 (a): a continuous and a dotted line; Fig. 6.2 (b): a continuous and a dashed space line],

b) Arranged next to each other.
See Fig. 6.3 for an example (two continuous lines either side of two dashed spaced lines).

6.3.3.3 Arrangement of two continuous lines parallel to each other with regularly recurring connecting elements between them
See Fig. 6.4 (a) and (b) for examples [Fig. 6.4 (a): blackened circular elements; Fig. 6.4 (b): blackened trapezoidal elements].

6.3.3.4 Arrangement of regularly recurring geometric pictorial elements in association with continuous lines

a) Without interruption of a continuous line. *See* Fig. 6.5 for examples.
b) With interruption of a continuous line. *See* Fig. 6.6 for examples.

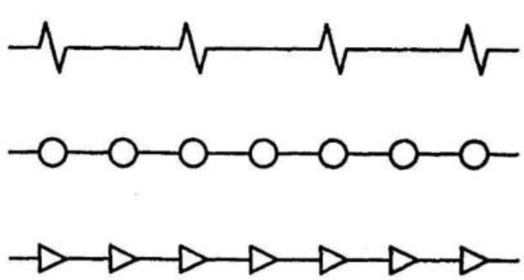


FIG. 6.6

6.4 Line Dimensions

6.4.1 Line Width

The width, *d,* of all types of lines shall be one of the following depending on the type and size of drawing. This series is based on a common ratio 1 : (= 1:1.4):

0.13 mm; 0.18 mm; 0.25 mm; 0.35 mm; 0.5 mm; 0.7 mm; 1 mm; 1.4 mm; 2 mm

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

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

6.4.2 Deviation in Line Width

Line widths may deviate from those specified in **6.4.1** providing that it is possible to differentiate unambiguously between two adjacent lines with different widths. If drawing equipment which produces constant line width is used, the deviation in line width between two such lines shall not be greater than ±0.1 *d.*

6.4.3 Configuration of Lines

For the preparation of drawings by hand, the lengths of the line elements should conform to those of Table 6.3.

Table 6.3 Configuration of Lines

(Clauses 6.4.3 *and* 6.8.6)

Line Element	Line Type No.	Length
Dots	04 to 07 and 10 to 15	<0.5 d
Gaps	02 and 04 to 15	*3d*
Short dashes	08 and 09	6 *d*
Dashes	02, 03 and 10 to 15	12 *d*
Long dashes	04 to 06, 08 and 09	24 *d*
Spaces	03	18 d

NOTE´ The lengths shown in this table are valid for line elements with semi-circular and squared ends. In the case of line elements with semi-circular ends, the length of the line element corresponds to the distance covered by a technical pen (with a tubular tip and using India ink) from the origin up to the end of the line element. The total length of such a line element is the sum of the length shown in the table plus d**.**

Formulae for the calculation of some of the basic types 01 line and line elements are given in IS 10714 (Part 21). The formulae are intended to facilitate the preparation of drawings using Computer-Aided Design (CAD) systems.

6.5 Draughting of Lines

6.5.1 *Spacing*

The minimum space between parallel lines should not be less than 0.7 mm, unless rules to the contrary are stated in other Indian Standards.

NOTE ´ In certain cases when computer-aided drawing techniques are used, the spacing of lines on the drawing does not represent the actual spacing, for example, for the representation of screw threads. This fact has to be considered when data sets *are* established, for example, for the operation of machine tools.

6.5.2 *Junctions*

6.5.2.1 *Types*
The basic types of lines, Nos. 02 to 06 and Nos. 08 to 15 should preferably meet at a dash (*see* Fig. 6.7 to 6.12). Lines of basic type No. 07 should preferably meet at a dot (*see* Fig. 6.13).

6.5.2.2 *Representation*
The requirement of **6.5.2.1** shall be fulfilled by starting the lines at the junction (*see* Fig. 6.14) or by using a complete, or partial, cross formed by dashes (*see* Fig. 6.15 and 6.16).

6.5.3 *Location of a Second Line*
Two different ways of draughting two parallel lines are shown in Fig. 6.17 (a) and (b). The preferred version is shown in Fig. 6.17 (a) (the second line is drawn below or to the right of the first line).

6.6 Colours

Lines may be drawn in black or white depending on the colour of the background. *Other standardized colours may also be used for drawing standardized lines*. In such case, the meaning of the colours shall be explained.

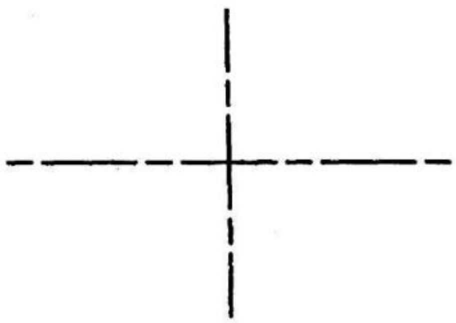


FIG. 6.7

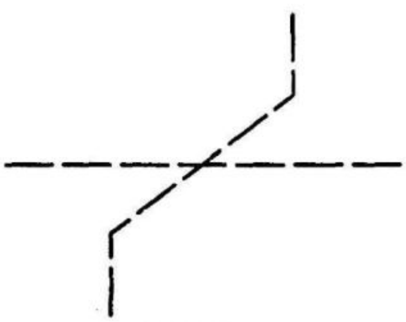


FIG. 6.8

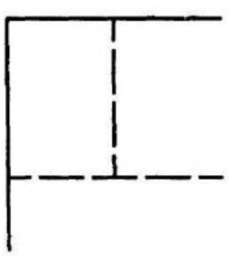


FIG. 6.9

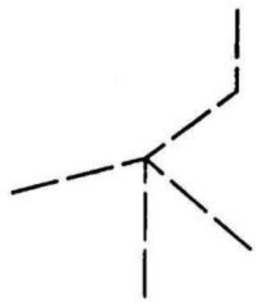


FIG. 6.10

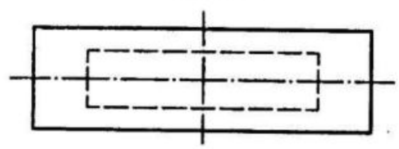


FIG. 6.11

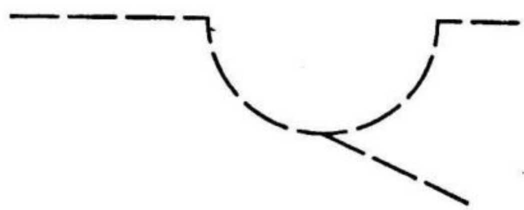


FIG. 6.12

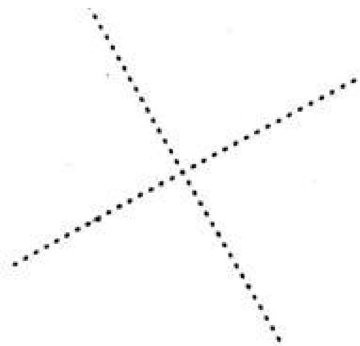


FIG. 6.13

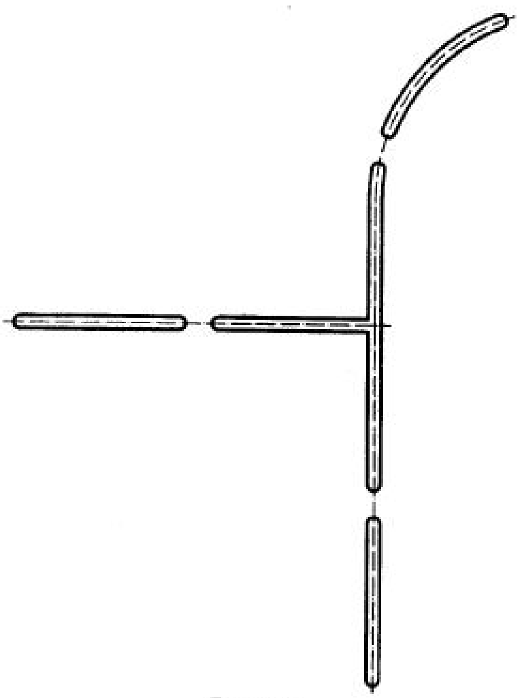


FIG. 6.14

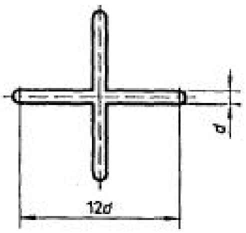


FIG. 6.15

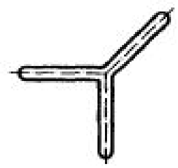


FIG. 6.16

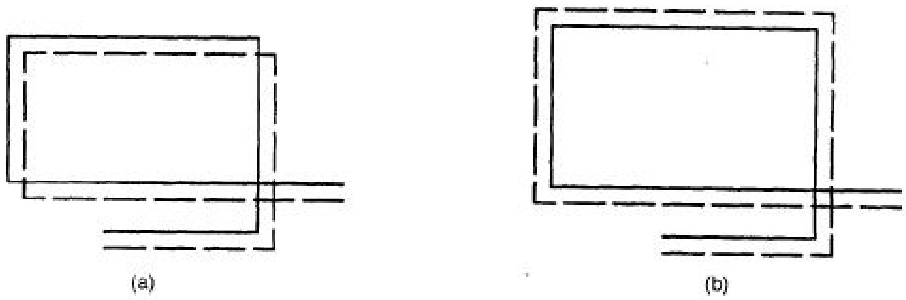


FIG. 6.17

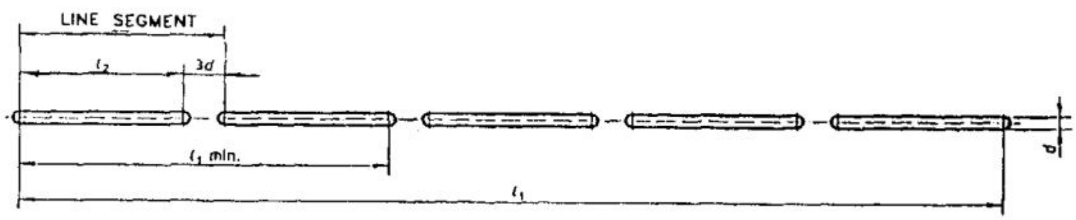


FIG. 6.18

6.7 Designation
The designation of the basic types of lines shall comprise the following elements in the order given:

a) `Line_;
b) Reference to this part of IS 10714:
c) The number of the basic type in accordance with Table 6.1;
d) The line width in accordance with 6.4.1; and
e) The colour (if applicable).

Examples- Designation of a line of type No. 03 (03), line width 0.25 mm (0.25):

Line IS 10714-20 -03x 0.25

Designation of a line of type No. 05 (05), line width 0.13 mm (0.13) and white in colour:

Line IS 10714-20 -05x 0.13/ white

6.8 Terms and Definitions
6.8.1 *Leader Line*
Continuous narrow line which establishes the connection between the features of a graphical representation and additional alphanumeric and/or written instructions (notes, technical requirements, item references, etc) in an unambiguous manner.
6.8.2 *Reference Line*

Continuous narrow line connecting with the leader line horizontally or vertically and on or at which the additional instructions are indicated.

6.9 Presentation of Leader Lines

Leader lines are executed as continuous narrow lines in accordance with IS 10714 (Part 20). They are drawn preferably at an angle to the relevant representation and/or the frame limiting the drawing sheet, and not parallel to adjacent lines, for example, hatching lines. The inclination to the relevant lines shall be > 15° (*see* Fig. 6.19 to 6.33).

Leader lines may be drawn with sharp kinks (*see* Fig. 6.38), and two or more leader lines may be joined up (*see* Fig. 6.20,6.23,6.25,6.26 and 6.31). They should not cross other leader lines, reference lines or indications, such as, graphical symbols or dimensional values.

Leader lines shall terminate at the end which touches the features as follows:

with a closed and filled or a closed arrowhead (included angle 15°) if the leader line ends at lines which represent outlines or edges of parts, pipings or cables in plans, charts or diagrams; arrowheads are also drawn at crossing points of these lines with other lines, for example, lines of symmetry (*see* the examples given in Fig. 6.19 to 6.29);

NOTE ´ If several parallel lines have to be designated, oblique strokes instead of arrowheads are permitted (*see* IEC 61082-1). *See* the example given in Fig 6.28. with a dot (d = 5 x line width) if the leader line ends within the outlines of an object (*see* the examples given in Fig. 6.29 to 6.31); without any termination if the leader line ends at another line, for example, dimension line or line of symmetry (*see* the examples given in Fig. 6.32 and 6.33).

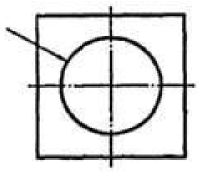


Fig 6.19

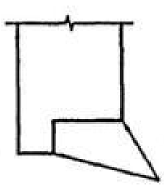


Fig 6.20

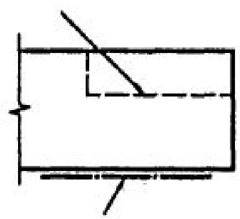


Fig. 6.21

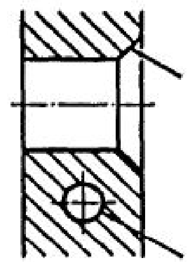


Fig. 6.22

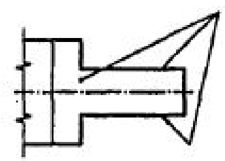


Fig. 6.23

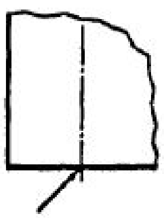


Fig. 6.24

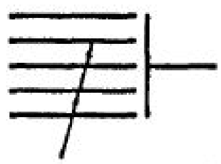


Fig. 6.25

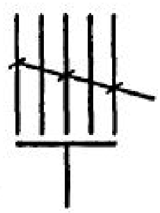


Fig. 6.26

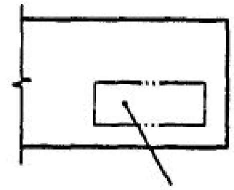


Fig. 6.27

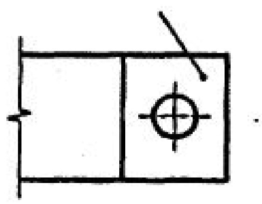


Fig 6.28


Fig 6.29

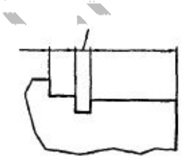


Fig. 6.30

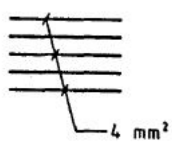


Fig 6.31

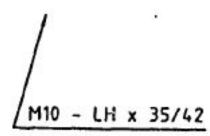


Fig 6.32

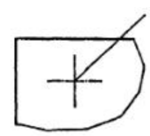


Fig 6.33

6.10 Presentation of Reference Lines

Reference lines are executed as continuous narrow lines in accordance with IS 10714 (Part 20). A reference line may be added to each leader line. It is drawn in one of the reading directions of the drawing.

The reference line shall be drawn either with a fixed length, for example, 20 x line width of the reference line (*see* the examples given in Fig. 6.35 and 6.37), or with a length adapted to the length of the indicated instructions (*see* the examples given in Fig. 6.34, 6.37, 6.41 and 6.42).

In particular cases of application the reference line has to be drawn *(see* the example given in Fig. 6.35).

However, the reference line may be omitted, if the leader line is drawn in one of the reading directions of the drawing and if the indicated instructions are written in the same direction *(see* the example given in Fig. 6.38), and in all other cases in which this line is not applicable *(see* the examples given in Fig. 6.30, 6.39 and 6.40).

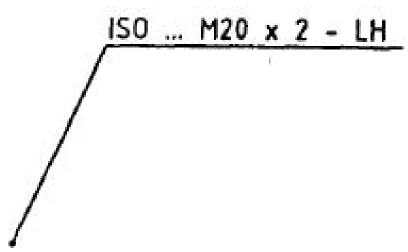


Fig. 6.34

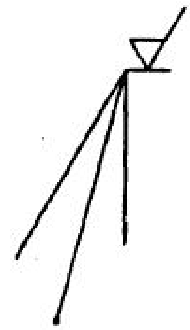


Fig. 6.35

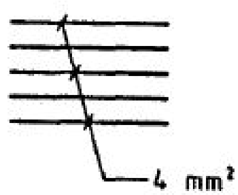


Fig. 6.36

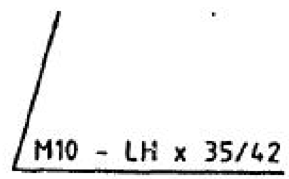


Fig. 6.37

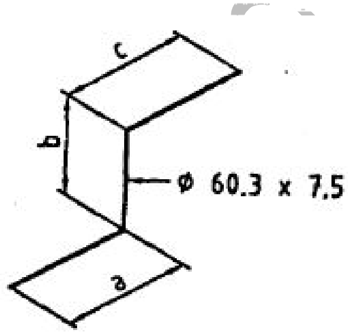


Fig 6.38

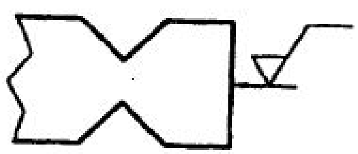


Fig 6.39

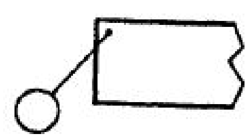


Fig 6.40

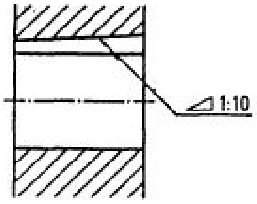


Fig 6.41

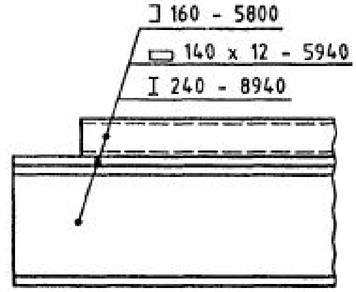


Fig 6.42

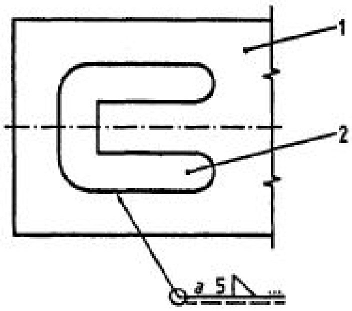


Fig 6.43

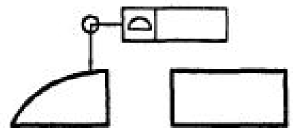


Fig 6.44

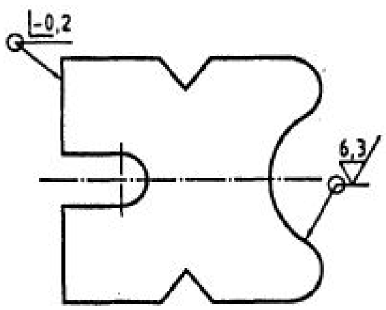


Fig 6.45

6.11 Indication of Instructions

The instructions belonging to the leader lines shall be indicated as follows:
preferably above the reference line *(see* the example given in Fig. 6.34, 6.37, 6.41 and 6.42 and in 6.13); centrically behind the leader or reference line *(see* the examples given in Fig. 6.36 and 6.38); or around, within or behind graphical symbols according to the valid Indian Standards (*see* the example given in Fig. 6.41 and 6.42 and in 6.13).
Taking into account the requirements for microcopying in IS 10164, the instructions should be written at a distance of twice the line width of the reference line above or below the reference line. They should not be drawn within the reference line and they should not touch it. If individual layers or assembled parts of an object are designated with one leader line, the order of the indications shall correspond with the order of the layers or the parts (*see* the example given in Fig. *6.42).*

6.12 Graphical Supplements Contained in Other Indian Standards
(*see* Table 6.4**)**

6.13 Meaning and Application of the Graphical Supplement 'Circle' for Leader Lines

The same required characteristic on a number of surfaces or corners of a part connected to each other may be indicated only once if a circle (d- 8 x width of the leader line) is drawn at the connecting point of the leader line and the reference line (see Fig. 6.43 to 6.45). This means that the same requirements apply to all surfaces or corners around the contour or profile of the represented part.

The :circle˘ sign shall not be used if either or both of the following occur:

a) the indications are ambiguous, and

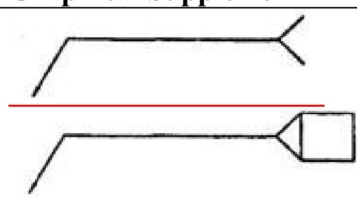
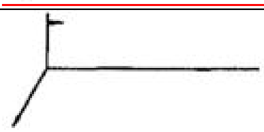
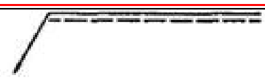
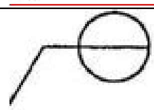
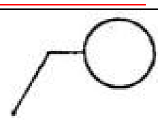
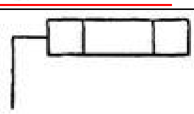
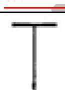
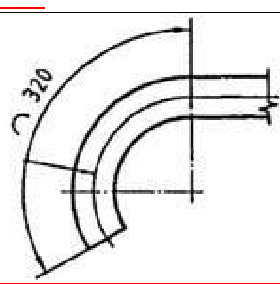
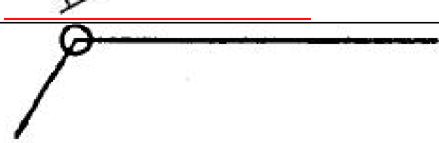
b) the indication concerns all surfaces or corners of a part.

6.14 Types of Lines and Their Applications in Construction Drawings

The first part of the number is the number of line type in IS 10714 (Part 20**)** *(see* Table 6.5).

Table 6.4 Graphical Supplement

(Clause 6.13*)*

No.	Graphical Supplement	Application
1		Indication of further information concerning welds e g. the number of the welding process
2		Designation of a field or site weld
3		Identification of the location of a weld
4		Datum target frame
5		Indication of item references (ISO 6433 does not specify only this method)
6		Frame used for geometrical tolerance requirements
7		Indication of several tolerance features
8		indication of dimensions of arc lengths
9		This sign (circle) has the geometrical (profile) tolerance all around the profile tolerance of the entire outline of the cross section surface texture on all

		surfaces around a part roughness on all surfaces a peripheral weld all around a part features, e.g. burr, all around a part machining allowance which applies to all surfaces the same state of corner all around a part

Table 6.5

Types of Lines and their Application in Construction and Mechanical Engineering Drawings

(Clause 6.5.1 and 6.17*)*

No.	Description and Representation	Application
01.1	Continuous Narrow Line	Boundaries of different materials in view, cut, section, hatching. Diagonals for indications of the opening, holes and recesses, arrow lines for stairs/ramp/sloping area, modular grid lines first stage, short centre lines, extension lines, dimensioning lines and its termination lines. Leader lines, visible outline of parts in view, existing contour lines, framing of details, simplified representations of the doors, windows, stairs fittings etc. *For Mechanical Engineering Drawings -* Imaginary lines of intersection, dimension lines, extension lines, leader lines and reference lines, hatching, outlines of revolved sections, short centre lines, root of screw threads, dimension line terminations, diagonals for the indication of flat surfaces, bending lines on blanks and processed parts framing of details, indication of repetitive details, interpretation lines of tapered features, location of laminations, projection lines, grid lines
	Continuous Narrow lines with Zigzag	Limits of partial or interrupted views, cuts and sections, and preferably mechanically represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a centre line
01.2	Continuous Wide Line	Visible outlines of parts in cut and section when hatching is used, Boundaries of different materials in view, cut, section. Visible outlines of parts of view, simplified representations of the doors, windows, stairs fittings etc., modular grid lines second stage, arrow lines for marking of view, cuts and sections, proposed contour on landscape drawings, crests of screw threads, limit of length of full depth thread, main representations in diagrams, maps, flow, charts, system lines (structural metal engineering), pattern lines of moulds in views, lines of cuts and section arrows
01.3	Continuous extra wide Line	Visible outlines of parts in cut and section when hatching is NOT used, reinforcing bars and lines of special importance
02.1	Dashed narrow line - - - - - - - - - - - - - - - - - - -	Existing contours on landscape drawings, subdivision of plant beds/grass, hidden outlines and hidden edges
02.2	Dashed wide line	Hidden outlines, indication of permissible areas of surface treatment
02.3	Dashed Extra wide line	Reinforcing bars in bottom layer on plan and far face layer in elevation when bottom and top layers and near and far face layers are shown on the same sketch

04.1	Long dashed dotted narrow line	Cutting planes, centrelines, lines of symmetry, framing of enlarged details, reference lines, limits of the partial or interrupted views, cut and sections, pitch circle for gears and holes
04.2	Long dashed dotted wide line	Cutting planes (at ends and changes of direction), outlines of visible parts situated in front of the cutting plane, indication of (limited) required areas of surface treatment, e. g. heat treatment
04.2	Long dashed dotted extra-wide line	Secondary lines for setting out and arbitrary reference lines, indication of lines or surfaces to which a special requirement applies, boundary lines for contracts, stages, zones etc.,
05.1	Long dashed double dotted narrow line	Alternative and extreme positions of movable park, centroidal line, outlines of adjacent parts. *For Mechanical Engineering Drawings -* outlines of adjacent parts, extreme positions of movable Darts, centroidal lines, initial outlines prior to forming, parts situated in front of a cutting plane, outlines of alternative executions, outlines of the finished part within blanks, framing of particular fields/areas, projected tolerance zone
05.2	Long dashed double dotted wide line	Outlines of hidden parts situated in front of the cutting plane
05.3	Long dashed double dotted extra wide line	Reinforcing prestressed bars and cables
07.1	Dotted narrow line	Outlines of parts not included in the project

6.15 Line Widths

On a construction drawing three line widths, narrow, wide and extra-wide, are normally used (*see* Table 6.6). The proportions between the line widths are 1:2:4. A special line width is used for representation and lettering of graphical symbols. This line width is situated between the width of the narrow and the wide line.

The line widths shall be chosen according to the type, size and scale of the drawing and the requirements at microcopying and other methods of reproduction.

Table 6.6 Line Widths
(Clause 6.15)
All dimensions are in millimetres

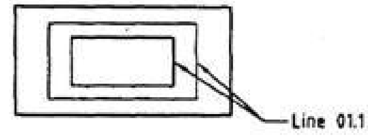
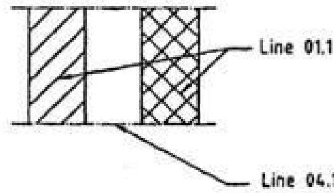
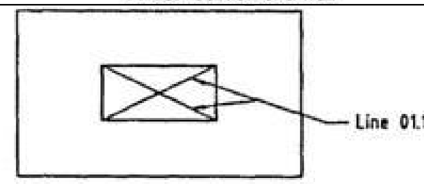
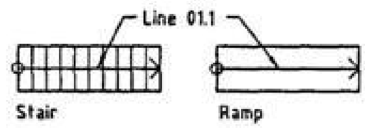
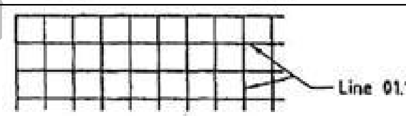
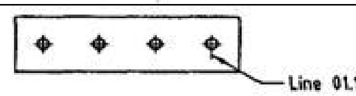
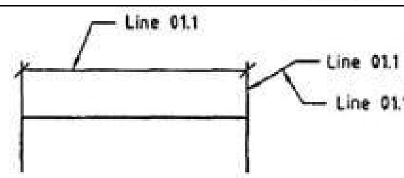
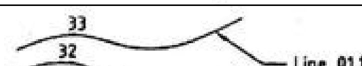
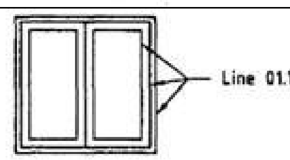
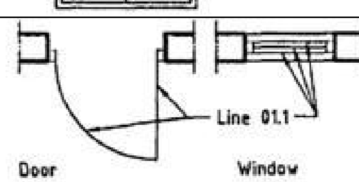
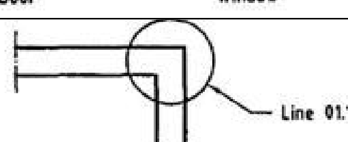
Line Group	Narrow Line	Wide Line	Extra-Wide Line
0.25	0.13	0.25	0.5
0.35	0.18	0.35	0.7
0.5	0.25	0.5	1
0.7	0.35	0.7	1.4
1	0.5	1	2

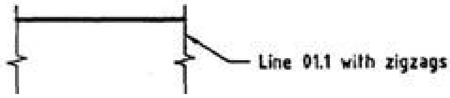
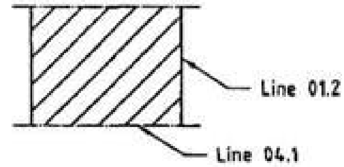
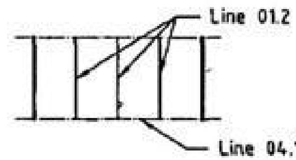
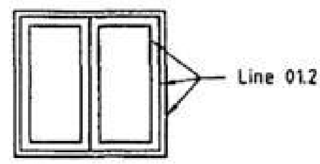
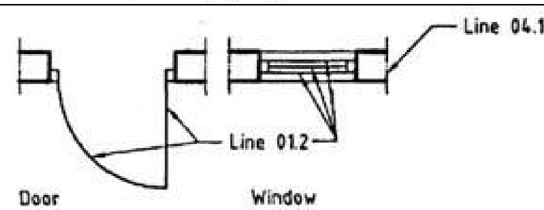
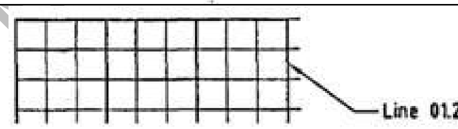
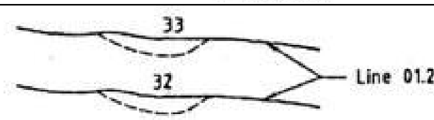
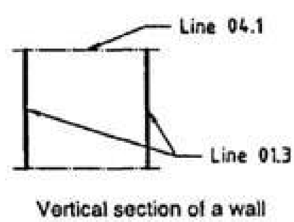
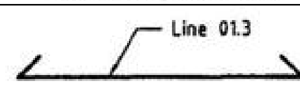
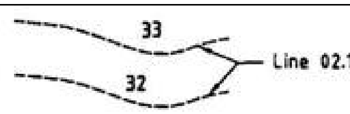
6.16 Examples of Application for Construction Drawings

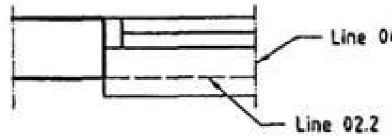
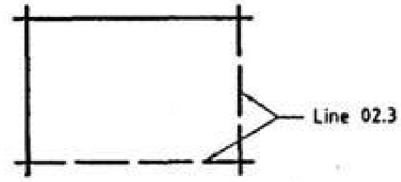
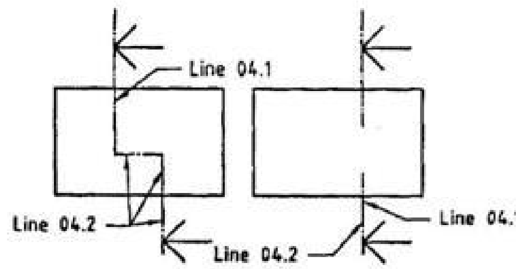
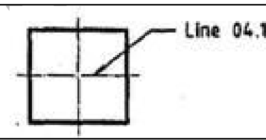
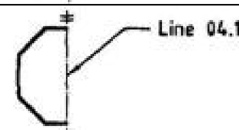
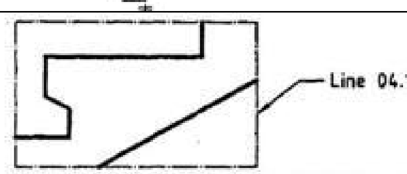
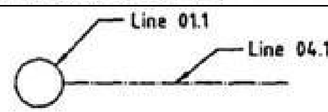
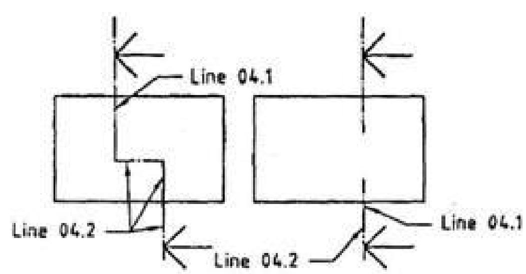
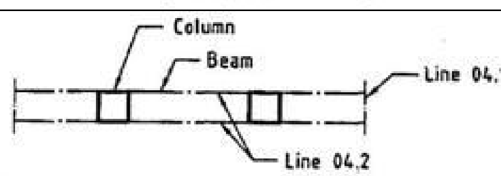
Examples of the application for construction drawings of the different types of lines, along with the corresponding reference numbers from 6.15, are given in Table 6.7.

Table 6.7 Examples of Application for Construction Drawings

(Clause 6.16)

No	Line type	Example of application
01.1	**Continuous narrow line**	
01.1.1	Boundaries of different materials in view, cut and section	 View of a floor with different materials
01.1.2	Hatching	 Vertical section of a wall
01.1.3	Diagonals for indication of openings, holes and recesses	 View of a wall with an opening
01.1.4	Arrow lines in stairs, ramps and sloping areas	
01.1.5	Modular grid lines, first stage	
01.1.6	Short centrelines	
01.1.7 01.1.8 01.1.9	Extension lines Dimension lines and their terminators Leader lines	
01.1.10	Existing contours on landscape drawings	
01.1.11	Visible outlines of parts in view (alternatively, see 01.2.3)	
01.1.12	Simplified representation of doors, windows, stairs, fittings elc. (alternatively, see 01 .2.4)	
01.1.13	Framing of details	

01.1.14	Limits of partial or interrupted views, cuts and sections, if the limit is not a line 04.1	
01.2	**Continuous wide line**	
01.2.1	Visible outlines of parts in cut and section when hatching is used	
01.2.2	Boundaries 01 different materials in view, cut and section	
01.2.3	Visible outlines of parts in view (alternatively, see 01 .1.11)	
01.2.4	Simplified representation of doors, windows, stairs, fittings etc. (alternatively, see 01.1 .12)	
01.2.5	Modular grid lines, second stage	
01.2.6	Arrow lines for marking of views, cuts and sections	
01.2.7	Proposed contours on landscape drawings	
01.3	**Continuous extra-wide line**	
01.3.1	Visible outlines of parts in cut and section when hatching is not used	
01.3.2	Reinforcing bars	
02.1	**Dashed narrow line**	
02.1.1	Existing contours on landscape drawings (alternatively, see 01.1.10)	
02.1.2	Subdivision of plant beds/grass	
02.2	**Dashed wide line**	

02.2.1	Hidden outlines	
02.3	**Dashed extra-wide line**	
02.3.1	Reinforcing bars in bottom layer on plan and far face layer in elevation when bottom and top layers are shown on the same sketch	
04.1	**Long dashed dotted narrow line**	
04.1.1	Cutting planes (drawn with line 04.2 at ends and changes of direction)	
04.1.2	Centrelines	
04.1.3	Lines of symmetry	
04.1.4	Framing of enlarged details	
04.1.5	Reference lines	
04.2	**Long dashed dotted wide line**	
04.2.1	Cutting planes (drawn with line 04.2 at ends and changes of direction; the rest is drawn with line 04.1	
04.2.2	Outlines of visible parts situated in front of the cutting plane	
04.3	**Long dashed dotted extra-wide line**	

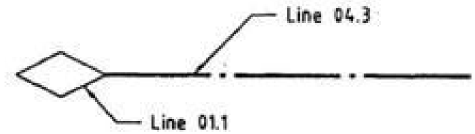
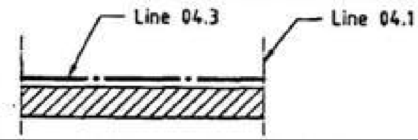
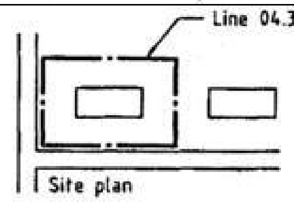
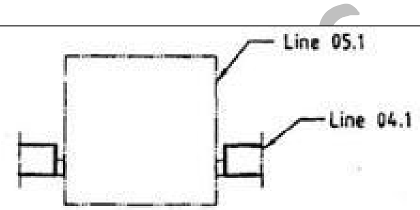
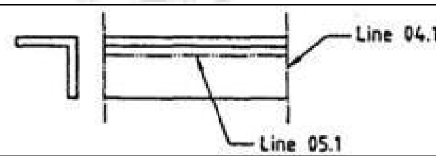
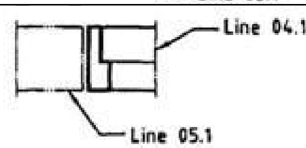
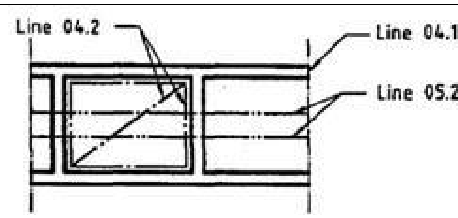
04.3.1	Secondary lines for setting out and arbitrary reference lines	
04.3.2	Indication of lines or surfaces to which a special requirement applies	
04.3.3	Boundary lines for contracts, stages, zones, elc.	
05.1	**Long dashed double-dotted narrow Fine**	
05.1.1	Alternative and extreme position of movable parts	
05.1.2	Centroidal lines	
05.1.3	Outlines of adjacent parts	
05.2	**Long dashed double-dotted wide line**	
05.2.1	Outlines of hidden parts situated in front of the cutting plane	
05.3	**Long dashed double-dotted extrawide line**	
05.3.1	Reinforcing prestressed bars and Cables	
07	**Dotted narrow line**	
07.1	Outlines of parts not included in the project	

Table 6.8 Line Groups

(Clause 6.18) All dimensions are in millimetres

Line Group	Line Width for Line No.	
	01.2-02 .2-04.2	01.1 -02.1-04.1-05.1
0.25	0.25	0.13
0.35	0.35	0.18
0.5 [1)]	0.5	0.25
0.7 [1)]	0.7	0.35

1	1	0.5
1.4	1.4	0.7
2	2	1
[1)] Preferred Line Groups		

6.17 Types of Lines and Their Application in Mechanical Engineering Drawings

The first part of the line number in Table 6.5 is the number of the basic type in accordance with IS 10714 (Part 20).
Examples of application are given in Table 6.9.

6.18 Line Widths and Line Groups

On mechanical engineering drawings two line widths are normally used. The proportions between the line widths should be 1 : 2.

The line groups are specified as shown in Table 6.8.

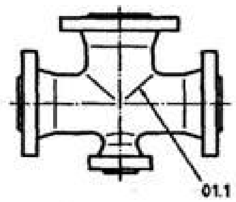
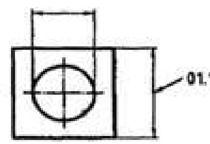
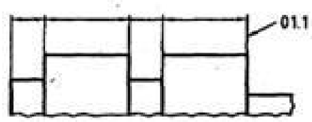
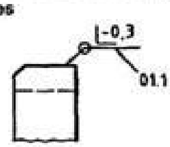
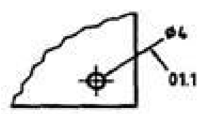
The widths and groups of lines should be chosen according to the type, size and scale of the drawing and according to the requirements for microcopying and/or other methods of reproduction.

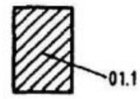
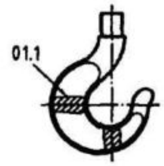
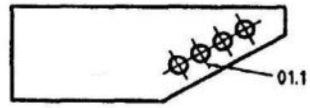
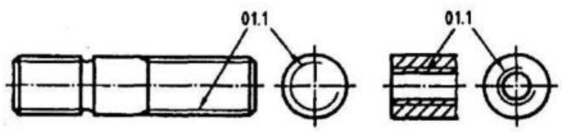
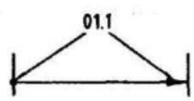
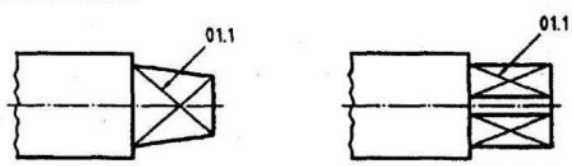
6.19 Examples of Application for Mechanical Engineering Drawings

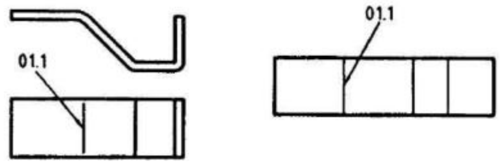
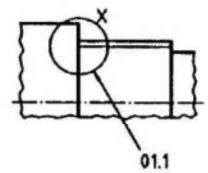
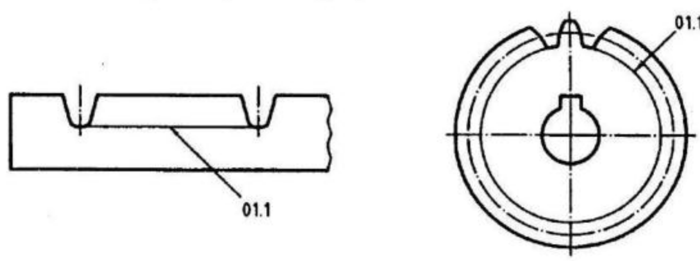
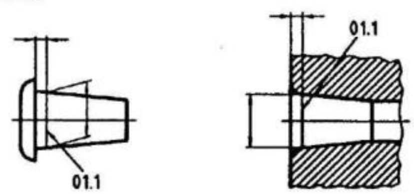
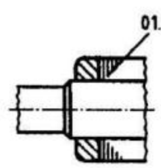
Table 6.9 gives examples of the application for mechanical engineering drawings of the different types of lines indicating the reference number given in Table 6.8. The figures are shown in first angle projection. It is understood that first angle projection could be used as well.

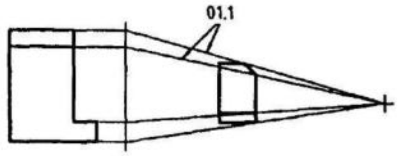
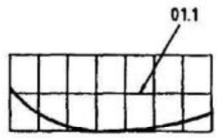
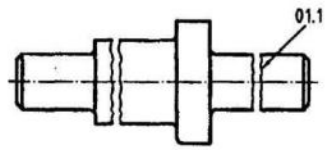
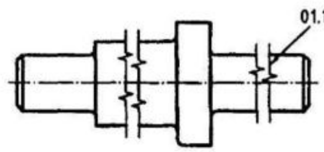
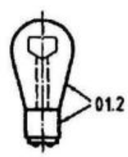
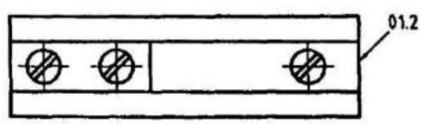
Table 6.9 Examples of Applications for Mechanical Engineering Drawing

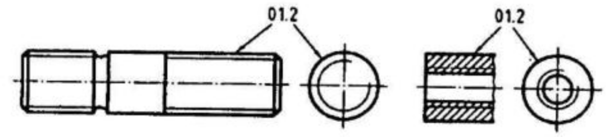
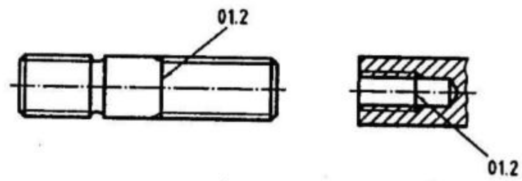
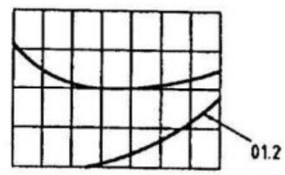
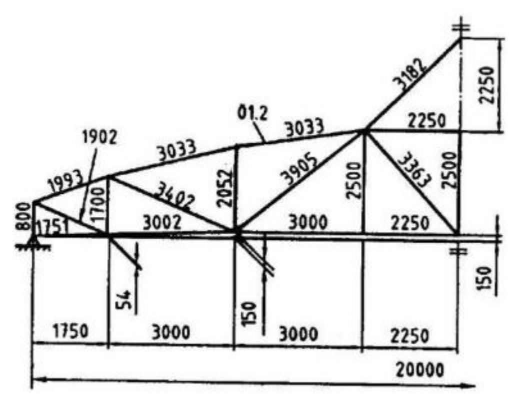
(Clause 6.18 and 6.20)

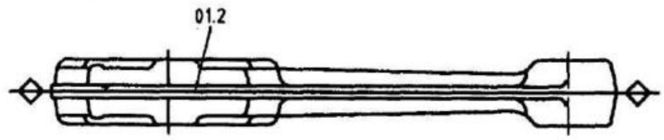
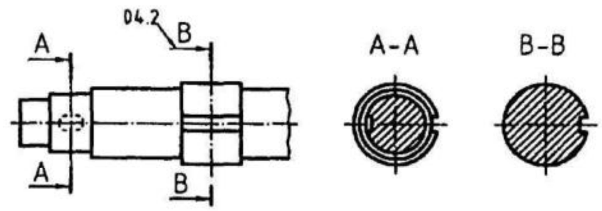
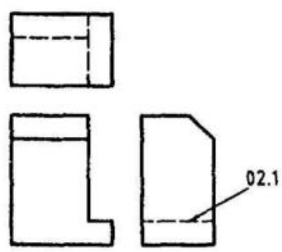
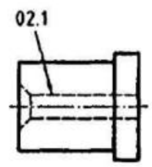
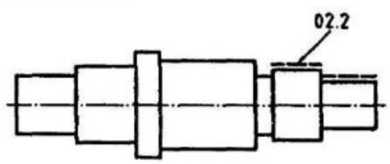
No.	Line Type and Example of Application
01.1	**Continuous narrow line**
01.1.1	Imaginary lines of intersection 
01.1.2	Dimension lines 
01.1.3	Extension lines 
01.1.4	Leader lines and reference lines  

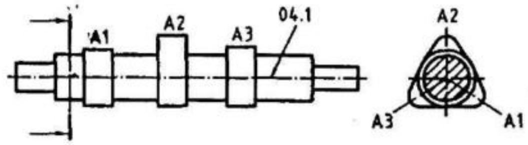
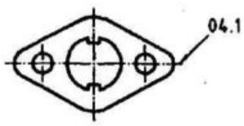
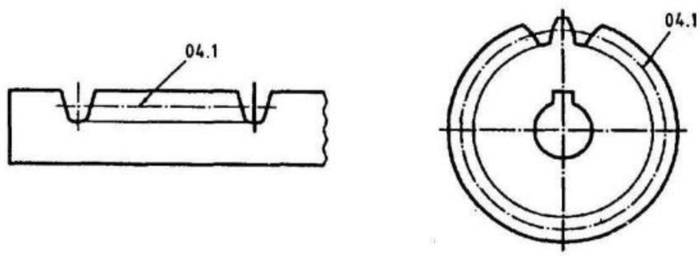
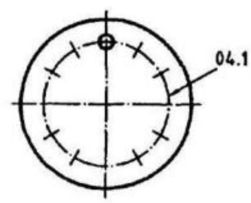
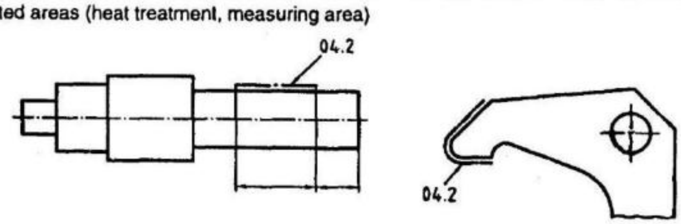
No.	Line Type and Example of Application
01.1.5	Hatching 
01.1.6	Outlines of revolved sections 
01.1.7	Short centre lines 
01.1.8	Root of screw threads 
01.1.9	Dimension line termination 
01.1.10	Diagonals for the indication of flat surfaces 

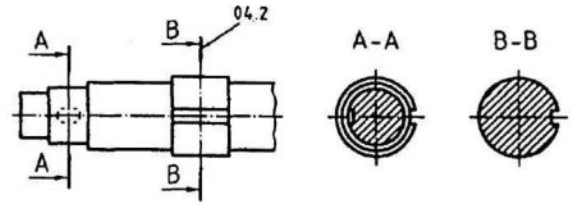
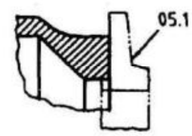
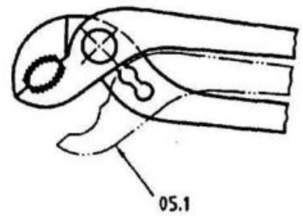
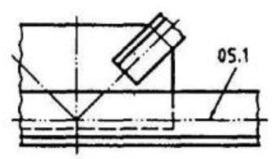
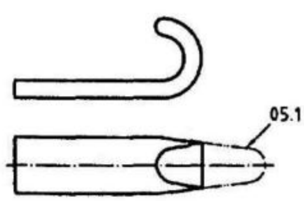
No.	Line Type and Example of Application
01.1.11	Bending lines on blanks and processed parts 
01.1.12	Framing of details 
01.1.13	Indication of repetitive details, e.g. root diameters of gears 
01.1.14	Interpretation lines of tapered features 
01.1.15	Location of laminations, e.g. transformer plates 

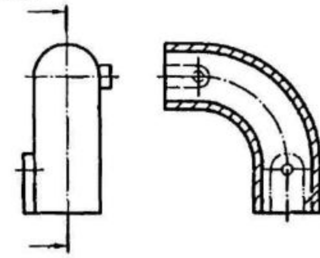
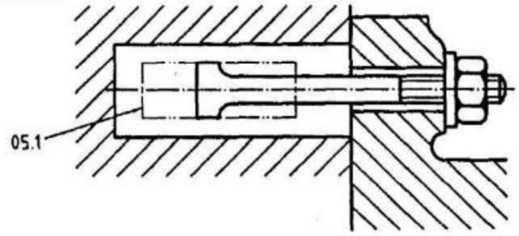
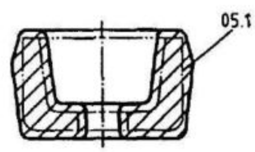
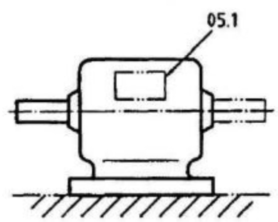
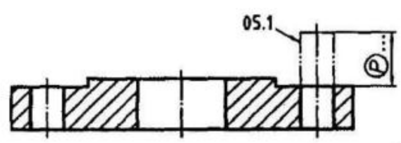
No.	Line Type and Example of Application
01.1.16	Projection lines 
01.1.17	Grid lines 
01.1.18	Continuous narrow freehand lines 
01.1.19	Continuous narrow lines with zigzags 
01.2	**Continuous wide line**
01.2.1	Visible edges 
01.2.2	Visible outlines 

<table>
<tr><th>No.</th><th>Line Type and Example of Application</th></tr>
<tr><td>01.2.3</td><td>Crests of screw threads

</td></tr>
<tr><td>01.2.4</td><td>Limit of length of full-depth thread

</td></tr>
<tr><td>01.2.5</td><td>Main representations in diagrams, maps, flow charts

</td></tr>
<tr><td>01.2.6</td><td>System lines

</td></tr>
</table>

No.	Line Type and Example of Application
01.2.7	Parting lines of moulds in views 
01.2.8	Lines of cuts and section arrows 
02.1	**Dashed narrow line**
02.1.1	Hidden edges 
02.1.2	Hidden outlines 
02.2	**Dashed wide line**
02.2.1	Indication of permissible surface treatment 

No.	Line Type and Example of Application
04.1	**Long-dashed dotted narrow line**
04.1.1	Centre lines 
04.1.2	Lines of symmetry 
04.1.3	Pitch circles of gears 
04.1.4	Pitch circles of holes 
04.2	**Long-dashed dotted wide line**
04.2.1	Indication of limited areas (heat treatment, measuring area) 

No.	Line Type and Example of Application
04.2.2	Indication of cutting planes 
05.1	**Long dashed double-dotted narrow line**
05.1.1	Outlines of adjacent parts 
05.1.2	Extreme positions of movable parts 
05.1.3	Centroidal lines 
05.1.4	Initial outlines prior to forming 

No.	Line Type and Example of Application
05.1.5	Parts situated in front of a cutting plane 
05.1.6	Outlines of alternative executions 
05.1.7	Outlines of the finished part within blanks 
05.1.8	Framings of particular fields/areas 
05.1.9	Projected tolerance zone 

SECTION 7 LETTERING

[Based on IS 9609 (Part 0): 2001/ISQ 3098-0 : 1997]

7.1 Scope

This section specifies the general requirements for lettering, on technical drawings. It includes font used by the CAD/other Softwares which is easily readable, printable. The font in regional languages used in CAD/other softwares is highly encouraged so that the exact information may be disseminates to diverse population of India (for lettering detailed purposes please refer IS 9609 (all parts))

7.2 General Requirements

7.2.1 Legibility, which shall be maintained by a space between characters of twice the line width used for lettering and the font size.
This spacing may be reduced to one line width for a better visual effect with combinations of particular characters, for example, LA, TV or Tr.

7.2.2 The font used in the Technical Drawing whether English or any Regional Languages shall be easily readable when read from the printout by normal vision

7.2.3 Any color may be used for displaying/printing of font.

7.2.4 Itallic or Bold function may be used as per the requirement of the drawing

SECTION 8A PROJECTION METHODS — SYNOPSIS

[Based on IS 15021 (Part 1) : 2001/ISQ 5456-1 : 1996]

8A.1 Scope
This section gives the various types of projection methods as well as their geometric relationships.

***8A.2* Definitions**

8A.2.1 *Pictorial Representation*
Parallel or central projection on a single projection plane giving a three-dimensional image of an object.
8A.2.2 True View
View of the features of an object that lie on a plane parallel to the projection plane; geometrically similar to the corresponding features of the object.
8A.2.3 *Exploded View*
Drawing of an assembly in pictorial representation in which all the components are drawn to the same scale and correctly orientated relative to each other, but are separated from each other in their correct sequence along common axes. *See* Examples of exploded view in Fig 8A.3 and 8A.4.

NOTE ´ This term should not be confused with representations where a covering layer is removed in order to show inner portions like those presented in section (cut-away view).

8A.2.4 *Principal View*
View of an object showing the important features, which may be chosen from the point of view of design, assembly, sales, service or maintenance.
8A.3 Survey of Projection Methods

Projection methods are defined by:

- the type of projectors, which may be either parallel or convergent;
- the position of the projection plane in relation to the projectors, either orthogonal or oblique;
- the position of the object (its main features), which may be either parallel/orthogonal or oblique to the projection plane

A survey of the various possibilities and their relationships is given in Table 8A.1.
8A.4 Geometrical Orientation
Geometrical orientation in space is given by coordinate axes and coordinate planes in accordance with the arrangement given by the right-hand rule.
8A.4.1 *Coordinate Axes*
Coordinate axes are imaginary lines in space which intersect at right angles to each other at the origin. There are three coordinate axes: *X, Y* and Z (*see* Fig. 8A.1), to be designated by capital letters.
8A.4.2 *Coordinate Planes*
Three imaginary planes in space which intersect each other at right angles. Each of the three coordinate planes is defined by two coordinate axes and includes the origin. They are designated by capital letters *XY, YZ* and *XZ {see* Fig. 8A.2).

NOTE ´ Coordinate planes and projection planes are not always the same, therefore, if necessary, appropriate indication (designation) should be shown on the drawing.

8A.5 Invariables

Depending on the projection method chosen, certain features of the object are represented in true view as follows.

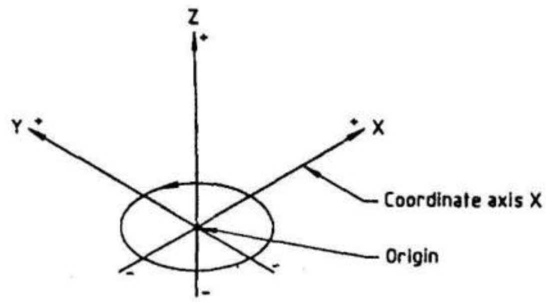


FIG. 8A.1

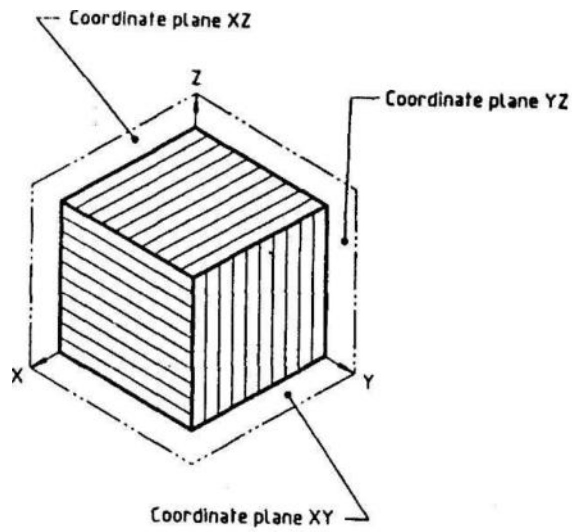


FIG. 8A.2

8A.5.1 The central projection invariable is :

- the size of angles in planes which are parallel to the projection plane; therefore the projection plane figures lying in planes parallel to the projection plane are similar.

8A.5.2 Oblique projection invariables are:

- the parallelism of lines, unless they are parallel to the projection lines;
- the divisional ratio of lines;
- the size of angles, length of lines and all plane figures in planes parallel to the projection plane.

8A.5.3 Orthogonal projection invariables are:

- the parallelism of lines, unless they are parallel to the projection lines;
- the divisional ratio of lines;
- the size of angles, length of lines and all plane figures in planes parallel to the projection plane;
- right angles, if one side of the right angle in the object is parallel to the projection plane.

Table 8A.1 Projection Systems

(Clause 8A.3)

Projection Centre	Position of Projection Plane to Projectors	Main Features o the Object in Relation to Projection Plane	Number of Projection Planes	Type of View	Type of Projection
Infinite (parallel projectors)	Orthogonal	Parallel/Orthogonal	One or more	Two-dimensional	Orthogonal [1S 15021 (Part 2)]
		Oblique	One	Three-dimensional	
	Oblique	Parallel/Orthogonal	One	Three-dimensional	Axonometric [1S 15021 (Part3)l
		Oblique	One	Three-dimensional	

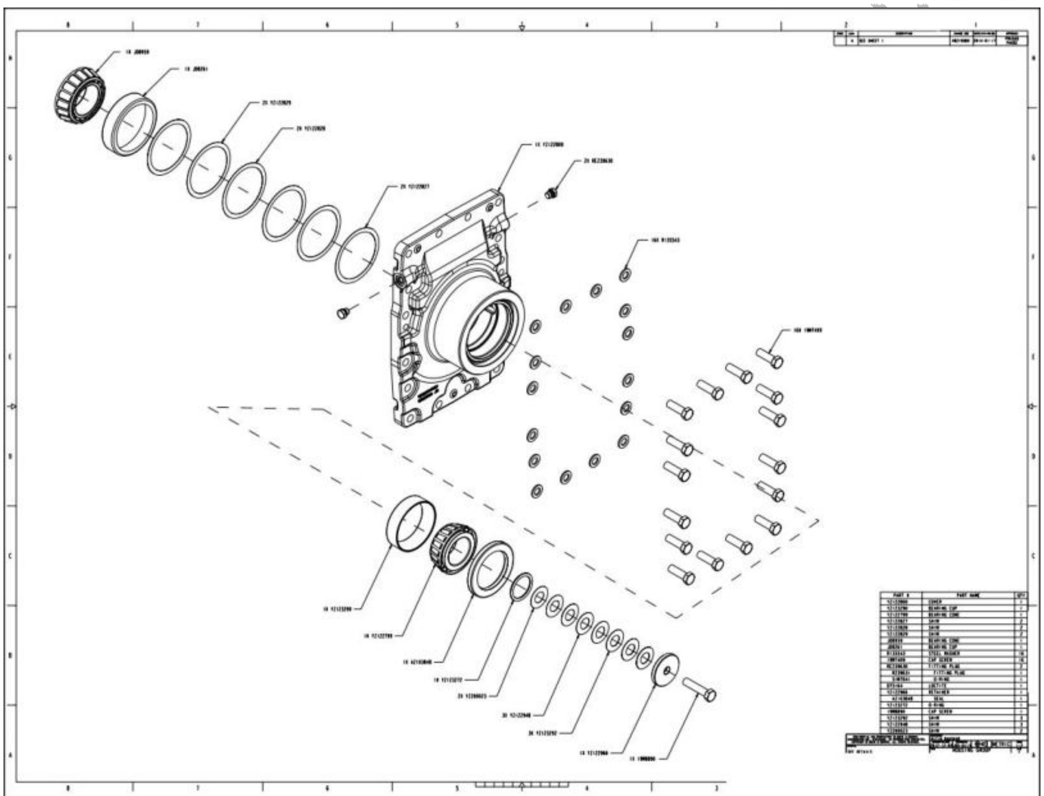


FIG 8A.3 Example of Exploded View

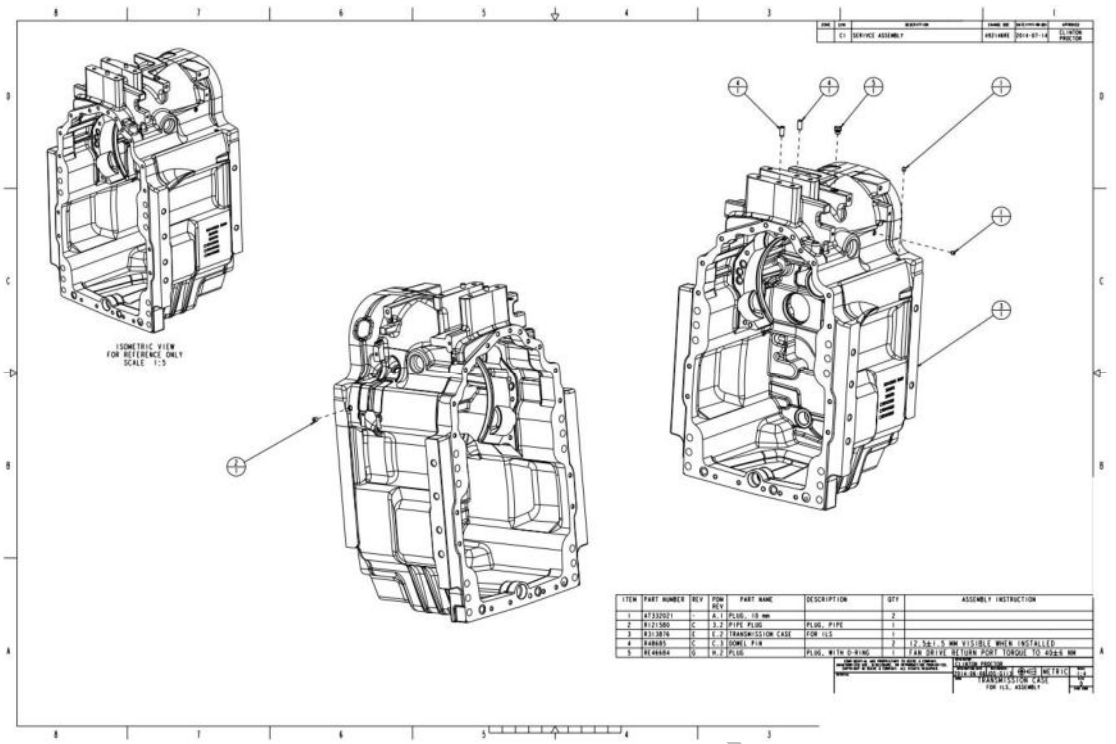


FIG 8A.4 Example of Exploded View

SECTION 8B PROJECTION METHODS — ORTHOGRAPHIC REPRESENTATIONS

[Based on IS 15021 (Part 2): 2001/ISQ 5456-2 : 1996]

8B.1 Scope

This section specifies basic rules for the application of orthographic representation to all types of technical drawings.

8B.2 General Principles

8B.2.1 *General*

Orthographic representation is obtained by means of parallel orthogonal projections and results in flat, two-dimensional views systematically positioned relative to each other. To show an object completely, the six views in the directions *a, b, c, d, e* and/may be necessary, in order of priority (*see* Fig. 8B.1 and Table 8B.1).

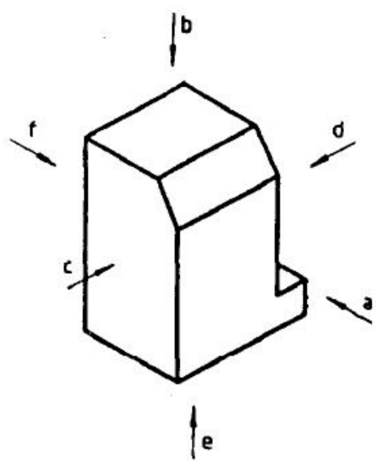


FIG. 8B.1

8B.2.2 *Designation of Views*

See Table 8B. 1.

Table 8B.1 Designation of Views

(Clauses 8B.2.1 *and 8B.2.2)*

Direction of observation		Designation of View
View in Direction	View from	
a	the front	A
b	above	B(E)[1)]
c	the left	C
d	the right	D
e	below	E
f	the rear	F

1) *See 8B3.4*

The most informative view of the object to be represented is normally chosen as the principal view (front view). This is view *A* according to the direction of viewing *a (see* Fig. 8.1 and Table 8.1), generally showing the object in the functioning or manufacturing or mounting position. The position of other views relative to the principal view in the drawing depends on the projection method chosen (first angle, third angle, reference arrows). In practice, not all six views (*A* to *F)* are needed. When views (cuts or sections) other than the principal view are necessary, these shall be selected in order to:

- limit the number of views, cuts and sections to the minimum necessary and sufficient to fully represent the object without ambiguity;
- avoid unnecessary repetition of detail.

8B.3 Methods of Representation

8B.3.1 *First Angle Projection*

The first angle projection method is an orthographic representation in which the object to be represented *(see* Fig. 8B.1**)** appears between the observer and the coordinate planes on which the object is orthogonally projected *(see* Fig. 8B.2**).**

The positions of the various views relative to the principal (front) view *A* are determined by rotating their projection planes around lines coinciding with or parallel to the coordinate axes on the coordinate plane (drawing surface) on which the front view A is projected *(see* Fig. 8B.2).

Therefore, in the drawing, with reference to the principal view *A,* the other views are arranged as follows *(see* Fig. 8B.3):

- View *B:* The view from above is placed underneath;
- View *E:* The view from below is placed above;
- View C: The view from left is placed on the right;
- View *D:* The view from the right is placed on the left;
- View *F:* The view from the rear is placed on the right or on the left, as convenient.

The identifying graphical symbol of this method is shown in Fig. 8B.4.

8B.3.2 *Third Angle Projection*

The third angle projection method is an orthographic representation in which the object to be represented *(see* Fig. 8B. 1), as seen by the observer, appears behind the coordinate planes on which the object is orthogonally projected (see Fig. 8B.5). On each projection plane, the object is represented as if seen orthogonally from infinite distance with transparent projection planes.

The position of the various views relative to the principal (front) view *A are* determined by rotating their projection planes around lines coinciding with or parallel to the coordinate axes on the coordinate plane (drawing surface) on which the front view *A* is projected (*see* Fig. 8B.5).

Therefore, in the drawing, with reference to the principal view *A,* the other views are arranged as follows (*see* Fig. 8B.6):

- View *B:* The view from above is placed above;
- View *E:* The view from below is placed underneath;
- View C The view from left is placed on the left;
- View *D* The view from the right is placed on the right;
- View FThe view from the rear may be placed on the left or on the right, as convenient.

The identifying graphical symbol of shown in Fig. 8B.7.

8B.3.3 *Reference Arrows Layout*

In those cases where it is advantageous to position the views not according to the strict pattern of the first or the third angle projection method, the use of the reference arrows method permits the various views to be freely positioned.

With the exception of the principal view, each view shall be identified by a letter in accordance with Fig. 8B. 1. A lower-case letter indicates in the principal view the direction

of observation of the other views, which are identified by the corresponding capital letter placed immediately above the view and on the left.
The identified views may be located irrespective of the principal view (*see* Fig. 8B.8). Whatever the direction of observation, the capital letters [*see* IS 9609 (Part 1)] identifying the views shall always be positioned to be read from the normal direction of viewing of the drawing. No graphical symbol for the indication of this method is needed on the drawing.

The view resulting from a mirrored orthographic representation may be indicated by using the capital letter for the designation of views (that is *'E', see* 8B.2.2).

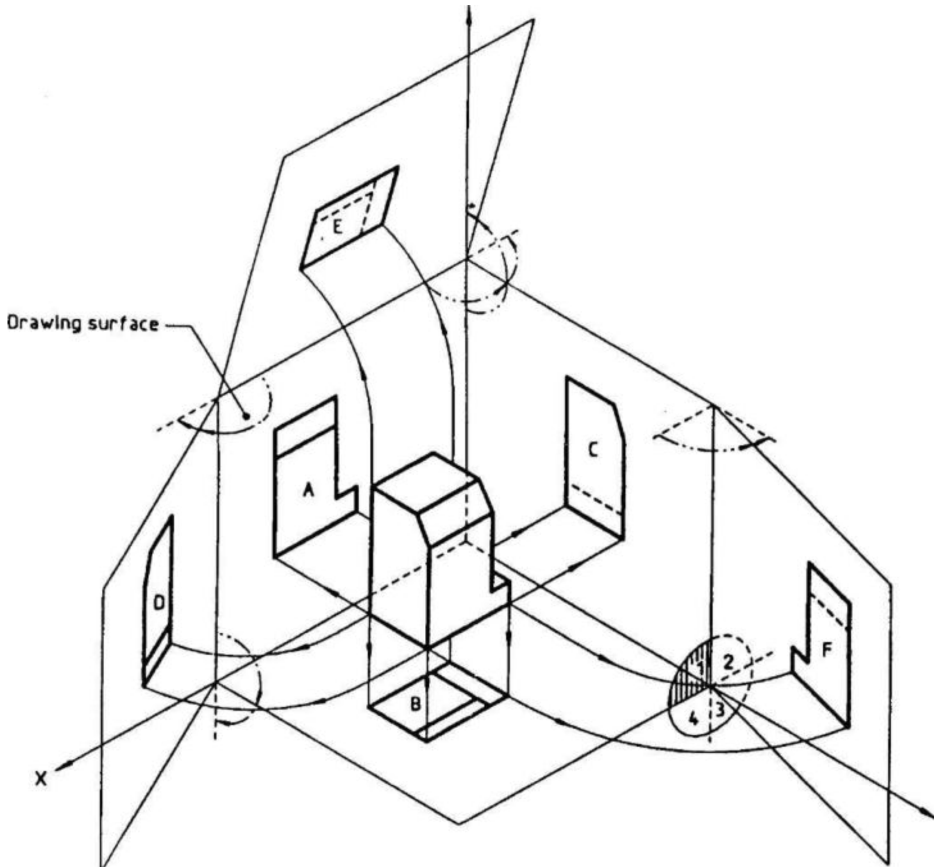


Fig. 8B.2

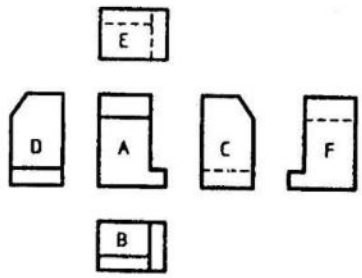


FIG. 8B.3

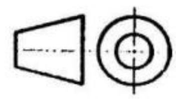


Fig 8B.4

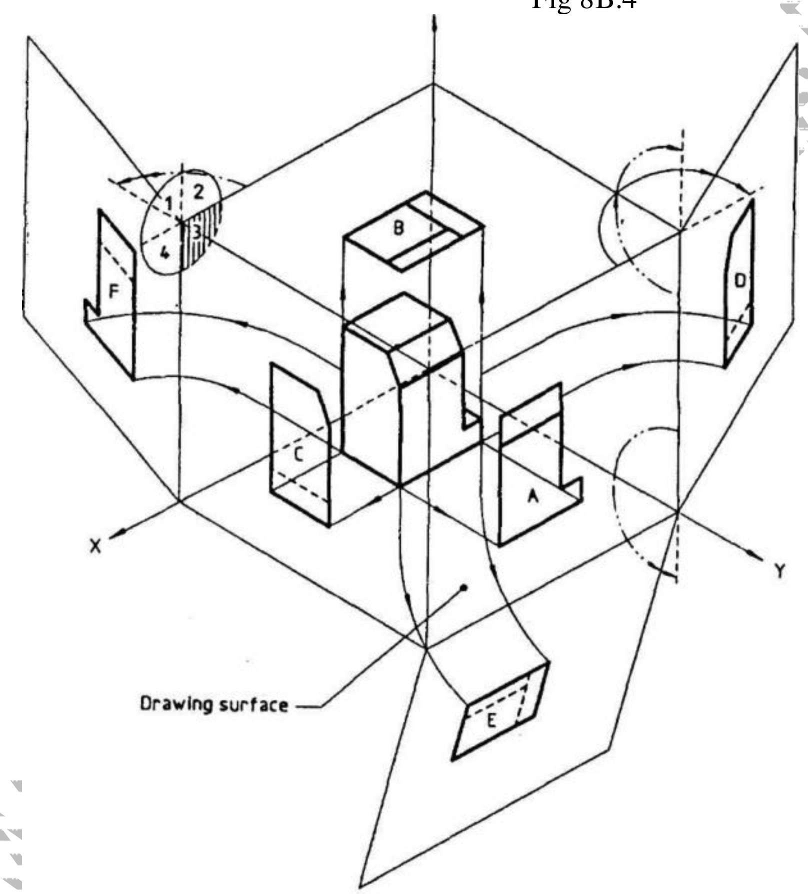


FIG. 8B.5

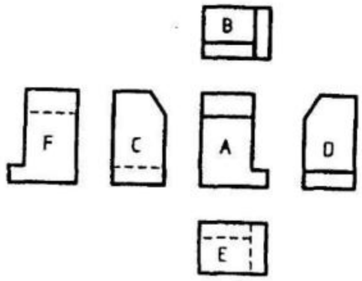


FIG. 8B.6

The identifying graphical symbol of this method is shown in Fig. 8B.7.

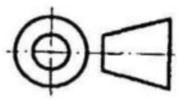


FIG. 8B.7

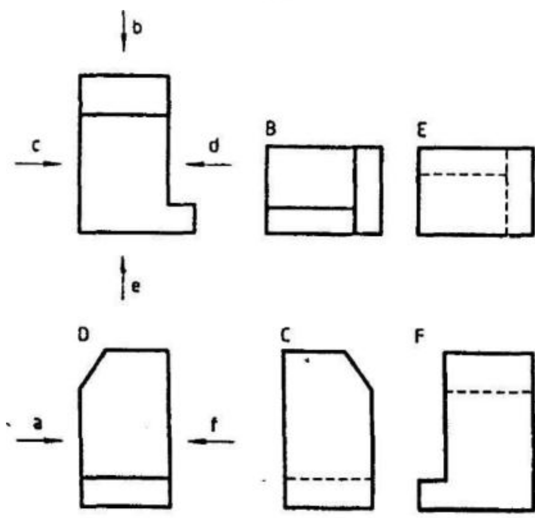


FIG. 8B.8

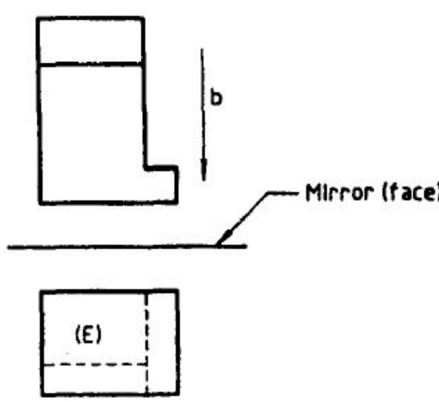


FIG. 8B.9

FIG. 8B.10

[1)] This method is preferably used in construction drawings

8B.3.5 *Layout of Views Using Reference Arrows*

In those cases where it is an advantage to position the views not according to the strict pattern of the first or the third angle projection methods, the use of reference arrows permits the various views to be freely positioned.

With the exception of the principal view, each view shall be identified by a capital letter which is repeated near the arrow needed to indicate the direction of viewing for the relevant view.

The designated views may be located irrespective of the principal view. The capital letters identifying the referenced views shall be placed either immediately below or above the relevant views. In any one drawing, the references shall be placed in the same way. No other indication is necessary *(see* Fig. 8B.11).

8B.3.6 *Indication of Method*

Where one of the methods specified earlier is being used, the said method must be indicated on the drawing by means of its distinguishing symbol as shown in Fig. 8B.4 or Fig. 8B.7.

The symbol shall be placed in a space provided for the purpose in the title block of the drawing.

For the layout of views using reference arrows specified in 8B.3.5, no distinguishing symbol is required.

8B.3.7 *Choice of* Views

8B.3.7.1 The most informative view of an object shall be used as the front or principal view. Generally, this view shows the part in the functioning position. Parts which can be used in any position should preferably be drawn in the main position of manufacturing or mounting.

8B.3.7.2 When other views (including sections) are needed, these shall be selected according to the following principles:

- to limit the number of views and sections to the minimum necessary and sufficient
- to fully delineate the object without ambiguity,
- to avoid the need for hidden outlines and edges,and
- to avoid unnecessary repetition of detail.

8B.3.8 *Special* Views

8B.3.8.1 If a direction of viewing different from those shown in 8B.2.2 is necessary, or if a view cannot be plotted in its correct position using the methods shown i n 8B.3. 1 and 8B.3.2, reference arrows as indicated in 8B.3.5 shall be used for the relevant view (*see* Fig. 8B.12 and 8B.13).

8B.3.8.2 Whatever the direction of viewing, the capital letters referencing the views shall always be positioned normal to the direction of reading.

8B.3.9 *Partial Views*

Partial views may be used where complete views would not improve the information to be given. The partial view shall be cut off by a continuous narrow freehand line (01.1. 18) or continuous narrow lines with zigzags (01.1.19) (*see* Fig. 8B. 12).

8B.3.10 *Local Views*

8B.3.10.1 Provided that the presentation is unambiguous, it is permitted to give a local view instead of a complete view for symmetrical items. The local view should be drawn in third angle projection, regardless of the arrangement used for the general execution of the drawing.

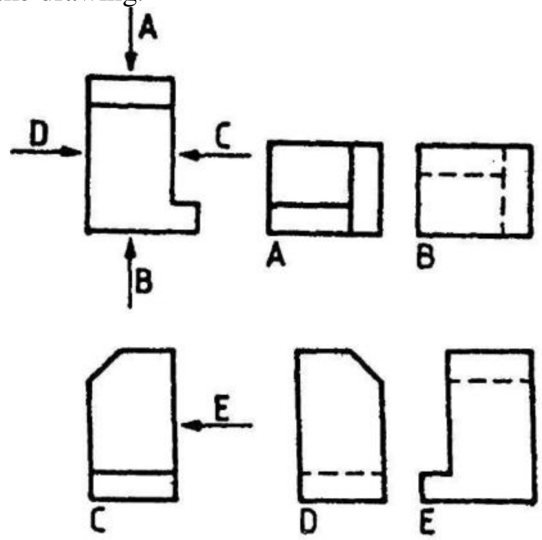


FIG. 8B.11

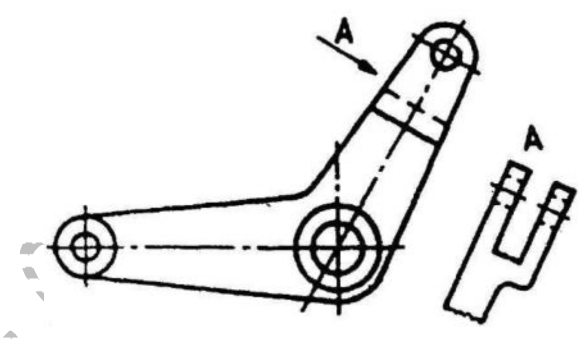


FIG. 8B.12

8B.3.10.2 Local views shall be drawn with con- the principal view by a centre line (04.1.2). *Examples* continuous wide lines (01.1.1), and shall be connected to of local views are shown in Fig. 10.27 to 10-30

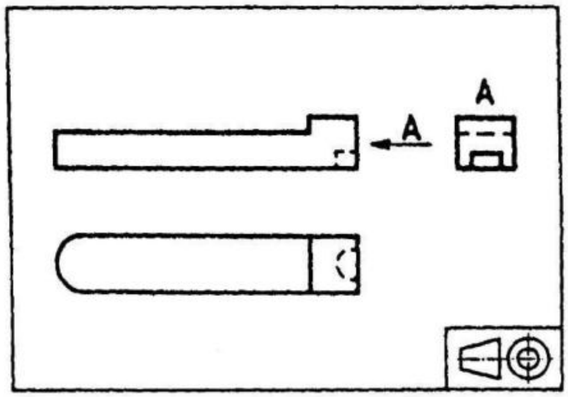


FIG. 8B.13

SECTION 8C PROJECTION METHODS — AXONOMETRIC REPRESENTATIONS [Based on IS 15021 (Part 3): 2001/ISQ 5456-3 :1996]

8C.1 Scope

This section specifies basic rules for the application of the recommended axonometric representations for all types of technical drawings.

8C.2 General

The general principles of presentation given in Section 8B shall be followed.

8C.2.1 *Position of the Coordinate System*
The position of the coordinate axes shall be chosen, by convention, so that one of the coordinate axes (the Z-axis) is vertical.

8C.2.2 *Position of the Object*
The object to be represented is located with its principal faces, axes and edges parallel to the coordinate planes. The object shall be orientated to show the principal view and the other views that would preferably be chosen when representing the same object in orthogonal projections.

8C.2.3 *Axes of Symmetry*
Axes and traces of planes of symmetry of the object shall not be drawn unless necessary.

8C.2.4 *Hidden Contours and Edges*
Hidden contours and edges should preferably be omitted.

8C.2.5 *Hatching*
Hatching to indicate a cut or section shall be drawn preferably at an angle of 45° with respect to axes and contours of the cut or section *(see* Fig. 8C.1). Hatching to indicate planes parallel to the coordinate planes shall be drawn parallel to the projected coordinate axis, as shown in Fig. 8C.2.

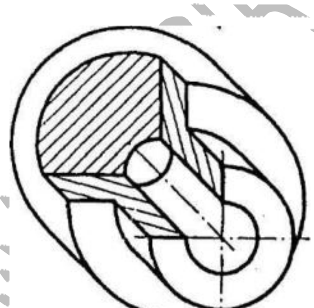


FIG. 8C.1

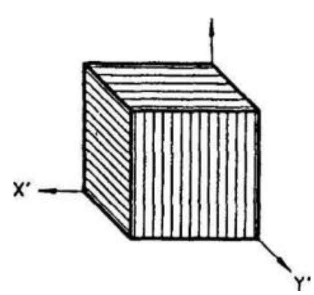


FIG 8C.2

8C.2.6 *Dimensioning*
Dimensioning of axonometric representations is normally avoided. If, for special reasons, dimensioning is considered necessary, the same rules given for orthogonal projections (Sections 7 and 12) shall be used *(see* Fig. 8C.6 and 8C.12).
8C.3 Recommended Axonometries
Recommended axonometries for technical drawings are:

- isometric axonometry *(see* 8C.3.1);
- dimetric axonometry *(see* 8C.3.2); and
- oblique axonometry *(see* 8C.3.3).

Coordinate axes *X*, *Y* and Z are to be indicated by upper case letters. If other items (for example, dimensions) have to be indicated in a table or drawing, lower-case letters x, v and j shall be used for better differentiation.

8C.3.1 *Isometric Axonometry*

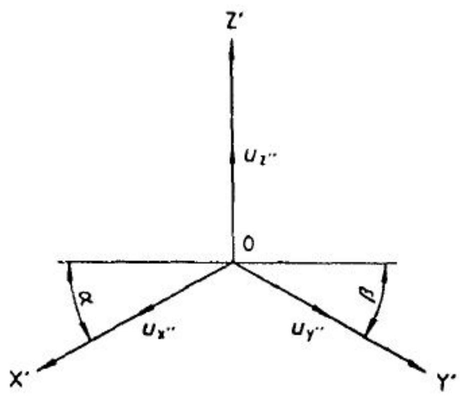
The isometric axonometry is the orthogonal axonometry in which the projection plane forms three equal angles with the three coordinate axes *X, Y* and Z[1)]

Three unit length segments «$_x$, u_y and u_z on the three coordinate axes *X,* Y and Z, are respectively projected orthogonally on the projection plane in three equal segments $u_{x'}$, $u_{y'}$ and $u_{z'}$ on the projected *X', Y'* and *Z'* axes whose lengths are:

$$u_{x'} = u_{y'} = u_{z'} = (2/3)^{1/2} = 0.816$$

The projection *X', Y* and Z' of the three coordinate axes *X, Y* and Z on the projection plane (drawing surface) is shown in Fig. 8C.3.

[1)] This gives a representation identical to that obtained by orthogonal projection of the principal view of a right hexahedron with all its faces equally inclined to the projection plane



$\alpha = \beta = 30°$

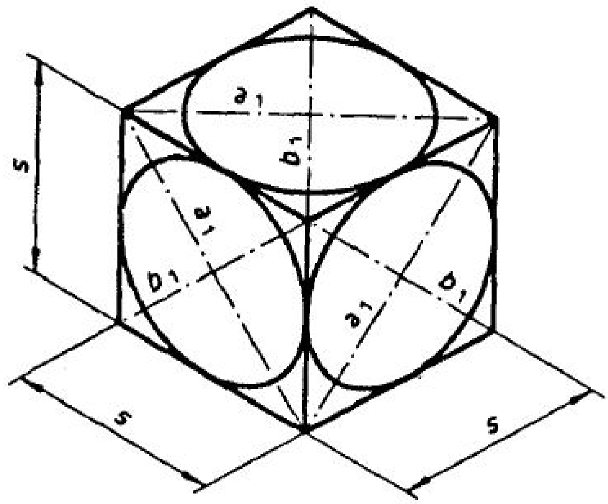
FIG. 8C.3

In drawing practice, the projected unit length segments on the X', Y' and Z' axes are taken as i<$_x$- = i<y" = ii/' = 1, which corresponds to a graphic representation of the object enlarged by a factor *(3/2)*^{U2}= 1.225.

The isometric axonometry of a right hexahedron with circles inscribed on its faces is represented in Fig. 8C.4.

The isometric axonometry gives the same visual importance to all three faces of the right hexahedron, and is therefore convenient to draw on an equilateral-triangle grid *(see* Fig. 8C.5).

An example of dimensioning for isometric axonometry is given in Fig. 8C.6.



Length of the ellipse axes:

$$a_1 = \sqrt{\frac{3}{2}}\, s \approx 1.22s$$

$$b_1 = \sqrt{\frac{1}{2}}\, s \approx 0.71s$$

FIG. 8C.4

8C.3.2 *Dimetric Axonometry*

Dimetric axonometry is used when a view of the object to be represented is of main importance. The projection of the three coordinate axes is given in Fig. 8C.7.

The ratio of the three scales is u_x': u_y-: u_z' = 1/2: 1 : 1.

The dimetric axonometry of a right hexahedron with circles inscribed in its faces is given in Fig. 8C.8.

8C.3.3 *Oblique Axonometry*

In oblique axonometry, the projection plane is parallel to one coordinate plane and to the main face of the object to be represented, whose projection remains in the same scale. Two of the projected coordinate axes are orthogonal. The direction of third projected coordinate axis and its scale are arbitrary. Several types of oblique axonometry are used, because of their ease of drawing.

