

SECOND EDITION

Textbook of
**ENGINEERING
DRAWING**

K Venkata Reddy

BS Publications

Textbook of Engineering Drawing

Second Edition

K. Venkata Reddy

Prof. & HOD of Mechanical Engineering Dept.
C.R. Engineering College,
Tirupati - 517 506

BSP BS Publications

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CHAPTER 1

Drawing Instruments and Accessories

1.1 Introduction

Engineering drawing is a two dimensional representation of three dimensional objects. In general, it provides necessary information about the shape, size, surface quality, material, manufacturing process, etc., of the object. It is the graphic language from which a trained person can visualise objects.

Drawings prepared in one country may be utilised in any other country irrespective of the language spoken. Hence, engineering drawing is called the universal language of engineers. Any language to be communicative, should follow certain rules so that it conveys the same meaning to every one. Similarly, drawing practice must follow certain rules, if it is to serve as a means of communication. For this purpose, Bureau of Indian Standards (BIS) adapted the International Standards on code of practice for drawing. The other foreign standards are : DIN of Germany, BS of Britain and ANSI of America.

1.2 Role of Engineering Drawing

The ability to read drawing is the most important requirement of all technical people in any profession. As compared to verbal or written description, this method is brief and more clear. Some of the applications are : building drawing for civil engineers, machine drawing for mechanical engineers, circuit diagrams for electrical and electronics engineers, computer graphics for one and all.

The subject in general is designed to impart the following skills.

1. Ability to read and prepare engineering drawings.
2. Ability to make free – hand sketching of objects.
3. Power to imagine, analyse and communicate, and
4. Capacity to understand other subjects.

1.3 Drawing Instrument and Aids

The Instruments and other aids used in draughting work are listed below :

- | | | |
|------------------|-------------------|-------------------|
| 1. Drawing board | 2. Mini draughter | 3. Instrument box |
| 4. Set squares | 5. Protractor | 6. Set of scales |
| 7. French curves | 8. Drawing sheets | 9. Pencils |
| 10. Templates | | |

1.3.1 Drawing Board

Until recently drawing boards used are made of well seasoned softwood of about 25 mm thick with a working edge for T-square. Now a days mini-draughters are used instead of T-squares which can be fixed on any board. The standard size of board depends on the size of drawing sheet size required.

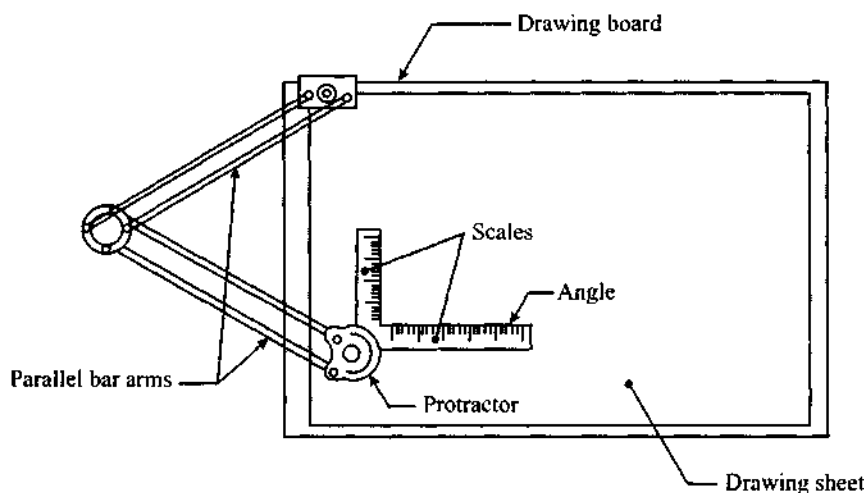


Fig. 1.1 Mini-draughter

1.3.2 Mini-Draughter

Mini-draughter consists of an angle formed by two arms with scales marked and rigidly hinged to each other (Fig. 1.1). It combines the functions of T-square, set-squares, scales and protractor. It is used for drawing horizontal, vertical and inclined lines, parallel and perpendicular lines and for measuring lines and angles.

1.3.3 Instrument Box

Instrument box contains 1. Compasses, 2. Dividers and 3. Inking pens. What is important is the position of the pencil lead with respect to the tip of the compass. It should be at least 1 mm above as shown in Fig. 1.2 because the tip goes into the board for grip by 1 mm.

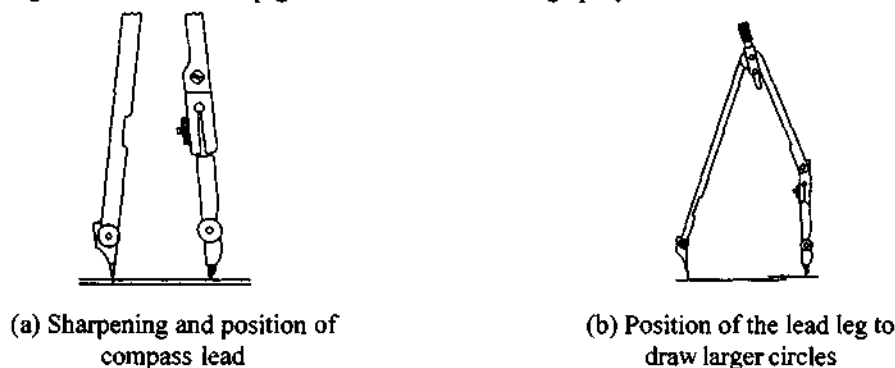


Fig. 1.2

1.3.4 Set of Scales

Scales are used to make drawing of the objects to proportionate size desired. These are made of wood, steel or plastic (Fig.1.3). BIS recommends eight set-scales in plastic/cardboard with designations M1, M2 and so on as shown in Table 1.1 Set of scales

