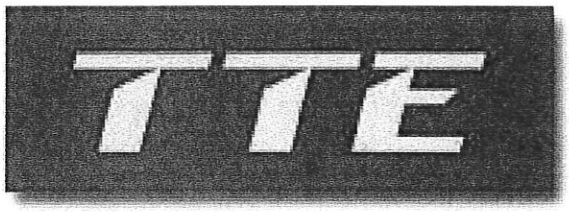


Phase 1 Fabrication

Carousel 1

Engineering Drawing

Technical Drawing Standards

(Based on BS EN 8888)

BS EN 8888:2004 Technical Product Documentation (TPD)
Specification for defining, specifying and graphically representing products

Contents

page

1 Layout of drawings

Drawing sheets

The 'A' series of drawing sheets shown in figure 1 is normally used. The drawing area and title block should be within a frame border. In general, material within the frame border forms part of any contract requirements.

A4 = 210 mm × 297 mm
A3 = 297 mm × 420 mm
A2 = 420 mm × 594 mm
A1 = 594 mm × 841 mm
A0 = 841 mm × 1189 mm
The sides of all sheets are in the ratio 1 : $\sqrt{2}$

A0 is nominally one square metre in area and forms the basis of the series

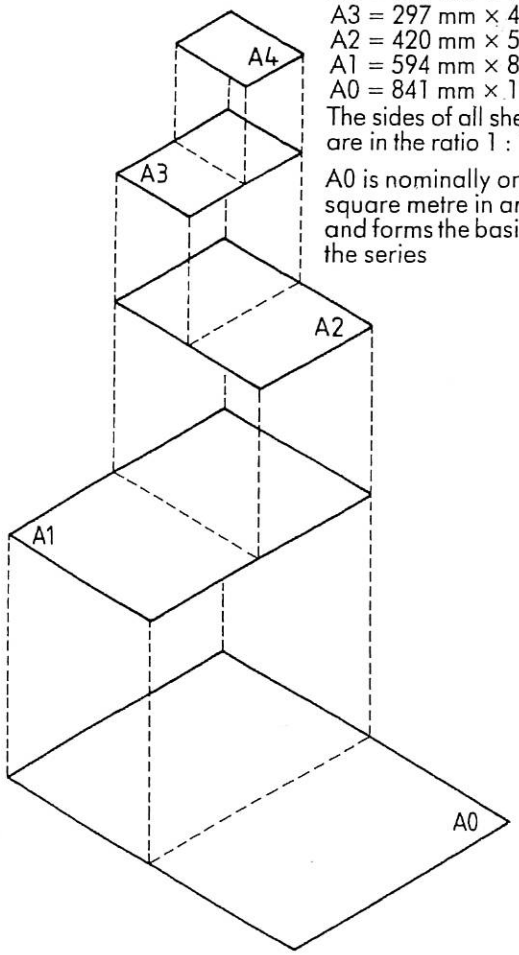


Figure 1. Relationship of the 'A' sizes

Title Block

The title block should be at the bottom of the sheet and extending to the lower right-hand corner of the frame.

Drawings should include the following basic information in title blocks:

(a) name;

(b) date;

(c) projection symbol (see section 5);

(d) original scale (see section 2);

(e) title;

(f) drawing number.

Types of drawings

There are different types of drawings, two of which are shown in figure 2.

For further information on item referencing, shown in figure 2(d), see section 8.

Drawing formats

Drawing sheets have two formats.

(a) *Portrait:* intended to be viewed with the longest side of the sheet vertical, see figure 2(a).

(b) *Landscape:* intended to be viewed with the longest side of the sheet horizontal, see figure 2(b), (c) and (d).

2 Scales

General

Every drawing should be drawn in proportion, i.e. to a uniform scale. The scale used should be stated on the drawing as a ratio, e.g. ORIGINAL SCALE 1:2. The words full size, half size, etc., should *not* be used.

Recommended scales

These are as follows:

Full size

1:1

On drawings smaller than full size (reduction scales):

1:2	1:5	1:10
1:20	1:50	1:100
1:200	1:500	1:1000

On drawings larger than full size (enlargement scales):

2:1	5:1	10:1
20:1	50:1	

Choice of scales

The scale to be chosen for a drawing depends on the size of the drawing sheet and the size of the object to be depicted. The scale should be large enough to permit easy and clear interpretation of the information. Details that are too small for clear dimensioning in the main representation should be shown in a separate view to a larger scale. See figure 13.

3 Lines and linework

Presentation

All lines should be uniformly black, dense and bold. Lines should be all in pencil or all in black ink.

Line thickness

Two thicknesses of line are recommended: thick and thin. Thick lines should be twice as thick (wide) as thin lines.

Types of line and their applications

See table 1 and figure 3.

Dashed lines (type E). The dashes should be of consistent length and spacing, approximately to the proportion shown in table 1. Dashed lines should start and end with dashes in contact with the hidden or visible lines from which they originate, except when the hidden line continues a visible line. Dashed lines should also meet with dashes at tangent points and corners.

Chain lines (type F, G and H). All chain lines should start and finish with a long dash, but note the length of the thick dash at the ends of the cutting plane line (type G) and at the changes of direction.

Where centre lines define centre points they should cross one another at long dash portions of the line.

Centre lines should extend only a short distance beyond the feature or view to which they apply. If required for dimensioning they should continue as projection lines. Common centre lines should not extend across the space between adjacent views.

Centre lines should not stop at another line of the drawing.

Where angles are formed in chain lines, long dashes should meet or cross at corners.

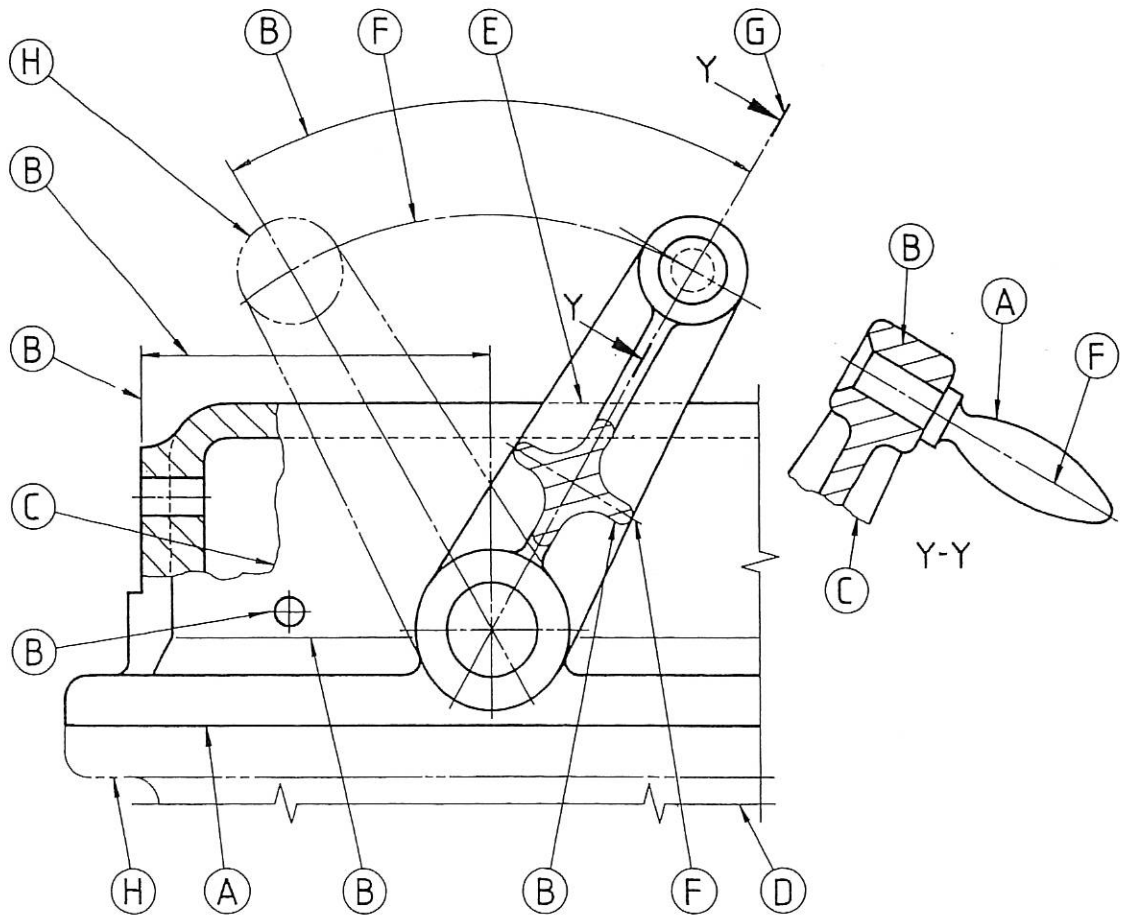
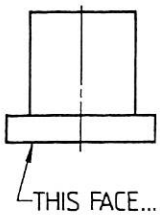
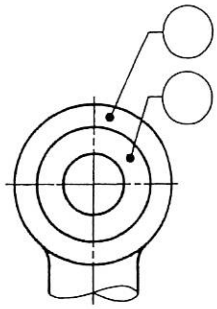


