SRI LANKA STANDARD 409 : PART 2 : 2004

UDC 741.05 : 62 : 003.63

SRI LANKA STANDARD
ENGINEERING DRAWING PRACTICE
PART 2 : RECOMMENDATIONS FOR DIMENSIONING AND TOLERANCING OF SIZE AND METHOD OF INDICATING SURFACE TEXTURE
(FIRST REVISION)

SRI LANKA STANDARDS INSTITUTION

ENGINEERING DRAWING PRACTICE
PART 2 : RECOMMENDATIONS FOR DIMENSIONING AND TOLERANCING OF SIZE AND METHOD OF INDICATING SURFACE TEXTURE (FIRST REVISION)

SLS 409 Part 2 : 2004

Gr. 20

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SRI LANKA

Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This standard does not purport to include all the necessary provisions of a contract.

CONTENT

Sri Lanka Standard
ENGINEERING DRAWING PRACTICE
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FOREWORD

This standard was approved by the sectoral committee on Materials, Mechanical Systems and Manufacturing Engineering and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2004.12.09

The proven record of standards applied to engineering drawing now enables its recognition as the graphical language of communication in engineering both nationally and internationally. Drawings made to the accepted standards in one country, when based on standards published by the International Organization for Standardization (ISO) are understood and can be used around the world in virtually all countries. With this in mind it was recognized and accepted to be important as a policy for this revision that particular attention and care should be paid to the quality of content of both text and figures to ensure their clarity and ease of understanding.

During the course of this revision particular attention has been paid to developments in computer aided drafting and it has been established that such systems are currently capable of complying with this standard. Any minor exceptions due to the limitation of a particular system would not be expected to prejudice the understanding of a drawing otherwise claimed to comply with this standard.

This standard is the first revision of SLS 409 published in 1977.

For convenience of use, this revision of **SLS 409** consist of the following three parts:

Part 1 Recommendations for general principles
Part 2 Recommendations for dimensioning and tolerancing of Size and Method of indicating surface texture
Part 3 Recommendations for geometrical tolerancing

The Sri Lanka Standards Institution gratefully acknowledges the uses of the following publications in the preparation of this standard;

a) ISO Standards Handbook on Technical Drawings - Third edition 1997 - Volume 1

b) BS 308 : 1985 Engineering Drawing Practice
Part 2 : Recommendations for dimensioning and tolerancing of size

NOTES ON THE PRESENTATION OF THIS STANDARD

1. The figures in this standard are independent and each is selected solely for its simplicity and clarity to illustrate, only the text to which it relates. They are not the only possible examples and they are not intended as design examples or to be fully dimensioned working drawings but otherwise are drawn according to the basic recommendations of this standard.

2. Linear dimensions shown in the figures are in millimeters.

3. Numerical values of dimensions and tolerances given in the figures throughout are arbitrarily chosen to assist in illustrating the point under consideration; they are typical and are not given as recommendations.

4. This standard recognizes both the first and third angle projection methods as having equal status but the first angle projection method is more frequently used.

5. Due to the limitations of size of the figures in this standard, the sizes of arrowheads may not confirm to the recommendations of **6.4** in **SLS 409 : Part 1 : 2004.**

1 SCOPE

This part of SLS 409 gives recommendation for the general principles of dimensioning and tolerancing, the methods of applying dimensions and tolerances of size and the methods of indicating surface texture on engineering drawings. Guidance is given on the interpretation of limits of size and toleranced centre distances.

NOTE : *Civil and structural engineering and construction service drawings are excluded. The special discipline aspects of naval architecture and aeronautical lofting are not included.*

2 REFERENCES

ISO 14 Straight-sided splines for cylindrical shafts with internal centering - Dimensions, tolerances and verifications

ISO 286 ISO systems of limits and fits
Part 1 : Bases of tolerances, deviations and fits
Part 2 : Tables of standard tolerance grades and limit deviations for holes and shafts

ISO 468 Surface roughness - Parameters, their values and general rules for specifying requirements

ISO 965 ISO general purpose metric screw threads - Tolerances
Part 1 : Principles and basic data
Part 2 : Limits of sizes for general purpose bolt and nut threads - Medium quality
Part 3 : Deviations for constructional threads

ISO 1119 Series of conical tapers and taper angles

ISO 3461 General principles for the creation of graphical symbols
Part 2 : Graphical symbols for use in technical product documentation