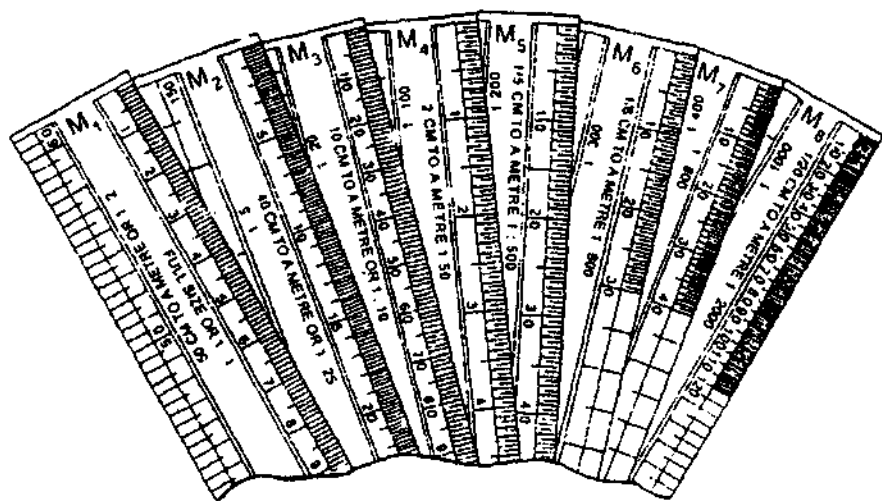


Fig. 1.3 Set of scales

Table 1.1 Set of Scales

	M1	M2	M3	M4	M5	M6	M7	M8
Scale on one edge	1:1	1:2.5	1:10	1:50	1:200	1:300	1:400	1:1000
Scale on other edge	1:2	1:5	1:20	1:100	1:500	1:600	1:800	1:2000

Note : Do not use the scales as a straight edge for drawing straight lines.

These are used for drawing irregular curved lines, other than circles or arcs of circles.

Table 1.2

Scales for use on technical drawings (IS : 46-1988)			
Category	Recommended scales		
Enlargement scales	50 : 1	20 : 1	10 : 1
	5 : 1	2 : 1	
Full size	1 : 1		
Reduction scales	1 : 2	1 : 5	1 : 10
	1 : 20	1 : 50	1 : 100
	1 : 200	1 : 500	1 : 1000
	1 : 2000	1 : 5000	1 : 10000

1.3.5 French Curves

French curves are available in different shapes (Fig.1.4). First a series of points are plotted along the desired path and then the most suitable curve is made along the edge of the curve. A flexible curve consists of a lead bar inside rubber which bends conveniently to draw a smooth curve through any set of points.

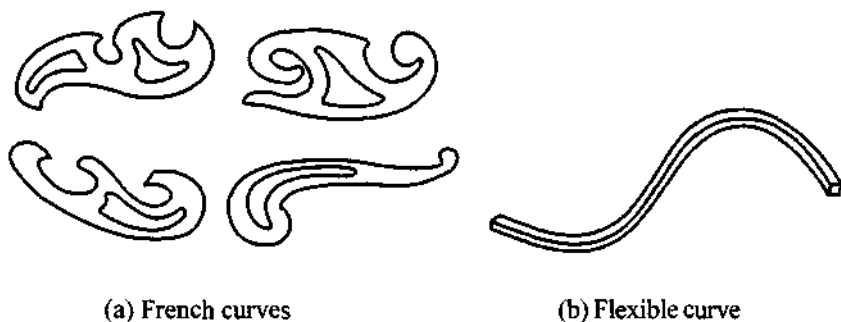


Fig. 1.4

1.3.6 Templates

These are aids used for drawing small features such as circles, arcs, triangular, square and other shapes and symbols used in various science and engineering fields (Fig.1.5).

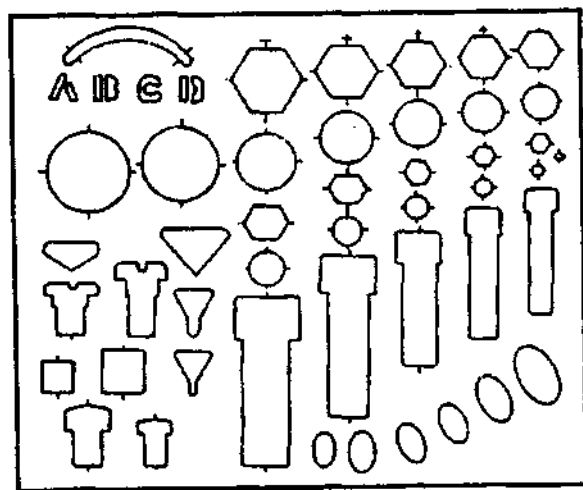


Fig. 1.5 Template

1.3.7 Pencils

Pencils with leads of different degrees of hardness or grades are available in the market. The hardness or softness of the lead is indicated by 3H, 2H, H, HB, B, 2B, 3B, etc. The grade HB denotes medium hardness of lead used for general purpose. The hardness increases as the value of

the numeral before the letter H increases. The lead becomes softer, as the value of the numeral before B increases (Fig.1.6).