Figure 3. Applications of the various types of line



(a) Leader line terminating in arrowhead



(b) Leader lines terminating in dots

Figure 5. Typical leader lines

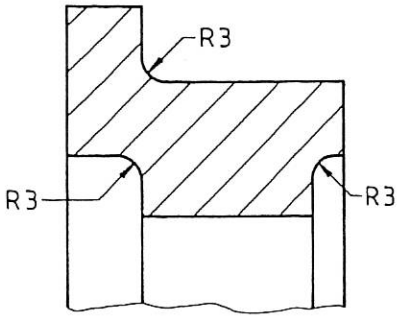


Figure 6. Dimensions repeated to avoid long leader lines

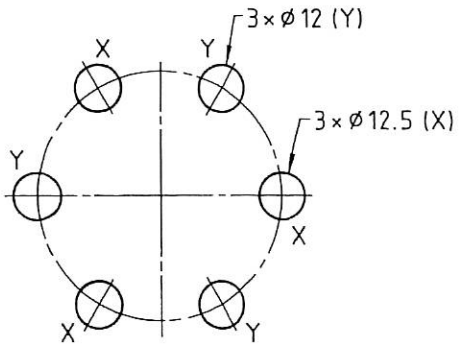


Figure 7. Letter symbols used to avoid long and intersecting leader lines

Leader lines

Leader lines are used to show where dimensions or notes apply. They are type B lines (see table 1) ending in arrowheads or dots. Arrowheads always touch and stop on a line; dots should be within the outline of an object (see figure 5).

An arrowed leader line applied to an arc should be in line with the arc centre.

When applied to a straight line an arrowed leader line should be nearly normal to the line.

Long or intersecting leader lines should not be used even if this means repeating dimensions or notes (see figure 6) or using letter symbols (see figure 7).

Leader lines should not pass through the intersection of other lines.

Arrowheads

Arrowheads should be triangular, with the length approximately three times the width, formed with straight lines and symmetrically placed about the dimension line, leader line or stem. Arrowheads should be filled in.

Sizes. Arrowheads on dimension and leader lines should be 3 mm to 5 mm long. Arrows showing direction of viewing should have arrowheads 7 mm to 10 mm long. The stem of such arrows should be approximately the same length as the arrowhead, but not less than this.

Examples of first and third angle projection are shown in figures 10 and 11. It is rarely necessary to show all six views.

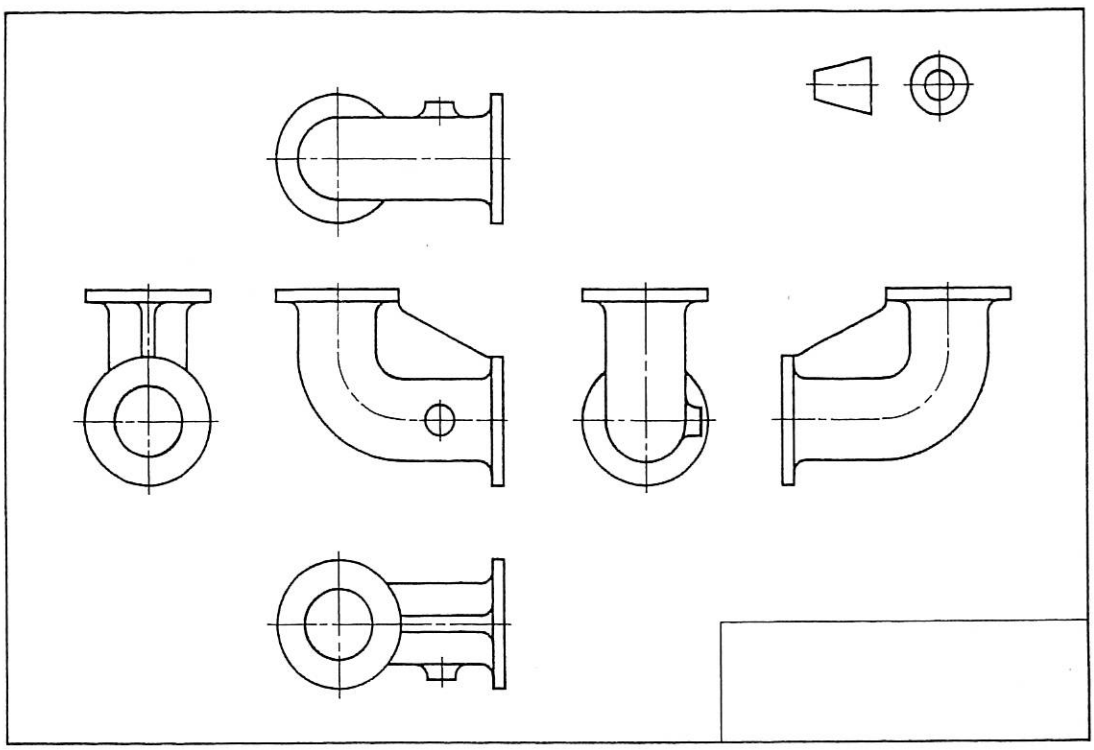


Figure 10. Example of first angle projection

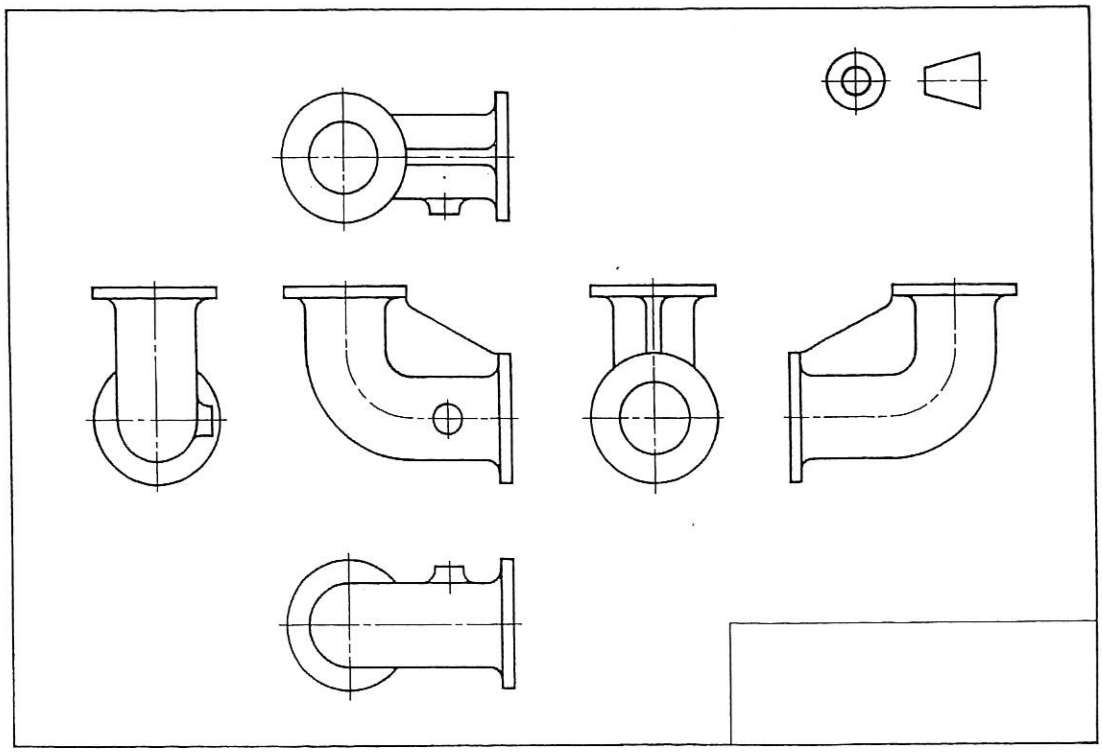


Figure 11. Example of third angle projection

This simplified representation may still be used for parts which are not truly symmetrical by adding a note identifying the asymmetrical features (see figure 15).

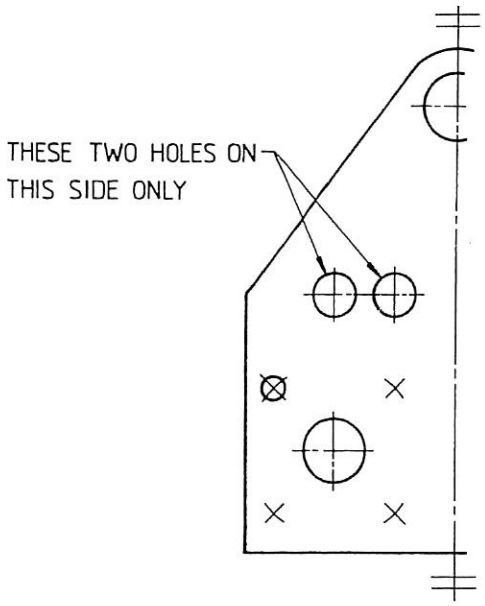


Figure 15. Symmetrical part with asymmetrical features added

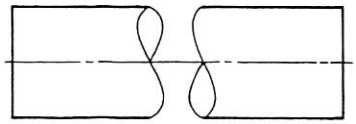
Interrupted views

To save space, only those portions of a large or long object which are sufficient to define it need to be shown, drawn close to each other (see figure 16).