8C.3.3.1 *Cavalier axonometry*

In this type of oblique axonometry, the projection plane is normally vertical and the projection of the third coordinate axis is chosen by convention at 45° to the remaining projected orthogonal axes; the scales on the three projected axes are identical:

$u_{x'} = u_{y'} = u_{z'} = 1$ (see Fig. 8C.9).

The four possible cavalier axonometries of a right hexahedron are shown in Fig. 8C.1O.

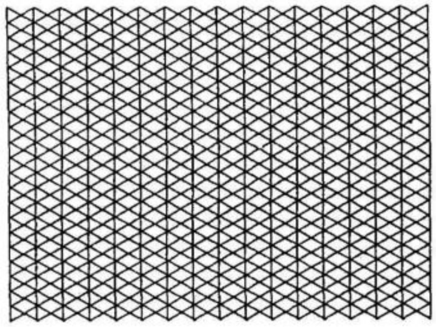


FIG. 8C.5

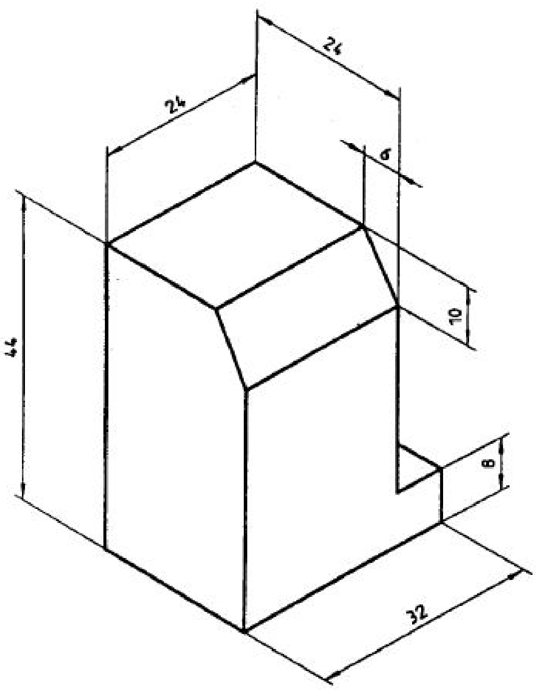


FIG. 8C.6

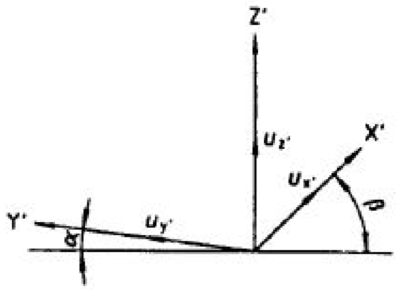


FIG. 8C.7

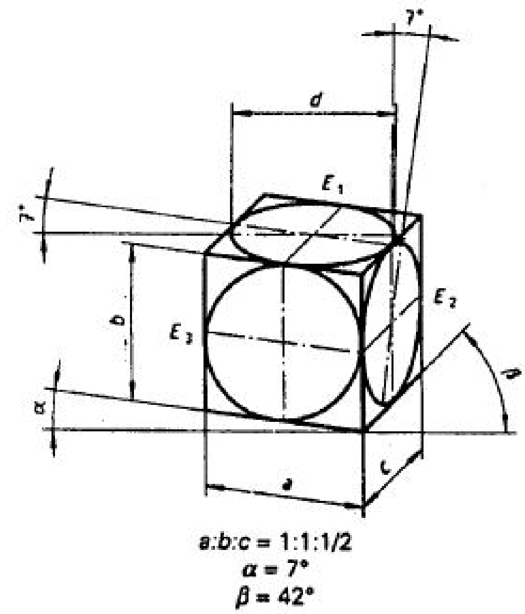


FIG. 8C.8

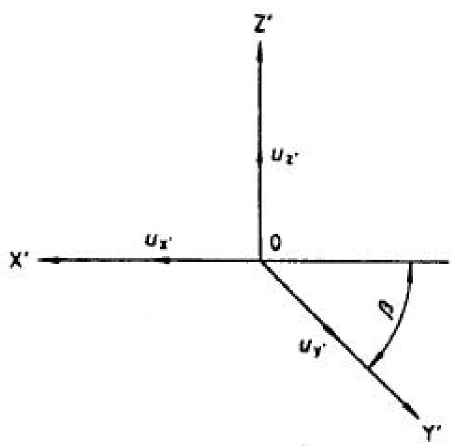


FIG. 8C.9

Cavalier axonometry is very simple to draw and makes if possible to dimension the drawing, but heavily distorts the proportions along the third coordinate axis

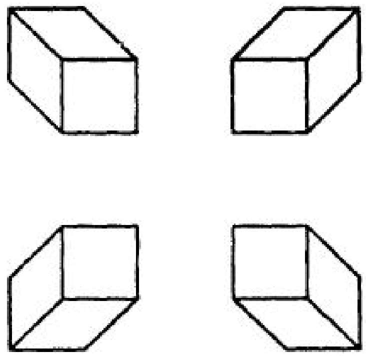
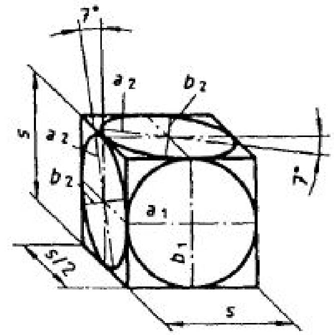


FIG. 8C.10



$a_1 = b_1 = s$

Length of the ellipse axes:

$a_2 = 1,06s$
$b_2 = 0,33s$

FIG. 8C.11

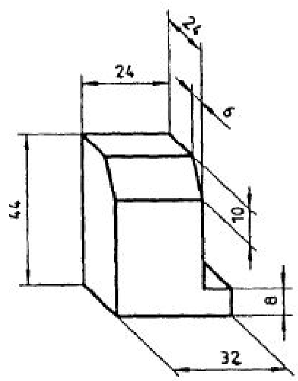


FIG. 8C.12

8C.3.3.2 *Cabinet axonometry*
Cabinet axonometry is similar to cavalier axonometry, except that on the third projected axis the scale is reduced by a factor of two. This provides a better proportion to the drawing. A cabinet axonometric representation of a right hexahedron with circles inscribed in its faces is shown in Fig. 8C.11.

An example of dimensioning is given in Fig. 8C. 12.

8C.3.3.3 *Planometric axonometry*
In planometric axonometry, the projection plane is parallel to the horizontal coordinate plane. Projections using angles (CL= 0°,90° or 180° should be avoided so that all necessary information can be presented (*see* Fig. 8C.13).

8C.3.3.3.1 *Normal planometric projection*
Possible projections of coordinate axes whose scales can be chosen in the ratio 1 : 1 : 1 are shown in Fig. 8C.14.

A right hexahedron with its dimensioning is given in Fig.8C.15. This type of oblique axonometry is particularly suited for town planning drawings.

8C.3.3.3.2 *Shortened planometric projection*

Possible projections of the coordinate axes whose scales can be chosen in the ratio 1 : 1 : 2/3 are shown in Fig. 8C. 14. A right hexahedron with its dimensioning is given in Fig. 8C. 16.

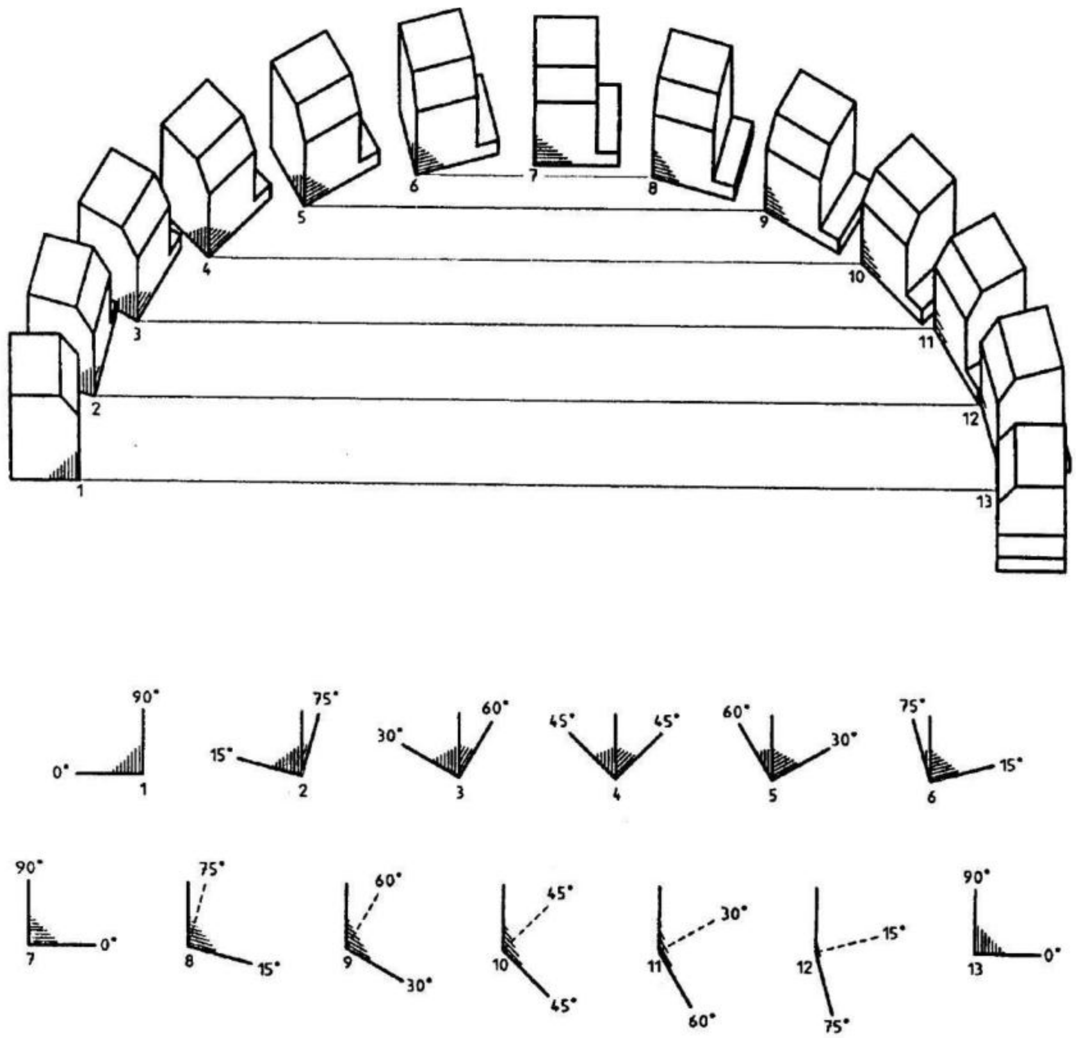


FIG. 8C.13

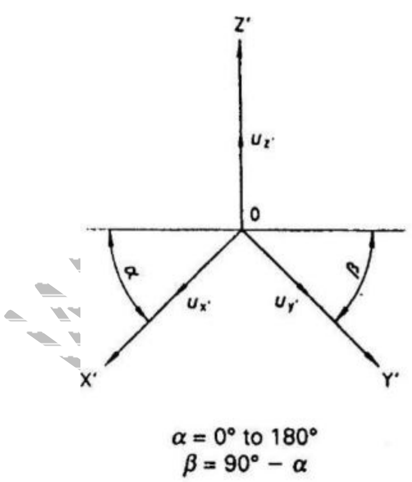


FIG. 8C.14

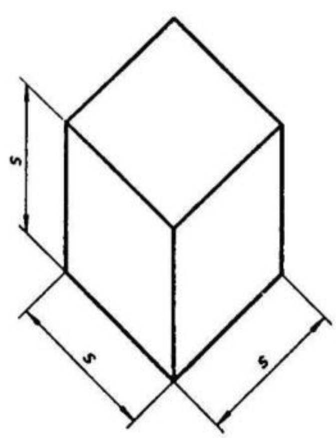


FIG. 8C.15

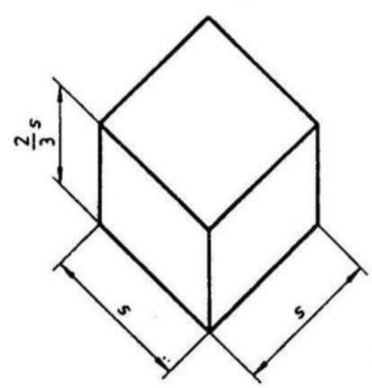


FIG. 8C.16

SECTION 8D PROJECTION METHODS — CENTRAL PROJECTION

[Based on IS 15021 (Part 4) : 2001/ISQ 5456-4 : 1996]

8D.1 Scope

This section specifies basic rules for the development and application of central projection in technical drawings.

8D.2 Definitions

8D.2.1 *Alignment Line*

Line parallel to a given line passing through the projection centre. Its intersection with the projection plane gives the vanishing point of all lines parallel to the given line.

8D.2.2 *Height of Projection*

Vertical distance of the projection centre from the basic plane.

8D.2.3 *Horizontal Distance*

Distance between the projection centre and the projection plane.

8D.2.4 *Projection Angle*

Angle formed by the projection plane and the horizon plane.

8D.2.5 *Scale Point*

Vanishing point of the horizontal direction orthogonal to that bisecting the angle formed by the horizon line and the alignment line of the given horizontal line, and allowing the true length of the projection of the given line to be determined.

8D.2.6 *Station of Observation*

Orthogonal projection of the projection centre onto the basic plane.

8D.3 Symbols

Letter symbols for terms used in central projection are given in Table 8D.1 and illustrated in Fig. 8D.1 and 8D.2, as well as in the figures mentioned in Table 8D. 1.

8D.4 Central Projection Methods

The mode of the central projection depends on the position of the object to be represented with respect to Ihe projection plane. For possible positions and applicable projection methods see 8D4.1 to 8D4.4.

8D.4.1 *One-point Method*

A one-point projection method is a central projection of an object having its principal face parallel to the projection plane (special position). All parallel outlines and edges of the object which are parallel to the projection plane retain their direction in this representation (horizontal lines remain horizontal and vertical lines remain vertical). All lines perpendicular to the projection plane converge at the vanishing point, *V,* coinciding with the main point, C (*see* Fig. 8D.3 and 8D.6.2.1 and 8D.6.3).

Table 8D.1 Letter Symbols
(*Clause* 8D.3)

Clause No.	Term	Letter Symbol	Figure
1)	Projection plane	*T*	8D.1
1)	Basic plane	*a*	8D.1
1)	Basic line	*X*	8D.1
8D.2.4	Projection angle	P	8D.5
1)	Horizon plane	*HT*	8D.1
1)	Horizon line	*h*	8D.1
8D.2.1	Alignment line	*VI*	8D.4
1)	Main point	*C*	8D.1
1)	Vanishing point	*V*	8D.4
1)	Main projector	*pL*	8D.1
1)	Projection centre	*O*	8D.1
8D.2.2	Height of projection	*H*	8D.1
8D.2.3	Horizontal distance	d	8D.1
1)	Vision cone	*K*	8D.2
1)	Circle of vision	*Ks*	8D.3
1)	Vision angle	*a*	8D.2
1)	Projector	*PI*	8D.3
1)	Distance point	*DP*	8D.13
8D2.5	Scale point	*MP*	8D.14
8D2.6	Station of observation	*Sp*	8D.1

1) terms already defined in IS 8930 (Part 2)

8D.4.2 Two-point Method
A two-point projection method is a central projection of an object having its vertical outlines and edges parallel to the projection plane (particular position). All horizontal lines of a representation converge at multiple vanishing points V_b V_2, V_3,..., on the horizon line *(see* Fig. 8D.4 and 8D.6.2.2 and 8D.6.4).

8D.4.3 *Three-point Method*

A three-point projection method is a central projection of an object having no outlines or edges parallel to the projection plane (any position). If the projection plane is inclined towards the projection centre, that is, $\oint > 90°$, the vanishing point for vertical lines is situated below the horizon line (*see* Fig 8D.5 and 8D.6.5.1 and 8D.6.5.2).

8D.4.4 *Coordinate Method*
Representation by the coordinate method is based on simple proportions.
The coordinates, related to the main projector of all relevant points of the object to be represented, are taken by the graphic method from the basic plane and elevation. From these point coordinates, the image coordinates are obtained by a calculation method and entered to scale. The image points are connected to each other to provide a clear representation of the object *(see* Fig. 8D.6).

8D.5 Principle

8D.5.1 *Location and Position of the Projection Plane*

The image size of an object can be varied by parallel shifting of the projection plane. If the object is placed in front of the projection plane, the representation will be enlarged. The object behind the projection plane will result in a smaller image. Figure 8D.7 shows the change in image size depending on the position of the object with respect to the projection plane.

Figure 8D.8 shows the change in image size depending on the method of representation with vertical or inclined projection planes. (3 is the included angle between the projection plane and the basic plane near the projection centre.

8D.5.2 *Circle of Vision and Vision Cone*

To obtain a fully instructive image of an object without peripheral distortions on the projection plane, the object must be positioned within a vision cone having an aperture angle not greater than 60° Heavy peripheral distortions occur on images outside the circle of vision; the image does not appear fully instructive since length, width and height do not match the object's inherent proportions (we Fig. 8D.9).

An object can be depicted nearly undistorted if the projectors result in a bundle of rays inclined not more than 30° with respect to the main projector. At this aperture angle the vision cone provides only a small distortion on the projection plane.

The main projector should hit the object to be depicted in a part which is visually important, so that the object is contained within the minimum vision cone.

8D.5.3 Distance

Different relative distances influence the image size and its appearance. When the distance between the object and the projection plane is fixed and the projection centre and the object lie on opposite sides of the projection plane, increasing the distance (d) between the projection centre and the projection plane gives enlarged and flattened representations. When the distance *(d)* is fixed and the object and the projection centre lie on opposite sides of the projection plane, increasing the distance between the object and the projection plane gives reduced and flattened representations.

8D.6 Principles and methods of Depictions

8D.6.1 ***Piercing Method***

Using the piercing method, the piercing points of projectors with the projection plane are shown by basic plane and elevation, and may be determined either by drawing or by calculation *(see* Fig. 8D. 10).

The piercing method allows even complex objects (round shapes, helicoids, etc) to be easily represented in central projection

8D.6.2 *Trace Point — Vanishing Point Methods*

With the trace point ´ vanishing point methods, the outlines and edges of the object to be depicted are imaged from basic plane and elevation.

8D.6.2.1 *Trace point — Vanishing point Method A (special position of the object)*

In Method A, one vertical face of the object is parallel to the vertical projection plane (special position of the object with respect to the projection plane), so that the vanishing point for those edges parallel to the projection plane is situated at infinity and the vanishing point for those edges perpendicular to the projection plane is the main point *(see* Fig. 8D.11).

8D.6.2.2 *Trace point – Vanishing point Method B (particular position of the object)*

In Method B, horizontal faces of the object are perpendicular to the vertical projection plane (particular position of the object with respect to the projection plane) so that the lines are represented by their trace on the projection plane and by their vanishing point *(see* Fig. 8D.12).

8D.6.3 *Distance Point Method (Special position of the object)*
The distance point method gives the central projection of an object without its basic plane, by setting up a perspective grid. The outlines and edges are parallel or perpendicular to the projection plane (special position). The distance point has the same distance from main point as the projection centre from the projection plane. All horizontal lines inclined at 45° with respect to the projection plane align to the distance point. The vanishing point of the depth lines of the grid is the main point (*see* Fig. 8D.13).

8D.6.4 *Scale Point Method (Particular position of the object)*
For any vanishing point there is a corresponding scale point. With the aid of scale points, certain dimensions of the object to be depicted may be transferred from the basic line in the projection plane on depth lines (*see* Fig. 8D.14). By means of the basic plane, a definite relation between the perspective representation of the object and the object itself may be established.

8D.6.5 *Trace Point Method with inclined Projection Plane*

8D.6.5.1 *Inclined projection plane P <90°*
Due to the inclination of the projection plane with respect to the horizon plane, the vanishing point for the vertical lines of the object to be depicted moves from infinite to finite. The angle ∮, that is the angle of the inclination of the projection plane with respect to the horizon plane, defines the position of the vanishing point above the horizon. Vertical object lines are represented as tilting lines, which gives an optical distortion suggesting a tapering form (*see* Fig. 8D. 15).

8D.6.5.2 *Inclined projection plane ∮ >90°*
Due to the inclination away from the projection centre, the vanishing point for vertical lines of the object to be depicted moves below the horizon line from infinite to finite, so that tilting projected vertical lines provide an optical distortion suggesting a tapering form (*see* Fig. 8D.16).

8D.6.6 *Coordinate Piercing Method*
The coordinate piercing method is based on simple proportions, in which each piercing point of the projectors in the projection plane is not established by drawing, but by calculation. This method is based on dividing the space in four quadrants by two reference planes, one horizontal and one vertical, each perpendicular to the projection plane, their common line being the main projector. The common lines of the horizontal and vertical reference planes and the projection plane are the X and Y axes of a rectangular Cartesian coordinate system situated in the projection plane, the origin of which is the main point. The projector *OP* of point *P* pierces the projection plane at point P˘(X, Y).

The coordinates X and Yof the point P˘ can be determined from the distances $PA_1 = B_1 C_1$ and $PB_1 = A_1C_1$ of the point *P* from the reference planes, from the object distance $D = OC_1$ and the distance d= *OC:*

$X = B_1C_17d/D$ and Y= A_1C_17/D
The values calculated for X and Yfor all points of the object to be represented are transferred into the coordinate system to obtain the representation of the object. The dimensions needed

for the calculation of B_1C_1, A_1C_1 and D are taken from the basic plane, elevation, side view, etc, of the object, whereby these planes may be drawn in various scales. The representation maybe reduced or enlarged in a similar mode by multiplying the coordinates X and Y by the scale factor (*see* Fig. 8D.17).

NOTE ´ B_1C_1 is positive(negative)when B_1 *is* on right (left) side of the main projector; A_{1C1} is positive (negative) when A_1 is above(below)the main projector

8D.7 Development of a Central Projection

By turning the basic plane into the projection plane (see Fig. 8D.1), it is possible to present the representation of the basic plane on the drawing surface and subsequently to create the complete representation of the dimensions taken from the elevation. There are two different ways to turn the basic plane.

8D.7.1 *Turning the Basic Plane Downwards*
The station of observation, *(Sp), is* placed at the distance *d* from C˘, below the basic line (X). The representation is above, and the basic plane is below the basic line; they do not cover each other. This arrangement is called regular arrangement and gives the best survey, but requires considerable space on the drawing surface (*see* Fig. 8D. 18).

8D.7.2 *Turning the Projection Plane Downwards*
The basic line becomes the axis of symmetry. This frequently-used arrangement saves space in the drawing surface and is called economy arrangement (*see* Fig. 8D. 19).

8D.8 Examples of Comparison of Different Depiction Methods –
Figures 8D.20,8D.21 and 8D.22 illustrate some of the different depiction methods described in 8D.6.

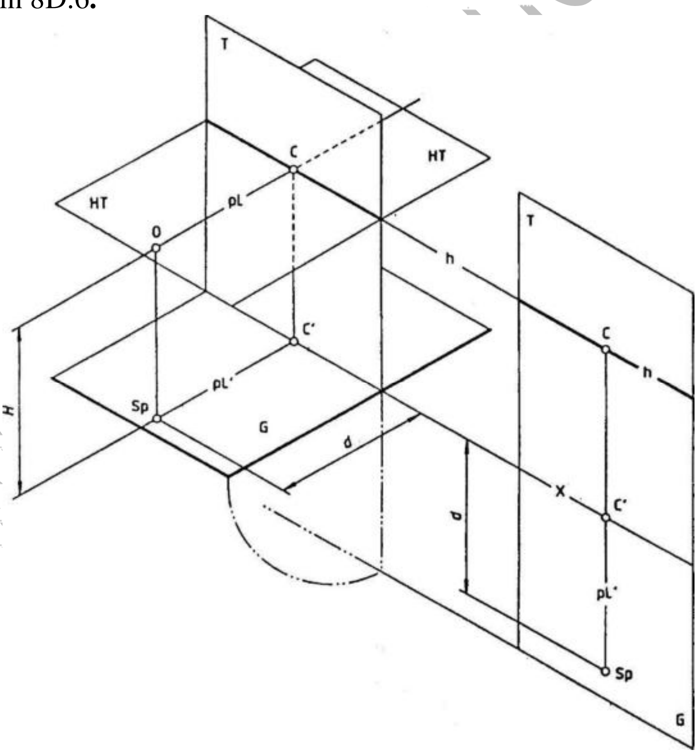


FIG 8D.1 Projection Model of the Central Projection

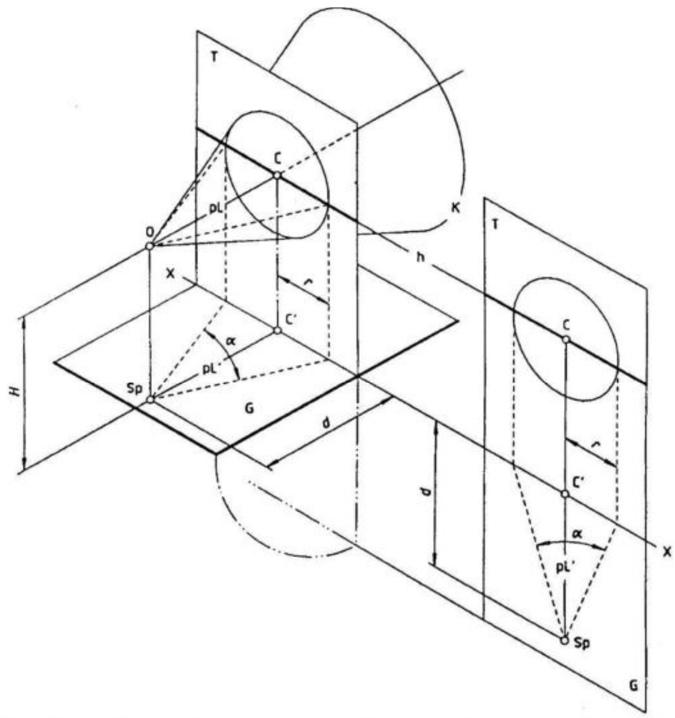


FIG. 8D.2 VISION CONE AND VISION ANGLE IN THE PROJECTION MODEL OF THE CENTRAL PROJECTION

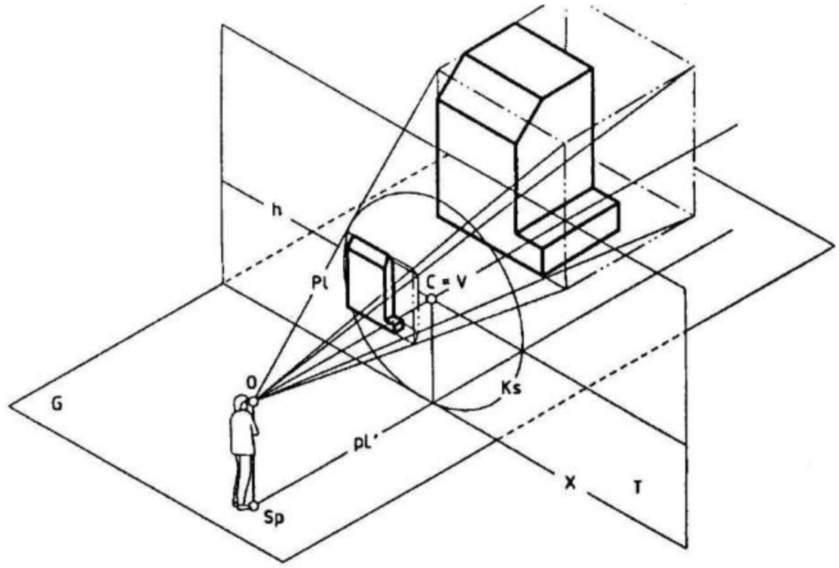


FIG. 8D.3 PROJECTION MODEL WITH VERTICAL PROJECTION PLANE AND AN OBJECT IN A SPECIAL POSITION WITH RESPECT TO THE PROJECTION PLANE

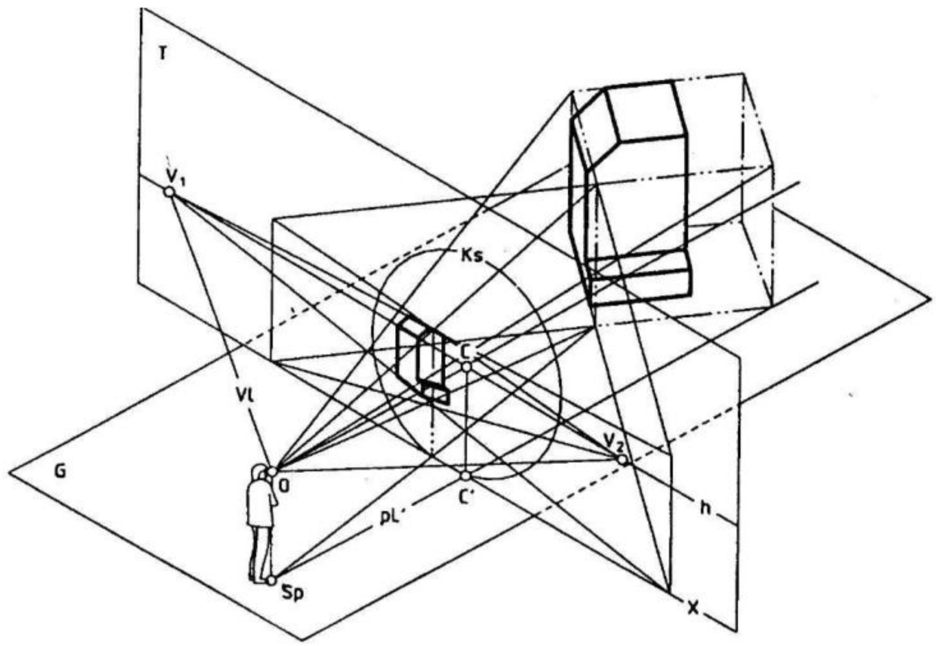


FIG. 8D.4 PROJECTION MODEL WITH VERTICAL PROJECTION PLANE AND AN OBJECT IN A PARTICULAR POSITION WITH RESPECT TO THE PROJECTION PLANE

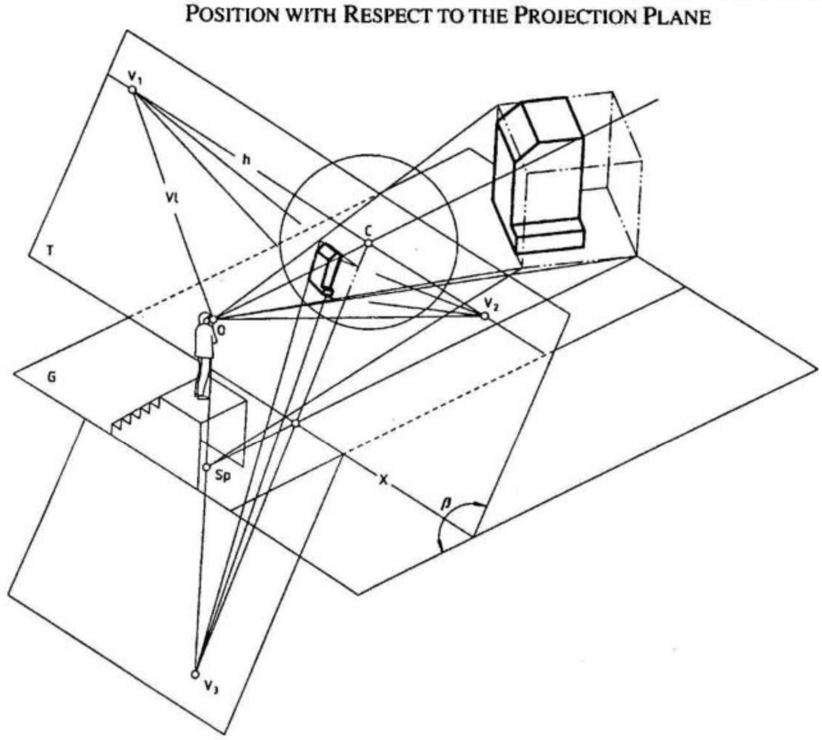


FIG. 8D.5 Projection Model with Inclined Projection Plane and an Object in Any Position with respect to the Projection Plane (p > 90°)

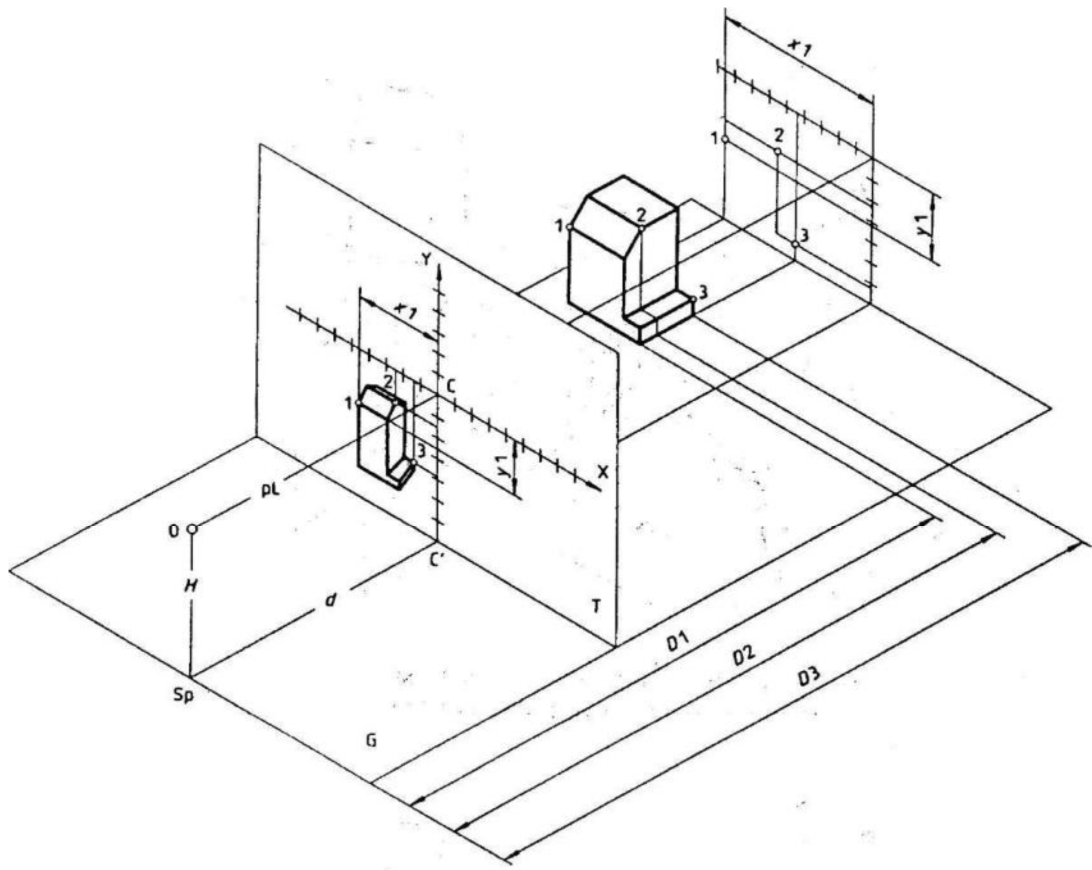


FIG. 8D.6 PROJECTION MODEL WITH VERTICAL PROJECTION PLANE AND AN OBJECT IN SPECIAL POSITION, SHOWING THE LENGTHS USED IN THE MATHEMATICAL FORMULA FOR CALCULATION OF THE PERSPECTIVE IMAGE

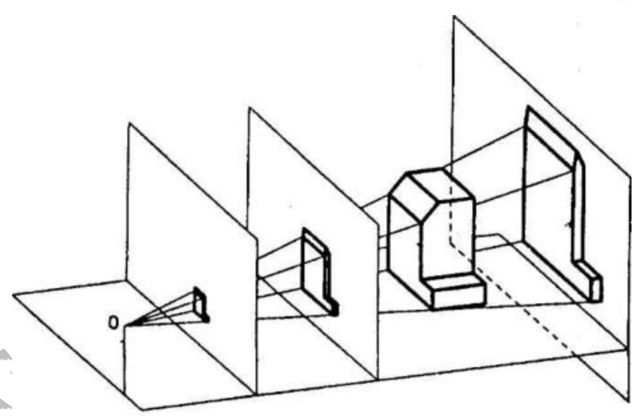


FIG. 8D.7 LOCATION OF PROJECTION PLANES

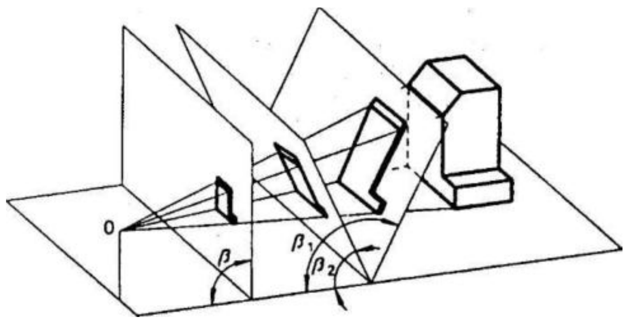
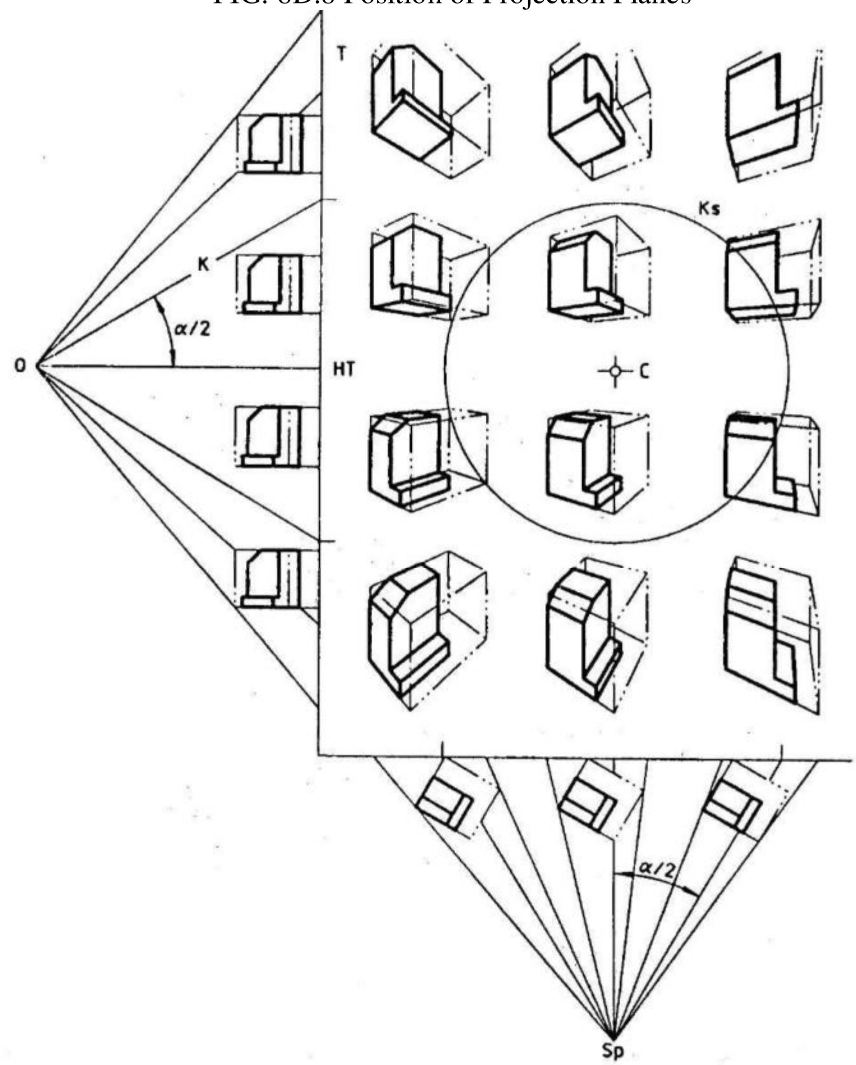
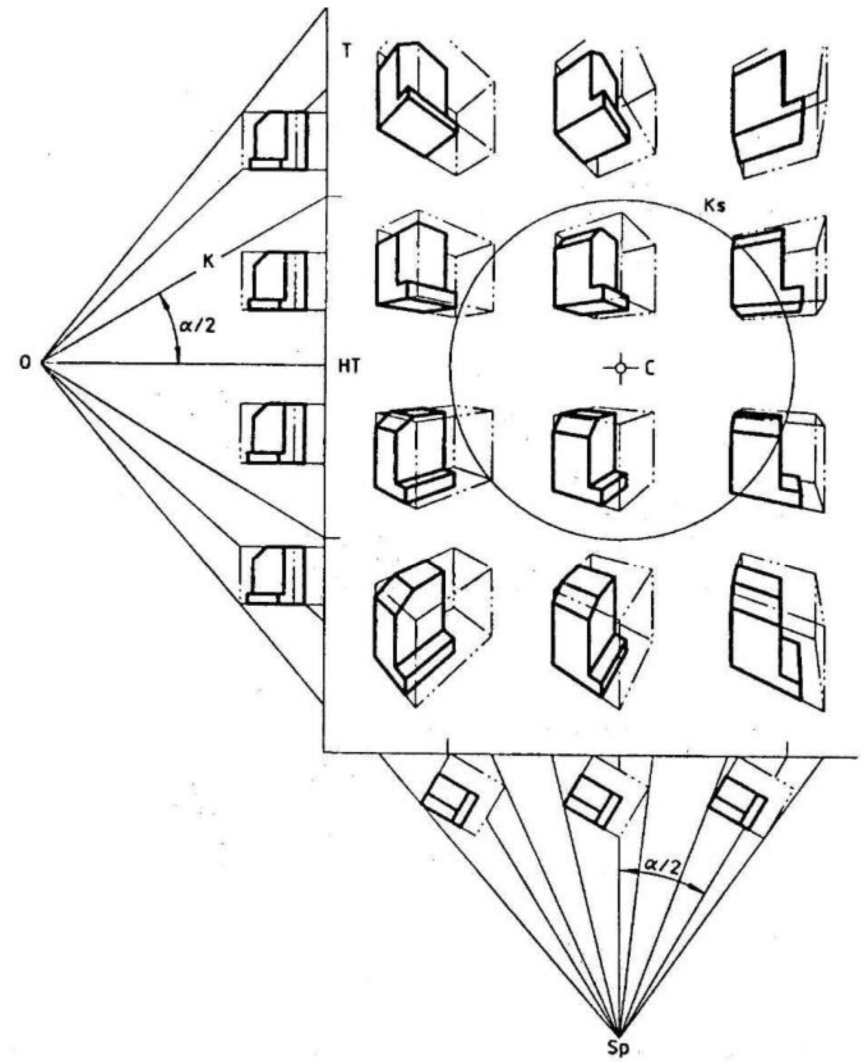
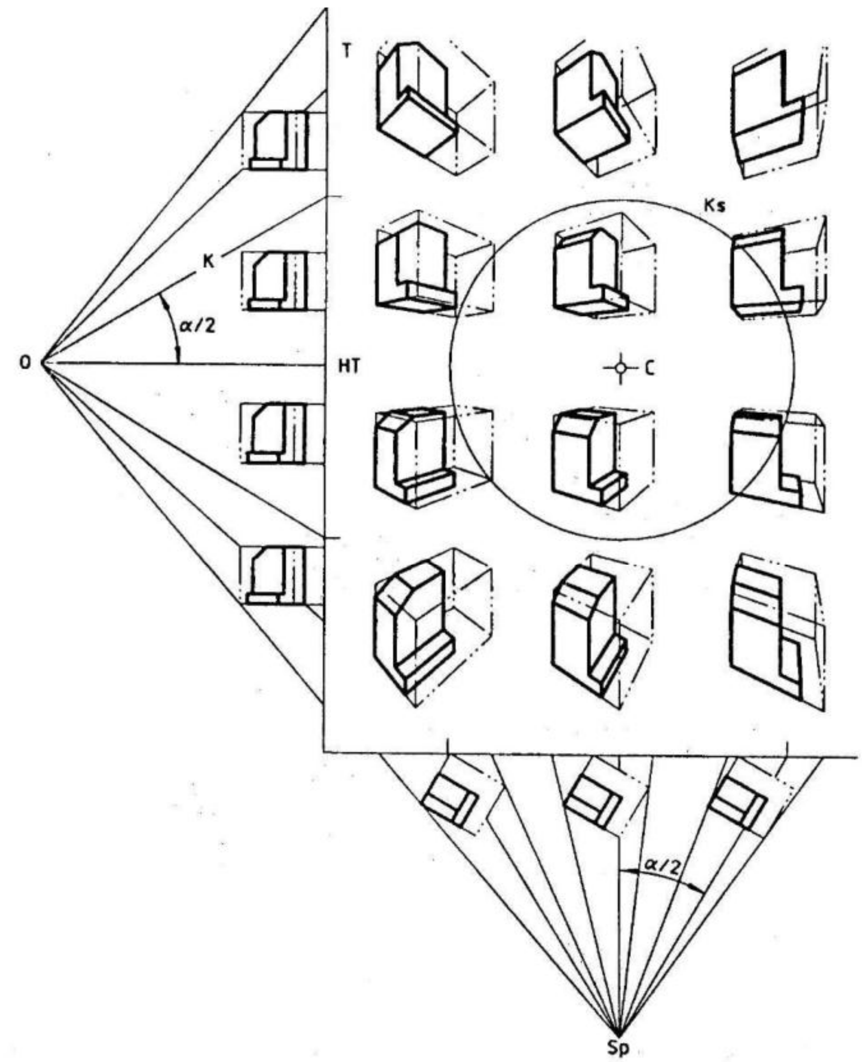


FIG. 8D.8 Position of Projection Planes




T
K
α/2
O
HT
Ks
C
α/2
Sp


T
K
α/2
O
HT
Ks
C
α/2
Sp

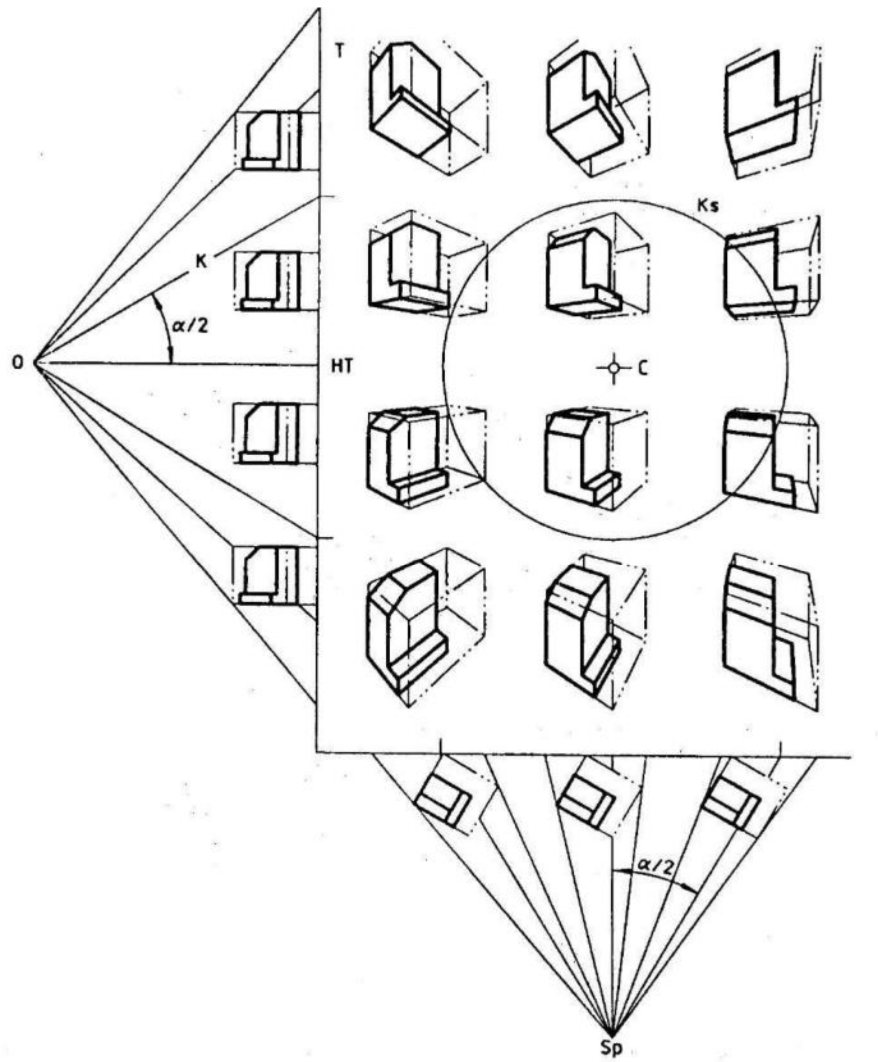


FIG. 8D.9 Object, Framed in a Cube, Within and Outside the Circle of Vision

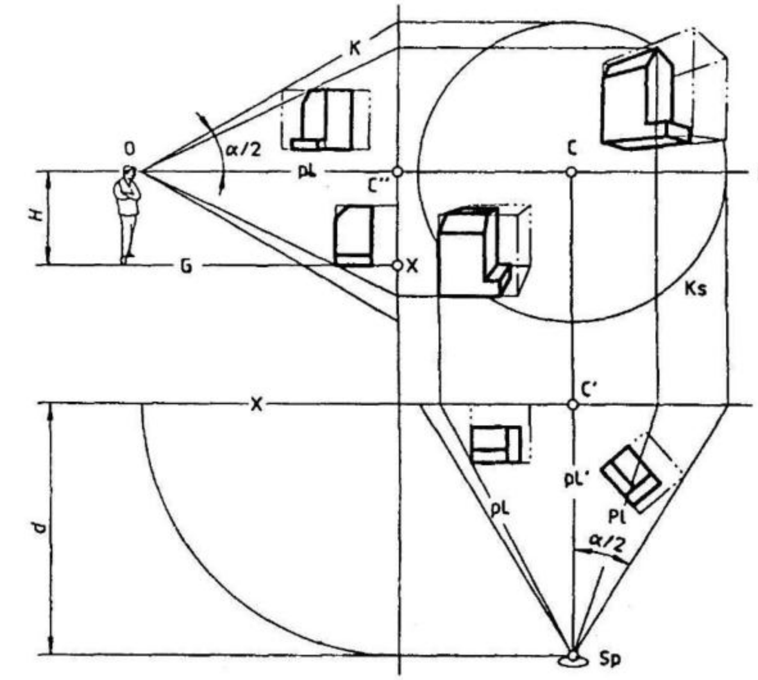


FIG. 8D.10 PROJECTION MODEL TURNED INTO THE DRAWING SURFACE WITH SIDE VIEW

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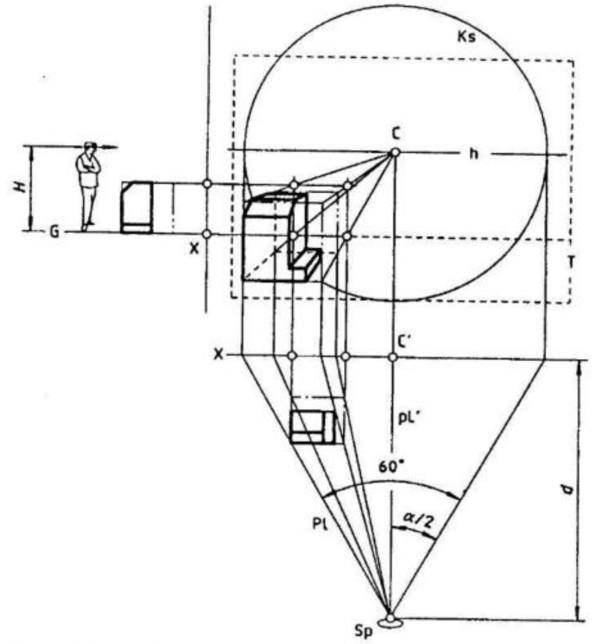

FIG. 8D.11 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN SPECIAL POSITION WITH RESPECT TO THE PROJECTION PLANE ACCORDING TO METHOD A

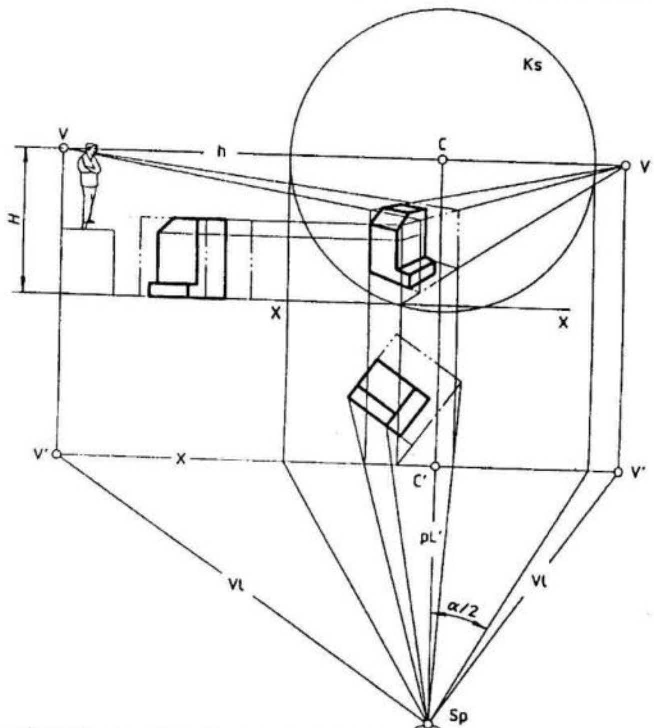

FIG. 8D.12 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN PARTICULAR POSITION WITH RESPECT TO THE PROJECTION PLANE ACCORDING TO METHOD B

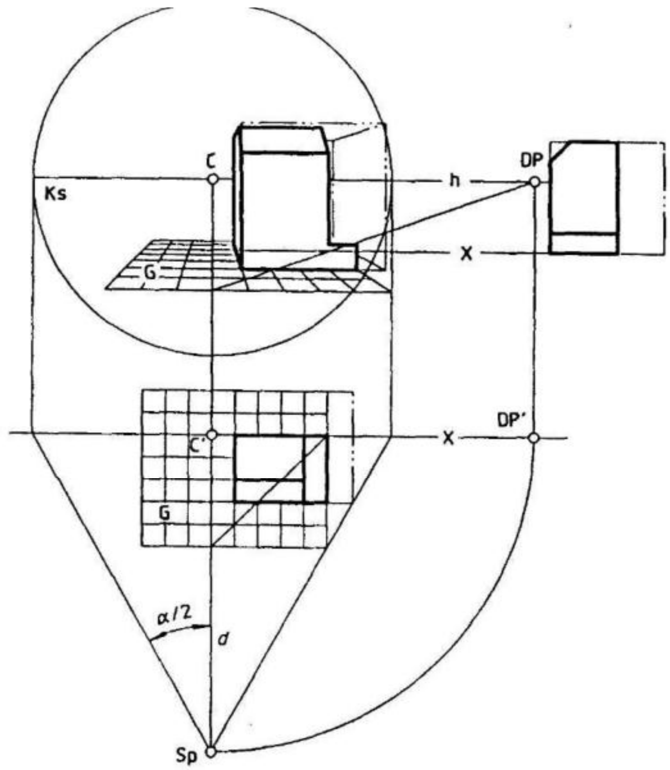

FIG. 8D.13 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN SPECIAL POSITION WITH RESPECT TO THE PROJECTION PLANE

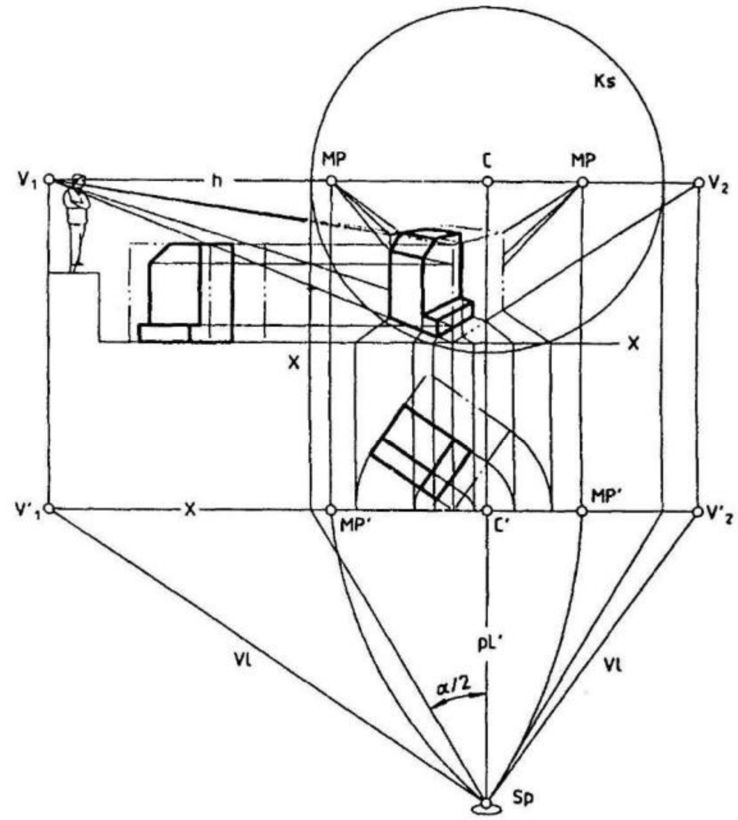

FIG. 8D.14 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN PARTICULAR POSITION WITH RESPECT TO THE PROJECTION PLANE

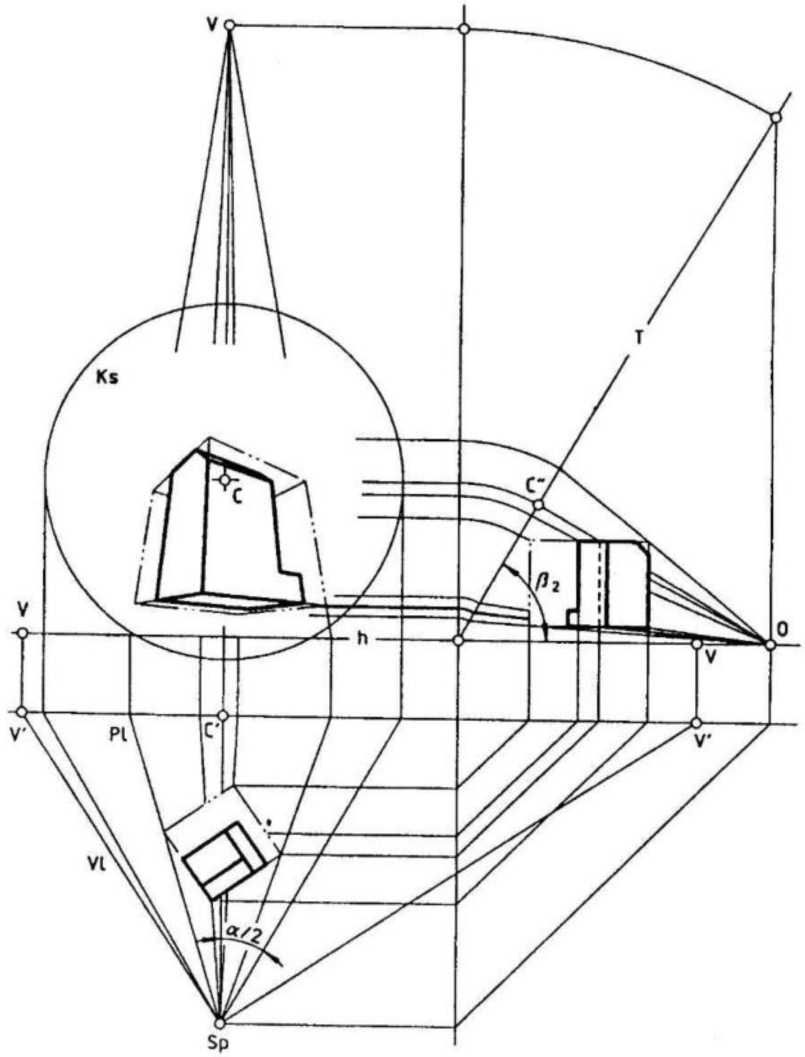

FIG. 8D.15 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN FRONT OF A PROJECTION PLANE INCLINED TOWARDS THE PROJECTION CENTRE

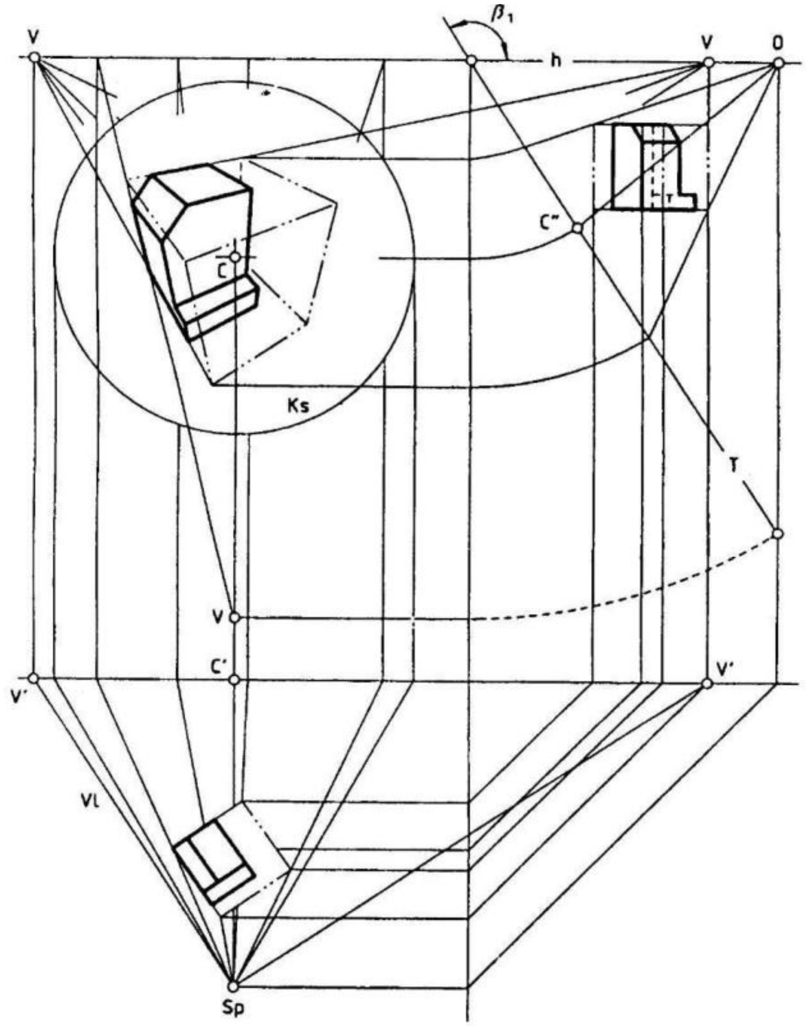

FIG. 8D.16 OBJECT, FRAMED IN A CUBE (INDICATED BY A DOUBLE-DASHED LINE), IN FRONT OF A PROJECTION PLANE INCLINED AWAY FROM THE PROJECTION CENTRE

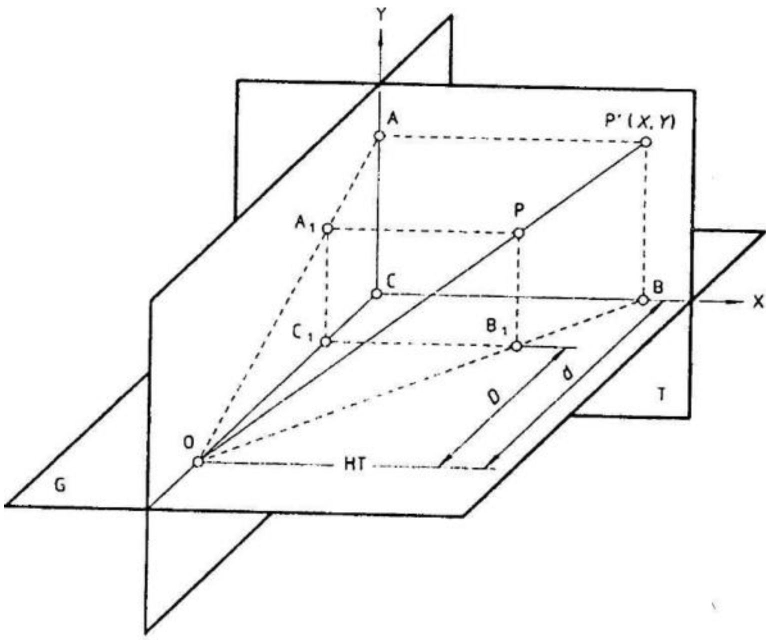

FIG. 8D.17 COORDINATE PIERCING METHOD

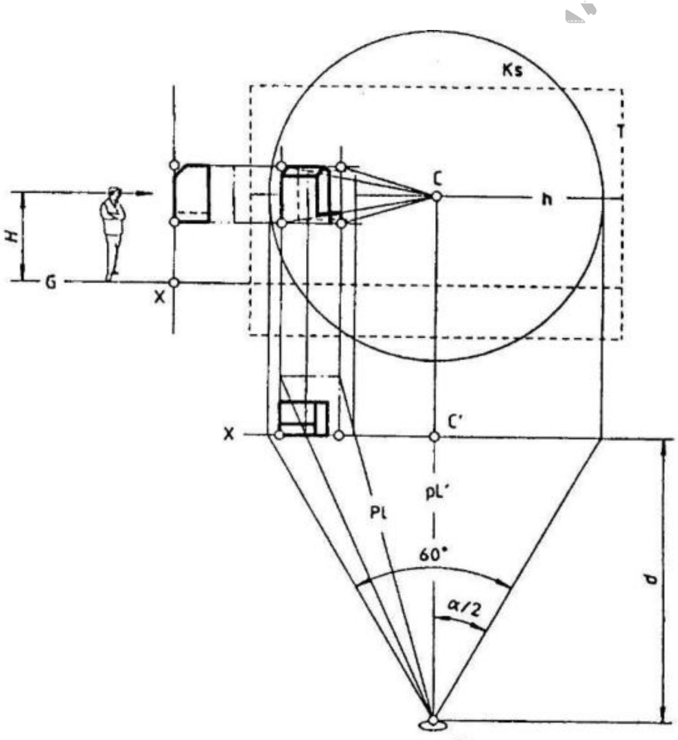

FIG. 8D.18 REGULAR ARRANGEMENT (THE REPRESENTATION IS PLACED ABOVE THE BASIC LINE X)

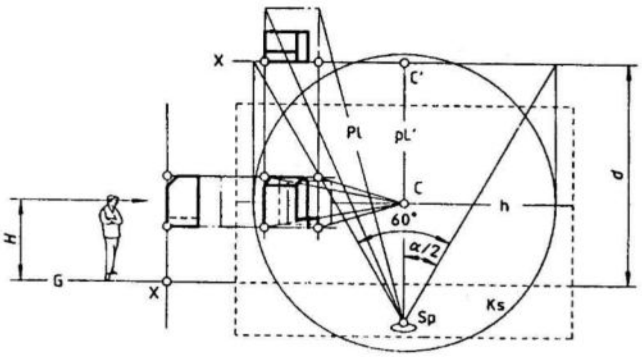

FIG. 8D.19 ECONOMY ARRANGEMENT (THE PERSPECTIVE REPRESENTATION IS PLACED BELOW THE BASIC LINE *X*)

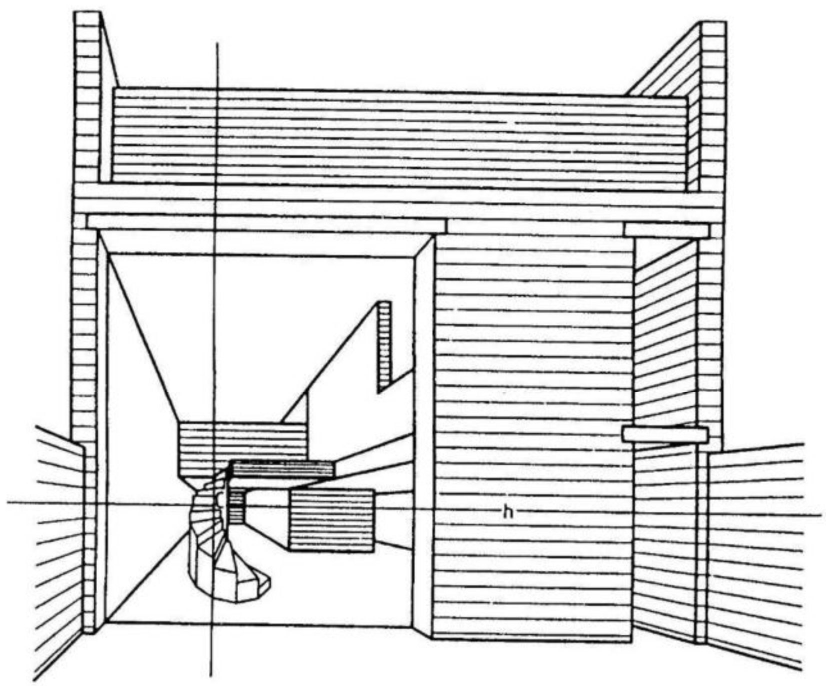

FIG. 8D.20 EXTERIOR SPACE IMAGE, PROJECTION WITH ONE VANISHING POINT; THE SPIRAL STAIRCASE HAS BEEN REPRESENTED ACCORDING TO THE METHOD DESCRIBED IN **8D.6.1**

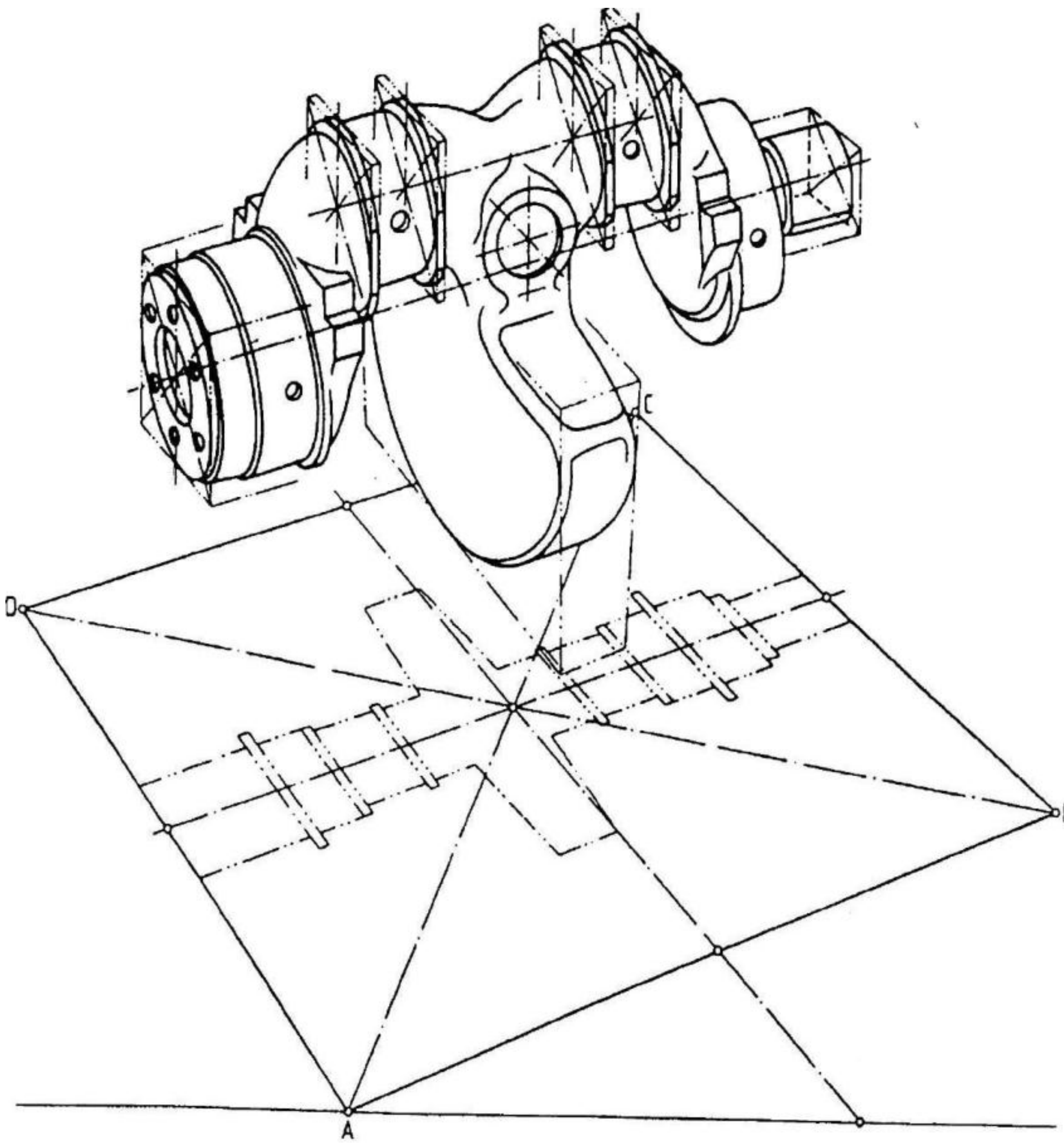

FIG. 8D.22 EXAMPLE OF DIMETRIC AXONOMETRY, REPRESENTATION OF AN ENGINE CRANKSHAFT

SECTION 9 TECHNICAL DRAWINGS — SIMPLIFIED REPRESENTATION OF PIPELINES — GENERAL RULES, ORTHOGONAL REPRESENTATION AND ISOMETRIC PROJECTION

[Based on IS 10990 (Part 1): 1991/ISO 6412-1 : 1989 and IS 10990 (Part 2): 1992/ISO 6412-2 : 1989]

9.1 Representation of Pipes, Etc

The flow line representing a pipe, etc, irrespective of its diameter), shall be a single continuous wide line (*see* Table 9.1 and Section 6), coinciding with the central line of the pipe (*see* ISO 4067-1).

Bends may be simplified by extending the straight length of the flow line to the vertex (*see* Fig. 9.1). However, bends may be shown for sake of clarity in the form illustrated in Fig. 9.2. In this case, if projections of bends would otherwise have been elliptical, these projections may be simplified by drawing circular arcs (*see* Fig. 9.3).

9.1.1 *Types of Line*

The types and thickness of line shown in Section 6 shall be used.

Table 9.1 Types of Line

(Clause *9.1)*

Line type in accordance with IS 10714 (Part 20)	Description	Application
01.2	Continuous wide line	Flow lines and connected parts
01.1	Continuous narrow Line	Hatching, dimensioning, leader lines, isometric grid lines
01.1	Continuous narrow free hand line	Limits of partial or interrupted views and sections
01.1	Continuous narrow line with zigzags	
02.2	Dashed wide line	Flow lines specified on other drawing
02.1	Dashed narrow line	Floor, Walls, Ceilings, Holes (hole punchings)
04.1	Long dashed dotted narrow line	Centrelines
04.3	Long dashed dotted extra wide line [1)]	Contract boundary
05.1	Long dashed double dotted narrow line	Outlines of adjacent parts, Parts situated/ in front of the cutting plane
[1)] Four times the thickness of line type 04.1		

9.1.1.1 *Spacing of lines*

In accordance with IS 10164, the space between parallel lines (including hatching) shall not be less than twice the thickness of the heaviest of these lines, with a minimum spacing of 0.7 mm.

The minimum spacing between adjacent flow lines and between flow lines and other lines should be 10 mm.

9.1.2 *Lettering*
Lettering shall be in accordance with IS 9609 (Part 1); lettering Type B vertical is preferred. The line thickness of the lettering shall be the same as the line thickness of those tpd-symbols to which the lettering is close or associated *(see* ISO 3461-1).
9.1.3 *Dimensioning*

9.1.3.1 In general, dimensioning shall be in accordance with IS 11669. Nominal dimensions may be indicated in accordance with ISO 3545 using the short designation 'DN' *(see* Fig. 9.1).
The outer diameter (d) and the wall thickness (/) of pipes may be indicated in accordance with IS 10720 *(see* Fig. 9.2). If necessary, an item list *(see* IS 11666) giving additional information on the pipes, including the associated equipment, may be added to the drawing. Lengths shall start from the outer faces of the pipe ends, flanges, or centre of the joint, whenever appropriate.
9.1.3.2 Pipes with bends should be generally dimensioned from central line to central line of the pipelines (*see* Fig. 9. i and Fig. 9.2). If it is necessary to specify the dimension from the outside or inside external protection or surface of the pipe, the dimension may be specified by arrows pointing to short thin strokes parallel to the projection line (*see* Fig. 9.3). The dimensions from outer to outer, from inner to inner tind from inner to outer vertex are shown in Fig. 9.3 (a), 9.3 (b) and 9.3 (c), respectively.

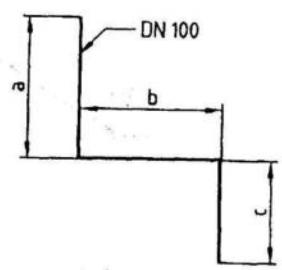

FIG. 9.1

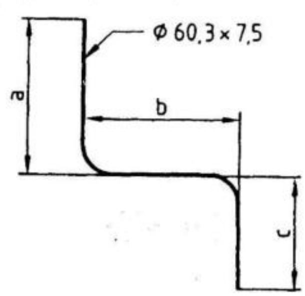

FIG 9.2

9.1.3.3 Radii and angles of bends maybe indicated shown in Fig. 9.4. The functional angle shall be indicated; in general, angles of 90° are not indicated.

9.1.3.4 Levels refer generally to the centre of the pipe and should be indicated in accordance with IS 11669 (*see* Fig. 9.5). If, in special cases, it is necessary to specify the level to the bottom of a pipe this shall be indicated by the reference arrow pointing to short thin strokes, as specified in 9.1.3.2 [*see* Fig. 9.3 and Fig. 9.8 (a)]. A similar rule shall be applied to indicate levels to the top of the pipe [*see* Fig. 9.8 (c)].

9.1.3.5 The direction of slope shall be indicated by a right-angled triangle above the flow line, pointing from the higher down to the lower level. The amount of slope shall be indicated in accordance with the methods shown in Fig. 9.6 to 9.8. It may be useful to specify the level of the sloping pipe, either at its higher or at its lower end, or at any convenient point, by referring to a datum level (*see* Fig. 9.8).

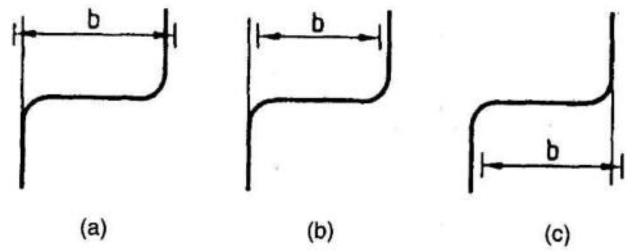

FIG. 9.3

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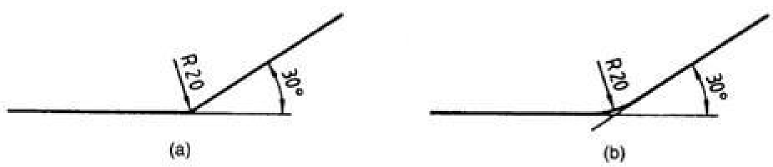


FIG. 9.4

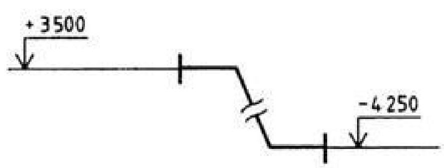


FIG. 9.5

FIG. 9.6

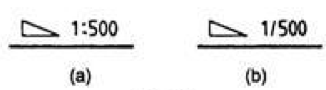


FIG. 9.7

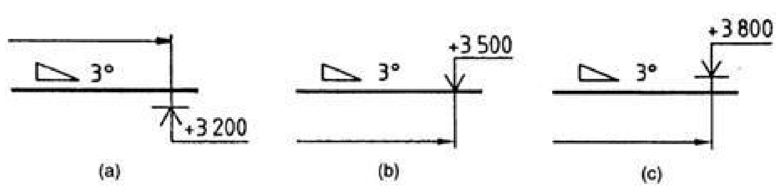


FIG. 9.8

9.1.3.6 The positions of the ends of the pipe shall be specified by indicating the coordinates referring to the centres of the end faces.

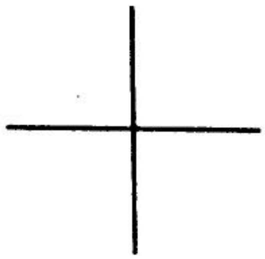


FIG. 9.9

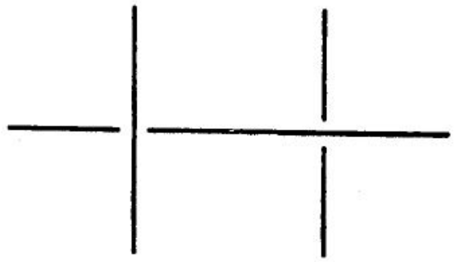


FIG. 9.10

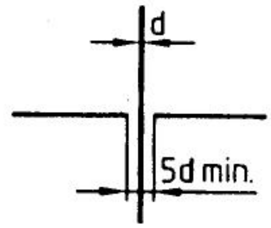


FIG. 9.11

9.1.4 *Tolerances*
Tolerances shall be indicated in accordance with IS 11667

9.2 Crossings and Connections

9.2.1 Crossings without connections shall normally be depicted without interrupting the flow line representing the hidden pipe (*see* Fig. 9.9; *see also* ISO 4067- 1); if, however, it is absolutely necessary to indicate that one pipe has to pass behind the other, the flow line representing the hidden pipe shall be interrupted (*see* Fig. 9.10). The width of each interruption shall not be less than five times the thickness of the continuous line (*see* Fig. 9.11).

9.2.2 Permanent junctions (whether made by welding or other processes) shall be marked by a prominent dot in accordance with ISO 1219 (see Fig. 9.12). The diameter of the dot shall be five times the thickness of the line.
9.2.3 Detachable connections should be represented in accordance with ISO 4067-1.

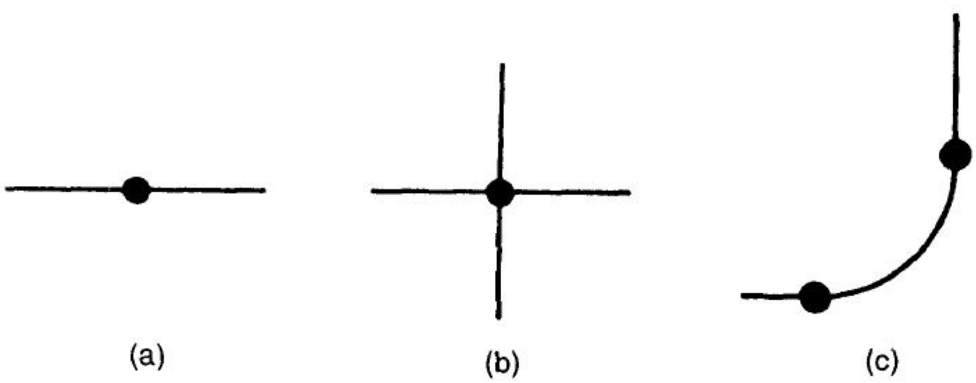


FIG. 9.12

9.3 Representation of Equipment

9.3.1 *General*
All items of equipment, machinery, valves, etc, shall be represented by means of graphical symbols with the same line thickness as the flow line (*see* ISO 346 1-2).

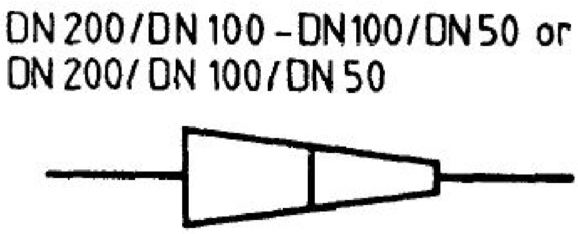
9.3.2 *Fittings*

9.3.2.1 Fittings, such as, nozzles, tee-pieces and bends, should be drawn with the same line thickness as the flow line.

9.3.2.2 Transition pieces for changing the cross-section shall be represented in accordance with Fig. 9.13 to 9.15. The relevant nominal sizes shall be indicated above the symbols.

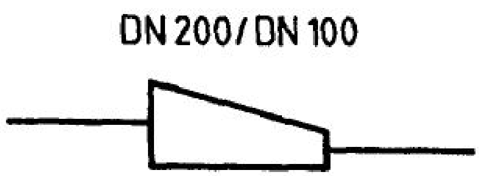
Concentric single

FIG. 9.13



Concentric multiple

FIG. 9.14



Eccentric single

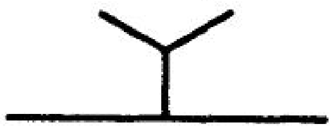
FIG. 9.15

9.3.3 *Supports and Hangers*

Supports and hangers shall be represented by their appropriate symbols in accordance with Fig. 9.16 to 9.19.

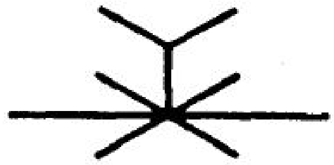
The representation of repeated accessories may be simplified as shown in Fig. 9.20.

NOTE ´ Figure 9.16 to 9.19 refer to hangers only. It should be understood that in case of supports, the same symbols should be used, but in t e reverse position.



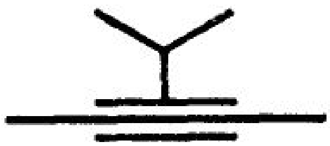
General

FIG. 9.16



Fixed

FIG. 9.17



Guided

FIG. 9.18

Shiding

FIG. 9.19

If necessary, an alphanumerical code giving more information about the type of supports and hangers, with {heir numbering, may be added to the symbols shown in Fig. 9.16 to 9,19. The code giving the numbering shall be given on the drawing or in associated documents (*see* Fig. 9.21).

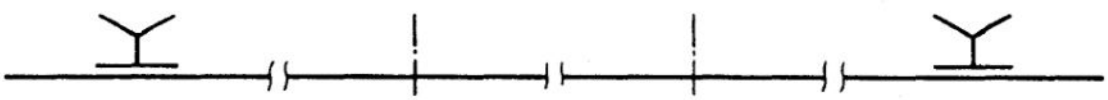


FIG. 9.20

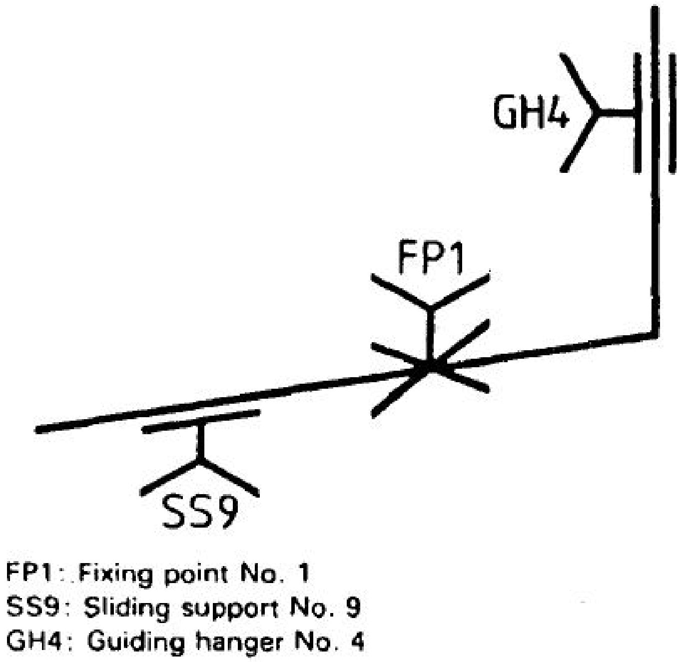


FIG. 9.21

9.3.4 *Additional Provisions*
Additional provisions such as insulation, coating, stream tracer lines, etc, may be specified in writing.