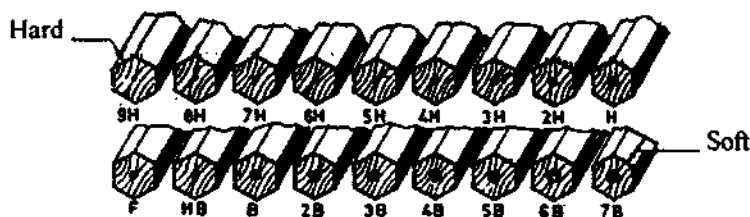


Fig. 1.6 Pencil Leads

The selection of the grade depends on the line quality desired for the drawing. Pencils of grades H or 2H may be used for finishing a pencil drawing as these give a sharp black line. Softer grade pencils are used for sketching work. HB grade is recommended for lettering and dimensioning.

Now a days mechanical pencils are widely used in place of wooden pencils. When these are used, much of the sharpening time can be saved. The number 0.5, 0.70 of the pen indicates the thickness of the line obtained with the lead and the size of the lead diameter.

Micro-tip pencils with 0.5 mm thick leads with the following grades are recommended.

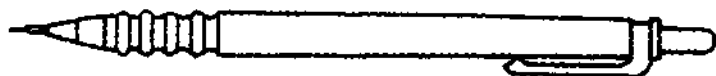


Fig. 1.7 Mechanical Pencil

HB Soft grade for Border lines, lettering and free sketching

H Medium grade for Visible outlines, visible edges and boundary lines

2H Hard grade for construction lines, Dimension lines, Leader lines, Extension lines, Centre lines, Hatching lines and Hidden lines.

CHAPTER 2

Lettering and Dimensioning Practices

(As per BIS : SP : 46 : 2003)

2.1 Introduction

Engineering drawings are prepared on standard size drawing sheets. The correct shape and size of the object can be visualised from the understanding of not only its views but also from the various types of lines used, dimensions, notes, scale etc. For uniformity, the drawings must be drawn as per certain standard practice. This chapter deals with the drawing practices as recommended by Bureau of Indian Standards (BIS) SP: 46:2003. These are adapted from what is followed by International Standards Organisation (ISO).

2.2 Drawing Sheet

The standard drawing sheet sizes are arrived at on the basic Principal of $x : y = 1 : \sqrt{2}$ and $xy = 1$ where x and y are the sides of the sheet. For example A0, having a surface area of 1 Sq.m; $x = 841$ mm and $y = 1189$ mm. The successive sizes are obtained by either by halving along the length or doubling the width, the area being in the ratio 1 : 2. Designation of sizes is given in Fig.2.1 and their sizes are given in Table 2.1. For class work use of A2 size drawing sheet is preferred.

Table 2.1

Designation	Dimension, mm Trimmed size
A0	841 × 1189
A1	594 × 841
A2	420 × 594
A3	297 × 420
A4	210 × 297

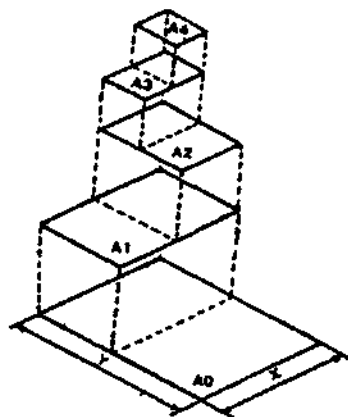


Fig. 2.1 Drawing Sheet Formats

2.2.1 Title Block

The title block should lie within the drawing space at the bottom right hand corner of the sheet. The title block can have a maximum length of 170 mm providing the following information.

1. Title of the drawing.
2. Drawing number.
3. Scale.
4. Symbol denoting the method of projection.
5. Name of the firm, and
6. Initials of staff who have designed, checked and approved.

The title block used on shop floor and one suggested for students class work are shown in Fig.2.2.

170					
DRN	NAME	DATE	MATERIAL	TOLERANCE	FINISH
CHD					
APPD					
PROJECTION		LEGAL OWNER	TITLE		
SCALE			IDENTIFICATION NUMBER		
65					

Fig. 2.2(a)

150			
20	NAME OF STUDENT	TITLE	
10	CLASS :	DRGNO:	SCALE
10	ROLL NO :	GRADE :	
10	DATE :	VALUED BY	
	50	50	50

Fig. 2.2(b)

2.2.2 Drawing Sheet Layout (Is 10711 : 2001)

The layout of a drawing sheet used on the shop floor is shown in Fig.2.3a, The layout suggested to students is shown in Fig.2.3b.