ISO 4156 Straight cylindrical involute splines - Metric module, side fit - Generalities, dimensions and inspection

ISO 4288 Geometrical product specifications (GPS) - Surface texture : Profile method - Rules and procedures for the assessment of surface texture

ISO 4759 Tolerances of fasteners

ISO 6410 Screw threads and thread parts
Part 1 : General conventions
Part 2 : Screw thread inserts
Part 3 ; Simplified representations

ISO 6413 Representation of splines and serrations

3 DEFINITIONS

For the purposes of this Part of **SLS 409**, the following definitions shall apply:

3.1 feature: An individual characteristic such as a flat surface, a cylindrical surface, two parallel surfaces, a shoulder, a screw thread, a slot, a profile etc.

3.2 functional feature: A feature that is essential to the performance or serviceability of the object of which it is a part. It may be a location feature (e.g. spigot which serves to locate a component in an assembly) or a working surface (e.g. bore of a bearing).

3.3 dimension: A numerical value, expressed in appropriate units of measurement, that defines a feature. Dimensions may be accompanied by lines, symbols and notes so that the features of an object will be completely defined.

3.4 functional dimension: A dimension that is essential to the function of an object or space (see Figure **1**).

3.5 non-functional dimension: A dimension that is not essential to the function of an object or space (see Figure **1**).

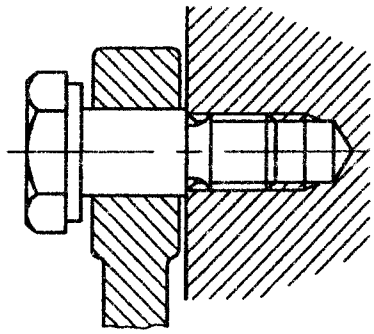
3.6 auxiliary dimension: A dimension given for information purposes only. It does not govern production or inspection operations and is derived from other values shown on the drawing or in related documents. An auxiliary dimension is given in parenthesis and no tolerances apply to it (see 'AUX' in Figure **1**).

3.7 tolerance: The total amount of variation permitted for the size of a dimension, a positional relationship or the form of a profile or other design requirement. The tolerance defines the maximum and minimum limits of size.

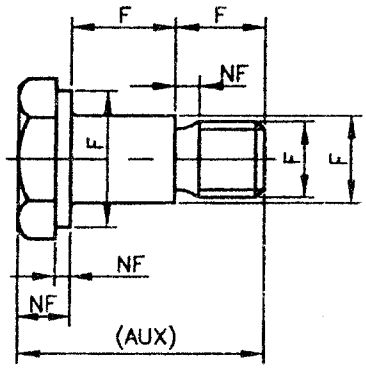
2.8 datum: A theoretically exact geometric reference such as an axis, plane, straight line, etc., to which toleranced features are related.

3.9 actual local size: An actual two -point measurement of a dimensioned feature.

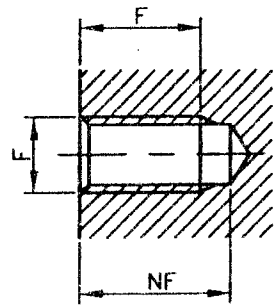
3.10 fit: The relationship resulting from the difference before assembly, between the sizes of two features (The hole and the shaft) which are to be assembles.



(a) Design requirement



(b) Shoulder screw



(c) Threaded hole

Key

F is a functional dimension
NF is a non–functional dimension
AUX is an auxiliary dimension without tolerance for information only

NOTE : *Geometric requirements have been omitted for simplicity*

FIGURE 1 - Application of dimensions to suit functional requirements

4 PRINCIPLES OF DIMENSIONING

4.1 Application

4.1.1 All dimensions, tolerances and information necessary for the complete description and function of an object should be expressed directly on a drawing and should appear once only. Any departure from this principle should be limited to special cases and be the subject of an explanatory note.

4.1.2 The dimensions should relate to the condition in which the object, part or product is to be used and include any specified surface treatment or finishing other than painting or lacquering.

4.1.3 The drawing may define the item as ready for assembly or service, or as the product of a foundry, forge, etc., supplied for further processing.

4.1.4 Dimensions should be placed on the view or section which shows the relevant features most clearly.

4.1.5 Preferred sizes should be used wherever practicable, e.g. holes, thread forms and fastener sizes, pins and standard material sizes.