9.3.5 *Adjoining Apparatus*
.
1f needed, adjoining apparatus, such as tanks, machinery, not belonging to the piping itself, may be represented by their outlines using long dashed double dotted narrow lines (*see* Table 9.1 and Section 6) as shown in Fig. 9.22.

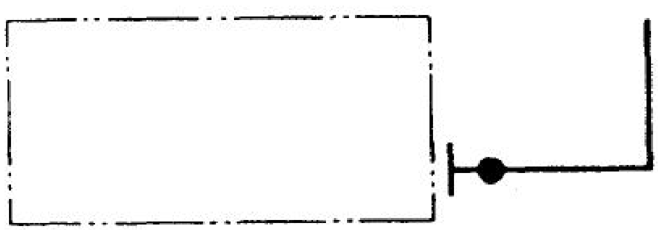


FIG. 9.22

9.3.6 *Direction of Flow*
The direction of flow shall be indicated by an arrowhead (*see* ISO 4067-1) on the flow line or near a graphical symbol representing a valve (*see* Fig. 9.23 and 9.24).

FIG. 9.23

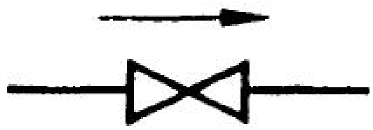


FIG. 9.24

9.3.7 *Flanges*

Flanges shall be represented, irrespective of their type and sizes,

´ by two concentric circles for the front view,

´ by one circle for the rear view,

´ by a stroke for the side view,

using lines of the same thickness as used for the representation of the pipes (*see* Fig. 9.22 and 9.25). A simplified representation of the flange holes may be shown by the appropriate number of crosses at their centrelines.

9.4 Examples

An example of orthogonal projection is given in Fig. 9.2S.

NOTE ´ Other examples are given in 1SO 3511-3 and 1SO *3753*.

9.5 Coordinates

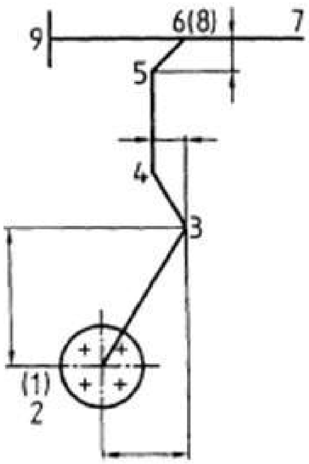
As far as it is necessary to use Cartesian coordinates, for instance for calculations or numerical control of machine tools, the coordinate axes shall comply with Fig. 9.26.

In all cases, the coordinates of individual pipes or pipe assemblies should comply with those adopted for the complete installation and shall be indicated on the drawing or in an associated document.

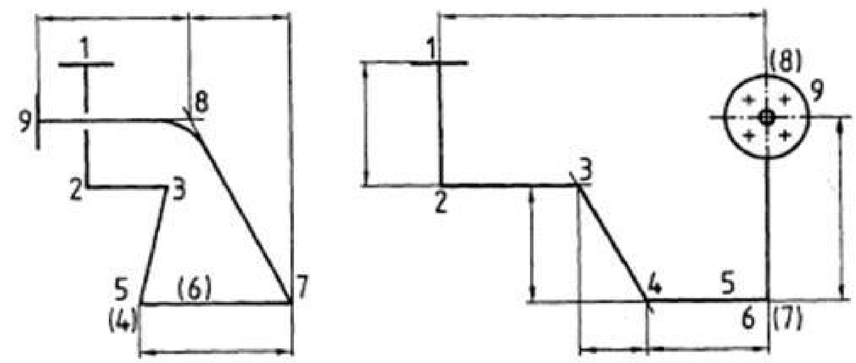
9.6 Deviations from the Direction of Coordinate Axes

9.6.1 *General*

Pipes, or parts of pipes, running parallel to the coordinate axes, shall be drawn parallel to the relevant axis without any further indication.



Reference number	Coordinates of the end points		
1	$x_1 = -8$	$y_1 = +72$	$z_1 = +50$
9	$x_9 = -20$	$y_9 = 0$	$z_9 = +40$



NOTE ´ Points at which the pipe changes direction and connections are indicated by reference numbers. The pipe and the reference numbers are identical to those in the isometric representation illustrated in Fig. 9.48. Reference numbers for points hidden behind other points are shown in brackets.

FIG 9.25

Deviations from the directions of the coordinate axes should be indicated by means of auxiliary hatched projection planes as shown in Fig. 9.27.

9.6.2 *Pipes in a Vertical Plane*

Pipes, or parts of pipes, situated in a vertical plane, shall be indicated by showing their projections on a horizontal plane [*see* Fig. 9.28 (a)].

9.6.3 *Pipes in a Horizontal Plane*

Pipes, or parts of pipes, situated in a horizontal plane, shall be indicated by showing their projections on a vertical plane [*see* Fig. 9.28 (b)].

9.6.4 *Pipes not Parallel to any Coordinate Plane*

Pipes, or parts of pipes, not running parallel to any coordinate plane, shall be indicated by showing both their projections on a horizontal and on a vertical plane [*see* Fig. 9.28 (c)].

9.6.5 *Auxiliary Projection Planes*

It is recommended that the right angles of the triangles limiting the auxiliary projection planes be indicated. Auxiliary projection planes may be emphasized by hatchings, parallel to the X- or Y-axis for horizontal auxiliary planes, and vertical for all other auxiliary planes.

If such hatching is not convenient it may be omitted, but in that case the rectangle (*see* Fig. 9.29) or the rectangular prism (*see* Fig. 9.30), of which a diagonal coincides with the pipe, should be shown, using continuous narrow lines (01. 1).

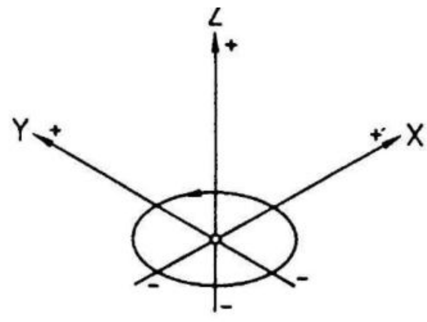


FIG. 9.26

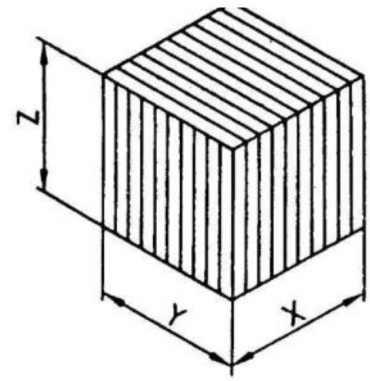


FIG. 9.27

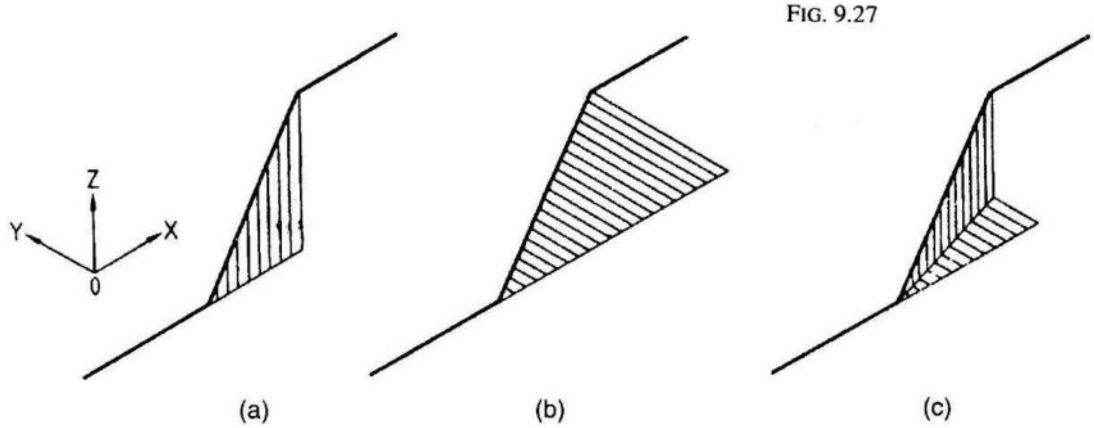


FIG 9.28

9.7 Dimensioning and Special Rules

9.7.1 *General*

Drawings shall be dimensioned in accordance with IS 11669, There are, however, special rules for isometric projection for pipelines which are specified in **9.7.2** to **9.7.10**.

9.7.2 *Diameters and Wall Thickness*

The outer diameter (d) and the wall thickness (t) of pipes may be indicated in accordance with IS 10720 (*see* Fig. 9.31). Nominal dimensions may be indicated in accordance with 1SO 3545 using the short designation ːDN˘ (*see* Fig. 9. 1).

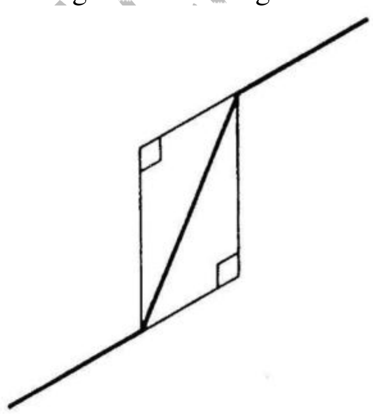


FIG. 9.29

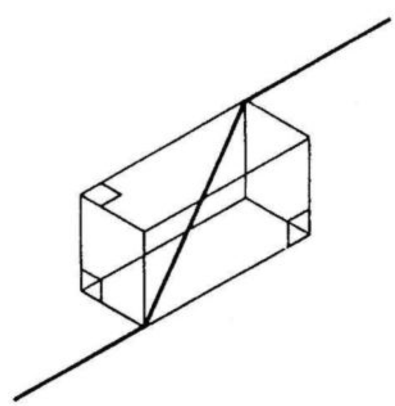


FIG. 9.30

9.7.3 *Longitudinal and Angular Dimensions*

Longitudinal and angular dimensions shall be indicated in accordance with IS 11669; the length shall start from the outer faces of the pipe ends, flanges, or centre of the joint, whenever appropriate.

9.7.4 *Pipes with Bends*

Pipes with bends shall be dimensioned from central line to central line or from the central line to the end of the pipe (*see* Fig. 9.31).

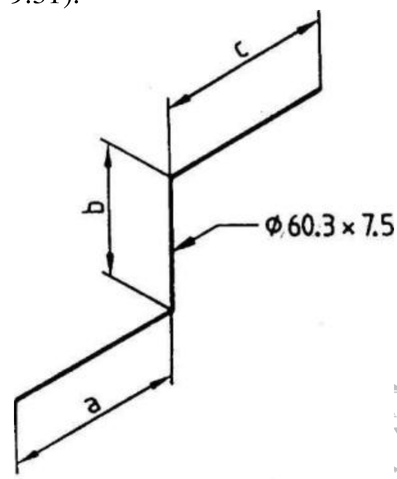


FIG. 9.31

9.7.5 *Radii and Angles of Bends*

Radii and angles of bends maybe indicated as shown in Fig. *9.32*. The functional angle shall be indicated.

NOTE ´ Bends may be simplified by extending the straight length of the flow line to the vertex. However, the actual bends in the pipes may be shown for sake of clarity. in this case, if projections of bends would otherwise have been elliptical, these projections may be simplified by drafting circular arcs.

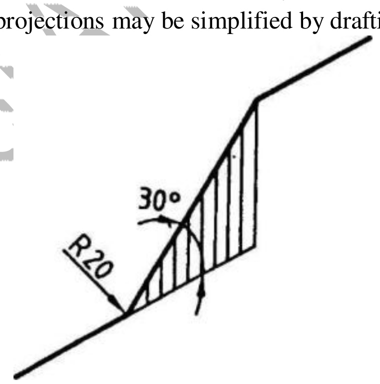


FIG 9.32

9.7.6 *Levels*

Levels should be indicated in accordance with IS 11669 and IS 10990 (Part 1) (see Fig. 9.33). The horizontal part of the leader line shall follow the direction of the associated flow line.

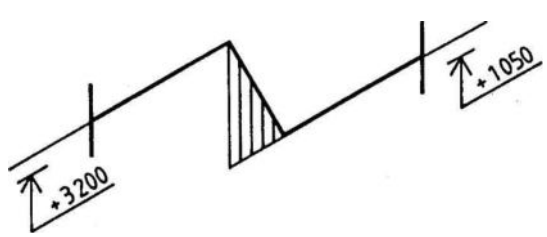


FIG 9.33

9.7.7 *Direction of Slope*

The direction of slope shall be indicated by a right-angled triangle above the flow line, pointing from higher down to the lower level, without changing the isometric direction of the flow line. The amount of slope shall be indicated in accordance with the method shown in Fig. 9.34 and in IS 10990 (Part 1). It may, however, be useful to specify the slope by referring to a datum level (*see* Fig. 9.34).

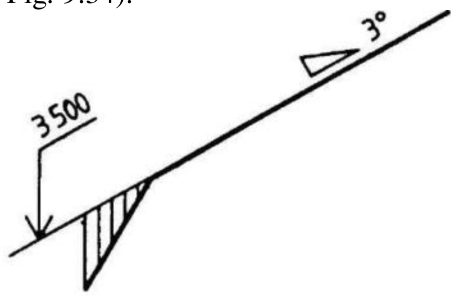


FIG. 9.34

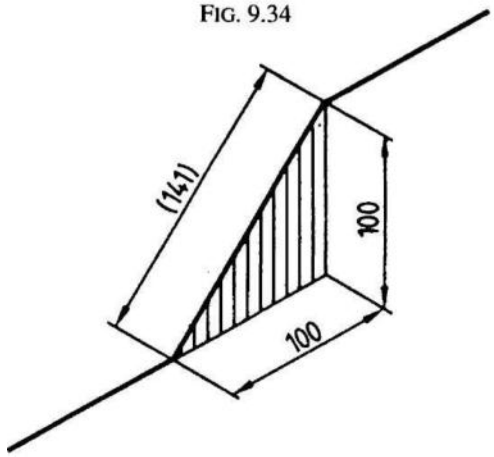


FIG. 9.35

9.7.8 *Positions of Ends of Pipes*

If necessary, the positions of the ends of the piping may be specified by indicating the coordinates referring to the centres of the end faces. In the case of adjacent drawings, a reference should be given. For example, ˸continued on drawing x˘.

9.7.9 *Redundant Dimensioning*

If necessary, the auxiliary hatched projection planes can be dimensioned (*see* Fig. 9.35). If it is necessary for manufacturing and/or technical reasons to indicate double dimensioning, one of the dimensions should be indicated in parenthesis.

9.7.10 *Dimensioning for Pipe-bending Machines*

The dimensioning is defined on the basis of a reference system (point of origin) (*see* Fig. 9.48).

9.8 Graphical Symbols

9.8.1 *General*

Graphical symbols for pipeline systems shall be drawn using the isometric projection method (*see* Fig. 9.36).

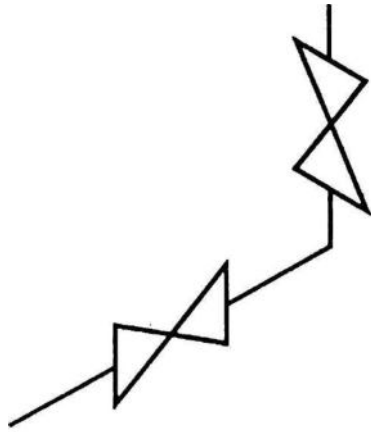


FIG. 9.36

9.8.2 *Examples of Graphical Symbols Drawn with the Isometric Projection Method*

9.8.2.1 *Valves*

See examples in Fig. 9.37 and 9.38.

NOTE ´ Valve actuators Should only be shown if it is necessary to define their positions or the kind of actuators (spindle, piston, etc.). If shown, an actuator with a position parallel to one of the coordinate axes need not be dimensioned. Deviations from such positions should be indicated (*see* Fig. 9.38).

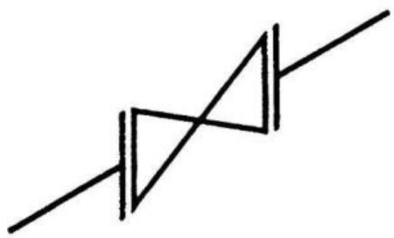


FIG. 9.37

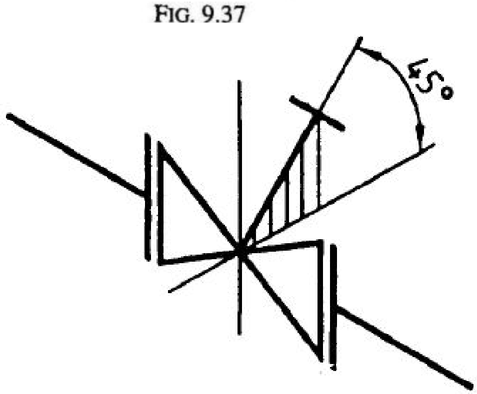


FIG. 9.38

9.8.2.2 *Transition pieces (Cones)*

The relevant nominal sizes shall be indicated above the graphical symbols (*see* Fig. 9.39).

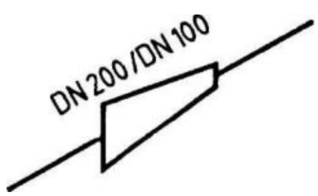


Fig 9.39

9.8.2.3 *Supports and hangers*
See examples given in Fig. 9.40 and 9.41 (see *also* **9.3.3**).

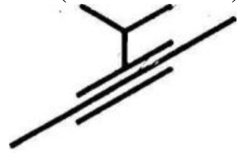


FIG. 9.40

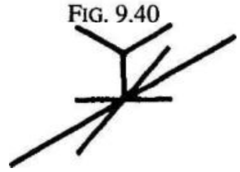


FIG 9.41

9.8.2.4 *Crossings*
Crossings shall be shown in accordance with 9.2. If it is absolutely necessary to indicate that one pipe has to pass behind the other, the flow line representing the hidden pipe shall be interrupted (*see* Fig. 9.42). The width of each interruption shall not be less than five times the thickness of the continuous line.

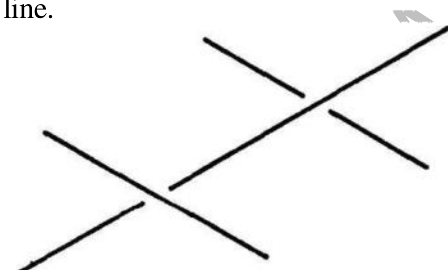


FIG 9.42

9.8.2.5 *Permanent Junctions*
See examples of a weld given in Fig. 9.43 and of a site weld in Fig. 9.44.

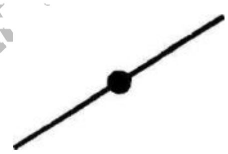


FIG 9.43

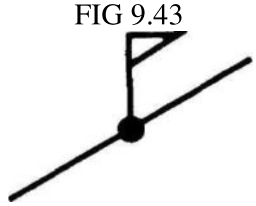


FIG 9.44

9.8.2.6 *General connections*
If the kind, or type, of connection is not specified, a general symbol should be used (instead of the more detailed symbols given in ISO 4067-1). *See example* given in Fig. 9.45.

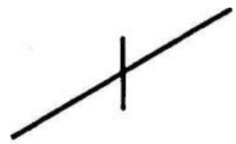


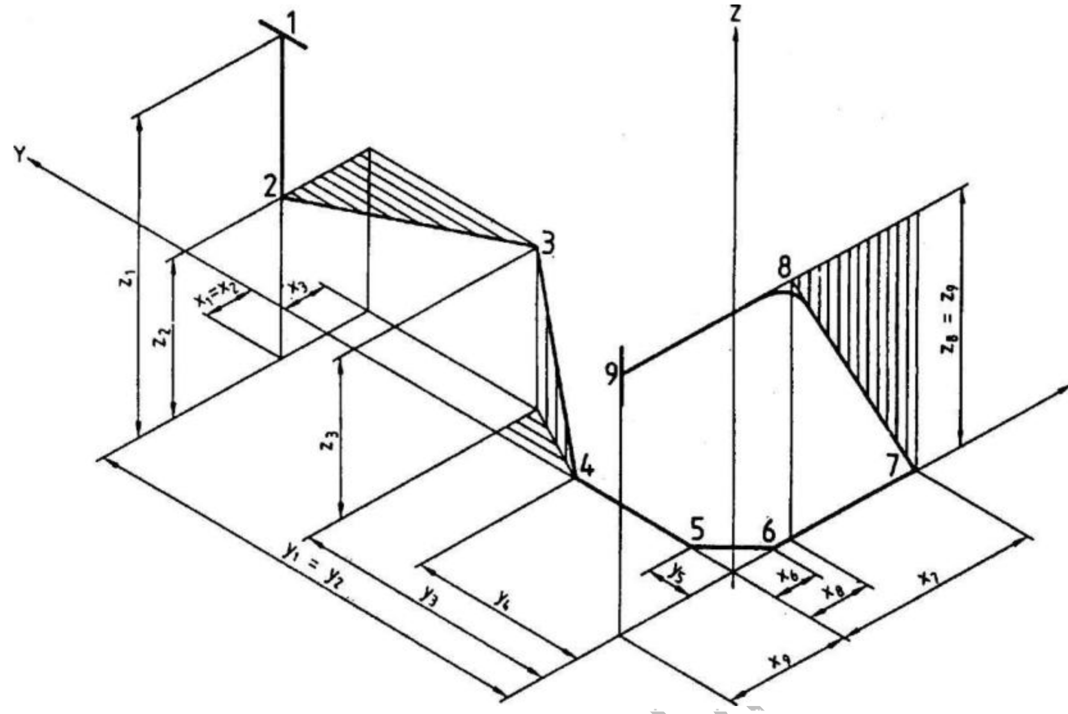
FIG. 9.45

FIG. 9.46

FIG 9.47

9.8.2.7 *Flanges*
See examples in Fig. 9.46 and 9.47.

9.9 Examples
Examples of isometric projections are given in Fig. 9.48 and 9.49.



Reference Number	Coordinates		
1	$x_1 = -8$	$y_1 = +72$	$z_1 = +50$
2	$x_2 = -8$	$y_2 = +72$	$z_2 = +25$
3	$x_3 = +7$	$y_3 = +42$	$z_3 = +25$
4	$x_4 = 0$	$y_4 = +28$	$z_4 = 0$
5	$X_5 = 0$	$y_5 = +7$	$z_5 = 0$
6	$x_6 = +7$	$y_6 = 0$	$z_6 = 0$
7	$x_7 = +32$	$y_7 = 0$	$z_7 = 0$
8	$x_8 = +10$	$y_8 = 0$	$z_8 = +40$
9	$x_9 = -20$	$y_9 = 0$	$z_9 = +40$

NOTE ´ Points at which the pipe changes direction and connections are indicated by reference numbers. The pipe and the reference numbers are identical to those in the orthogonal representation illustrated in Fig. 9.25.

FIG 9.48

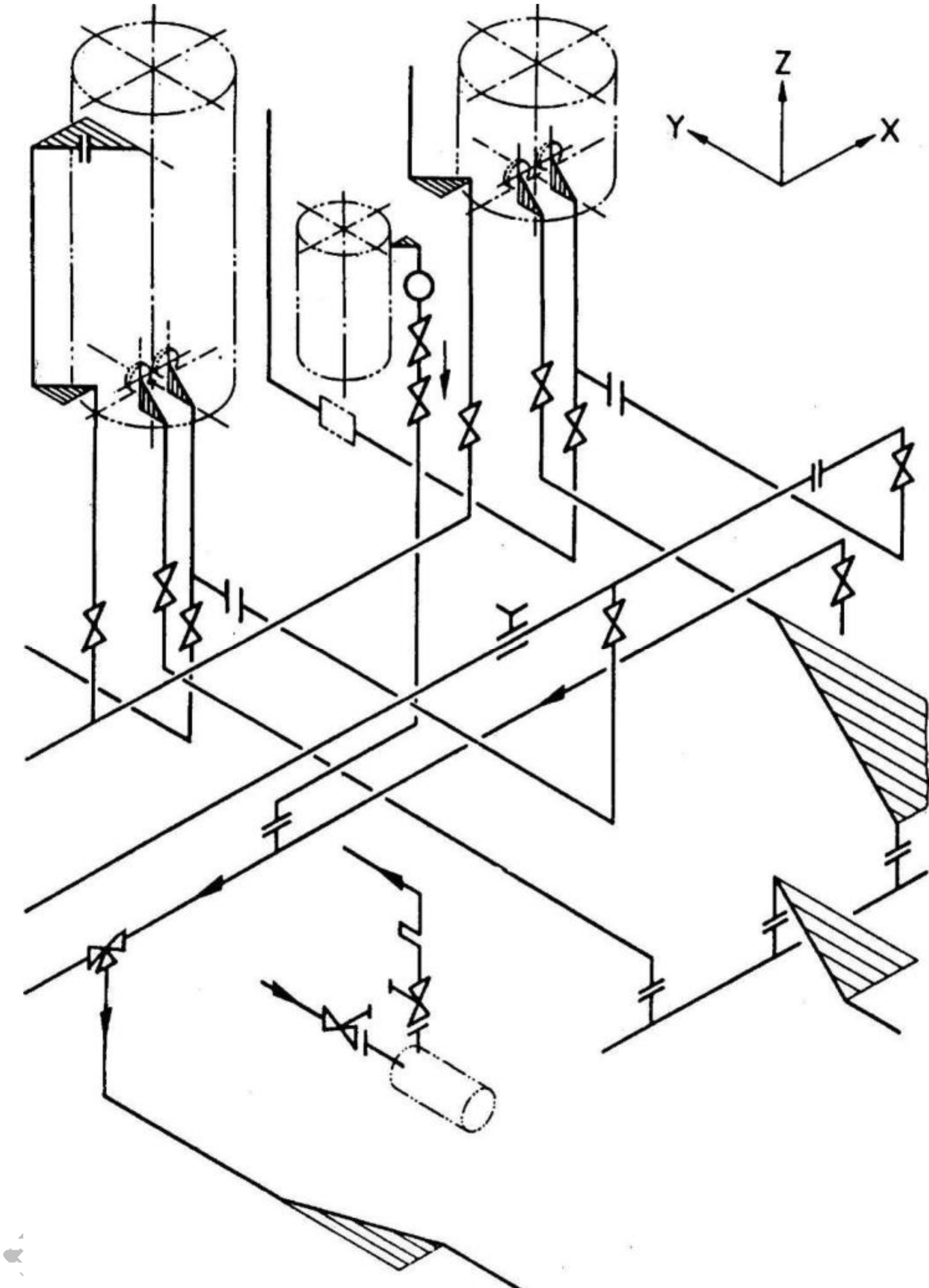


FIG 9.49

SECTION 10- SECTIONS ON MECHANICAL ENGINEERING DRAWINGS

[Based on IS 10714-44:2006/1S0 128-44;2001]

10.1 Scope

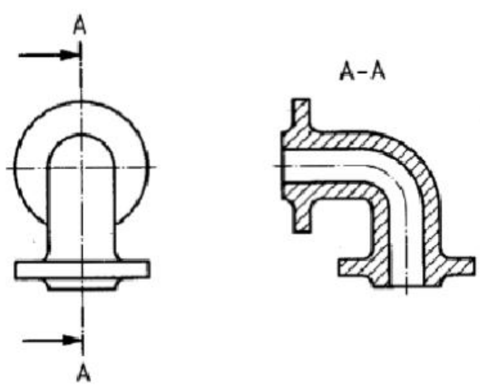
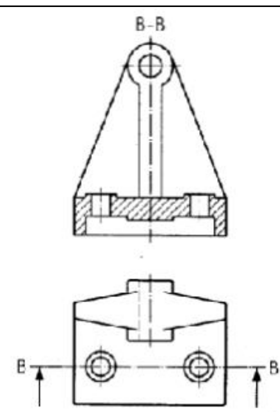
This section specifies general principles for presenting sections on mechanical engineering drawings.

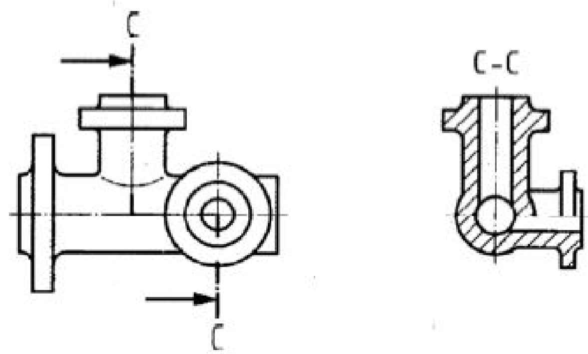
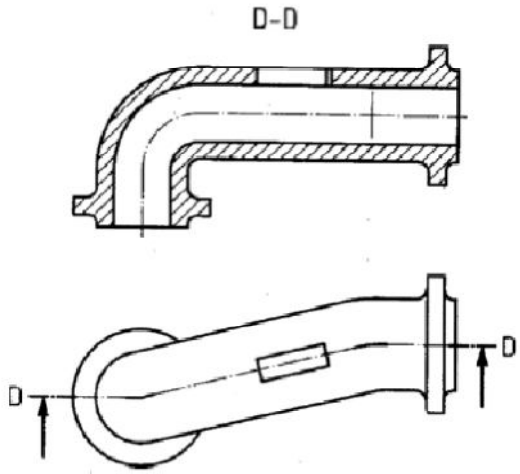
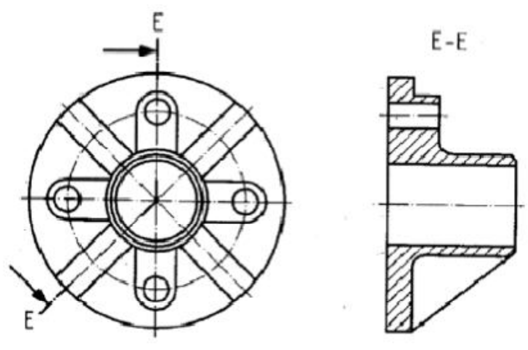
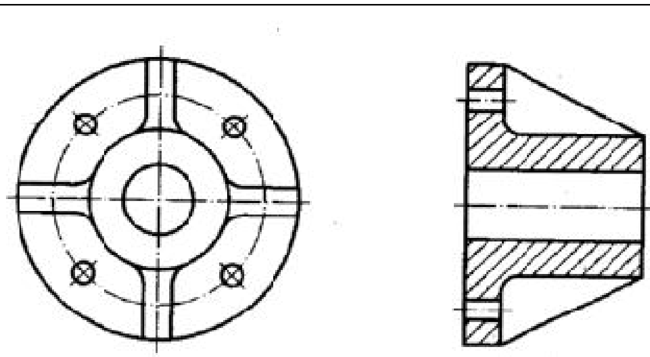
10.2 General

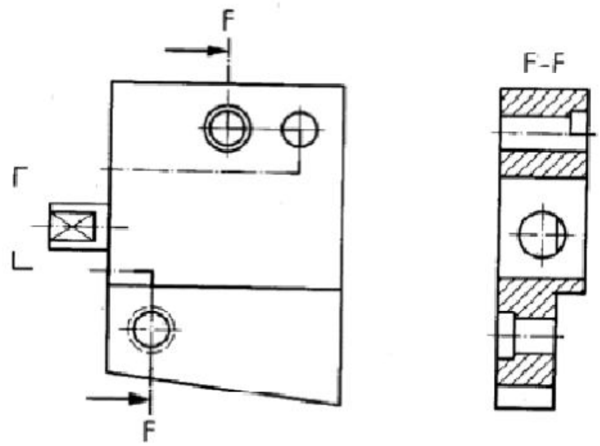
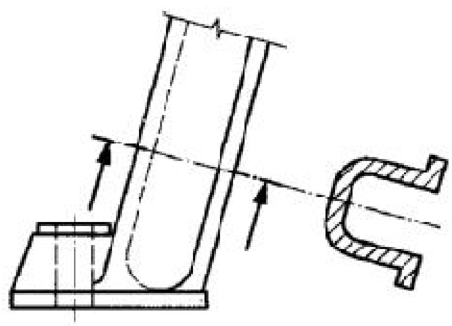
In principle, ribs, fasteners, shafts, spokes of wheels and the like are not cut in longitudinal sections, therefore not be represented as sections. The need for sectioning is the prerogative of the drawing creator and should be used to provide more clarity on internal and complex features of the component.

10.3 Cutting planes

A cutting plane is an imaginary plane that intersects the component. The outer boundary of surfaces in contact plane are shown by a solid line and the component area in contact with the sectioning plane is shown by solid hatching lines.

Types of Section	Examples 	Remarks
Planer or One Plan		
		

Offset Section		
Offset Section contiguous planes three planes		
two intersecting planes - Revolve Sections		
		

Cutting Planes – Partially Outside Objecst		When it is sometime necessary to position the cutting plane partly outside the object, it not, however, necessary to show the long-dashed dotted narrow line
Removed Sections		

10.4 Arrangement of successive sections
Successive sections may be arranged in a manner similar to the examples shown in Figure 10.9 to Figure 10.11, in as much as it is suitable for the layout and understanding of the drawing.

Unless they contribute to the clarification of the drawing, outline and edges behind the cutting plane may be omitted.

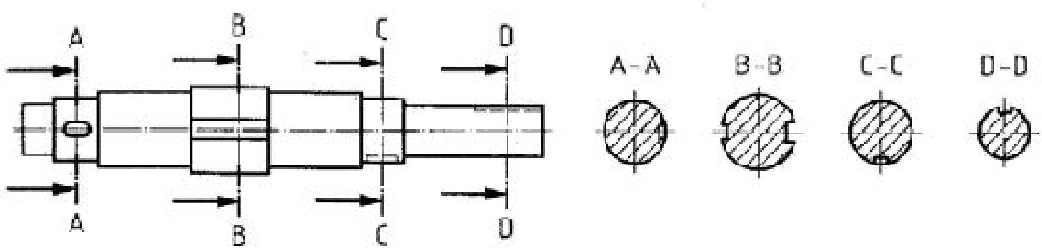


FIG 10.9 Successive sections – Example 1

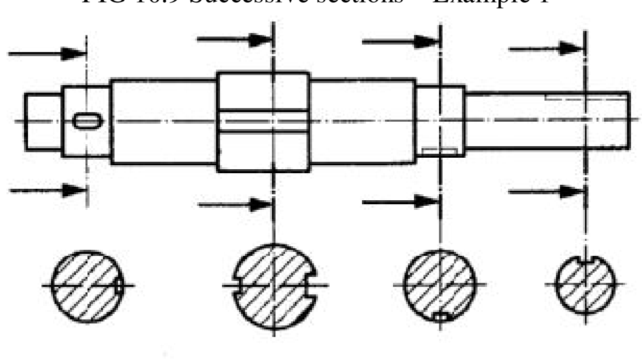


FIG 10.10 Successive sections – Example 2

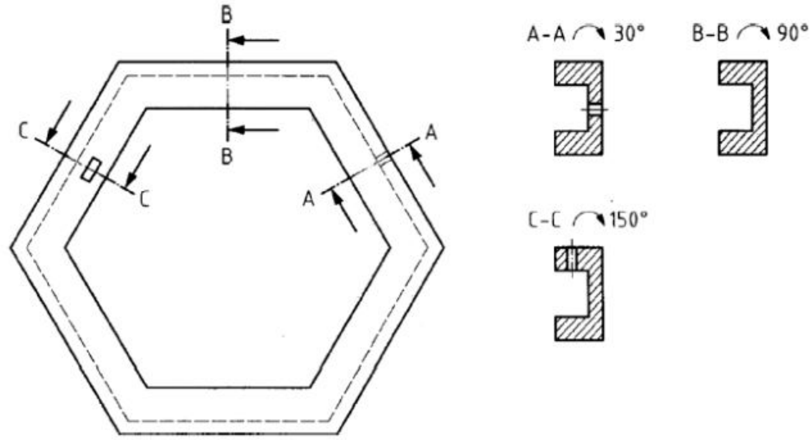


FIG 10.11 Successive sections ‾ Example 3

SECTION 11A– CONVENTIONAL REPRESENTATION OF SCREW THREADS AND THREADED PARTS

[Based on IS 10715-1:1999/1S0 6410-1:1993]

11A.1 Scope

This section specifies the methods for representing screw threads and threaded parts on technical drawings.

11A.2 Representation

11A.2.1 *Detailed representation of threads*

In certain types of technical product documentation(e.g. publications, user manuals, etc.) the detailed representation of a thread either in a side view or in a section (*see* Fig 11A.1 to 11A.3) may be needed to illustrate Single or assembled park. Neither pitch nor Profile of the threads need usually be drawn exactly to scale.

In technical drawings, the detailed representation of threads (*see* Fig 11A.1 to 11A.3) should only be used if absolutely necessary and whenever possible the helix should be represented by straight lines (*see* Fig 11A.2).

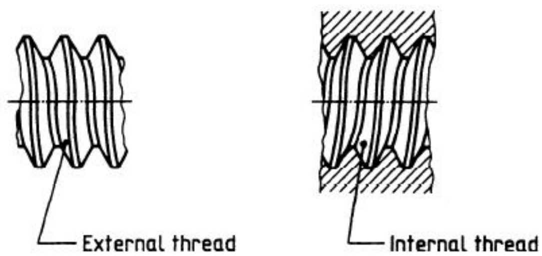


FIG 11A.1

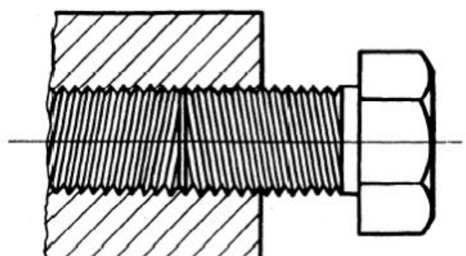


FIG 11A.2

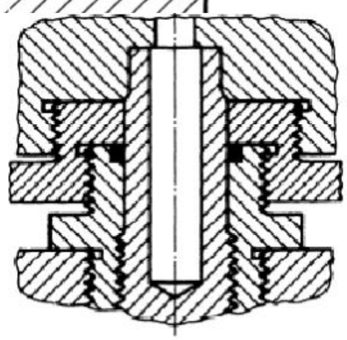


FIG 11A.3

11A.2.2 *Conventional representation*

Normally, by convention, the representation of threads and threaded parts in all types of technical drawings is simplified as shown in Fig 11A.4 to 11A.7.

11A.2.2.1 *Views and sections of screw threads*

For visible screw threads in side views and sections, the crests[1)] of threads shall be defined by a continuous wide line (type 01.2) and the roots[2)] of threads by a continuous narrow line (type 01.1),as shown in Fig 11A.4 to 11A.13.

The space between the lines representing the crest and root of the thread should approximate as closely as possible the depth of the thread, but, in all cases, this spacing shall be not less than

- twice the thickness of the thick line, or
- 0.7 mm,

whichever is the larger.

NOTE ˉ In certain cases, for example in computer-aided draughting,
- a distance of l.5 mm for threads of nominal diameter d ħ 8mm is generally acceptable,
- a simplified representation is recommended for threads of nominal diameter d Ħ6 mm, (*see* IS 10715-3/ ISO 6410-3).

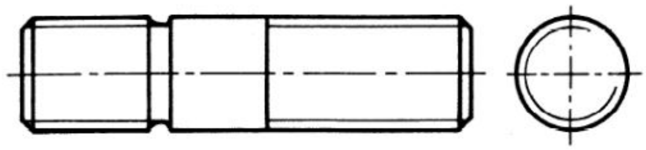


FIG 11A.4

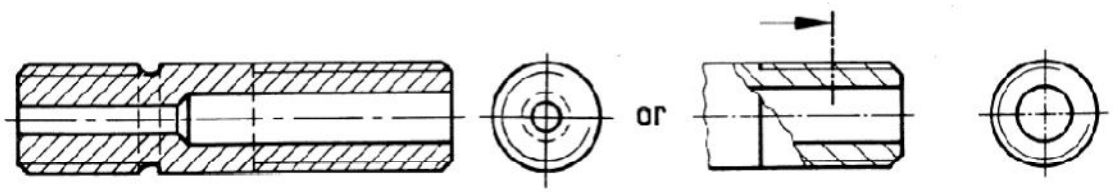


FIG 11A.5

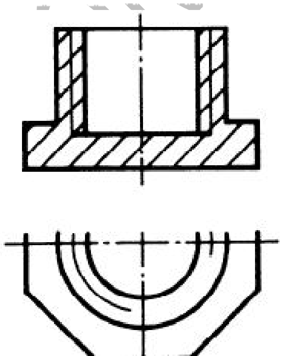


FIG 11A.6

[1]:Crest˘ normally refers to the major diameter for external threads and to the minor diameter for internal threads.
[2]:Root˘ normally refers to the minor diameter for external threads and to the major diameter for internal threads.

11A.2.2.2 *End view of screw threads*

On an end view of a screw thread, the thread roots shall be represented by a Portion of a circle, drawn with a continuous narrow line (type 01.1) approximately equal to three-quarters of the circumference(see Figures 11A.4 and 11A.5), preferably open in the right hand upper quadrant. The thick line representing the chamfer circle is generally omitted on the end view(*see* Fig 11A.4 and 11A.5).

NOTE - The Portion of the circle may also have anyother position relative to the intersecting axes(*see* Fig 11A.6).

11A.2.2.3 *Hidden screw threads*
Where it is necessary to show hidden screw threads, the crests and the roots shall be represented by dashed narrow lines (type 02.1) as shown in Fig 11A.7.

11A.2.2.4 *Hatching of sections of threaded parts*
For threaded Parts shown in section, hatching shall extend to the line defining the crests of the thread(*see* Figures 11A.5 to 11A.8).

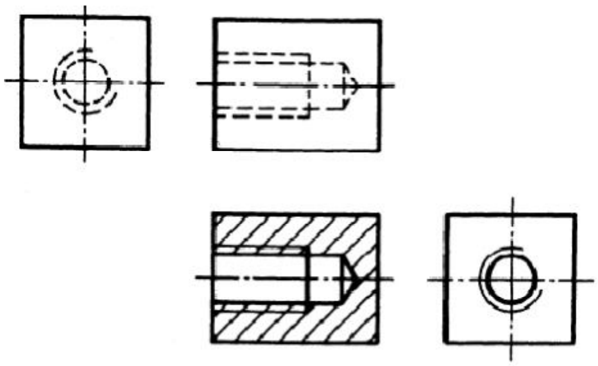


FIG 11A.7

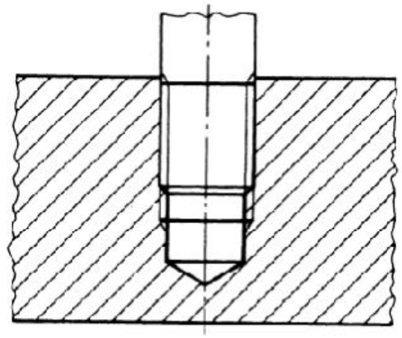


FIG 11A.8

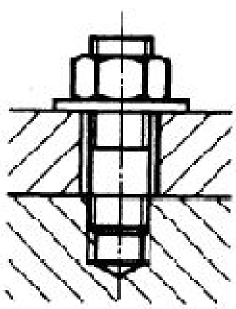


FIG 11A.9

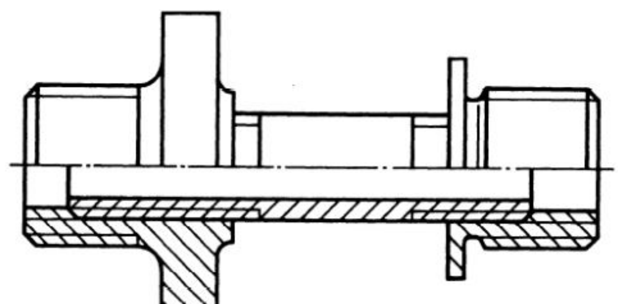


FIG 11A.10

11A.2.2.5 *Limit of length of full depth thread*
The limit of the length of full depth thread

- shall be shown, if visible, by a continuous wide line (type 01.2)
- may be shown, if hidden, by a dashed narrow line(type 02.1).

These limit lines shall terminate at the lines defining the major diameter of the thread (*see* Fig 11A.4, 11A.8 to 11A.11 and 11A.13).

11A.2.2.6 *Thread run-outs*
Thread run-outs are beyond the effective ends of the thread except for the end of studs.

They shall be represented by a continuous inclined thin line (type B, ISO 128) if functionally necessary(*see* Fig 11A.8) or for dimensioning (*see* Fig 11A.13).However it is allowed not to represent the run-out wherever possible (*see* Fig 11A.4, 11A.5 and 11A.7).

11A.2.3 *Assembled threaded parts*
The conventions specified in 11A.2.2 apply also to assemblies of threaded parts. However, externally threaded part shall always be shown covering internally threaded parts and shall not be hidden by them (*see* Fig 11A.8 and 11A.10). The thick line representing the limit of the useful length of the internal screw thread shall be drawn to the root of the internal thread (*see* Fig 11A.8 and 11A.9).

11A.3 Indication and dimensioning of threaded parts

11A.3.1 *Designation*
The type of screw thread and its dimensions shall be indicated by means of the designation specified in the relevant Indian Standards for threads.

When indicating the designation on technical drawings, the description block as well as the Indian Standard block shall be omitted.

In general, the screw thread designation covers

- the abbreviation of the kind of thread (standardized symbol, e.g. M, G, Tr, HA, etc.);
- the nominal diameter or size (e.g. 20,1/2, 40, 4.5, etc.);

and, if necessary,

- the lead (L), in mm;
- the pitch (P), in mm;
- the direction of lead (see 11A.3.4),

as well as additional indications, such as

- the tolerance class according to the relevant Indian Standard;
- thread engagement (S = short, L = long,N = normal);
- the number of starts.

Examples:

a) M20 x 2 - 6G/6h ¯ LH
b) M20 x L3 ¯ P1.5 ¯ 6H ¯ S
c) G 1/2 A
d) Tr 40 x 7
e) HA 4.5

11A.3.2 *Dimensioning*
11A.3.2.1T he nominal diameter, d, always refers to the crest of the external thread (*see* Fig 11A.11 and 11A.13or the root of the internal thread (*see* Fig 11A.12).

The dimension of the thread length normally refers to the length of the full depth thread (*see* Fig 11A.11)unless the run-out is functionally necessary (e.g. studs) and therefore specifically drawn (*see* Fig 11A.8 and 11A.13).

11A.3.3 *Thread length and blind hole depth*
It is generally necessary to dimension the length of thread but the blind hole depth may usually be omitted.

The need for indicating the blind hole depth depends mostly on the part itself and the tool used for threading. When the dimension of the hole depth is unspecified, it shall be depicted as being 1.25 times that of the thread length (*see* Fig 11A.14). A short designation as shown in Fig 11A.15 may also be used.

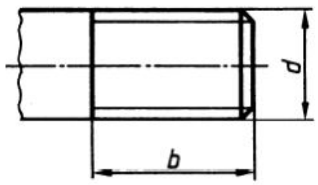


FIG 11A.11

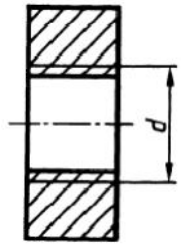


FIG 11A.12

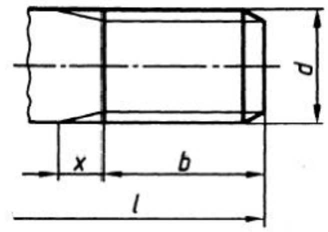


FIG 11A.13

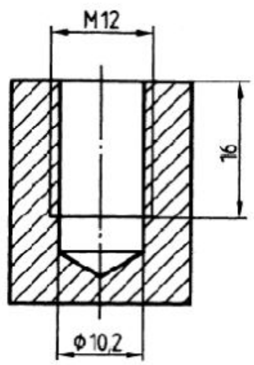


FIG 11A.14

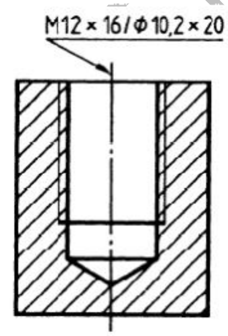


FIG 11A.15

11A.3.4 *Indication of direction of lead*

Right-hand threads need not be denoted in general. Left-hand threads shall be denoted by adding the abbreviation LH to the thread designation. Right hand and Left-hand threads on the same part shall be denoted, in every case. Right-hand threads shall be denoted, if necessary, by adding the abbreviation ‘RH’ to the thread designation.

SECTION 11B– CONVENTIONAL REPRESENTATION OF SCREW THREADS AND THREADED PARTS – SIMPLIFIED REPRESENTATION

[Based on IS 10715-3:1999/1S0 6410-3:1993]

11B.1 Scope

This section specifies the rules for the simplified representation of threaded parts.

11B.2 Simplified representation

11B.2.1 *General*

In simplified representation only essential features shall be shown. The degree of simplification depends on the kind of object represented, the scale of the drawing and the purpose of the documentation

Therefore, the following features shall not be drawn in simplified representation of threaded parts:

- edges of chamfers of nuts and heads;
- thread run-outs;
- the shape of ends of screws;
- undercuts.

11B.2.2 *Screws and nuts*

When it is essential to show the shapes of screw heads, drive patterns or nuts, the examples of simplified representations shown in Table 11B.1 shall be used. Combination of features not shown in Table 11B.1, may also be used. A simplified representation of the opposite (threaded) end view is not necessary.

11B.2.3 *Small diameter threads*

It is permissible to simply the representation and/or the indications of dimensions if

- the diameter (on the drawing) is Ħ6 mm or
- there is a regular pattern of holes or threads of the same type and size.

The designation shall include all necessary features normally shown in a conventional representation and/or dimensioning.

The designation shall appear on a line which points to the centre line of the hole and terminates in an arrowhead (*see* Fig 11B.1 to 11B.4).

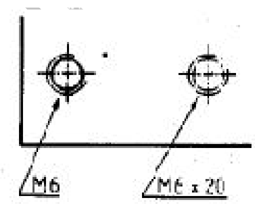


FIG 11B.1

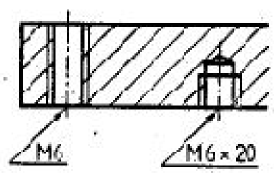
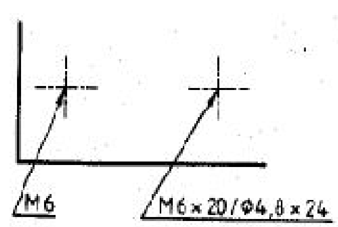


FIG 11B.2



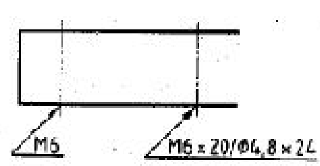
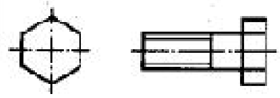
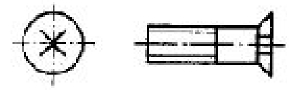
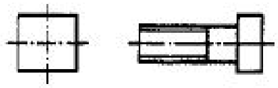
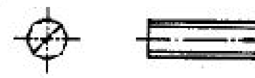
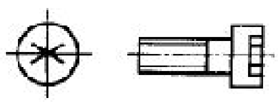
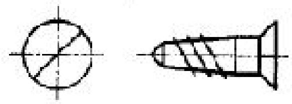
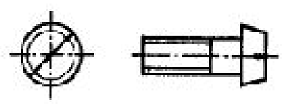
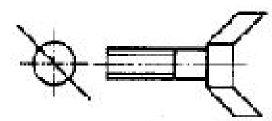
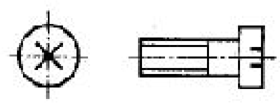
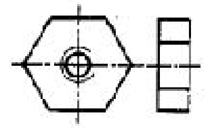
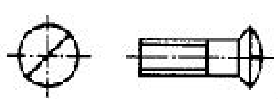
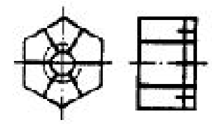
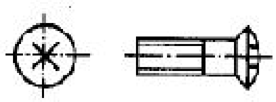
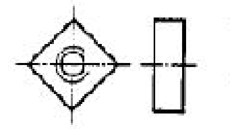
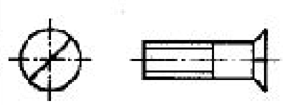
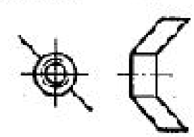


FIG 11B.3 FIG 11B.4

Table11B.1 – Examples of simplified reprsentations
(*Clause* 11B2.2)

No.	Designation	Simplified representation	No.	Designation	Simplified representation
1	Hexagon head screw		9	Countersunk screw, cross slot	
2	Square head screw		10	Set screw, slot	
3	Hexagon socket screw		11	Wood and self-tapping screw, slot	
4	Cylinder screw (pan-head type), slot		12	Wing screw	
5	Cylinder screw, cross slot		13	Hexagon nut	
6	Oval countersunk screw, slot		14	Crown nut	
7	Oval countersunk screw, cross slot		15	Square nut	
8	Countersunk screw, slot		16	Wing nut	

Metric Screw Threads ISO 724								
				Minor Diameter		Thread Height		
Nominal Diameter	Pitch	Root Radius	Pitch diameter	External Thrd	Internal Thrd	Internal Thrd	External Thrd	Tap Drill mm
M 1.00	0.25	0.036	0.838	0.693	0.729	0.153	0.135	0.75
M 1.10	0.25	0.036	0.938	0.793	0.829	0.153	0.135	0.85
M 1.20	0.25	0.036	1.038	0.893	0.929	0.153	0.135	0.95
M 1.40	0.30	0.043	1.205	1.032	1.075	0.184	0.162	1.10
M 1.60	0.35	0.051	1.373	1.171	1.221	0.215	0.189	1.25
M 1.80	0.35	0.051	1.573	1.371	1.421	0.215	0.189	1.45
M 2.00	0.40	0.058	1.740	1.509	1.567	0.245	0.217	1.60
M 2.20	0.45	0.065	1.908	1.648	1.713	0.276	0.244	1.75
M 2.50	0.45	0.065	2.208	1.948	2.013	0.276	0.244	2.05
M 3.00	0.50	0.072	2.675	2.387	2.459	0.307	0.271	2.50
M 3.50	0.60	0.087	3.110	2.764	2.850	0.368	0.325	2.90
M 4.00	0.70	0.101	3.545	3.141	3.242	0.429	0.379	3.30
M 4.50	0.75	0.108	4.013	3.580	3.688	0.460	0.406	3.80
M 5.00	0.80	0.115	4.480	4.019	4.134	0.491	0.433	4.20
M 6.00	1.00	0.144	5.350	4.773	4.917	0.613	0.541	5.00
M 7.00	1.00	0.144	6.350	5.773	5.917	0.613	0.541	6.00
M 8.00	1.25	0.180	7.188	6.466	6.647	0.767	0.677	6.80
M 9.00	1.25	0.180	8.188	7.466	7.647	0.767	0.677	7.80
M 10.00	1.50	0.217	9.026	8.160	8.376	0.920	0.812	8.50
M 11.00	1.50	0.217	10.026	9.160	9.376	0.920	0.812	9.50
M 12.00	1.75	0.253	10.863	9.853	10.106	1.074	0.947	10.20
M 14.00	2.00	0.289	12.701	11.546	11.835	1.227	1.083	12.00
M 16.00	2.00	0.289	14.701	13.546	13.835	1.227	1.083	14.00
M 18.00	2.50	0.361	16.376	14.933	15.394	1.534	1.353	15.50
M 20.00	2.50	0.361	18.376	16.933	17.294	1.534	1.353	17.50
M 22.00	2.50	0.361	20.376	18.933	19.294	1.534	1.353	19.50
M 24.00	3.00	0.433	22.051	20.319	20.752	1.840	1.624	21.00
M 27.00	3.00	0.433	25.051	23.319	23.752	1.840	1.624	24.00
M 30.00	3.50	0.505	27.727	25.706	26.211	2.147	1.894	26.50
M 33.00	3.50	0.505	30.727	28.706	29.211	2.147	1.894	29.50
M 36.00	4.00	0.577	33.402	31.093	31.670	2.454	2.165	32.00
M 39.00	4.00	0.577	36.402	34.093	34.670	2.454	2.165	35.00
M 42.00	4.50	0.650	39.077	36.479	37.129	2.760	2.436	37.50
M 45.00	4.50	0.650	42.077	39.479	40.129	2.760	2.436	40.50
M 48.00	5.00	0.722	44.752	41.866	42.857	3.067	2.706	43.00
M 52.00	5.00	0.722	48.752	45.866	46.587	3.067	2.706	47.00
M 56.00	5.50	0.794	52.428	49.252	50.046	3.374	2.977	50.50
M 60.00	5.50	0.794	56.428	53.252	54.046	3.374	2.977	54.50
M 64.00	6.00	0.866	60.103	56.639	57.505	3.681	3.248	58.00
M 68.00	6.00	0.866	64.103	60.639	61.505	3.681	3.248	62.00

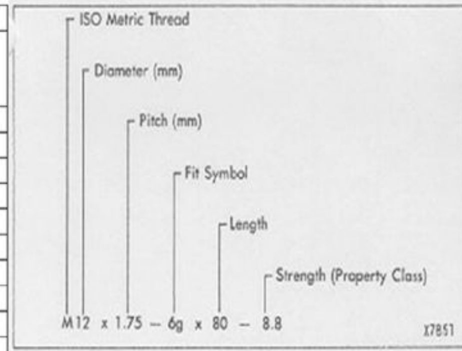


Fig. 20 — Metric Bolt Descriptive Symbols

Metric screw sizes

ISO 261 standard preferred threads							
Nominal diameter *D*(mm) ISO 261		**Pitch *P* (mm)**		**Nominal diameter *D* (mm)**		**Pitch *P* (mm)**	
1st choice ISO 262	**2nd choice**	**coarse**	**fine**	**1st choice**	**2nd choice**	**coarse**	**fine**
1		0.25	0.2	16 (M16)		2	1.5
1.2		0.25	0.2		18	2.5	2 or 1.5
	1.4	0.3	0.2	20 (M20)		2.5	2 or 1.5
1.6		0.35	0.2		22	2.5	2 or 1.5
	1.8	0.35	0.2	24 (M24)		3	2
2		0.4	0.25		27	3	2
2.5		0.45	0.35	30 (M30)		3.5	2
3		0.5	0.35		33	3.5	2
	3.5	0.6	0.35	36 (M36)		4	3
4 (M4)		0.7	0.5		39	4	3
5 (M5)		0.8	0.5	42 (M42)		4.5	3
6 (M6)		1	0.75		45	4.5	3
	7	1	0.75	48 (M48)		5	3
8 (M8)		1.25	1 or 0.75		52	5	4
10 (M10)		1.5	1.25 or 1	56 (M56)		5.5	4
12 (M12)		1.75	1.5 or 1.25		60	5.5	4
	14	2	1.5	64 (M64)		6	4

SECTION 11C– SIMPLIFIED REPRESENTATION OF SPRINGS

[Based on IS 10716-1:1999/1S0 2162-1:1993]

11C.1 Scope

This section specifies rules for the simplified representation of compression, extension, torsion, disc, spiral and leaf springs on technical drawings.

11C.2 General

In simplified representations, springs are represented as follows.

- Coiled wire springs: by a line following the axis of the spring wire.
- Other types of springs: by lines showing the characteristics of the respective type of springs and their elements.

Further the Spring shall be adequately indicated with the following values:

a) Solid length of spring (it is the length of spring when it is fully compressed)
b) Free length of spring (it is the maximum length without any load)
c) Stiffness (compression index)
d) Load carrying capacity in per sq meter

The representations shown are examples only.

11C.3 Helical compression springs

The following requirements shall be applied for the indication of the geometrical characteristics of wire made springs on a simplified representation (*see* Table 11C.1). The data of compression springs normally used is as per Fig 11C.1

a) Cross-section of the material
Cylindrical: the appropriate graphical symbol Ø need not be indicated.
Other than cylindrical: the appropriate graphical symbol shall be indicated ▭ (e.g. □,).

b) Direction of helix
Right-hand: assumed as normal and the designation RH need not be indicated.
Left-hand: exceptional and the designation LH shall be indicated.

c) Shape of ends
Ground: no indication is necessary.
Other than ground: the type shall be specified on the drawing, with dimensions if necessary.

11C.4 Helical extension springs

The requirements for the indication of the Cross-section of the material and direction of helix are identical to those given in clause 11C.3. (*see* Table 11C.2 for representation)

The shape of the ends shall be specified on the drawing, with dimensions if necessary.

The spring and its ends usually have the same diameter.

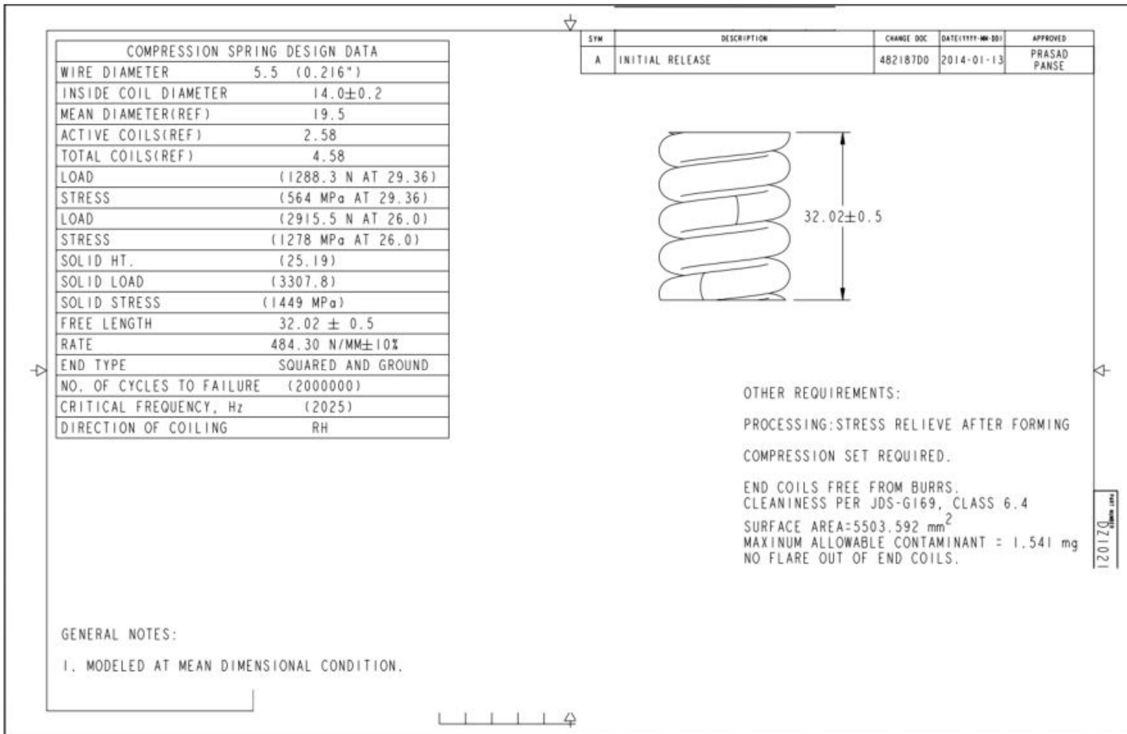


FIG 11C.1

11C.5 Torsion springs

The requirements for the indication of the direction of helix and the Cross-section of the material for No.1 in Table 11C.3 are identical to those given in clause 11C.3. For No.2 and No.3 in Table 11C.3, the cross-section of the material shall be indicated.

The shape of the ends shall be specified on the drawing, with dimensions if necessary.

11C.6 Disc springs (Belleville) (*see* Table 11C.4)

11C.7 Spiral springs

The Cross-section of the material shall be indicated (see example No.1 in Table 11C.5). In cases No.1 and No.2in Table 11C.5, the shape of theends needs to be indicated.

11C.8Leaf springs (*See* Table 11C.6)

Table 11C.1 – Helical compression springs

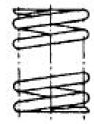
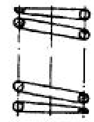
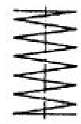
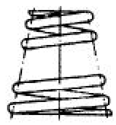
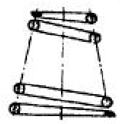
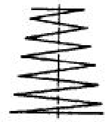
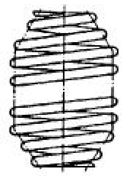
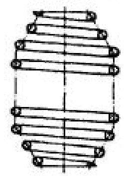
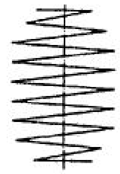
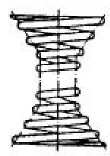
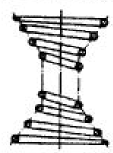
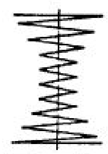
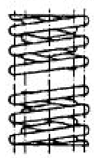
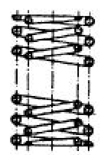
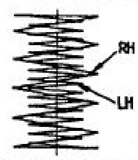
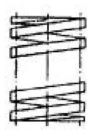
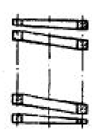
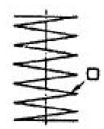
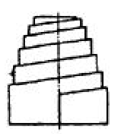
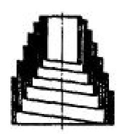
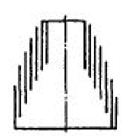
No.	Type of spring	Representation		
		View	Section	Simplified
1	Cylindrical helical compression spring			
2	Conical helical compression spring			
Combinations of cylindrical (1) and conical (2) helical compression springs.				
3	Double-conical helical compression spring Barrel spring			
4	Double-conical helical compression spring Waisted spring			
5	Spring nest of, for example, two cylindrical helical compression springs			
6	Cylindrical helical compression spring of material having square cross-section			
7	Conical helical compression spring of strip having rectangular cross-section Volute spring			

Table 11C.2 – Helical extension springs

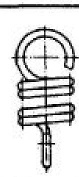
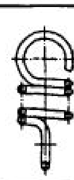
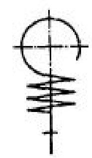
No.	Type of spring	Representation		
		View	Section	Simplified
1	Cylindrical helical extension spring			

Table 11C.3 – Torsion springs

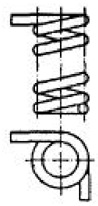
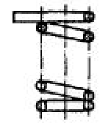
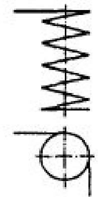
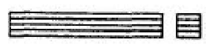
No.	Type of spring	Representation		
		View	Section	Simplified
1	Cylindrical helical torsion spring			
		View		Simplified
2	Torsion bar spring having circular cross-section			
3	Stacked laminated torsion bar spring of strips having rectangular cross-section			

Table 11C.4 – Disc springs

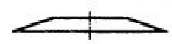
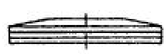
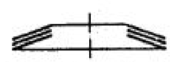
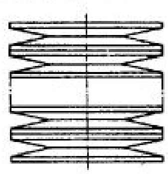
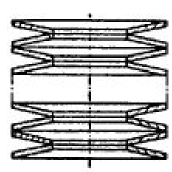
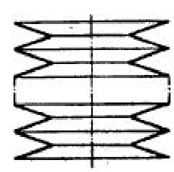
No.	Type of spring	Representation		
		View	Section	Simplified
1	Disc spring, single			
2	Multi-disc spring (disc laminated in parallel)			
3	Multi-disc spring (disc laminated in series) Disc spring column			

Table 11C.5 – Spiral springs

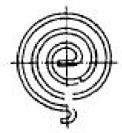
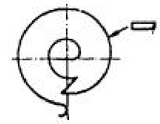
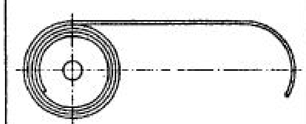
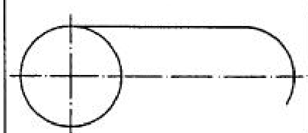
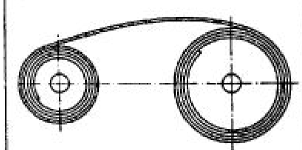
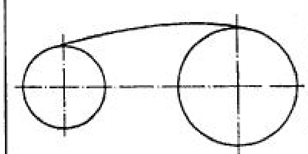
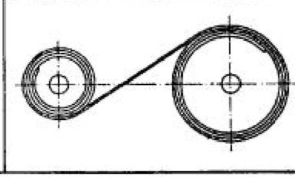
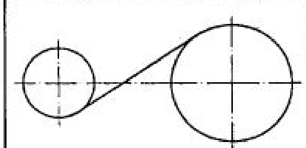
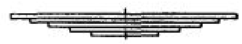
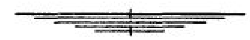
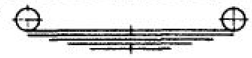
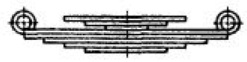
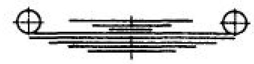
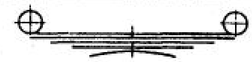
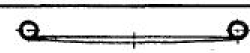
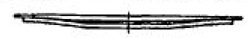
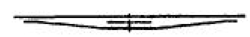
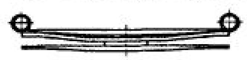
No.	Type of spring	Representation	
		View	Simplified
1	Spiral spring of strip having rectangular cross-section		
2	Constant force extension spring		
3	Constant force spring — A-Motor		
4	Constant force spring — B-Motor		

Table 11C.6 – Leaf springs

No.	Type of spring	Representation	
		View	Simplified
1	Laminated leaf spring without eyes		
2	Laminated leaf spring with eyes		
3	Laminated leaf spring with eyes and helper spring		
4	Laminated leaf spring with eyes and auxiliary spring		
5	Parabolic single-leaf spring with eyes		
6	Parabolic multi-leaf spring without eyes		
7	Parabolic multi-leaf spring with eyes		
8	Parabolic multi-leaf spring with eyes and helper spring		
9	Parabolic multi-leaf spring with eyes and auxiliary spring		

SECTION 11D– CONVENTIONAL REPRESENTRATION OF GEARS ON TECHNCIAL DRAWING

[Based on IS 10717:1983/1S0 2203:1973]

11D.1 Scope

This section establishes the conventional representation of the toothed portion of gears including worm gearing and chain wheels. It is applicable to details drawings and assembly drawings.

As a fundamental principle a gear is represented (except in axial section) as a solid part without teeth, but with addition of pitch surfaces in a thin long chain line.

11D.2 Detail drawing (individual gears)

11D.2.1 *Contours and edges*

Represent the contours and the edges of the each gear (*see* Fig 11D.1, 11D.2 and 11D.3), as if they were:

- in an unsectioned, a solid gear bounded by the tip surface.
- in an axial section, a spur gear having two diametrically opposed teeth, represented unsectioned, even in the case of a gear that does not have spur teeth or that has an odd number of teeth.

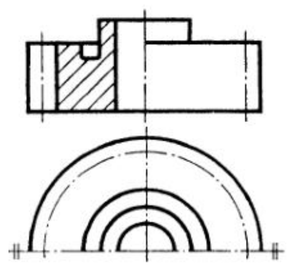


FIG 11D.1

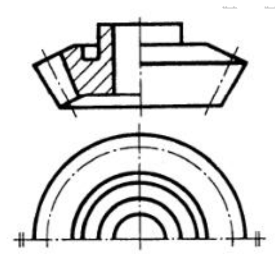


FIG 11D.2

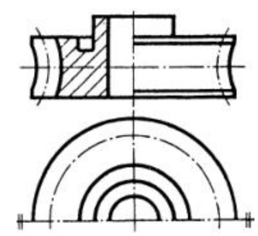


FIG 11D.3

11D.2.2 *Pitch surface*

Drawn the pitch surface with a long dashed double dotted narrow line, even in concealed portions and sectional views, and represent it:

a) in a projection normal to the axis, by its pitch circle (external pitch circle in case of a bevel gear and median pitch circle in the case of a worm wheel) {*see* Fig 11D.1, 11D.2 and 11D.3}.

b) in a projection parallel to the axis, by its apparent contour, extending the line behind the gear contour on each side (*see* Fig 11D.1, 11D.2 and 11D.3).

11D.2.3 *Root surface*

As a general rule, do not represent the root surface except in sectional views.

However, if it seems helpful to show it also on unsectioned views, always draw it, in this case, a continuous narrow line (*see* Fig 11D.4, 11D.5 and 11D.6).

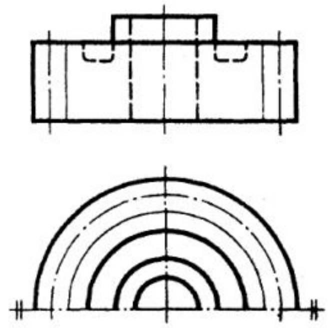


FIG 11D.4

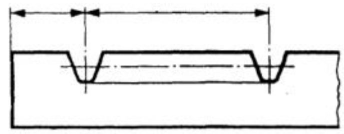


FIG 11D.5

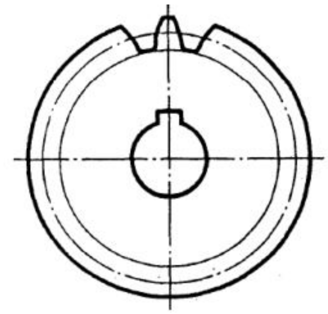


FIG 11D.6

11D.2.4 *Teeth*

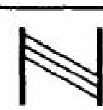
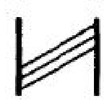
Specify the teeth profile either by reference to a standard or by a drawing to a suitable scale.

If it is essential to show one or two teeth on the drawing itself (either to define the ends of a toothed portion or rack, or in order to specify the position of the teeth in relation to a given axial plane), draw them as continuous wide lines (*see* Fig 11D.5 and 11D.6).

It it is necessary to indicate the direction of the teeth of a gear or rack on the view of the tooth surface in a projection parallel to the gear axes, three continuous narrow lines of the corresponding form and direction should be shown (*see* Table 11D.1 and Fig 11D.7).

NOTE: If mating gears are represented, the direction of the teeth should be shown on one gear only.

Table 11D.1 – Indication of direction of teeth

Tooth system	Symbol
Helical to the right	
Helical to the left	
Double helical	 
Spiral	 

11D.3 Assembly drawings (gear pairs)

The specified rules for the representation of gears on detail drawings are equally applicable to assembly drawings. However, for a pair of bevel gears in projection parallel to the axis, extend the line drawn for the pitch surface to the point where the axes meet (*see* Fig 11D.9 and 11D.10).

Neither of the two gears of a gear pair assumed to be hidden by the other in the portion in mesh (*see* Fig 11D.8), except in the following two cases:

- If one of the gears, the whole of which is located in front of the other, effectively conceals part of it (*see* Fig 11D.9, 11D.10 and 11D.11).
- If both gears are represented in axial section, in which case, one of the two gears, chosen arbitrarily, is assumed to be partly concealed by the other (*see* Fig 11D.9).

In these two cases, concealed contour edges need not be represented if they are not essential to the clarity of the drawing (*see* Fig 11D.9 and 11D.10).

11D.3.1 *External engagement of cylindrical gears (see* Fig 11D.8*)*
11D.3.2 *Internal engagement of cylindrical gears (see* Fig 11D.9*)*
11D.3.3 *Engagement of pinion with rack (see Fig* 11D.10*)*
11D.3.4 *Engagement of bevel gears, axis inter-section at any angle (see* Fig 11D.11)
11D.3.5 *Engagement with cylindrical worm in cross-section (see* Fig 11D.12)
11D.3.6 *Chain wheels (see* Fig 11D.13)
11D3.7 *Typical example of Gear drawing (See* Fig 11D.14)

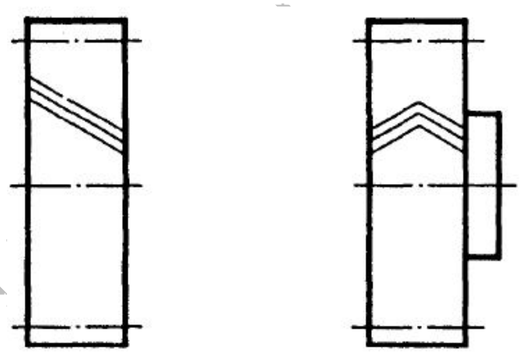


FIG 11D.7

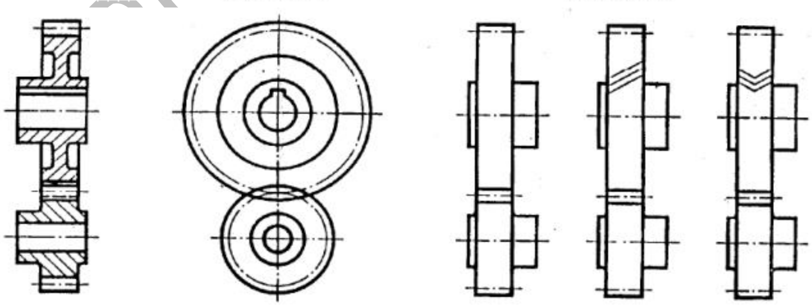


FIG 11D.8

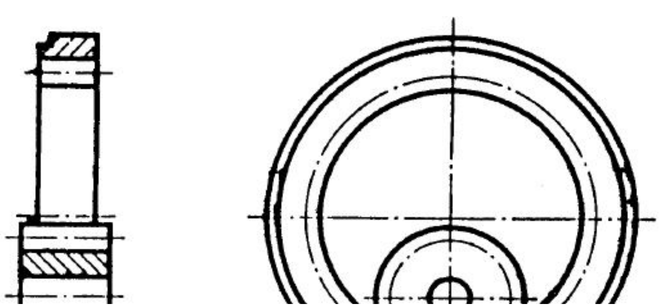


FIG 11D.9

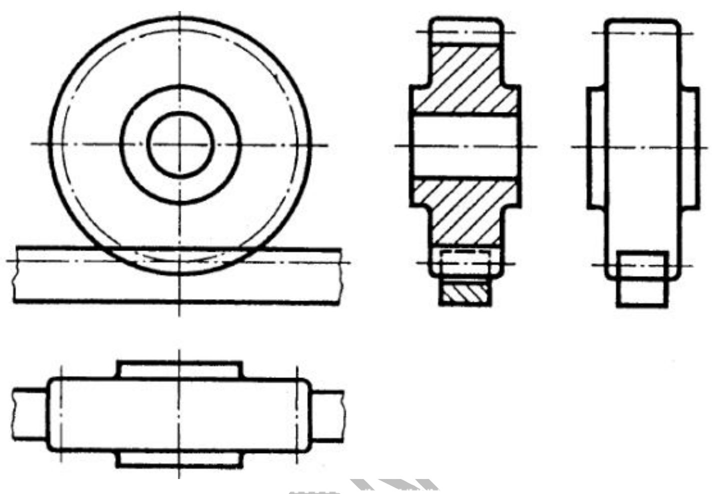


FIG 11D.10

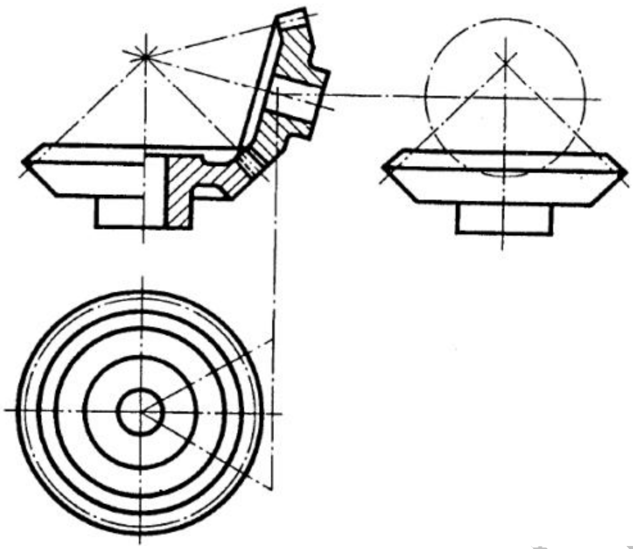


FIG 11D.11

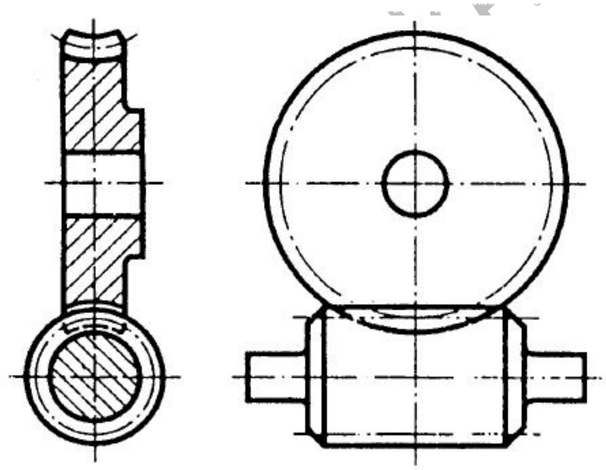


FIG 11D.12

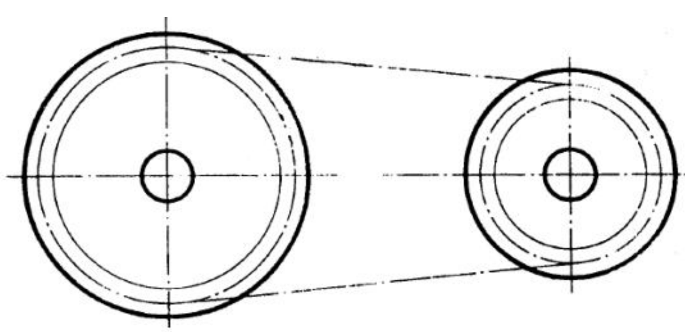
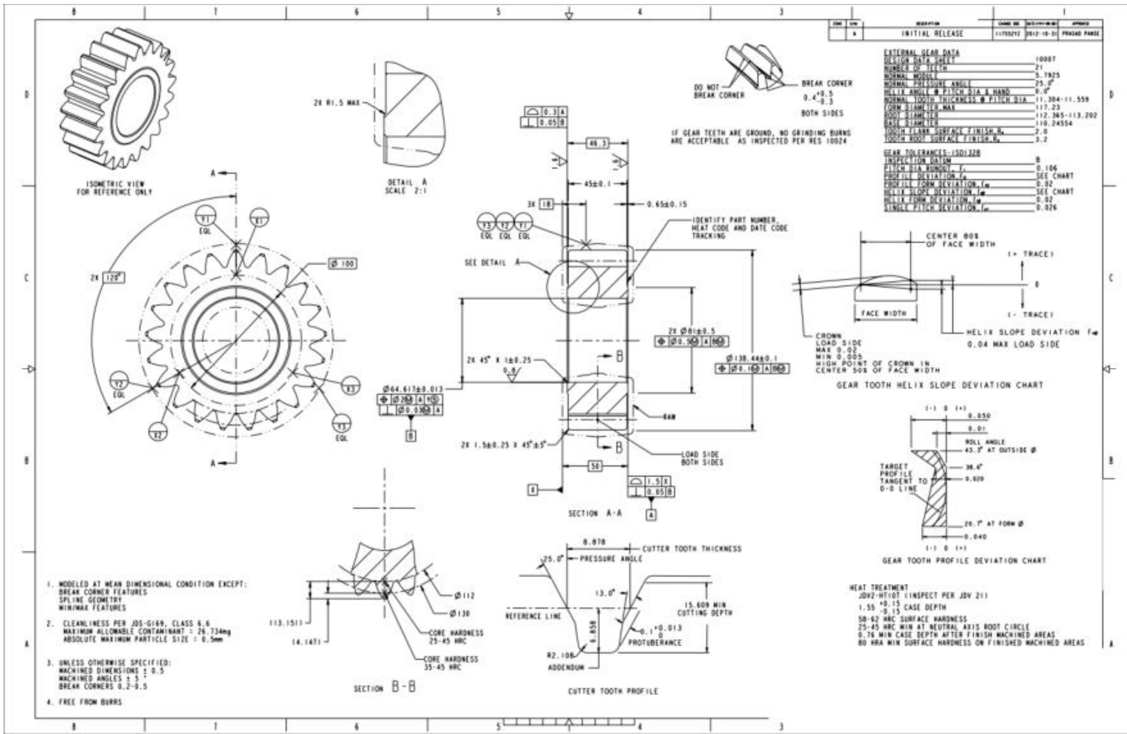


FIG 11D.13



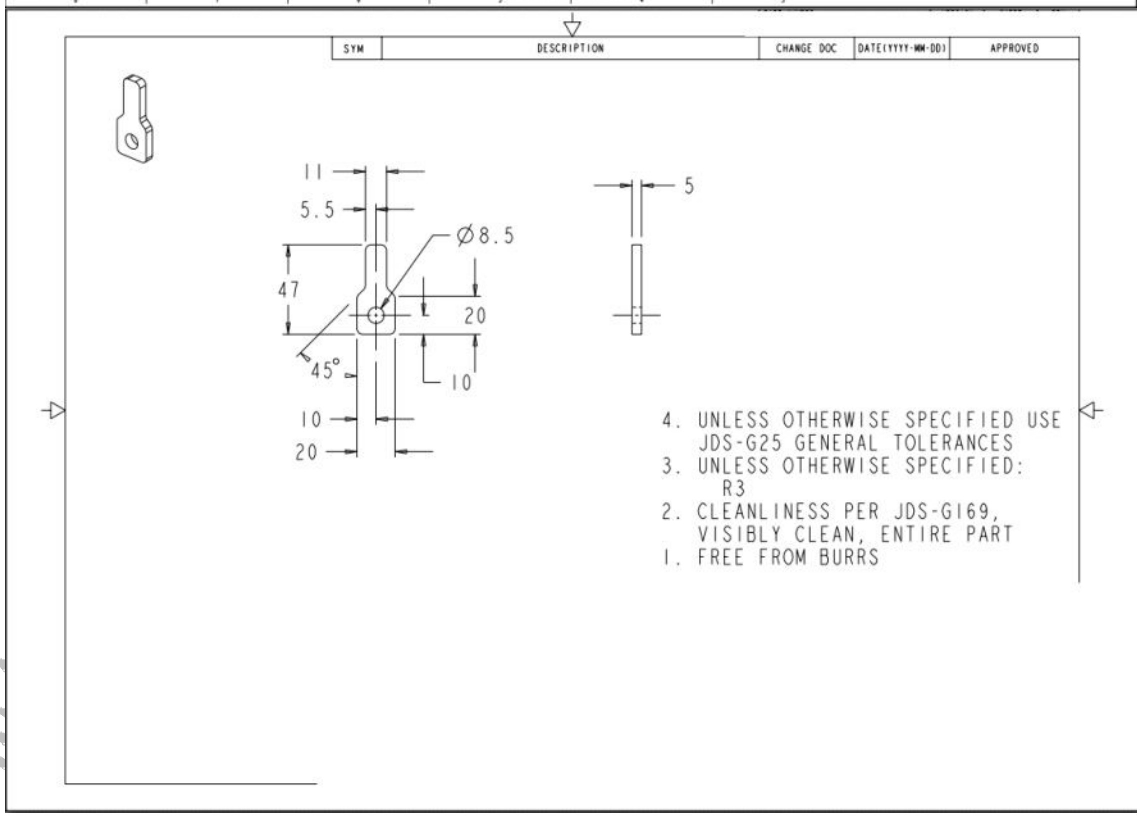


FIG 11D.14 Example of Gear Drawing

SECTION 12– GENERAL PRINCIPLES FOR INDICATION OF DIMENSIONS AND TOLERANCES ON TECHNCIAL DRAWING

[Based on IS 11669 /1SO129-1:2004]

12.1 SCOPE

This section establishes the general principles of dimensioning applicable for all types of technical drawings.