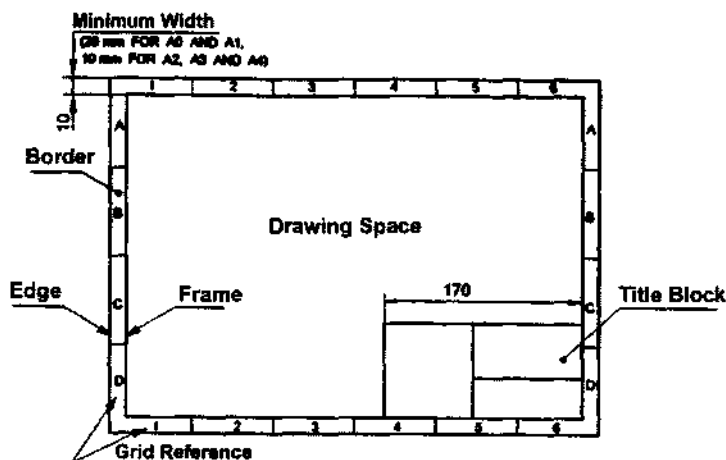


Fig. 2.2 (a) General features of a drawing sheet

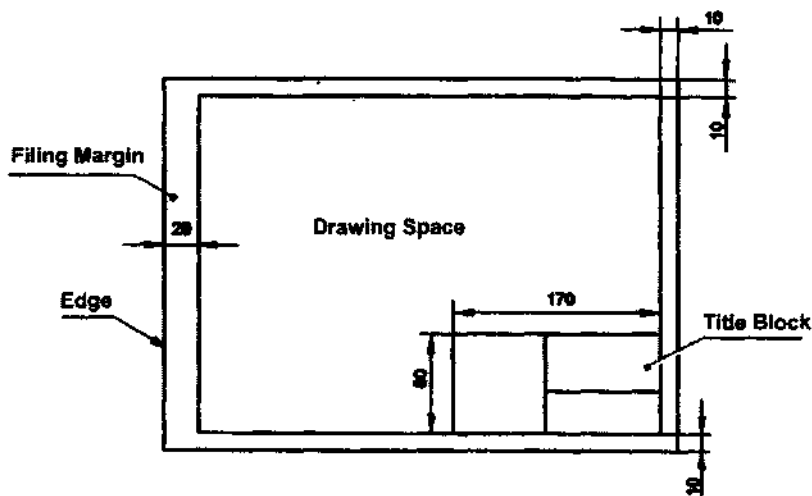


Fig. 2.3 (b) Layout of sheet for class work

2.2.3 Folding of Drawing Sheets

IS : 11664 – 1999 specifies the method of folding drawing sheets. Two methods of folding of drawing sheets, one suitable for filing or binding and the other method for keeping in filing cabinets are specified by BIS. In both the methods of folding, the Title Block is always visible.

2.4. Shows the method in which drawing sheets may be unfolded and refolded, without the necessity of removal from the file.

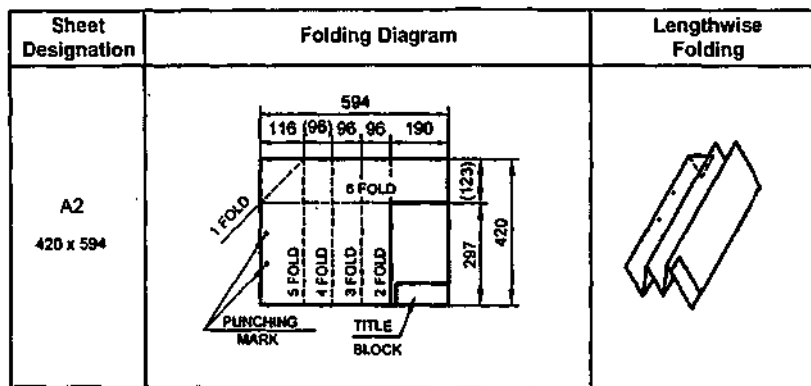


Fig. 2.4(a) Folding of drawing sheet for filing or binding

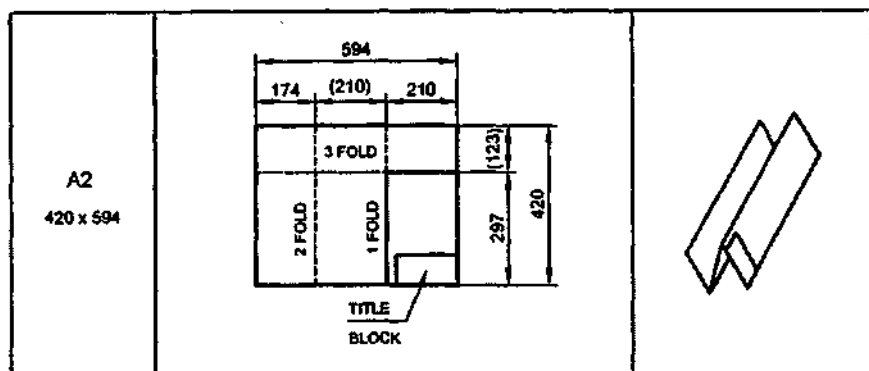


Fig. 2.4(b) Folding of drawing sheet for storing in filing cabinet

2.2.4 Lines (IS 10714 (Part 20): 2001 and SP 46: 2003)

Just as in English textbook the correct words are used for making correct sentences; in Engineering Graphics, the details of various objects are drawn by different types of lines. Each line has a definite meaning and sense to convey.

IS 10714 (Part 20): 2001 (General principles of presentation on technical drawings) and SP 46:2003 specify the following types of lines and their applications:

- **Visible Outlines, Visible Edges :** Type 01.2 (**Continuous wide lines**) The lines drawn to represent the visible outlines/ visible edges / surface boundary lines of objects should be outstanding in appearance.
- **Dimension Lines :** Type 01.1 (**Continuous narrow Lines**) Dimension Lines are drawn to mark dimension.
- **Extension Lines :** Type 01.1 (**Continuous narrow Lines**)
- There are extended slightly beyond the respective dimension lines.

- **Construction Lines: Type 01.1 (Continuous narrow Lines)**

Construction Lines are drawn for constructing drawings and should not be erased after completion of the drawing.

- **Hatching / Section Lines : Type 01.1 (Continuous Narrow Lines)**

Hatching Lines are drawn for the sectioned portion of an object. These are drawn inclined at an angle of 45° to the axis or to the main outline of the section.

- **Guide Lines : Type 01.1 (Continuous Narrow Lines)**

Guide Lines are drawn for lettering and should not be erased after lettering.

- **Break Lines : Type 01.1 (Continuous Narrow Freehand Lines)**

Wavy continuous narrow line drawn freehand is used to represent break of an object.

- **Break Lines : Type 01.1 (Continuous Narrow Lines With Zigzags)**

Straight continuous narrow line with zigzags is used to represent break of an object.