4.1.6 Each drawing shall use the same units, e.g.millimetres (unit symbol 'mm') for all dimensions but without showing the unit symbol. In order to avoid misinterpretation, the predominant unit used on a drawing should be shown as a note.

Where other units have to be shown as part of the drawing specification (for example, Nm for torque or kPa for pressure) the appropriate unit symbol shall be shown with the value.

4.1.7 Dimensions should be expressed to the least number of significant digits (e.g.35 not 35.0). See **3** for the expression of toleranced dimensions.

4.1.8 The decimal marker is a point which should be bold, given a full letter space and be placed on the baseline. It is recommended that where there are more than four figures to the right or left of the decimal marker a full space should divide each group of three figures counting from the position of the decimal marker, e.g. 12 500.

NOTE : *ISO recommends the decimal marker to be a comma*

4.1.9 Dimensions of less than unity should be preceded by the cipher '0'. e.g.0.25.

4.1.10 Angular dimensions on engineering drawings should be expressed either in degrees, minutes and seconds or in degrees and decimals of a degree, for example.

22^0	22.5^0
22^0 30'	22.55^0
22^0 30' 30"	0.25^0

A full space should be left between the degrees symbol and the minute figure, and between the minute symbol and the second figure. Angular dimensions expressed in degrees, minutes and seconds but of less than unity should be preceded by the cipher '0' and a degree and/or minute symbol as appropriate, e.g. 0^0 15', 0^0 0' 30".

NOTE : *The radian is the unit for angular measurement in the International System of Units (SI) but is not normally used on engineering drawings.*

4.1.11 The practice of dual dimensioning (e.g. millimetres and inches) is not permitted but, if it is considered necessary to quote a conversion, the dimension to which the part is to be made and inspected should be shown first, with the conversion shown in parentheses.

4.2 Limitations

4.2.1 No more dimensions than are necessary to define a part or an end product shall be shown on a drawing. No feature of a part or an end product shall be defined by more than one dimension in any one direction.

Exceptions may, however, be made;

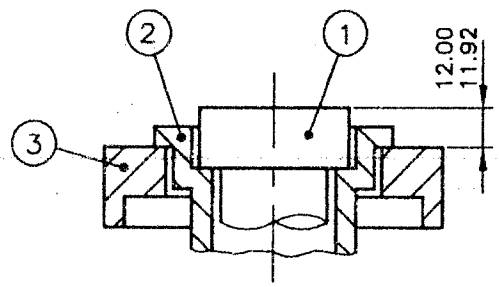
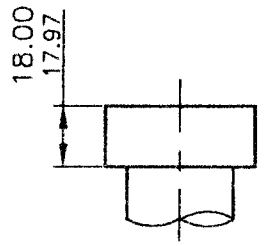
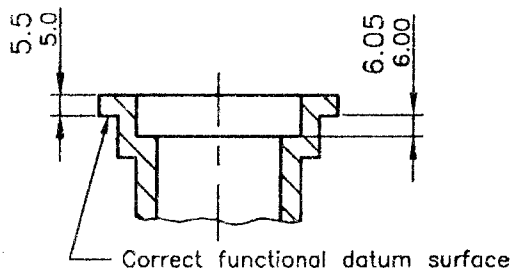
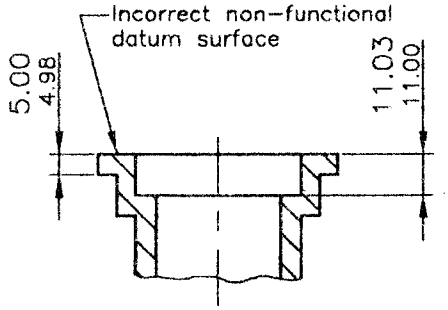
a) where it is necessary to give additional dimensions at intermediate stages of production (for example, the size of a feature prior to carburizing and finishing); or

b) where the addition of an auxiliary dimension would be advantageous.

4.2.2 Production processes or inspection methods should not be specified unless they are essential to ensure satisfactory functioning or interchangeability.

4.3 Functional dimensioning

4.3.1 The functional dimensions should be expressed directly on the drawing (see Figure 1). The application of this principle will result in the selection of datum features on the basis of the function of the product and the method of locating it in any assembly of which it may form a part. If any datum feature other than one based on the function of the product is used, finer tolerances will be necessary and products which would satisfy the functional requirements may be rejected because they exceed these finer tolerances (see Figure 2).