NOTE -The figures in this section merely illustrate the text and are not intended to reflect actual usage. Consequently, they have been simplified to indicate only the relevant general principles applicable in any technical area.

12.2 Terms and definitions

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

12.2.1 *Feature*

12.2.1.1 *Geometrical feature*

Point, line or surface

NOTE - The word geometrical may be deleted if no risk of misunderstanding occurs, hence, in this section the word `feature_ will be used alone.

12.2.1.2 *Feature of size*

Geometrical shape defined by a linear or angular dimension which is a size.

NOTE 1 -The feature of size can be a cylinder, a sphere, two parallel opposite surfaces, a cone or a wedge.

NOTE 2 -The meanings of the terms :plain workpiece˘ and :single features˘ are close to that of :feature of size˘.

12.2.1.3 *Reference feature*

Feature which is used as the origin for the determination of another feature.

12.2.1.4 *Repeated feature*

Periodicity of features of the same spacing or angle referred to one or more reference features.

12.2.2 *Lines of dimensioning*

12.2.2.1 *Centre line*

Line on a drawing indicating the geometrical centre of the represented feature(s).

12.2.2.2 *Dimension line*

Straight or curved line on a drawing between two features, or between a feature and an extension line, or between two extension lines indicating the dimension graphically

NOTE - The dimensional value and any tolerance indication are attached to the dimension line.

12.2.2.3 *Extension line*

Line connecting the feature(s) to be dimensioned and the ends of the corresponding dimension line.

12.2.2.4 *Leader line*

Line connecting information or requirements or a reference line with a feature or a dimension line.

12.2.2.5 *Line of symmetry*

Straight line on a drawing indicating the plane or axis of symmetry.

12.2.2.6 *Origin circle*
Starting point of running dimensioning or coordinate dimensioning.

12.2.2.7 *Terminator*
Indication signifying the extremities of a dimension or leader line.

12.2.3 *Dimensions*
12.2.3.1 *Dimension*
Distance between two features or the size of a feature of size.

NOTE - Linear and angular dimensions exist.

12.2.3.2 *Basic dimension (dimensional value)*
Numerical value of a dimension expressed in a specific unit and indicated on drawings with lines and relevant symbols.

NOTE 1 - When no tolerance is indicated, the basic dimension is often called the dimensional value.
NOTE 2 - Unit of dimension should be linear or angular.
NOTE 3 - The tolerance limits and/or permissible deviations are applied to the basic dimension.

12.2.3.3 *Linear dimension*
Linear distance between two features or the linear size of a feature of size.

NOTE - In mechanical engineering drawings, linear dimensions are classified in size, distances and radii.

12.2.3.4 *Angular dimension*
The angle between two features or the angle of an angular feature of size.

NOTE - In mechanical engineering drawings, angular dimensions are classified in angular size and angular distances.

12.2.3.5 *Tolerance of dimension*
Difference between the upper and lower tolerance limits of a dimension.

12.2.3.6 *Auxiliary dimension*
Dimensions derived from other dimensions given for information purposes only.

12.2.4 *Arrangement of dimensions*
12.2.4.1 *Chain dimensioning*
Method of dimensioning where single dimensions are arranged in a row.

12.2.4.2 *Coordinate dimensioning*
Method of dimensioning from a reference feature in a coordinate system.

12.2.4.3 *Parallel dimensioning*
Method of dimensioning from a reference feature with parallel or concentric dimension lines.

12.2.4.4 *Running dimensioning*
Method of dimensioning from a reference feature where each feature is dimensioned.

12.2.4.5 *Tabular dimensioning*
Method of dimensioning where features and/or dimensions are indicated by allocated numbers or letters and recorded in tables.

12.3 Principles of dimensioning and of indication of tolerances

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

Dimensions are one of several types of geometrical requirements, which may be used to define a feature or component clearly and unambiguously. Other types of geometrical requirements, which most often are needed to obtain an unambiguous definition of the feature (e.g. in mechanical engineering) are geometrical tolerances (form, orientation, location and run-out), surface texture requirements and requirements for corners.

NOTE - In the construction engineering, tolerances are often given in separate documents.

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

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

Where all linear dimensions are expressed in the same unit, the unit symbol may be omitted, provided the drawing or associated documentation carries a statement of the unit used.

12.3.2 *Positioning of dimensions*
Dimensions should be placed on that view or section which shows the relevant feature(s) most clearly (*see* Fig 12.1).

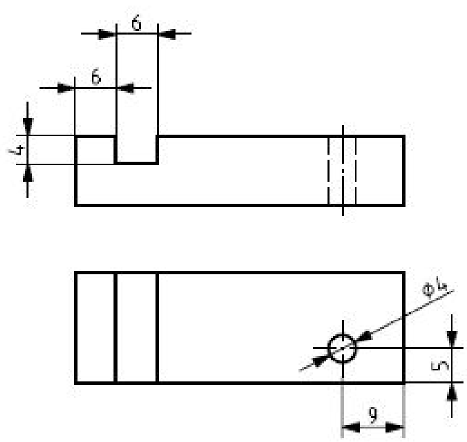


FIG 12.1

Where several features or objects are depicted in close proximity, their relative dimensions should be grouped, together, separately, for ease of reading (*see* Fig 12.2).

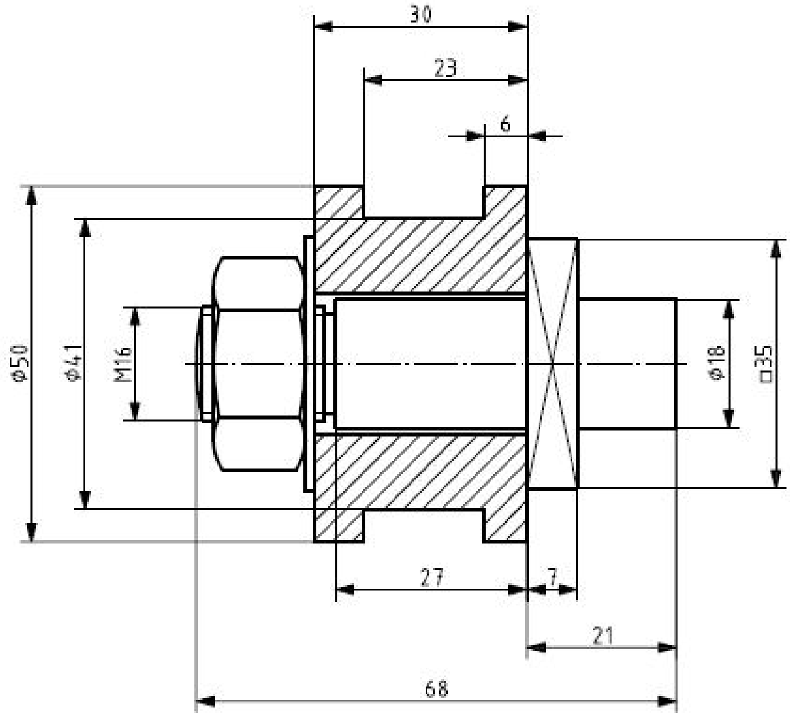


FIG 12.2

12.3.3 *Units of dimensions*
Dimensions shall be indicated using only one unit of dimension. Where a variety of units of dimension areused within one document, they shall be clearly indicated.

For dimensions, SI units shall be used (see IS 10005/ISO 1000).

Limit deviations shall be expressed in the same unit as the basic dimension.

12.4 Elements of dimensioning
12.4.1 *General*

The elements of dimensioning are extension lines, dimension lines, leader lines, terminators, indication of origins and dimensional values (basic dimensions). Various elements of dimensioning are illustrated in Fig 12.3; the origin circle is indicated in Fig 12.62 to 12.64.

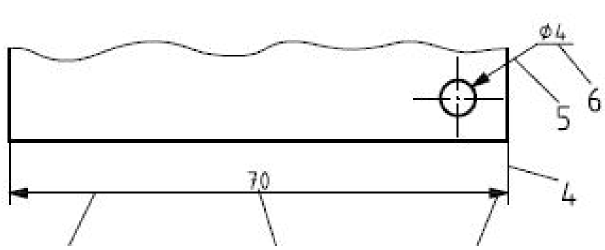


FIG 12.3

Key
1 dimension line
2 dimensional value
3 terminator (in this case, an arrowhead)
4 extension line
5 leader line
6 reference line

12.4.2 *Dimension line*

Dimension lines shall be drawn with a continuous narrow line.
Dimension lines shall be indicated in the case of
- linear dimensions parallel to the length to be dimensioned (*see* Fig 4),
- angular dimensions or dimensions of an arc as a circular arc around the vertex of the angle or the centre of the arc (*see* Fig 12.5 and 12.6), and
- radii generated from the geometrical centre of the radius (*see* Fig 6).

Where space is limited, dimension lines may be indicated with extensions and reversed arrowheads (*see* Fig 12.1).

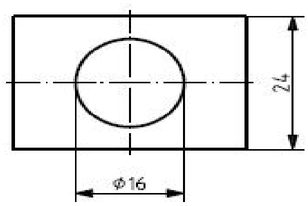


FIG 12.4

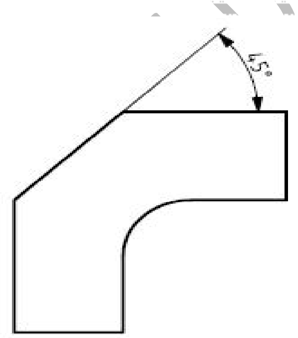


FIG 12.6

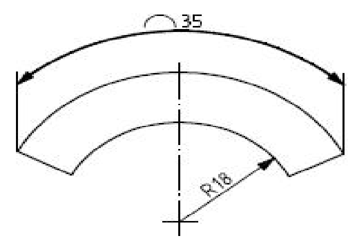


FIG 12.6

Where the feature is shown broken, the corresponding dimension line shall be shown unbroken (*see* Fig 12.7).

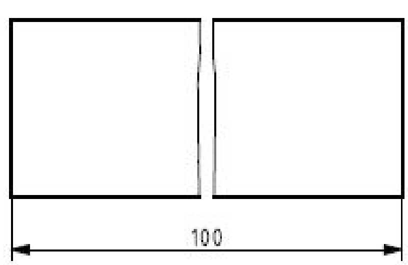


FIG 12.7

Intersection of dimension lines with any other line should be avoided, but where intersection is unavoidable they shall be shown without a break (*see* Fig 12.8).

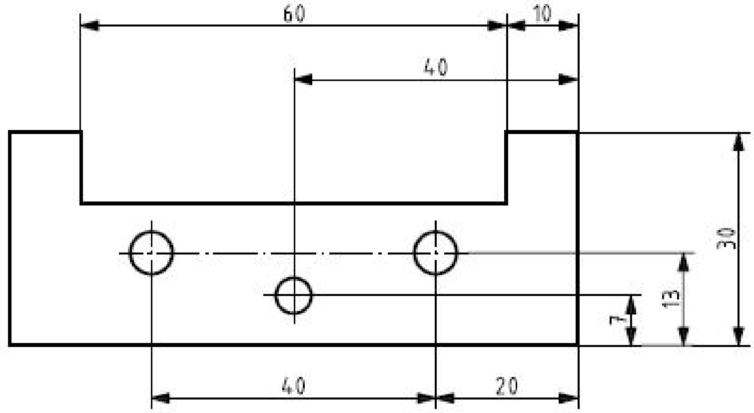


FIG 12.8

Dimension lines may be shown not in full, when

- dimensions of diameters are indicated (*see* Fig 12.9),
- only a part of a symmetrical feature is drawn in a view or section (*see* Fig 12.55 and 12.56),
- a feature is drawn half in a view and half in a cut (*see* Fig 12.9),
- the reference feature for dimensioning is not on the drawing sheet and there is no need for its indication(*see* Fig 12.40 R62),
- referring to grids on construction drawings (*see* Fig 12.10).

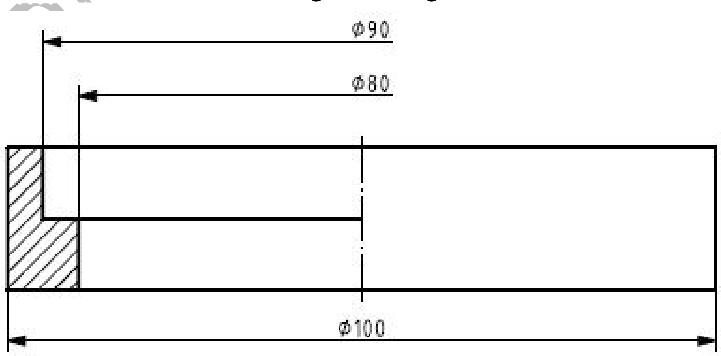


FIG 12.9

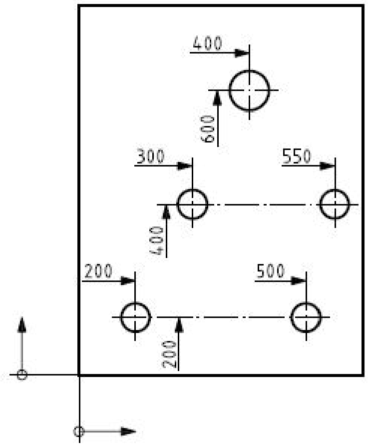
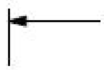


FIG 12.10

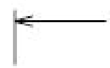
12.4.3 *Terminators and origin indicators*

12.4.3.1The termination of dimension lines shall be according to one of the representations shown in Fig 12.11.



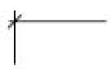
a) Arrowhead, closed and filled 30°

b) Arrowhead, closed 30°

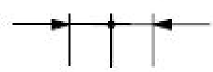


c) Arrowhead, open 30°

d) Arrowhead, open 90°



e) Oblique stroke



f) Point (used only if no place for arrowhead ; the oblique stroke may also be used)

FIG 12.11

12.4.3.2The indication of the origin of the dimension line shall be as shown in Fig 12.12.

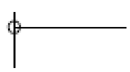


FIG 12.12

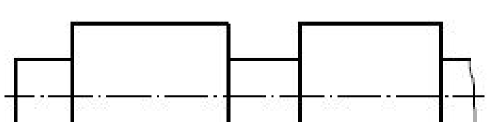
12.4.4 *Extension line*

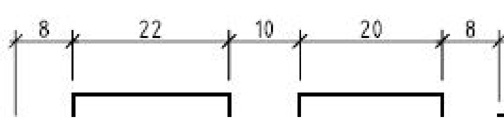
Extension lines shall be drawn as continuous narrow lines.

Extension lines shall extend approximately 8 times the line width beyond the respective dimension line.

Extension lines should be drawn perpendicular to the corresponding physical length (*see* Fig 12.4 and 12.5, 12.7 to 12.9 and 12.13).

It is permissible to have a gap (approximately 8 times the line width) between the feature and





the beginning of the extension line in certain technical fields (*see* Fig 12.14).

FIG 12.13 FIG 12.14

The extension lines may be drawn obliquely, but parallel to each other (*see* Fig 12.15).

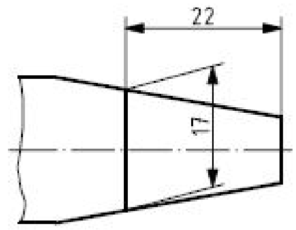


FIG 12.15

Intersecting projected contours of outlines shall extend approximately 8 times the line width beyond the point of intersection (*see* Fig 12.16).

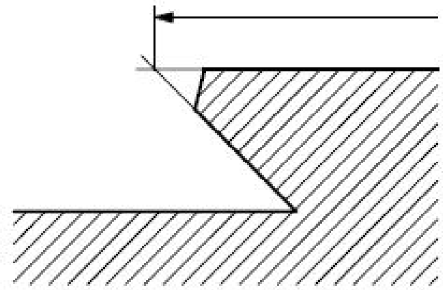


FIG 12.16

In the case of projected contours of transitions and similar features, the extension lines apply at the point of intersection of the projection lines (*see* Fig 12.17).

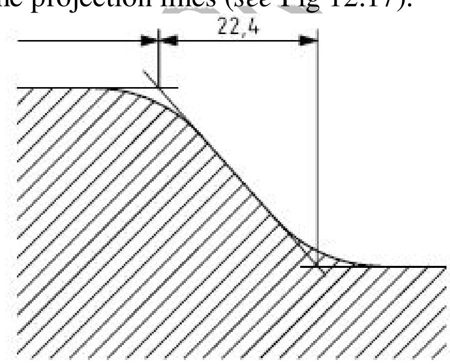
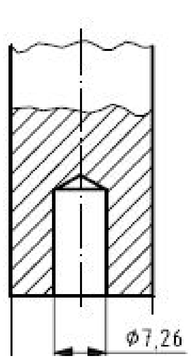


FIG 12.17

Extension lines may be interrupted if their continuation is unambiguous (see Fig 12.18 and 12.19). In the case of angular dimensions, the extension lines are the extensions of the angle legs (*see* Fig 12.19).



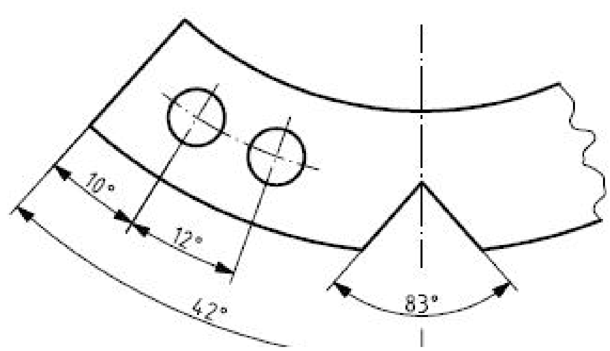


FIG 12.18 FIG 12.19

12.4.5 *Leader line*

Leader lines shall be drawn using a continuous narrow line.

Leader lines should not be longer than necessary and should be drawn obliquely to the feature, but shall have an angle distinctive from that of any existing hatching (*see* Fig 12.20, 12.25 and 12.27).

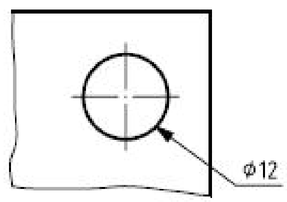


FIG 12.20

12.4.6 *Dimensional values (basic dimensions)*

12.4.6.1 *Indication*

Dimensional values shall be indicated on drawings in characters of sufficient size to ensure complete legibility on the original drawing as well as on reproductions made from microfilms. Lettering B vertical accordingly.

12.4.6.2 *Positions of dimensional values*

Dimensional values shall be placed parallel to their dimension line and near the middle of and slightly above that line (*see* Fig 12.21 and 12.22).Dimensional values shall be placed in such a way that they are not crossed or separated by any line.

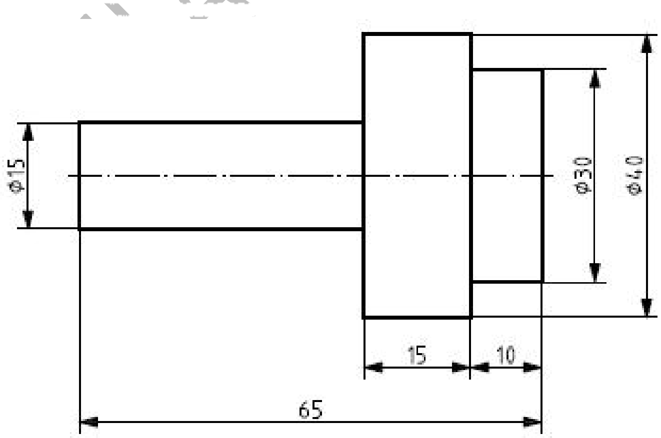


FIG 12.21

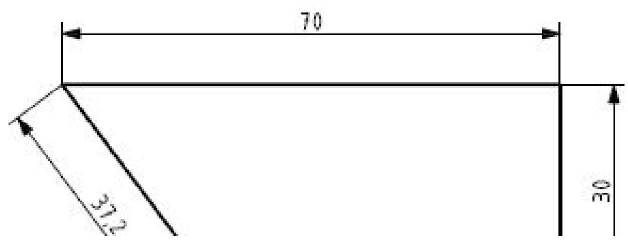


FIG 12.22

For exceptions, *see* 12.4.6.3

Values on oblique dimension lines shall be oriented as shown in Fig 12.23.

Values of angular dimensions shall be oriented as shown in Fig 12.24.

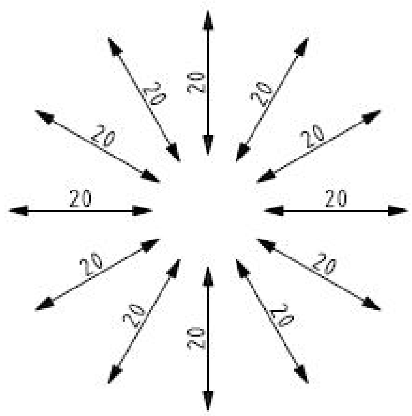


FIG 12.23

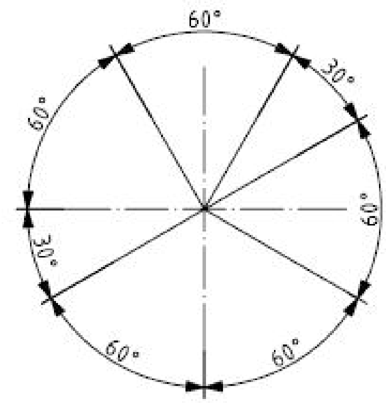


FIG 12.24

12.4.6.3 *Positions of dimensional values*

The position of dimensional values frequently needs adaptation to different situations:

a) dimensional values can be above the extension of the dimension line beyond one of the terminators, if space is limited (*see* Fig 12.25);

b) dimensional values can be shown on a reference line, and attached to the dimension line by a leader line, terminating on the dimension line that is too short for the dimensional value to be indicated in the usual way between the extension lines (*see* Fig 12.25);

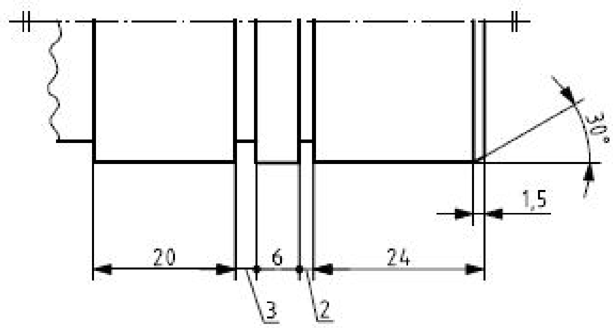


FIG 12.25

c) dimensional values can be placed above a horizontal extension of a dimension line where space does not allow placement parallel to the dimension line (*see* Fig 12.26);

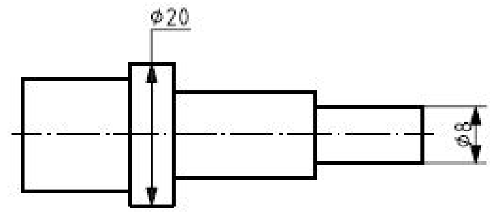


FIG 12.26

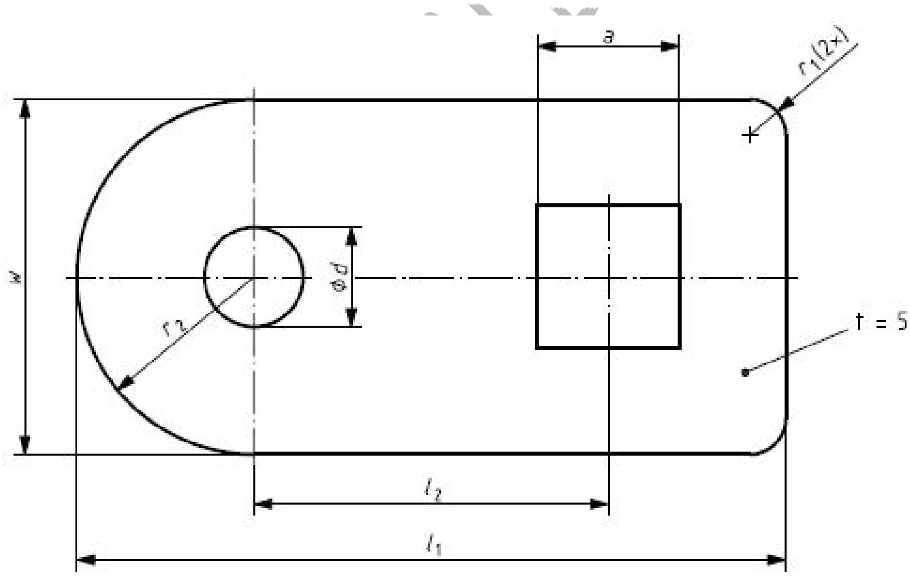
d) in running dimensioning, the values shall be indicated near the arrowhead (*see* Figs 12.63 and 12.64).

12.4.7 *Letters representing dimensions*

Letters may be used to represent dimensional values and these shall be defined on the same drawing or in associated documentation (*see* Fig 12.27).

12.4.8 *Tabular dimensioning*

This method of dimensioning enables a series of variable common features of a feature or assembly to be presented in tabular form (*see* Fig 12.27).



No.	a	d	l_1	l_2	r_1	r_2	w
1	□ 2	⌀ 10	100	50	R6	(R16)	32
2	□ 6	⌀ 16	120	64	R6	(R20)	40
3	□ 8	⌀ 20	140	78	R8	(R24)	48

FIG 12.27

12.5 Elements of indication of tolerances

12.5.1 *General rules*

When general tolerances (e.g. ISO 2768-1 and ISO 2768-2) are indicated on a drawing, they shall be stated inside or near the title block.

The symbols of, for example, tolerance classes and the digits indicating the permissible deviations, shall be written in the same lettering height as the basic dimension. It is also permitted to use a lettering height which is one size smaller than the lettering height of the basic dimension, but not smaller than 2.5 mm.

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

- symbols of the tolerance classes
- limit deviation (*see* 12.5.2),
- limits of dimension (*see* 12.5.3), or
- statistical tolerancing.

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

12.5.2 Limit deviations

The components of the toleranced dimension shall be indicated in the following order (*see* Figs 12.28 to 12.31):

a) the basic dimension;
b) the limit deviations.

Limit deviations, according to ISO 286-1, shall be indicated either by indicating the upper deviation above the lower deviation (*see* Figs 12.28 and 12.30), or by indicating the upper deviation before the lower deviation on the same line, separated from it by a slash (*see* Fig 12.29).

If one of the two limit deviations is zero, this shall be expressed by the digit zero (*see* Fig 12.30).

If the tolerance is symmetrical in relation to the basic dimension, the limit deviation shall be indicated once only, preceded by the sign ʽ±ˇ (*see* Fig 12.31).

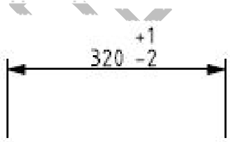


FIG 12.28

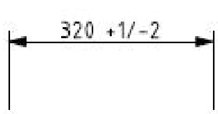


FIG 12.29

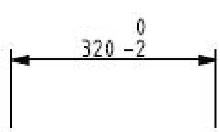


FIG 12.30

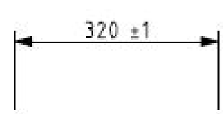


FIG 12.31

12.5.3 *Limits of dimensions*

12.5.3.1 The limits of dimensions are indicated by a maximum and a minimum (*see* Fig 12.32).

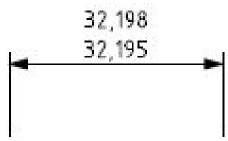


FIG 12.32

12.5.3.2 To limit the dimension in one direction only, this should be indicated by adding ːmin.˘ or ːmax.˘ to the dimensional value (*see* Fig 12.33).

FIG 12.33

12.5.3.3 For limit deviations for angular dimensions, *see* **12.6.5**.

12.6 Indications of special dimensions

12.6.1 *Arrangement of graphical and letter symbols with dimensional values*

The following symbols shall be used with dimensions to identify the shape of a dimensioned feature. The following symbols shall precede the dimensional value (*see* Fig 12.6, Fig 12.34 to 12.38 and Table 12.1):

-Ø: Diameter;
-R: Radius;
-□: Square;
-SØ: Spherical diameter;
-SR: Spherical radius;
- ∩ : Arc;
-t=: Thickness.

Table 12.1 - Examples of applications of graphical and letter symbols

Symbols and their representation	Meaning
⌀50	Diameter 50
□50	Square 50
R50	Radius 50
S⌀50	Spherical diameter 50
SR50	Spherical radius 50
⌒50	Arc length 50
+12,25 +12,25	Indication of level 12,25
50	Out-of-scale 50
(50)	Auxiliary dimension 50

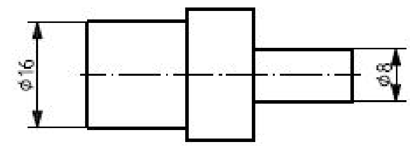


FIG 12.34

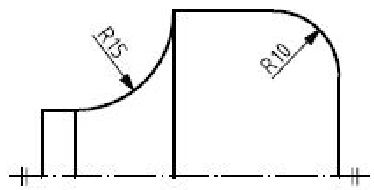


FIG 12.35

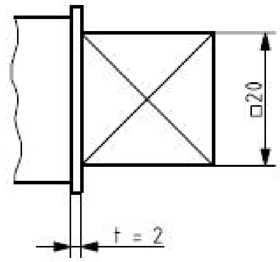


FIG 12.36

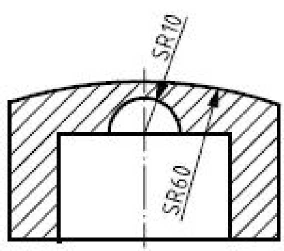


FIG 12.37

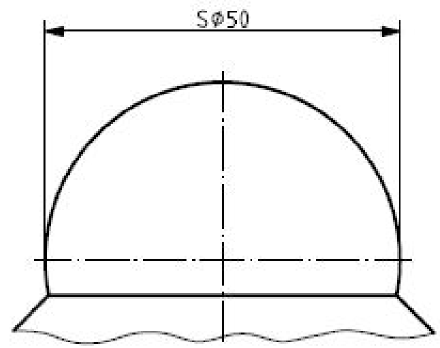


FIG 12.38

12.6.2 *Diameters*
The graphical symbol Ø shall precede the dimensional value (*see* Fig 12.34 and 12.39).

When a diameter can be illustrated by one arrowhead, the dimension line shall exceed the centre (*see*
Fig 12.9 and 12.39).

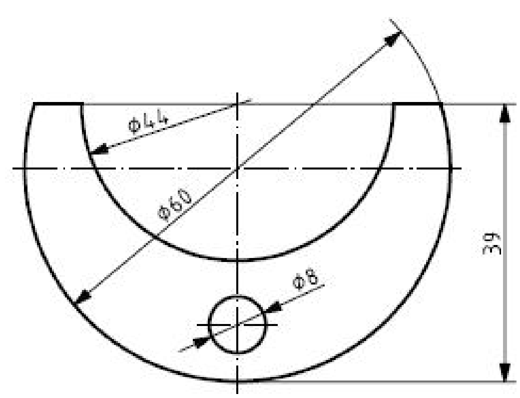


FIG 12.39

12.6.3 *Radii*

The letter symbol R shall precede the dimensional value of a radius (*see* Fig 12.35).

When dimensioning radii, only one terminator shall be used. It shall be indicated at the intersection of dimension line and arc (*see* Fig 12.40). In the case of an arrowhead as terminator and depending on the size of the radius on the drawing, the arrowhead may be either inside or outside the outline or extension line of the feature.

Where the centre of a radius falls outside the available space, the dimension line of the radius shall be either broken or interrupted perpendicular according to whether or not it is necessary to locate the centre (*see* Fig 12.40).

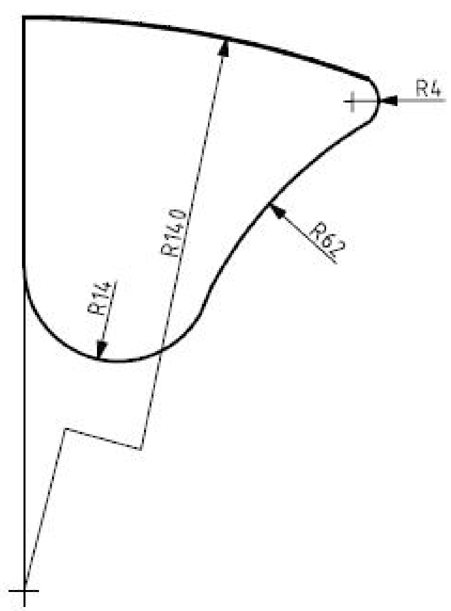


FIG 12.40

12.6.4 *Spheres*

If a spherical shape is illustrated, the symbol SØ or SR shall precede the dimensional value (*see* Figs 12.37and 12.38).

12.6.5 *Arcs, chords and angles*

The dimensioning of arcs, chords and angles shall be as shown in Fig 12.41. The graphical symbol of an arc shall precede the dimensional value.

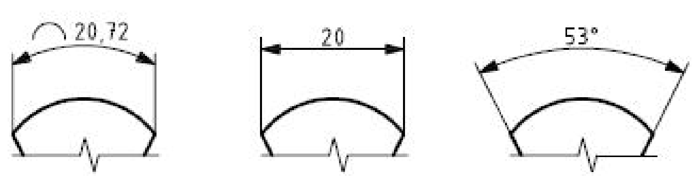


FIG 12.41

If the included angle of an arc is greater than 90°, the extension lines shall point to the centre of the arc. If the relation between the arc length and the dimensional value is ambiguous, it shall be indicated by a leader line, terminated by an arrowhead at the arc length to be dimensioned and by a point or a circle at the dimension line (see Fig 12.42). Connected dimensions of arcs, as well as linear or angular dimensions connected at an arc dimension, are indicated by an extension line (*see* Fig 12.42).

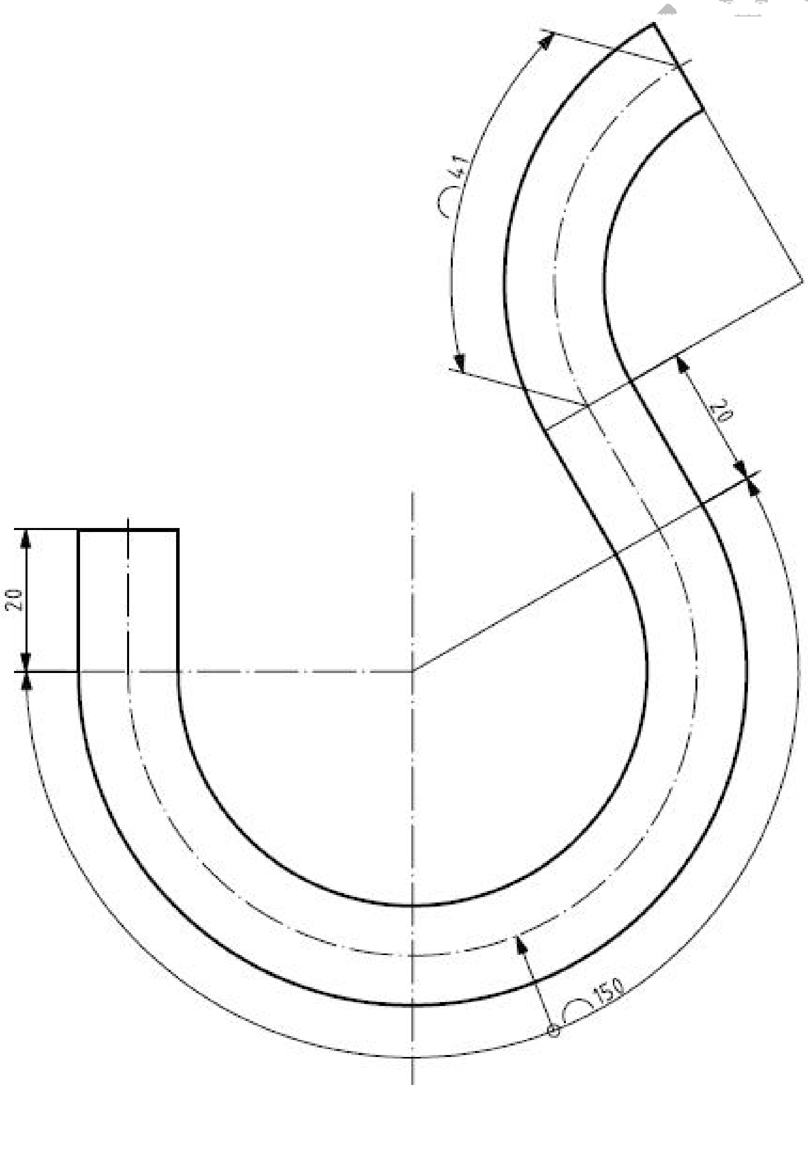


FIG 12.42

The rules given in Clause 12.5 are equally applicable to angular dimensions, except that the units of the angular basic dimension as well as the limit deviations shall always be indicated (*see* Fig 12.43 to 12.46). If the angular basic dimension or the angular limit deviation is expressed in either minutes of a degree or seconds of a minute of a degree, the value of the minute or second should be preceded by 0° or 0° 0′, as applicable.

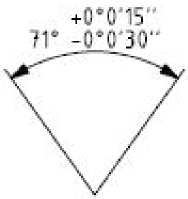


FIG 12.43

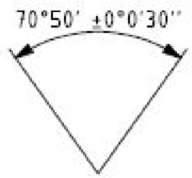


FIG 12.44

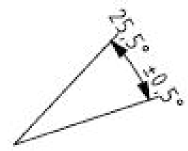


FIG 12.45

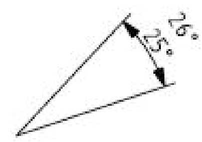


FIG 12.46

12.6.6 *Squares*

The graphical symbol □ shall precede the dimensional value if only one side of the square is dimensioned (*see* Fig 12.36).

12.6.7 *Equally spaced and repeated features*

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

Linear spacings may be dimensioned as shown in Fig 12.47.

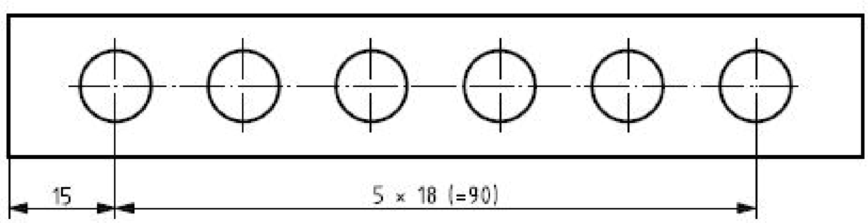


FIG 12.47

Repeated linear and angular spacings may be indicated with the number of spacings and their dimensional value or angle separated by the symbol "×". If there is any possibility of confusion between the length of thespace and the number of spacings, one space shall be dimensioned as shown in Fig 12.48.

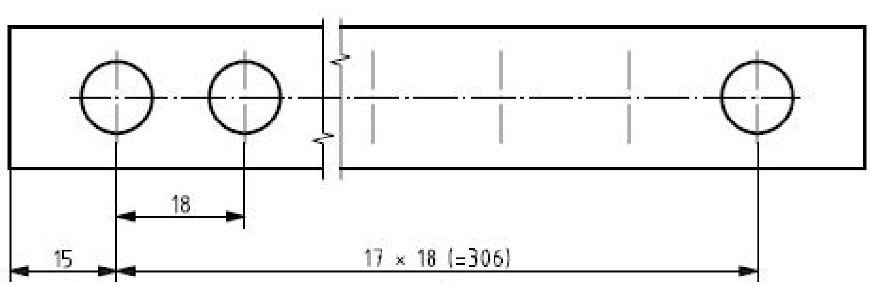


FIG 12.48

Angular spacings may be dimensioned as shown in Fig 12.49

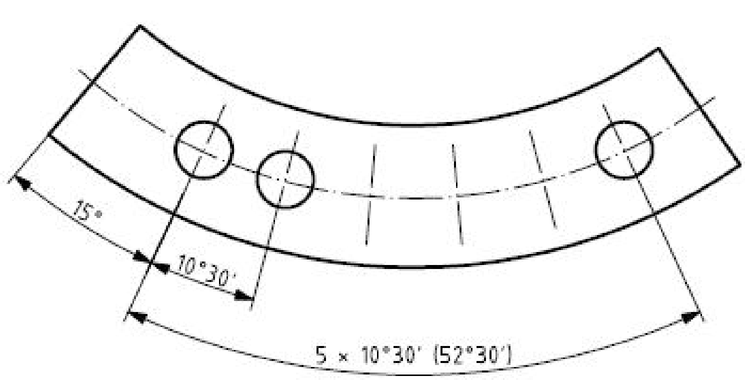


FIG 12.49

The angles of the spacings may be omitted where angles or spacings are self-evident and the indication does not lead to confusion (*see* Fig 12.50).

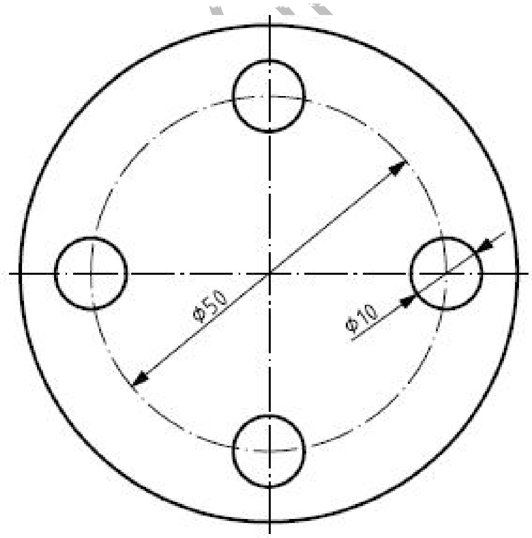


FIG 12.50

If the representation is unambiguous in showing that repeated features have the same dimensions, the dimension may be indicated once (*see* Fig 12.51).

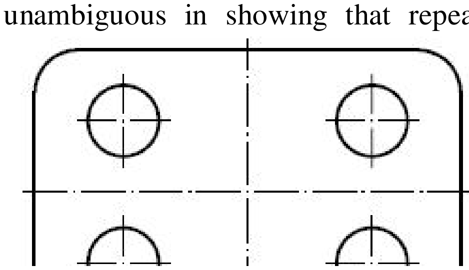


FIG 12.51

Circular spacings may be dimensioned by indicating the number of features (*see* Fig 12.52).

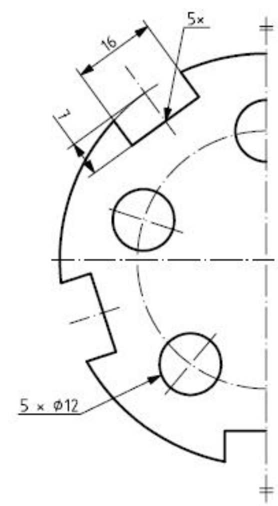


FIG 12.52

Features having the same dimensional value may be dimensioned by indicating the number of features and separating their dimensional value by the sign ‘×’ (*see* Fig 12.53).

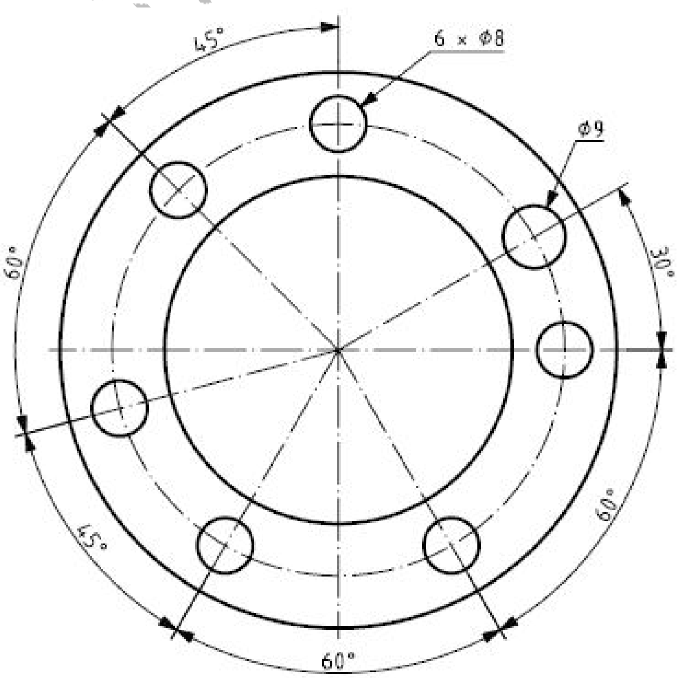


Fig 12.53

In order to avoid repeating the same dimensional value or to avoid long leader lines, reference letters may be used in connection with an explanatory table or note (*see* Figure 12.54). Leader lines may be omitted. If there presentation is unambiguous, the indication of the number of features may be omitted.

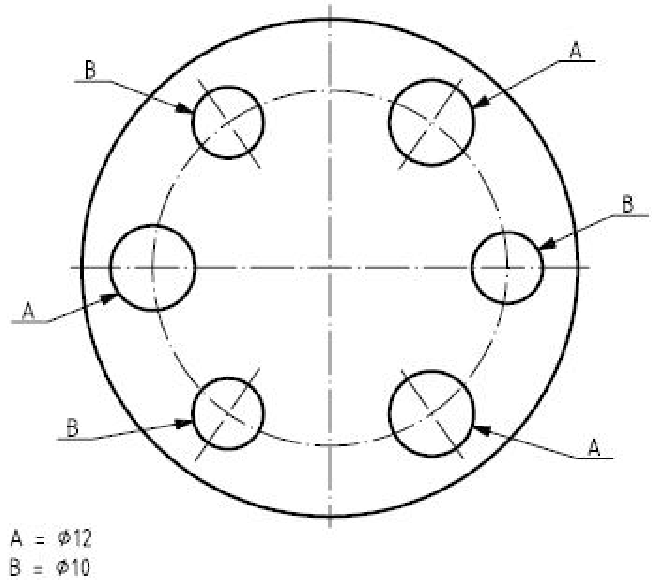


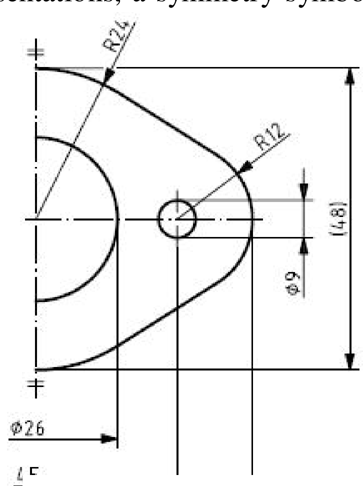
FIG 12.54

12.6.8 *Symmetrical parts*

The dimensions of symmetrical arranged features shall be indicated once only (*see* Fig 12.55 and 12.56).

Usually, the symmetry of features should not be dimensioned (*see* Fig12.55 to 12.57).

In the case of half or quarter representations (*see* Fig 12.55), and if also required in the case of full representations, a symmetry symbol is added at the end of the axis of symmetry (*see* Fig 12.55 and 12.56).



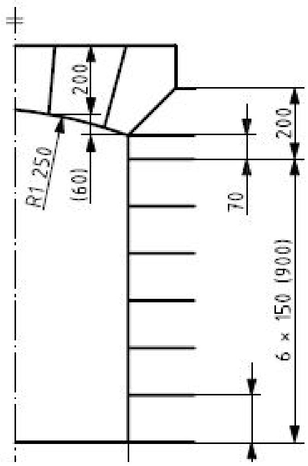


FIG 12.55

FIG 12.56

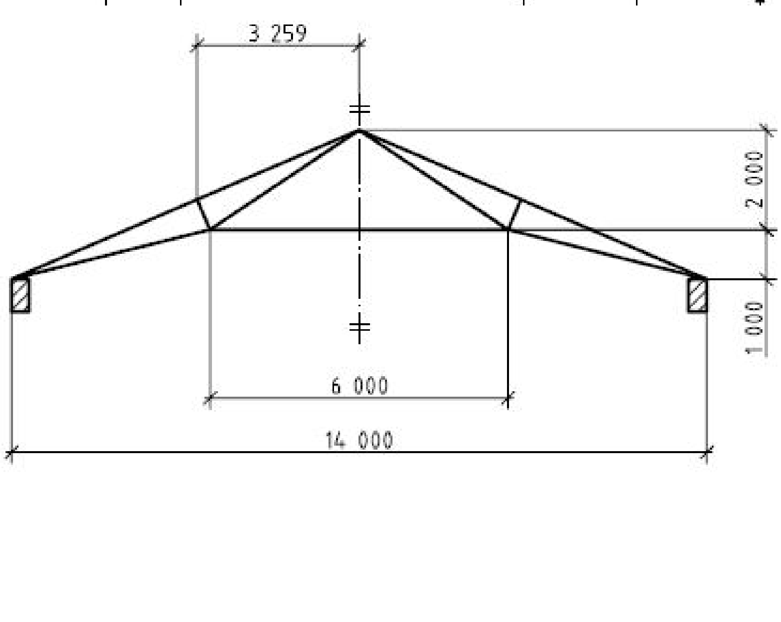


FIG 12.57

12.6.9 *Indication of levels*

Levels on vertical views, sections and cuts shall be indicated by an open 90° arrowhead connected with a vertical line and horizontal line above which the numerical value of level is placed (*see* Fig 12.58).

Levels for specified points on horizontal (planes) views and sections shall be indicated by a numerical value of the level placed above a line connected to the point indicated by `X_ (*see* Fig 12.59).

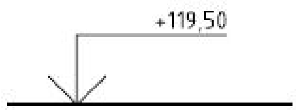


FIG
12.58 FIG
12.59

12.6.10 *Dimensions of out-of-scale represented features*
In exceptional cases, such as modifications, out-of-scale features shall be marked by the means of under lining the dimensional value.

12.6.11 *Auxiliary dimensions*
Auxiliary dimensions in drawings are for information only. They shall be given within parentheses, and shall never be toleranced (*see* Fig 12.55 and 12.56).

12.7 Arrangements of dimensions
12.7.1 *General*
Dimension lines shall be arranged as parallel, chain or running dimensioning or in combination.
12.7.2 *Parallel dimensioning*
The dimension lines shall be drawn parallel in one, two or three orthogonal directions or concentrically (*see* Fig 12.60 and 12.61).

FIG 12.60

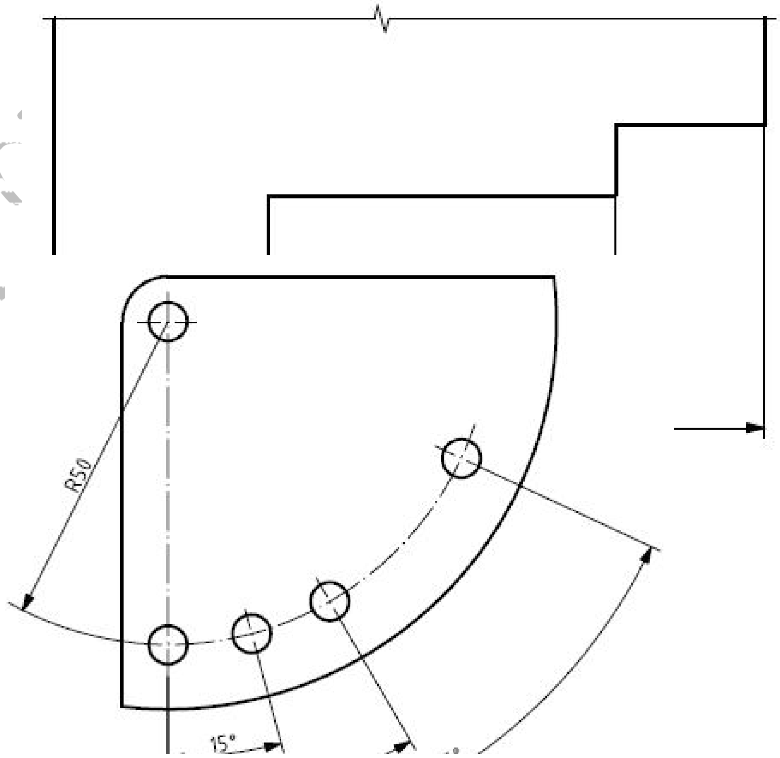


FIG 12.61

12.7.3 *Running dimensioning*

Running dimensioning may be used where there are space limitations or circumstances related to special needs in different branches of industry. The common origin shall be indicated as shown in Fig 12.62 to 12.64.

Dimensional values may be placed either

- near the terminator, in line with the corresponding extension line (*see* Fig 12.62 and 12.63), or
- near the terminator, above and clear of the dimension line (*see* Fig 12.64).

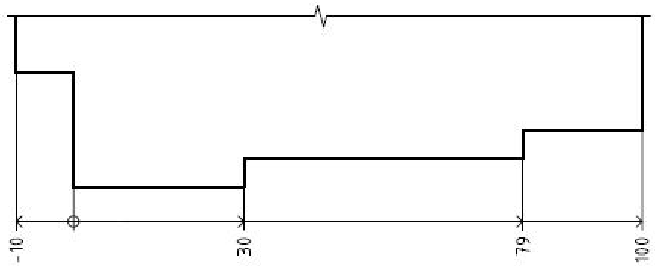


FIG 12.62

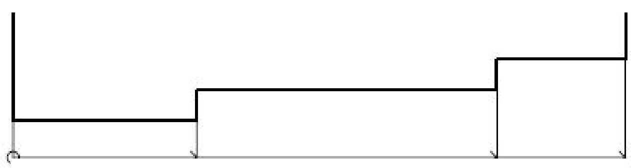


Fig 12.63

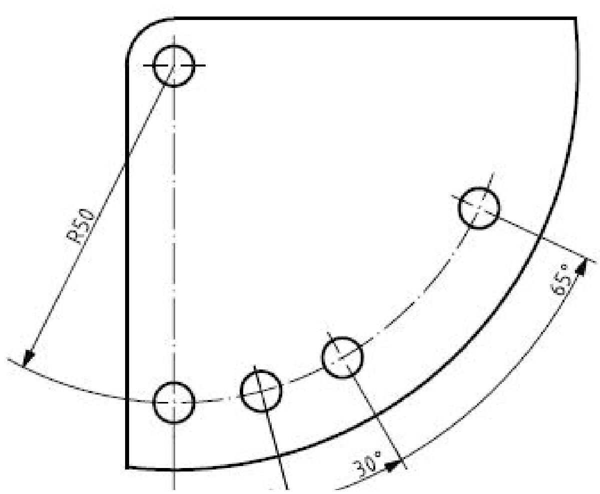


FIG 12.64

12.7.4 *Chain dimensioning*

Using chain dimensioning, chains of single dimensions shall be arranged in a row (*see* Fig 12.65).

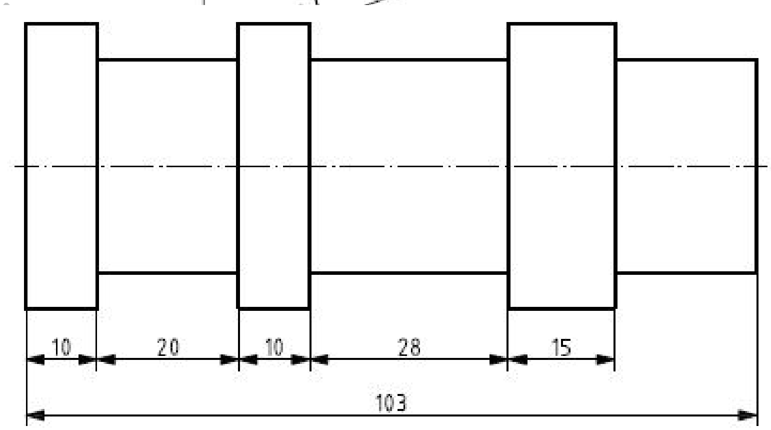


FIG 12.65

12.7.5 *Coordinate dimensioning*

Cartesian coordinates are defined starting from the origin by linear dimensions in orthogonal directions (*see* Fig 12.66 and 12.67). The values of the coordinates shall appear either adjacent to each point or in tabular form. Neither dimension lines nor extension lines are drawn.

NOTE - In construction engineering, :X˘ and :Y˘ axes can be used in various ways to comply with national standards. Also, for three-dimensional systems in the construction field, the height, often designated `Z_, might not have the same common origin as the :X˘ and :Y˘ axes.

Polar coordinates are defined starting from the origin by a radius and an angle. They shall always be positive, and are indicated anticlockwise relative to the polar axis (*see* Fig 12.68).

The positive and negative directions of the coordinate axes are shown in Fig 12.67. The dimensional values indicated in the negative directions shall have negative signs.

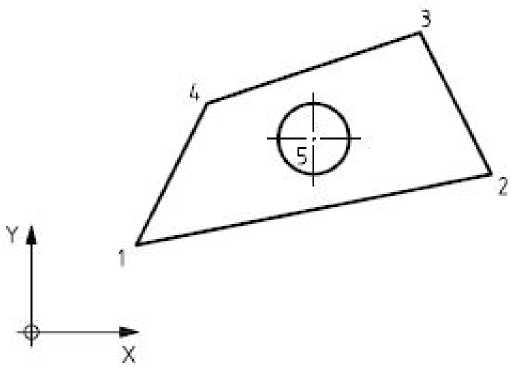
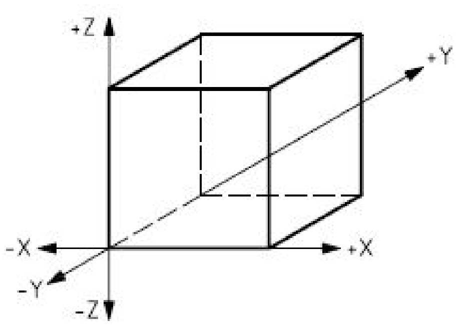


FIG 12.66

Position	X	Y	d



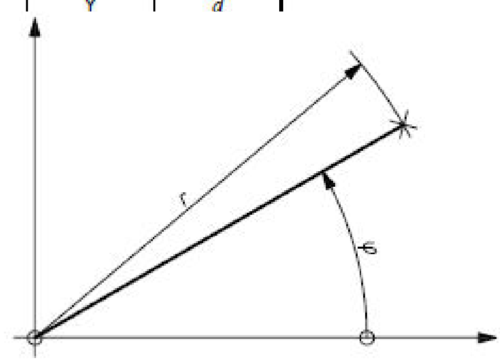


FIG 12.67

FIG 12.68

The origin of the coordinate system may be at the corner on a feature or outside the drawing (*see* Fig 12.66and 12.69).

The coordinate values may be indicated directly near their coordinates (*see* Fig 12.69).

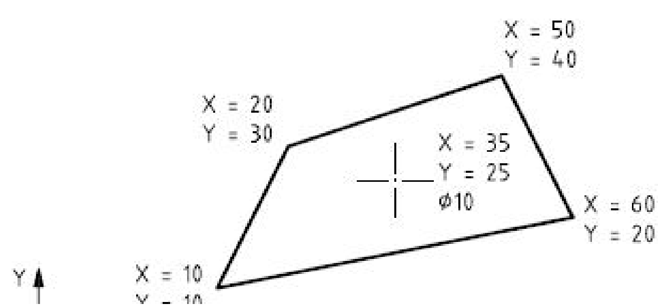
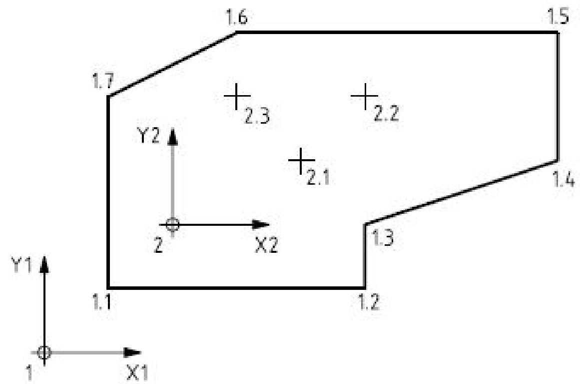


FIG 12.69

The main coordinate system may have subsystems. If this is the case, the origin of the coordinate systems and the specific positions within the coordinate systems shall be numbered continuously by arabic numbers. A point shall be used as a separation symbol (*see* Fig 12.70).



Coordinate origin	Position	X1, X2	Y1, Y2	d_1	d_2
1	1	0	0	—	—
1	1.1	10	10	—	—
1	1.2	50	10	—	—
1	1.3	50	20	—	—
1	1.4	80	30	—	—
1	1.5	80	50	—	—
1	1.6	30	50	—	—
1	1.7	10	40	—	—
1	2	20	20	⌀10	—
2	2.1	20	10	⌀5	—
2	2.2	30	20	—	⌀10
2	2.3	10	20	⌀5	—

FIG 12.70

12.7.6 *Combined dimensioning*

Two or more methods of dimensioning may be combined on a drawing.

Fig 12.71 shows an example of running dimensioning in combination with single dimensions.

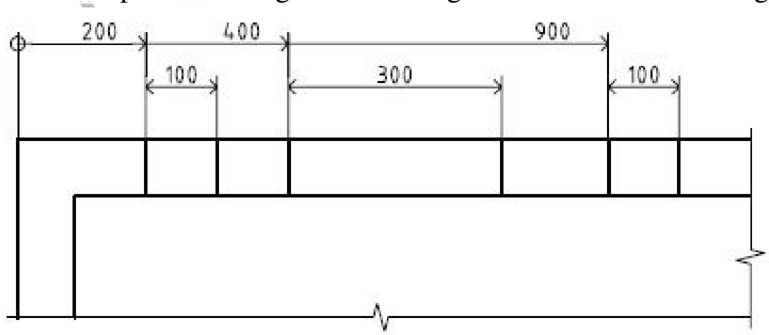
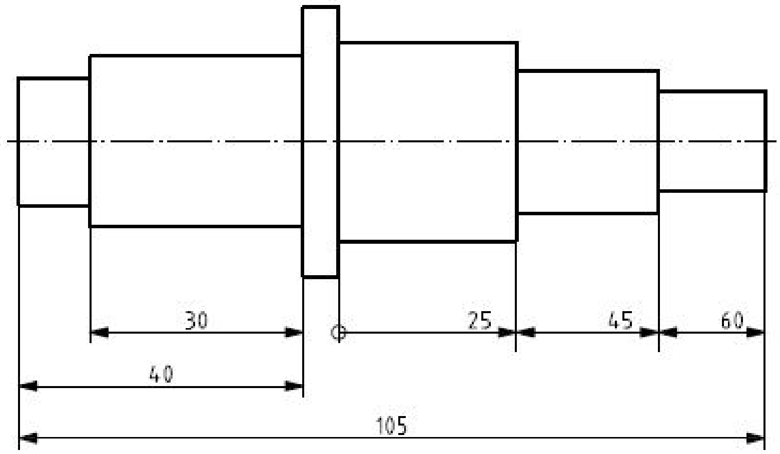


FIG 12.71

Fig 12.72 shows an example of parallel dimensioning in combination with running dimensioning.

FIG 12.72



Section 13 SYSTEMS OF LIMITS AND FITS

[Based on IS 919 (Part 1):2014/ISO 286-1:2010]

13.1 Scope

This section is for tolerances to be used for linear sizes of features of the following types:

a) cylinder;

b) two parallel opposite surfaces.

It defines the basic concepts and the related terminology. It provides a standardized selection of tolerance classes for general purposes from amongst the numerous possibilities.

Additionally, it defines the basic terminology for fits between two features of size without constraints of orientation and location and explains the principles of `basic hole_ and `basic shaft_.

13.2 Reference Temperature

The standard reference temperature is 20°C for industrial measurements and consequently, for dimensions defined by the system. If the product temperature is other than this temperature (in steady state) then the product dimensions and/or shape will change and the measured dimensions will be different from those measured at 20°C; the fits so realized would be at variance with those specified at the standard reference temperature. For example, a M.S. circular shaft of diameter 100 mm would experience an increase of x micrometers for a 10°C temperature increase.

13.3 DEFINITIONS for Tolerances, Limits and Fits

13.3.1 *Feature of size*

Geometrical shape defined by a linear or angular dimension which is a size

13.3.2 *Nominal integral feature*

Theoretically exact integral feature as defined by a technical drawing or by other means

13.3.3 *Hole*

Internal feature of size of a workpiece, including internal features of size which are not cylindrical

13.3.4 *Basic hole*

Hole chosen as a basis for a hole-basis fit system

13.3.5 *Shaft*

External feature of size of a workpiece, including external features of size which are not cylindrical

13.3.*6* *Basic shaft*

Shaft chosen as a basis for a shaft-basis fit system

13.3.7 *Nominal size*

Size of a feature of perfect form as defined by the drawing specification

13.3.8 *Actual size*

Size of the associated integral feature

NOTE -- The actual size is obtained by measurement.

13.3.10 *Limits of size*

Extreme permissible sizes of a feature of size

NOTE -- To fulfil the requirement, the actual size shall lie between the upper and lower limits of size; the limits of size are also included.

13.3.11 *Upper limit of size ULS*

largest permissible size of a feature of size *See* Fig 13.1

13.3.12 *Lower limit of size LLS*
Smallest permissible size of a feature of size *See* Fig 13.1.

13.3.13 *Deviation*
value minus its reference value
NOTE ‾ For size deviations, the reference value is the nominal size and the value is the actual size.

13.3.14 *Limit deviation*
Upper limit deviation or lower limit deviation from nominal size

13.3.15 *Upper limit deviation*
ES (to be used for internal features of size) *es* (to be used for external features of size) upper limit of size minus nominal size
See Fig 13.1
NOTE ‾ Upper limit deviation is a signed value and may be negative, zero or positive.

13.3.*16* *Lower limit deviation*
EI (to be used for internal features of size) *ei* (to be used for external features of size) lower limit of size minus nominal size
See Fig 13.1.
NOTE ‾ Lower limit deviation is a signed value and may be negative, zero or positive.

13.3.17 *Fundamental deviation*
Limit deviation that defines the placement of the tolerance interval in relation to the nominal size
NOTE 1 The fundamental deviation is that limit deviation, which defines that limit of size which is the nearest to the nominal size (*see* Fig 13.1).
NOTE 2 The fundamental deviation is identified by a letter (e.g. B, d).

13.3.18 *Value*
Variable value added to a fixed value to obtain the fundamental deviation of an internal feature of size See Table 3.

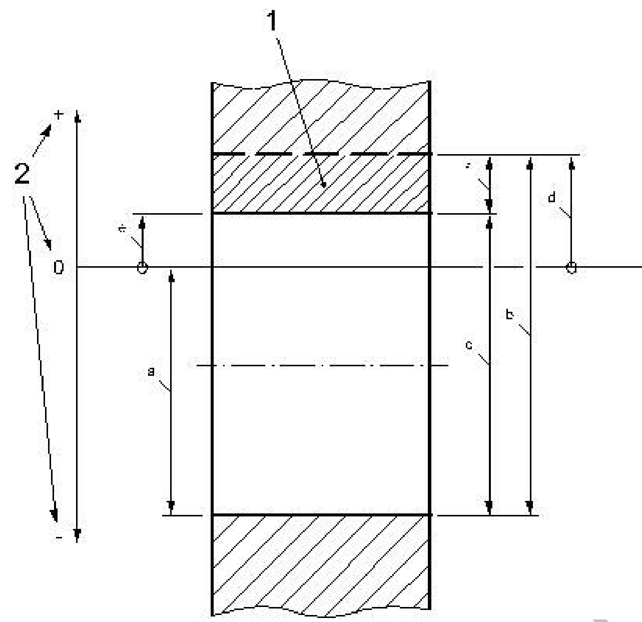
13.3.19 *Tolerance*
Difference between the upper limit of size and the lower limit of size
NOTE 1 The tolerance is an absolute quantity without sign.
NOTE 2 The tolerance is also the difference between the upper limit deviation and the lower limit deviation.

13.3.20 *Tolerance limits*
Specified values of the characteristic giving upper and/or lower bounds of the permissible value

13.3.21 *Standard tolerance grade*
Group of tolerances for linear sizes characterized by a common identifier
NOTE A specific tolerance grade is considered as corresponding to the same level of accuracy for all nominal sizes.

13.3.22 *Tolerance interval*
Variable values of the size between and including the tolerance limits
NOTE The tolerance interval does not necessarily include the nominal size (*see* Fig 13.1). Tolerance limits may be two-sided (values on both sides of the nominal size) or one-sided (both values on one side of the nominal size). The case where the one tolerance limit is on one side, the other limit value being zero, is a special case of a one-sided indication.

13.3.23 *Tolerance class*
Combination of a fundamental deviation and a standard tolerance grade
NOTE The tolerance class consists of the fundamental deviation identifier followed by the tolerance grade number (e.g. D13, h9, etc.).



1 tolerance interval
2 sign convention for deviations
A Nominal size.
B Upper limit of size.
C Lower limit of size.
D Upper limit deviation.
E Lower limit deviation (in this case also fundamental deviation).
F Tolerance.

NOTE The horizontal continuous line, which limits the tolerance interval, represents the fundamental deviations for a hole. The dashed line, which limits the tolerance interval, represents the other limit deviation for a hole.

FIG 13.1 ´ Illustration of definitions (a hole is used in the example)

13.3.24 *Clearance*
Difference between the size of the hole and the size of the shaft when the diameter of the shaft is smaller than the diameter of the hole

NOTE In the calculation of clearance, the obtained values are positive

13.3.24 *Minimum clearance*
In a clearance fit difference between the lower limit of size of the hole and the upper limit of size of the shaft See Fig 13.2.

13.3.25 *Maximum clearance*
in a clearance or transition fit difference between the upper limit of size of the hole and the lower limit of size of the shaft See Fig 13.2 and 13.4.

13.3.26 *Interference*
Difference before mating between the size of the hole and the size of the shaft when the diameter of the shaft is larger than the diameter of the hole

NOTE In the calculation of an interference, the obtained values are negative

13.3.27 *Minimum interference*
In an interference fit difference between the upper limit of size of the hole and the lower limit of size of the shaft See Fig 13.3.

13.3.28 *Maximum interference*
In an interference or transition fit difference between the lower limit of size of the hole and the upper limit of size of the shaft See Fig 13.3 and 13.4.

13.3.29 *Fit*
Relationship between an external feature of size and an internal feature of size (the hole and shaft of the same type) which are to be assembled

13.3.30 *Clearance fit*

Fit that always provides a clearance between the hole and shaft when assembled, i.e. the lower limit of size of the hole is either larger than or, in the extreme case, equal to the upper limit of size of the shaft See Fig 13.2.

13.3.31 *Interference fit*

Fit that always provides an interference between the hole and the shaft when assembled, i.e. the upper limit of size of the hole is either smaller than or, in the extreme case, equal to the lower limit of size of the shaft See Fig 13.3.

13.3.32 *Transition fit*

Fit which may provide either a clearance or an interference between the hole and the shaft when assembled See Fig13.4.

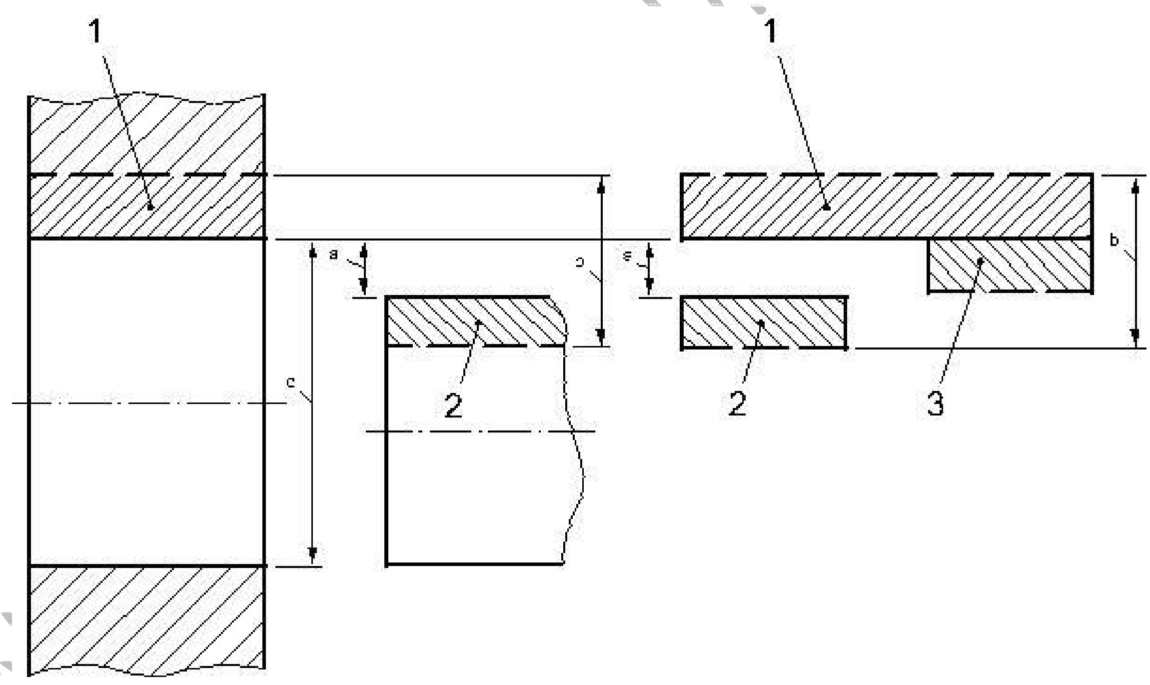
NOTE -- In a transition fit, the tolerance intervals of the hole and the shaft overlap either completely or partially; therefore, if there is a clearance or an interference depends on the actual sizes of the hole and the shaft.

13.3.33 *Hole-basis fit system*

Fits where the fundamental deviation of the hole is zero, i.e. the lower limit deviation is zero *See* Fig 13.5

13.3.34 *Shaft-basis fit system*

Fits where the fundamental deviation of the shaft is zero, i.e. the upper limit deviation is zero *See* Fig 13.6.



a) Detailed b) Simplified

1 tolerance interval of the hole

2 tolerance interval of the shaft, case 1: when the upper limit of size of the shaft is lower than the lower limit of size of the hole, the minimum clearance is larger than zero

3 tolerance interval of the shaft, case 2: when the upper limit of size of the shaft is identical to the lower limit of size of the hole, the minimum clearance is zero

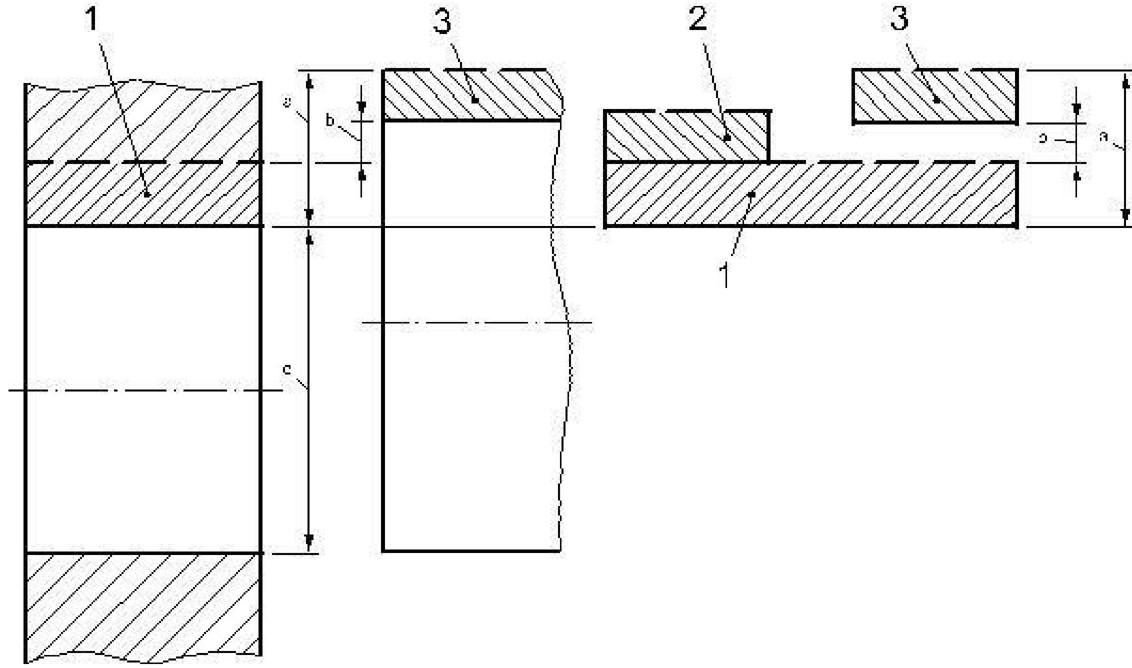
a Minimum clearance.

b Maximum clearance.

c Nominal size = lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

FIG 13.2 ´ Illustration of definitions of a clearance fit (nominal model)



a) Detailed b) Simplified

1 tolerance interval of the hole

2 tolerance interval of the shaft, case 1: when the lower limit of size of the shaft is identical to the upper limit of size of the hole, the minimum interference is zero

3 tolerance interval of the shaft, case 2: when the lower limit of size of the shaft is larger than the upper limit of size of the hole, the minimum interference is larger than zero

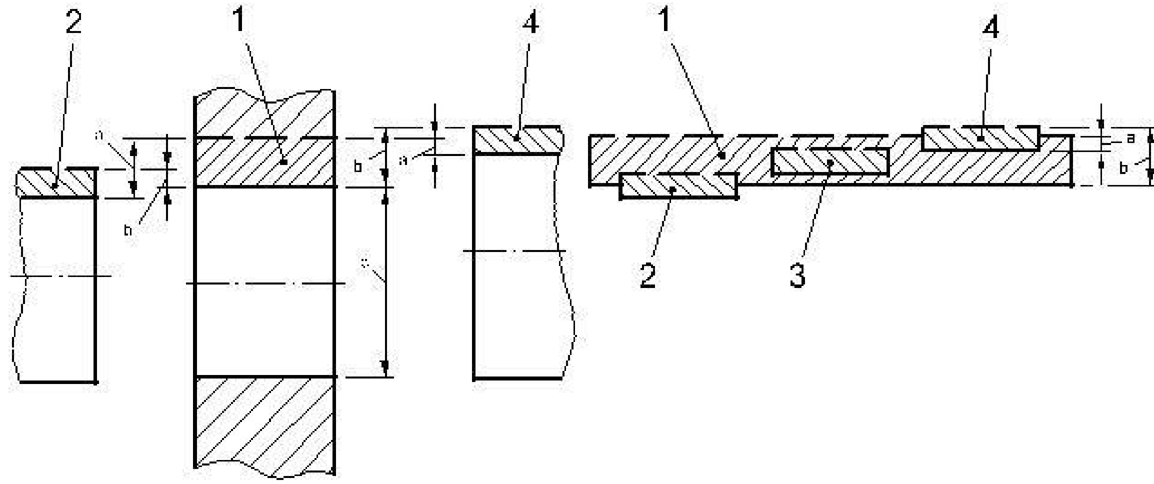
a Maximum interference.

b Minimum interference.

c Nominal size □□lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

FIG 13.3 ´ Illustration of definitions of an interference fit (nominal model)

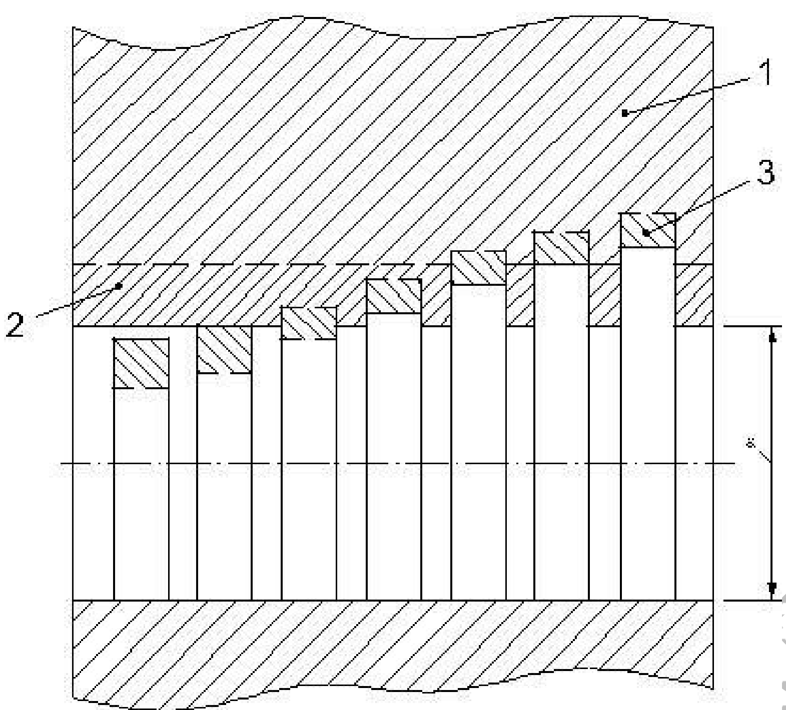


a) Detailed b) Simplified

1	tolerance interval of the hole
2-4	tolerance interval of the shaft (some possible placements are shown)
a	Maximum clearance.
b	Maximum interference.
c	Nominal size lower limit of size of the hole.

NOTE The horizontal continuous wide lines, which limit the tolerance intervals, represent the fundamental deviations. The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

FIG 13.4 ´ Illustration of definitions of a transition fit (nominal model)



1 basic hole `H_
2 tolerance interval of the basic hole
3 tolerance interval of the different shafts
aNominal size.

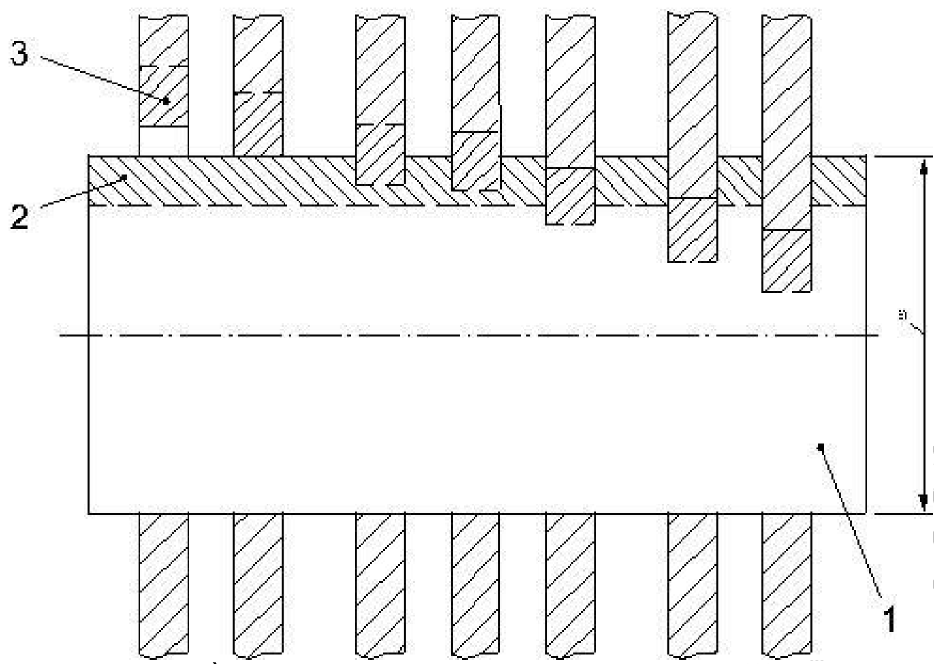
NOTE 1 -- The horizontal continuous lines, which limit the tolerance intervals, represent the fundamental deviations for a basic hole and different shafts.

NOTE 2 -- The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

NOTE 3 -- The figure shows the possibility of combinations between a basic hole and different shafts, related to their standard tolerance grades.

NOTE 4 --Possible examples of hole-basis fits are: H7/h6, H6/k5, H6/p4.

FIG 13.5 ´ Hole-basis fit system



1	basic shaft `h_
2	tolerance interval of the basic shaft
3	tolerance interval of the different holes
a	Nominal size

NOTE 1-- The horizontal continuous lines, which limit the tolerance intervals, represent the fundamental deviations for a basic shaft and different holes.

NOTE 2 -- The dashed lines, which limit the tolerance intervals, represent the other limit deviations.

NOTE 3 -- The figure shows the possibility of combinations between a basic shaft and different holes, related to their standard tolerance grades.

NOTE 4 --Possible examples of shaft-basis fits are: h6/G7, h6/H6, h6/M6.

FIG 13.6 ´ Shaft-basis fit system

13.4 Tolerance Class

13.4.1 *Magnitude of the tolerance*

The tolerance class expresses the magnitude of the tolerance. The magnitude of the tolerance is a function of the standard tolerance grade number and the nominal size of the toleranced feature.

13.4.2 *Standard tolerance grades*

The standard tolerance grades are designated by the letters IT followed by the grade number, e.g. IT7.

Values of standardised tolerances are given in Table 13.1. Each of the columns gives the values of the tolerances for one standard tolerance grade between standard tolerance grades IT01 and IT18 inclusive. Each row in Table 13.1 is representing one range of sizes. The limits of the ranges of sizes are given in the first column of Table 13.1.

NOTE 1 When the standard tolerance grade is associated with a letter or letters representing a fundamental deviation to form a tolerance class, the letters IT are omitted, e.g. H7.

NOTE 2 From IT6 to IT18, the standard tolerances are multiplied by the factor 10 at each fifth step. This rule applies to all standard tolerances and may be used to extrapolate values for IT grades not given in Table 1.

EXAMPLE For the nominal size range 120 mm up to and including 180 mm, the value of IT20 is:

IT20 = IT15 × 10 = 1,6 mm × 10 = 16 mm

13.4.3 *Placement of tolerance interval*

The tolerance interval (former term: tolerance zone) is a variable value contained between the upper and the lower limits of size. The tolerance class expresses the position of the tolerance interval relative to the nominal size, by means of the fundamental deviation. The information on the position of the tolerance interval, i.e. on the fundamental deviation, is identified by one or more letters, called the fundamental deviation identifiers:

A graphical overview of the position of the tolerance intervals relative to the nominal sizes and the signs (+ or) of the fundamental deviations for holes and shafts are given in Fig 13.7,13.8 and 13.9.

13.4.4 *Fundamental deviation*

The fundamental deviation is that limit deviation, which defines that limit of size, which is the nearest to the nominal size (*see* Fig 13.7).

The fundamental deviations are identified and controlled by:

upper case letter(s) for holes (A . . . ZC), *see* Tables 13.2 and 13.3;

lower case letter(s) for shafts (a . . . zc), *see* Tables 13.4 and 13.5.

NOTE 1 -- To avoid confusion, the following letters are not used: I, i; L, l; O, o; Q, q; W, w.