- **Dashed Narrow Lines : Type 02.1 (Dashed Narrow Lines)**

Hidden edges / Hidden outlines of objects are shown by dashed lines of short dashes of equal lengths of about 3 mm, spaced at equal distances of about 1 mm. the points of intersection of these lines with the outlines / another hidden line should be clearly shown.

- **Center Lines : Type 04.1 (Long-Dashed Dotted Narrow Lines)**

Center Lines are drawn at the center of the drawings symmetrical about an axis or both the axes. These are extended by a short distance beyond the outline of the drawing.

- **Cutting Plane Lines : Type 04.1 and Type 04.2**

Cutting Plane Line is drawn to show the location of a cutting plane. It is long-dashed dotted narrow line, made wide at the ends, bends and change of direction. The direction of viewing is shown by means of arrows resting on the cutting plane line.

- **Border Lines**

Border Lines are continuous wide lines of minimum thickness 0.7 mm

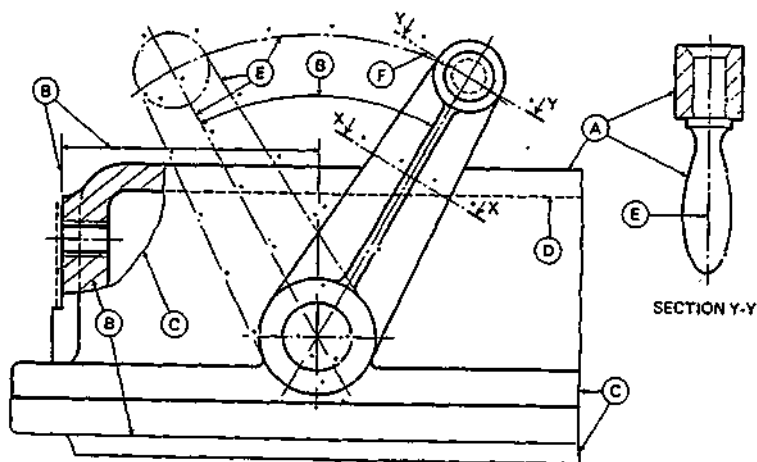


Fig. 2.5 Types of Lines

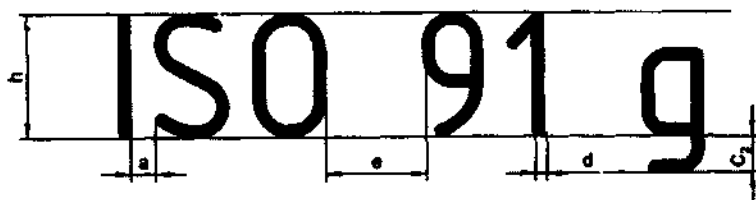
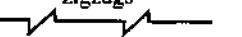


Fig. 2.6

Understanding the various types of lines used in drawing (i.e.,) their thickness, style of construction and appearance as per BIS and following them meticulously may be considered as the foundation of good drawing skills. Table 2.2 shows various types of lines with the recommended applications.

Table 2.2 Types of Lines and their applications (IS 10714 (Part 20) : 2001) and BIS: SP46 : 2003.

No.	Line description and Representation	Applications
01.1	Continuous narrow line B 	Dimension lines, Extension lines
		Leader lines, Reference lines
		Short centre lines
		Projection lines
		Hatching
		Construction lines, Guide lines
		Outlines of revolved sections
		Imaginary lines of intersection
01.1	Continuous narrow freehand line C 	Preferably manually represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a center line ^a .
01.1	Continuous narrow line with zigzags A 	Preferably mechanically represented termination of partial or interrupted views, cuts and sections, if the limit is not a line of symmetry or a center line ^a .
01.2	Continuous wide line 	Visible edges, visible outlines
		Main representations in diagrams, maps, flow charts
02.1	Dashed narrow line D 	Hidden edges
		Hidden outlines
04.1	Long-dashed dotted narrow line E 	Center lines / Axes, Lines of symmetry
		Cutting planes (Line 04.2 at ends and changes of direction)
04.2	Long-dashed dotted wide line F 	Cutting planes at the ends and changes of direction outlines of visible parts situated in front of cutting plane

Line widths (IS 10714 : 2001)

Line width means line thickness.

Choose line widths according to the size of the drawing from the following range : **0.13, 0.18, 0.25, 0.35, 0.5, 0.7 and 1 mm.**

BIS recommends two line widths on a drawing. Ratio between the thin and thick lines on a drawing shall not be less than **1 : 2.**

Precedence of Lines

1. When a Visible Line coincide with a Hidden Line or Center Line, draw the Visible Line. Also, extend the Center Line beyond the outlines of the view.
2. When a Hidden Line coincides with a Center Line, draw the Hidden Line.
3. When a Visible Line coincides with a Cutting Plane, draw the Visible Line.
4. When a Center line coincides with a Cutting Plane, draw the Center Line and show the Cutting Plane line outside the outlines of the view at the ends of the Center Line by thick dashes.

2.3 LETTERING [IS 9609 (PART 0) : 2001 AND SP 46 : 2003]

Lettering is defined as writing of titles, sub-titles, dimensions, etc., on a drawing.

2.3.1 Importance of Lettering

To undertake production work of an engineering components as per the drawing, the size and other details are indicated on the drawing. This is done in the form of notes and dimensions.

Main Features of Lettering are legibility, uniformity and rapidity of execution. Use of drawing instruments for lettering consumes more time. **Lettering should be done freehand with speed.**

Practice accompanied by continuous efforts would improve the lettering skill and style. Poor lettering mars the appearance of an otherwise good drawing.