Description	drawing
(a) Assembly drawing showing a given functional requirement, namely the limits of height of the top face of item 1 above the top face of item 3, with a tolerance of 0.08mm	
(b) Detail of head of item 1 showing given limits of size, with a tolerance of 0.03mm	
(c) Item 2 dimensioned from a functional datum surface NOTE: *One direct dimension with a tolerance of 0.05mm is needed to satisfy the condition shown in (a). A nominal flange thickness of 5mm has been assumed. This value is non-functional and can have any large tolerance.*	
(d) Item 2 dimensioned from a non-functional datum surface NOTE: *Tolerances have had to be reduced; two dimensions with tolerances of,say.0.02mm for the flange and 0.03mm are now needed to satisfy the condition shown in (a).*	

NOTE: *Geometric requirements have been omitted for simplicity*

FIGURE 2 - Effect of changing datum surfaces from those determined by functional requirements.

This recommendation does not preclude the preparation of special drawings, wholly dimensioned from a common datum point, to suit particular numerically controlled machining systems where it is known that the overall accuracy of the system to be used will be adequate to ensure that the finer tolerances, arising from dimensioning other than directly from functional datum features, are met.

4.3.2 Occasionally indirect functional dimensioning is justified or necessary. In such cases, care shall be exercised so that the effect of directly shown functional dimensioning is maintained. Figure 4 shows the effect of acceptable indirect functional dimensioning that maintains the dimensional requirements established by Figure 3.

4.3.3 The non-functional dimensions should be placed in a way which is most convenient for production and inspection.

4.3.4 A dimension is not complete without a tolerance although the tolerance may not always appear with the dimension.

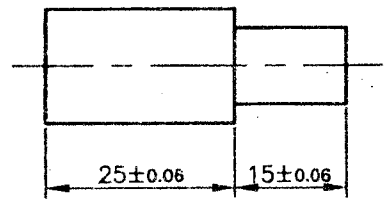


FIGURE 3 - Functional dimensioning

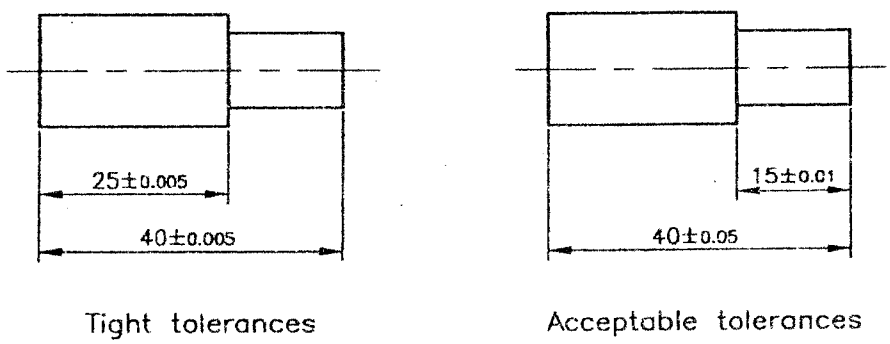


FIGURE 4 -Indirect functional dimensioning

5 METHOD OF DIMENSIONING

5.1 Terms for elements of dimensioning

The elements of dimensioning are shown in Figure 5.

5.2 Projection lines, dimension lines and leader lines .

5.2.1 The use of projection lines, dimension lines and leader lines is shown in Figure 5.

5.2.2 Projection lines, dimension lines and leader lines should normally be placed outside the outline of the view and are thin continuous lines of type B, as defined in Table 3 of **SLS 409 Part 1 : 2004.**

5.2.3 Intersection of dimension lines, projection lines and leader lines should be avoided but, where intersection is unavoidable, they are generally shown without a break. Breaks are only introduced for clarity and then only in the projection lines.