NOTE 2 -- The fundamental deviations are not defined individually for each specific nominal size, but for ranges of nominal sizes as given in Tables 13.2 to 13.5.

The fundamental deviation in micrometres is a function of the identifier (letter) and the nominal size of the toleranced feature.

Tables 13.2 and 13.3 contain the signed values of the fundamental deviations for hole tolerances. Tables 4 and 5 contain the signed values of the fundamental deviations for shaft tolerances.

The sign + is used when the tolerance limit identified by the fundamental deviation is above nominal size and the sign is used when the tolerance limit identified by the fundamental deviation is below nominal size.

Each of the columns in Tables 13.2 to 13.5 gives the values of the fundamental deviation for one fundamental deviation identifier letter. Each of the rows is representing one range of sizes. The limits of the ranges of sizes are given in the first column of the tables.

The other limit deviation (upper or lower) is established from the fundamental deviation and the standard tolerance (IT) as shown in Fig 13.8 and 13.9.

NOTE 3 -- The concept of fundamental deviations does not apply to JS and js. Their tolerance limits are distributed symmetrically about the nominal size line (*see* Fig 13.8 and 13.9).

NOTE 4 -- The ranges of sizes in Tables 13.2 to 13.5 are in many cases (for deviations a to c and r to zc or A to C and R to ZC) subdivisions of the main ranges of Table 13.1.

The last six columns on the right side of Table 13.3 contain a separate table with -values. is a function of the tolerance grade and the nominal size of the toleranced feature. It is only relevant for deviations K to ZC and for standard tolerance grades IT3 to IT7/IT8.

The value of shall be added to the fixed value given in the main table, whenever + is indicated, to form the correct value of the fundamental deviation.

13.4.5 *Designation of the tolerance class (writing rules)*

The tolerance class shall be designated by the combination of an upper-case letter(s) for holes and lower- case letters for shafts identifying the fundamental deviation and by the number representing the standard tolerance grade.

Example H7 (holes), h7 (shafts).

13.4.5.1 *Size and its tolerance*

A size and its tolerance shall be designated by the nominal size followed by the designation of the required tolerance class, or shall be designated by the nominal size followed by + and/or limit deviations.

13.4.5.2 *Determination of a tolerance class*

Determination of a tolerance class is derived from fit requirements (clearances, interferences).

13.5 Determination of the limit deviations (reading rules)

The determination of the limit deviations for a given toleranced size, e.g. the transformation of a tolerance class into + and tolerancing can be performed by the use of Table 13.1 to 13.5 The tolerance class is decomposed into the fundamental deviation identifier and the standard tolerance grade number.

Example Toleranced size for a hole 90 F7 and for a shaft 90 f7

where

90	is the nominal size in millimetres;
F	is the fundamental deviation identifier for a hole;
f	is the fundamental deviation identifier for a shaft;
7	is the standard tolerance grade number;
	is the envelope requirement according to ISO 14405-1 (if necessary).

13.5.1 *Standard tolerance grade*

From the standard tolerance grade number, the standard tolerance grade (ITx) is obtained. From the nominal size and the standard tolerance grade the magnitude of the tolerance, e.g. the standard tolerance value is obtained by the use of Table 1.

Example 1 Toleranced size for a hole 90 F7 Ⓔ and for a shaft 90 f7 Ⓔ

The standard tolerance grade number is `7_, hence, the standard tolerance grade is IT7.

The standard tolerance value has to be taken from Table 13.1 in the line of the nominal size range above 80 mm up to and including 120 mm and in the column of the standard tolerance grade IT7.

Consequently, the standard tolerance value is: 35 µm.

Example 2 Toleranced size for a hole 28 P9 Ⓔ

The standard tolerance grade number is `9_, hence, the standard tolerance grade is IT9.

The standard tolerance value has to be taken from Table 13.1 in the line of the nominal size range above 18 mm up to and including 30 mm and in the column of the standard tolerance grade IT9.

Consequently the standard tolerance value is: 52 µm.

13.5.2 *Position of the tolerance interval*

From the nominal size and the fundamental deviation identifier the fundamental deviation (the upper or lower limit deviation) is obtained by use of Tables 13.2 and 13.3 for holes (upper-case letters) and Tables 13.4 and 13.5 for shafts (lower-case letters).

Example 1 Toleranced size for a hole 90 F7 Ⓔ

The fundamental deviation identifier is `F‗, hence, this is a hole case and Table 13.2 applies. From Table 13.2, line `80 to 100‗ and column `F‗, the lower limit deviation *EI* is: +36 µm.

Example 2 Toleranced size for a shaft 90 f7 Ⓔ

The fundamental deviation identifier is `f‗, hence, this is a shaft case and Table 13.4 applies. From Table 13.4, line `80 to 100‗ and column `f‗, the upper limit deviation *es* is: 36 µm.

Example 3 Toleranced size for a hole 28 P9 Ⓔ

The fundamental deviation identifier is `P‗, hence, this is a hole case and Table 13.3 applies. From Table 13.3, line `24 to 30‗ and column `P‗, the upper limit deviation *ES* is: 22 µm.

13.5.3 *Establishment of limit deviations*

One of the limit deviations (upper or lower) has already been determined. The other limit deviations (upper or lower) are obtained by calculation according to the formulae given in Fig 13.8 and 13.9 and using the standard tolerance values of Table 13.1.

Example 1 Toleranced size for a hole 90 F7

According to 13.5.1 IT7 = 35 µm

According to 13.5.2 Lower limit deviation *EI* = +36 µm

According to formula in Figure 8 Upper limit deviation *ES* = *EI* + IT = +36 + 35 = +71 µm

From that follows: 90 F7 +0,071 90+0,036

Example 2 Toleranced size for a shaft 90 f7

According to 13.5.1 IT7 = 35 µm

According to 13.5.2 Upper limit deviation *es* = 36 µm

According to formula in Fig 13. 9 Lower limit deviation *ei* = *es* IT = 36 35 = 71 µm

From that follows: 90 f7 0,036 90 0,071

13.5.4 *Establishment of limit deviations using -values*

For determining the fundamental deviations K, M and N for standard tolerance grades up to and including IT8 and P to ZC up to and including IT7, the values from the columns on the right of Table 13.3 shall be taken into consideration.

Example 1 Toleranced size for a hole 20 K7 Ⓔ

Table 13.1: IT7 in the range above 18 mm up to and including 30 mm IT7 = 21 µm

Table 13.3: in the range above 18 mm up to and including 24 mm for IT7 = 8 µm

For K in the range above 18 mm up to and including 24 mm:

Upper limit deviation *ES* = 2 + = 2 + 8 = +6 µm

Lower limit deviation *EI* = *ES* IT = +6 21 = 15 µm

From that follows: 20 0,006

K7 20 0,015

Example 2 Toleranced size for a hole 40 U6

Table 13.1: IT6 in the range above 30 mm up to and including 50 mm IT6 = 16 µm

Table 13.3: in the range above 30 mm up to and including 40 mm for IT6 = 5 µm

For U in the range above 30 mm up to and including 40 mm:

Upper limit deviation *ES* = 60 + = 60 + 5 = 55 µm

Lower limit deviation *EI* = *ES* IT = 55 16 = 71 µm

0.055

From that follows: 40 U6 40 0.071

NOTE -- For this interference fit, the envelope requirement has been omitted intentionally. For strong interference fits, it is not necessary to apply the envelope requirement

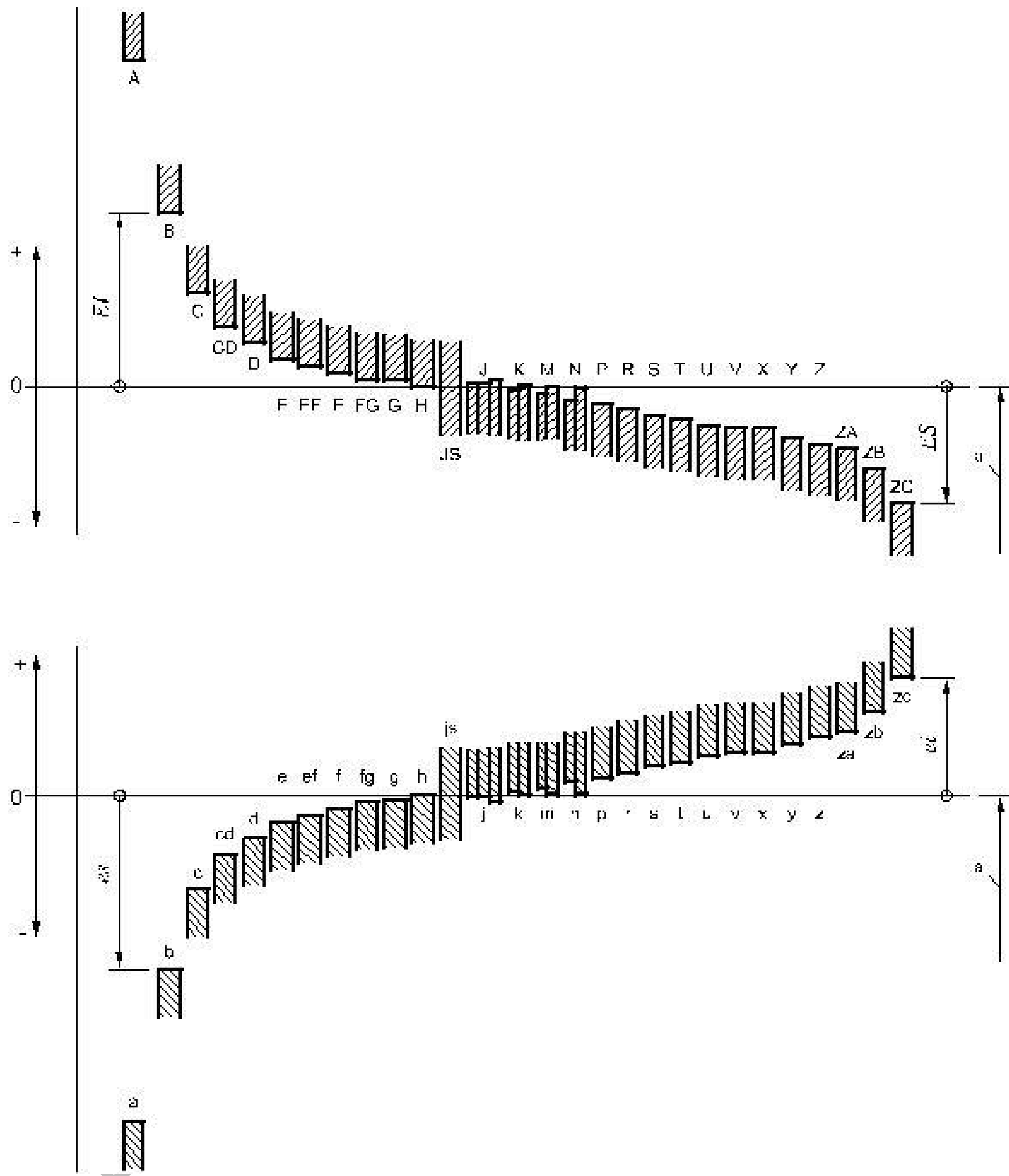
13.5.*5 Selection of tolerance classes*

Whenever possible, the tolerance classes should be chosen from those corresponding to the classes for holes and shafts given in Figures 10 and 11, respectively. The first choice should preferably be made from the tolerance classes, shown in the frames.

NOTE 1-- The tolerance system of limits and fits gives the possibility of a very wide choice among the various tolerance classes (*see* Tables 13.2 to 13.5). By restricting the selection of tolerance classes, an unnecessary multiplicity of tools and gauges can be avoided.

NOTE 2-- The tolerance classes of Fig 13.10 and 13.11 apply only to general purposes which do not require a more specific selection of tolerance classes. Keyways, for example, require a more specific selection.

NOTE 3 --Deviations js and JS may be replaced by the corresponding deviations j and J if necessary in a specific application.



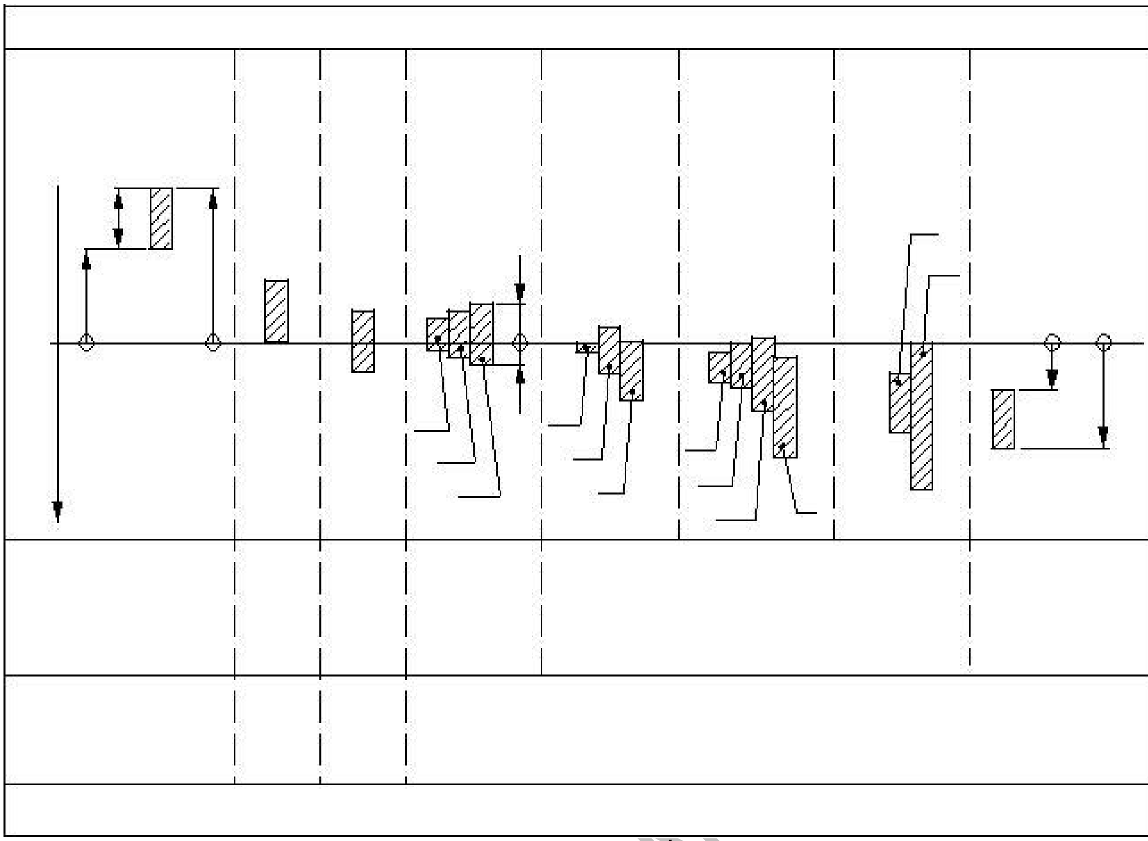
EI, ES fundamental deviations of holes (examples)
ei, es fundamental deviations of shafts (examples)

a Nominal size.

NOTE 1 -- According to convention, the fundamental deviation is the one defining the nearest limit to the nominal size.

NOTE 2 --For details concerning fundamental deviations for J/j, K/k, M/m and N/n, see Fig 13.8 and 13.9.

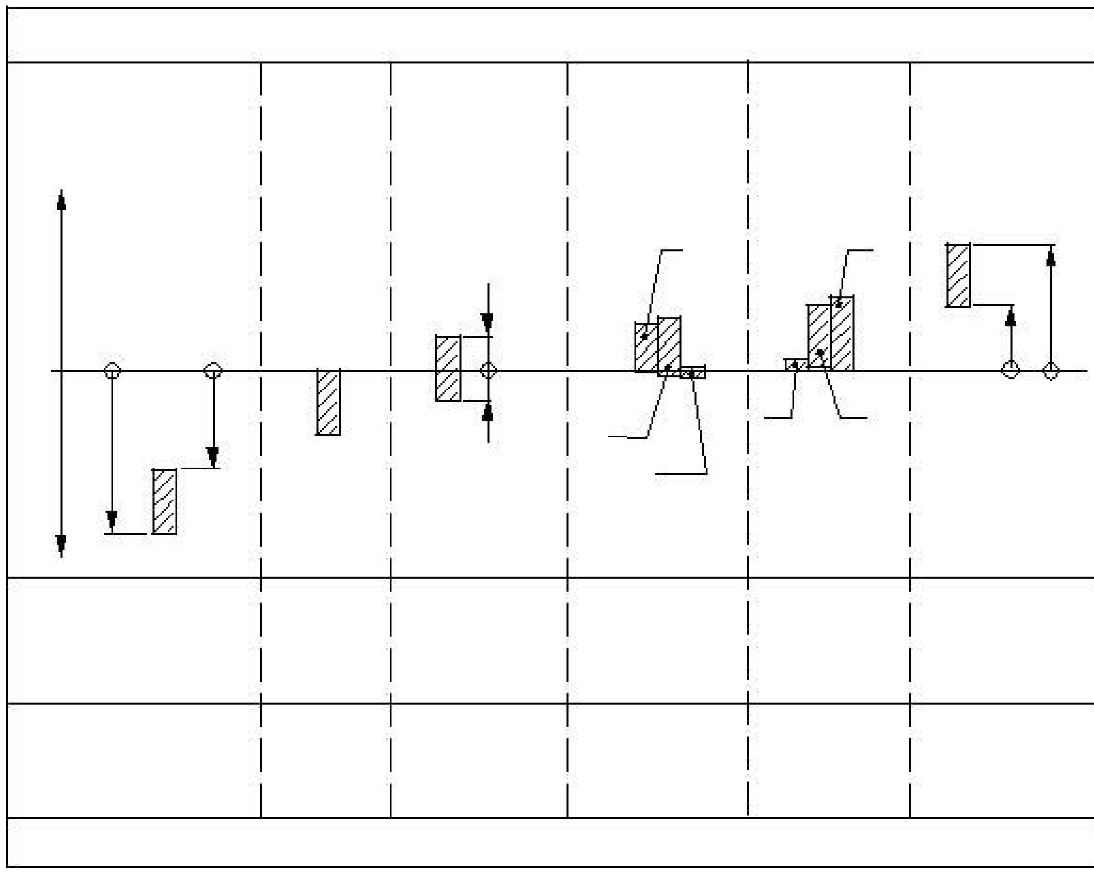
FIG 13.7 ´ Schematic representation of the placement of the tolerance interval (fundamental deviation) relative to the nominal size



1 K1 to K3, and also K4 to K8 for sizes for which ´ nominal size u 3 mm (for the significance of the dash, see e.g. footnote `a_ to Table 2)
2 K4 to K8 for sizes: 3 mm nominal size u 500 mm
3 K9 to K18
4 M1 to M6
5 M9 to M18
6 N1 to N8
7 N9 to N18

NOTE --The represented tolerance intervals correspond approximately to a nominal size range of above 10 mm up to and including 18 mm.

FIG 13.8 ´ Limit deviations for holes



1 j5, j6

2 k1 to k3, and also k4 to k7 for sizes for which ´ nominal size u 3 mm (for the significance of the dash, see e.g. footnote `a_ to Table 2)

3 k4 to k7 for sizes for which 3 mm nominal size u 500 mm

4 k8 to k18

NOTE --The represented tolerance intervals correspond approximately to a nominal size range of above 10 mm up to and including 18 mm.

FIG 13.9 ´ Limit deviations for shafts

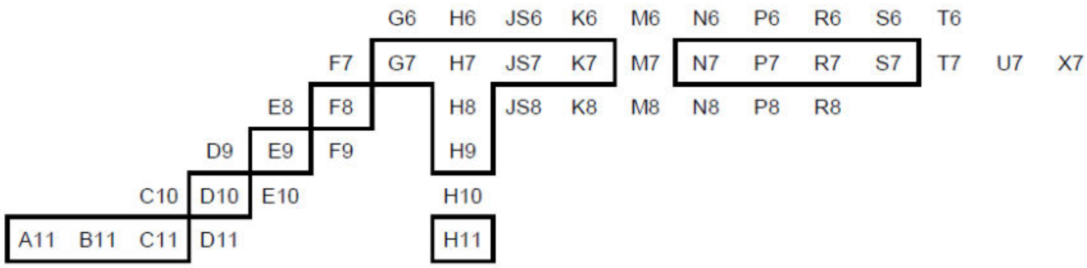


Fig 13.10 Holes

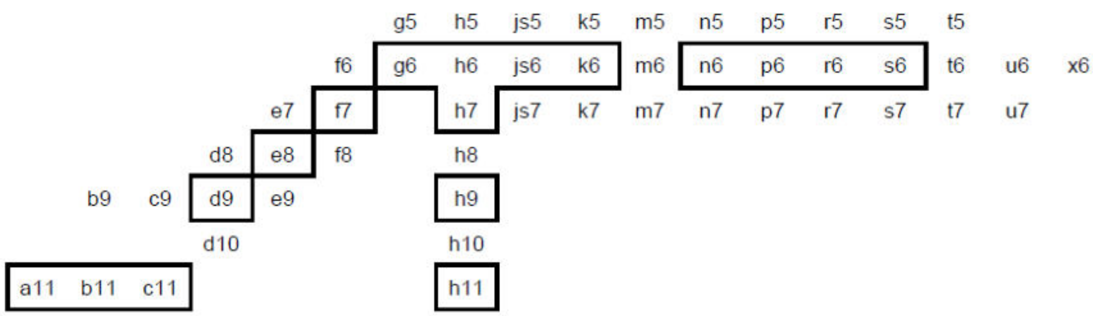


FIG 13.11 Shafts

Table 13.1 — Values of standard tolerance grades for nominal sizes up to 3 150 mm

Nominal size mm		Standard tolerance grades																	
		IT01	IT0	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
Above	Up to and including	Standard tolerance values																	
		µm												mm							
´	3	0,3	0,5	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,6	1	1,4
3	6	0,4	0,6	1	1,5	2,5	4	5	8	12	18	30	48	75	0,12	0,18	0,3	0,48	0,75	1,2	1,8
6	10	0,4	0,6	1	1,5	2,5	4	6	9	15	22	36	58	90	0,15	0,22	0,36	0,58	0,9	1,5	2,2
10	18	0,5	0,8	1,2	2	3	5	8	11	18	27	43	70	110	0,18	0,27	0,43	0,7	1,1	1,8	2,7
18	30	0,6	1	1,5	2,5	4	6	9	13	21	33	52	84	130	0,21	0,33	0,52	0,84	1,3	2,1	3,3
30	50	0,6	1	1,5	2,5	4	7	11	16	25	39	62	100	160	0,25	0,39	0,62	1	1,6	2,5	3,9
50	80	0,8	1,2	2	3	5	8	13	19	30	46	74	120	190	0,3	0,46	0,74	1,2	1,9	3	4,6
80	120	1	1,5	2,5	4	6	10	15	22	35	54	87	140	220	0,35	0,54	0,87	1,4	2,2	3,5	5,4
120	180	1,2	2	3,5	5	8	12	18	25	40	63	100	160	250	0,4	0,63	1	1,6	2,5	4	6,3
180	250	2	3	4,5	7	10	14	20	29	46	72	115	185	290	0,46	0,72	1,15	1,85	2,9	4,6	7,2
250	315	2,5	4	6	8	12	16	23	32	52	81	130	210	320	0,52	0,81	1,3	2,1	3,2	5,2	8,1
315	400	3	5	7	9	13	18	25	36	57	89	140	230	360	0,57	0,89	1,4	2,3	3,6	5,7	8,9
400	500	4	6	8	10	15	20	27	40	63	97	155	250	400	0,63	0,97	1,55	2,5	4	6,3	9,7
500	630			9	11	16	22	32	44	70	110	175	280	440	0,7	1,1	1,75	2,8	4,4	7	11
630	800			10	13	18	25	36	50	80	125	200	320	500	0,8	1,25	2	3,2	5	8	12,5
800	1 000			11	15	21	28	40	56	90	140	230	360	560	0,9	1,4	2,3	3,6	5,6	9	14
1 000	1 250			13	18	24	33	47	66	105	165	260	420	660	1,05	1,65	2,6	4,2	6,6	10,5	16,5
1 250	1 600			15	21	29	39	55	78	125	195	310	500	780	1,25	1,95	3,1	5	7,8	12,5	19,5
1 600	2 000			18	25	35	46	65	92	150	230	370	600	920	1,5	2,3	3,7	6	9,2	15	23
2 000	2 500			22	30	41	55	78	110	175	280	440	700	1 100	1,75	2,8	4,4	7	11	17,5	28
2 500	3 150			26	36	50	68	96	135	210	330	540	860	1 350	2,1	3,3	5,4	8,6	13,5	21	33

Table 13.2 — Values of the fundamental deviations for holes A to M Fundamental deviation values in micrometres

Nominal size mm		Fundamental deviation values																		
		Lower limit deviation, *EI*												Upper limit deviation, *ES*						
Above	Up to and including	All standard tolerance grades												IT6	IT7	IT8	Up to and including IT8	Above IT8	Up to and including IT8	Above IT8
		A[a]	B[a]	C	CD	D	E	EF	F	FG	G	H	JS	J			K[c,d]		M[b,c,d]	
—	3	+270	+140	+60	+34	+20	+14	+10	+6	+4	+2	0	Deviations = ± ITn/2, where n is the standard tolerance grade number	+2	+4	+6	0	0	−2	−2
3	6	+270	+140	+70	+46	+30	+20	+14	+10	+6	+4	0		+5	+6	+10	−1 + *Δ*		−4 + *Δ*	−4
6	10	+280	+150	+80	+56	+40	+25	+18	+13	+8	+5	0		+5	+8	+12	−1 + *Δ*		−6 + *Δ*	−6
10	14	+290	+150	+95	+70	+50	+32	+23	+16	+10	+6	0		+6	+10	+15	−1 + *Δ*		−7 + *Δ*	−7
14	18																			
18	24	+300	+160	+110	+85	+65	+40	+28	+20	+12	+7	0		+8	+12	+20	−2 + *Δ*		−8 + *Δ*	−8
24	30																			
30	40	+310	+170	+120	+100	+80	+50	+35	+25	+15	+9	0		+10	+14	+24	−2 + *Δ*		−9 + *Δ*	−9
40	50	+320	+180	+130																
50	65	+340	+190	+140		+100	+60		+30		+10	0		+13	+18	+28	−2 + *Δ*		−11 + *Δ*	−11
65	80	+360	+200	+150																
80	100	+380	+220	+170		+120	+72		+36		+12	0		+16	+22	+34	−3 + *Δ*		−13 + *Δ*	−13
100	120	+410	+240	+180																
120	140	+460	+260	+200		+145	+85		+43		+14	0		+18	+26	+41	−3 + *Δ*		−15 + *Δ*	−15
140	160	+520	+280	+210																
160	180	+580	+310	+230																
180	200	+660	+340	+240		+170	+100		+50		+15	0		+22	+30	+47	−4 + *Δ*		−17 + *Δ*	−17
200	225	+740	+380	+260																
225	250	+820	+420	+280																
250	280	+920	+480	+300		+190	+110		+56		+17	0		+25	+36	+55	−4 + *Δ*		−20 + *Δ*	−20
280	315	+1 050	+540	+330																
315	355	+1 200	+600	+360		+210	+125		+62		+18	0		+29	+39	+60	−4 + *Δ*		−21 + *Δ*	−21
355	400	+1 350	+680	+400																
400	450	+1 500	+760	+440		+230	+135		+68		+20	0		+33	+43	+66	−5 + *Δ*		−23 + *Δ*	−23
450	500	+1 650	+840	+480																
500	560					+260	+145		+76		+22	0					0		−26	
560	630																			
630	710					+290	+160		+80		+24	0					0		−30	
710	800																			
800	900					+320	+170		+86		+26	0					0		−34	
900	1 000																			
1 000	1 120					+350	+195		+98		+28	0					0		−40	
1 120	1 250																			
1 250	1 400					+390	+220		+110		+30	0					0		−48	
1 400	1 600																			
1 600	1 800					+430	+240		+120		+32	0					0		−58	
1 800	2 000																			
2 000	2 240					+480	+260		+130		+34	0					0		−68	
2 240	2 500																			
2 500	2 800					+520	+290		+145		+38	0					0		−76	
2 800	3 150																			

[a] Fundamental deviations A and B shall not be used for nominal sizes ≤ 1 mm.

[b] Special case: for tolerance class M6 in the range above 250 mm up to and including 315 mm, *ES* = −9 µm (instead of −11 µm according to the calculation).

[c] For determining the values K and M, see 4.3.2.5.

[d] For *Δ* values, see Table 3.

Table 13.3 — Values of the fundamental deviations for holes A to M
Fundamental deviation values in micrometres

Nominal size mm		Fundamental deviation values Upper limit deviation, ES															Values for Δ					
Above	Up to and including	Up to and including IT8	Above IT8	Up to and including IT7	Standard tolerance grades above IT7												Standard tolerance grades					
		N[a,b]		P to ZC[a]	P	R	S	T	U	V	X	Y	Z	ZA	ZB	ZC	IT3	IT4	IT5	IT6	IT7	IT8
—	3	−4	−4	Values as for standard tolerance grades above IT7 increased by Δ	−6	−10	−14		−18		−20		−26	−32	−40	−60	0	0	0	0	0	0
3	6	−8 + Δ	0		−12	−15	−19		−23		−28		−35	−42	−50	−80	1	1,5	1	3	4	6
6	10	−10 + Δ	0		−15	−19	−23		−28		−34		−42	−52	−67	−97	1	1,5	2	3	6	7
10	14	−12 + Δ	0		−18	−23	−28		−33		−40		−50	−64	−90	−130	1	2	3	3	7	9
14	18									−39	−45		−60	−77	−108	−150						
18	24	−15 + Δ	0		−22	−28	−35		−41	−47	−54	−63	−73	−98	−136	−188	1,5	2	3	4	8	12
24	30							−41	−48	−55	−64	−75	−88	−118	−160	−218						
30	40	−17 + Δ	0		−26	−34	−43	−48	−60	−68	−80	−94	−112	−148	−200	−274	1,5	3	4	5	9	14
40	50							−54	−70	−81	−97	−114	−136	−180	−242	−325						
50	65	−20 + Δ	0		−32	−41	−53	−66	−87	−102	−122	−144	−172	−226	−300	−405	2	3	5	6	11	16
65	80					−43	−59	−75	−102	−120	−146	−174	−210	−274	−360	−480						
80	100	−23 + Δ	0		−37	−51	−71	−91	−124	−146	−178	−214	−258	−335	−445	−585	2	4	5	7	13	19
100	120					−54	−79	−104	−144	−172	−210	−254	−310	−400	−525	−690						
120	140	−27 + Δ	0		−43	−63	−92	−122	−170	−202	−248	−300	−365	−470	−620	−800	3	4	6	7	15	23
140	160					−65	−100	−134	−190	−228	−280	−340	−415	−535	−700	−900						
160	180					−68	−108	−146	−210	−252	−310	−380	−465	−600	−780	−1 000						
180	200	−31 + Δ	0		−50	−77	−122	−166	−236	−284	−350	−425	−520	−670	−880	−1 150	3	4	6	9	17	26
200	225					−80	−130	−180	−258	−310	−385	−470	−575	−740	−960	−1 250						
225	250					−84	−140	−196	−284	−340	−425	−520	−640	−820	−1 050	−1 350						
250	280	−34 + Δ	0		−56	−94	−158	−218	−315	−385	−475	−580	−710	−920	−1 200	−1 550	4	4	7	9	20	29
280	315					−98	−170	−240	−350	−425	−525	−650	−790	−1 000	−1 300	−1 700						
315	355	−37 + Δ	0		−62	−108	−190	−268	−390	−475	−590	−730	−900	−1 150	−1 500	−1 900	4	5	7	11	21	32
355	400					−114	−208	−294	−435	−530	−660	−820	−1 000	−1 300	−1 650	−2 100						
400	450	−40 + Δ	0		−68	−126	−232	−330	−490	−595	−740	−920	−1 100	−1 450	−1 850	−2 400	5	5	7	13	23	34
450	500					−132	−252	−360	−540	−660	−820	−1 000	−1 250	−1 600	−2 100	−2 600						
500	560	−44			−78	−150	−280	−400	−600													
560	630					−155	−310	−450	−660													

Nominal size mm		Fundamental deviation values Upper limit deviation, *ES*															Values for Δ					
Above	Up to and including	Up to and including IT8	Above IT8	Up to and including IT7	Standard tolerance grades above IT7												Standard tolerance grades					
		N[a,b]		P to ZC[a]	P	R	S	T	U	V	X	Y	Z	ZA	ZB	ZC	IT3	IT4	IT5	IT6	IT7	IT8
630	710	−50		Values as for standard tolerance grades above IT7 increased by Δ	−88	−175	−340	−500	−740													
710	800					−185	−380	−560	−840													
800	900	−56			−100	−210	−430	−620	−940													
900	1 000					−220	−470	−680	−1 050													
1 000	1 120	−66			−120	−250	−520	−780	−1 150													
1 120	1 250					−260	−580	−840	−1 300													
1 250	1 400	−78			−140	−300	−640	−960	−1 450													
1 400	1 600					−330	−720	−1 050	−1 600													
1 600	1 800	−92			−170	−370	−820	−1 200	−1 850													
1 800	2 000					−400	−920	−1 350	−2 000													
2 000	2 240	−110			−195	−440	−1 000	−1 500	−2 300													
2 240	2 500					−460	−1 100	−1 650	−2 500													
2 500	2 800	−135			−240	−550	−1 250	−1 900	−2 900													
2 800	3 150					−580	−1 400	−2 100	−3 200													

[a] For determining the values N and P to ZC, see 4.3.2.5

[b] Fundamental deviations N for standard tolerance grades above IT8 shall not be used for nominal sizes ≤ 1 mm.

Table 13.4 — Values of the fundamental deviations for shafts a to j Fundamental deviation values in micrometres

Nominal size mm		Fundamental deviation values														
		Upper limit deviation, *es*												Lower deviation, *ei*		
Above	Up to and includ-ing	All standard tolerance grades												IT5 and IT6	IT7	IT8
		a	b	c	cd	d	e	ef	f	fg	g	h	js	j		
´	3	270	140	60	34	20	14	10	6	4	2	0		2	4	6
3	6	270	140	70	46	30	20	14	10	6	4	0		2	4	
6	10	280	150	80	56	40	25	18	13	8	5	0		2	5	
10	14	290	150	95	70	50	32	23	16	10	6	0		3	6	
14	18															
18	24	300	160	110	85	65	40	25	20	12	7	0		4	8	
24	30															
30	40	310	170	120	100	80	50	35	25	15	9	0		5	10	
40	50	320	180	130												
50	65	340	190	140		100	60		30		10	0		7	12	
65	80	360	200	150												
80	100	380	220	170		120	72		36		12	0		9	15	
100	120	410	240	180												
120	140	460	260	200									numb			
140	160	520	280	210		145	85		43		14	0		11	18	
160	180	580	310	230									gra			
180	200	660	340	240												
200	225	740	380	260		170	100		50		15	0	toler	13	21	
225	250	820	420	280												
250	280	920	480	300		190	110		56		17	0	stan	16	26	
280	315	1 050	540	330												
315	355	1 200	600	360		210	125		62		18	0	t	18	28	
355	400	1 350	680	400									is			
400	450	1 500	760	440		230	135		68		20	0	wh	20	32	
450	500	1 650	840	480												
500	560					260	145		76		22	0	,2/			
560	630												±			
630	710					290	160		80		24	0				
710	800												Devi			
800	900					320	170		86		26	0				
900	1 000															
1 000	1 120					350	195		98		28	0				
1 120	1 250															
1 250	1 400					390	220		110		30	0				
1 400	1 600															
1 600	1 800					430	240		120		32	0				
1 800	2 000															
2 000	2 240					480	260		130		34	0				
2 240	2 500															
2 500	2 800					520	290		145		38	0				
2	3 150															

	800																			
a	Fundamental deviations a and b shall not be used for nominal sizes u 1 mm.																			

Table 13.5 — Values of the fundamental deviations for shafts k to zc
Fundamental deviation values in micrometres

Nominal size mm		Fundamental deviation values Lower limit deviation, *ei*															
Above	Up to and inclu-ding	IT4 to IT7	Up to and includ-ing IT3 and above IT7	All standard tolerance grades													
		k		m	n	p	r	s	t	u	v	x	y	z	za	zb	zc
—	3	0	0	+2	+4	+6	+10	+14		+18		+20		+26	+32	+40	+60
3	6	+1	0	+4	+8	+12	+15	+19		+23		+28		+35	+42	+50	+80
6	10	+1	0	+6	+10	+15	+19	+23		+28		+34		+42	+52	+67	+97
10	14	+1	0	+7	+12	+18	+23	+28		+33		+40		+50	+64	+90	+130
14	18										+39	+45		+60	+77	+108	+150
18	24	+2	0	+8	+15	+22	+28	+35		+41	+47	+54	+63	+73	+98	+136	+188
24	30								+41	+48	+55	+64	+75	+88	+118	+160	+218
30	40	+2	0	+9	+17	+26	+34	+43	+48	+60	+68	+80	+94	+112	+148	+200	+274
40	50								+54	+70	+81	+97	+114	+136	+180	+242	+325
50	65	+2	0	+11	+20	+32	+41	+53	+66	+87	+102	+122	+144	+172	+226	+300	+405
65	80						+43	+59	+75	+102	+120	+146	+174	+210	+274	+360	+480
80	100	+3	0	+13	+23	+37	+51	+71	+91	+124	+146	+178	+214	+258	+335	+445	+585
100	120						+54	+79	+104	+144	+172	+210	+254	+310	+400	+525	+690
120	140						+63	+92	+122	+170	+202	+248	+300	+365	+470	+620	+800
140	160	+3	0	+15	+27	+43	+65	+100	+134	+190	+228	+280	+340	+415	+535	+700	+900
160	180						+68	+108	+146	+210	+252	+310	+380	+465	+600	+780	+1 000
180	200						+77	+122	+166	+236	+284	+350	+425	+520	+670	+880	+1 150
200	225	+4	0	+17	+31	+50	+80	+130	+180	+258	+310	+385	+470	+575	+740	+960	+1 250
225	250						+84	+140	+196	+284	+340	+425	+520	+640	+820	+1 050	+1 350
250	280	+4	0	+20	+34	+56	+94	+158	+218	+315	+385	+475	+580	+710	+920	+1 200	+1 550
280	315						+98	+170	+240	+350	+425	+525	+650	+790	+1 000	+1 300	+1 700
315	355	+4	0	+21	+37	+62	+108	+190	+268	+390	+475	+590	+730	+900	+1 150	+1 500	+1 900
355	400						+114	+208	+294	+435	+530	+660	+820	+1 000	+1 300	+1 650	+2 100
400	450	+5	0	+23	+40	+68	+126	+232	+330	+490	+595	+740	+920	+1 100	+1 450	+1 850	+2 400
450	500						+132	+252	+360	+540	+660	+820	+1 000	+1 250	+1 600	+2 100	+2 600
500	560	0	0	+26	+44	+78	+150	+280	+400	+600							
560	630						+155	+310	+450	+660							
630	710	0	0	+30	+50	+88	+175	+340	+500	+740							
710	800						+185	+380	+560	+840							
800	900	0	0	+34	+56	+100	+210	+430	+620	+940							
900	1 000						+220	+470	+680	+1 050							
1 000	1 120	0	0	+40	+66	+120	+250	+520	+780	+1 150							
1 120	1 250						+260	+580	+840	+1 300							
1 250	1 400	0	0	+48	+78	+140	+300	+640	+960	+1 450							
1 400	1 600						+330	+720	+1 050	+1 600							
1 600	1 800	0	0	+58	+92	+170	+370	+820	+1 200	+1 850							
1 800	2 000						+400	+920	+1 350	+2 000							
2 000	2 240	0	0	+68	+110	+195	+440	+1 000	+1 500	+2 300							
2 240	2 500						+460	+1 100	+1 650	+2 500							
2 500	2 800	0	0	+76	+135	+240	+550	+1 250	+1 900	+2 900							
2 800	3 150						+580	+1 400	+2 100	+3 200							

13.6 Fit system

13.6.1 *Designation of fits (writing rules)*

A fit between mating features shall be designated by

the common nominal size;
the tolerance class for the hole;
the tolerance class for the shaft.

Example 52 H7/g6 or 52 H7
g6

13.6.2 *Determination of the limit deviations (reading rules)*

To read the fit designation (e.g. 52H7/g6 Ⓔ), apply the rules described in 13.5. To determine the clearances and interferences.

13.6. 3 *Determination of a fit*

There are two possibilities to determine a fit. Determination of a fit either by experience or by calculating the permissible clearances and/or interferences derived from the functional requirements and the production possibilities of the mating parts.

13.6.4 *Practical recommendations for determining a fit*

There are more characteristics than the sizes of the mating parts and their tolerances, which influence the function of a fit. In order to give a complete technical definition of a fit, further influences shall be taken into consideration.

Further influences may be, for example, form, orientation and location deviations, surface texture, density of the material, operating temperatures, heat treatment and material of the mating parts.

Form, orientation and location tolerances may be needed as a supplement to the size tolerances on the mating features of size in order to control the intended function of the fit.

13.6.5 *Selection of the fit system*

The first decision to be made is whether to adopt the `hole-basis fit system_ (hole H) or the `shaft-basis fit system_ (shaft h). However, it has to be noted, that there are no technical differences regarding the function of the parts. Therefore the choice of the system should be based on economic reasons.

The `hole-basis fit system_ should be chosen for general use. This choice would avoid an unnecessary multiplicity of tools (e.g. reamers) and gauges.

The `shaft-basis fit system_ should only be used where it will convey unquestionable economical advantages (e.g. where it is necessary to be able to mount several parts with holes having different deviations on a single shaft of drawn steel bar without machining the latter).

13.6.6 *Determination of a specific fit by experience*

Based on the decision taken, the tolerance grades and the fundamental deviation (placement of tolerance interval) should then be chosen for the hole and the shaft to give the corresponding minimum and maximum clearances or interferences that best meet the required conditions of use.

For normal ordinary engineering purposes, only a small number of the many possible fits is required. Fig 13.12 and 13.13 indicate those fits which will be found to meet many of the needs of an average engineering organization. For economic reasons, the first choice for a fit should, whenever possible, be made from the tolerance classes shown in the frames (*see* Fig 13.12 and 13.13).

Satisfactory fits are obtained by the following combinations of basic holes system (*see* Fig 13.12) or for special applications the combinations of basic shafts system (*see* Fig 13.13).

Basic hole	Tolerance classes for shafts																	
	Clearance fits							Transition fits				Interference fits						
H 6						g5	h5	js5	k5	m5		n5	p5					
H 7					f6	**g6**	**h6**	**js6**	**k6**	m6	**n6**		**p6**	**r6**	**s6**	t6	u6	x6
H 8				e7	**f7**		**h7**	js7	k7	m7					s7		u7	
			d8	**e8**	f8		h8											
H 9			d8	**e8**	f8		h8											
H10	b9	c9	d9	e9			h9											
H 11	**b11**	**c11**	d10				h10											

FIG 13.12 ´ Preferable fits of the hole-basis system

Basic shaft	Tolerance classes for holes																	
	Clearance fits							Transition fits				Interference fits						
h 5						G6	H6	JS6	K6	M6		N6	P6					
h 6					F7	**G7**	**H7**	**JS7**	**K7**	M7	**N7**		**P7**	**R7**	**S7**	T7	U7	X7
h 7				E8	**F8**		**H8**											
h 8			D9	E9	F9		H9											
h 9				E8	**F8**		**H8**											
			D9	**E9**	F9		**H9**											
	B11	C10	**D10**				H10											

FIG 13.13 ´ Preferable fits of the shaft-basis system

13.6.7 *Determination of a specific fit by calculation*

In certain special functional cases, it is necessary to calculate the permissible clearances and/or interferences derived from the functional requirements of the mating parts. The clearances and/or interferences and the span of the fit obtained from that calculation have to be transformed into limit deviations and if possible into tolerance classes.

SECTION 14 DIMENSIONING OF CONES

[Based on IS 10718: 1993/1S0 3040: 2009]

14.1 Scope

This section establishes the definition of cones and specifies the graphical symbol to be used for their indication and methods for their dimensioning and tolerancing. The term `cone_ relates to right-angle circular cones only.

NOTE 1 -- For simplicity, only truncated cones have been represented in this section. However this section can be applied to any type of cone within its scope.

NOTE 2 -- This section is not intended to prevent the use of other methods of dimensioning.

14.2 Definitions

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

14.2.1 *RateofTaper*

C: ratio of the difference in the diameters of two sections of a center the distance between them

NOTE -- It is expressed by the following formula (*see* also Fig 14.1):

$$C=\frac{D-d}{L}=2\tan$$

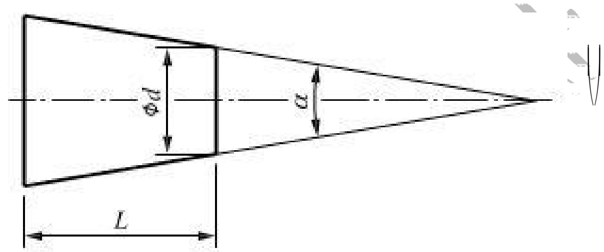


FIG 14.1

14.3 Graphical Symbol for a Cone

A cone shall be indicate during the graphical symbol illustrated in Fig 14.2positioned on a reference line (*see* Fig14.7).The orientation of the graphical symbol shall coincide with at of the cone (*see* Fig 14.7and Fig 14.8).

For the size and line thickness of the graphical symbol, *see* ISO81714-1

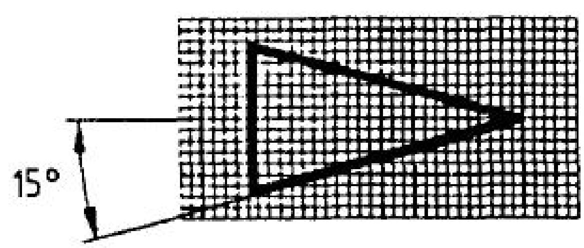


FIG. 14.2

14.4 DimensioningofCones

14.4.1 *Characteristics of cones*

In order to define a cone, the characteristics and dimensions showing Table 1 may be used in those combinations most appropriate for the function of the cone.

Table1—Characteristicsanddimensionsofcones

Characteristics and dimensions	Letter symbol	Examples of indication	
		Preferred method	Optional method

Characteristics			
Rate of taper	*C*	1:5 1/5	0,2:1 20%
Cone angle		35°	0,6rad
Cone diameter			
at the largerend	*D*		
at the smaller end	*d*		
at the selected cross-section	D_x		
Length			
Cone length	*L*		
Length including cone length	$L \rightarrow$		
Length locating a cross-section at which Dx is specified	*L*		

No more dimensions than are necessary shall be specified. However, additional dimensions (*for example*, half the included angle) maybe given as `auxiliary_ or `reference_ dimensions in brackets for information.

Typical combinations of cone characteristics and dimensions are shown in Fig 14.3, Fig 14.4, Fig 14.5 and Fig 14.6

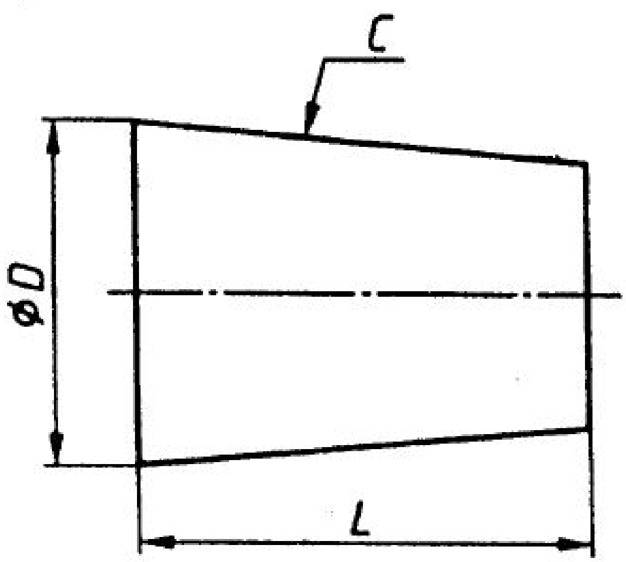


FIG. 14.3

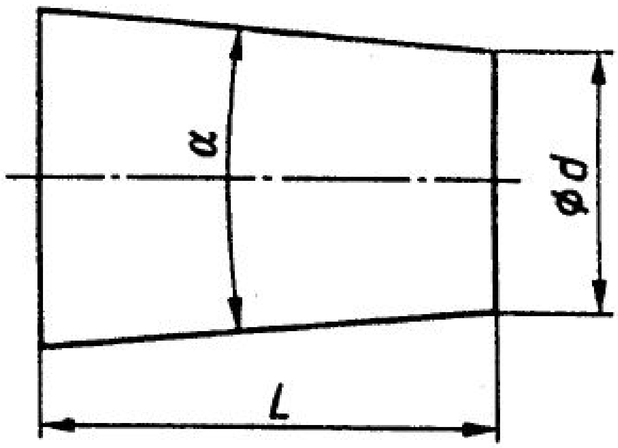


FIG. 14.4

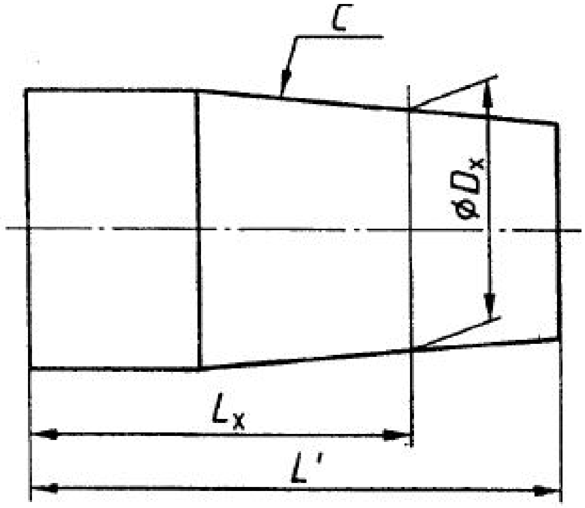


FIG. 14.5

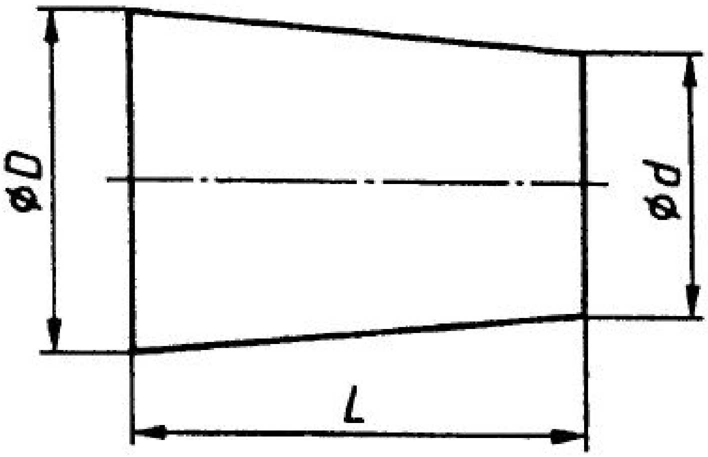


FIG. 14.6

14.4.4.2 *Indication of Rate of Taper on Drawings*

The graphical symbol and the rate of taper of a cone shall be indicated near the feature, and the reference line shall be connected to the outline of the cone by already lines showing Fig 14.7. The reference line shall be drawn parallel to the centreline of the cone, and the orientation of the graphical symbol shall coincide with that of the cone

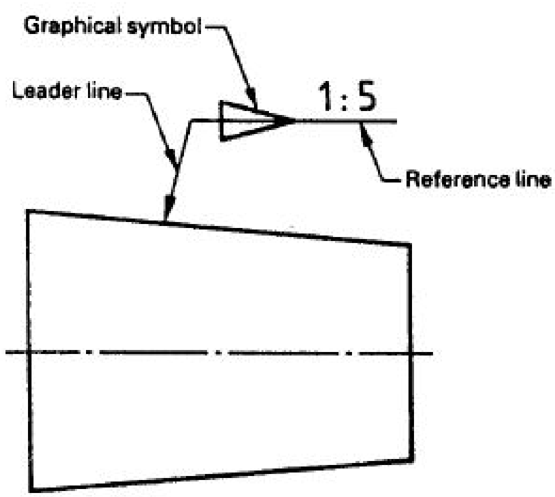


FIG. 14.7

14.4.3 *Standardized series of cones*

When the taper to be indicated is one of a standardized series of conical taper (in particular Morseormetric taper), the tapered feature may be designated by specifying the standard series (*see* ISO1119) and appropriate number (*see* Fig14.8).

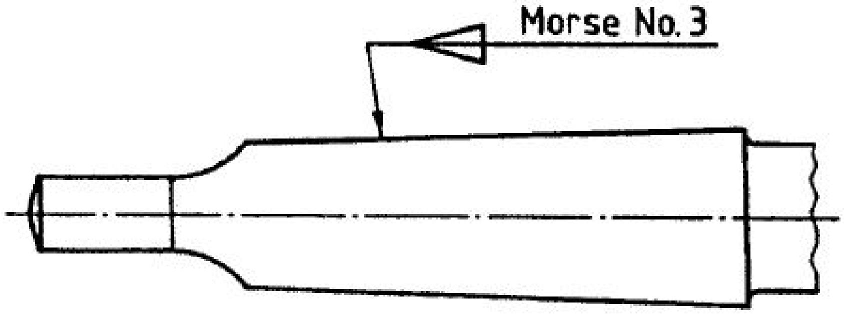


FIG. 14.8

SECTION 15 INDICATION OF SURFACE TEXTURE IN TECHNICAL PRODUCT DOCUMENTATION

[Based on ISO 1302: 2002]

15.1 Scope

This International Standard specifies the rules for the indication of surface texture in technical product documentation (e.g. drawings, specifications, contracts, reports) by means of graphical symbols and textual indications.
It is applicable to the indication of requirements for surfaces by means of
a) profile parameters, according to ISO 4287, related to the

- *R*-profile (roughness parameters),
- *W*-profile (waviness parameters), and
- *P*-profile (structural parameters),

b) motif parameters, according to ISO 12085, related to the

- roughness motif, and
- waviness motif,

c) parameters related to the material ratio curve according to ISO 13565-2 and ISO 13565-3.

NOTE -- For the indication of requirements for surface imperfections (pores, scratches etc.), which cannot be specified using surface texture parameters, reference is made to ISO 8785, which covers surface imperfections.

15.2 Definitions

15.2.1 *Basic Graphical Symbol*
surface texture graphical symbol indicating that a requirement for surface texture exists *See* Fig 15.1.

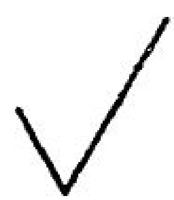


FIG. 15.1 BASIC GRAPHICAL SYMBOL FOR SURFACE TEXTURE

15.2.1 *Expanded Graphical Symbol*
⟨surface texture⟩ expanded basic graphical symbol indicating that material is either to be removed or not removed in order to obtain the specified surface texture *See* Fig 15.2 and Fig 15.3.

15.2.2 *Complete Graphical Symbol*
⟨surface texture⟩ basic or expanded graphical symbol expanded in order to facilitate the addition of complementary surface texture requirements *See* Fig 15.4

15.2.3 *Surface (texture) Parameter*
parameter expressing a micro-geometrical property of a surface

NOTE -- See annex E for examples of surface texture parameter designations.

15.2.4 *(surface) Parameter Symbol*
symbol indicating the type of surface texture parameter

NOTE The parameter symbols consist of letters and numerical values (e.g. *Ra*, *Ramax*, *Wz*, *Wz*1*max*, *AR*, *Rpk*, *Rpq*).

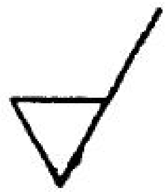


FIG. 15.2 EXPANDED GRAPHICAL SYMBOL INDICATING THAT REMOVAL OF MATERIAL IS REQUIRED

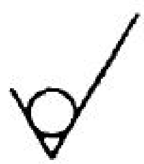


FIG. 15.3 EXPANDED GRAPHICAL SYMBOL WHEN REMOVAL OF MATERIAL IS NOT PERMITTED

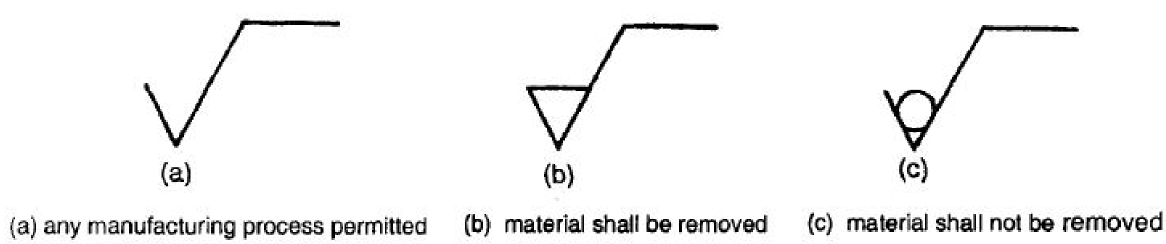


FIG. 15.4 COMPLETE GRAPHICAL SYMBOL

15.3 Graphical symbols for the indication of surface texture

15.3.1 *General*
Requirements for surface texture are indicated on technical product documentation by several variants of graphical symbols, each having its own significant meaning. The graphical symbols specified in 4.2 and 4.3 shall be supplemented with complementary surface texture requirements in the form of numerical values, graphical symbols and text (*see* also clauses 5, 6, 7 and 8).

15.3.2 *Basic graphical symbol*
The basic graphical symbol shall consist of two straight lines of unequal length inclined at approximately 60° to the line representing the considered surface, as shown in Fig 15.1. The basic graphical symbol in Fig 15.1 should not be used alone (without complementary information). Its use shall be to provide collective indications as shown in Fig 15.23 and Fig 15.26.
If the basic graphical symbol is used with complementary, supplemental information (*see* clause 5), then no further decision is required as to whether removal of material is necessary for obtaining the specified surface or whether removal of material is not permitted for obtaining the specified surface .

15.3.3 *Expanded graphical symbols*

15.3.3.1 *Removal of material required*
If removal of material ´ for example, by machining ´ is required for obtaining the specified surface, a bar shall be added to the basic graphical symbol, as shown in Fig 15.2 The expanded graphical symbol in Fig 15.2 should not be used alone (without complementary information).

15.3.3.2 *Removal of material not permitted*
If removal of material is not permitted for obtaining the specified surface, a circle shall be added to the basic graphical symbol, as shown in Fig 15.3.

15.3.4 *Complete Graphical Symbol*
When complementary requirements for surface texture characteristics have to be indicated a line shall be added to the longer arm of any of the graphical symbols illustrated in Fig 15.1 to 15.3, as shown in Fig 15.4.

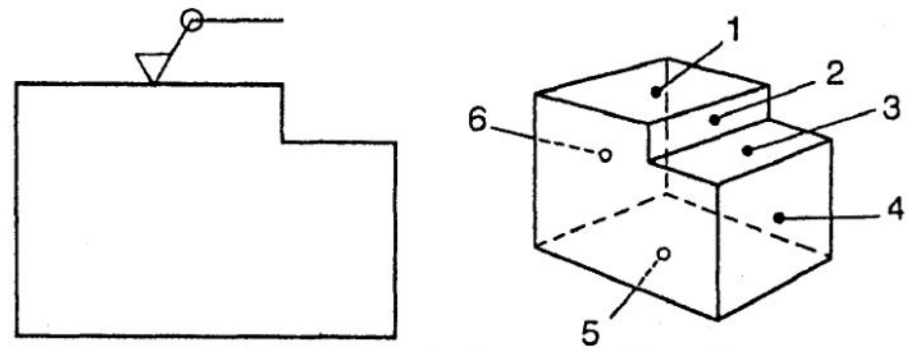
For use in the written text of ´ for example, reports or contracts ´ the textual indication for Fig 15.4,

a) is APA4)
for b) it is MRR5)
and for c) NMR6).

15.3.5 *Graphical symbol for "all surfaces around a workpiece outline"*

When the same surface texture is required on all surfaces around a workpiece outline (integral features),represented on the drawing by a closed outline of the workpiece, a circle shall be added to the complete graphical symbol illustrated in Figure 4, as shown in Fig 15.5. Surfaces shall be indicated independently if any ambiguity may arise from the all around indication.

4) Any process allowed.
5) Material removal required.
6) No material removed.



NOTE — The outline on the drawing represent the six surfaces shown on the 3D-representation of the workpiece.

FIG. 15.5 EXAMPLE OF A SURFACE TEXTURE REQUIREMENT APPLYING TO ALL (SIX) SURFACES REPRESENTED BY THE OUTLINE ON THE DRAWING

15.4

15.4.1 *General*
In order to ensure that a surface texture requirement is unambiguous, it may be necessary, in addition to the indication of both a surface texture parameter and its numerical value, to specify additional requirements (e.g. transmission band or sampling length, manufacturing process, surface lay and its orientation and possible machining allowances). It may be necessary to set up requirements for several different surface texture parameters

15.4.2 *Position of complementary surface texture requirements*
The mandatory positions of the various surface texture requirements in the complete graphical symbol are shown in Fig 15.6.

The complementary surface texture requirements in the form of

- surface texture parameters,
- numerical values, and
- transmission band/sampling length,

shall be located at the specific positions in the complete graphical symbol in accordance with the following.

15.4.2.(a)*Position a — Single surface texture requirement*
Indicate the surface texture parameter designation, the numerical limit value and the transmission band/sampling length is to be indicated in the complete graphical symbol, a double space (double blank) shall be inserted between the parameter designation and the limit value.

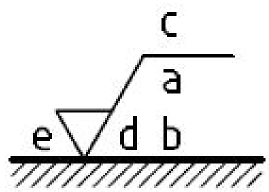


FIG 15.6

Position of (a to e) for location of complimentary requirements where a as per Clause 15.4.2 (a), b as per Clause 15.4.2 (b), c as per Clause 15.4.2 (c), d as per Clause 15.4.2 (d), e as per Clause 15.4.2 (e)

Generally, the transmission band or sampling length shall be indicated followed by an oblique stroke (/),followed by the surface texture parameter designation, followed by its numerical value using one text string.

Example 1 0,0025-0,8/Rz 6,8 (example with transmission band indicated).
Example 2 -0,8/Rz 6,8 (example with only sampling length indicated).

Especially for the motif method, the transmission band shall be indicated, followed by an oblique stroke (/),followed by the value of the evaluation length, followed by another oblique stroke, followed by the surface texture parameter designation, followed by its numerical value.

EXAMPLE 3 0,008-0,5/16/R 10.

NOTE -- Generally, the transmission band is the wavelength range between two defined filters (see ISO 3274 and ISO 11562) and, for the motif method, the wavelength range between two defined limits (see ISO 12085).

15.4.2 (b)*Position a and b — Two or more surface texture requirements*

Indicate the first surface texture requirement at position `a_ as in a). Indicate the second surface texture requirement at position `b_. If a third requirement or more is to be indicated, the graphical symbol is to been larged accordingly in the vertical direction, to make room for more lines. The position `a_ and `b_ are to be moved upwards when the symbol is enlarged.

15.4.2 (c)*Position c — Manufacturing method*

Indicate the manufacturing method, treatment, coatings or other requirements for the manufacturing processetc. to produce the surface, for example, turned, ground, plated (see also clause 7).

15.4.2 (d)*Position d — Surface lay and orientation*

Indicate the symbol of the required surface lay and the orientation, if any, of the surface lay,

for example, `=_,
`X_, `M_ (see also clause 8).

15.4.2 (e)*Position e — Machining allowance*

Indicate the required machining allowance, if any, as a numerical value given in millimetres,

15.4.3 *Indication of Manufacturing Method or Related Information*

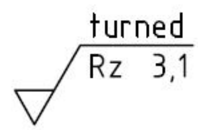
The surface texture parameter value of an actual surface is strongly influenced by the detailed form of the profile curve. A parameter designation, parameter value and transmission band ´ indicated solely as a surface texture requirement ´ do not therefore necessarily result in an unambiguous function of the surface. It is consequently necessary in almost all cases to state the manufacturing process, as this process to some extent results in a particular detailed form of the profile curve.

There may also be other reasons for finding it appropriate to indicate the process.

The manufacturing process of the specified surface can be presented as text and added to the complete symbol as shown in Fig 15.7 and Fig 15.8.

MRR turned Rz 3,1

a) in text

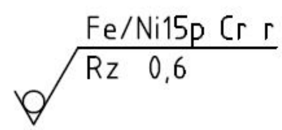


b) on drawing

FIG 15.7 Indication of machining process and requirement for roughness of resulting surfaces

NMR Fe/Ni15p Cr r; Rz 0,6

a) in text



b) on drawing

FIG 15.8 Indication of coating and roughness requirement.

15.4.4 *Indication of the surface lay*

The surface lay and direction of the lay emanating from the manufacturing process (e.g. traces left by tools) may be indicated in the complete symbol by using the symbols shown in Table 2 and illustrated by the example in Fig 15.9. The indication of surface lay by the defined symbols (e.g. the perpendicularity symbol in Fig 15.8) is not applicable to textual indications.

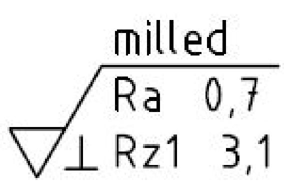
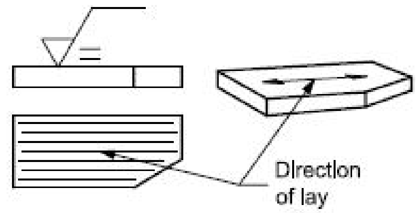
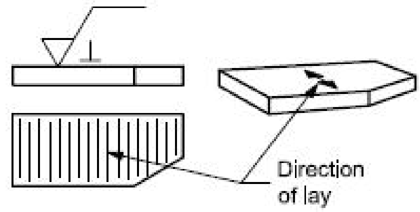
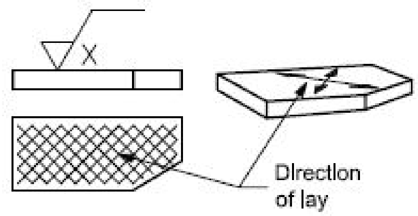
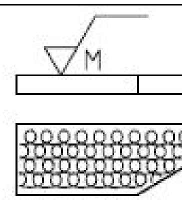
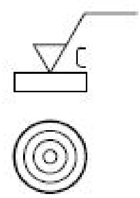
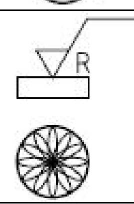
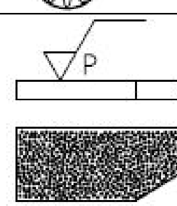


FIG 15.8 Direction of lay of surface pattern indicated perpendicular to drawing plane

NOTE The direction of lay is the direction of the prevailing surface pattern, which is usually determined by the manufacturing process used.

The symbols in Table 15.1 indicate the lay and direction of lay in relation to the drawing plane containing the surfacetexture requirement.

Table 15.1 Indication of Lay

Graphical Symbol	Interpretation and example	
=	Parallel to plane of projection of view in which symbol is used	
⊥	Perpendicular to plane of projection of view in which symbol is used	
X	Crossed in two oblique directions relative to plane of projection of view in which symbol is used	
M	Multi-directional	
C	Approx. circular relative to centre of surface to which symbol applies	
R	Approx. radial relative to centre of surface to which symbol applies	
P	Lay is particulate, non-directional, or protuberant	
If it is necessary to specify a surface pattern which is not clearly defined by these symbols, this shall be achieved by the addition of a suitable note to the drawing.		

15.4.5 *Indication of machining allowance*

The machining allowance is generally indicated only in those cases where more process stages are shown in the same drawing. Machining allowances are therefore found (e.g. on drawings of raw cast and forged workpieces with the final workpiece being shown in the raw workpiece). The indication of the machining allowance by the defined symbol is not applicable to textual indications.

When the machining allowance is indicated, it may occur that the requirement for the machining allowance is the only requirement added to the complete symbol. The machining allowance may also be indicated in connection with a normal surface texture requirement (see Fig 15.9)

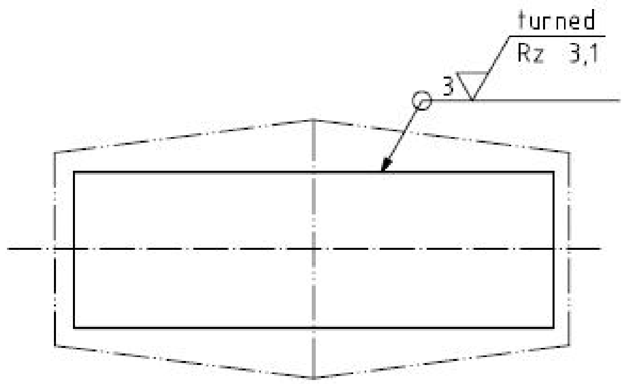


FIG 15.9 ´ Indication of surface texture requirements for `final_ workpiece (including requirement for 3 mm machining allowance for all surfaces)

15.5 Position on Drawings and Other Technical Product Documentation

15.5.1 *General*
Surface texture requirements shall be indicated only once for a given surface and, if possible, on the same view where the size or location, or both, are indicated and tolerance Unless otherwise specified, the indicated surface texture requirements are applicable for the surface after machining, coating, etc.

15.5.2 *Position and orientation of graphical symbol and its annotation*

15.5.2.1 *General*
The general rule is that the graphical symbol together with the complementary information shall be oriented so that they are readable from the bottom or right-hand side of the drawing (see Fig 15.10).

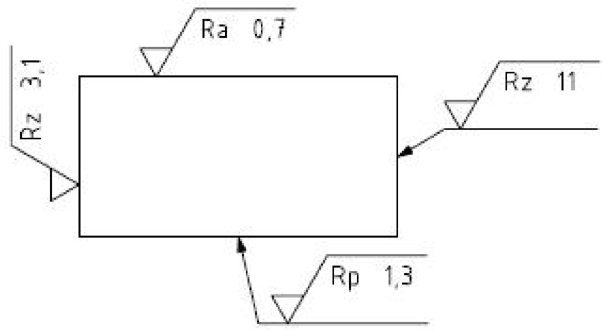


FIG 15.10 ´ Direction of reading of surface texture requirements

15.5.2.2 *On outline or by reference line and leader line*

The surface texture requirement (graphical symbol) shall touch the surface or be connected to it by means of a reference/leader line terminating in an arrowhead.

As a general rule, the graphical symbol, or the leader line terminating in an arrowhead (or other relevant terminator), shall point at the surface from outside the material of the workpiece ´ either to the outline (representing the surface) or the extension of it (*see* Fig 15.11 and 15.12).

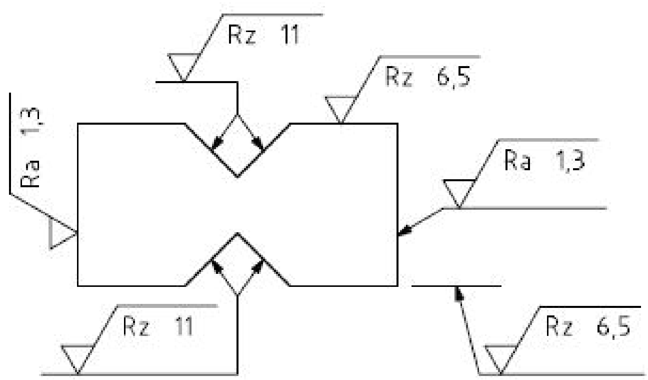


FIG 15.11 ´ Surface texture requirements on contour line representing surface

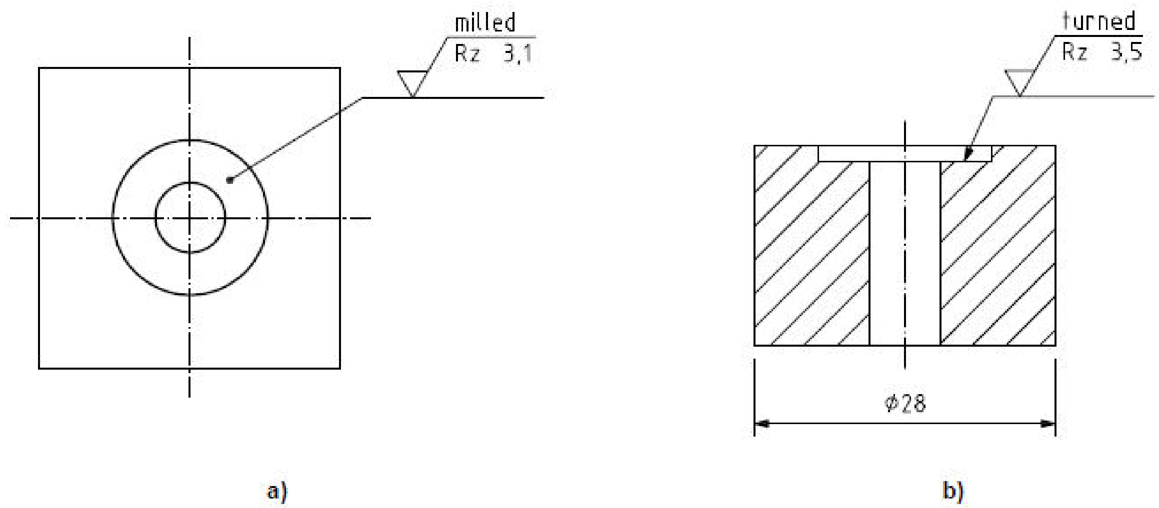


FIG 15.12´ Alternative use of reference lines and leader lines

15.5.2.3 *On Dimension Line in Connection with Feature-of-Size Dimension*

If there is no risk of misinterpretation, the surface texture requirement may be indicated in connection with the dimensions given, as shown in Fig 15.13.

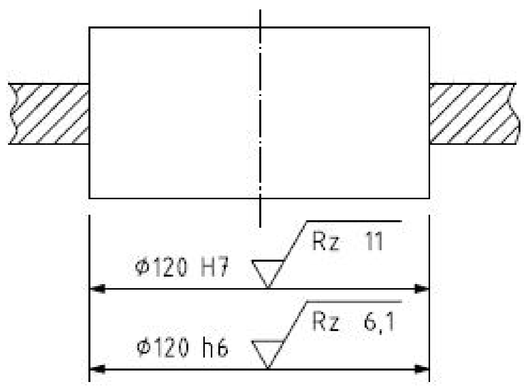


FIG 15.13´ Surface texture requirement ´ Feature-of-size dimension

15.5.2.4 On Tolerance Frame for Geometrical Tolerances.

The surface texture requirement may be placed on top of the tolerance frame for geometrical tolerances, as shown in Fig 15.14 a) and b).

FIG 15.14 ´ Surface texture requirement ´ Geometrical tolerances indication

15.5.2.5 *On Extension Lines*

The surface texture requirement may be directly placed on extension lines or be connected to it by a reference/leader line terminating in an arrowhead, as shown in Figures 15.11 and 15.15.

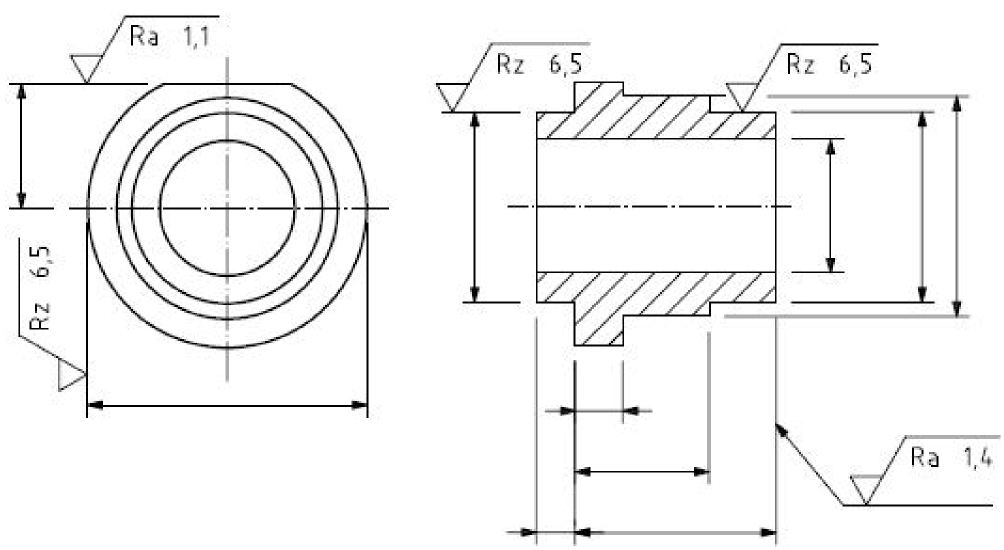


FIG 15.15´ Surface texture requirements ´ Extension lines of cylindrical features

15.5.6 *Cylindrical and Prismatic Surfaces*

Cylindrical as well as prismatic surfaces may be specified only once if indicated by a centreline and if each prismatic surface has the same surface texture requirement (*see* Fig 15.15). However, each prismatic surface shall be indicated separately if different surface textures are required on the individual prismatic surfaces (*see* Fig15.16).

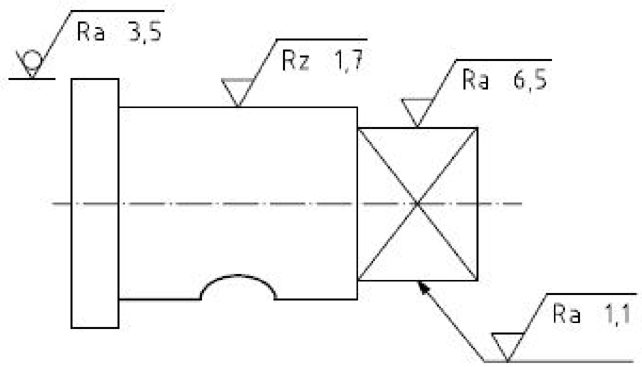


FIG 15.16 Surface texture requirements ´ Cylindrical and prismatic surfaces

15.6 Simplified Drawing Indications of Surface Texture Requirements

15.6.1 *Majority of surfaces having same surface texture requirement*

If the same surface texture is required on the majority of the surfaces of a workpiece, this surface texture requirement should be placed close to the title block of the drawing.

The general graphical symbol corresponding to this surface texture shall be followed by

- a basic symbol in parentheses without any other indication (*see* Fig 15.17), or
- the special deviating surface texture requirement or requirements in parentheses (*see* Fig 15.18), in order to indicate requirements that deviate from the general surface texture requirement.

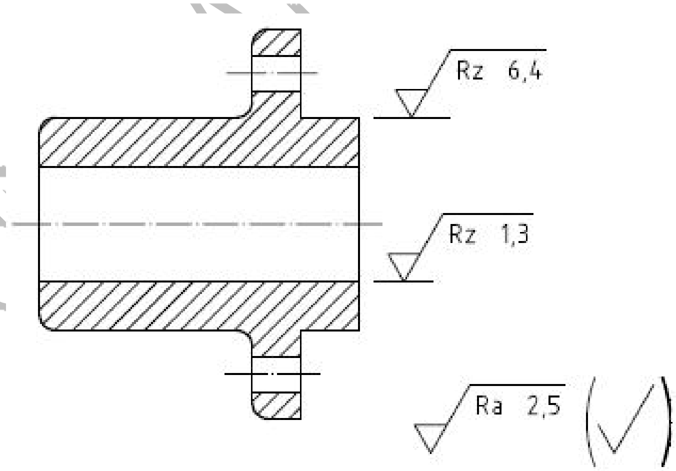


FIG 15.17 Simplified indication ´ Majority of surfaces with same required surface texture

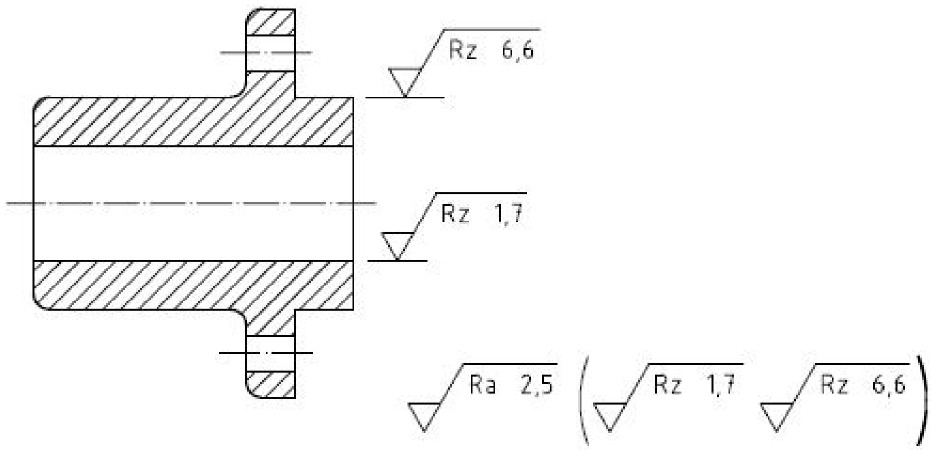


FIG 15.18 Simplified indication ´ Majority of surfaces with same required surface texture

Surface texture requirements that deviate from the general surface texture requirement shall be indicated directly on the drawing in the same view of the particular surfaces in question (*see* Fig 15.17 and 15.18).

15.6.2 *Common Requirements on Multiple Surfaces*

15.6.2.1 *General*

To avoid the necessity of repeating a complicated indication a number of times, or where space is limited, or if the same surface texture is required on a large number of surfaces of the workpiece, a simplified reference indication may be invoked as follows.

15.6.2.2 *Indication by graphical symbol with letters*

A simplified reference indication may be used on the surface provided that its meaning is explained near the workpiece in question, near the title block or in the space devoted to general notes (*see* Fig 15.19).

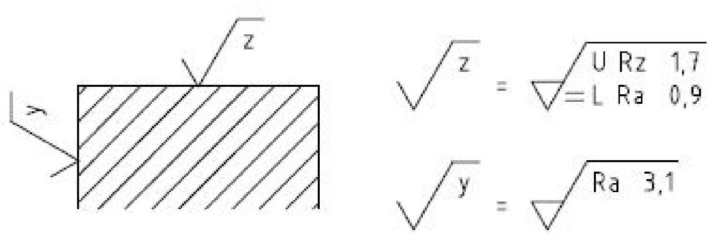


FIG 15.19 ´ Reference indication in case of minimal drawing space

15.6.2.3 *Indication by Graphical Symbol Alone*

The corresponding graphical symbol shown in Fig 15.1, 15.22 or 15.33 may be used on the appropriate surface and its meaning given on the drawing as shown in Figures 15.20 to 15.22.

FIG 15.20 ´ Simplified indication of surface texture requirements ´ Unspecified manufacturing process

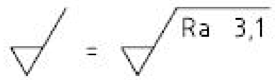


FIG 15.21 ´ Simplified indication of surface texture requirement ´ Removal of material required

FIG 15.22 ´ Simplified indication of surface texture requirement ´ Removal of material not permitted

15.7 Indication of two or more manufacturing methods

If it is necessary to define surface texture both before and after treatment, this shall be explained in a note or in accordance with Fig 15.23.

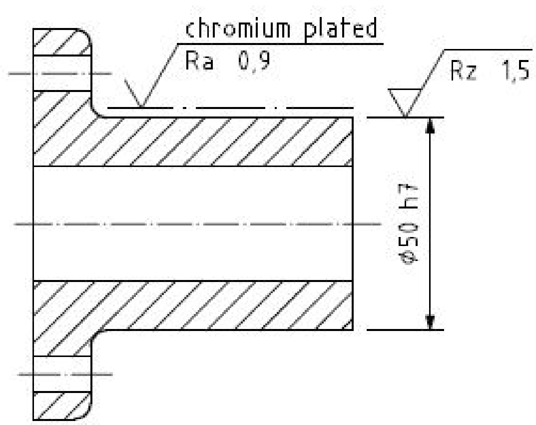


FIG 15.23 ´ Indication of surface texture requirement before and after treatment (in this case, coating)

15.8 Synoptive Tables

See Table 15.2 to 15.5

Table 15.2 Graphical symbols without inscription

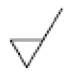
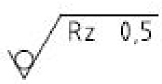
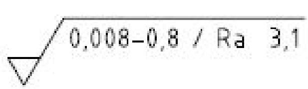
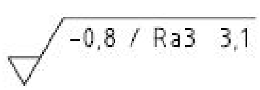
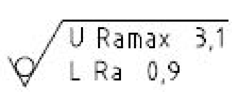
Reference No.	Symbol	Meaning
1		Basic graphical symbol: may only be used in isolation when its meaning is`the surface under consideration_ or when explained by a note.
2		Expanded graphical symbol: machining surface with no indication of otherdetails; in isolation, this expanded graphical symbol may only be usedwhen its meaning is `a surface to be machined_.
3		Expanded graphical symbol: surface from which removal of material isprohibited; this expanded graphical symbol may also be used in a drawingrelating to a manufacturing process to indicate that a surface is to be leftin the state resulting from a preceding manufacturing process, regardlessof whether this state was achieved by removal of material or otherwise

Table 15.3 Graphical symbols with indication of surface texture

Reference No.	Symbol	Meaning
1		The process is not permitted to remove material, unilateral upperspecification limit, default transmission band, *R*-profile, maximumheight of roughness 0,5 ≈m, evaluation length of five samplinglengths (default), `16 %-rule_ (default)
2		The process shall remove material, unilateral upper specificationlimit, default transmission band, *R*-profile, maximum height ofroughness 0,3 ≈m, evaluation length of five sampling lengths(default), `max-rule_.
3		The process shall remove material, unilateral upper specificationlimit, transmission band 0,008-0,8 mm, *R*-profile, arithmetic meandeviation 3,1 ≈m, evaluation length of 5 sampling lengths (default),`16 %-rule_ (default)
4		The process shall remove material, unilateral upper specificationlimit, transmission band: sampling length 0,8 mm (≅s default0,002 5 mm) according to ISO 3274, *R*-profile, arithmetic meandeviation 3,1 ≈m, evaluation length of three sampling lengths(default), `16 %-rule_ (default).
5		The process is not permitted to remove material, double-sidedupper and lower specification limits, default transmission band forboth limits, *R*-profile, upper limit: arithmetic mean deviation 3,1 ≈mevaluation length of five sampling lengths (default), `max-rule_,lower limit: arithmetic mean deviation 0,9 ≈m, evaluation length offive

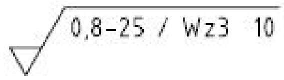
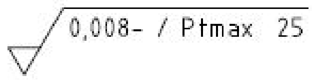
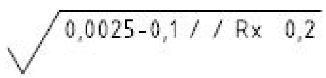
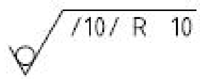
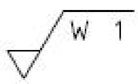
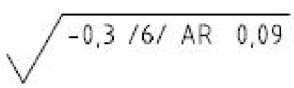
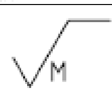
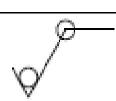
		sampling lengths (default), `16 %-rule_ (default.)
6		The process shall remove material, unilateral upper specificationlimit, transmission band 0,8 - 25 mm, *W*-profile, maximum height ofwaviness 10 ≒m, evaluation length of three sampling lengths,`16 %-rule_ (default).
7		The process shall remove material, unilateral upper specificationlimit, transmission band ≅s = 0,008 mm, no long-wave filter, *P*profiletotal profile height 25 ≒m, evaluation length equalworkpiece length (default), `max-rule_.
8		Any manufacturing process, unilateral upper specification limit,transmission band ≅s = 0,002 5 mm; *A* = 0,1 mm, evaluation length3,2 mm (default), roughness motif parameter, maximum depth ofroughness motif 0,2 ≒m, `16 %-rule_ (default).
9		The process is not permitted to remove material, unilateral upper specification limit, transmission band ≅s = 0.008 mm (default),*A* = 0,5 mm (default), evaluation length 10 mm, roughness motifparameter, mean depth of roughness motif 10 mm, `16 %-rule_(default).
10		The process shall remove material, unilateral upper specificationlimit, transmission band *A* = 0,5 mm(default), *B* = 2,5 mm (default),evaluation length 16 mm (default), waviness motif parameter,mean depth of waviness motif 1mm, `16 %-rule_ (default).
11		Any manufacturing process, unilateral upper specification limit,transmission band ≅s = 0,008 mm (default); *A* = 0,3 mm,evaluation length 6 mm, roughness motif parameter, meanspacing of roughness motif 0,09 mm, `16 %-rule_ (default).
NOTE-- Surface texture parameters, transmission bands/sampling lengths and parameter values and choice of symbols are given as examples only.		