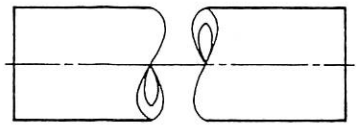
The break lines may be shown conventionally for a solid shaft (see figure 16(a)) and for a hollow shaft (see figure 16(b)) using a type B line (see table 1).

Alternatively, any break line may be drawn using a type C or type D line (see table 1) as illustrated in figure 16(c), (d), and (e). The type D break line continues for a short distance beyond the outline.

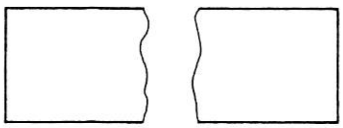
Type C and type D break lines may also be used on sectional views.



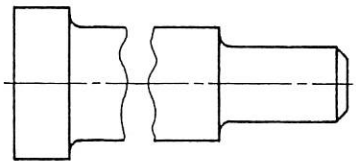
(a) Conventional break lines for solid shaft



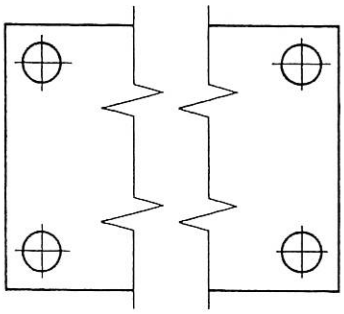
(b) Conventional break lines for hollow shaft



(c) General break lines (type C lines)



(d) Type C break lines used for solid shaft



(e) Type D break lines

Figure 16. Interrupted views

Hatching

General. In general, sections and sectional views should be hatched but hatching is often omitted in industry to save time and money. It is normal practice to use hatching in British Standards so it has been used throughout this publication. Hatching is drawn with type B lines (see table 1), equally spaced at a well defined angle, preferably at 45°.

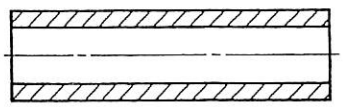
Spacing between hatching lines. Hatching lines should preferably be not less than 4 mm apart. However, when hatching very small areas this spacing should be reduced but never to less than 1 mm.

Hatching separated areas. Separated sectioned areas of a single component should be hatched in the same direction and with the same spacing (see figure 20(a)).

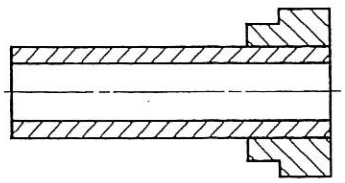
Hatching assembled parts. Where different sectioned parts meet on an assembly drawing, the direction of the hatching should normally be reversed and staggered (see figure 20(b)). In cases where hatching on adjacent parts must be at the same angle the lines should be staggered and may be more closely spaced (see figure 20(c)).

Hatching large areas. The hatching of a large area may be limited to that part of the area which touches adjacent hatched parts, or the outline of the large part (see figure 21).

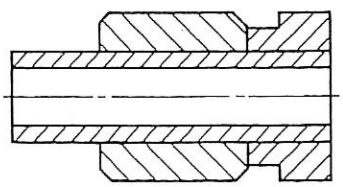
Thin material in section. Thin material in section may be filled in, in preference to showing the material thickness out of scale and hatched. When adjacent parts are thus shown a clear space of not less than 1 mm should be left between them (see figure 22).



(a) Hatching separated areas.



(b) Hatching adjacent parts



(c) Hatching adjacent parts at the same angle

Figure 20. Hatching separated areas and adjacent parts

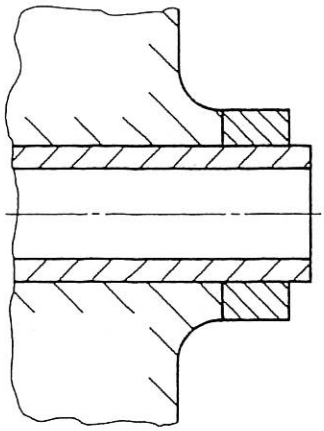


Figure 21. Hatching large areas

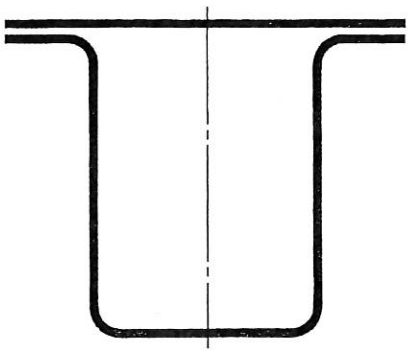


Figure 22. Section through thin material

Half sectional views. Symmetrical parts may be drawn half in outside view and half in section (see figure 27).

Local or part sectional views. A local sectional view, shown in figure 28, may avoid the need for a complete sectional view. The localized break is shown with a type C line (see table 1).

Revolved sections. Cross sections may be revolved in place (see figure 29). Type B lines (see table 1) are used for their outlines.

Removed sections. Cross sections, instead of being revolved in place, may be removed as shown in figure 30.

When a removed section is symmetrical it may be shown:

(a) in projection and conventionally identified as in section AA;

(b) in any convenient place on the drawing and conventionally identified as in section BB;

(c) near the main view and connected with it by its line of symmetry through the cutting plane. The line of symmetry is a type F line (see table 1). In this case no section identification is needed.

When a removed section is not symmetrical one of the methods described in (a) and (b) has to be used.

The outline of a removed section is a type A line (see table 1).

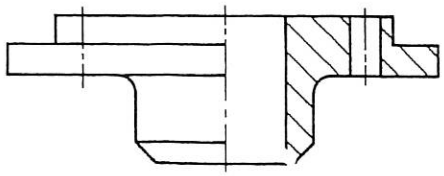


Figure 27. Half sectional view

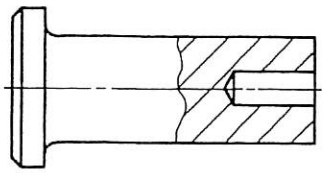


Figure 28. Local or part sectional view

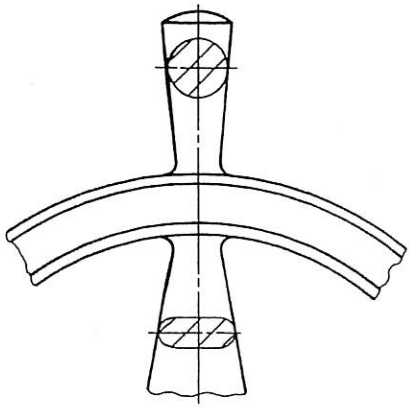


Figure 29. Revolved sections

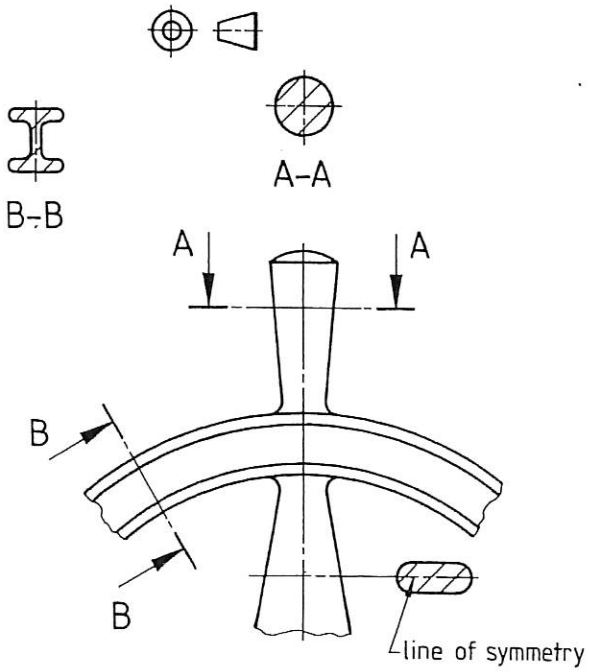


Figure 30. Removed sections

8 Item references

General

Item references are used on assembly drawings to identify the items in the assembly. Item references are shown in an item list which gives such information as the number required of each item and its part number. The item list may appear on the assembly drawing (see figure 2(d)) or separately.

Numerals are generally used for item references (see figure 33). The numerals should be at least twice the height of characters used for dimensions and notes and are generally encircled with a type B line (see table 1).

Arrangement

Item references should be arranged, preferably, in columns and rows. They should be connected to the items by leader lines ending in dots within the item outlines. When this is not possible, arrowheads may be used touching the outlines. The leader lines should not be drawn at right angles to the outlines of the items they refer to.