BIS and ISO Conventions

IS 9609 (Part 0) : 2001 and SP 46 : 2003 (Lettering for technical drawings) specify lettering in technical product documentation. This BIS standard is based on ISO 3098-0 : 1997.

2.3.2 Single Stroke Letters

The word single-stroke should not be taken to mean that the lettering should be made in one stroke without lifting the pencil. It means that the thickness of the letter should be uniform as if it is obtained in one stroke of the pencil.

2.3.3 Types of Single Stroke Letters

1. Lettering Type A : (i) Vertical and (ii) Sloped (at 75° to the horizontal)
2. Lettering Type B : (i) Vertical and (ii) Sloped (at 75° to the horizontal)

Type B Preferred

In Type A, height of the capital letter is divided into 14 equal parts, while in Type B, height of the capital letter is divided into 10 equal parts. Type B is preferred for easy and fast execution, because of the division of height into 10 equal parts.

Vertical Letters Preferred

Vertical letters are preferred for easy and fast execution, instead of sloped letters.

Note : Lettering in drawing should be in CAPITALS (i.e., Upper-case letters).

Lower-case (small) letters are used for abbreviations like mm, cm, etc.

2.3.4 Size of Letters

- Size of Letters is measured by the height **h** of the CAPITAL letters as well as numerals.
- Standard heights for CAPITAL letters and numerals recommended by BIS are given below :

1.8, 2.5, 3.5, 5, 6, 10, 14 and 20 mm

Note: Size of the letters may be selected based upon the size of drawing.

Guide Lines

In order to obtain correct and uniform height of letters and numerals, guide lines are drawn, using 2H pencil with light pressure. HB grade conical end pencil is used for lettering.

2.3.5 Procedure for Lettering

1. Thin horizontal guide lines are drawn first at a distance '**h**' apart.
2. *Lettering Technique* : Horizontal lines of the letters are drawn from left to right. Vertical, inclined and curved lines are drawn from top to bottom.
3. After lettering has been completed, the guidelines are not erased.

2.3.6 Dimensioning of Type B Letters (Figs 2.5 and 2.6)

BIS denotes the characteristics of lettering as :

- h (height of capital letters),
- c_1 (height of lower-case letters),
- c_2 (tail of lower-case letters),
- c_3 (stem of lower-case letters),
- a (spacing between characters),
- b_1 & b_2 (spacing between baselines),
- e (spacing between words) and
- d (line thickness),

Table 2.3 Lettering Proportions

Recommended Size (height h) of Letters / Numerals	
Main Title	5 mm, 7 mm, 10 mm
Sub-Titles	3.5 mm, 5 mm
Dimensions, Notes, etc.	2.5 mm, 3.5 mm, 5 mm

2.3.7 Lettering practice

Practice of lettering capital and lower case letters and numerals of type B are shown in Figs.2.7 and 2.8.

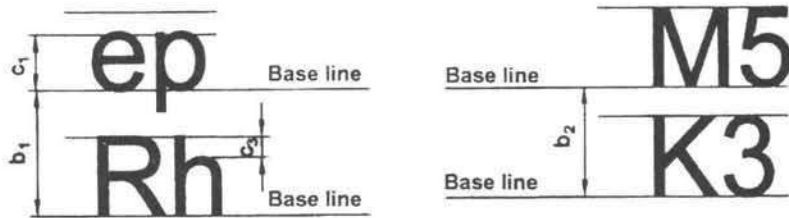


Fig. 2.7 Lettering

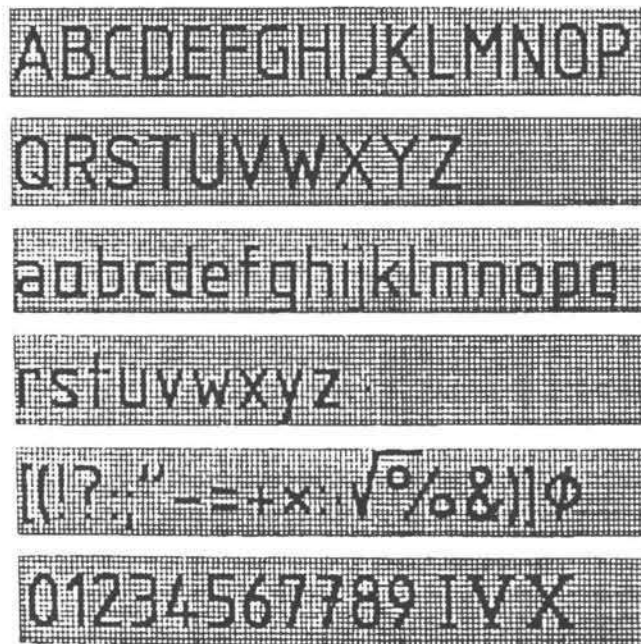


Fig. 2.8 Vertical Lettering

The following are some of the guide lines for lettering (Fig 2.9 & 2.10)

1. Drawing numbers, title block and letters denoting cutting planes, sections are written in 10 mm size.
2. Drawing title is written in 7 mm size.
3. Hatching, sub-titles, materials, dimensions, notes, etc., are written in 3.5 mm size.
4. Space between lines = $\frac{3}{4}$ h.
5. Space between words may be equal to the width of alphabet M or $\frac{3}{5}$ h.