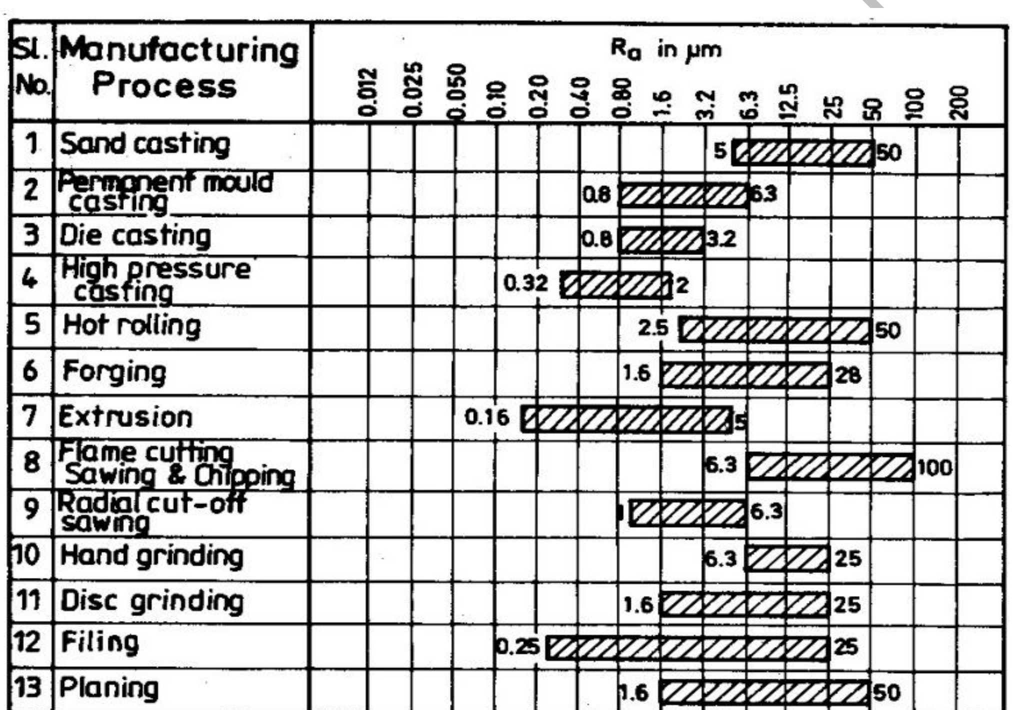
Table 15.4 Symbols with Simplified Information

Reference No	Symbol	Meaning
1		Manufacturing method: milled
2		Surface pattern: direction of lay multidirectional
3		Surface texture requirement applies to complete closed outline of the projection view

4	3 √	Machining allowance 3 mm
NOTE-- The manufacturing method, surface pattern and machining allowance are given as examples only.		

Table 15.5 Simplified Symbols

Reference No	Symbol	Meaning
1	√	The meaning is defined by text added to the drawing
2	√y √z	



14	Shaping	1.6	25
15	Drilling	1.6	20
16	Turning & Milling	0.32	25
17	Boring	0.4	6.3
18	Reaming	0.4	3.2
19	Broaching	0.4	3.2
20	Hobbing	0.4	3.2
21	Surface grinding	0.063	5
22	Cylindrical grinding	0.063	5
23	Honing	0.025	0.4
24	Lapping	0.012	0.16
25	Polishing	0.04	0.16
26	Burnishing	0.04	0.8
27	Super finishing	0.016	0.32

SECTION 16 SIMPLIFIED REPRESENTATION OF THE ASSEMBLY OF PARTS WITH FASTENERS – GENERAL PRINCIPLES

[Based on IS 15023 (Part 1):2001 /1S05845-1 : 1995]

16.1 Scope

This section establishes general principles for the simplified representation of holes, bolts (screws), rivets, etc, on technical drawings.

16.2 Simplified Representation of Fasteners

16.2.1 *Representation on Projection Planes Normal to the Axes of the Fasteners*

In order to represent holes, bolts and rivets on projection planes normal to their axes, the symbolic representation shall be drawn in continuous wide line (O1.2) in accordance with Section 6. The position of the fastener is indicated by a cross (see Fig. 16. 1).

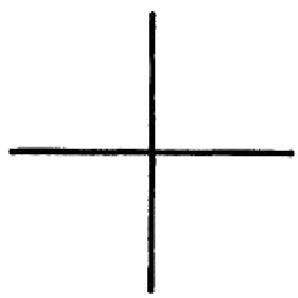


FIG. 16.1

Additional information should be indicated in accordance with Tables 16.1 and 16.2.
A prominent dot may be placed in the centre of the cross in order to facilitate the use of drawing copies as a template (*see* example in Fig. 16.2). The diameter of the dot shall be five times the thickness of the line used for indicating the cross.

Table 16.1 Symbolic Representation of Holes, Bolts and Rivets to Fit in Holes
(*Clause* 16.2.1)

Hole[1)] and bolt or rivet	Hole			
	without countersinking	countersunk on near side	countersunk on far side	countersunk on both sides
Drilled and fitted in the workshop				
Drilled in the workshop and fitted on site				
Drilled and fitted on site				

1) To distinguish bolts and rivets from holes, the correct designation of the hole or fastener shall be given

EXAMPLE

The designation for a hole of diameter 13 mm is Ø 13, the designation for a bolt with metric screw thread of diameter 12 mm and length 50 mm is M12 × 50, while that for a rivet of diameter 12 mm and length 50 mm is Ø 12 × 50.

Table 16.2 Symbolic Representation of Holes
(*Clause* 16.2.2)

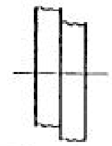
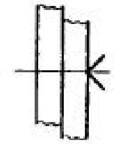
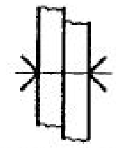
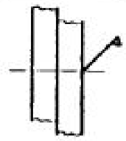
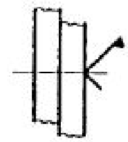
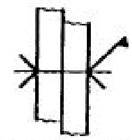
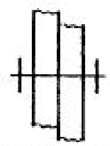
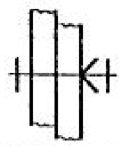
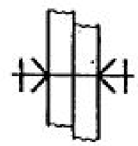
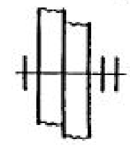
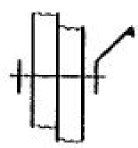
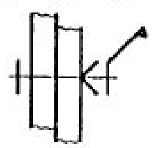
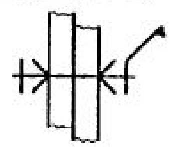
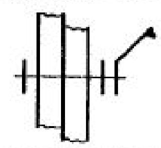
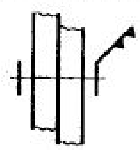
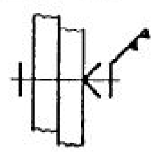
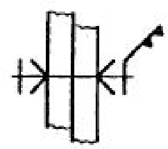
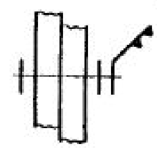
Hole	Hole without countersinking	Hole countersunk on one side only	Hole countersunk on both sides
Drilled in the workshop			
Drilled on site			

Table 16.3 Symbolic Representation of Bolts or Rivets to Fit in Holes
(*Clause* 16.2.2)

Bolt or rivet[1]	Hole without countersinking	Hole countersunk on one side only	Hole countersunk on both sides	Bolt with designated nut position
Fitted in the workshop				
Fitted on site				
Hole drilled on site and bolt or rivet fitted on site				

1) To distinguish bolts from rivets, the correct designation of the fastener shall be given.

EXAMPLE

The designation for a bolt with metric screw thread of diameter 12 mm and length 50 mm is M12 × 50, while that for a rivet of diameter 12 mm and length 50 mm is ⌀ 12 × 50.

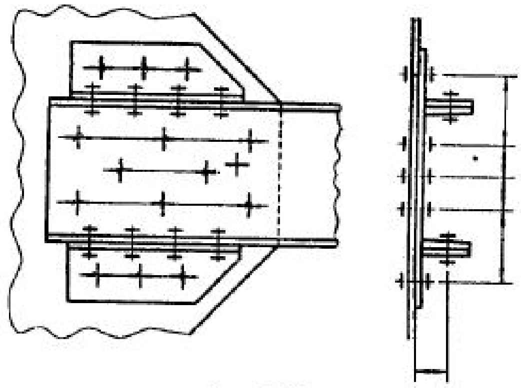


FIG. 16.2

16.2.2 *Representation on Projection Planes Parallel to the Axes of the Fastener*

In order to represent holes, bolts and rivets on projection planes parallel to their axes, the symbolic representation shown in Tables 16.2 and 16.3 shall be adopted. The horizontal line of this symbolic representation shall be drawn in a continuous narrow line (01.1); all other parts shall be drawn in a wide line (01 .2), in accordance with Section 6.

16.3 Dimensioning

Dimension lines shall be terminated in accordance with Section 6.

16.3.1 The extension lines shall be separated from the symbolic representation of holes, bolts and rivets on projection planes parallel to their axes (*see* Fig. 16.2).

16.3.2 The diameter of holes shall be indicated on a leader line pointing to the symbolic representation of a hole (*see* Fig. 16.3).

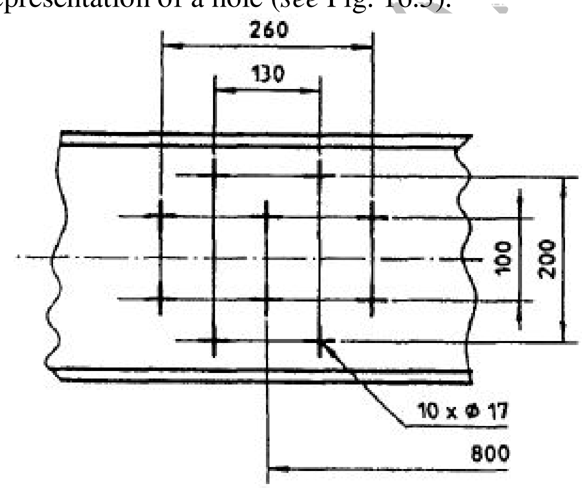


FIG. 16.3

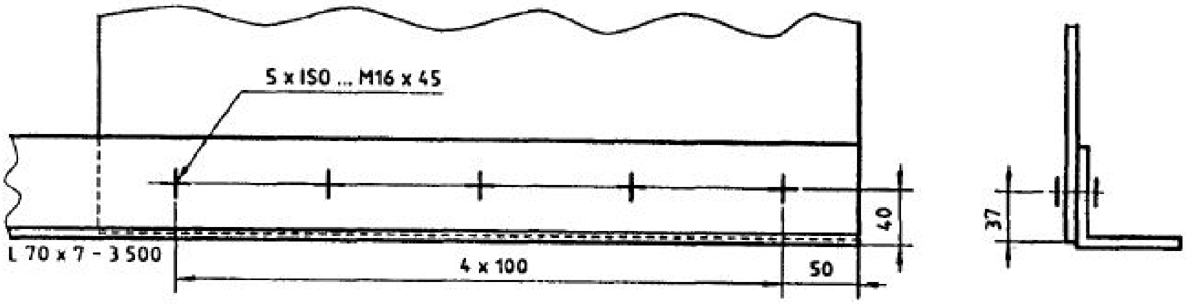


FIG. 16.4

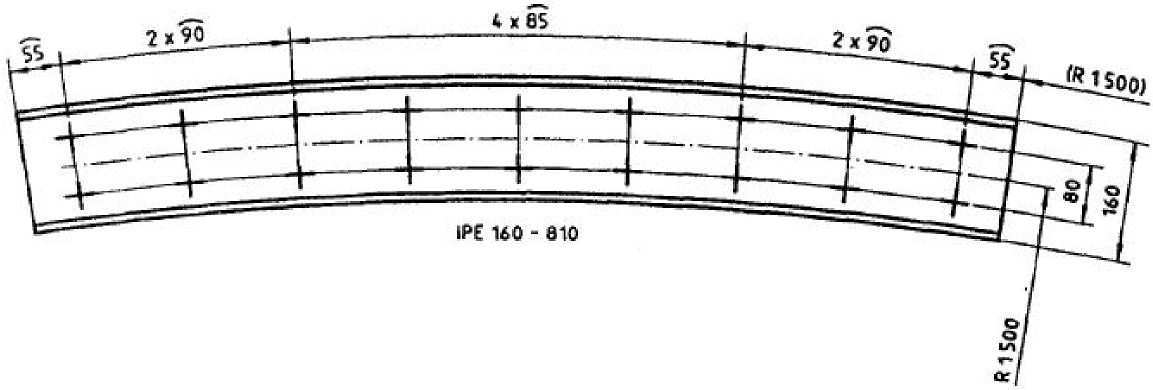


FIG. 16.5

16.3.3 To indicate the characteristics of bolts and rivets, their designations shall be given on a leader line pointing to the symbolic representation (*see* Fig. 16.4).

16.3.4 The designation of holes, bolts and rivets, when referring to a group of identical elements, can be restricted to one exterior element. In this case the designation shall be preceded by the number of holes, bolts or rivets constituting the group (*see* Fig. 16.3 and 16.4).

16.3.5 Holes, bolts and rivets equidistant from a centreline may be dimensioned as **shown in** Fig. 16.3 to 16.5.

SECTION 17– SIMPLIFIED REPRESENTATION OF BARS AND PROFILE SECTIONS

[Based on IS 10720:1999/ISO 5261-1995]

17.1 Scope

This section specifies rules for the simplified representation of bars and profile sections in assembly and detail drawings concerning, among others:

- structural metal work consisting of plates and sheets, profile sections and compound elements(including bridges, frameworks, pilings, etc);
- lifting and transport appliances;
- storage tanks and pressure vessels; and
- lifts, moving stairways and conveyor belts,

For details on the dimensions on the various Sections of bars and beams etc please refer IS 808:1989.

17.2 Complementary rules for the simplified representation of bars and profile sections

The simplified representation of bars and profile sections shall consist of their relevant IS designation followed, if necessary, by the cutting length, separated by a hyphen. This designation may also be used when filling in an item list (Section 2).

Example:

The simplified representation of an equal leg angle profile in accordance with IS 808, measuring 50 mm x 50 mm x 4 mm and having a cutting length of 1 000 mm shall consist of the following IS designation:

Angle profile IS 808 -50x50x 4-1000

If there is no designation specified in a standard, the designation shall be composed of the graphical symbol followed by the necessary dimensions, in accordance with Tables 17.1 and 17.2

Table 17.1 applies to the designation of bar sections.

Example:

The simplified representation of a rectangular solid bar section measuring 50 mm x 10 mm and having a cutting length of 100 mm shall consist of the following designation:

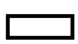
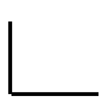
 50 x 10 - 100

Table 17.2 applies to the designation of profile sections and indicates which graphical symbols may be replaced by case letters, if appropriate, for simplification.

Example:

The simplified representation of an angle profile section measuring 89 mm x 60 mm x7 mm and having a cutting length of 500 mm shall consist of one of the following two designations:



89 x 60 x 7 - 500
or
L 89 x 60 x 7 - 500

The designation shall be positioned in close proximity to the relevant item (*see* Figure 17.1 to 17.3). Figure 17.3 includes L-shaped profiles for which the graphical symbols are positioned to reflect the arrangement for assembly.

17.3 Schematic representation of structural metal work

Compound frames of structural metal work can be schematically represented by continuous wide lines (type 01.2) indicating the centroidal lines of the intersecting elements. In this case, the values of the distances between the reference points of the centroidal lines shall be indicated directly on the represented elements (*see* Figure 17.4).

Closed dimensional chains are permitted. However, in the case of cumulative tolerances, equalization via one of the dimensions shall be indicated.

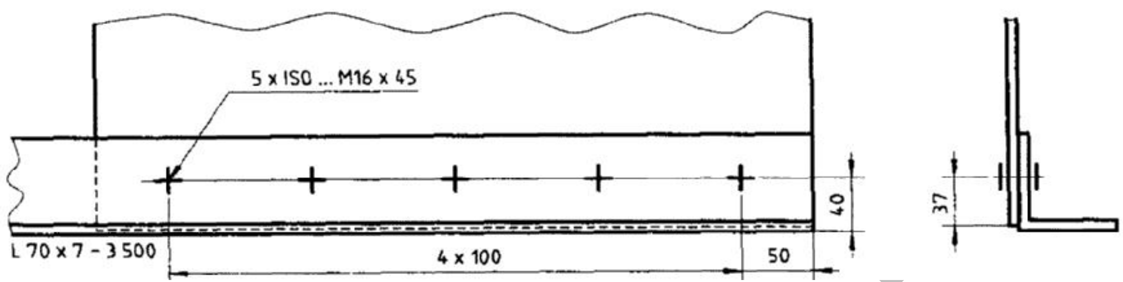


FIG 17.1 ¯ Section in one plane

Table 17.1 - Graphical Symbols and Dimensions for Bar Sections

Description of bar section	Dimensions	Designation	
		Graphical symbol	Necessary dimensions
Circular solid section	⌀d	∅	d
Tube	⌀d, t		d × t
Square solid section	b	□	b
Square hollow section	b, t		b × t
Rectangular solid section	b, h	—	b × h
Rectangular hollow section	b, h, t		b × h × t
Hexagonal solid section	s	⬡	s
Hexagonal hollow section	s, t		s × t
Triangular solid section	b	△	b
Semicircular solid section	b, h	◠	b × h

Table 17.2 - Graphical Symbols and Dimensions for profile Sections

Description of profile section	Designation		
	Graphical symbol	Alternative letter symbol	Dimensions
Angle section	∟	L	Characteristic dimensions
T-section	T	T	
I-beam section	I	I	
H-beam section	H	H	
Channel section	[	U	
Z-section	⎤	Z	
Rail section			
Bulb angle section			
Bulb flat section			

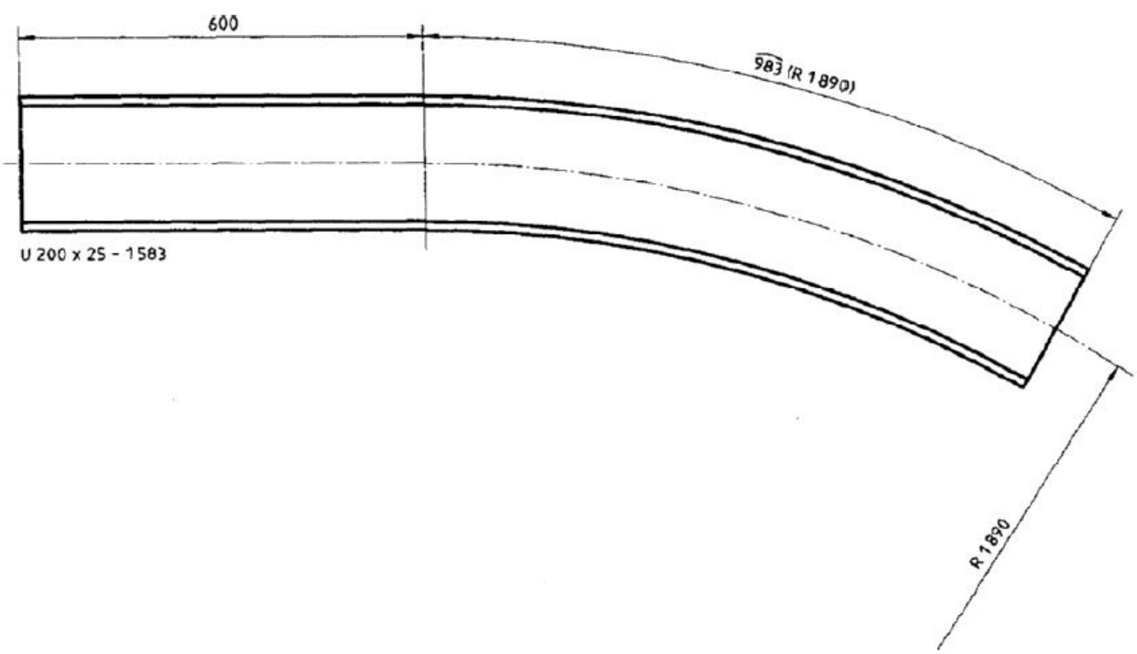


FIG 17.2

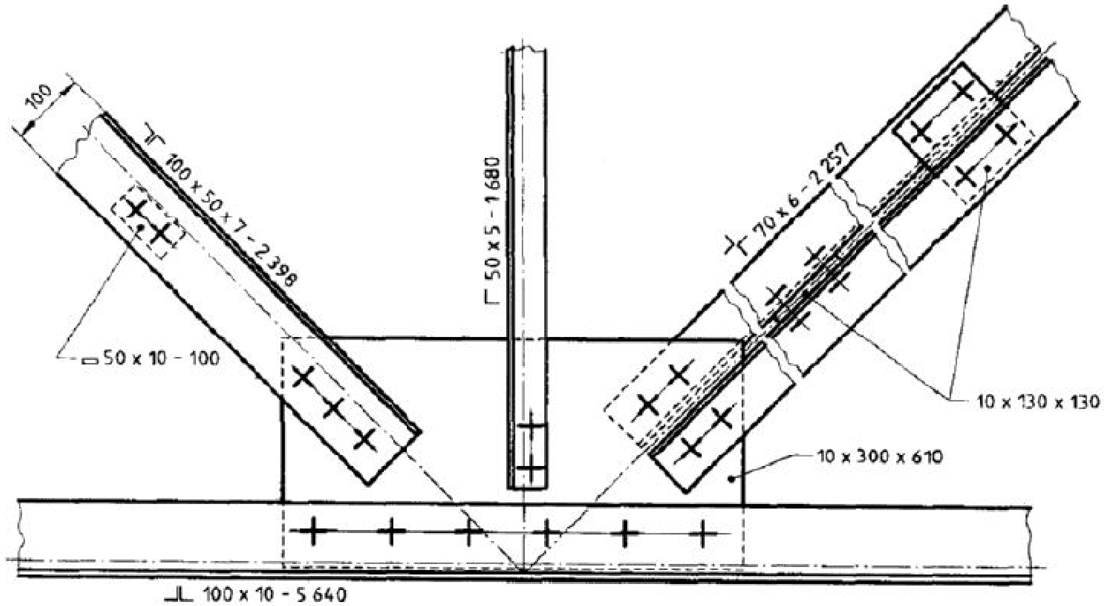


FIG 17.3

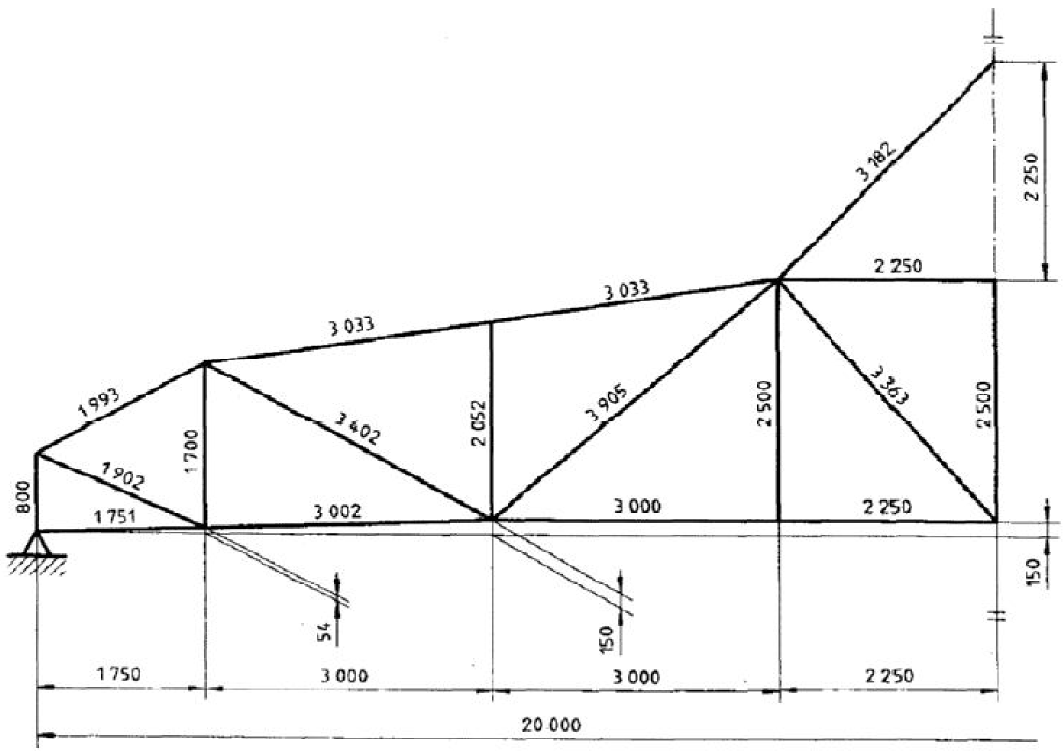


FIG 17.4

SECTION 18 – SYMBOLIC REPRESENTATION OF WELDED JOINTS ON DRAWINGS

[Based on ISO 2553:2013]

18.1 Scope

This section defines the rules to be applied for symbolic representation of welded joints on technical drawings. This may include information about the geometry, manufacture, quality and testing of the welds. The principles of this standard may also be applied to soldered and brazed joints.

18.2 Terms and definitions

18.2.1 *Welding symbol*

Symbol consisting of an arrow line and a reference line and which may also include elementary and supplementary symbols, dimensions and/or tail, used on technical drawings to indicate welded joint type, location and joint preparation.

18.2.2 *Basic welding symbol*

Symbol consisting of an arrow line, reference line and tail used when the joint is not specified and only to indicate that a welded joint is to be made.

18.2.3 *Arrow line*

Leader line used to indicate the joint that is to be welded generally drawn at 135° to the reference line.

18.2.4 *Reference line*

Part of the welding symbol on which the elementary symbol is located, generally drawn parallel to the bottom edge of the drawing.

18.2.5 *Tail*

V shaped element added to the end of the continuous reference line away from the arrow line.

18.2.6 *Arrow side*

Side of the joint to which the arrow line is pointing.

18.2.7 *Other side*

Opposite side of the joint to the arrow side.

18.2.8 *Elementary symbol*

Symbol forming part of the welding symbol and drawn on the reference line to indicate the type of weld and joint preparation.

18.2.9 *Supplementary symbol*

Symbol used in conjunction with elementary symbols to convey additional information about the joint.

18.2.10 *Complimentary information*

Non-symbolic information, relevant to the welds being made, which may be included in the tail of the welding symbol.

18.2.11 *Intermittent weld*

Series of weld elements made at intervals along a joint.

18.2.11.1 *Chain intermittent weld*
Intermittent weld on each side of a joint (usually fillet welds in T and lap joints) arranged so that the welds lie opposite one another along the joint.

18.2.11.2 *Staggered intermittent weld*
Intermittent weld on each side of a joint (usually fillet welds in T and lap joints) arranged so that the welds on one side lie opposite to the spaces on the other side along the joint.

18.2.12 *Offset*
Distance between the start of welding on one side of a staggered intermittent weld made on both sides of the joint and the start of welding on the other side.

18.2.13 *Back run*
Final run deposited on the root side of a fusion weld.

18.2.14 *Backing weld*
Backing in the form of a weld.

18.2.15 *Nominal weld length*
Design length of a weld.

18.2.15.1 *Nominal length of weld elements*
In intermittent welds, the design length of the elements of the weld.

18.2.16 *Nominal throat thickness (a)*
Design value of the height of the largest isosceles triangle that can be inscribed in the section of a fillet weld.

18.2.17 *Leg length (z)*
Distance from the actual or projected intersection of the fusion faces and the toe of a fillet weld, measured
across the fusion face.

18.2.18 *Penetration depth*
<Butt welds> thickness of the weld metal excluding any reinforcement.

18.2.19 *Deep penetration throat thickness (s)*
<Fillet welds> nominal or effective throat thickness to which a certain amount of fusion penetration is added.

18.2.20 *Flare-bevel weld*
Butt weld between a joint member with a curved surface and another with a planar surface.

18.2.21 *Flare-V weld*
Butt weld between two members with curved surfaces.

18.2.22 *Field weld*
Weld made outside workshops usually at the place of final installation.

18.3 Welding symbol

18.3.1 *General*

A reference line and arrow line are required elements. Additional elements may be included to convey specific information.

It is preferable that the welding symbol is shown on the same side of the joint that the weld is to be made, i.e. the arrow side.

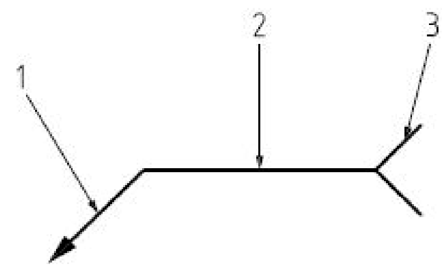
The thickness of the arrow lines, reference line, elementary symbols and lettering shall be in accordance with ISO 128 and ISO 3098-2.

In order not to overburden drawings, reference should be made to notes in the drawing or other design-related documents.

18.3.2 *Basic welding symbol*

If joint details are not specified and the only requirement is to indicate that a joint is to be welded, the basic symbol shown in Figure 18.1may be used. In this case, a dual reference line is not required for system A as no details concerning the weld are being conveyed.

The basic welding symbol shall comprise an arrow line, reference line and a tail.



Key

1 arrow line
2 reference line
3 tail

NOTE-- This symbol is often used to indicate the location of tack welds.

FIG 18.1 - Basic welding symbol (joint details and type not specified)

18.3.3 *Welding symbol systems*

This section recognizes two different systems, A and B, to designate the arrow side and other side on drawings.

The symbolic representation in system A is based on a dual reference line consisting of a continuous line and a dashed line.

The symbolic representation in system B is based on a single reference line.

Clauses, Tables and Figures which carry the suffix `A_ or `B_ are applicable only to system A or system B respectively.

Clauses, tables and figures which do not have a suffix are applicable to both systems.

System A and B shall not be mixed and drawings shall clearly indicate which system is used including units of measurement in accordance with ISO 129-1.

Examples of comprehensive welding symbols showing the location of elements are given in Figure 18A.1.

18.3.4 *Elementary symbols*

18.3.4.1 *General*

Elementary symbols, in accordance with Table 18.1, can be added to the reference line in both systems A and B to indicate the type of weld to be made.

Elementary symbols form part of the welding symbol and shall be drawn attached to the reference line generally at the mid-point.

Elementary symbols may be complemented by:

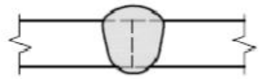
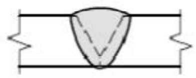
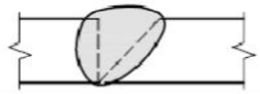
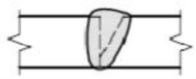
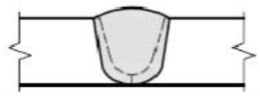
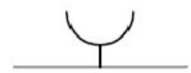
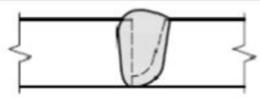
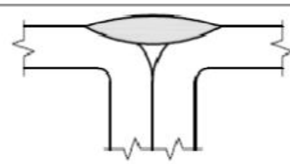
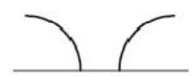
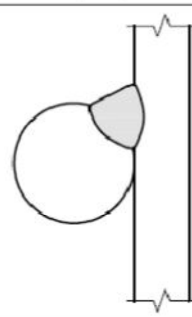
- supplementary symbols (*see* 18.3.5 and Table 18.3);
- dimensions (*see* Clause 18.4);
- complementary information.

The orientation of the elementary symbols shall not be changed to that shown.

Annex 18B gives guidance on tolerances and transition points for butt welds, edge welds and fillet welds.

If clear illustration by means of symbols is not possible, cross sections of the welds may be drawn and dimensioned.

Table 18.1 – Elementary symbols

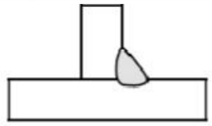
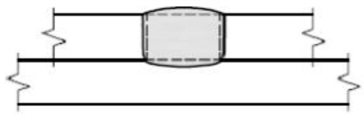
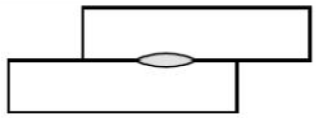
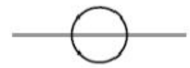
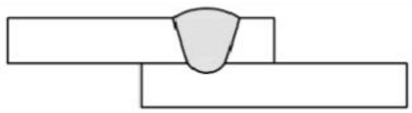
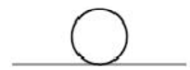
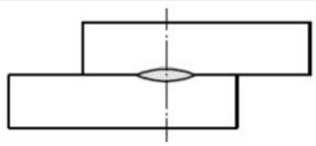
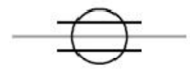
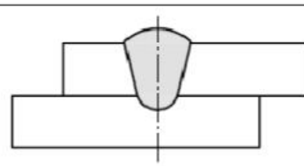
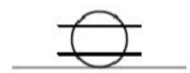
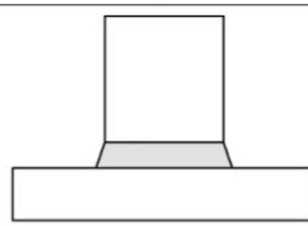
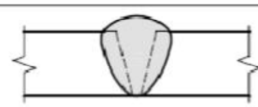
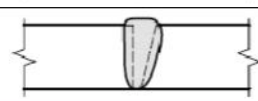
No.	Designation	Illustration (dashed lines show joint preparation prior to welding)	Symbol[a]
1	Square butt[b]		
2	Single-V butt[b]		
3	Single-V butt with broad root face[b]		
4	Single-bevel butt[b]		
5	Single-bevel butt with broad root face[b]		
6	Single-U butt [b]		
7	Single-J butt[b]		
8	Flare V		
9	Flare bevel		

a The grey line is not part of the symbol. It indicates the position of the reference line.

b Butt welds are full penetration unless otherwise indicated by dimensions on the welding symbol or by reference to other information, for example the WPS.

c May be used for joints with more than 2 members.

Table 18.1 – Elementary symbols (continued)

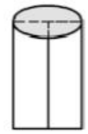
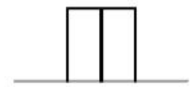
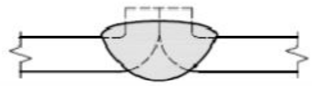
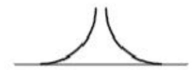
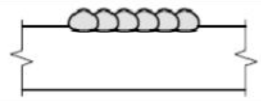
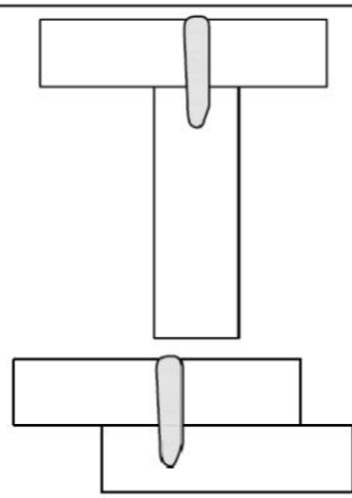
No.	Designation	Illustration (dashed lines show joint preparation prior to welding)	Symbol[a]
10	Fillet		
11	Plug (in slots or circular holes)		
12	Resistance spot (including projec-tion welding in system A)		
13	Fusion spot (and projection welding in system B)		
14	Resistance seam		
15	Fusion seam		
16	Stud		
17	Steep-flanked single-V butt[b]		
18	Steep-flanked single-bevel butt[b]		

[a] The grey line is not part of the symbol. It indicates the position of the reference line.

[b] Butt welds are full penetration unless otherwise indicated by dimensions on the welding symbol or by reference to other information, for example the WPS.

[c] May be used for joints with more than 2 members.

Table 18.1 – Elementary symbols (continued)

No.	Designation	Illustration (dashed lines show joint preparation prior to welding)	Symbol[a]
19	Edge[c]		
20	Flanged butt/corner weld		
21	Overlay		
22	Stake[c]		

[a] The grey line is not part of the symbol. It indicates the position of the reference line.

[b] Butt welds are full penetration unless otherwise indicated by dimensions on the welding symbol or by reference to other information, for example the WPS.

[c] May be used for joints with more than 2 members.

18.3.4.2 *Combination of elementary symbols*

Elementary symbols may be combined as required to represent particular weld configurations.

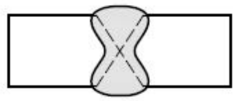
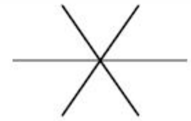
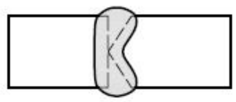
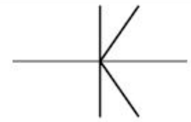
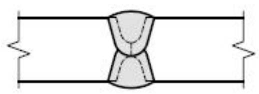
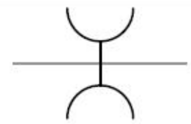
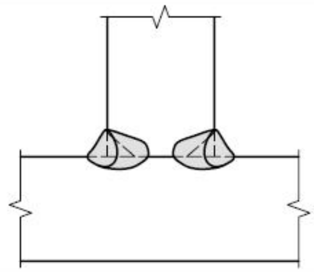
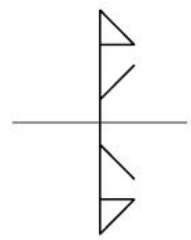
18.3.4.3 *Double-sided but welds*

The elementary symbols shall be arranged opposite each other on the reference line, including all required information, when used to represent symmetrical welds.

In the case of symmetrical double-sided welds with identical symbols and dimensions, the dashed
reference line should be deleted for system A (*see* Table 18.2).

An *example* of an asymmetrical double-sided weld is shown in Table 18A.3.

Table 18.2 – Combined elementary symbols to represent double-sided welds

No.	Weld type	Illustration of weld[a]	Symbol[b]
1	Double-V butt		
2	Double bevel butt		
3	Double-U butt		
4	Double bevel butt (with broad root face) and fillet welds		

a Welds may be partial or full penetration which is to be indicated by dimensions on the welding symbol (*see* Table 18.5) or by reference to other information, for example the WPS.

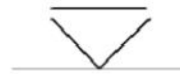
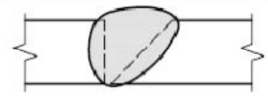
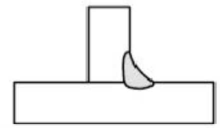
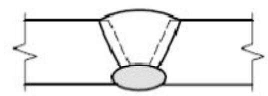
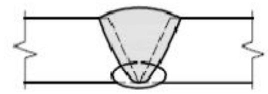
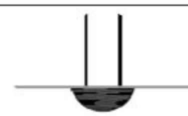
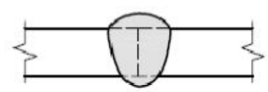
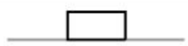
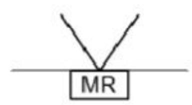
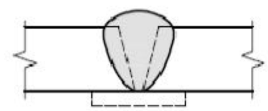
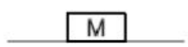
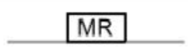
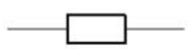
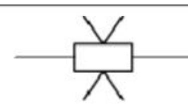
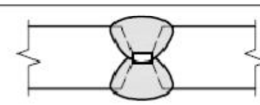
b The grey line is not part of the symbol. It indicates the position of the reference line.

18.3.5 *Supplementary symbols*

18.3.5.1 *General*

Additional information concerning the required joint may be provided by the use of supplementary symbols in accordance with Table 18.3. Supplementary symbols can, for example, provide information about the shape of the weld or how the welded joint shall be made.

Table 18.3 – Supplementary symbols

No.	Designation	Symbol[a]	Application example[a]	Illustration of weld
1	Flat-finished flush[b]			
2	Convex[b]			
3	Concave[b]			
4	Toes blended smoothly[c]			No example
5	a) Back run[d] (made after the single-V butt weld)			
	b) Backing weld[d] (made before the single-V butt weld)			
6	Specified root reinforcement (butt welds)[e]			
7a	Backing (unspecified)			
7b	Permanent backing [f]			
7c	Removable/temporary backing[f]			
8	Spacer			

[a] The grey line is not part of the symbol and is included to show the position of symbol on reference line and/or the arrow line only.

[b] Welds that require approximately flush or convex faces without post weld finishing are specified by use of the flush or convex contour symbol.

Welds to be finished flush or convex by post weld finishing or that require a flat but not flush surface require additional information, e.g. addition of a note in the tail of the welding symbol

Other symbols in accordance with ISO 1302 may be used to specify surface finish.

[c] The toes shall be blended smoothly by welding or finishing. Processing details may be specified in the work instructions or WPS.

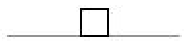
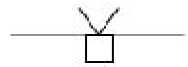
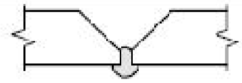
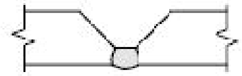
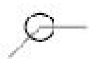
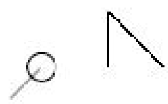
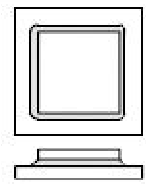
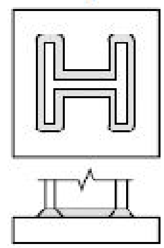
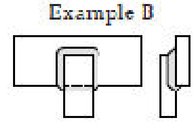
[d] The weld run sequence may be indicated on the drawing e.g. by use of multiple reference lines, a note in the tail or by reference to a weld procedure specification.

[e] In system B, also used to designate flanged butt/corner welds (*see* 18.3.5.6)

[f] M = material to be part of the final welded joint, MR = material to be removed after welding. Further information on the material can be included in the tail or elsewhere.

[g] Explanations of *a*, *z*, *n*, *l* and *(e)* are given in Clause 18.4.

Table 18.3 – Supplementary symbols (continued)

No.	Designation	Symbol[a]	Application example[a]	Illustration of weld
9	Consumable insert			 a) Joint showing insert in place  b) Welded joint showing root bead (insert incorporated into root). Single V but weld not shown
10	Weld all-around			 Example A  Example B  Example C

[a] The grey line is not part of the symbol and is included to show the position of symbol on reference line and/or the arrow line only.

[b] Welds that require approximately flush or convex faces without post weld finishing are specified by use of the flush or convex contour symbol.

Welds to be finished flush or convex by post weld finishing or that require a flat but not flush surface require additional information, e.g. addition of a note in the tail of the welding symbol

Other symbols in accordance with ISO 1302 may be used to specify surface finish.

[c] The toes shall be blended smoothly by welding or finishing. Processing details may be specified in the work instructions or WPS.

[d] The weld run sequence may be indicated on the drawing e.g. by use of multiple reference lines, a note in the tail or by reference to a weld procedure specification.

[e] In system B, also used to designate flanged butt/corner welds (see 18.3.5.6)

[f] M = material to be part of the final welded joint. MR = material to be removed after welding. Further information on the material can be included in the tail or elsewhere.

[g] Explanations of a, z, n, l and (e) are given in Clause 18.4.

18.3.5.2 *Weld all-around symbol*

The weld all-around symbol, added at the junction of the arrow and reference lines, may be used to designate a continuous weld, single or double-sided, extending around a series of connected joints (*see* Table 18.3).

The series of joints may involve different directions and may lie in more than one plane but the weld shall always be of the same type and dimensions.

The weld all-around symbol shall not be used if:

a) the weld does not start and end at the same point, i.e. it is not continuous;
b) the weld type changes, for example from a fillet weld to a butt weld;
c) the dimensions change, for example the nominal throat thickness of a fillet weld. In this case, each weld shall be identified using a separate welding symbol;

NOTE -- The weld all-around symbol is not used to indicate that welds are to be made everywhere.

Welds extending around the circumference of a circular section/hole or slot do not require the use of the weld all-around symbol to specify a continuous weld.

18.3.5.3 *Welds of the same type made by point to point*

The weld between two points symbol may be used to designate a continuous weld, of the same type, extending between two points. In this case, the weld does not start and stop at the same point, and the weld all around symbol shall not be used (*see* Table 18.3). The end points of the weld shall be clearly indicated and the welding symbol shall clearly indicate the joint to be welded.

Fig 18.2 gives an example of how a continuous weld extending around a series of connected points but where the weld does not start and end at the same point, can be designated by one welding symbol.

18.3.5.4 *Field welds*

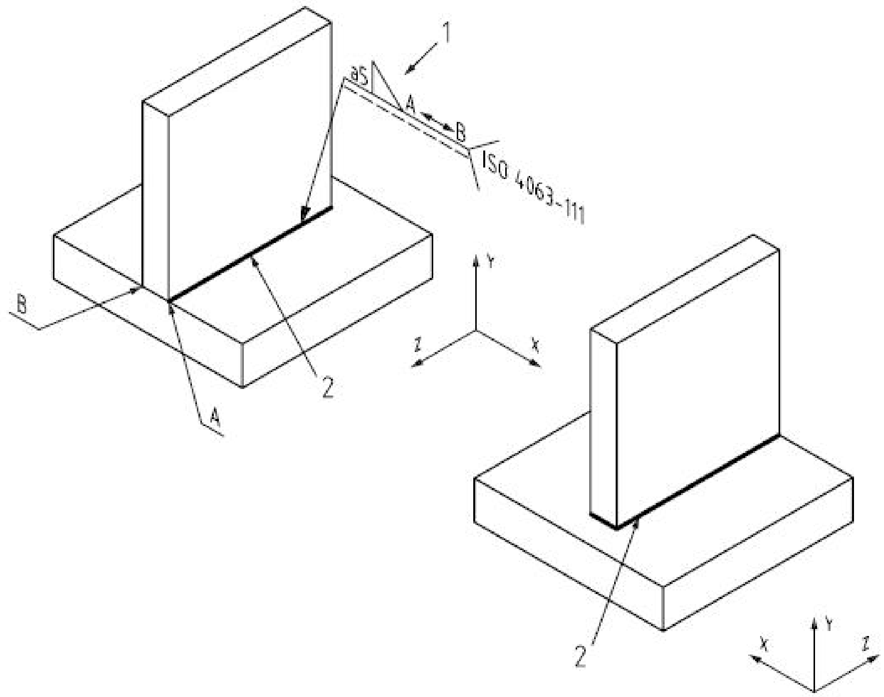
Field welds shall be specified by adding the field weld symbol at the junction of the arrow and reference lines (*see* Table 18.3). The symbol shall be placed perpendicularly to and above the reference line. The symbol applies to the whole welding symbol.

18.3.5.5 *Root reinforcement – but welds made from one side*

The root reinforcement symbol shall only be used when complete joint penetration plus a specified minimum root reinforcement dimension is required in butt welds made from one side (*see* Figure 18.3).The root reinforcement symbol shall be placed opposite the elementary symbol and on the other side of the reference line.

18.3.5.6 *Welds on flanged but and flanged corner joints*

Welds on flanged butt and flanged corner joints shall be specified using the symbols shown in Table 18.4.

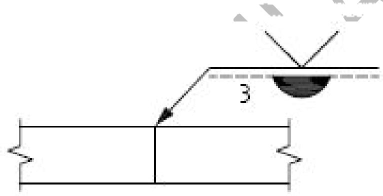


Key

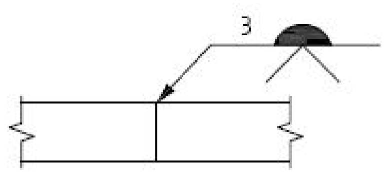
1 welding symbol
2 visual response (welded in accordance with the welding symbol)
A, B weld end positions

There is no weld from point B to point A (fillet weld not possible).
Any identifier may be used to identify the points between welds e.g. A, B and X, Y etc.

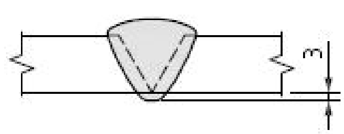
FIG 18.2 - Example of a welding symbol for a fillet weld made between two points A and B



a) System A welding symbol



b) System B welding symbol



c) Weld produced using either system

FIG 18.3 - Example of a weld with specified root reinforcement

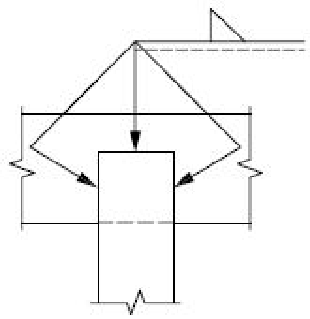
18.3.6 *Arrow line*
18.3.6.1 *General*
An arrow line shall be used to indicate the joint to be welded.
The arrow line shall:

- point to and shall be in contact with a solid line comprising part of the joint on the drawing (visible line);
- be drawn at an angle to and joined to a reference line and completed with a closed filled arrowhead.

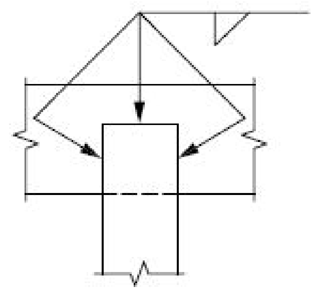
The arrow line may be joined to either end of the reference line.

18.3.6.2 *Multiple arrow lines*

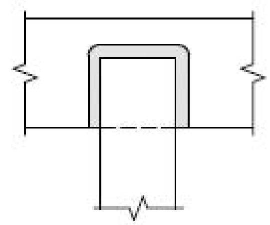
Two or more arrow lines may be combined with a single reference line to indicate the locations of identical welds (*see* Fig 18.4).



a) System A welding symbol



b) System B welding symbol



c) Weld produced using either symbol

FIG 18.4 - Examples of use of multiple arrow lines

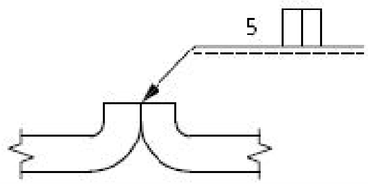
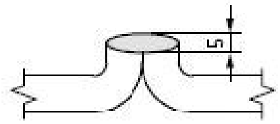
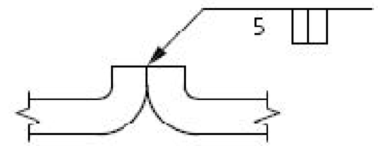
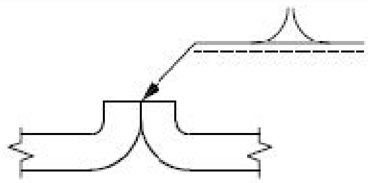
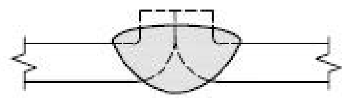
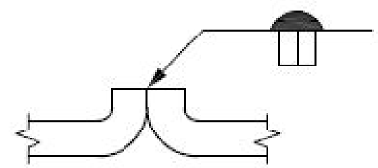
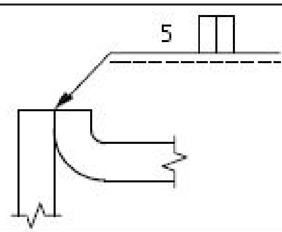
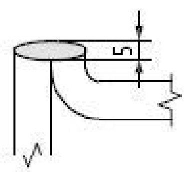
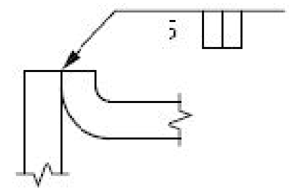
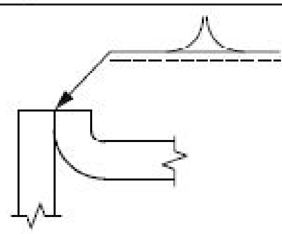
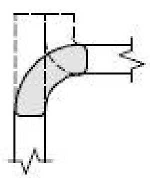
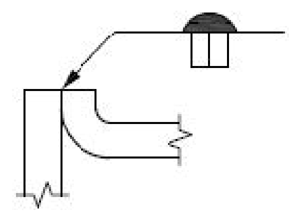
18.3.6.3 *Broken arrow lines*

For butt welds in plates (excluding T-butt welds) when a specific joint member is required to be prepared (e.g. single-bevel or single-J butt welds), the arrow line shall have a break and point toward that member.

The arrow line need not be broken if it is obvious or if there is no preference as to which member is to be prepared.

Examples of the use of broken arrow lines are given in Table 18A.1.

Table 18.4 – Welds on flanged but and flanged corner joints

No.	Weld type	System A welding symbol	Illustration of weld	System B welding symbol
		FLANGED BUTT JOINTS		
1	Edge			
2	Flanged butt			
		FLANGED CORNER JOINTS		
3	Edge			
4	Flanged corner			

18.3.7 *Reference line and weld location*

18.3.7.1 *Reference line*

The reference line when combined with elementary symbols, is used to indicate the side of the joint on which the weld is to be made.

NOTE: The reference line can be drawn parallel to the side edge of the drawing (whole welding symbol rotatedby 90°) but should only be done when space does not permit drawing parallel to the bottom edge.

18.3.7.1A *Reference line – System A*

The reference line consists of two parallel lines of equal length: a continuous line and a dashed line (*see* Examples in Annex 18A).The dashed line may be drawn above or below the continuous line but shall preferably be drawn below. The dashed line should be omitted for symmetrical welds and for spot and seam welds made at the interface between two components.

18.3.7.1B *Reference line – System B*

The reference line shall be drawn as a continuous line (*see* Examples in Annex 18A).

18.3.7.2 *Weld location*

18.3.7.2.1 *Arrow side/other side*

The arrow side is the side of the joint to which the arrowhead is pointing (*see* Fig 18.5).
The other side is the opposite side of the joint to which the arrowhead is pointing. The arrow side and other side always form part of the same joint.
The other side of a joint shall not be confused with a hidden weld forming part of a different joint.

Examples of how to designate welds on the arrow side and other side of joints are given in Table 18A.2.

18.3.7.2.1A *Arrow side/other side – System A*

Elementary symbols shall be located on the continuous line when the weld is to be made on the arrow side of the joint.
Elementary symbols shall be located on the dashed (identification) line when the weld is to be made on the other side of the joint.

18.3.7.2.1B *Arrow side/other side – System B*

Elementary symbols shall be located below the reference line when the weld is to be made on the arrow side of the joint.
Elementary symbols shall be located above the reference line when the weld is to be made on the other side of the joint.

NOTE 1--In system A, the component of the reference line on which the elementary symbol is placed determines the side of the joint which is to be welded - the dashed line can be drawn above or below the solid line.

NOTE 2-- In system B, the position of the elementary symbol above or below the reference line determines the side of the joint on which the weld is made

18.3.7.2.2 *Plug, slot, spot, seam and projection welds*

The arrow line shall point to and be in contact with the outer surface of one of the joint members, at the centreline of the required weld.
In the case of welds made at the interface between two members, the elementary symbol shall be placed centrally on the reference line (*see* Table 18A.2) and there is no arrow side/other side

relevance. In this case, the dashed reference line may be omitted from system A welding symbols.

18.3.7.2.2A *Projection weld – System A*

The arrow line shall point to the sheet containing the projection and the elementary symbol shall be placed centrally on the reference line (*see* Table 18A.2). The projection welding process shall be clearly identified e.g. in the tail (ISO 4063‑23).

18.3.7.2.2B *Projection weld – System B*

The arrow line shall point to the sheets to be welded and the elementary symbol shall be placed above or below the reference line to designate which sheet contains the projection (*see* Table18A.2). The projection welding process shall be identified e.g. in the tail (PW).

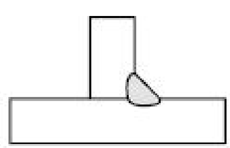
18.3.7.3 *Multiple reference lines*

Two or more reference lines can be used to indicate a series of operations. The first operation shall be specified on the reference line closest to the arrowhead. Subsequent operations shall be specified sequentially on the other reference lines (*see* Figure 18.6).

NOTE-- For joints requiring more than one weld type, combined symbols may also be used (*see* Table 18.2).

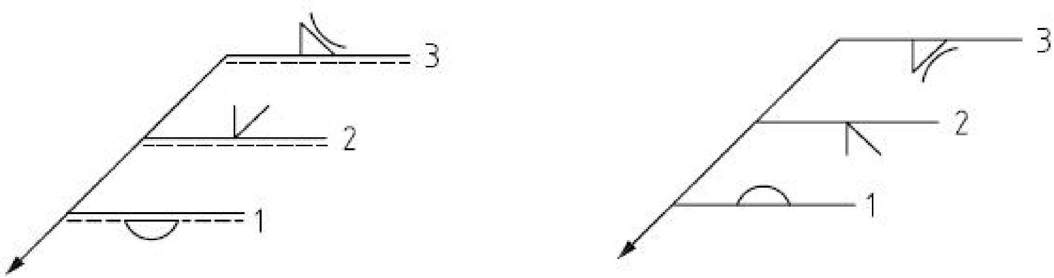
a) System A - Arrow side (symbol on solidc) System B - Arrow side (symbol below
component of reference line)reference line)

b) System A - Other side (symbol on dashedd) System B - Other side (symbol above
component of reference line) reference line)



e) Same weld produced using four options a) to d)

FIG 18.5 - Examples of welding symbols to illustrate arrow side and other side



a) Example ´ System A b) Example ´ System B

Key

1 first operation
2 second operation
3 third operation

1, 2 and 3 are shown to indicate the order of the welding operations and are not to be included on drawings.

FIG 18.6 - Multiple reference lines

18.3.8 *Tail*

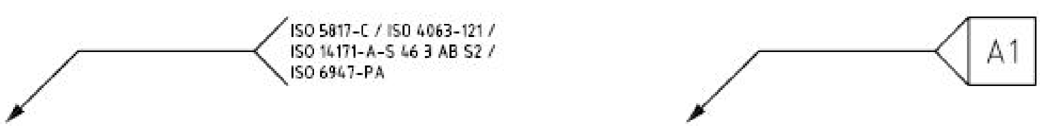
The tail is an optional element which may be added to the end of the continuous reference line (*see* Fig 18.7) where additional complementary information is included as part of the welding symbol, for example:

a) quality level for example in accordance with ISO 5817, ISO 10042, ISO 13919 etc.;
b) the welding process, reference number in accordance with ISO 4063 or abbreviation;
c) filler material for example in accordance with ISO 14171, ISO 14341, etc.;
d) welding position for example in accordance with ISO 6947;
e) supplementary information to be considered when making the joint

The information shall be listed and separated by a forward slash (/), [*see* Figure 18.7a)].

A closed tail shall only be used to indicate reference to a specific instruction e.g. reference to a welding procedure specification (WPS), welding procedure qualification record (WPQR) or other document [*see* Fig 18.7b)].

Repetition of additional information on symbols on a drawing shall be avoided. A single general note on the drawing shall be used instead.



a) Open tail b) Closed tail

FIG 18.7 - Examples of the use of a tail on welding symbols

18.4 Dimensioning of welds

18.4.1 *General*
Dimensions shall be specified on the same side of the reference line as the associated elementary symbol(*see* Table 18.5 and Fig 18A.1).

Drawings shall clearly indicate the units of measurement. Dual units of measure shall be avoided. If it is desired to show conversions from one system of measure to another, a table of conversions should be included on the drawing.

18.4.2 *Cross-sectional dimensions*
Cross-sectional dimensions shall be placed to the left of the elementary symbol. Letters shall only be combined with cross-sectional dimensions for fillet welds (*see* 18.4.5).

18.4.3 *Length dimensions*
18.4.3.1 *General*
Nominal weld length dimensions shall be placed to the right of the elementary symbol.

In the absence of a length dimension, the weld shall be continuous along the entire length of the joint except when using the weld from point to point symbol where the weld extends only between the identified points.

Start and end points of welds that are not continuous along the entire length of the joint shall not be part of the welding symbol but indicated clearly as part of the drawing.

18.4.3.2 *Intermittent welds*
18.4.3.2.1 *General*
Dimensions of intermittent welds shall be placed to the right of the elementary symbol (*see* Table 18.5):

a) number of weld elements, n
b) length of weld elements, l
c) spacing between weld elements, e (in parentheses)

A multiplication symbol shall be placed between the number of elements, n, and the length of the weld elements, l. If the number of weld elements is not specified, the intermittent weld shall be made along the whole length of the joint.

NOTE-- Other methods, commonly used by Pacific Rim countries, for designating intermittent welds are shown in Annex 18C.

18.4.3.2.2 *Chain intermittent welds*
Chain intermittent welds made on both sides of the joint shall include all information for welds made on both sides of the joint.

18.4.3.2.3 *Staggered intermittent welds*
Staggered intermittent welds made on both sides of the joint, shall be designated using the `Z_ symbol across the reference line (*see* Table 18.3, item 13). In the absence of any information concerning the offset, the centres of the weld elements on one side of the joint shall correspond with the centres of the gaps on the opposite side of the joint. Otherwise, the offset shall be specified in the tail or elsewhere.

18.4.3.2.4 *Extent of welding*

Additional weld lengths at the ends of intermittent welds shall be specified using separate welding symbols. Unwelded lengths at the ends of intermittent welds shall be specified on the drawing.

18.4.4 *Butt welds*

18.4.4.1 *Penetration depth*

The required penetration depth shall be placed to the left of the elementary symbol (*see* Table 18.5, No. 1).

In the absence of any cross-sectional dimension, butt welds shall always be full penetration.

Where joint geometry or joint preparation are not specified, an alternative symbol can be used to represent butt welds on drawings by specifying the required weld quality - *see* Clause 18.6.

Where a specified root reinforcement is required, the minimum dimension of the root reinforcement shall be placed to the left of the root reinforcement symbol (*see* Fig 18.3).

18.4.4.2 *Double-sided welds*

In double-sided butt welds, each weld shall be separately dimensioned.

NOTE-- Full penetration symmetrical butt welds do not need to be dimensioned.

18.4.4.3 *Flanged butt welds*

Flanged butt welds are always full penetration welds (the raised edges are completely melted). These welds require no dimensioning.

18.4.4.4 *Flare bevel and flare-V butt welds*

Flare bevel and flare-V butt welds shall always be dimensioned. Examples of how to dimension these types of weld are given in Table 18.5, No 1.6 and 1.7.

18.4.5 *Fillet welds*

18.4.5.1 *Weld size*

The letter, *a*, nominal throat thickness, or *z*, leg length, shall be placed in front of the dimension to the left of the elementary symbol (*see* Table 18.5, No. 2.1).

For fillet welds with unequal leg lengths the dimensions of each leg shall be included, preceded by the letter *z*, e.g. *z*14 *z*28. If the required leg lengths cannot be identified clearly using the welding symbol, additional sketches or indications shall be given on the drawing or in other documents. See Table 18.5,No. 2.3.

For fillet welds made on both sides of a joint, the dimensions of both welds shall be specified even if they are identical (symmetrical).

18.4.5.2 *Deep penetration fillet weld*

The letter, *s*, shall be placed in front of the required deep penetration throat thickness. This shall be placed in front of the nominal throat thickness, *a*, and its dimension as shown in Table 18.5, No. 2.2.

18.4.6 *Plug welds in circular holes*

The diameter symbol, *d*, shall be placed in front of the required plug weld diameter at the faying surface, and to the left of the plug weld symbol (*see* Table 18.5, No. 3).

If plug welds are to be partially filled, the depth of filling shall be indicated inside the elementary symbol. In the absence of a depth dimension, the plug shall be completely filled (*see* Table 18.5, No. 3.1 and No. 3.2).

Intermittent welds shall be designated additionally with the number, and centre-to-centre spacing of welds to the right of the elementary symbol (*see* Table 18.5, No. 3.3).

18.4.7 *Plug welds in slots*

The required weld width, *c*, at the faying surface, shall be placed to the left of the plug weld symbol (*see* Table 18.5, No. 4).

If plug welds are to be partially filled, the depth of filling shall be indicated inside the elementary symbol(*see* Table 18.5, No. 4.2). In the absence of a depth dimension, the slot shall be completely filled.

Intermittent welds shall be designated additionally with the number, length and spacing of weld elements to the right of the elementary symbol (*see* Table 18.5, No. 4.3).

NOTE-- The plug weld symbol is not used to designate fillet welds in holes or slots.

18.4.8 *Spot welds*

The required spot weld diameter, *d*, shall be placed to the left of the spot weld symbol (*see Table 18.5, No. 5).*

Welds in series shall be designated with the number, and spacing of welds to the right of the elementary symbol (*see* Table 18.5, No. 5.1 and No. 5.2).

18.4.9 *Seam welds*

The required weld width, *c*, at the faying surface, shall be placed to the left of the seam weld symbol (*see* Table 18.5, No. 6).

Intermittent welds shall be additionally designated with the number, length and spacing of weld elements to the right of the elementary symbol (*see* Table 18.5, No. 6.1).

18.4.10 *Edge welds*

The required weld metal thickness of the edge weld shall be placed to the left of the edge weld symbol(*see* Table 18.5, No. 7).

18.4.11 *Stud welds*

The required stud diameter, *d*, shall be placed to the left of the stud weld symbol (*see* Table 18.5, No. 8).

Welds in series shall be designated with their number and spacing to the right of the elementary symbol.

18.4.12 *Overlay welds*

The required overlay thickness shall be placed to the left of the overlay welding symbol (*see* Table 18.5, No. 9).

Table 18.5 – Weld dimensions

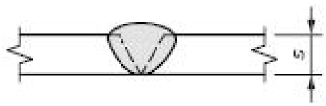
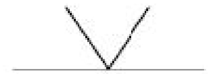
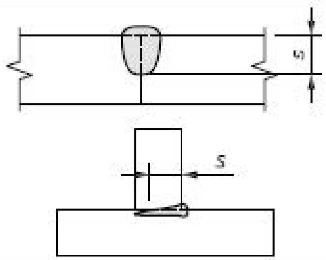
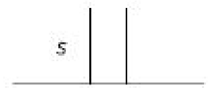
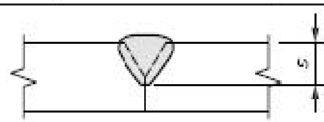
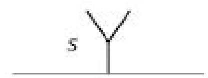
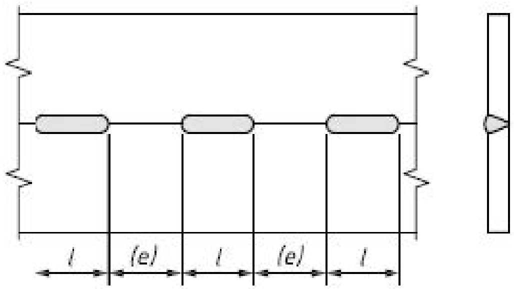
Weld type	Illustration	Symbol[a]	Comments
BUTT			
Full penetration			s = Penetration depth NOTE 1 No dimension to the left of the elementary symbol indicates butt welds shall be full penetration. NOTE 2 No dimension to the right of the elementary symbol indicates butt welds shall be continuous.
Partial penetration			s = penetration depth Letter s to be replaced by required dimension. NOTE No dimension to the right of the elementary symbol indicates butt welds shall be continuous.
			
Intermittent			n = number of weld elements l = nominal length of weld elements e = distance between weld elements n, l and e to be replaced by required values. NOTE No dimension to the left of the elementary symbol indicates the welds shall be full penetration.

Table 18.5 – Weld dimensions (continued)

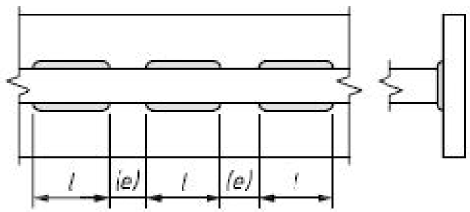
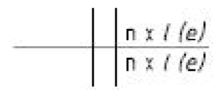
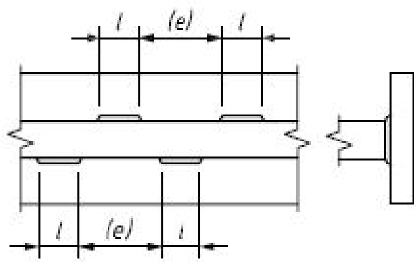
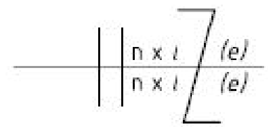
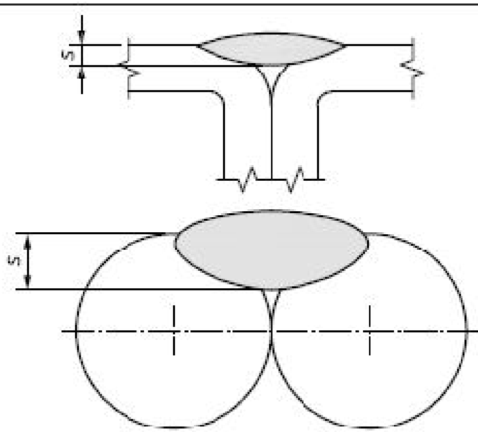
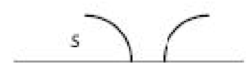
No.	Weld type	Illustration	Symbol[a]	Comments
1.4	Chain intermittent			n = number of weld elements l = nominal length of weld elements e = distance between weld elements n, l and e to be replaced by required values. NOTE No dimension to the left of the elementary symbol indicates the welds shall be full penetration.
1.5	Staggered intermittent			n = number of weld elements l = nominal length of weld elements e = distance between weld elements n, l and e to be replaced by required values. NOTE No dimension to the left of the elementary symbol indicates the welds shall be full penetration.
1.6	Flare V			s = penetration depth letter s to be replaced by required dimension.

Table 18.5 – Weld dimensions (continued)

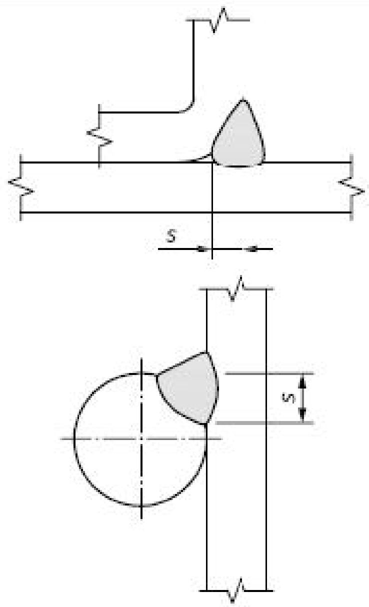
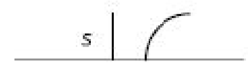
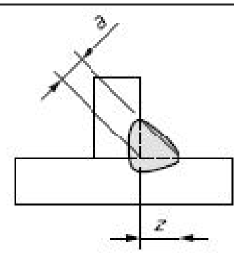
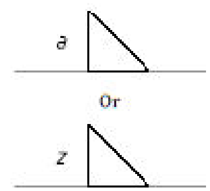
No.	Weld type	Illustration	Symbol[a]	Comments
1.7	Flare bevel			s = penetration depth letter s to be replaced by required dimension.
2	FILLET			
2.1	Fillet			a = nominal throat thickness z = leg length a, and z are to be included on the welding symbol with the required values.

Table 18.5 – Weld dimensions (continued)

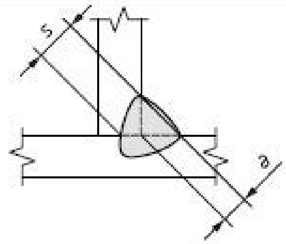
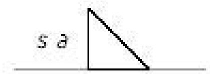
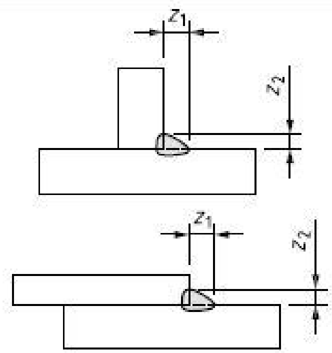
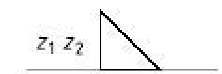
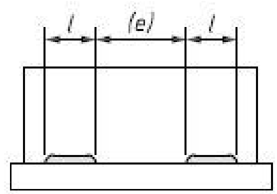
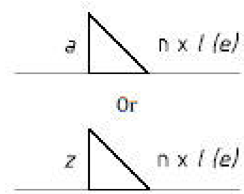
No.	Weld type	Illustration	Symbol[a]	Comments
2.2	Deep penetration			s = deep penetration throat thickness NOTE s and a are to be included on the welding symbol with the required values.
2.3	Unequal legs			$z_1 \neq z_2$ If the required leg lengths cannot be identified clearly using the welding symbol, additional sketches or indications are to be given on the drawing or in other documents. z_1 and z_2 are to be included on the welding symbol with the required leg lengths e.g. $z_1 4$ $z_2 8$
2.4	Intermittent			n = number of weld elements l = nominal length of weld elements e = distance between weld elements a or z are to be included on the welding symbol with the required value. n, l and e to be replaced by required values.

Table 18.5 – Weld dimensions (continued)

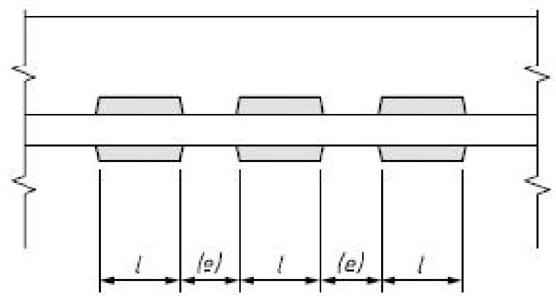
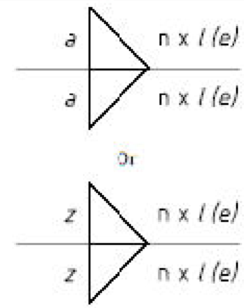
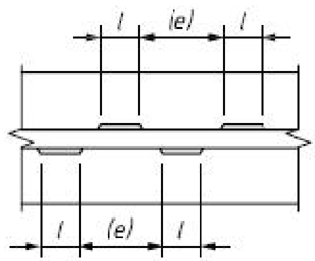
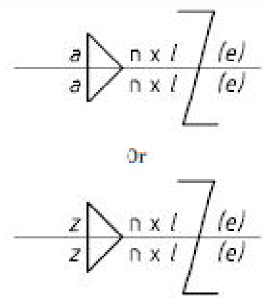
No.	Weld type	Illustration	Symbol^a	Comments
2.5	Chain intermittent			n = number of weld elements l = nominal length of weld elements *e* = distance between weld elements *a* or *z* are to be included on the welding symbol with the required value. *n*, *l* and *e* to be replaced by required values
2.6	Staggered intermittent			

Table 18.5 – Weld dimensions (continued)

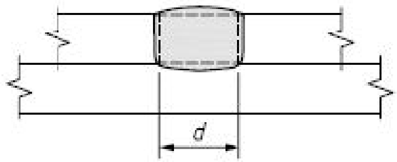
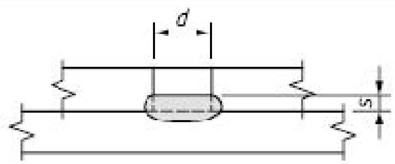
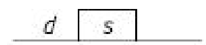
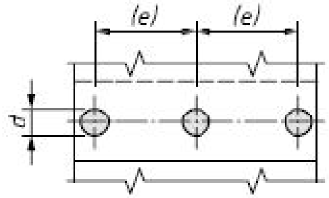
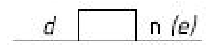
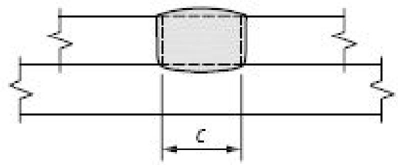
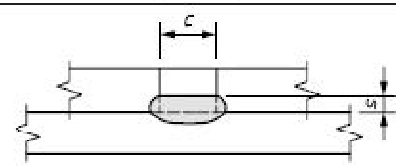
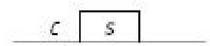
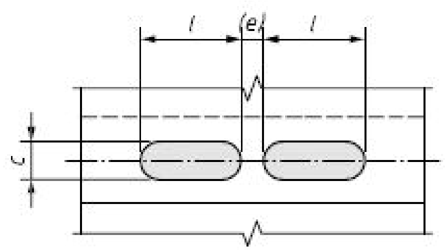
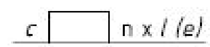
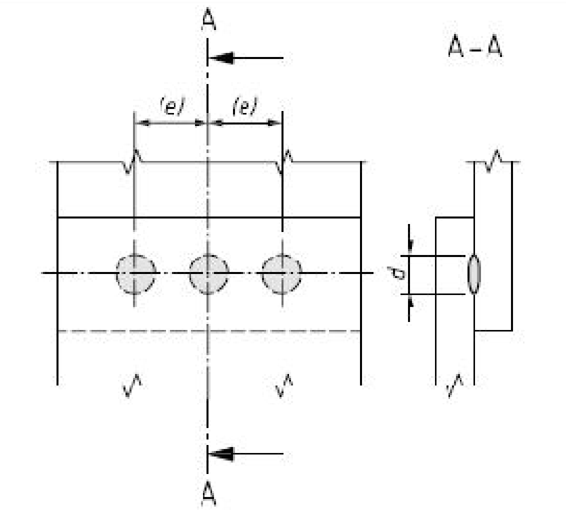
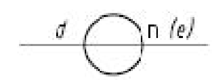
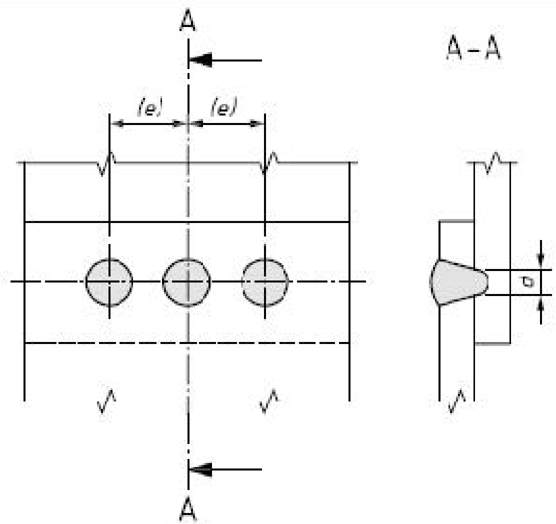
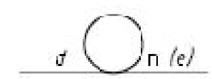
No.	Weld type	Illustration	Symbol[a]	Comments
3	**PLUG WELDS IN CIRCULAR HOLES**			
3.1	Complete fill			d = required diameter of the plug at the faying surface s = depth of filling, used if the hole is to be partially filled e = distance between weld elements (centre to centre) n = number of weld elements d to be included on the welding symbol with the required value. s, n and e, to be replaced by required values.
3.2	Partial fill			
3.3	Intermittent			

Table 18.5 – Weld dimensions (continued)

No.	Weld type	Illustration	Symbol[a]	Comments
4	**PLUG WELDS IN SLOT**			
4.1	Complete fill			c = required width of the slot at the faying surface s = depth of filling, used if the slot is to be partially filled c to be included on the welding symbol with the required value. s, to be replaced by required value.
4.2	Partial fill			
4.3	Intermittent			c = required width of the slot at the faying surface n = number of weld elements l = nominal length of weld elements e = distance between weld elements c to be included on the welding symbol with the required value. n, l and e, to be replaced by required values.

No.	Weld type	Illustration	Symbol[a]	Comments
5	**SPOT**			
5.1	Resistance			*d* = required spot weld diameter at the faying surface *e* = distance between welds (centre to centre) *n* = number of welds *d* shall be replaced by the required spot weld diameter. *n* and *e* are replaced by required dimensions.
5.2	Fusion			*d* = required spot weld diameter at the faying surface *e* = distance between welds (centre to centre) *n* = number of welds

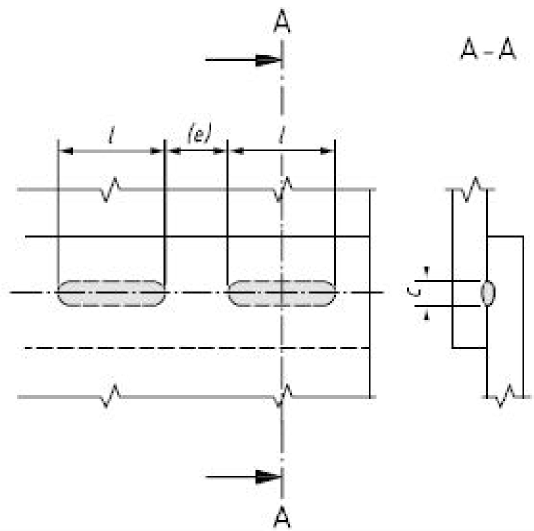
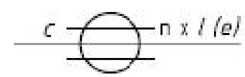
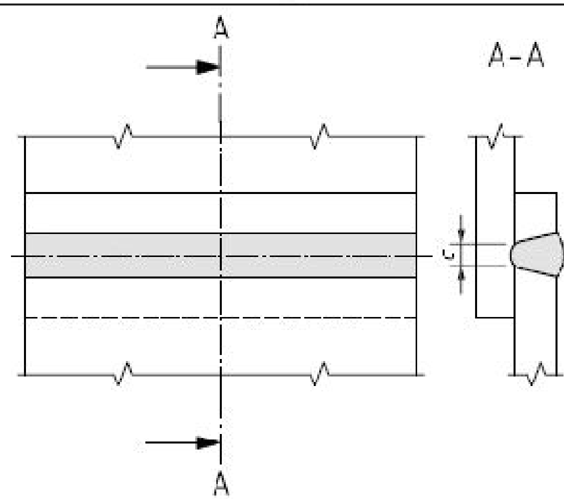
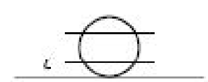
No.	Weld type	Illustration	Symbol^a	Comments
6	**SEAM**			
6.1	Resistance			*c* = required seam weld width at the faying surface *n* = number of weld elements *l* = nominal length of weld elements *e* = distance between weld elements For continuous resistance seam welds, only the required seam width is specified.
6.2	Fusion			*c* = required seam weld width at the faying surface Intermittent welds to be designated using *n*, *l* and *e* as for resistance welds.

Table 18.5 – Weld dimensions (continued)

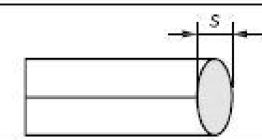
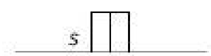
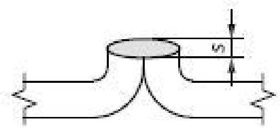
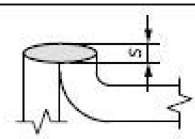
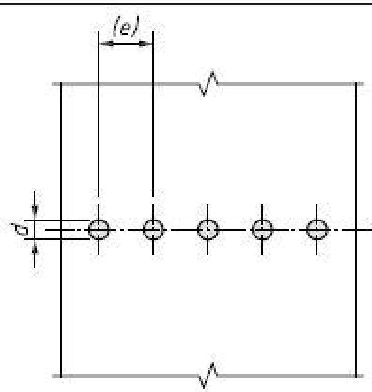
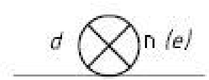
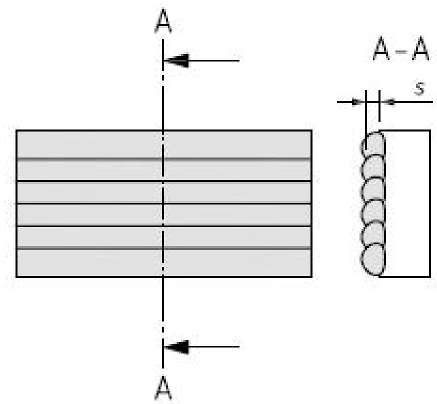
No.	Weld type	Illustration	Symbol[a]	Comments
7	**EDGE**			
7.1	Lap			s = weld metal thickness the minimum distance from the external surface of the weld to the bottom of the penetration
7.2	Flanged butt			
7.3	Flanged corner			
8	**STUD**			
8.1	Series			d = stud size n = number of studs e = distance between studs (centre to centre)

Table 18.5 – Weld dimensions (continued)

No.	Weld type	Illustration	Symbol[a]	Comments
9	**OVERLAY WELDING**			
9.1	Overlay			s = overlay thickness

[a] The grey line is not part of the symbol. It indicates the position of the reference line.

18.5 Dimensioning of joint preparations

18.5.1 *General*

If required, information concerning the joint dimensions and geometry prior to welding may be included as part of the welding symbol or may be specified elsewhere e.g. by reference to the relevant part of ISO 9692 or on the WPS.

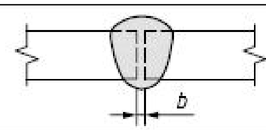
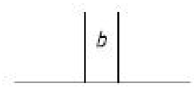
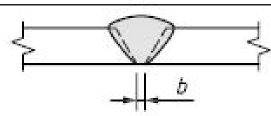
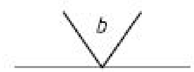
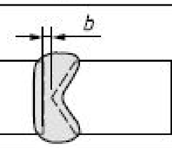
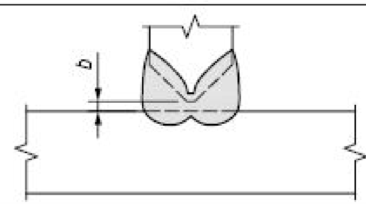
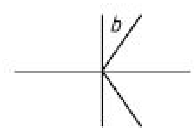
If Information on joint dimensions is to be included it should not overburden the drawings. Reference to other information should be considered first to eliminate the need for this information as part of the symbol.

18.5.2 *Root gap*

The root gap, *b*, of a butt joint may be specified inside the elementary symbol (*see* Table 18.6).

The root gap shall only be shown on one side of the reference line.

Table 18.6 - Examples of designating root gap

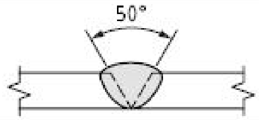
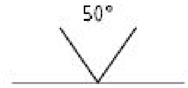
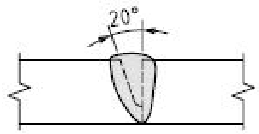
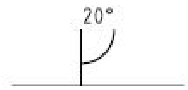
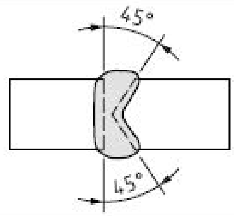
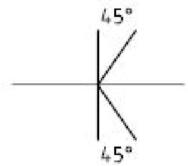
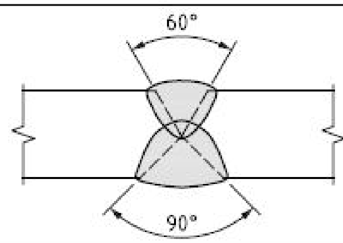
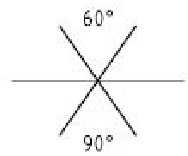
No.	Weld type	Illustration	Symbol
1	Square butt		
2	V butt		
3	Double bevel butt	 	

18.5.3 *Included angle*

The included angle (groove angle), α, of a butt joint can be specified outside the elementary symbol (*see* Table 18.7).