Similar items used more than once

These generally need only one item reference. The number used is given by a small numeral placed to the right and slightly below the item reference (see figure 33, items 6 to 8).

Associated items

Only one leader should be used for item references of associated items (see figure 33, items 6 to 8 and 9 to 12). The circles should either touch or be joined with a short type B line (see table 1).

Assembly instructions

Any necessary assembly instruction may be added to an item reference (see figure 33, item 4).

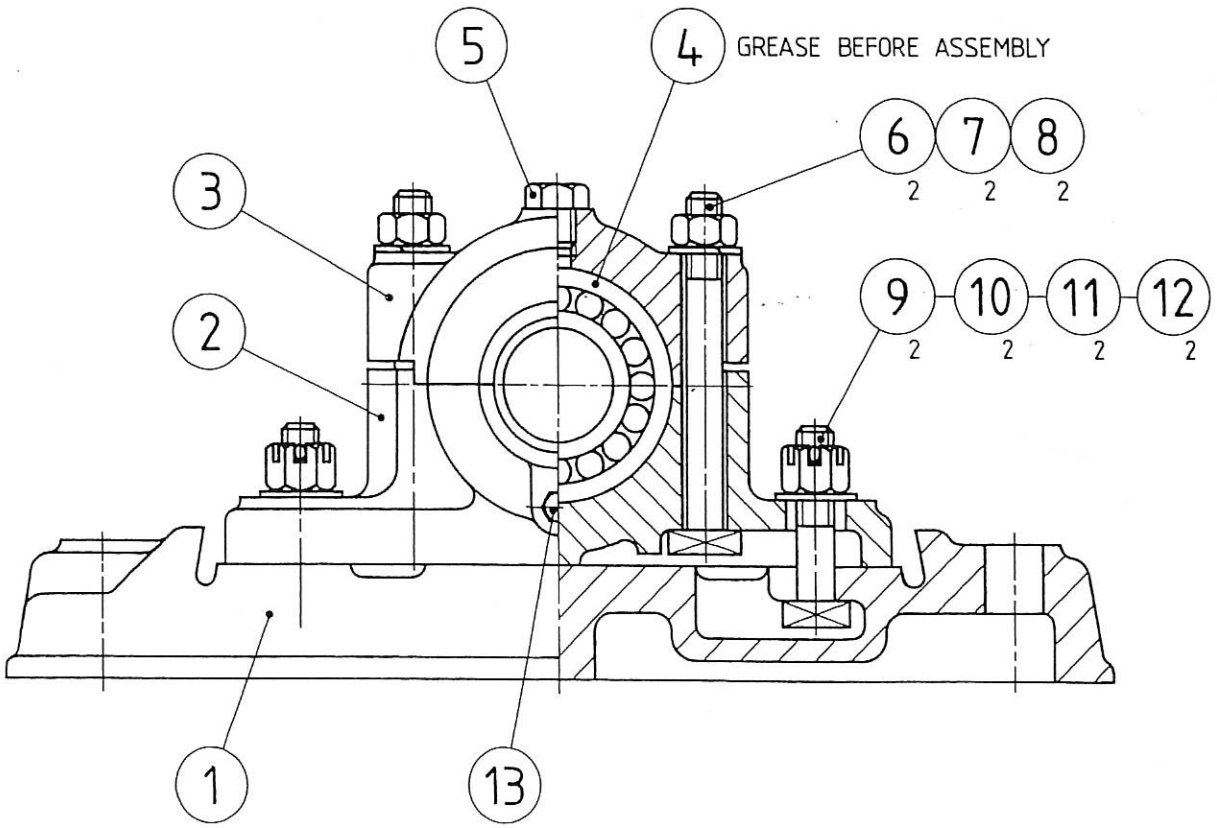


Figure 33. Item references

10 Conventional representations

Adjacent parts

If adjacent parts have to be shown, they should be drawn with type H lines (see table 1). It is important that the adjacent part should never hide the principal part but may be hidden by the latter (see figure 34).

Imaginary intersections

These may be indicated with type B lines (see table 1) not touching the outlines (see figure 35 and figure 24).

Simplified representation of intersections

Intersection lines, e.g. between cylinders or cylinders and prisms, may be approximated by arcs or straight lines, where the projection of true lines of intersection is unnecessary. A type A line (see table 1) is used.

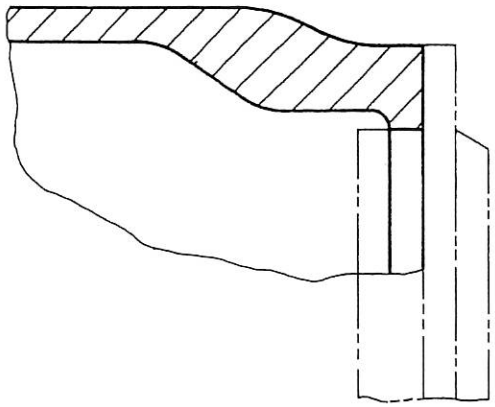


Figure 34. Adjacent part

Plane faces on cylindrical parts

Flat surfaces such as squares, tapered squares and local flats (see figure 36) may be indicated by crossed diagonal type B lines (see table 1).

Knurling

The type of knurling is indicated by showing only part of the surface so treated (see figure 37) using type B lines (see table 1).

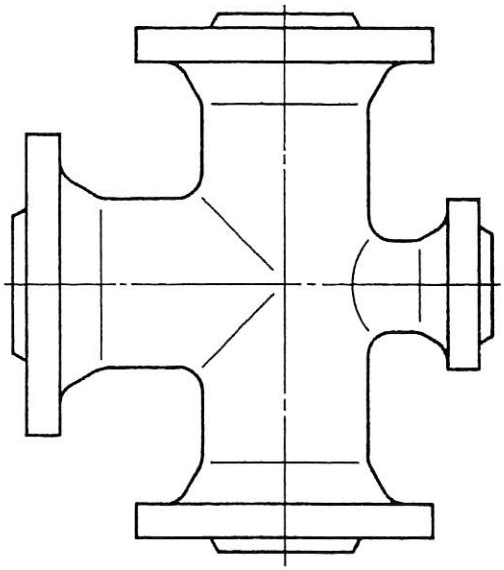


Figure 35. Imaginary intersection lines

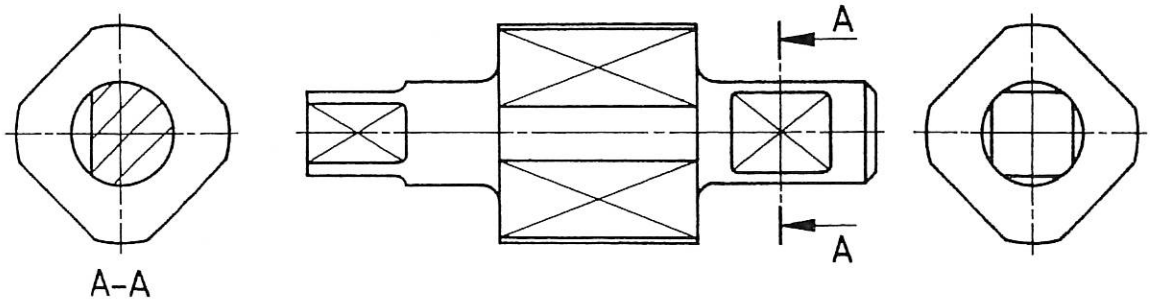
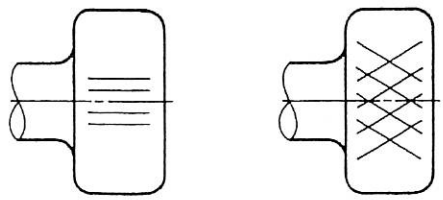


Figure 36. Indication of flat features on a shaft



Diagonal lines drawn at about 30° to centre line

(a) Straight (b) Diamond

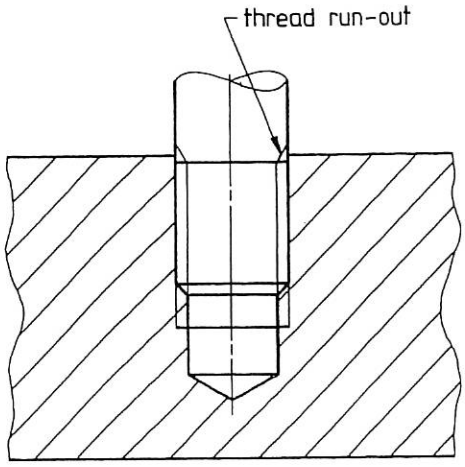
Figure 37. Examples of knurling

Screw threads

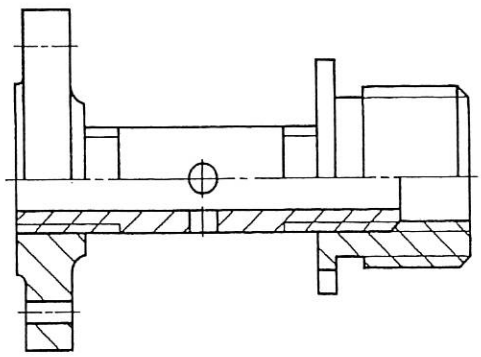
For all normal purposes the conventional representation of screw threads, as shown in figures 40 and 41, is preferred whatever the screw thread type. The type and dimensions of standard screw threads are normally given in note form in accordance with the relevant standard (see figures 81 and 82). Views of special screw threads may need to be directly dimensioned.