NOTE : *In this context, outlines are never broken*

5.2.4 Projection lines may start just clear of the outline of the feature for clarity and should extend a little beyond the dimension line (see Figure 5)

5.2.5 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 **6(a), 6(b)** and **6(c).** To gain clarity, the points may be emphasized by a small dot, as in Figure **6(c).**

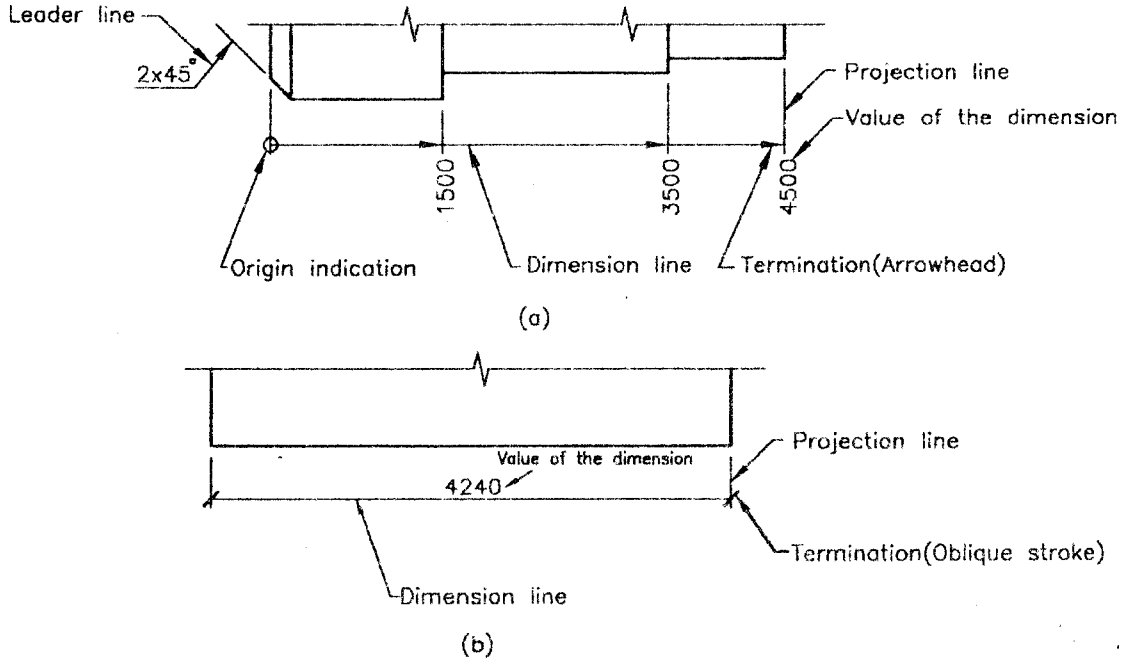


FIGURE 5 - Elements of dimensioning and use of lines

5.2.6 Projection lines should normally be drawn perpendicular to the dimension required as in Figure **7(a)**. In certain circumstances, for example on tapers, better clarity is achieved by drawing the projection lines obliquely as in Figure **7(b)**.