For double-sided joints, including symmetrical joints, the preparation angle(s) shall be included on both sides of the welding symbol.

Table 18.7 - Examples of designating included angle

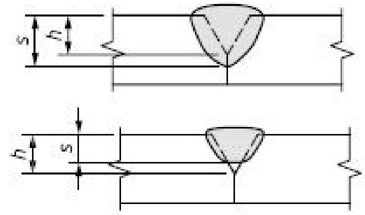
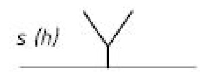
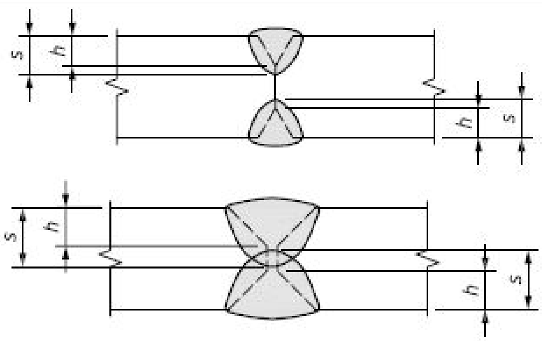
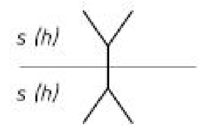
No.	Weld type	Illustration	Symbol
1	V butt		
2	J butt		
3	Double bevel butt (symmetrical)		
4	Double V butt (asym-metrical)		

18.5.4 *Radii and root faces – U and J butt joints*
The radii and dimensions of root faces of U and J butt joints are not to be specified as part of welding symbols and shall be specified elsewhere, in a cross section, detail, or other data e.g. the relevant part of ISO 9692 referenced in the tail of the welding symbol.

18.5.5 *Depth of joint preparation*
The depth of joint preparation of V-, single-bevel-, U-, J-butt, flare-V and flare bevel welds can be specified to the left of the elementary symbol. The depth of joint preparation in parentheses shall follow the required penetration depth (*see* Table 18.8).

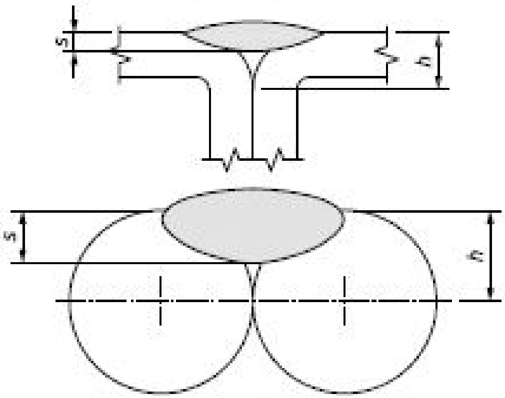
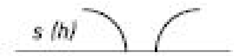
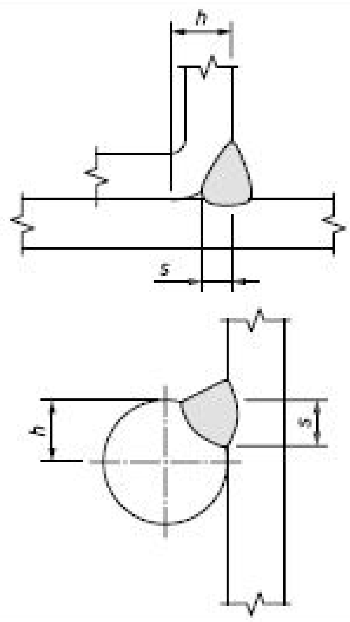
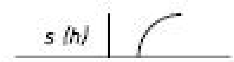
Example 8 (6).
NOTE -- The depth of joint preparation in butt welds can be greater than, equal to, or smaller than the size of the finished weld.

Table 18.8 - Examples of joint preparation depth designation

No.	Weld type	Illustration	Symbol[a]
1	V butt		
2	Double V butt		

[a] *s* and *h* are replaced by the actual values.

Table 18.8 - Examples of joint preparation depth designation (continued)

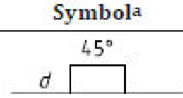
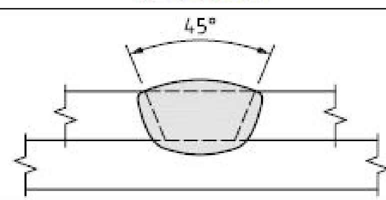
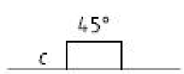
No.	Weld type	Illustration	Symbol[a]
3	Flare V		
4	Flare bevel		

[a] *s* and *h* are replaced by the actual values.

18.5.6 *Countersunk angle for plug and slot welds*

The included angle of countersink of plug and slot welds may be indicated by placing the required dimension above the elementary symbol (*see* Table 18.9).

Table 18.9 - Countersink angle in plug and slot welds

No.	Weld type	Symbol[a]	Illustration
1	Plug		
2	Slot		

[a] c and d are measured at the faying surface (*see* 18.4.6 and 18.4.7) and shall be indicated on the drawing in accordance with Table 18.5.

18.6 Alternative butt weld symbol with required weld quality

18.6.1 *General*

The alternative symbol shown in Table 18.10can be used to represent butt welds by only specifying the required weld quality. All additional information shall be designated in accordance with this standard.

When using this method, the joint preparation and welding process(es) are determined by the productionunit to meet the specified weld quality.

NOTE-- All other information is specified in the WPS or other documentation based on the available equipment. Different WPSs can be used in other workshops with different equipment but the technical drawing will not need to be revised for each workshop.

Table 18.10 - Alternative simplified butt weld symbol

Symbol	Description
⊠	Butt weld where joint preparation is not defined

18.6.2 *Example*

An example of a welding symbol based on required weld quality is shown in Fig 18.8.

Full penetration welds shall not be dimensioned (*see* Clause 18.4).

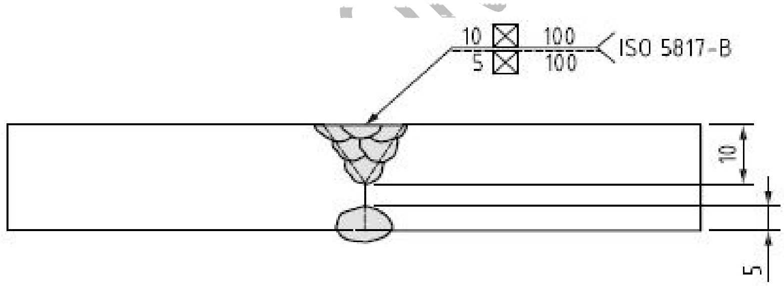
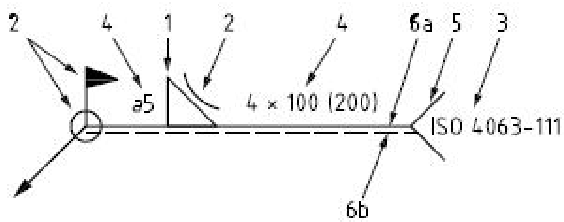


FIG 18.8 - Example of a welding symbol based on required weld quality

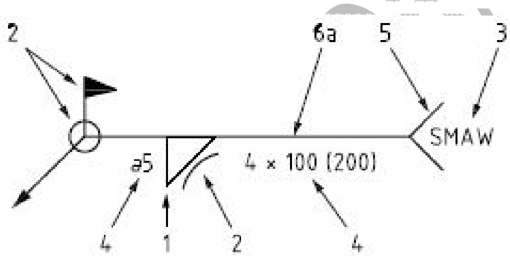
Annex 18A
Examples of the use of welding symbols

The examples given in Annex 18A are illustrative only and are intended to demonstrate the proper application of drawing principles. They are not intended to represent good design practices, or to replace code or specification requirements.

Fig 18A.1 shows examples of comprehensive welding symbols showing the location of weld elements.



a) Example of a comprehensive welding symbol in accordance with system A



b) Example of comprehensive welding symbol in accordance with system B

Key

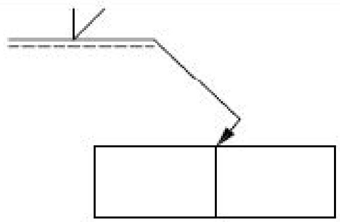
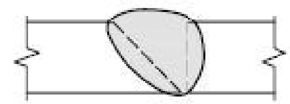
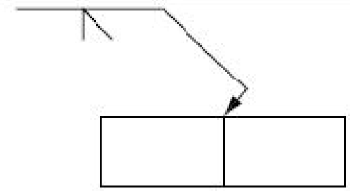
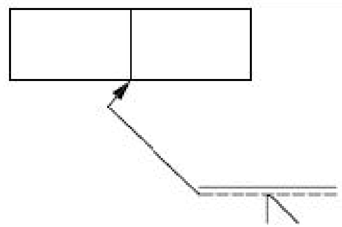
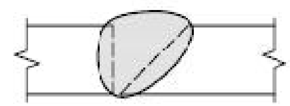
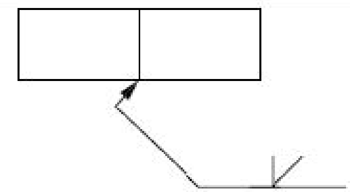
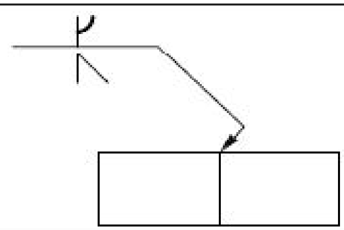
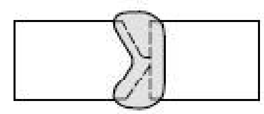
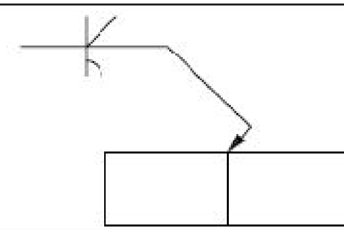
1 elementary symbol (fillet weld)
2 supplementary symbol (concave fillet weld contour, field weld, weld all-around)
3 complementary information (shielded metal arc welding (SMAW)/process 111 in accordance with ISO 4063)
4 dimensions (5 mm nominal throat thickness intermittent fillet weld, composing 4 weld elements 100 mm in length with 200mm spacing between elements)
5 tail
6a reference line (continuous)
6b dashed line (identification line) - system A only

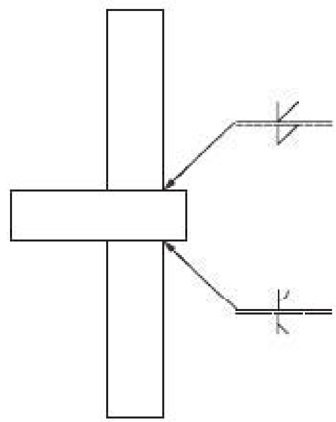
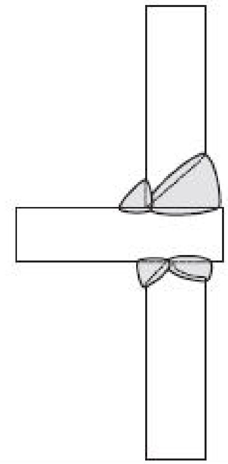
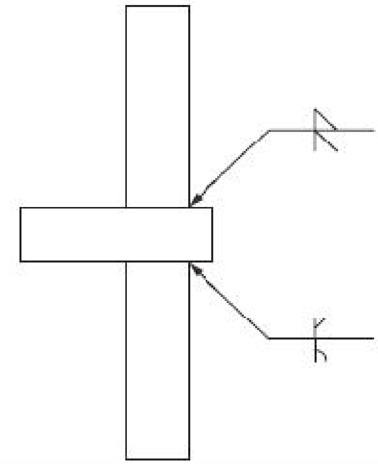
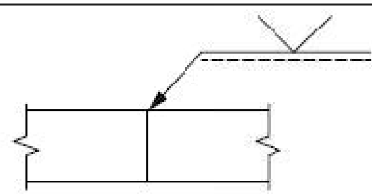
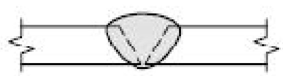
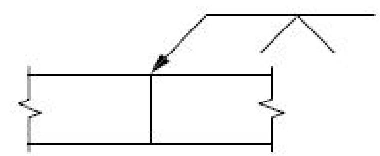
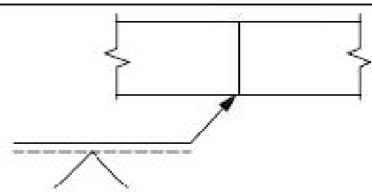
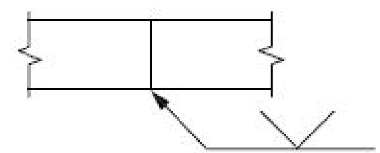
FIG 18A.1 - Examples of comprehensive welding symbols (5 mm nominal throat thickness intermittent fillet weld, composing 4 weld elements 100 mm in length with 200mm spacing between elements)

The welding symbols shown in Fig 18A.1designate the same weld on the arrow side of the joint.

NOTE--In system A the dashed component of the reference line can be drawn above or below the continuous line (*see* 4.7.1.1). The examples given in Tables 18A.1 to18 A.3only show the preferred case where the dashed line is drawn below the continuous line.

Table 18A.1 – Examples of use of broken arrow lines

No.	System A welding symbol	Illustration of weld	System B welding symbol
1			
2			
3			

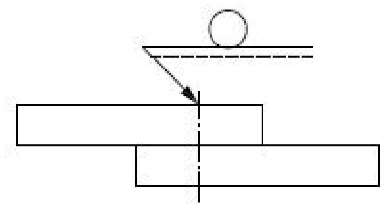
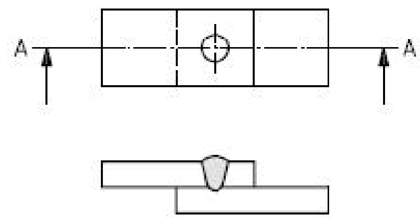
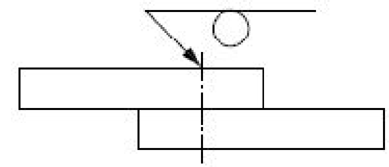
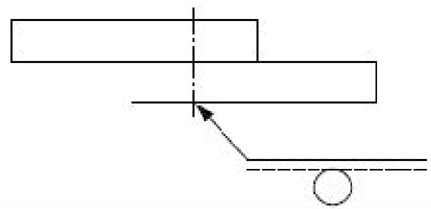
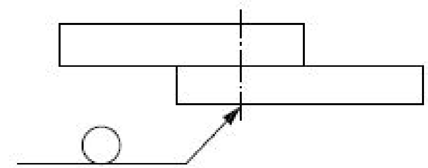
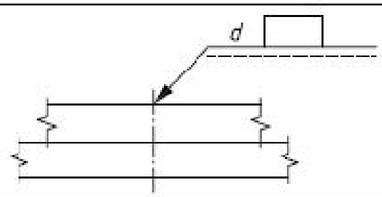
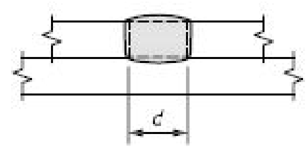
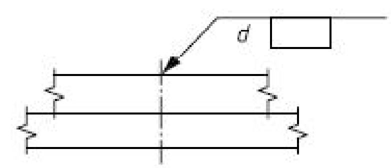
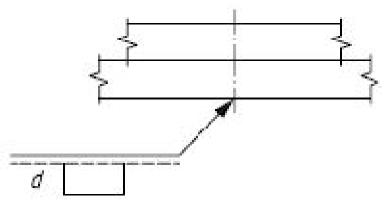
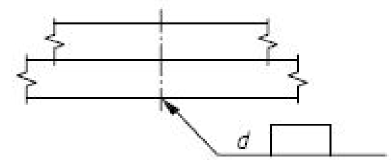
No.	Weld type	Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
1	Single bevel butt Fillet Single J butt Single bevel butt (broad root face)	Arrow Other Arrow Other			
2 a)	Butt	Arrow			
2 b)	Butt	Other			

[a] The dashed line is preferred to be drawn below the continuous line.

[b] Plug welds require the diameter of the hole to be indicated by use of the Ø symbol.

[c] Orientation of the slot is to be shown on the drawing or indicated elsewhere.

Table 18A.2 – Examples of arrow side and other side welds

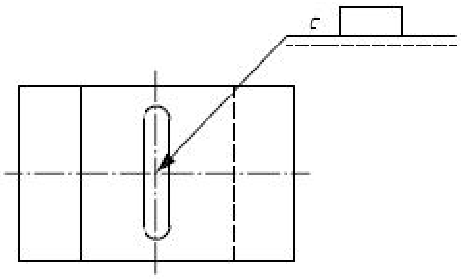
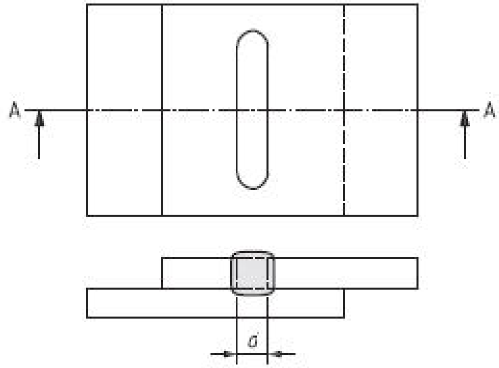
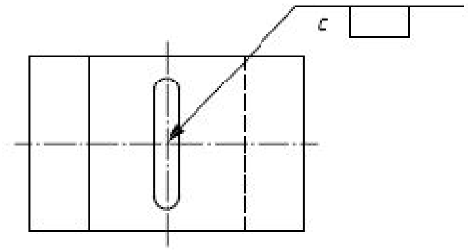
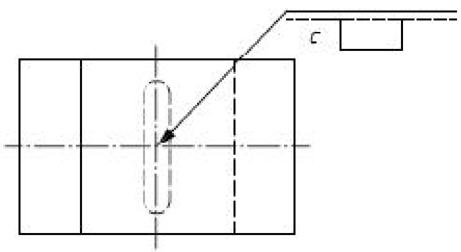
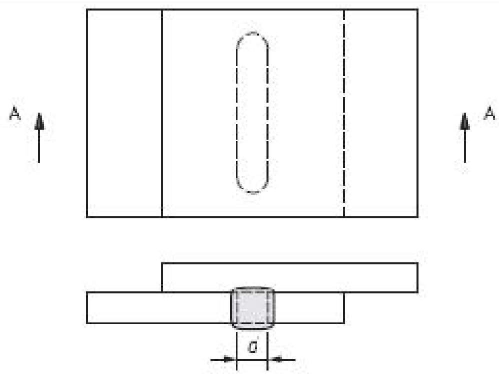
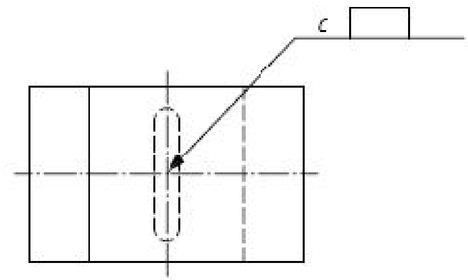
Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
Arrow			
Other			
Arrow			
Other			

ashed line is preferred to be drawn below the continuous line.

velds require the diameter of the hole to be indicated by use of the Ø symbol.

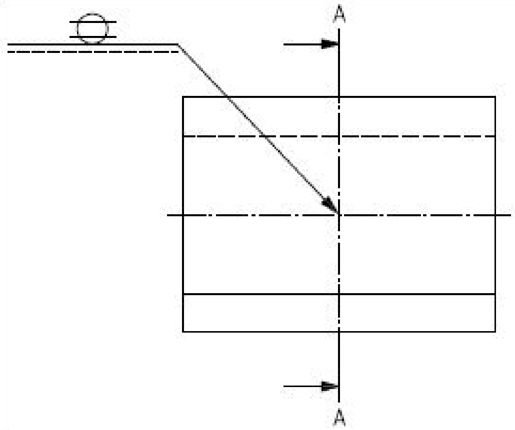
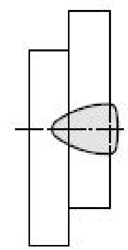
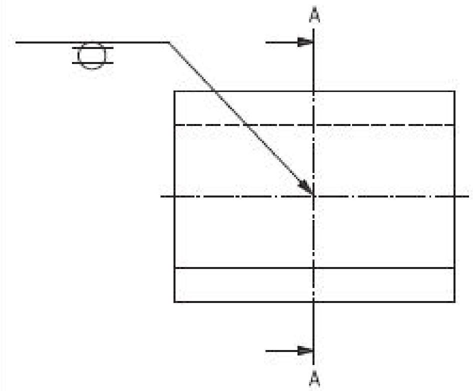
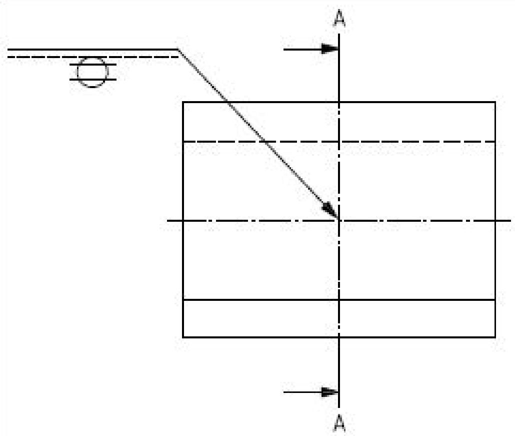
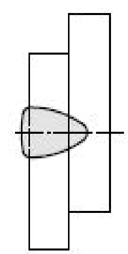
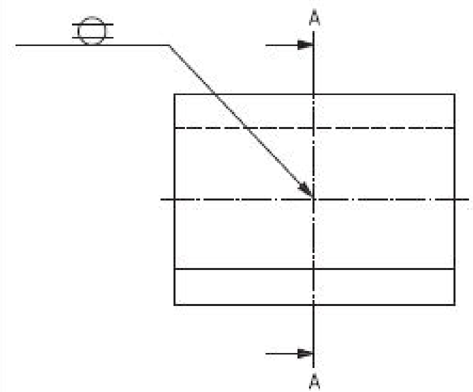
tation of the slot is to be shown on the drawing or indicated elsewhere.

Table 18A.2 – Examples of arrow side and other side welds (continued)

Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
Arrow			
Other			

ashed line is preferred to be drawn below the continuous line.
velds require the diameter of the hole to be indicated by use of the Ø symbol.
tation of the slot is to be shown on the drawing or indicated elsewhere.

Table 18A.2 – Examples of arrow side and other side welds (continued)

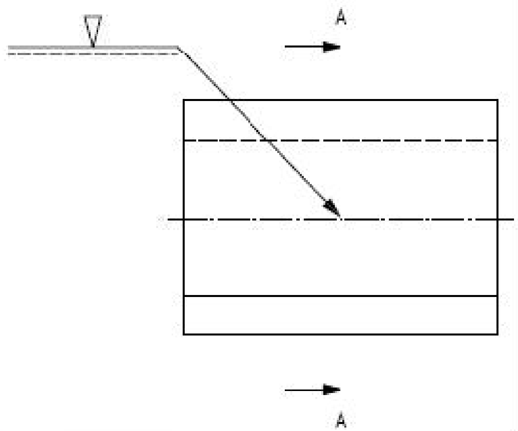
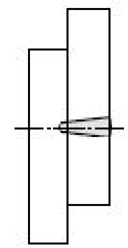
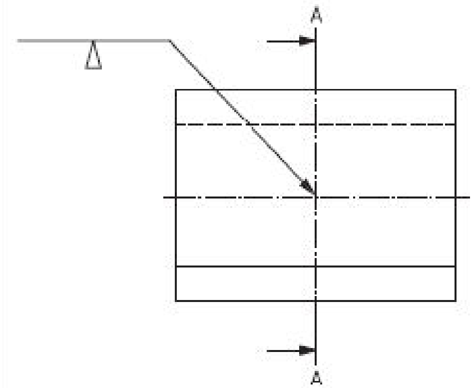
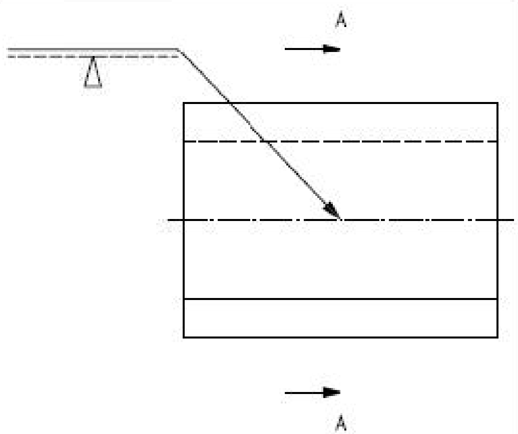
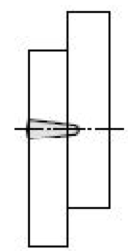
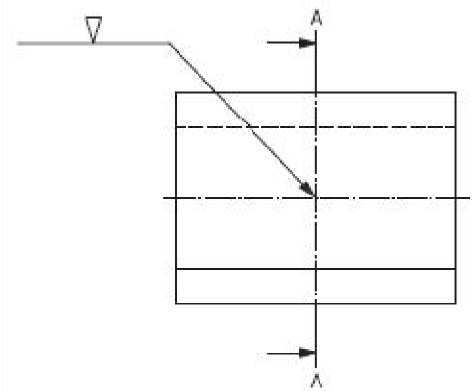
No.	Weld type	Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
6 a)	Fusion seam	Arrow			
6 b)	Fusion seam	Other			

[a] The dashed line is preferred to be drawn below the continuous line.

[b] Plug welds require the diameter of the hole to be indicated by use of the Ø symbol.

[c] Orientation of the slot is to be shown on the drawing or indicated elsewhere.

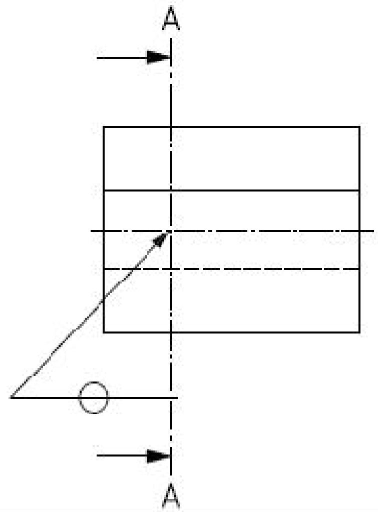
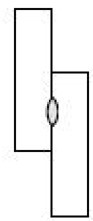
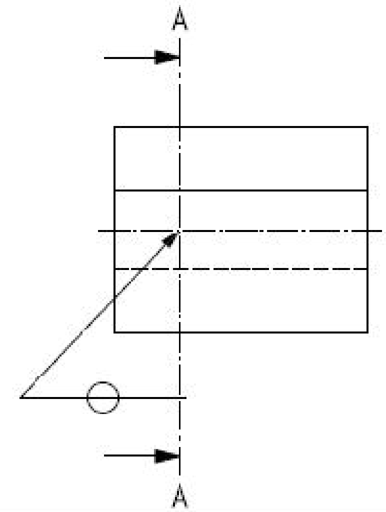
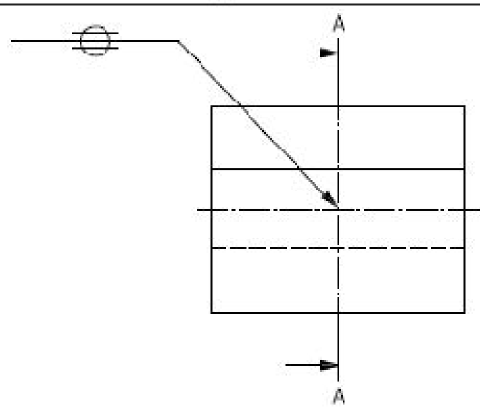
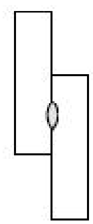
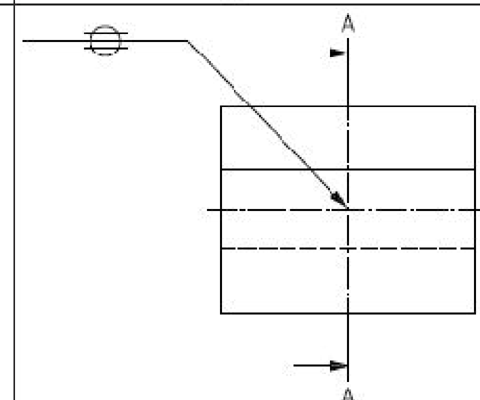
Table 18A.2 – Examples of arrow side and other side welds (continued)

No.	Weld type	Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
6 c)	Stake				
6 d)	Stake				

[a] The dashed line is preferred to be drawn below the continuous line.

[b] Plug welds require the diameter of the hole to be indicated by use of the Ø symbol.

[c] Orientation of the slot is to be shown on the drawing or indicated elsewhere.

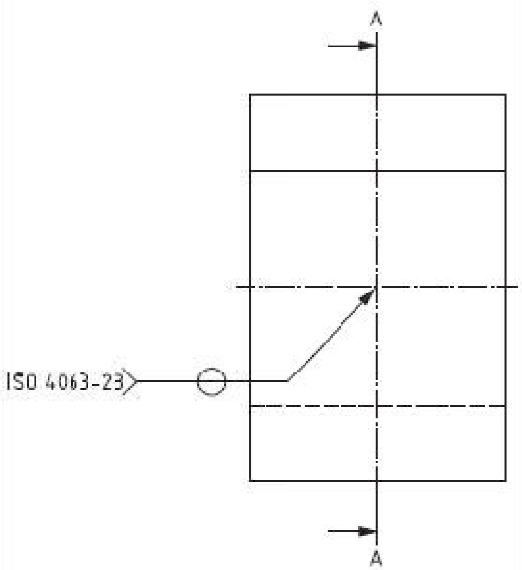
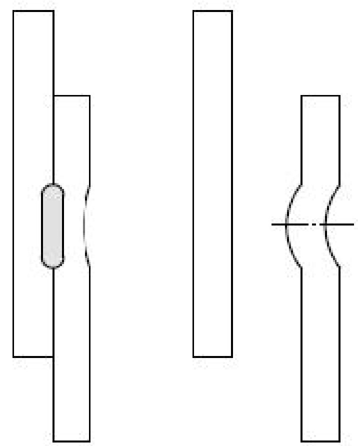
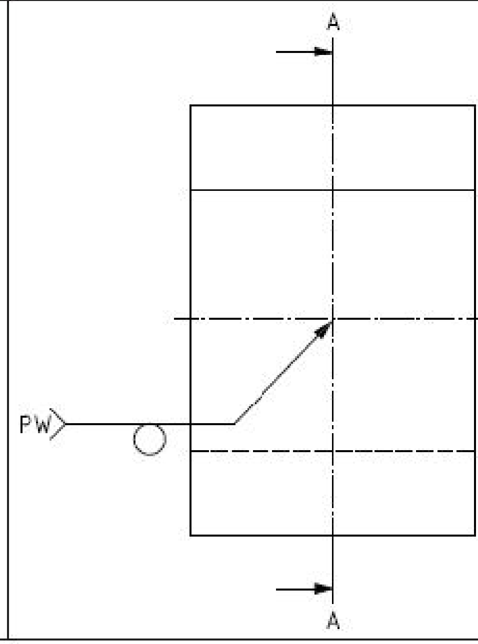
No.	Weld type	Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
7	Resist-ance spot	No side signifi-cance with resist-ance welds at the inter-face			
8	Resist-ance seam	No side signifi-cance with resist-ance welds at the inter-face			

[a] The dashed line is preferred to be drawn below the continuous line.

[b] Plug welds require the diameter of the hole to be indicated by use of the Ø symbol.

[c] Orientation of the slot is to be shown on the drawing or indicated elsewhere.

Table 18A.2 – Examples of arrow side and other side welds (continued)

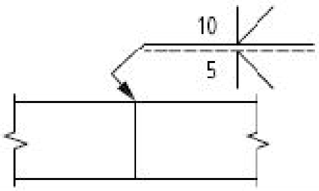
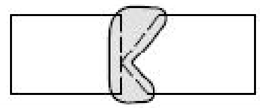
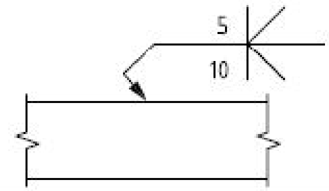
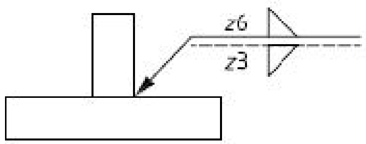
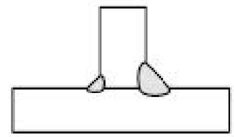
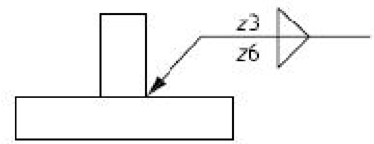
No.	Weld type	Side	System A welding symbol[a]	Illustration of weld	System B welding symbol
9	Projection	Arrow points to the sheet containing the projection			

[a] The dashed line is preferred to be drawn below the continuous line.

[b] Plug welds require the diameter of the hole to be indicated by use of the Ø symbol.

[c] Orientation of the slot is to be shown on the drawing or indicated elsewhere.

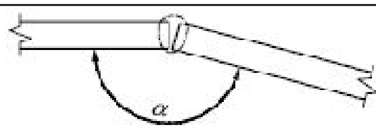
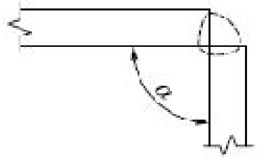
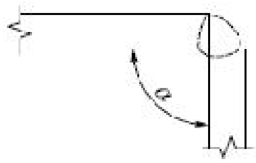
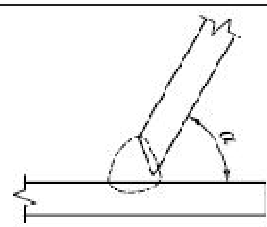
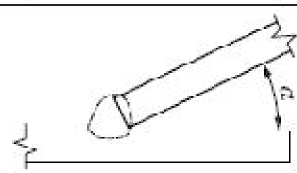
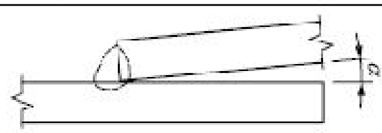
Table 18A.3 – Examples of welding symbols for asymmetrical welds

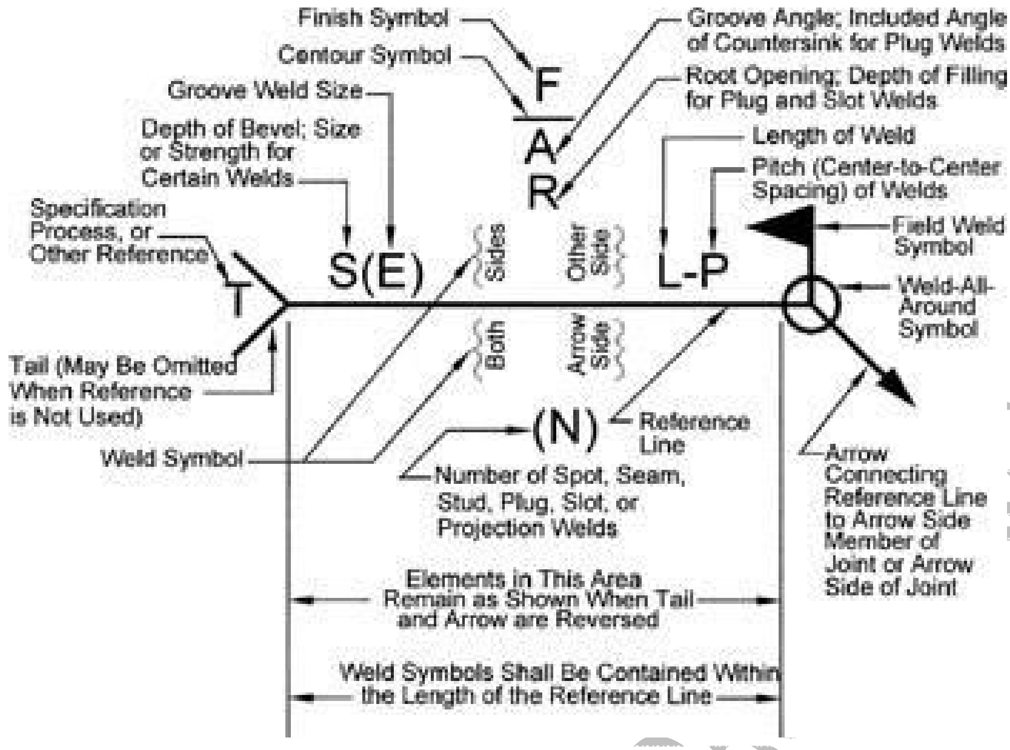
No.	Weld type	System A welding symbol[a]	Illustration of weld	System B welding symbol
1	Butt			
2	Fillet[b]			

[a] Asymmetrical welds are always dimensioned regardless if they are partial or full penetration welds (see Clause 6).

[b] If throat thickness is specified, symbol *a* is used in place of *z*.

Annex 18B
Tolerances and transition points for weld types

Joint type	Weld type	Transition/tolerance	α	Symbol
Butt	Butt		135° to 180° inclusive	Table 18.1, No.1
Corner	Fillet		Over 30° and less than 135°	Table 18.1, No.10
Edge	Edge		0° to 30° inclusive	Table 18.1, No.19
Angle	Butt		45° to 90° inclusive	Table 18.1, No.4
Angle	Fillet		Over 5° and less than 45°	Table 18.1, No.10
Lap	Fillet		0° to 5° inclusive	Table 18.1, No.10


Finish Symbol
Contour Symbol
Groove Weld Size
Depth of Bevel; Size or Strength for Certain Welds
Specification Process, or Other Reference
Tail (May Be Omitted When Reference is Not Used)
Weld Symbol
Groove Angle; Included Angle of Countersink for Plug Welds
Root Opening; Depth of Filling for Plug and Slot Welds
Length of Weld
Pitch (Center-to-Center Spacing) of Welds
Field Weld Symbol
Weld-All-Around Symbol
F
A
R
T
S(E)
L-P
(N)
Sides
Both
Other Side
Arrow Side
Reference Line
Number of Spot, Seam, Stud, Plug, Slot, or Projection Welds
Arrow Connecting Reference Line to Arrow Side Member of Joint or Arrow Side of Joint
Elements in This Area Remain as Shown When Tail and Arrow are Reversed
Weld Symbols Shall Be Contained Within the Length of the Reference Line

Annex 18C
Alternative methods for designating intermittent butt and fillet welds

18C.1 General
The alternative methods for designating intermittent butt and fillet welds are included for informational purposes only. These methods are used or adapted in at least AWS A2.4:2007, AS 1101.3-2005 and JIS C Z 3021:2010. Information on how to designate other intermittent weld types can be found in these standards.

18C.2 Butt welds
18C.2.1 *Intermittent butt welds*
The pitch of intermittent butt welds is defined as the distance between the centres of adjacent weld elements on one side of the joint. The pitch of intermittent butt welds is specified to the right of the length dimension following a hyphen (*see* Table 18C.1).

18C.2.2 *Chain intermittent butt welds*
The dimensions of chain intermittent butt welds are specified on both sides of the reference line. The elements of chain intermittent butt welds are made approximately opposite one another across the joint(*see* Table 18C.1).

18C.2.3 *Staggered intermittent butt welds*
The dimensions of staggered intermittent butt welds are specified on both sides of the reference line,and the butt weld symbols are offset on opposite sides of the reference line (see Table 18C.1).

18C.3 Fillet welds
18C.3.1 *Intermittent fillet welds*
The pitch of intermittent fillet welds is defined as the distance between the centres of adjacent weld elements on one side of the joint. The pitch of intermittent fillet welds is specified to the right of the length dimension following a hyphen (*see* Table 18C.2).

18C.3.2 *Chain intermittent fillet welds*
The dimensions of chain intermittent fillet welds are specified on both sides of the reference line. The
elements of chain intermittent fillet welds are made approximately opposite one another across the joint
(see Table 18C.2).

18C.3.3 *Staggered intermittent fillet welds*
The dimensions of staggered intermittent fillet welds are specified on both sides of the reference line, and the fillet weld symbols shall be offset on opposite sides of the reference line (*see* Table 18C.2).

Table 18C.1 - Butt welds

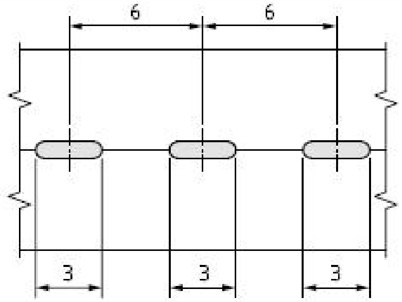
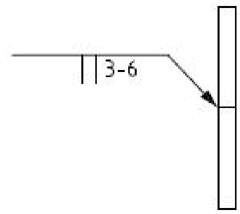
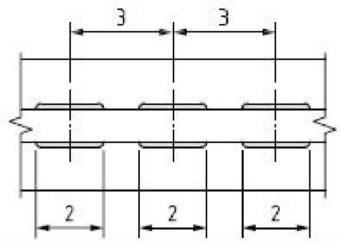
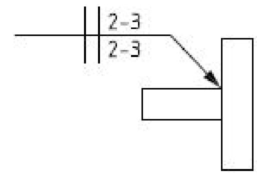
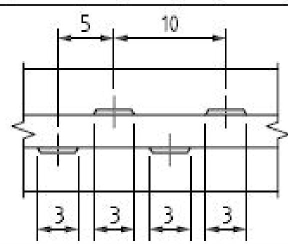
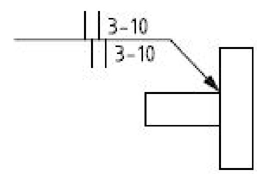
No.	Weld type	Illustration of weld	AWS A2.4 welding symbol
1	Intermittent		
2	Chain Intermit-tent		
3	Staggered Intermittent		

Table 18C.2 - Fillet welds

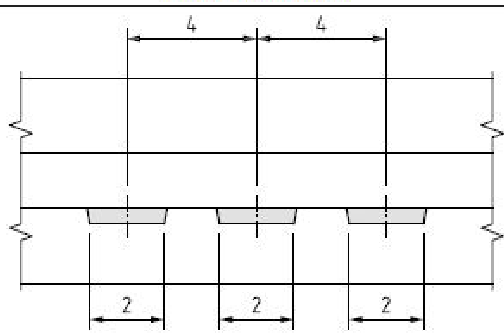
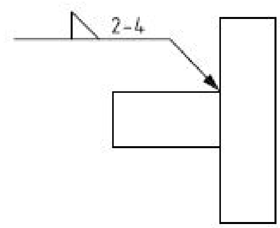
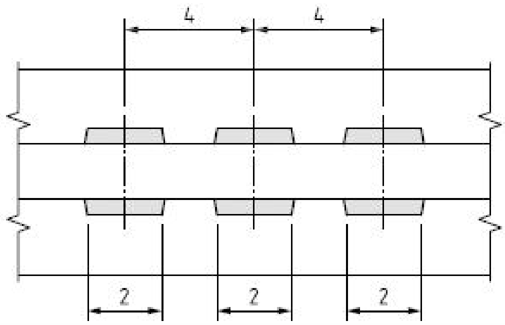
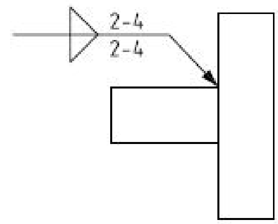
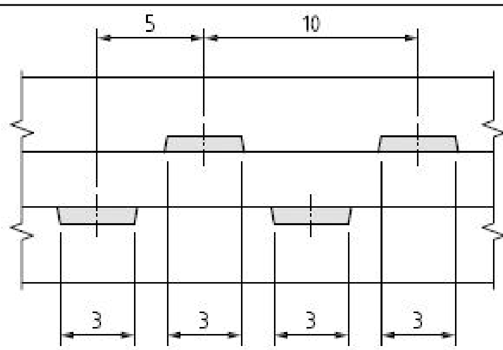
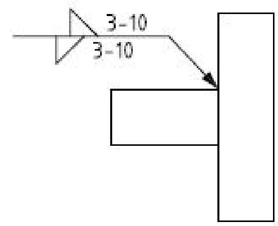
No.	Weld type	Illustration of weld	AWS A2.4 welding symbol
1	Intermittent		

Table 18C.2 - Fillet welds (continued)

No.	Weld type	Illustration of weld	AWS A2.4 welding symbol
2	Chain intermittent		
3	Staggered intermittent		

SECTION 19 – GEOMETRICAL TOLERANCING-TOLERANCES OF FORM, ORIENTATION, LOCATION AND RUN-OUT

[Based on IS 8000:2014/1SO 1101:2012]

19.1 Scope

This Section contains basic information and gives requirements for the geometrical tolerancing of workpieces.

19.2 Basic concept

19.2.1 Geometrical tolerances shall be specified in accordance with functional requirements. Manufacturing and inspection requirements can also influence geometrical tolerancing.

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

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

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

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

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

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

19.2.6 The tolerance applies to the whole extent of the considered feature unless otherwise specified.

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

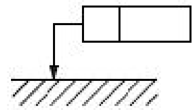
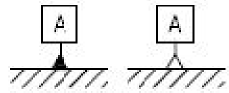
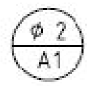
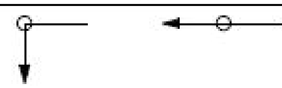
19.3 Symbols

See **Tables 19.1 and 19.2**

Table 19.1 – Symbols for geometrical characteristics

Tolerances	Characteristics	Symbol
Form	Straightness	—
	Flatness	▱
	Roundness	○
	Cylindricity	⌭
	Profile any line	⌒
	Profile any surface	⌓
Orientation	Parallelism	//
	Perpendicularity	⊥
	Angularity	∠
	Profile any line	⌒
	Profile any surface	⌓
Location	Position	⌖
	Concentricity (for centre points)	◎
	Coaxiality (for axes)	◎
	Symmetry	⌯
	Profile any line	⌒
	Profile any surface	⌓
Run-out	Circular run-out	↗
	Total run-out	⌰

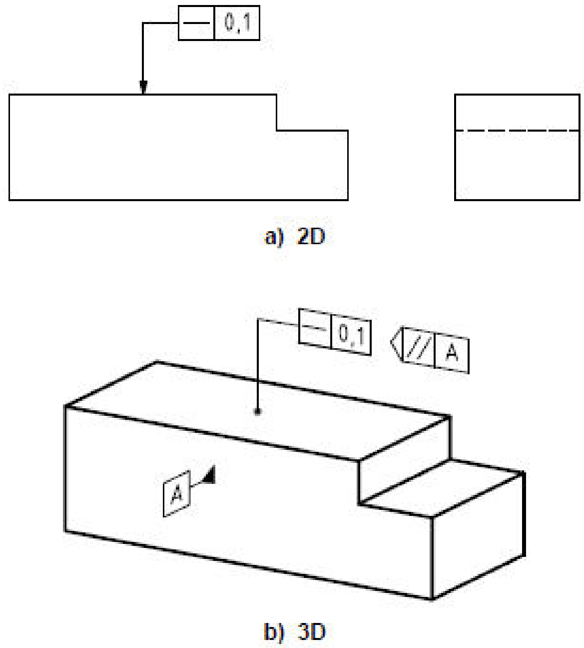
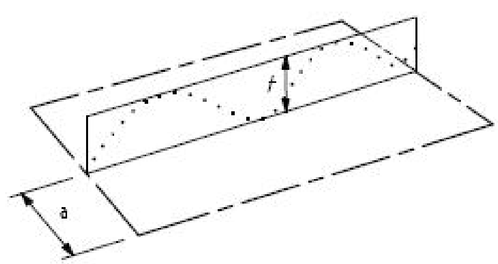
Table 19.2 – Additional symbols

Description	Symbol
Toleranced feature indication	
Datum feature indication	
Datum target indication	
Theoretically exact dimension	$\boxed{50}$
Median feature	Ⓐ
Unequally disposed tolerance zone	UZ
Between	◄►
From … to	►
Projected tolerance zone	Ⓟ
Maximum material requirement	Ⓜ
Least material requirement	Ⓛ
Free state condition (non-rigid parts)	Ⓕ
All around (profile)	
Envelope requirement	Ⓔ
Common zone	CZ
Minor diameter	LD
Major diameter	MD
Pitch diameter	PD
Line element	LE
Not convex	NC
Any cross-section	ACS
Direction feature	◄ // | B
Collection plane	○ // | B
Intersection plane	◁ // | B
Orientation plane	◁ // | B ▷

19.4 Definition of geometrical tolerances

An explanation based on examples of the various geometrical tolerances and their tolerance zones are provided in this clause. The illustrations accompanying the definitions only show those deviations which relate to the specific definition.

19.4.1 *Straightness tolerance*

Symbol	Indication and explanation
—	Any extracted (actual) line on the upper surface, parallel to the plane of projection (2D) or datum plane A, as specified by the intersection plane indicator (3D), shall be contained between two parallel straight lines 0.1 apart.  FIG 19.1
	Definition of tolerance zone
	The tolerance zone, in the considered plane, is limited by two parallel straight lines a distance *t* apart and in the specified direction only.  [a] Any distance FIG 19.2

Symbol	Indication and explanation

<table>
<tr>
<td>—</td>
<td>
Any extracted (actual) generating line on the cylindrical surface shall be contained between two parallel planes 0.1 apart.
NOTE--The definition for an extracted generating line has not been standardized.

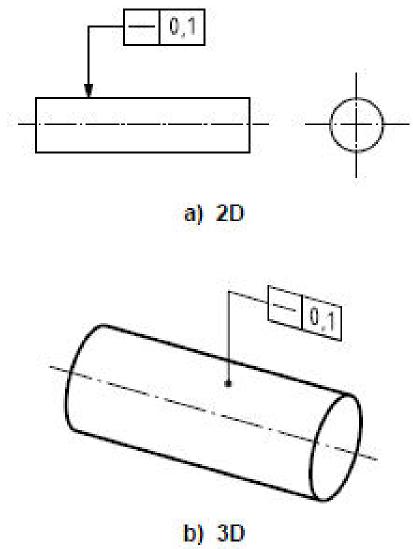


FIG 19.3
</td>
</tr>
<tr>
<td></td>
<td>Definition of the tolerance zone</td>
</tr>
<tr>
<td></td>
<td>
The tolerance zone is limited by two parallel planes a distance t apart.

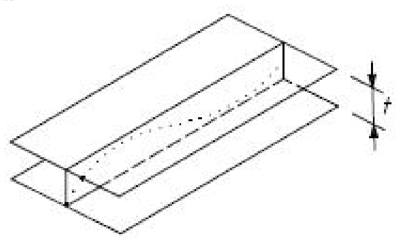


FIG 19.4
</td>
</tr>
</table>

Symbol	Indication and explanation

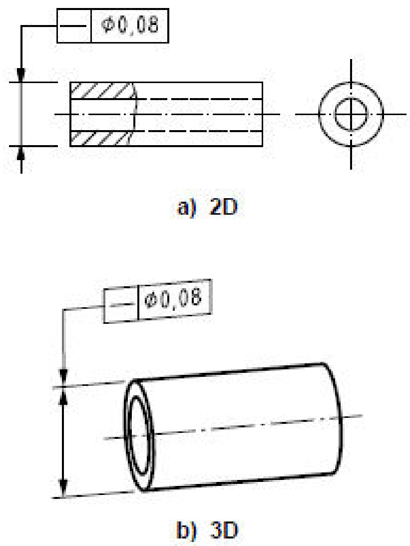
<table>
<tr><td rowspan="3">—</td><td>The extracted (actual) median line of the cylinder to which the tolerance applies shall be contained within a cylindrical zone of diameter 0.08.


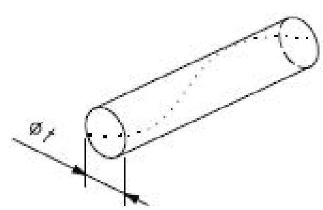
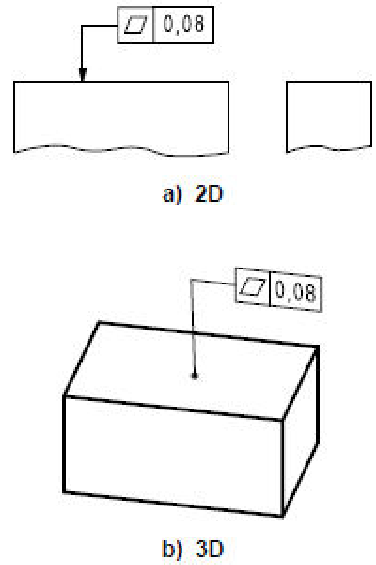
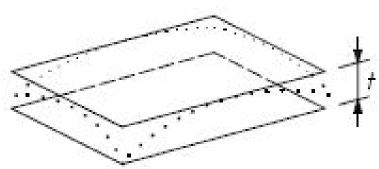
FIG 19.5</td></tr>
<tr><td>Definition of the tolerance zone</td></tr>
<tr><td>The tolerance zone is limited by a cylinder of diameter t, if the tolerance value is preceded by the symbol.


FIG 19.6</td></tr>
</table>

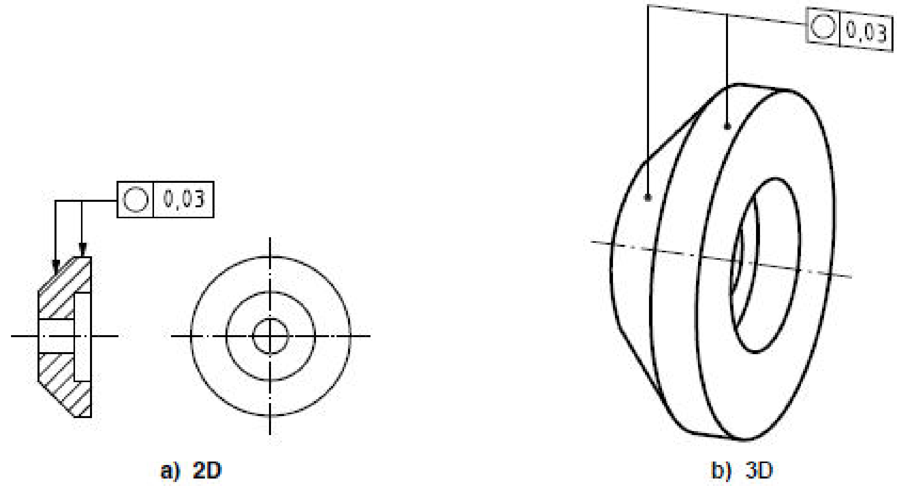
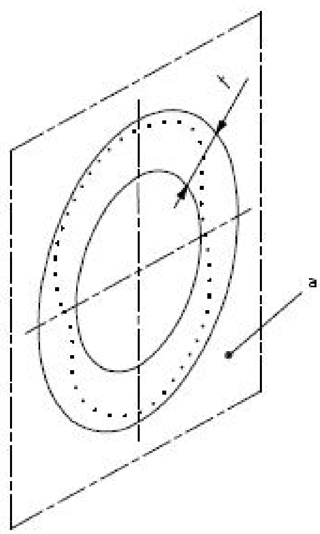
19.4.2 *Flatness tolerance*

Symbol	Indication and explanation

▱	The extracted (actual) surface shall be contained between two parallel planes 0.08 apart.  FIG 19.7
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel planes a distance *t* apart.  FIG 19.8

19.4.3 *Roundness tolerance*

Symbol	Indication and explanation
○	For the cylindrical surface, the extracted (actual) circumferential line, in any cross-section of the cylindrical, shall be contained between two coplanar concentric circles, with a difference in radii of 0.03.

	 FIG 19.9
	Definition of the tolerance zone
	The tolerance zone, in the considered cross-section, is limited by two concentric circles with a difference in radii of *t*.  [a] Any cross-section FIG 19.10

Symbol	Indication and explanation

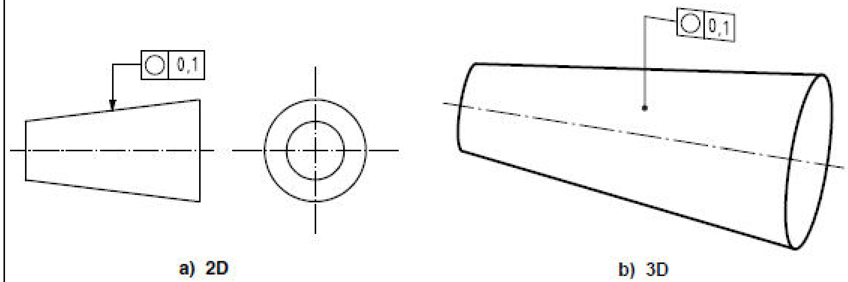
<table>
<tr><td>○</td><td>Any extracted (actual) circumferential line, resulting in the intersection of the (actual) revolute surface and a section cone (having as axis, the axis of the associated revolute surface and its generatrix normal to the revolute surface) shall be contained in a conical zone (of the section cone) limited by two circles 0.1 apart (this distance is taken on the generatrix).
NOTE--The definition of an extracted circumferential line has not been standardized.


FIG 19.11</td></tr>
</table>

19.4.4 *Cylindricity tolerance*

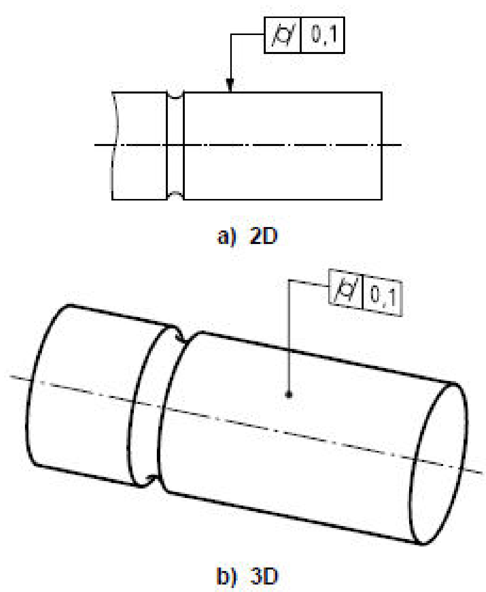
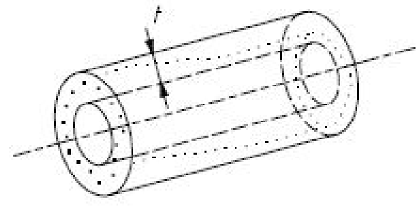
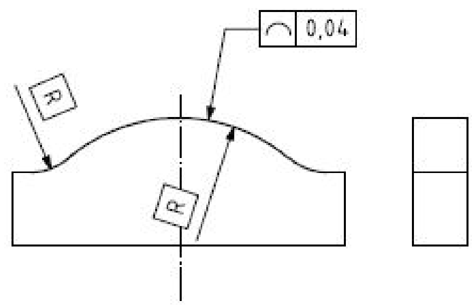
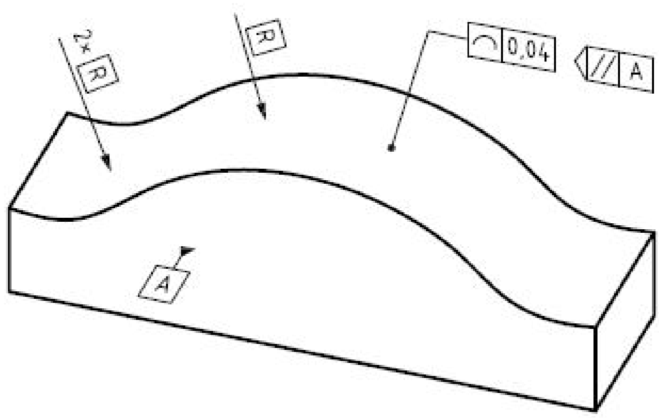
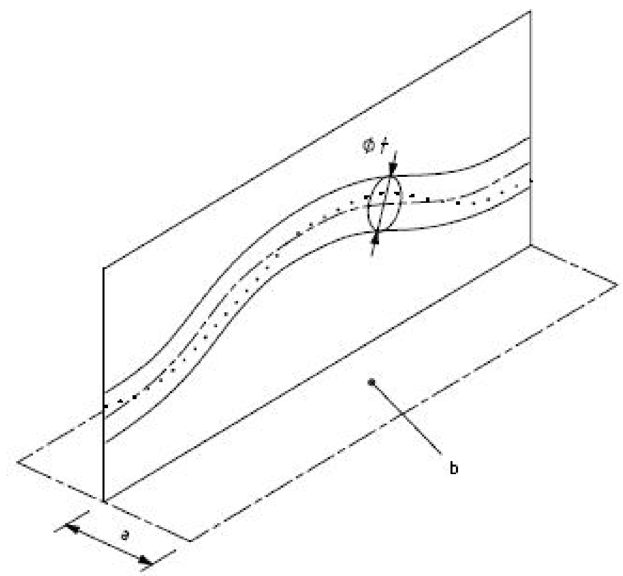
<table>
<tr><th>Symbol</th><th>Indication and explanation</th></tr>
<tr><td rowspan="3">⌭</td><td>The extracted (actual) cylindrical surface shall be contained between two coaxial cylinders with a difference in radii of 0.1.


FIG 19.12</td></tr>
<tr><td>Definition of the tolerance zone</td></tr>
<tr><td>The tolerance zone is limited by two coaxial cylinders with a difference in radii of t.</td></tr>
</table>

	 FIG 19.13

19.4.5 *Profile tolerance of a line not related to a datum*

Symbol	Indication and explanation
⌒	In each section, parallel to the plane of projection in which the indication is shown, the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0.04, the centres of which are situated on a line having the theoretically exact geometrical form.  a) 2D In each section, parallel to datum plane A, as specified by the intersection plane indicator, the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0.04, the centres of which are situated on a line having the theoretically exact geometrical form.  b) 3D

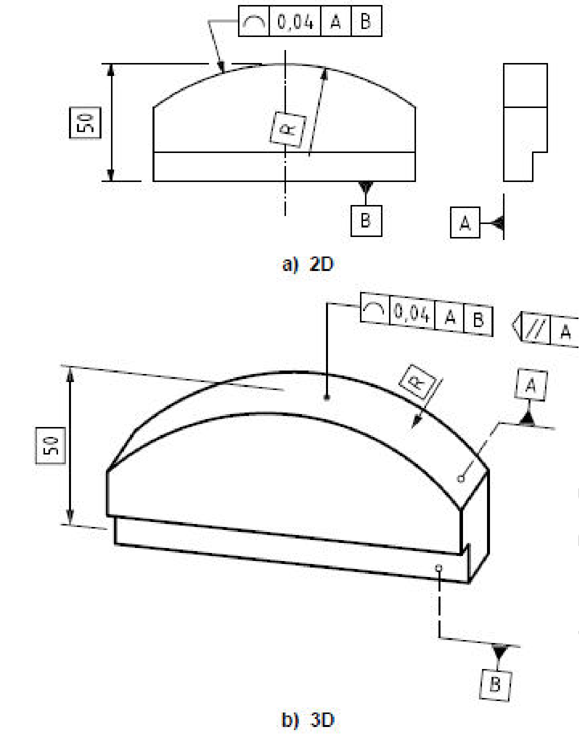
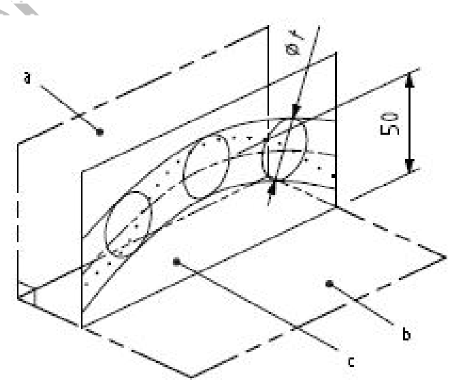
<table>
<tr><td></td><td>FIG 19.14</td></tr>
<tr><th>Symbol</th><th>Definition of the tolerance zone</th></tr>
<tr><td>⌒</td><td>The tolerance zone is limited by two lines enveloping circles of diameter t, the centres of which are situated on a line having the theoretically exact geometrical form.


a Any distance.
b Plane perpendicular to the drawing plane in Fig 19.14.

FIG 19.15</td></tr>
</table>

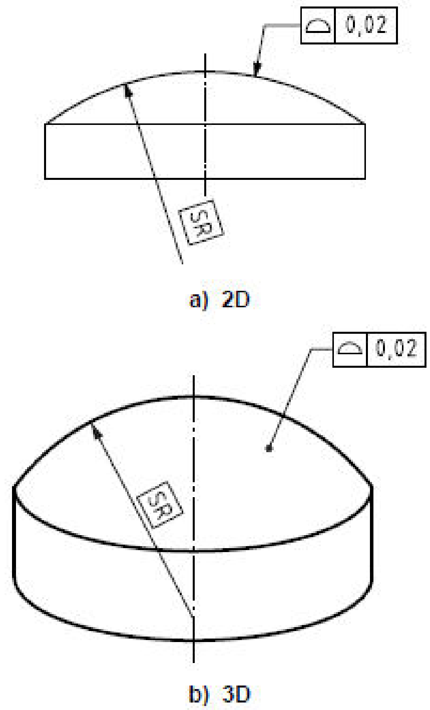
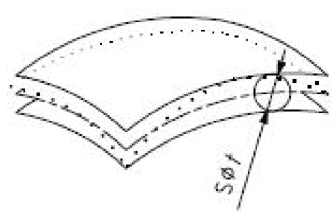
19.4.6 *Profile tolerance of a line related to a datum system*

Symbol	Indication and explanation
⌒	In each section, parallel to the plane of projection (2D) or datum plane A, as specified by the intersection plane indicator (3D), the extracted (actual) profile line shall be contained between two equidistant lines enveloping circles of diameter 0.04, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B.

	FIG 19.16 
	Definition of the tolerance zone
	The tolerance zone is limited by two lines enveloping circles of diameter *t*, the centres of which are situated on a line having the theoretically exact geometrical form with respect to datum plane A and datum plane B.  a Datum A. b Datum B. c Plane parallel to datum A. FIG 19.17

19.4.7 *Profile tolerance of a surface not related to a datum*

Symbol	Indication and explanation

⌓	The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of diameter 0.02, the centres of which are situated on a surface having the theoretically exact geometrical form.  FIG 19.18
	Definition of the tolerance zone
	The tolerance zone is limited by two surfaces enveloping spheres of diameter *t*, the centres of which are situated on a surface having the theoretically exact geometrical form.  FIG 19.19

19.4.8 *Profile tolerance of a surface related to a datum*

Symbol	Indication and explanation
⌓	The extracted (actual) surface shall be contained between two equidistant surfaces enveloping spheres of diameter 0.1, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A.

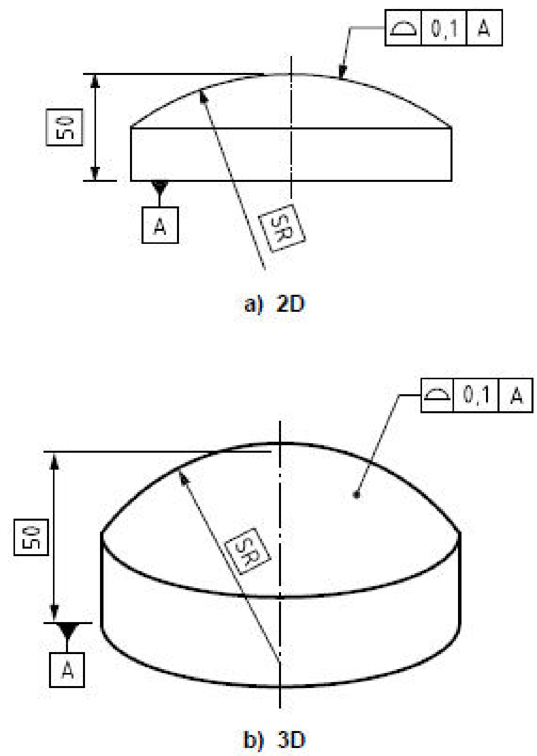
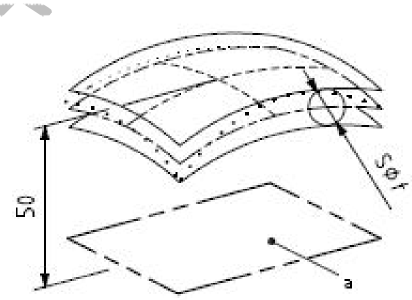


FIG 19.20

Definition of the tolerance zone

The tolerance zone is limited by two surfaces enveloping spheres of diameter *t*, the centres of which are situated on a surface having the theoretically exact geometrical form with respect to datum plane A.



a Datum A.

FIG 19.21

19.4.9 *Parallelism tolerance*

19.4.9.1 *Parallelism tolerance of a line related to a datum system*

Symbol	Indication and explanation
//	The extracted (actual) median line shall be contained between two parallel planes 0.1 apart which are parallel to datum axis A. The planes limiting the tolerance zone are parallel to datum plane B as specified by the direction of the leader line and the secondary datum (2D) or orientation plane indicator (3D) (the direction of the width of the tolerance zone is perpendicular to datum plane B).

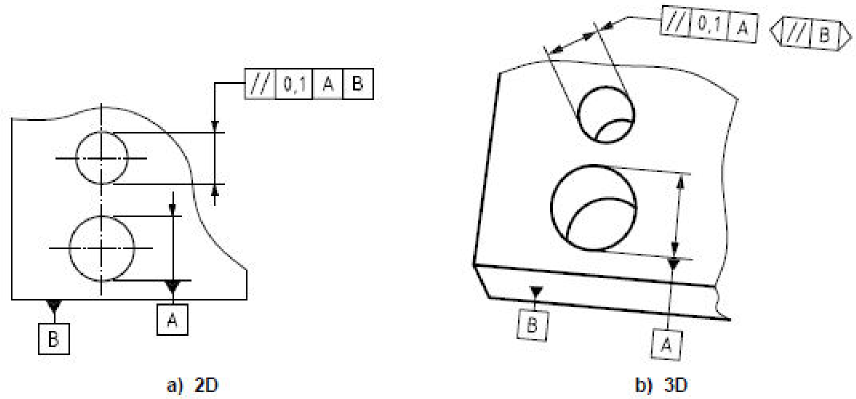


FIG 19.22

Definition of the tolerance zone

The tolerance zone is limited by two parallel planes a distance *t* apart. The planes are parallel to the datums and in the direction specified.

a Datum A.
b Datum B.

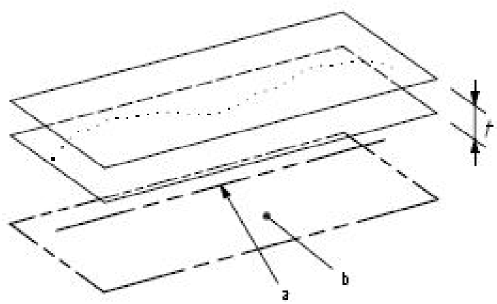
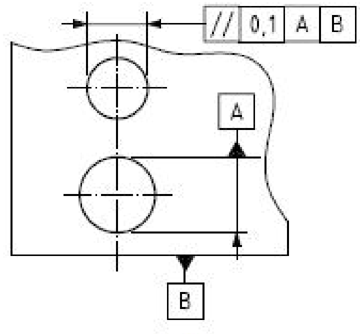


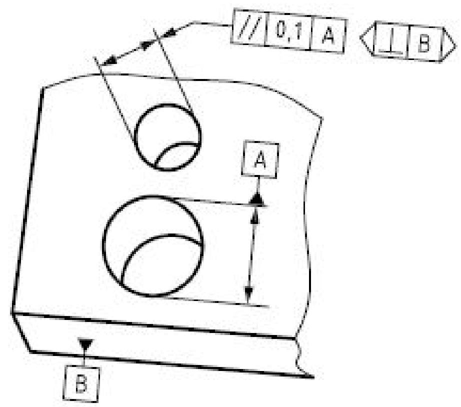
FIG 19.23

Symbol	Indication and explanation
//	The extracted (actual) median line shall be contained between two parallel planes 0.1 apart, which are parallel to datum axis A. The planes limiting the tolerance zone are perpendicular to datum plane B as specified by the direction of the leader line and the secondary datum (2D) or the orientation plane indicator (3D) (the direction of the width of the tolerance zone is parallel to datum plane B).



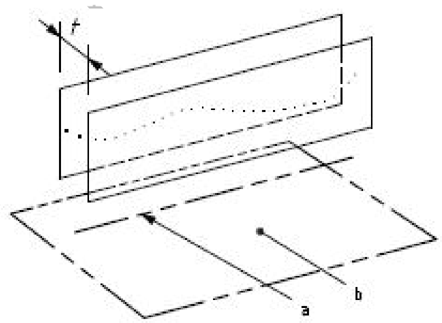
a) 2D

FIG 19.24



b) 3D

Definition of the tolerance zone



a Datum A.
b Datum B.

FIG 19.25

Symbol	Indication and explanation

The extracted (actual) median line shall be contained between two pairs of parallel planes, which are parallel to datum axis A, and positioned 0.1 and 0.2 apart respectively. The direction of the width of the tolerance zones is specified with respect to datum plane B by the direction of the leader lines and the secondary datum (2D) or the orientation plane indicators (3D).

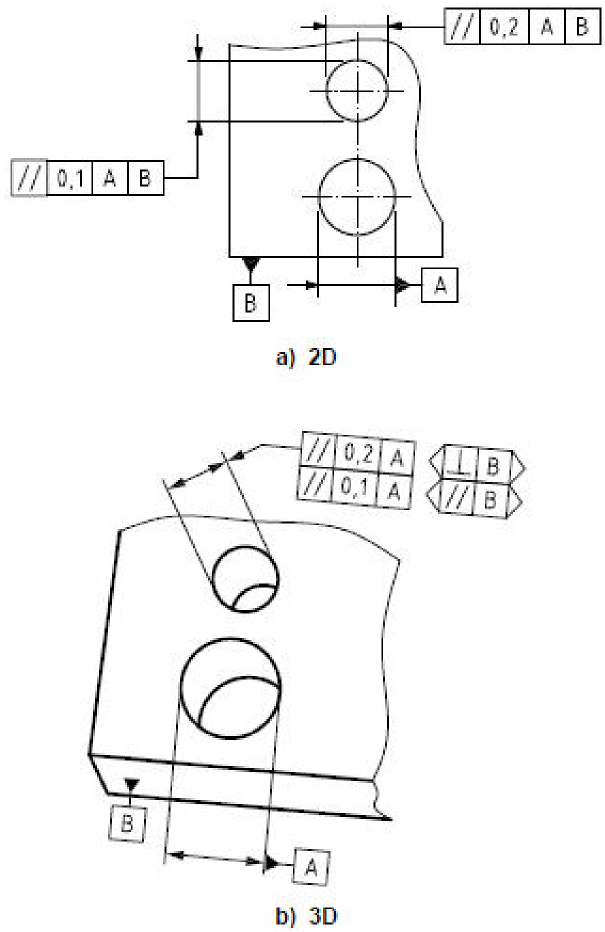


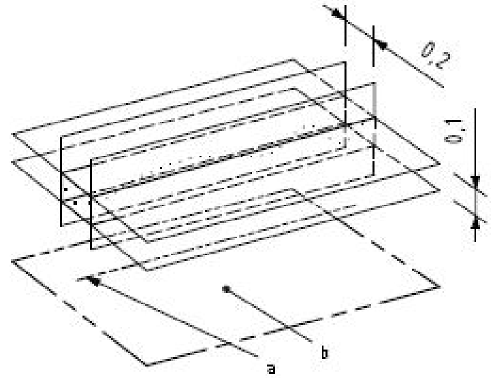
FIG 19.26

Definition of the tolerance zone

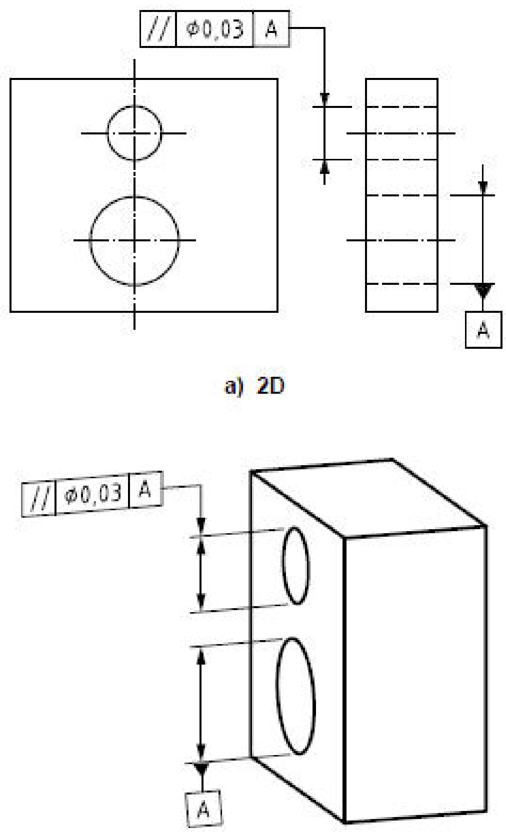
The extracted (actual) median line shall be contained between two pairs of parallel planes, which are parallel to the datum axis A, and positioned 0.1 and 0.2 apart respectively. The orientations of the tolerance zones specified with respect to datum plane B by the orientation plane indicators:

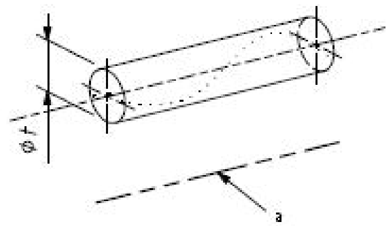
- the planes limiting the tolerance zone of 0.2 mm are perpendicular to the orientation plane B as specified by the orientation plane indicator;

- the planes limiting the tolerance zone of 0.1 mm are parallel to the orientation plane B as specified by the orientation plane indicator.

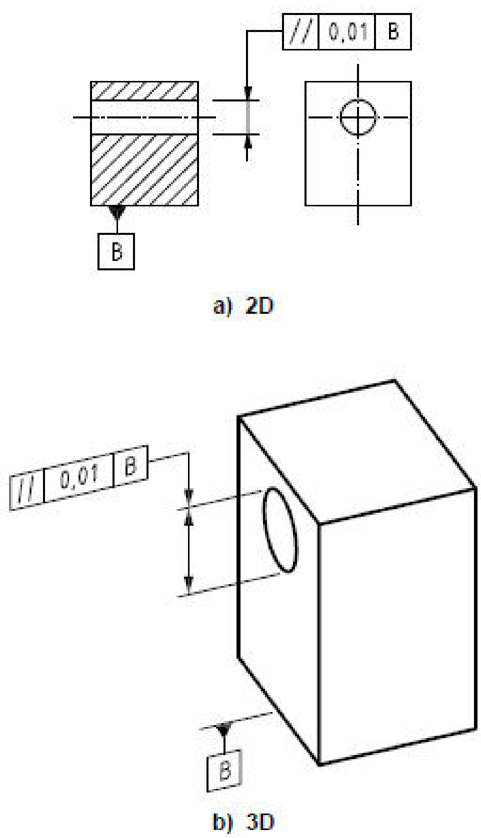
	a Datum A. b Datum B.  FIG 19.27

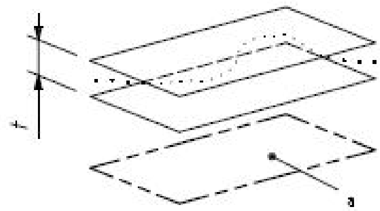
19.4.9.2 *Parallelism tolerance of a line related to a datum line*

Symbol	Indication and explanation
//	The extracted (actual) median line shall be within a cylindrical zone of diameter 0.03, parallel to datum axis A.  b) 3D FIG 19.28

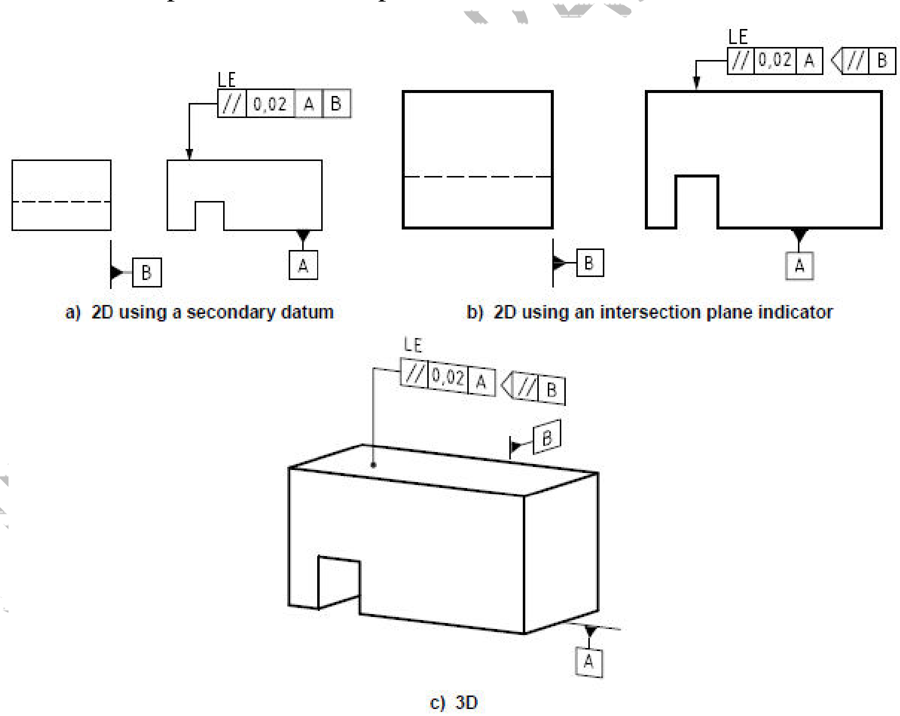
	Definition of the tolerance zone
	The tolerance zone is limited by a cylinder of diameter *t*, parallel to the datum, if the tolerance value is preceded by the symbol Ø.  a Datum A. FIG 19.29

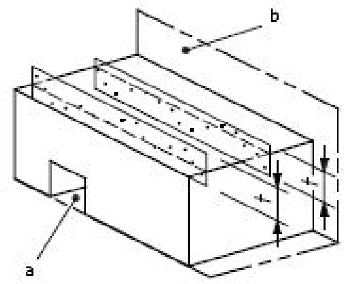
19.4.9.3 *Parallelism tolerance of a line related to a datum plane*

Symbol	Indication and explanation
//	The extracted (actual) median line shall be contained between two parallel planes 0.01 apart, which are parallel to datum plane B.  FIG 19.30
	Definition of the tolerance zone

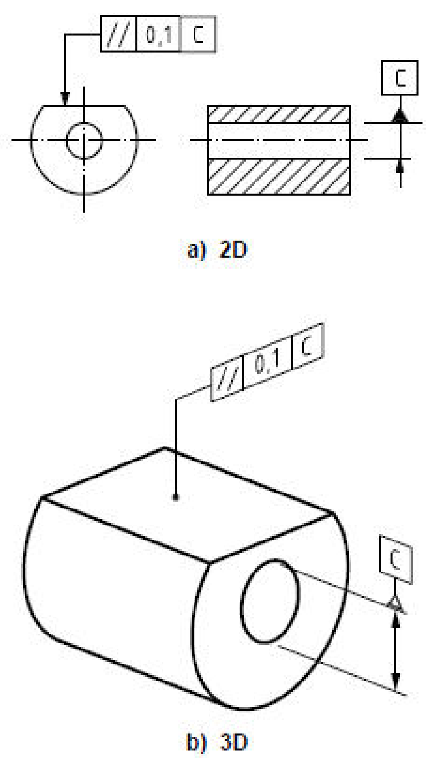
	The tolerance zone is limited by two parallel planes a distance *t* apart and parallel to the datum.  a Datum B. FIG 19.31

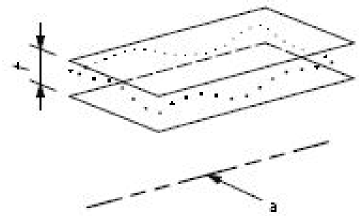
19.4.9.4 *Parallelism tolerance of a surface related to a datum plane*

Symbol	Indication and explanation
//	Each extracted (actual) line, parallel to datum plane B as specified by the intersection plane indicator, shall be contained between two parallel lines 0.02 apart, which are parallel to datum plane A.  FIG 19.32
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel lines a distance *t* apart and oriented parallel to datum plane A, the lines lying in a plane parallel to datum plane B.

	a Datum A. b Datum B.  FIG 19.33

19.4.9.5 *Parallelism tolerance of a surface related to a datum line*

Symbol	Indication and explanation
//	The extracted (actual) surface shall be contained between two parallel planes 0.1 apart, which are parallel to datum axis C.  FIG 19.34
	Definition of the tolerance zone

	The tolerance zone is limited by two parallel planes a distance *t* apart and parallel to the datum.  a Datum C. FIG 19.35

19.4.9.6 *Parallelism tolerance of a surface related to a datum plane*

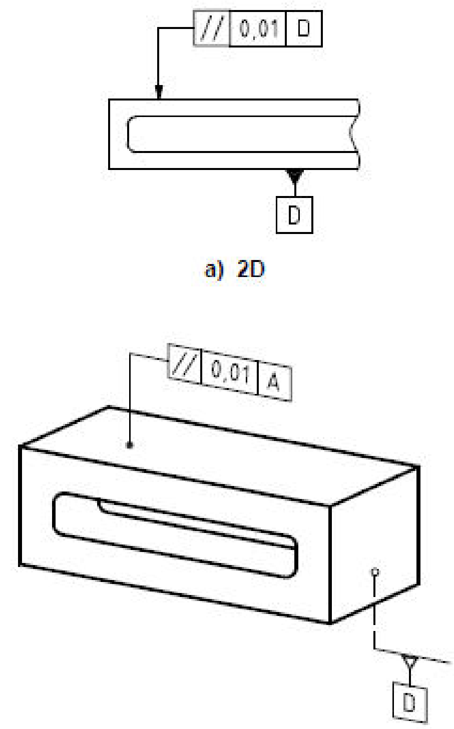
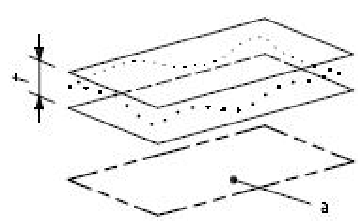
Symbol	Indication and explanation
//	The extracted (actual) surface shall be contained between two parallel planes 0.01 apart, which are parallel to datum plane D.  a) 2D b) 3D FIG 19.36
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel planes a distance *t* apart and parallel to the datum plane.  a Datum D.

	FIG 19.37

19.4.10 *Perpendicularity tolerance*

19.4.10.1 *Perpendicularity tolerance of a line related to a datum line*

<table>
<tr><th>Symbol</th><th>Indication and explanation</th></tr>
<tr><td rowspan="3">⊥</td><td>The extracted (actual) median line shall be contained between two parallel planes 0.06 apart, which are perpendicular to datum axis A.