Thread run-outs. These are only shown where they are functionally necessary. The method of indication is shown on the stud in figure 41 (a).

Assembled threaded parts. Externally threaded parts are shown covering internally threaded parts on sectional views and end views (see figure 41 (a) and (b)).



(a)



(b)

Figure 41. Conventions for assembled screw threads

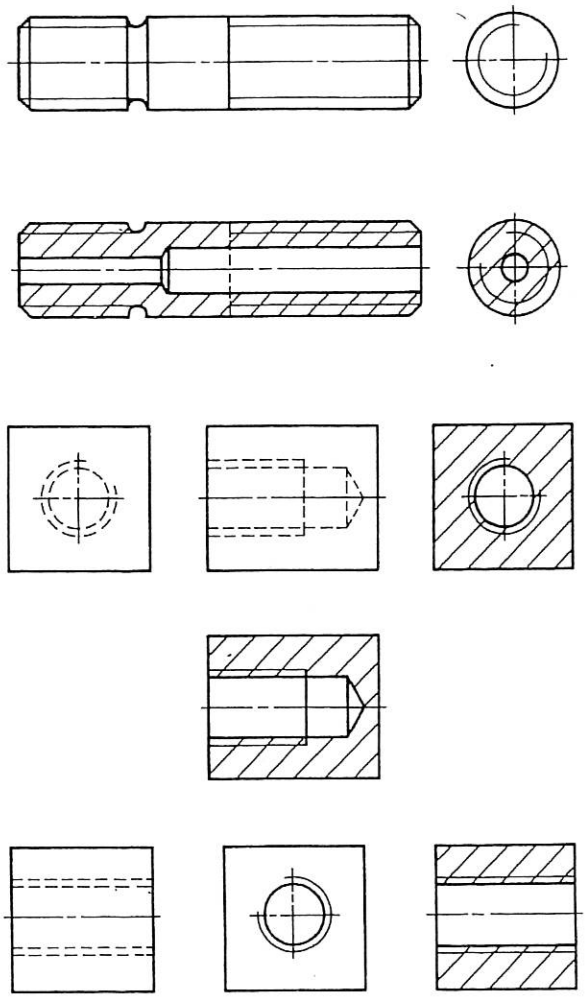


Figure 40. Conventions for screw threads

Bearings

A general convention for all types of rolling bearings in section is shown in figure 42.

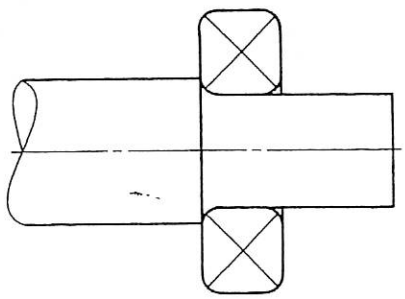
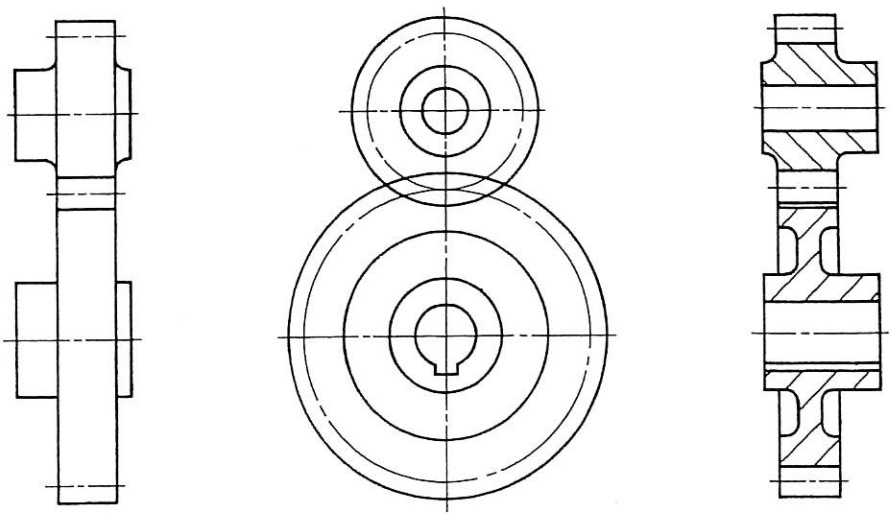
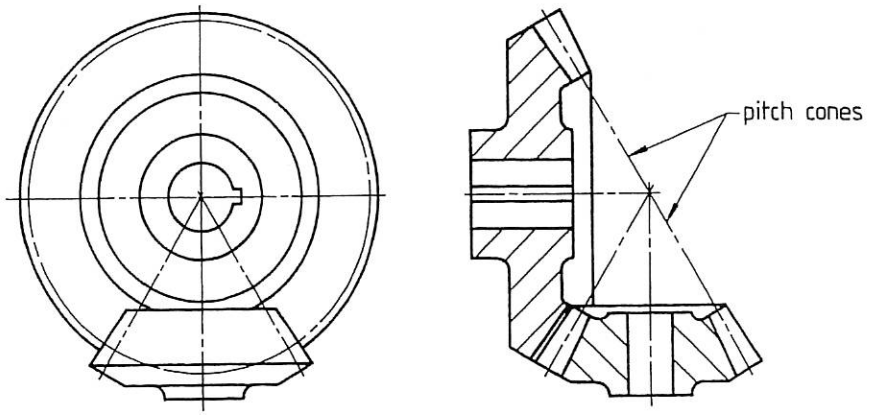


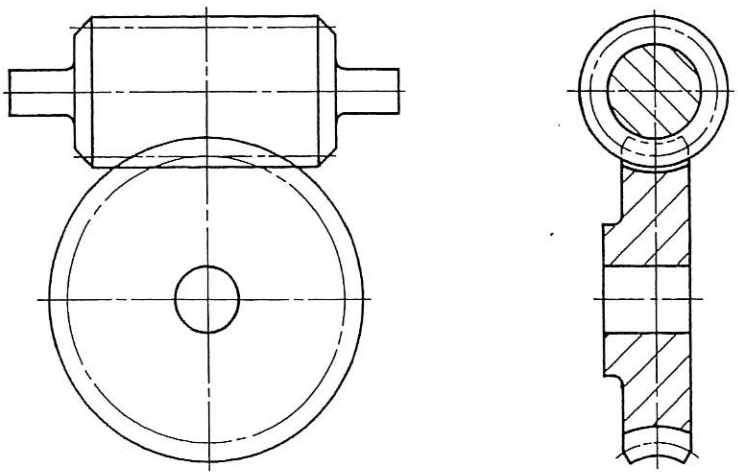
Figure 42. Convention for rolling bearing



(a) Spur gears



(b) Bevel gears



(c) Cylindrical worm and worm wheel

Figure 45. Conventions for gears in mesh

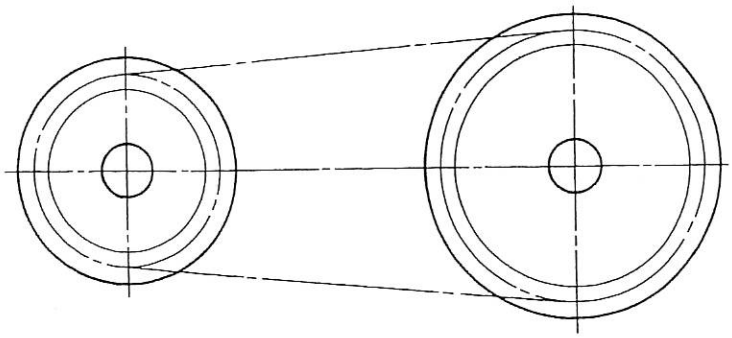


Figure 46. Chain wheels

11 Principles of dimensioning

General

Each dimension necessary for the complete definition of a finished product should be given on the drawing and should appear once only. It should not be necessary for a dimension to be calculated from other dimensions or for the drawing to be scaled.

There should be no more dimensions than are necessary to define the product.

Dimensions for a particular feature should preferably be placed on a single view rather than on several, and on that view which shows the relevant feature most clearly.

Preferred sizes should be used wherever practicable, particularly for holes, thread sizes, bolts, studs, pins, etc., and for work where the sizes and surface finish of standard stock would be satisfactory (see particularly PD 6481).

Linear dimensions on drawings are normally in millimetres (unit symbol 'mm'). The unit symbol may be omitted provided the drawing carries a statement of the unit used. When other units are used, their unit symbol should be shown with the value.

Dimensions should be expressed to the least number of significant figures, e.g. 35 not 35.0. See section 14 for the expression of toleranced dimensions.