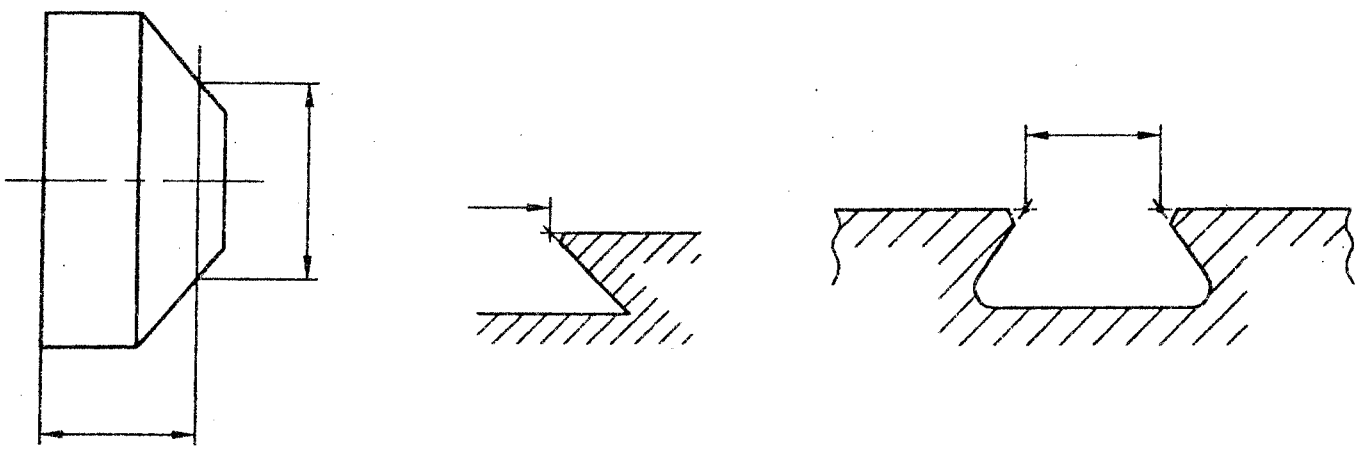


FIGURE 6 - Projection lines from point of intersections

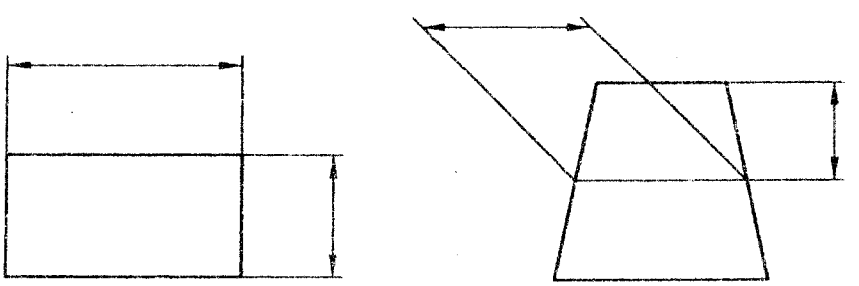


FIGURE 7 - Perpendicular and oblique projection lines

5.2.7 Projection lines and dimension lines for chords, arcs and angles should be as shown in Figure **8, 9** and **10** respectively.

5.2.8 Centre lines, extensions of centre lines and projected continuations of outlines should never be used as dimension lines. Dimension lines should generally be placed with their terminations at projection lines and not at outlines.

5.2.9 Dimension lines should be drawn unbroken where the feature they refer to is shown interrupted (see Figure **11**).

5.2.10 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 **12**.

5.3 Termination and origin indication.

Dimension lines shall show distinct termination (i.e., either arrowheads, oblique strokes or dots), or, where applicable, an origin indication.

5.3.1 Two types of dimension line termination (see Figure **13**) and an origin indication (see Figure **14**) are specified in this standard. They are,

a) the arrowhead, drawn as short lines forming barbs at any convenient included angle between 15^0 and 90^0. The arrowhead may be open, closed or closed and filled in as in Figure **13 (a)**.

b) the oblique stroke, drawn as a short line inclined at 45^0 as in Figure **13 (b)**.

c) the origin indicator drawn as a small open circle of approximately 3 mm in diameter as shown in Figure **14**

5.3.2 The size of the termination shall be proportionate to the size of drawing on which they are used but not larger than is necessary to read the drawing.

5.3.3 One style of arrowhead termination only shall be used on a single drawing. However, where space is too small for an arrowhead the oblique stroke or a dot may be substituted.(see Figure **22**).