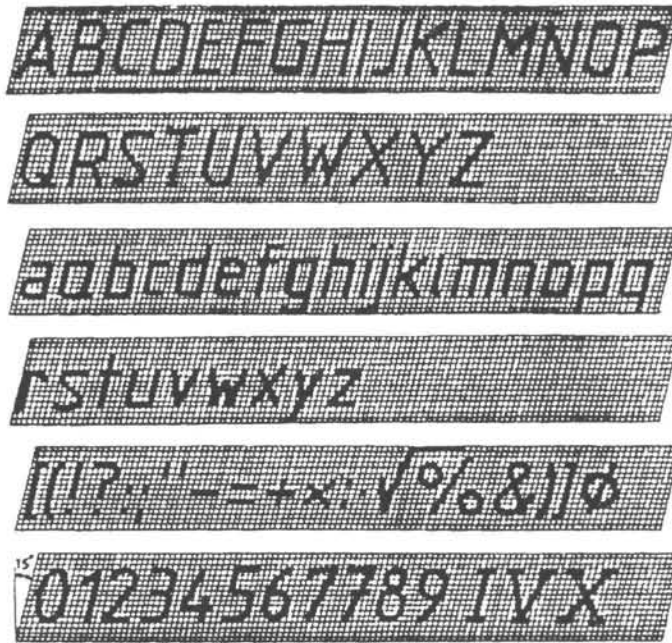


Fig. 2.9 Inclined Lettering

6. Space between letters should be approximately equal to $1/5$ h. Poor spacing will affect the visual effect.
7. The spacing between two characters may be reduced by half if this gives a better visual effect, as for example LA, TV; over lapped in case of say LT, TA etc, and the space is increased for letters with adjoining stems.

CAPITAL Letters

- Ratio of height to width for most of the CAPITAL letters is approximately = 10:6
- However, for **M** and **W**, the ratio = 10:8 for **I** the ratio = 10:2

Lower-case Letters

- Height of lower-case letters *with* stem / tail (b, d, f, g, h, j, k, l, p, q, t, y) = $c_2 = c_3 = h$
- Ratio of height to width for lower-case letters *with* stem or tail = 10:5
- Height of lower-case letters *without* stem or tail c_1 is approximately = $(7/10) h$
- Ratio of height to width for most lower-case letters *without* stem or tail = 7 : 5
- However, for **m** and **w**, the ratio = 7 : 7. For **I** and **I**, the ratio = 10:2

Numerals

- For numerals 0 to 9, the ratio of height to width = 10 : 5. For l, ratio = 10 : 2

Spacing

- Spacing between characters = $a = (2/10)h$
- Spacing between words = $e = (6/10)h$

SMALL SPACES SHOULD BE
USED FOR GOOD LETTER
SPACING

Correct

POOR LETTER SPACING
RESULTS FROM SPACES
BEING TOO BIG

In correct

(a)

↓
NIGHT

↓
NUMBERS

Letters with adjoining stems
require more spacing

↑
VITAL

↑↑
ALTAR

Letter combinations with over lapping
letters

(b)

Fig. 2.10 Guide lines for lettering

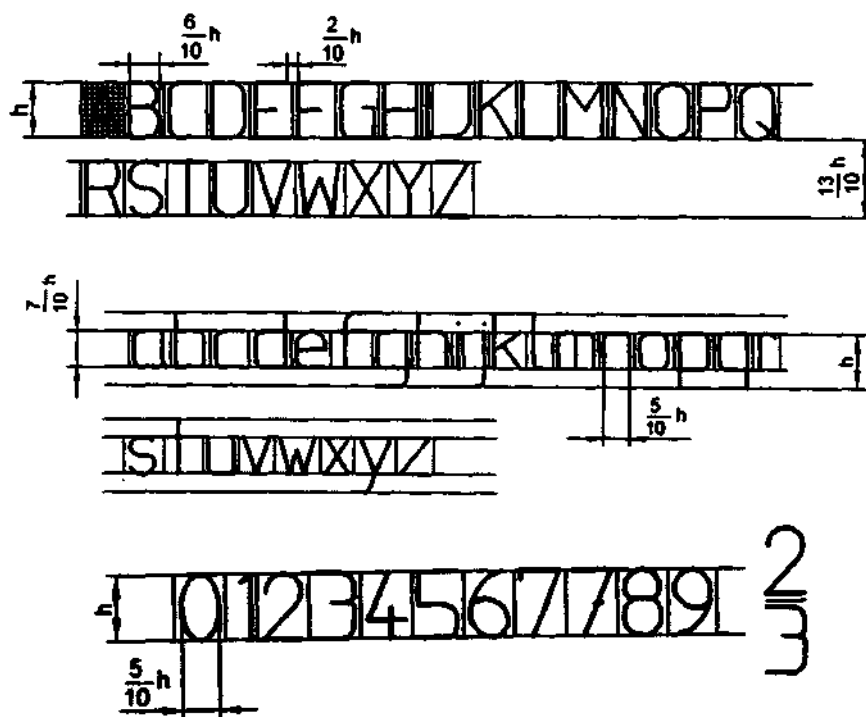


Fig. 2.11 Vertical capital & Lowercase letters and numerals of type B

EXAMPLE IN LETTERING PRACTICE

Write freehand the following, using single stroke vertical CAPITAL letters of 5 mm (h) size



Fig. 2.12

2.4 Dimensioning

Drawing of a component, in addition to providing complete shape description, must also furnish information regarding the size description. These are provided through the distances between the surfaces, location of holes, nature of surface finish, type of material, etc. The expression of these features on a drawing, using lines, symbols, figures and notes is called dimensioning.