The decimal marker is a point which should be bold, given a full letter space and placed on the baseline. It is recommended that where there are more than four numerals to the left of the decimal marker, a full space should divide each group of three numerals counting from the position of the decimal marker, e.g. 400 or 1000 but 12 500. Points and commas should not be used to separate groups of numerals. In many countries the comma is used as the decimal marker.

Dimensions of less than unity should be preceded by zero, e.g. 0.5.

Angular dimensions should be expressed in degrees and minutes, e.g.

20°

22° 30′

A full space should be left between the degree symbol and the minute numeral.

When an angle is less than one degree it should be preceded by 0°, e.g. 0° 30′.

Functional dimensioning

The functional dimensions are those that directly affect the function of a product and should be shown directly on the drawing. The dimensions labelled f in figure 48 are functional.

For tolerances in functional dimensioning see appendix B. See also PP 7309.

Projection lines and dimension lines

Projection lines and dimension lines should normally be placed outside the outline of the view (see figure 49). They are type B lines (see table 1).

Crossing of projection and dimension lines should be avoided. Where crossing is unavoidable, neither line is broken in general. Breaks are only used for clarity and then only in the projection line. In this context outlines are never broken.

Projection lines should start just clear of the outline of the feature and should extend a little beyond the dimension line, as shown in figure 49.

Where projection lines refer to points on surfaces or to imaginary points of intersection, they should touch or pass through the points, as shown in figure 50(a) and (b). To gain clarity, the points may be emphasized by a small dot, as in figure 50(b).

Projection lines should normally be drawn perpendicular to the dimension required.

In certain circumstances, for example on tapers, clarity is improved by drawing the projection lines obliquely (see figure 51).

Centre lines, extensions of centre lines and continuations of outlines should never be used as dimension lines. They may, however, be used as projection lines.

Examples of the recommended uses of dimension lines are shown in figure 52.

Dimension lines should be drawn unbroken even if the feature they refer to is shown interrupted (see figure 53).

When symmetrical parts are drawn partially, the portions of the dimension lines should extend a short distance beyond the axis of symmetry and the second terminations are omitted, as shown in figure 54. The full value of the dimension is shown.

Terminations on dimension lines

Arrowheads and common origin circles, see figure 49, are used as terminations on dimension lines.

Arrangement of dimensions

Dimensions should be placed near the middle of, and usually above and clear of, the dimension line (see the 89 dimension in figure 49), and in such a way that they are not crossed or separated by any other line of the drawing.

For easy reading, dimensions should be placed so that they can be read from the bottom or from the right-hand side of the drawing, as shown in figures 55 and 56. Dimensions should preferably be placed outside the zones shown hatched in figure 55.

Where there is limited space for dimensioning, the dimension should be placed centrally or above, or in line with, the extension of one of the dimension lines (see figure 57).

In some countries a line is shown joining the points of the arrowheads. This is not a recommended practice in this country.

Larger dimensions should be placed outside smaller dimensions as in figure 58.

Where it is necessary to indicate that a feature is not drawn to scale, it should have its dimension underlined (see appendix A, drawing number 2).

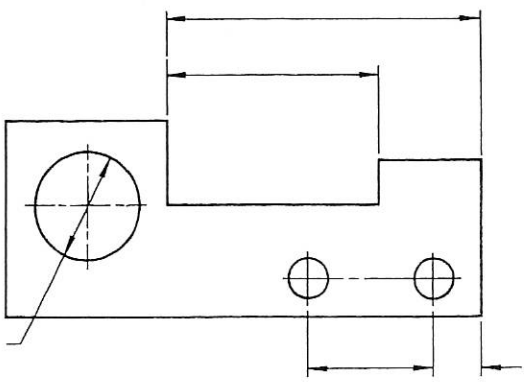


Figure 52. Examples of dimension lines

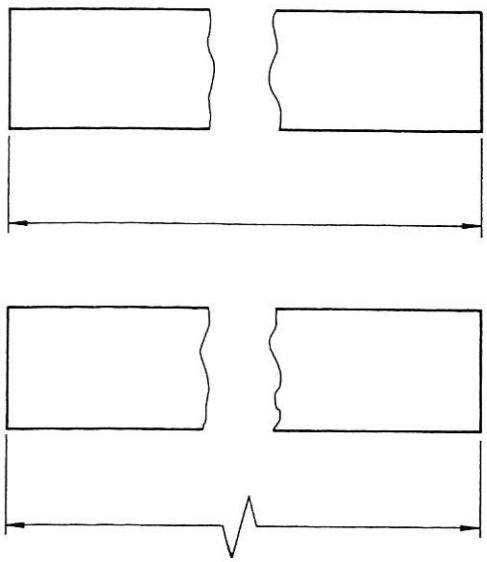


Figure 53. Dimensioning interrupted features

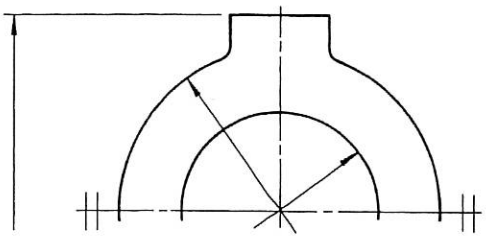


Figure 54. Dimension lines on partial view of a symmetrical part

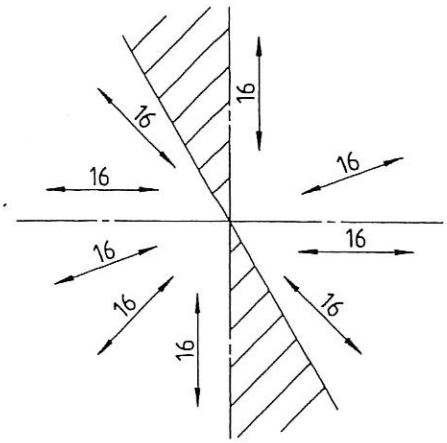


Figure 55. Orientation of linear dimensions

Dimensioning methods

Parallel dimensioning. Parallel dimensioning consists of a number of dimensions originating from a datum feature (see figure 61).

Superimposed running dimensioning is simplified parallel dimensioning and may be used where there are space limitations. The common origin is indicated as shown in figure 62. Dimensions may be placed near the arrowhead and either:

(a) above and clear of the dimension line, as in figure 62(a); or

(b) in line with the corresponding projection line, as in figure 62(b).

Chain dimensioning. Chains of dimensions (see figure 63) should be used only where the possible accumulation of tolerances does not endanger the function of the part.

Combined dimensioning. This method uses chain dimensioning and parallel dimensioning on the same drawing (see figure 64).

Dimensioning by coordinates. Superimposed running dimensioning may be used in two directions at right angles, as in figure 65. The common origin can be any suitable datum feature.

The dimensioning shown in figure 65 may be simplified by using a table, as in figure 66. It may be necessary to identify groups of holes (or other features) separately.

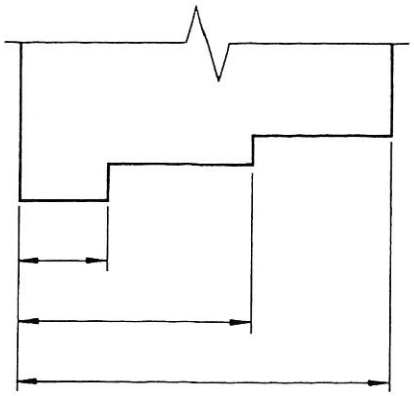
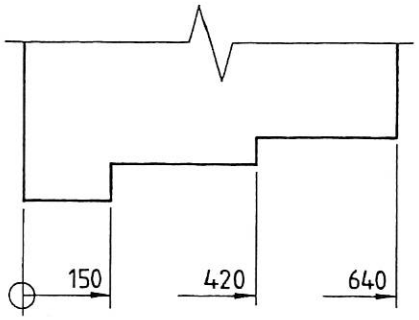
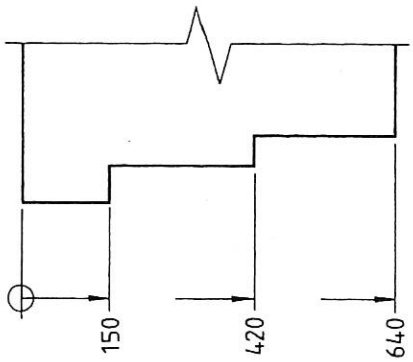


Figure 61. Parallel dimensioning



(a)



(b)

Figure 62. Superimposed running dimensioning

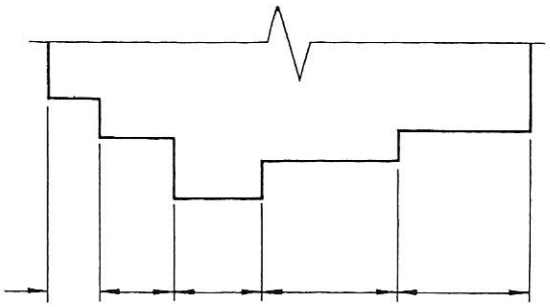


Figure 63. Chain dimensioning

12 Methods of dimensioning common features

Diameters

A dimension giving the diameter of a circle or cylinder is shown by the symbol ø in front of the numerals. The symbol should be as large as the following numerals and the slanting line should be about 30° clockwise from the vertical, in the direction in which it is read (see figure 67). Part or incomplete circles are dimensioned as radii (see below).