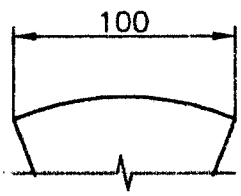


FIGURE 8 - Chord

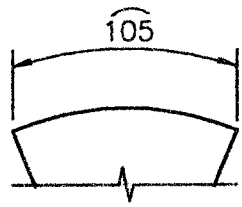


FIGURE 9 - Arc

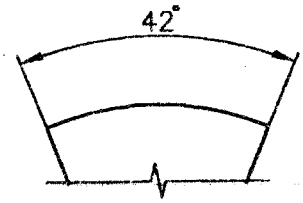


FIGURE 10 - Angle

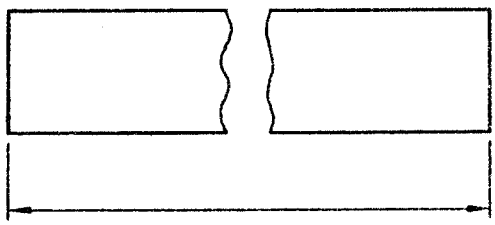


FIGURE 11 - Dimensioning of interrupted features

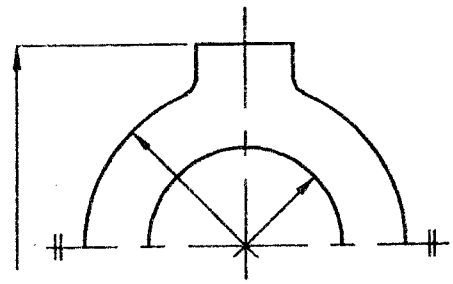


FIGURE 12 - Dimension lines on partial view of a symmetrical part

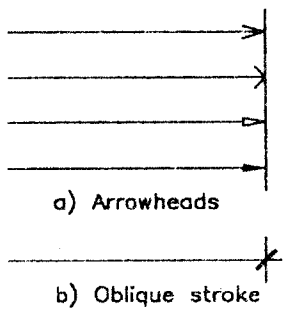


FIGURE 13 - Termination of dimension lines

FIGURE 14 - Origin indication

5.3.4 Arrowhead terminations shall be shown within the limits of the dimension line where space is available as in Figure **15 (a)**. Where space is limited, the arrowhead termination may be shown outside the intended limits of the dimension line that is extended for that purpose as in Figure **15 (b)**.

5.3.5 Only one arrowhead termination, with its point on the arc end of the dimension line shall be used where a radius is dimensioned (see Figure **16**). The arrowhead termination may be either on the inside or on the outside of the feature outline (or its projection line) depending upon the size of the feature.

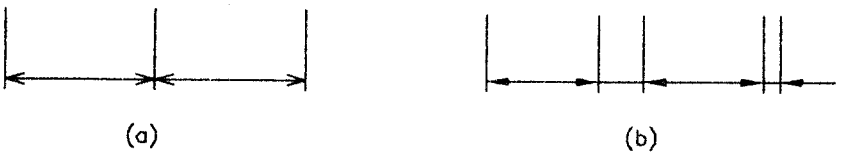


FIGURE 15 - Arrowhead terminations

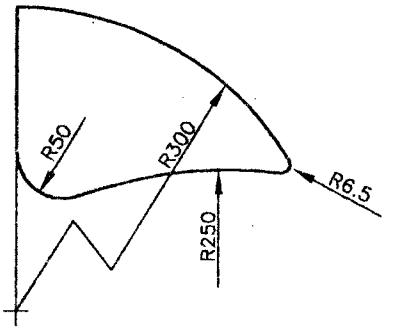


FIGURE 16 - Radius dimensioning

The dimension line for a radius should pass through or be in line with the centre of circle of which the arc is a part.

5.4 Indicating dimensional values on drawings

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

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

5.4.1 Values shall be indicated on a drawing according to one of the following two methods. Only one method should be used on any one drawing.

Method 1

Dimensional values shall be placed parallel to their dimension lines and preferably near the middle, above and clear of the dimension line as in Figure **17 (a)**.

An exception may be made where superimposed running dimensions are used (see **5.2.2**).

However, values shall be indicated so that they can be read from the bottom or from the right-hand side of the drawing with regard to the orientation of the drawing format. Values on oblique dimension lines shall be oriented as shown in Figure **17(b)**.

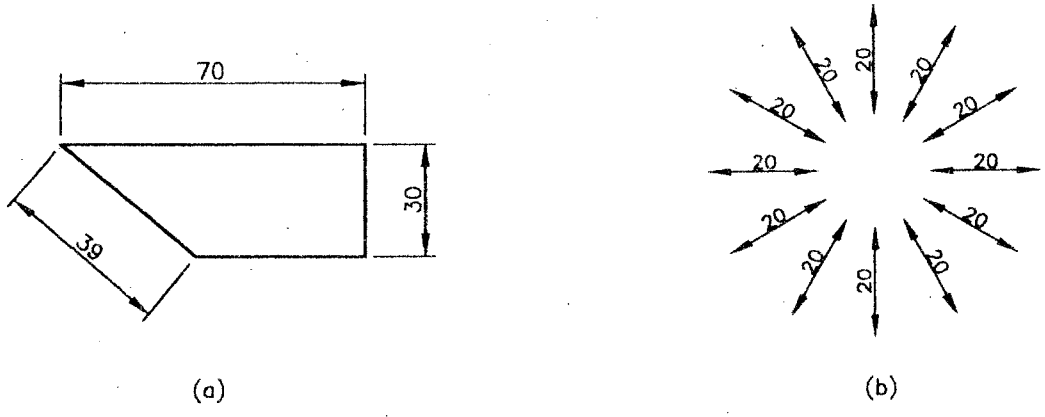
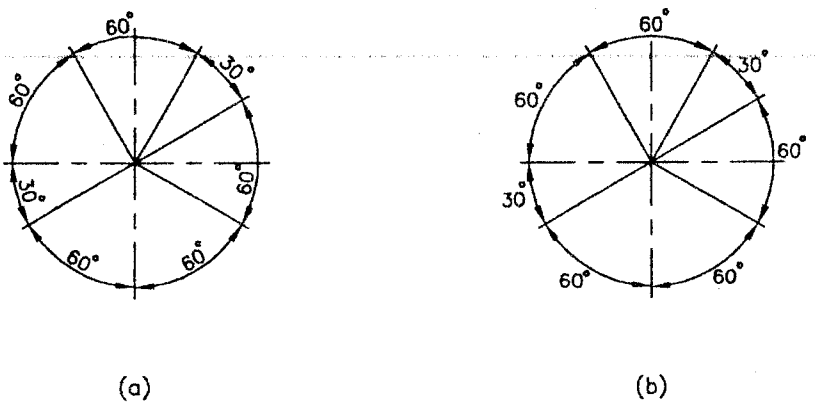