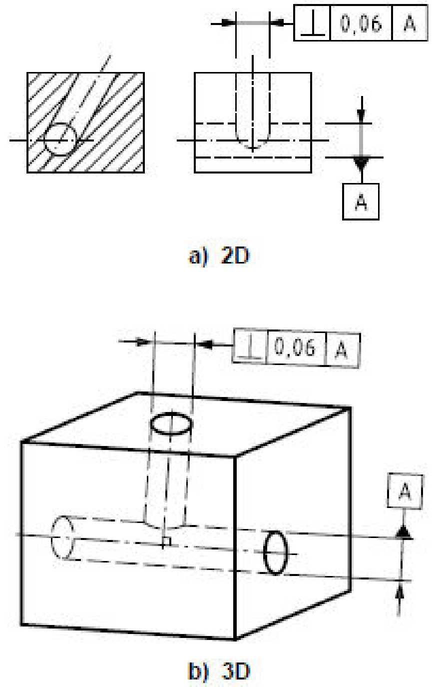


FIG 19.38</td></tr>
<tr><td>Definition of the tolerance zone</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.

a Datum A.

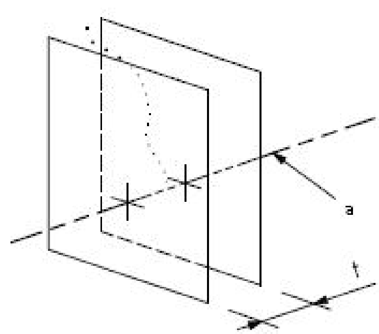


FIG 19.39</td></tr>
</table>

19.4.10.2 *Perpendicularity tolerance of a line related to a datum system*

<table>
<tr><th>Symbol</th><th>Indication and explanation</th></tr>
<tr><td rowspan="4">⊥</td><td>The extracted (actual) median line of the cylinder shall be contained between two parallel planes 0.1 apart, which are perpendicular to datum plane A and in the orientation specified with respect to datum plane B.

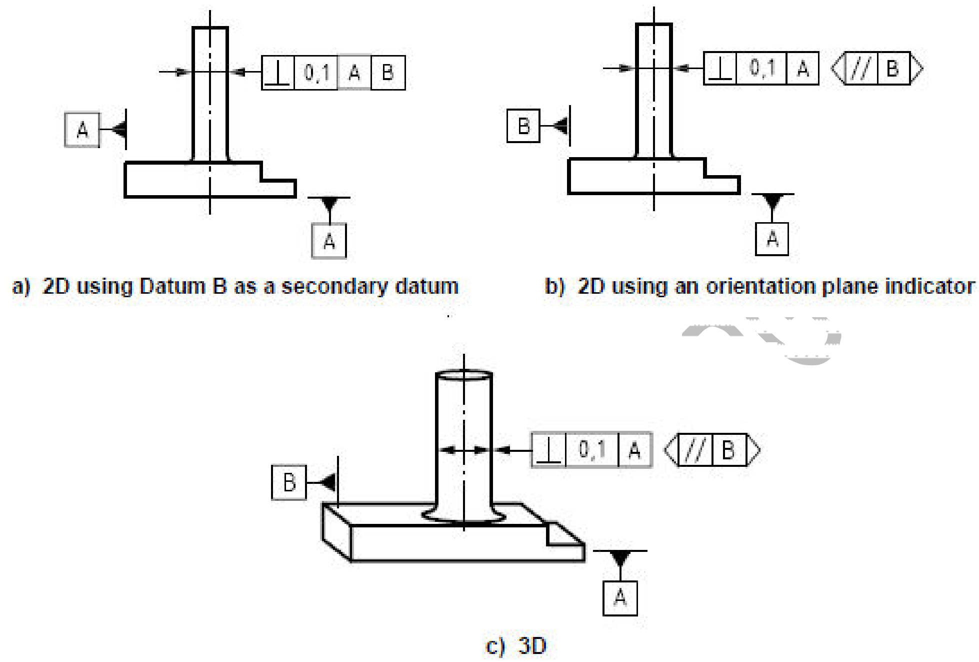



FIG 19.40</td></tr>
<tr><td>Definition of the tolerance zone</td></tr>
<tr><td>The tolerance zone is limited by two parallel planes a distance t apart. The planes are perpendicular to datum A and parallel to datum B.
a Datum A.
b Datum B.

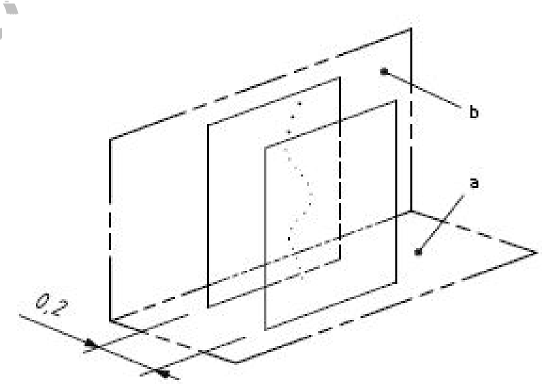



FIG 19.41</td></tr>
</table>

<table>
<tr><th>Symbol</th><th>Indication and explanation</th></tr>
<tr><td>⊥</td><td>The extracted (actual) median line of the cylinder shall be contained between two pairs of parallel planes, perpendicular to datum plane A, and positioned 0.1 and 0.2 apart respectively. The direction of the width of the tolerance zones is specified with respect to datum plane B by the plane of projection (2D) or the</td></tr>
</table>

orientation plane indicators (3D).

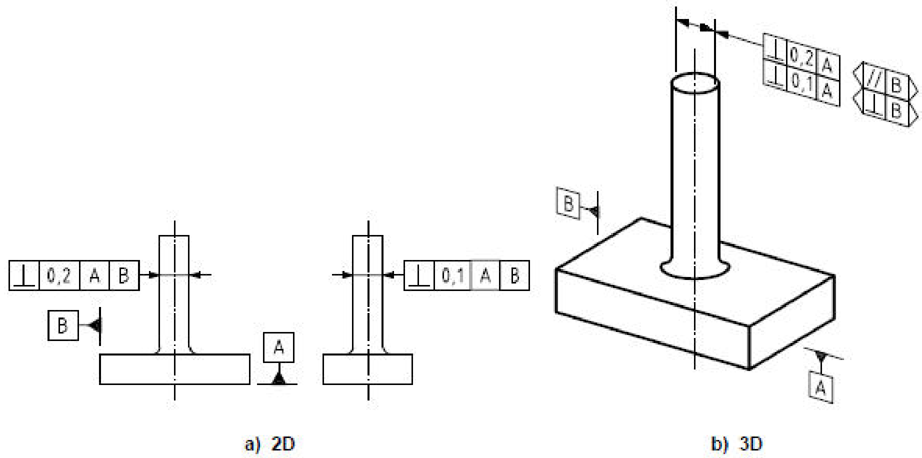
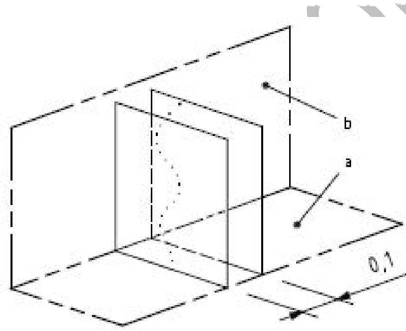
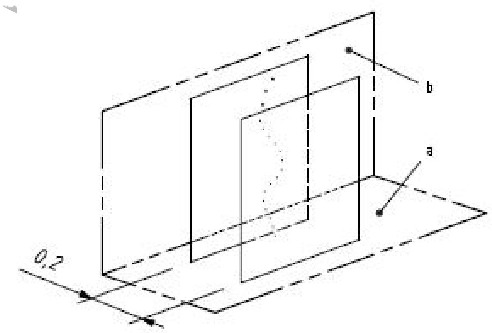


FIG 19.42

Definition of the tolerance zone

The tolerance zone is limited by two pairs of parallel planes a distance 0,1 and 0,2 apart and perpendicular to each other. Both planes are perpendicular to the datum A, one pair of planes being parallel to datum B (*see* Fig 19.44), the other pair being perpendicular to datum B (*see* Fig 19.43).



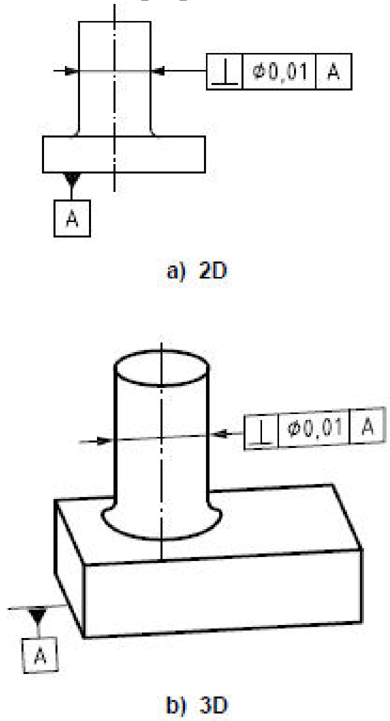
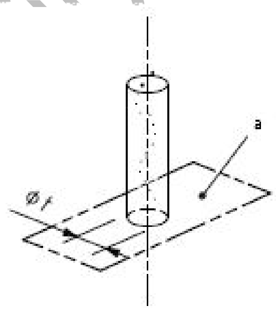


a Datum A.
b Datum B.

FIG 19.43 FIG 19.44

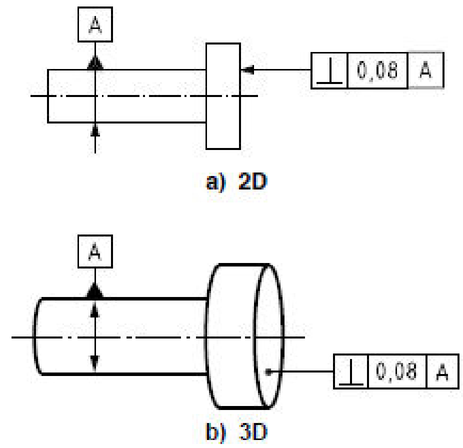
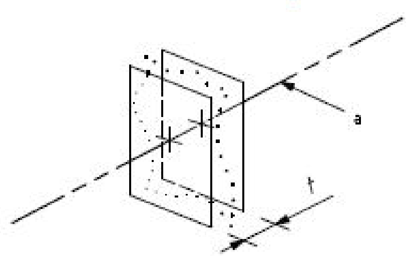
19.4.10.3 *Perpendicularity tolerance of a line related to a datum plane*

Symbol	Indication and explanation

⊥	The extracted (actual) median line of the cylinder shall be within a cylindrical zone of diameter 0.01, which is perpendicular to datum plane A.  FIG 19.45
	Definition of the tolerance zone
	The tolerance zone is limited by a cylinder of diameter *t* perpendicular to the datum if the tolerance value is preceded by the symbol Ø.  a Datum A. FIG 19.46

19.4.10.4 *Perpendicularity tolerance of a surface related to a datum line*

Symbol	Indication and explanation

⊥	The extracted (actual) surface shall be contained between two parallel planes 0.08 apart which are perpendicular to datum axis A.  FIG 19.47
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel planes a distance *t* apart and perpendicular to the datum.  a Datum A. FIG 19.48

19.4.10.5 *Perpendicularity tolerance of a surface related to a datum plane*

Symbol	Indication and explanation

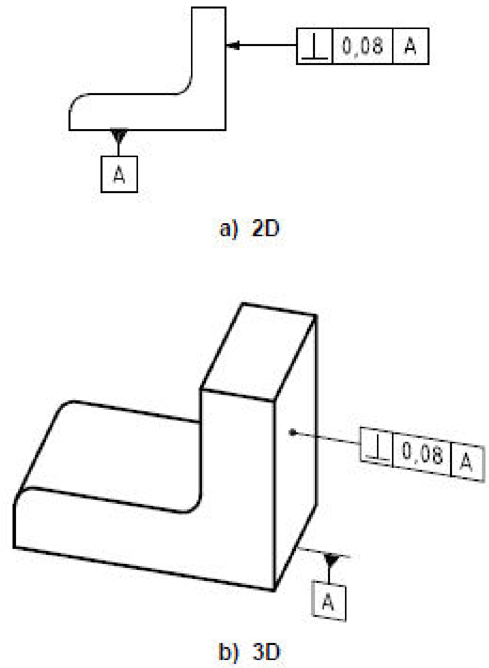
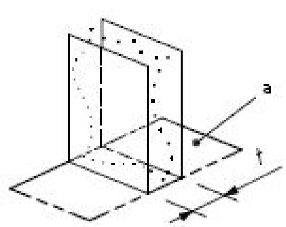
<table>
<tr>
<td rowspan="3">⊥</td>
<td>The extracted (actual) surface shall be contained between two parallel planes 0.08 apart, which are perpendicular to datum plane A.


FIG 19.49</td>
</tr>
<tr>
<td>Definition of the tolerance zone</td>
</tr>
<tr>
<td>The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum.


a Datum A.
FIG 19.50</td>
</tr>
</table>

19.4.11 *Angularity tolerance*

19.4.11.1 *Angularity tolerance of a line related to a datum line*

Symbol	Indication and explanation
∠	The extracted (actual) median line shall be contained between two parallel planes 0.08 apart that are inclined at a theoretically exact angle of 60° to the common datum straight line A-B.

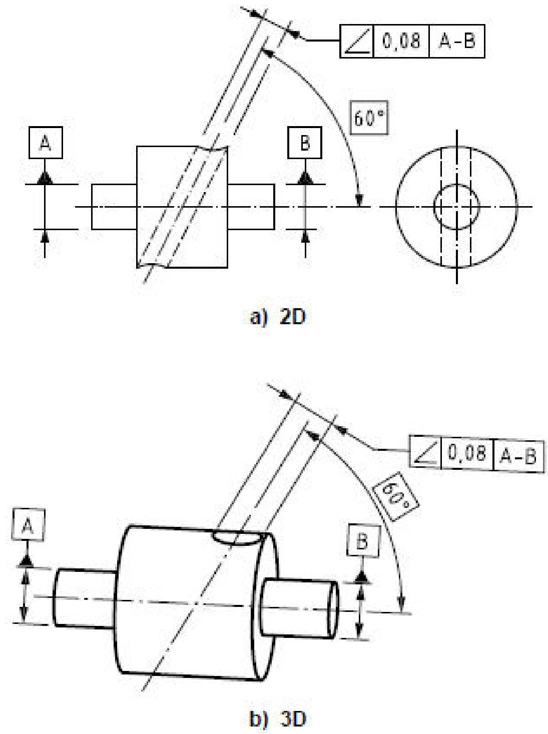
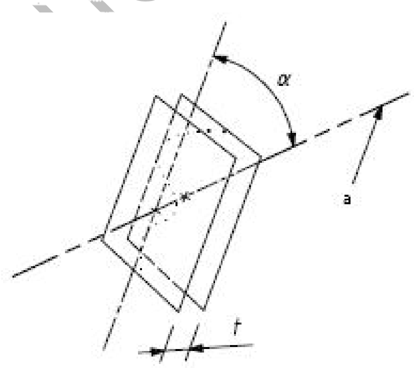


FIG 19.51

Definition of the tolerance zone

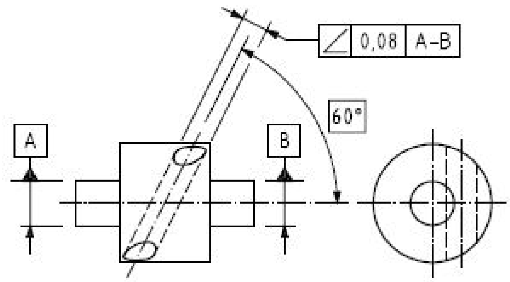
Line and datum line in the same plane: The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the datum.



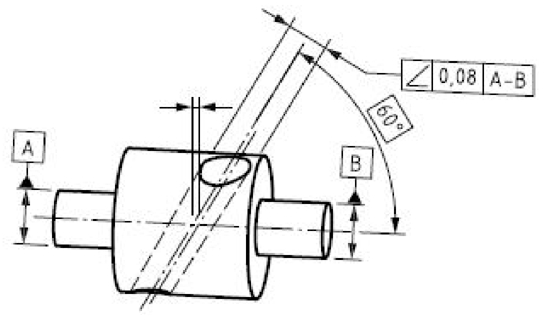
a Datum A-B.

FIG 19.52

Symbol	Indication and explanation
∠	The extracted (actual) median line shall be contained between two parallel planes 0.08 apart that are inclined at a theoretically exact angle of 60° to the common datum straight line A-B.



a) 2D

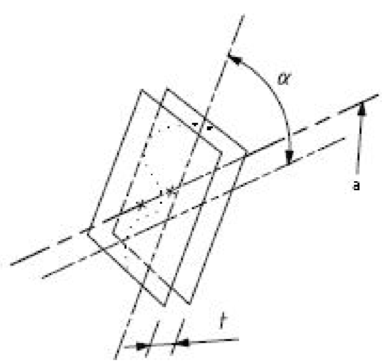


b) 3D

FIG 19.53

Definition of the tolerance zone

The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the datum. The considered line and the datum line are not in the same plane.



a Datum A-B.

FIG 19.54

19.4.11.2 *Angularity tolerance of a line related to a datum plane*

Symbol	Indication and explanation
∠	The extracted (actual) median line shall be contained between two parallel planes 0.08 apart that are inclined at a theoretically exact angle of 60° to datum plane A.

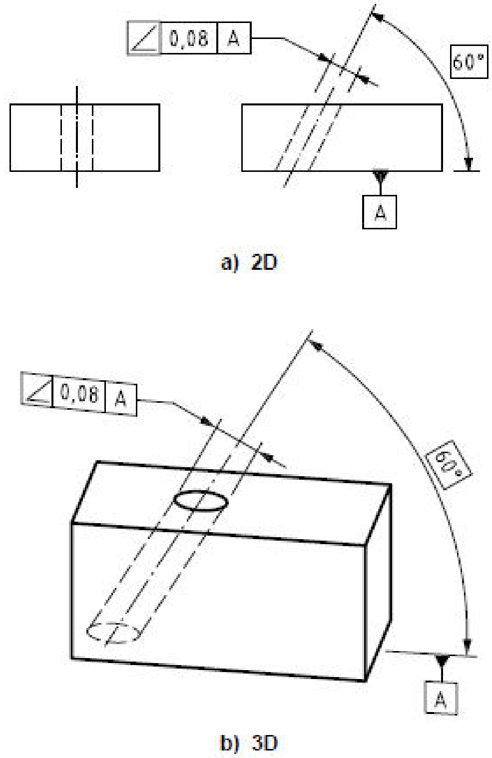
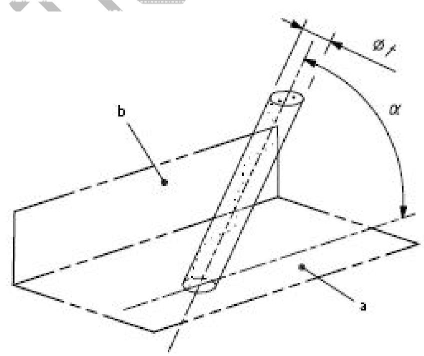


FIG 19.55

Definition of the tolerance zone

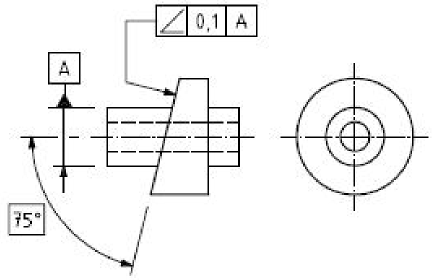
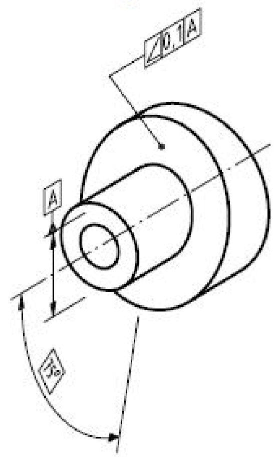
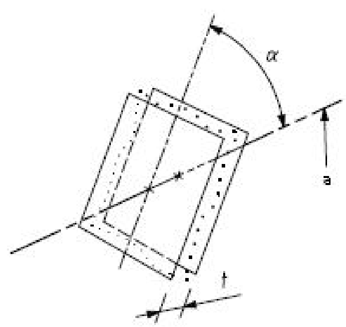
The tolerance zone is limited by a cylinder of diameter *t* if the tolerance value is preceded by the symbol . The cylindrical tolerance zone is parallel to a datum plane B and inclined at the specified angle to datum plane A.



a Datum A.
b Datum B.
FIG 19.56

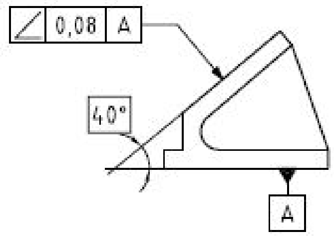
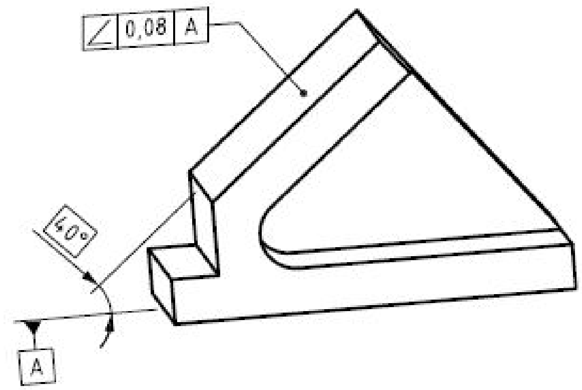
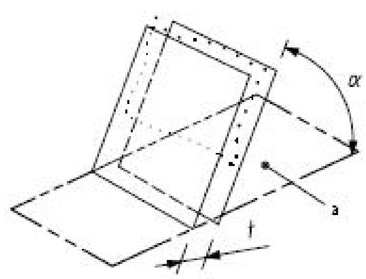
19.4.11.3 *Angularity tolerance of a surface related to a datum line*

Symbol	Indication and explanation
∠	The extracted (actual) surface shall be contained between two parallel planes 0.1 apart that are inclined at a theoretically exact angle of 75° to datum axis A.

	 a) 2D  FIG 19.57 b) 3D
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the datum.  a Datum A. FIG 19.58

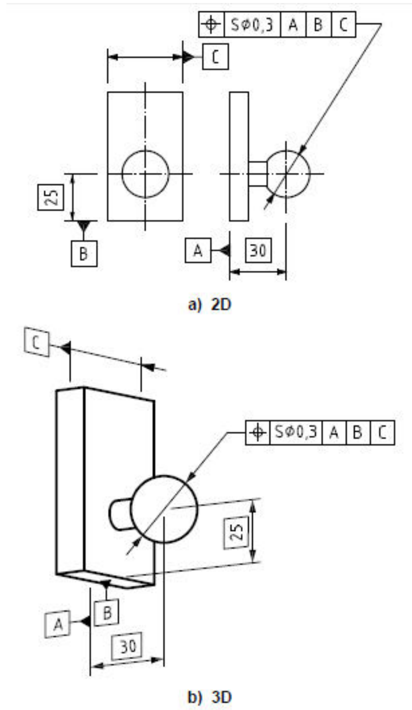
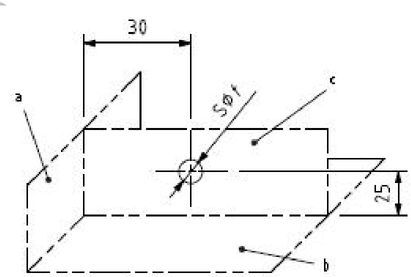
19.4.11.4 *Angularity tolerance of a surface related to a datum plane*

Symbol	Indication and explanation

∠	The extracted (actual) surface shall be contained between two parallel planes 0.08 apart that are inclined at a theoretically exact angle of 40° to datum plane A.  a) 2D  b) 3D FIG 19.59
	Definition of the tolerance zone
	The tolerance zone is limited by two parallel planes a distance *t* apart and inclined at the specified angle to the datum.  a Datum A. FIG 19.60

19.4.12 *Position tolerance*
19.4.12.1 *Position tolerance of a point*

Symbol	Indication and explanation

⌖	The extracted (actual) centre of the sphere shall be within a spherical zone of diameter 0.3, the centre of which coincides with the theoretically exact position of the sphere, with respect to datum planes A and B and to datum median plane C. .  FIG 19.61 NOTE- The definition of extracted (actual) centre of a sphere has not been standardized
	Definition of the tolerance zone
	The tolerance zone is limited by a sphere of diameter *t* if the tolerance value is preceded by the symbol S. The centre of the spherical tolerance zone is fixed by theoretically exact dimensions with respect to datums A, B and C.  a Datum A. b Datum B. c Datum C. FIG 19.62

19.4.12.2 *Position tolerance of a line*

Symbol	Indication and explanation
⌖	The extracted (actual) centre line of each of the scribe lines shall be contained between two parallel planes 0.1 apart, which are symmetrically disposed about the theoretically exact position of the considered line, with respect to datum planes A and B.

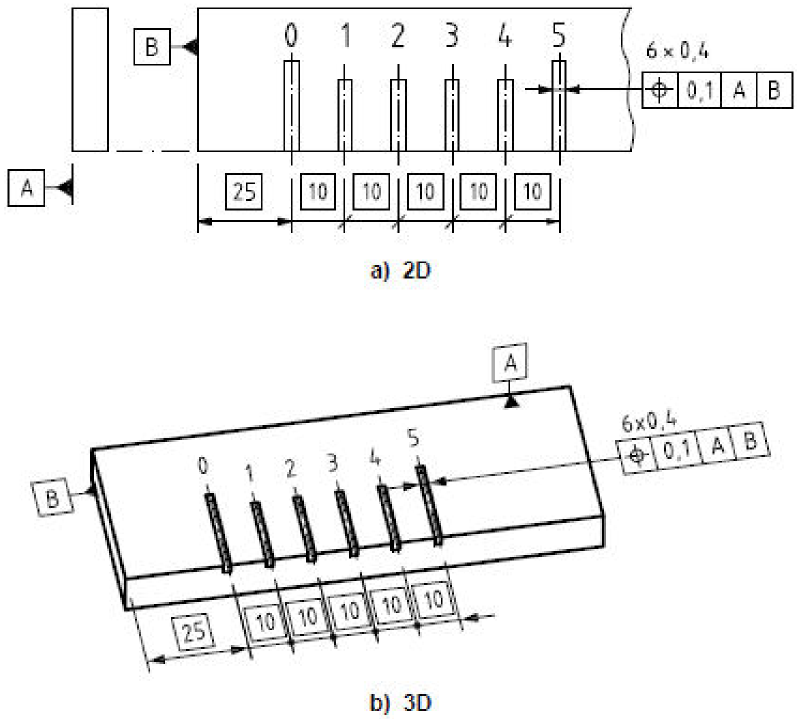
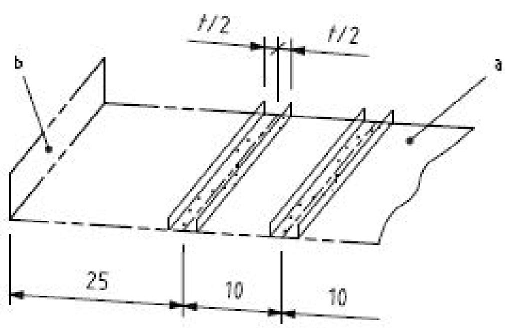


FIG 19.63

Definition of the tolerance zone

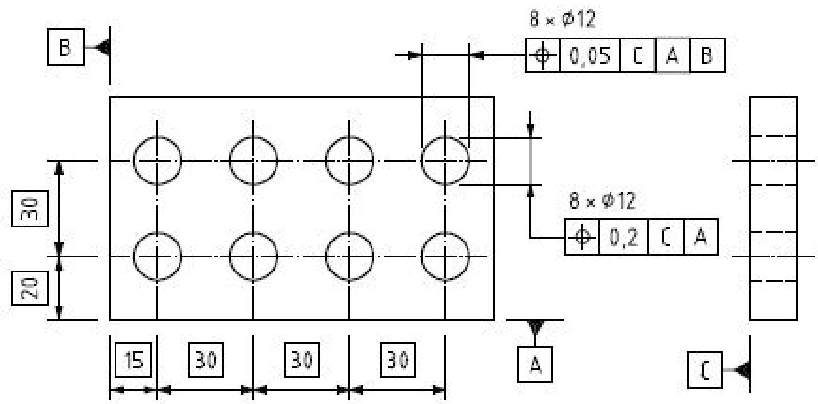
The tolerance zone is limited by two parallel planes a distance *t* apart and symmetrically disposed about the centre line. The centre line is fixed by theoretically exact dimensions with respect to datums A and B. The tolerance is specified in one direction only.



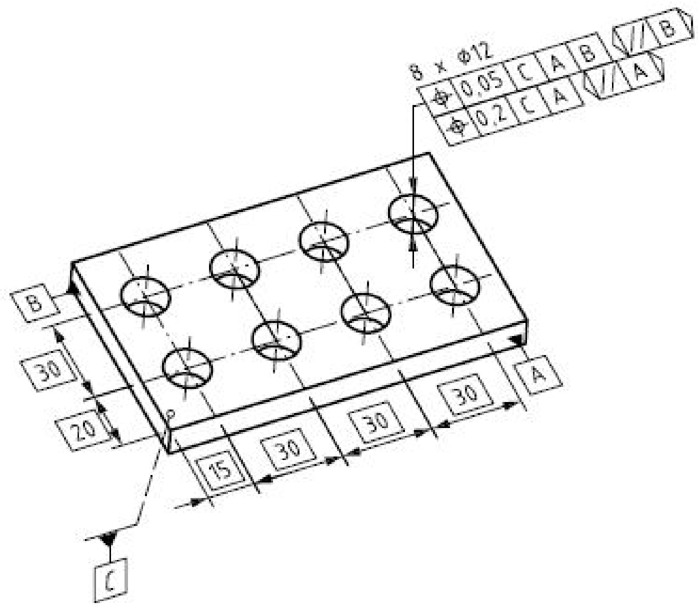
a Datum A.
b Datum B.

FIG 19.64

Symbol	Indication and explanation
⌖	The extracted (actual) median line of each hole shall be contained between two pairs of parallel planes, positioned 0.05 and 0.2 apart respectively, in the direction specified, and perpendicular to each other. Each pair of parallel planes is orientated with respect to the datum system and symmetrically disposed about the theoretically exact position of the considered hole, with respect to datum planes C, A and B.



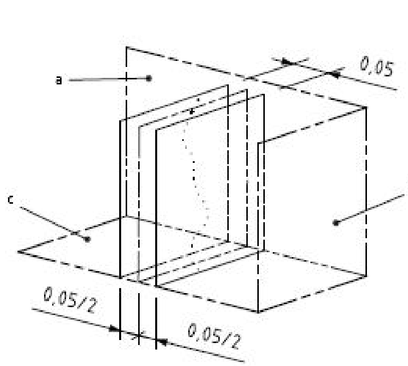
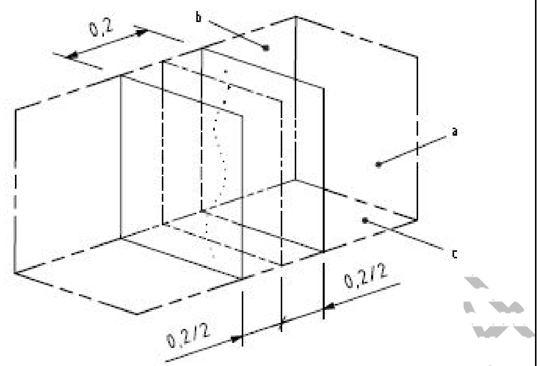
a) 2D

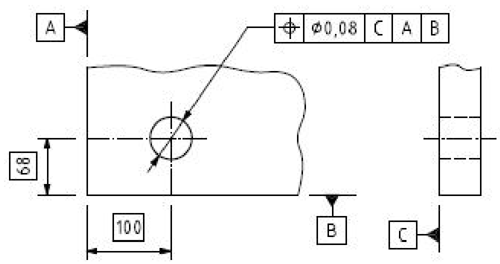
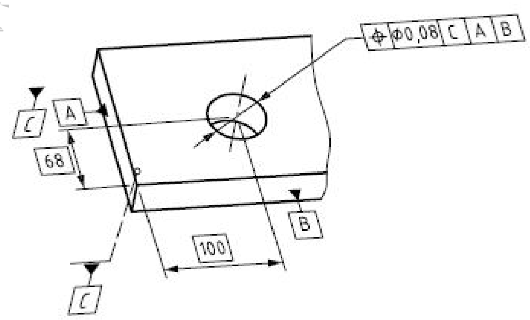


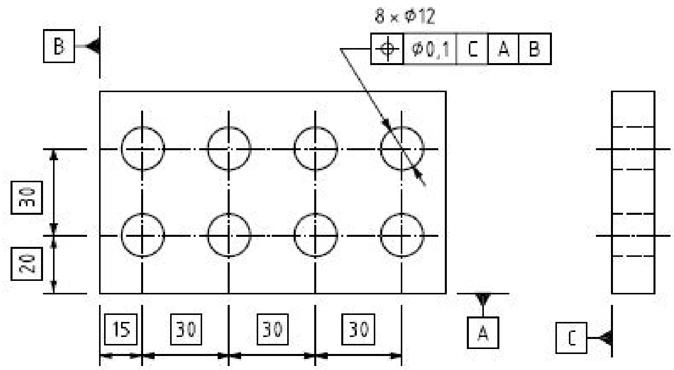
b) 3D

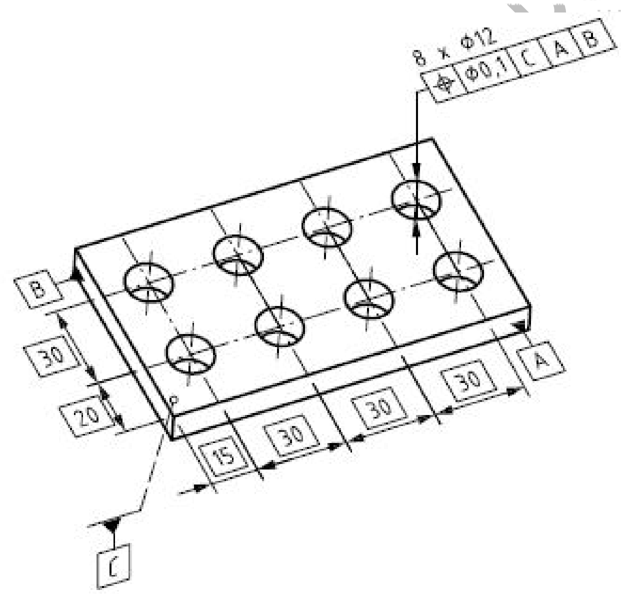
FIG 19.65

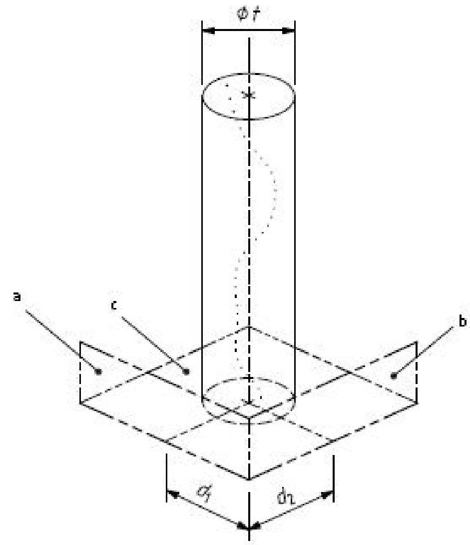
Symbol	*Definition of the tolerance zone*
⌖	The tolerance zone is limited by two pairs of parallel planes a distance 0,05 and 0,2 apart respectively and symmetrically disposed about the theoretically exact position. The theoretically exact position is fixed by theoretically exact dimensions with respect to datums C, A and B. The tolerance is specified in two directions with respect to the datums.

	 a Datum A. b Datum B. c Datum C. FIG 19.66  a Datum A. b Datum B. c Datum C. FIG 19.67

Symbol	Indication and explanation
⌖	The extracted (actual) median line shall be within a cylindrical zone of diameter 0.08, the axis of which coincides with the theoretically exact position of the considered hole, with respect to datum planes C, A and B.  a) 2D  FIG 19.68 b) 3D
	The extracted (actual) median line of each hole shall be within a cylindrical zone of diameter 0.1, the axis of which coincides with the theoretically exact position of the considered hole, with respect to datum planes C, A, and B.

	 a) 2D

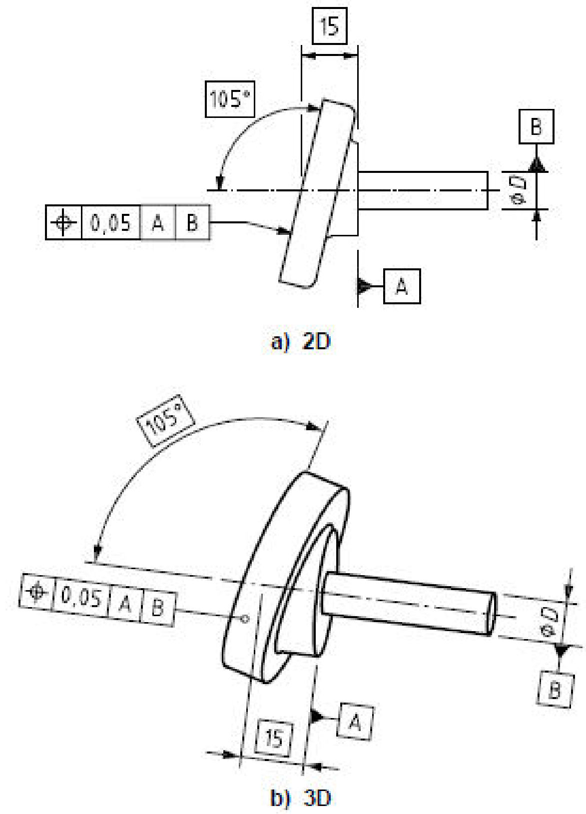
Symbol	Indication and explanation
⌖	 b) 3D FIG 19.69
	Definition of the tolerance zone

<table>
<tr><td></td><td>The tolerance zone is limited by a cylinder of diameter t if the tolerance value is preceded by the symbol. The axis of the tolerance cylinder is fixed by theoretically exact dimensions with respect to datums C, A and B.


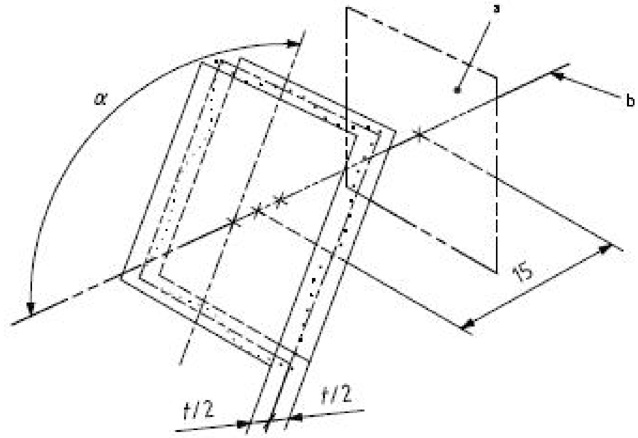
a Datum A.
b Datum B.
c Datum C.
FIG 19.70</td></tr>
</table>

19.4.12.3 *Position tolerance of a flat surface or a median plane*

Symbol	Indication and explanation

⌖	The (actual) contained parallel apart, disposed exact surface, datum datum  extracted surface shall be between two planes 0.05 which are symmetrically about the theoretically position of the with respect to plane A and axis B. FIG 19.71

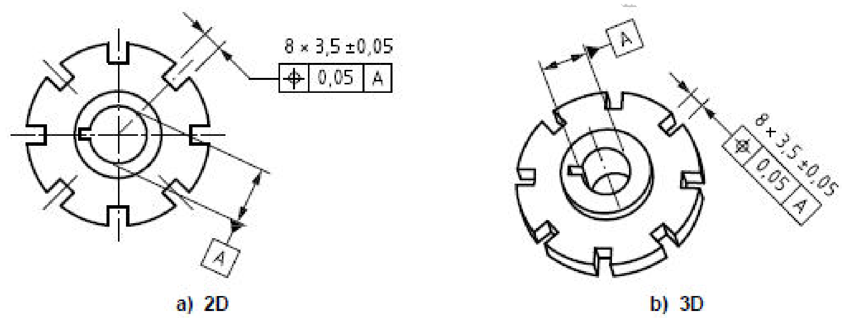
Symbol	*Definition of the tolerance zone*
⌖	The tolerance zone is limited by two parallel planes a distance *t* apart and symmetrically disposed about the theoretically exact position fixed by theoretically exact dimensions with respect to datums A and B.



a Datum A.
b Datum B.

FIG 19.72

The extracted (actual) median surface shall be contained between two parallel planes 0.05 apart, which are symmetrically disposed about the theoretically exact



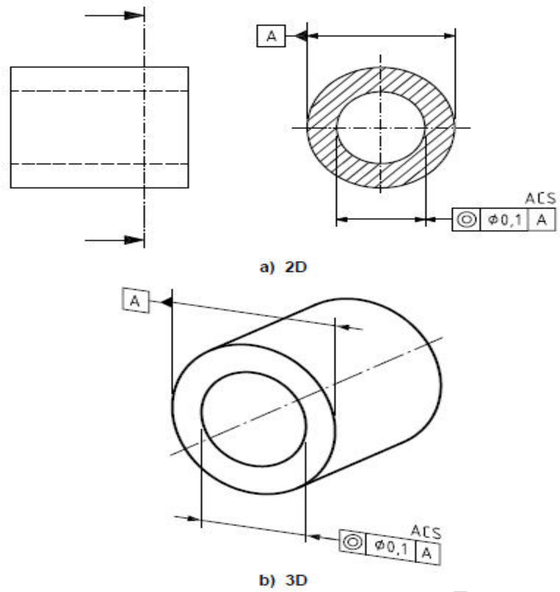
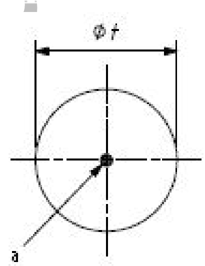
position of the median plane, with respect to datum axis A.

FIG 19.73

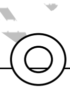
19.4.13 *Concentricity and coaxiality tolerance*

19.4.13.1 *Concentricity tolerance of a point*

Symbol	Indication and explanation
	The extracted (actual) centre of the inner circle in any cross-section shall be within a circle of diameter 0.1, concentric with datum point A defined in the same cross-section.

	 FIG 19.74
	*Definition of the tolerance zon***e**
	The tolerance zone is limited by a circle of diameter *t*; the tolerance value shall be preceded by the symbol. The centre of the circular tolerance zone coincides with the datum point.  a Datum point A. FIG 19.75

19.4.13.2 *Concentricity tolerance of an axis*

Symbol	Indication and explanation
	The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0.08, the axis of which is the common datum straight line A-B.

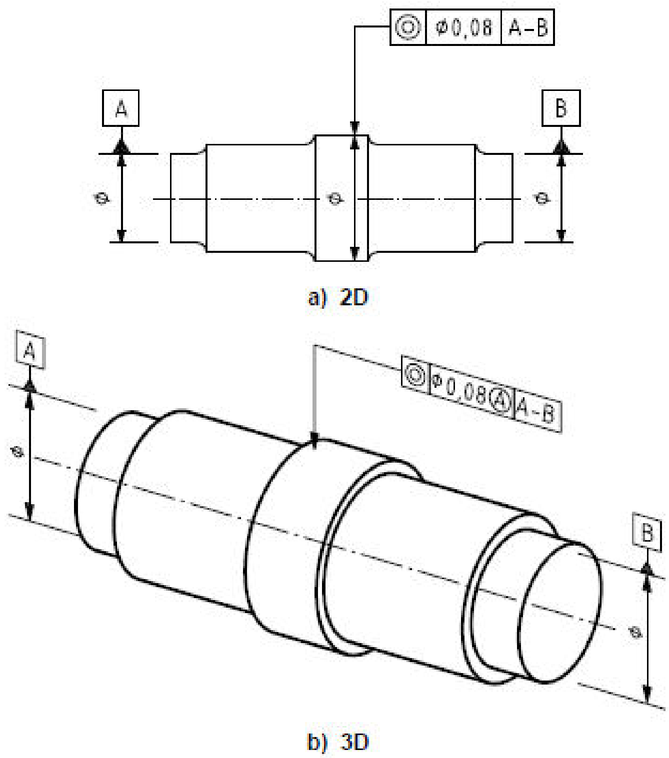
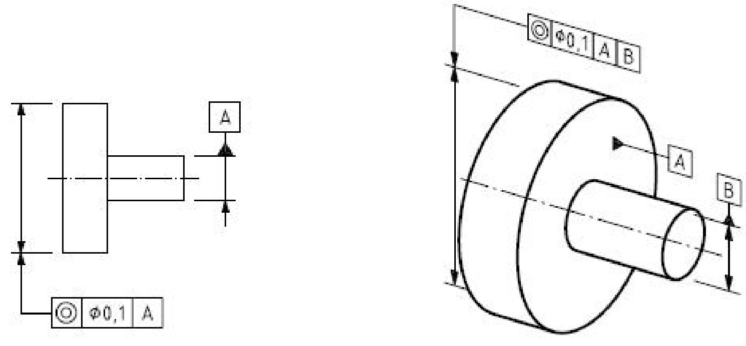
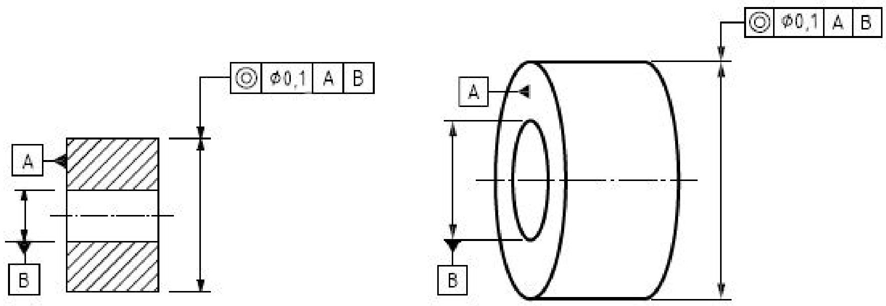


FIG 19.76

The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0.1, the axis of which is datum axis A [*see* Fig 19.77a) and 19.77b)].

	FIG 19.77 

Symbol	Indication and explanation
◎	The extracted (actual) median line of the toleranced cylinder shall be within a cylindrical zone of diameter 0.1, the axis of which is datum axis B which is perpendicular to datum plane A [*see* Fig 19.78a) and 19.78b)].  FIG 19.78
	Definition of the tolerance zone
	The tolerance zone is limited by a cylinder of diameter *t*; the tolerance value shall be preceded by the symbol . The axis of the cylindrical tolerance zone coincides with the datum.  a Datum A-B (Fig 19.77). Secondary datum B perpendicular to primary datum A (not shown) (Fig 19.78). FIG 19.79

19.4.14 *Symmetry tolerance*
19.4.14.1 *Symmetry tolerance of a median plane*

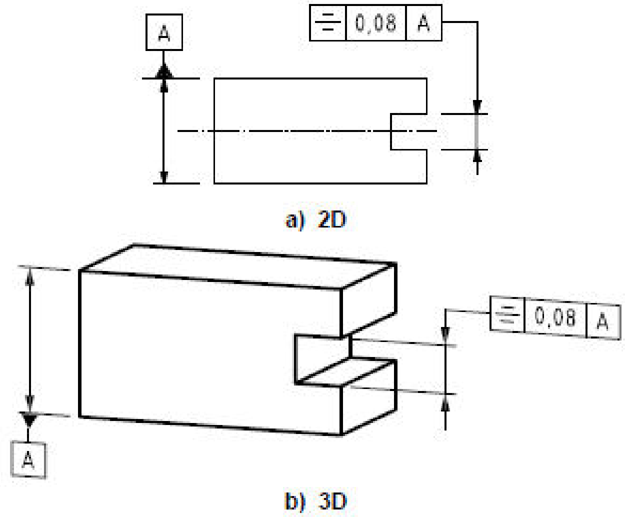
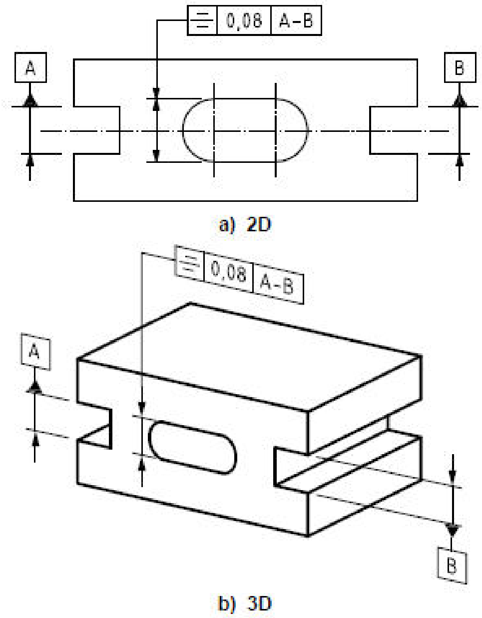
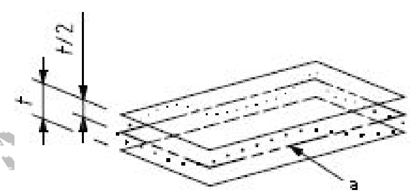
Symbol	Indication and explanation
⌯	The extracted (actual) median surface shall be contained between two parallel planes 0.08 apart, which are symmetrically disposed about datum plane A.  FIG 19.80
	The extracted (actual) median surface shall be contained between two parallel planes 0.08 apart, which are symmetrically disposed about the common datum plane A-B.

	FIG 19.81 

Symbol	*Definition of the tolerance zone*
⌯	The tolerance zone is limited by two parallel planes a distance *t* apart, symmetrically disposed about the median plane, with respect to the datum.  a Datum. FIG 19.82

19.4.15 *Circular run-out tolerance*
19.4.15.1 *Circular run-out tolerance – Radial*

Symbol	Indication and explanation
↗	The extracted (actual) line in any cross-section plane perpendicular to datum axis A shall be contained between two coplanar concentric circles with a difference in

radii of 0.1 (see FIG 19.83).

The extracted (actual) line in any cross-section plane parallel to datum plane B shall be contained between two coplanar circles that are concentric to datum axis A, with a difference in radii of 0.1 (see Figure 19.84).

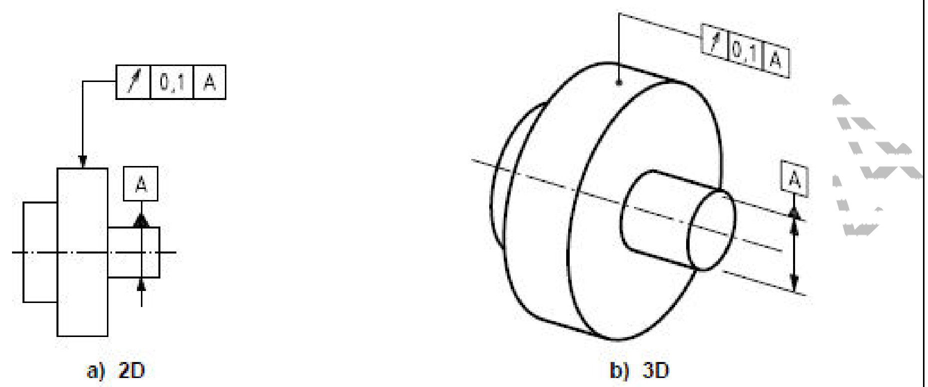


FIG 19.83

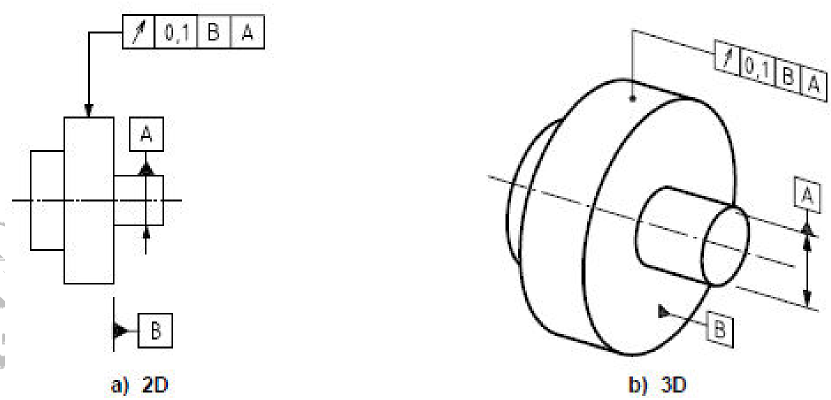


FIG 19.84

Symbol	Indication and explanation

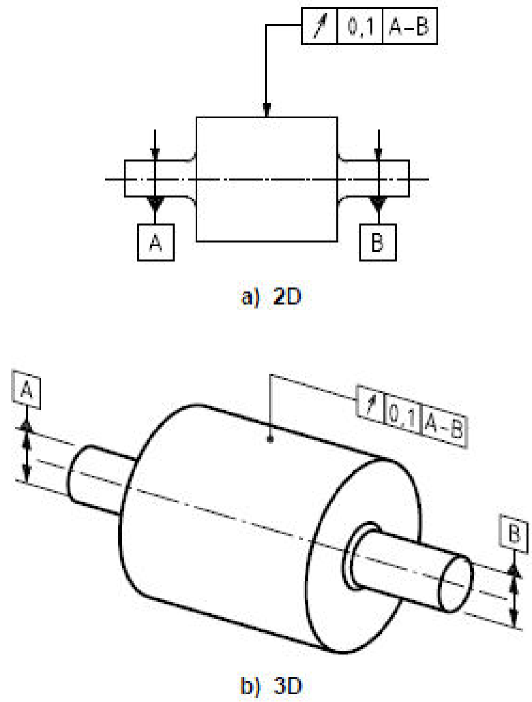
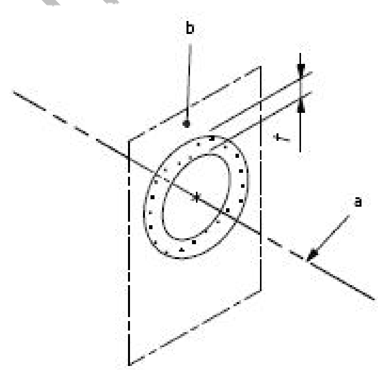
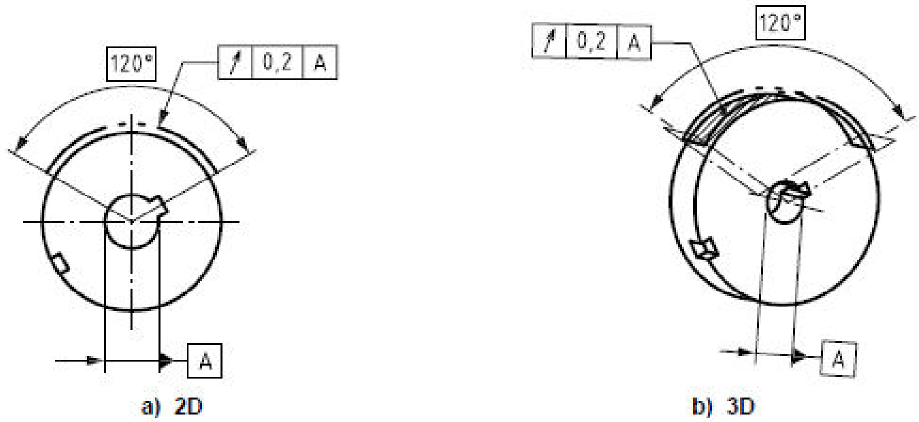
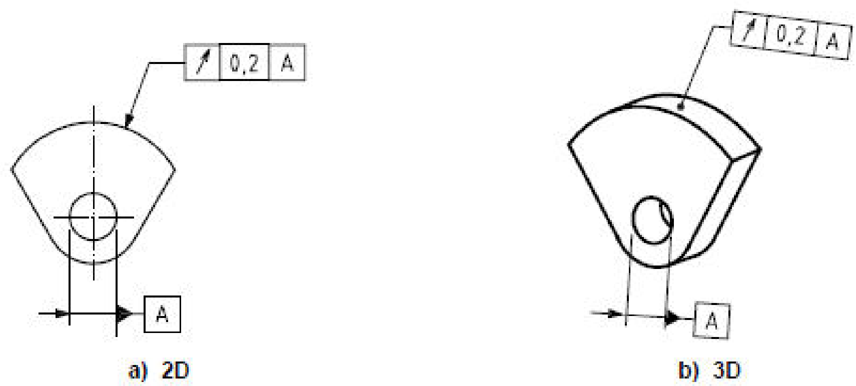
<table>
<tr>
<td rowspan="3">↗</td>
<td>The extracted (actual) line in any cross-section plane perpendicular to common datum straight line A-B shall be contained between two coplanar concentric circles with a difference in radii of 0.1.


FIG 19.85</td>
</tr>
<tr>
<td>Definition of the tolerance zone</td>
</tr>
<tr>
<td>The tolerance zone is limited within any cross-section perpendicular to the datum axis by two concentric circles with a difference in radii of t, the centres of which coincide with the datum.


a Datum.
b Cross-section plane.
FIG 19.86</td>
</tr>
</table>

Symbol	Indication and explanation
↗	The extracted (actual) line in any cross-section plane perpendicular to datum axis A shall be contained between two coplanar concentric circles with a difference in radii of 0.2.

	 FIG 19.87  FIG 19.88 Run-out usually applies to complete features, but could be applied to a restricted part of a feature (*see* Fig 19.87).

19.4.15.2 *Circular run-out tolerance – Axial*

Symbol	Indication and explanation
	The extracted (actual) line in any cylindrical section, the axis of which coincides

with datum axis D, shall be contained between two circles with a distance of 0.1.

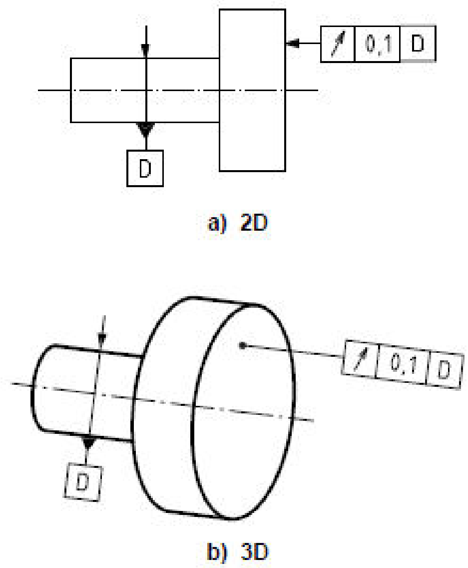
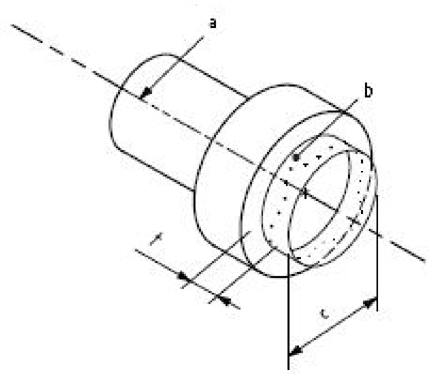


FIG 19.89

Definition of the tolerance zone

The tolerance zone is limited to any cylindrical section by two circles a distance *t* apart lying in the cylindrical section, the axis of which coincides with the datum.

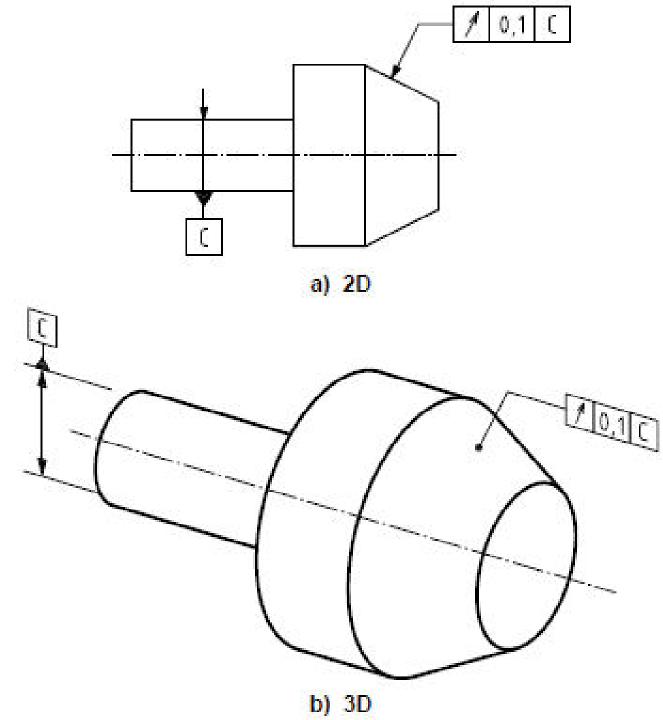


a Datum D.
b Tolerance zone.
c Any diameter.

FIG 19.90

19.4.15.3 *Circular run-out tolerance in any direction*

Symbol	Indication and explanation

	The extracted (actual) line in any conical section, the axis of which coincides with datum axis C, shall be contained between two circles within the conical section with a distance of 0.1.  FIG 19.91

Symbol	Indication and explanation

When the generator line for the toleranced feature is not straight, the apex angle of the conical section will change depending on the actual position [see FIG 19.93 (right) and FIG 19.92 b)].

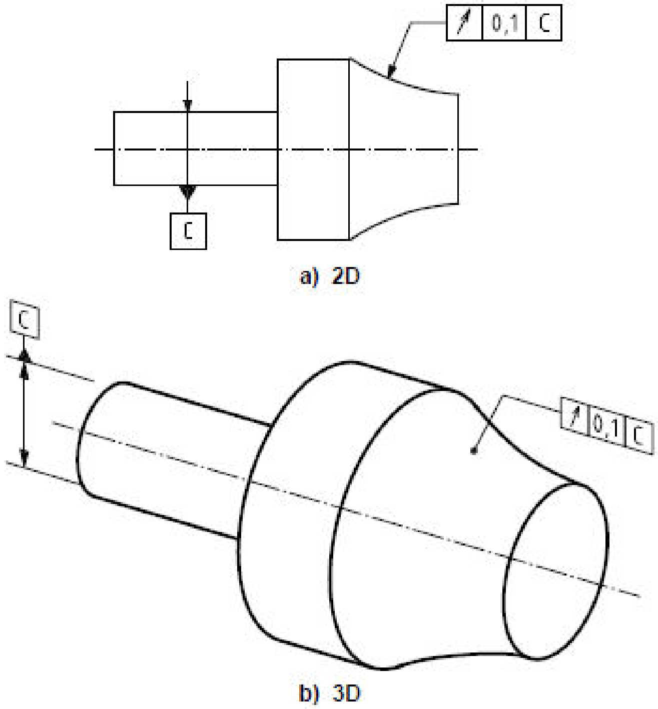
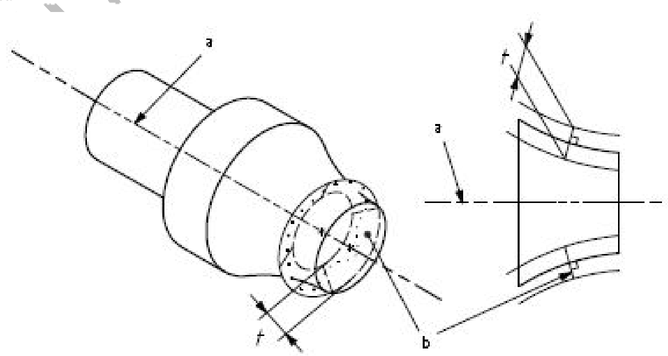


FIG 19.92

Definition of the tolerance zone

The tolerance zone is limited within any conical section by two circles a distance *t* apart, the axes of which coincide with the datum.

The width of the tolerance zone is normal to the specified geometry unless otherwise indicated.



a Datum C.

b Tolerance zone.

FIG 19.93

19.4.15.4 *Circular run-out tolerance in a specified direction*

Symbol	Indication and explanation
	The extracted (actual) line in any conical section (angle α) corresponding to a direction feature (cone of half-angle α), the axis of which coincides with datum

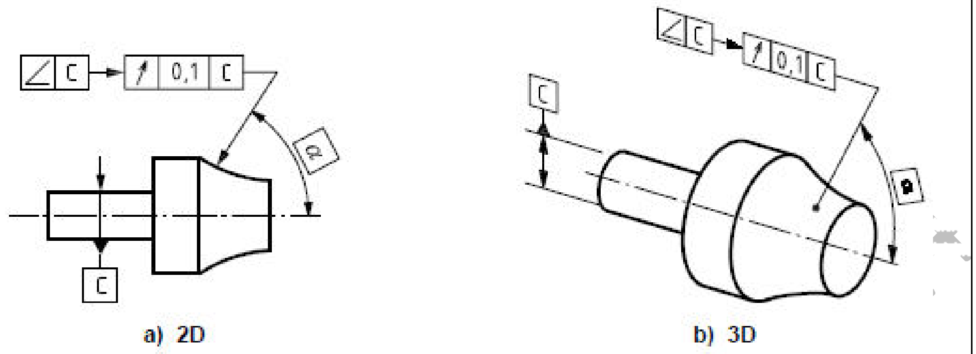
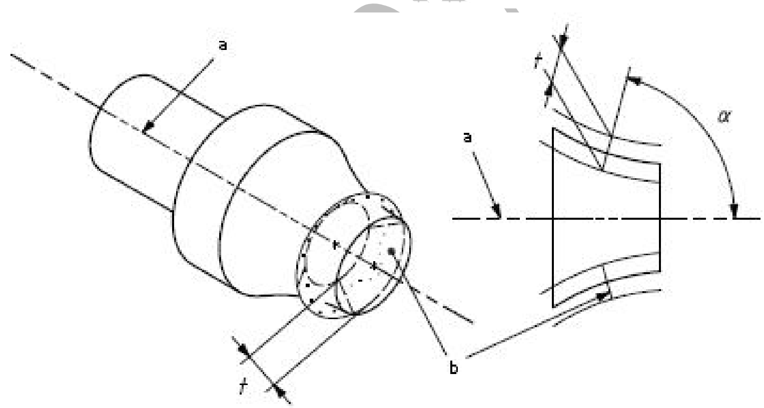
<table>
<tr><td></td><td>axis C, shall be contained between two circles 0.1 apart within the conical section.


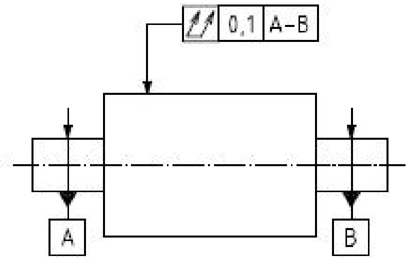
FIG 19.94</td></tr>
<tr><td></td><td>Definition of the tolerance zone</td></tr>
<tr><td></td><td>The tolerance zone is limited within any conical section of the specified angle by two circles a distance t apart, the axes of which coincide with the datum.


a
Datum C.
b Tolerance zone.
FIG 19.95</td></tr>
</table>

19.4.16 *Total run-out tolerance*

19.4.16.1 *Total radial run-out tolerance*

Symbol	**Indication and explanation**

<table>
<tr><td rowspan="3">⌰</td><td>The extracted (actual) surface shall be contained between two coaxial cylinders with a difference in radii of 0.1 and the axes coincident with the common datum straight line A-B.


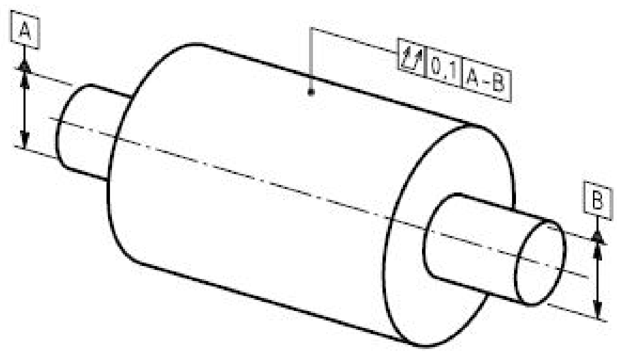
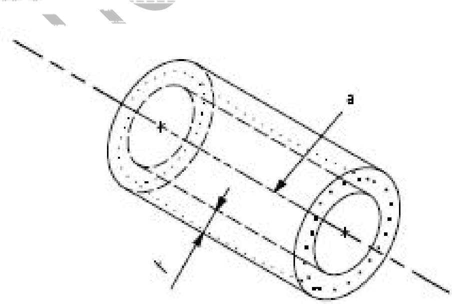
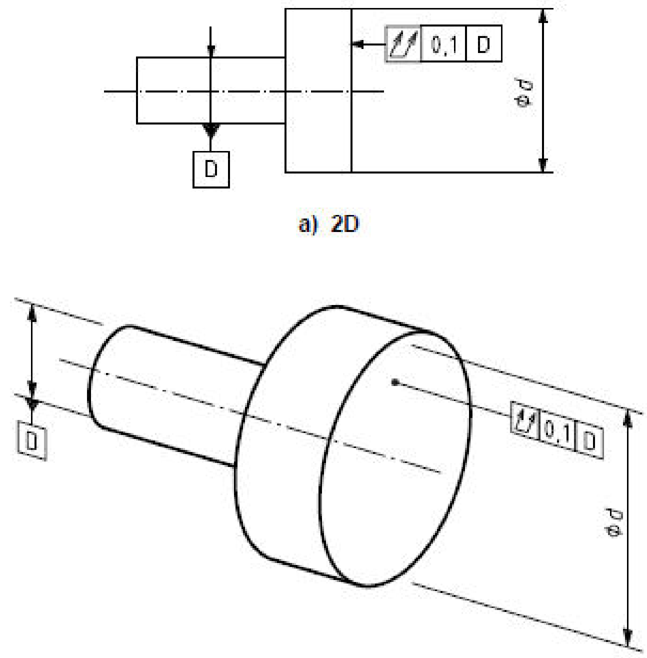
a) 2D


FIG 19.96
b) 3D</td></tr>
<tr><td>Definition of the tolerance zone</td></tr>
<tr><td>The tolerance zone is limited by two coaxial cylinders with a difference in radii of t, the axes of which coincide with the datum.


a Datum A-B.
FIG 19.97</td></tr>
</table>

19.4.16.2 *Total axial run-out tolerance*

Symbol	Indication and explanation
⌰	The extracted (actual) surface shall be contained between two parallel planes 0.1 apart, which are perpendicular to datum axis D.



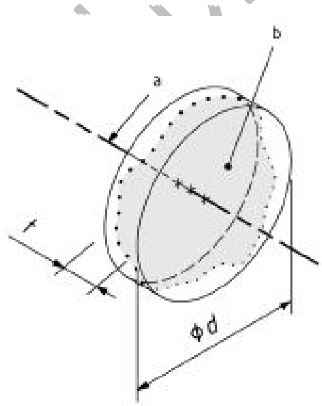
a) 2D

b) 3D

FIG 19.98

Definition of the tolerance zone

The tolerance zone is limited by two parallel planes a distance *t* apart and perpendicular to the datum.



a Datum D.
b Extracted surface.

FIG 19.99

Section 20

GENERAL TOLERANCES FOR LINEAR AND ANGULAR DIMENSIONS

20.1 General

Specifies the permissible machining variations in linear and angular dimensions without tolerance indications and is applicable for all machining processes with chips like turning, milling, etc and without chips like drawing, printing, embossing, pipe bending, etc, and is not applicable for production methods like casting, forging, processing, welding, flame cutting, etc.

20.2 Deviations

20.2.1 *Linear Dimensions*

Shall be as given in Table 20.1,

20.2.2 *Radii and Chamfer*

Shall be as given in Table 20.2.

20.2.3 *Angular Dimensions*
Shall be as given in Table 20.3.

20.2.4 *Indication in Drawing*
In the space provided for the purpose of drawings or otherwise, two methods of indications are suggested:

a) Class of deviation required shall be indicated, f*or example*, Medium IS 2102, Coarse IS 2102, etc.
b) The values of the permissible variations to be shown in general note for dimensions without tolerance indications.

Table 20.1 Deviations for Linear Dimensions
(*Clause* 20.2.1)
All dimensions in millimetres.

Class of Deviation	Range of Nominal Dimensions												
	Above	0.5	3	6	30	120	315	1 000	2 000	4 000	8 000	12 000	16 000
	Up to and Including	3	6	30	120	315	1 000	2 000	4 000	8 000	12 000	16 000	20 000
Fine		± 0.05	± 0.05	± 0.1	± 0.15	± 0.2	± 0.3	± 0.5	± 0.8	—	—	—	—
Medium		± 0.1	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2	± 3	± 4	± 5	± 6
Coarse		—	± 0.2	± 0.5	± 0.8	± 1.2	± 2	± 3	± 4	± 5	± 6	± 7	± 8
Extra coarse		—	± 0.5	± 1	± 1.5	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 12

Table 20.2 Deviations for Radii and Chamfers

(Clause 20.2.2)

All dimensions in millimetres.

Class of Deviation		Range of Nominal Dimensions				
	Above	0.5	3	6	30	120
	Up to and including	3	6	30	120	315
Fine and medium		± 0.2	± 0.5	± 1	± 2	± 4
Coarse and extra coarse		± 0.2	± 1	± 2	± 4	± 8

Table 20.3 Deviations for Angular Dimensions

(Clause 20.2.3)

All dimensions in millimetres.

Class of Deviation	Permissible Variations on Length of Shorter Side of Angle							
	Upto 10		Over 10 to 50		Over 50 to 120		Over 120	
	Degree	mm per 100 mm	Degree	mm per 100 mm	Degree	mm per 100 mm	Degree	mm per 100 mm
Fine and Medium	±1°	±1.8	±30′	±0.9	±20′	±0.6	±10	±0.3
Coarse	±1°30′	±2.6	±50′	±1.5	±25′	±0.7	±15′	±0.4
Extra coarse	±3°	±5.1	±2°	±3.5	±1°	±1.8	±30′	±0.9

SECTION 21– ABBREVIATIONS

21.1 Scope

This section covers such of the abbreviations which are recommended for use in general engineering drawings. Abbreviations already covered in specific subjects, such as, units and quantities, tolerancing, gears, fluid power, electrical and electronics are not dealt in this section.

21.2 Common abbreviation

Abbreviations are the same both for singular and plural usage. Only capital letters are used for abbreviations to ensure maintenance of legibility bearing in mind reproduction and reduction processes. Abbreviations which have already been standardized nationally/internationally using lower case letters should, however, be written according to the corresponding standard. Table 20.1 lists some of the recommended common abbreviations.

21.2.1 When using abbreviations and symbols in engineering drawings, the following points are to be borne in mind.

a) They should be used sparingly only when a space saving in drawing is necessary.
b) Short words such as day, unit, time, etc. should preferably be written in full, even when an abbreviation has been standardized.
c) Periods (full stop symbol) are to be used except where the abbreviation marks a word (for example No., Fig.).
d) For hyphenated words, abbreviations are to be with the hyphen.
e) Sometimes one and the same letter symbol may represent more than one term or quantity. Hence it is advisable not to use such symbols mean two different terms in one and the same drawing. If it becomes unavoidable, the symbols may be provided with suitable sub-script.

Table 21.1 – Recommended abbreviations

Term	Abbreviation
Across flats	AF
Alteration	ALT
Approved	APPD
Approximate	APPROX
Arrangement	ARRGT
Assembly	ASSY
Auxiliary	AUX
Cast iron	CI
Centreline on a view	℄
Centre of gravity	CG
Centres	CRS
Chamfered, chamfer (in a note)	CHAM
Checked	CHKD
Cheese head	CH HD
Constant	CONST
Continued	CONTD
Counterbore	CBORE
Countersunk	CSK
Countersunk head	CSK HD
Cylinder or cylindrical	CYL
Diameter (in a note)	DIA
Diameter (preceding a dimension)	Ø

Dimension	DIM
Drawing	DRG
East	E
Equi-spaced or Equally spaced	EQUI SP
Etcetra	etc
External	EXT
Figure	FIG.
Full indicated movement	FIM
General	GEN
Head	HD
Hexagon head	HEX HD
Hexagon or Hexagonal	HEX
Horizontal	HORZ
Hydraulic	HYD
Indian Standard	IS
Inside diameter	ID
Inspection/Inspectioned	INSP
Insulation or Insulated	INSUL
Internal	INT
Least material condition	LMC
Left hand	LH
Long	LG
Machine	MC
Material	MATL
Maximum	MAX
Maximum material condition	MMC
Mechanical	MECH
Minimum	MIN
Miscellaneous	MISC
Nominal	NOM
North	N
Not to scale	NTS
Number	NO.
Opposite	OPP
Outside diameter	OD
Pitch circle diameter	PCD
Quality	QLY
Quantity	QTY
Radius (in a note)	RAD
Radius (preceding a dimension)	R
Reference	REF
Required	REQD
Right hand	RH
Round head	RD HD
Screw or screwed	SCR
Serial number	SL NO.
Sheet (referring to drawing sheet)	SH
Sketch (prefix to a drawing NO.)	SK
South	S
Specification	SPEC
Spherical	SPHERE
Spherical diameter (only preceding a dimension)	SØ
Spherical radius	SR

(only preceding a dimension)	
Spotface	SFACE
Square (in a note)	SQ
Square (preceding a dimension)	☐ or ⊠
Standard	STD
Symmetrical (in a note)	SYM
Taper on diameter or width	
Temperature (in a note)	TEMP
Thick	THK
Thread (in a note)	THD
Through (in a note)	THRU
Tolerance	Tol
Typical/typically	TYP
Undercut	UCUT
Volume	VOL
Weight	WT
West	W
With reference to or with respect to	WRT

EXAMPLES OF DRAWINGS

LIST OF REFERRED AND OTHER RELEVANT INDIAN STANDARDS AND INTERNATIONAL STANDARDS

Standard	***Title***
IS 813:1986	Scheme of symbols for welding
IS 919 (Part 1) : 2014/ ISO 286-1:2010	Geometrical product specifications (GPS) -- ISO code system for tolerances on linear sizes -- Part 1: Basis of tolerances, deviations and fits
IS 919 (Part 2) : 2014/ ISO 286-2:2010	Geometrical product specifications (GPS) -- ISO code system for tolerances on linear sizes -- Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts
IS 1076 (Part 1) : 1985/ ISO 3 :1973	Preferred numbers -- Series of preferred numbers
IS 1076 (Part 2) : 1985/ ISO 17:1973	Guide to the use of preferred numbers and of series of preferred numbers
IS 1076 (Part 3): 1985/ ISO 497:1973	Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers
IS 2102 (Part 1) : 1993/ ISO 2768-1:1989	General tolerances -- Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
IS 2102 (Part 2) : 1993/ ISO 2768-2:1989	General tolerances -- Part 2: Geometrical tolerances for features without individual tolerance indications
IS 3073:1967	Assessment of Surface Roughness
IS 3403:1981	Dimensions For Knurls
IS 4218 (Part 1) : 2001/ ISO 68-1:1998	ISO general purpose screw threads -- Basic profile -- Part 1: Metric screw threads
IS 4218 (Part 2) : 2001/ ISO 261:1998	ISO general purpose metric screw threads -- General plan
IS 4218 (Part 3) : 1999/ ISO 724:1993	ISO general-purpose metric screw threads -- Basic dimensions
IS 4218 (Part 4) : 2001/ ISO 262:1998	ISO general purpose metric screw threads -- Selected sizes for screws, bolts and nuts
IS 7283:1992	Hot rolled bars for production of bright bars and machined parts for engineering applications
IS 8000 (Part 1) : 2014/ ISO 1101:2012	Geometrical product specifications (GPS) -- Geometrical tolerancing -- Tolerances of form, orientation, location and run-out
IS 8000 (Part 2) : 2014/ ISO 2692:2006	Geometrical product specifications (GPS) -- Geometrical tolerancing -- Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR)
IS 8000 (Part 3) : 1985/ ISO 1660:1987	Technical drawings -- Dimensioning and tolerancing of profiles
IS 8000 (Part 4) :1976	Geometrical tolerancing on technical drawings Part IV Practical examples of indications on drawings
IS 8930 (Part 1) : 2014/ ISO 10209-1:2012	Technical product documentation -- Vocabulary -- Terms relating to technical drawings, product definition and related documentation
IS 8930 (Part 2) : 2001/1S0	Technical Product Documentaion - Vocabulary - Part 2 :

10209-2:1993	Terms Relating to Projection Methods
IS 8976:1978	Guide for preparation and arrangement of sets of drawings and parts lists
IS/ISO 9178-1:1988	Templates for Lettering and Symbols - Part 1 : General Principles and Identification Markings
IS 9609 (Part 0) : 2001/1S0 3098-0:1997	Technical Product Documentation - Lettering - Part 0 : General Requirements
IS 9609 (Part 6) : 2001/1S0 3098-5:1997	Technical Product Documentation - Lettering - Part 6 : Cad Lettering of the Latin Alphabet, Numberals and Marks
IS 10164: 1985/ISO 6428:1982	Requirements to execute technical drawings for microcopying
IS 10711: 2014/ISO 5457:1999	Technical product documentation -- Sizes and layout of drawing sheets
IS 10712: 2014/ISO 6433:1981	Technical product documentation -- Part references
IS 10713: 1983/ISO 5455:1979	Technical drawings -- Scales
IS 10714 (Part 20) :2001/ISO 128-20:1996	Technical Drawings - General Principles of Presentation - Part 20 Basic Conventions for Lines
IS 10714 (Part 21) :2001/ISO 128-21:1997	Technical Drawings - General Principles of Presentation - Part 21 : Preparation of Lines by Cad Systems
IS 10715 (Part 1) : 1999/ISO 6410-1:1993	Technical Drawings - Screw Threads and Threaded Parts - Part 1 : General Conventions
IS 10715 (Part 3) : 1999/ISO 6410-3:1993	Technical Drawings - Screw Threads and Threaded Parts - Part 3 : Simplified Representation
IS 10716 (Part 1) : 1999/ISO 2162-1 : 1973	Technical Product Documentation - Springs - Part 1 : Simplified Representation
1S 10717: 1983/ISO 2203:1973	Conventional representation of gears on technical drawings
IS 10718: 1993/ISO 3040:1990	Technical drawings - Dimensions and tolerancing of cones
IS 10719: 1983/ISO 1302:1978	Method of indicating surface texture on technical drawings
IS 10720: 1999/ISO 5261: 1995	Technical Drawings - Simplified Representation of Bars and Profile Sections
IS 10721: 2014/IS0 5459:1981	Geometrical product specifications (GPS) -- Geometrical tolerancing -- Datums and datum systems
IS 10990 (Part 1) : 1991/ ISO 6412-1:1989	Technical drawings - Simplified representation of pipelines Part 1 General rules and orthogonal representation
IS 10990 (Part 2): 1992/ISO 6412-2:1989	Technical drawings - Simplified representation of pipelines Part 2 Isometric projections
IS 11663:1986	Conventional representation of common features and materials on technical drawings
IS 11664:1986	Folding of drawing prints
IS 11665: 2014/ ISO 7200:1984	Technical product documentation -- Data fields in title blocks and document headers
IS 11666: 2014/1SO 7573:1983	Technical product documentation -- Parts lists
IS 11667: 1991/ISO 406:1987	Technical drawing - Linear and angular tolerancing - Indication on drawings
ISO 129-1	Technical drawings -- Indication of dimensions and tolerances -- Part 1: General principles

IS 11670:1993	Technical Drawings - Abbreviations and Symbols for Use in Technical Drawings
IS 14440:1997	Drawing Instruments - Tubular tips for hand held technical pens using India ink on tracing paper
IS 15021 (Part 1) : 2001/ISO 5456-1:1996	Technical Drawings - Projection Methods - Part 1 : Synopsis
IS 15021 (Part 2) : 2001/ ISO 5456-2:1996	Technical Drawings - Projection Methods - Part 2 : Orthographic Representations
IS 15021 (Part 3) : 2001/ ISO 5456-3:1996	Technical Drawings - Projection Methods - Part 3 : Axonometric Representations
IS 15021 (Part 4) : 2001/ ISO 5456-4:1996	Technical Drawings - Projection Methods - Part 4 : General Preojection
IS 15023 (Part 1) : 2001/ ISO 5845-1:1995	Technical Drawings - Simplified Representation of the Assembly of Parts with Fasteners - Part 1 : General Principles
IEC 61082-1: (1991)	Preparation of documents used in electrotechnology - Part 1: Rules
ISO 128-22:1999	Technical drawings -- General principles of presentation -- Part 22: Basic conventions and applications for leader lines and reference lines
ISO 128-23	Technical drawings -- General principles of presentation -- Part 23: Lines on construction drawings
ISO 128-24	Technical drawings -- General principles of presentation -- Part 24: Lines on mechanical engineering drawings
ISO 128-25	Technical drawings -- General principles of presentation -- Part 25: Lines on shipbuilding drawings
ISO 216:2007	Writing paper and certain classes of printed matter -- Trimmed sizes -- A and B series, and indication of machine direction
ISO 544:2011	Welding consumables -- Technical delivery conditions for filler materials and fluxes -- Type of product, dimensions, tolerances and markings
ISO 657-1:1989	Hot-rolled steel sections -- Part 1: Equal-leg angles -- Dimensions
ISO 1119:2011	Geometrical product specifications (GPS) -- Series of conical tapers and taper angles
ISO 1219-1:1991	Fluid power systems and components -- Graphical symbols and circuit diagrams -- Part 1: Graphical symbols for conventional use and data-processing applications
ISO 1219-2:1995	Fluid power systems and components -- Graphical symbols and circuit diagrams -- Part 2: Circuit diagrams
ISO 1302:2002	Geometrical Product Specifications (GPS) -- Indication of surface texture in technical product documentation
ISO/IEC 2382-4:1999	Information technology -- Vocabulary -- Part 4: Organization of data
ISO 2553:2013	Welding and allied processes -- Symbolic representation on drawings -- Welded joints
ISO 2560: 2009	Welding consumables -- Covered electrodes for manual metal arc welding of non-alloy and fine grain steels -- Classification

ISO 3511-3:1984	Process measurement control functions and instrumentation -- Symbolic representation -- Part 3: Detailed symbols for instrument interconnection diagrams
ISO 3545-1:1989	Steel tubes and fittings -- Symbols for use in specifications -- Part 1: Tubes and tubular accessories with circular cross-section
ISO 3545-2:1989	Steel tubes and fittings -- Symbols for use in specifications -- Part 2: Square and rectangular hollow sections
ISO*3545-3:1989*	Steel tubes and fittings -- Symbols for use in specifications -- Part 3: Tubular fittings with circular cross-section
ISO 3581:2003	Welding consumables -- Covered electrodes for manual metal arc welding of stainless and heat-resisting steels -- Classification
ISO 4063:2009	Welding and allied processes -- Nomenclature of processes and reference numbers
ISO 4067-2:1980	Building and civil engineering drawings -- Installations -- Part 2: Simplified representation of sanitary appliances
ISO 5817 :2014	Welding -- Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) -- Quality levels for imperfections
ISO 5864:1993	ISO inch screw threads -- Allowances and tolerances
ISO 6947:2011	Welding and allied processes -- Welding positions
ISO 9175-1:1988	Tubular tips for hand-held technical pens using India ink on tracing paper -- Part 1: Definitions, dimensions, designation and marking
ISO *10042:2005*	Welding -- Arc-welded joints in aluminium and its alloys -- Quality levels for imperfections