The dimensions of diameters should be placed on the view that most clearly shows the information, for example, on a longitudinal view in preference to an end view which would show a number of concentric circles (see figure 67).

Where a projection line and dimension line would intersect, the dimensions may be applied to the features by leader lines (see figure 68).

Examples of dimensioning circles are shown in figure 69.

The diameter of a spherical surface should be dimensioned as in figure 70.

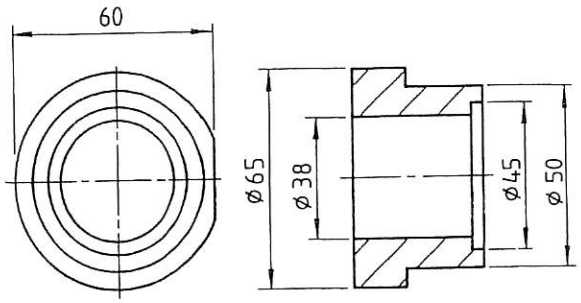


Figure 67. Dimensions of diameters placed on best view for clarity

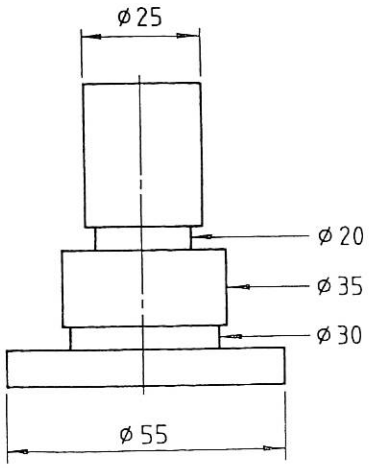


Figure 68. Dimensions applied to features by leader lines

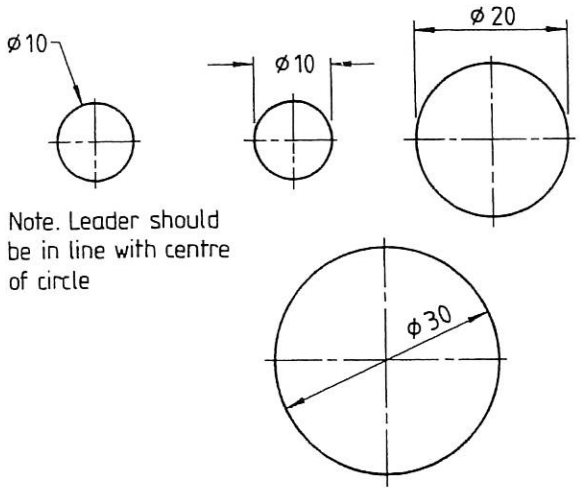
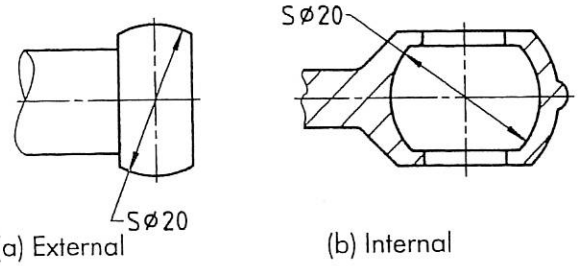


Figure 69. Dimensioning circles



(a) External (b) Internal

Figure 70. Dimensioning spherical diameters

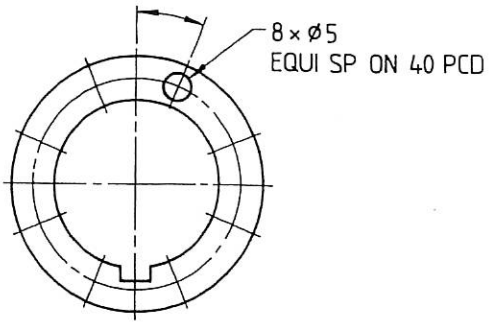
Positioning of holes and other features on circles and arcs

The positioning of holes and other features should be given by spacing them on circles as shown in figure 75 or by giving them rectangular coordinates or centre distances as in figure 76.

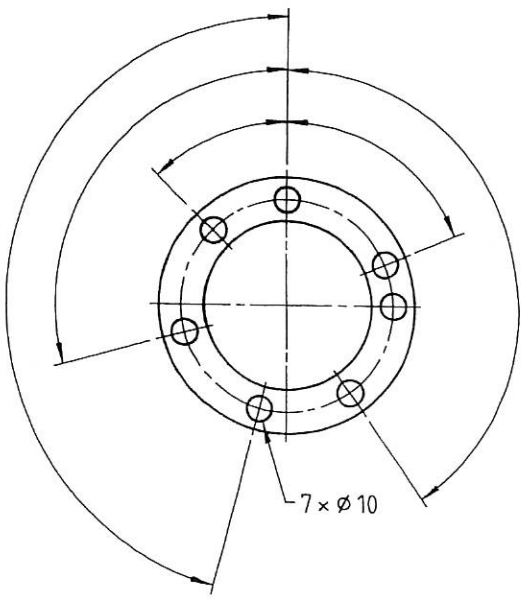
The choice of dimensioning method should be influenced primarily by the design requirements rather than by a method of manufacture.

Dimensioning of equally-spaced features

The dimensioning of equally-spaced features may be simplified by using the methods shown in figure 77. The value defining the number of spaces precedes that defining the size of each space.



(a) Holes equally spaced



(b) Holes unequally spaced

Figure 75. Dimensioning hole positions on a circle by angular spacing

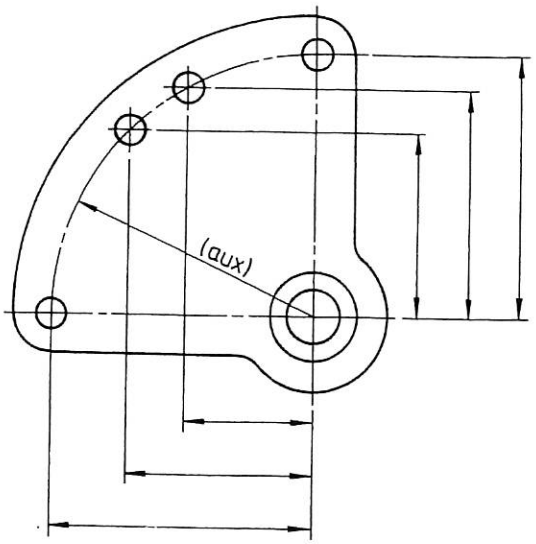
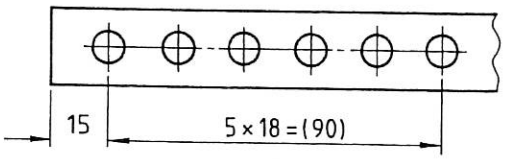
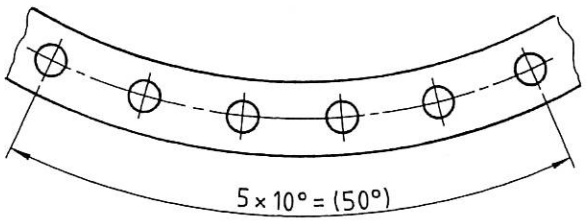


Figure 76. Dimensioning hole positions by coordinates



(a) Linear spacing



(b) Spacing on an arc

Figure 77. Dimensioning of equally-spaced features

Screw threads

Designation of ISO metric screw threads
ISO metric screw threads should be designated in accordance with BS 3643: Part 1. The complete designation comprises a designation for the thread system and size, and a designation for the thread tolerance class.

Thread system and size. The letter M, standing for ISO metric thread, is followed by the values of the nominal diameter and pitch, both in millimetres, with a multiplication sign between them, e.g. M8 × 1.

The absence of a value for the pitch, e.g. M8, means that a coarse pitch is specified. (The coarse pitch for an M8 thread is 1.25 mm.)

Thread tolerance class. For general use tolerance class 6H is suitable for internal threads and tolerance class 6g for external threads. The thread tolerance class is preceded by a hyphen, e.g. M10–6H or M10 × 1 – 6g.

Screw threads are dimensioned as in figures 81 and 82.

Length of thread (parallel threads). The length of full thread (i.e. the distance to the point at which the root ceases to be fully formed) should be dimensioned as in figures 81(b) and 82.

Where necessary, the length to the limit of the thread run-out should be dimensioned as in figures 81(b) and 82(c).

Undercuts. Where an undercut is necessary it should be dimensioned as shown in BS 1936. See drawing 2 in appendix A where the dimensions on detail X are those for an M20 thread.