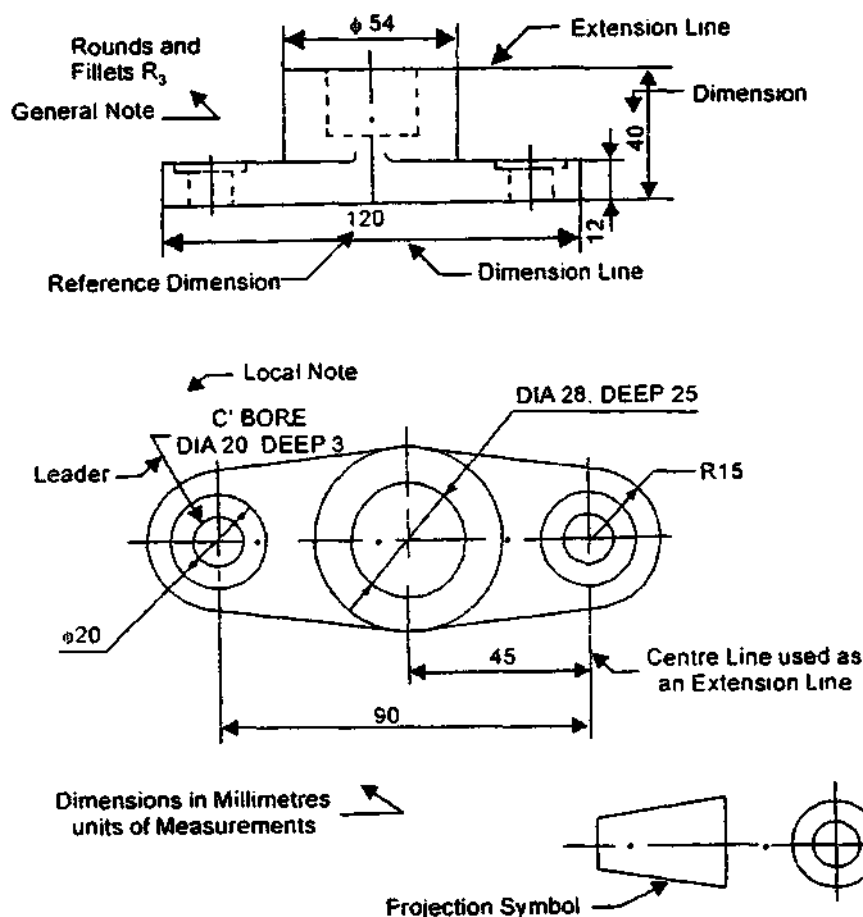


Fig.2.13 Elements of Dimensioning

2.4.1 Principles of Dimensioning

Some of the basic principles of dimensioning are given below.

1. All dimensional information necessary to describe a component clearly and completely shall be written directly on a drawing.
2. Each feature shall be dimensioned once only on a drawing, i.e., dimension marked in one view need not be repeated in another view.
3. Dimension should be placed on the view where the shape is best seen (Fig.2.14)
4. As far as possible, dimensions should be expressed in one unit only preferably in millimeters, without showing the unit symbol (mm).
5. As far as possible dimensions should be placed outside the view (Fig.2.15).
6. Dimensions should be taken from visible outlines rather than from hidden lines (Fig.2.16).

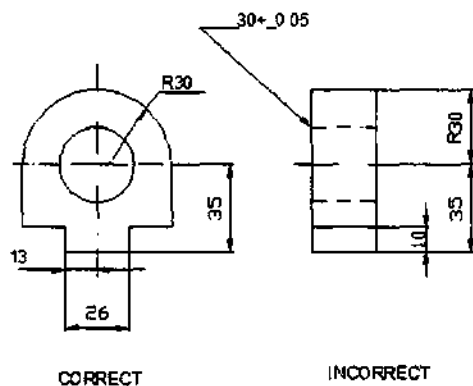


Fig. 2.14 Placing the Dimensions where the Shape is Best Shown

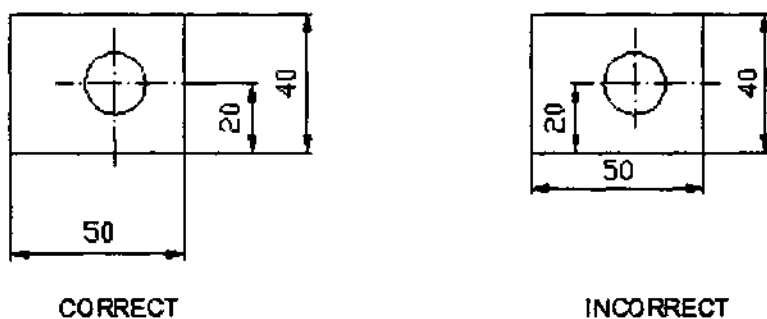


Fig. 2.15 Placing Dimensions Outside the View

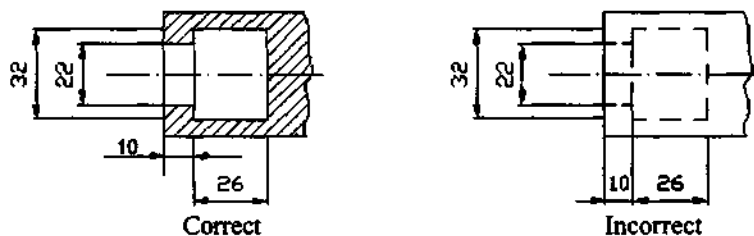


Fig. 2.16 Marking the dimensions from the visible outlines

7. No gap should be left between the feature and the start of the extension line (Fig.2.17).
8. Crossing of centre lines should be done by a long dash and not a short dash (Fig.2.18).