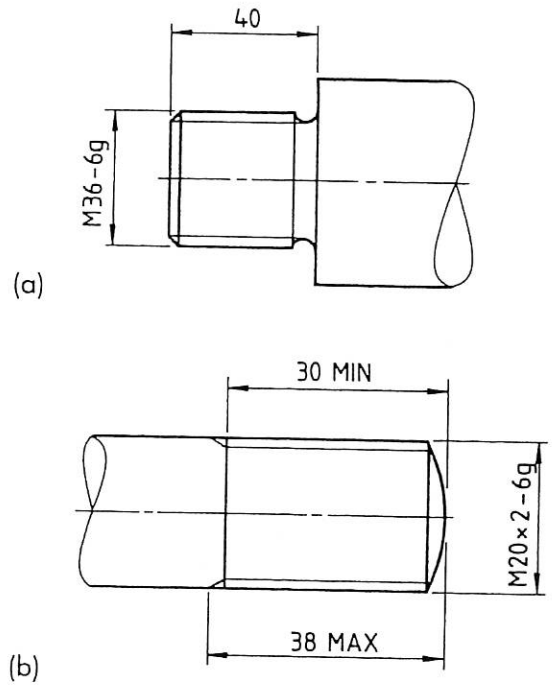


Figure 81. Dimensioning external screw threads

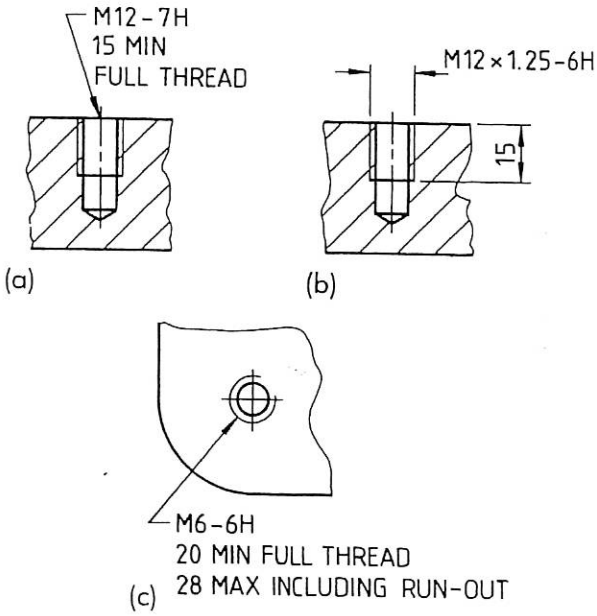


Figure 82. Dimensioning internal screw threads

14 Toleranced dimensions

General

All dimensions, except auxiliary dimensions (see section 11), are subject to tolerances. Tolerances for dimensions which affect functioning and interchangeability are particularly important, see BS 4500 and PP 7309. Appropriate tolerances may also be used to indicate where unusually wide variations are permissible.

Application of tolerances

Tolerances should be applied either to individual dimensions, or by a general note giving uniform or graded tolerances to classes of dimensions, for example,

TOLERANCES UNLESS OTHERWISE STATED
LINEAR ± 0.4 ANGULAR ± 0° 30'

Tolerancing of individual linear dimensions

The method shown in figure 86 is recommended where it is required to tolerance an individual linear dimension. This method specifies directly both limits of size of the dimension. The tolerance is the difference between the limits of size.

The larger limit of size is placed above the smaller and both are given to the same number of decimal places.

Tolerancing of individual angular dimensions

The methods shown in figure 87 may be used to tolerance individual angular dimensions.

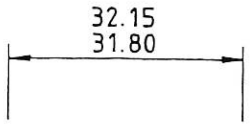


Figure 86. Linear dimension toleranced by specifying limits of size directly

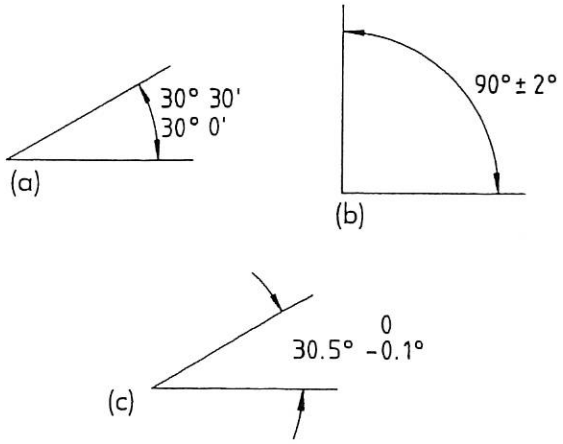
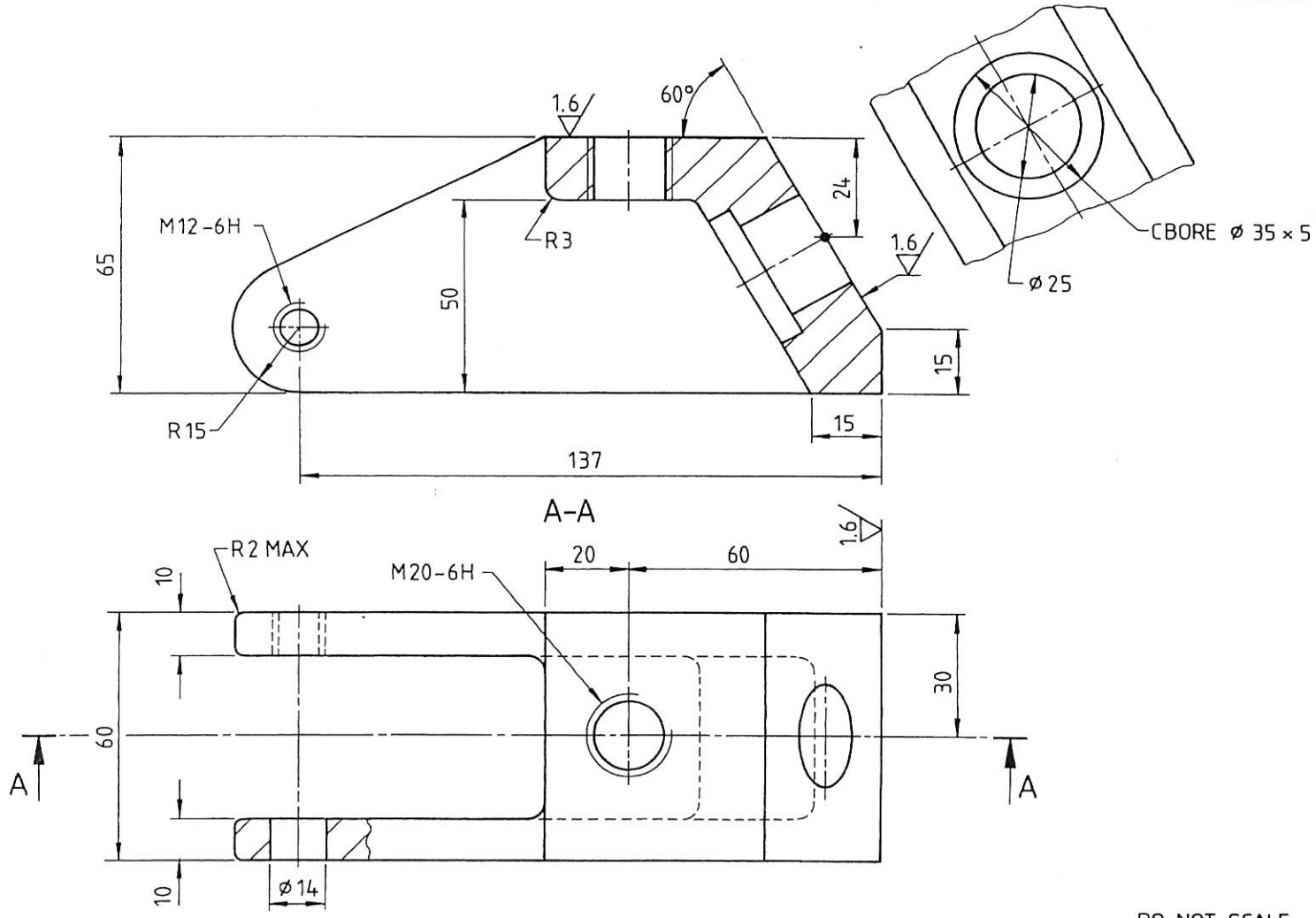


Figure 87. Tolerancing angular dimensions

Appendix A Typical drawings



FILLET RADII R3 MIN

DO NOT SCALE

FINISH	TOLERANCE	MATERIAL	PROJECTION	DRAWN MAP	ORIGINAL	ALL DIMENSIONS IN mm	
AS CAST OR TO BS1134	CAST DIMS ± 1.5	MALLEABLE IRON		DATE 86 06 10	SCALE	SWIVEL BRACKET	DRG NO.
WHERE STATED	MACHINED DIMS ± 0.2	TO BS 310		CHECKED RJW	1:2		1
THREADS TO BS 3643	ANGULAR DIMS ± 0° 30'			DATE 86 06 27			