FIGURE 17 - Dimensional values

Angular dimensional values may be oriented either as in Figure **18 (a)** or Figure **18(b).**

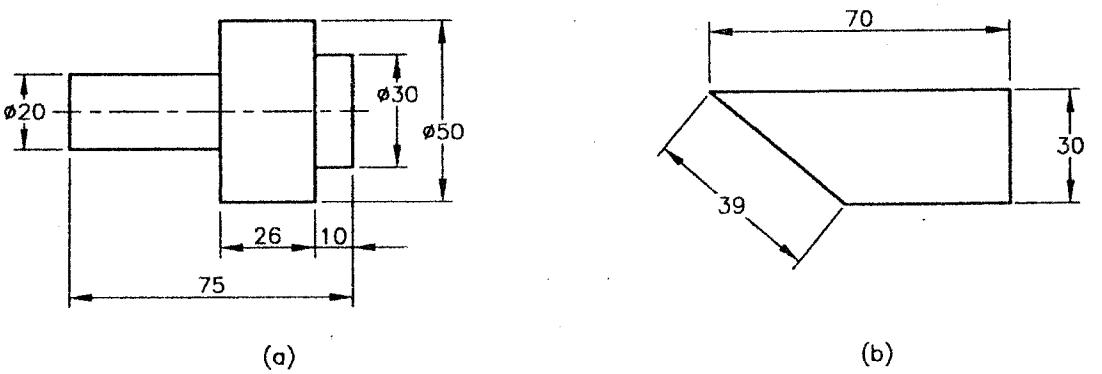


(a) (b)

FIGURE 18 - Angular dimensional values

Method 2

Dimensional values shall be indicated so that they can be read from the bottom of the drawing sheet with regard to the orientation of the drawing format. Non-horizontal dimension lines are interrupted, preferably near the middle so that the value can be inserted as shown in Figures **19(a)** and **19(b).**



(a) (b)

FIGURE 19 - Dimensional values

Angular dimensional values may be oriented either as in Figure **18(b)** or Figure **20**.

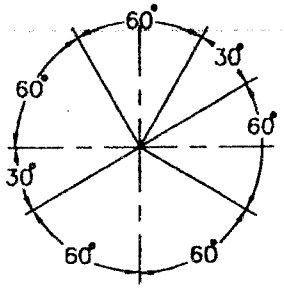


FIGURE 20 - Angular dimensional values

5.4.2 The positioning of dimensional values frequently needs adapting to different situations. Therefore, for example, values can be

a) closer to a termination to avoid having to follow a long dimension line where only part of the dimension line needs to be shown (see Figure **21**)

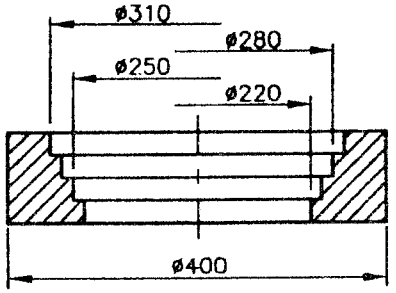


FIGURE 21 - Arrangement of dimensions to avoid congestion

b) above the extension of the dimension line beyond one of the terminations if space is limited (see Figure **22**).

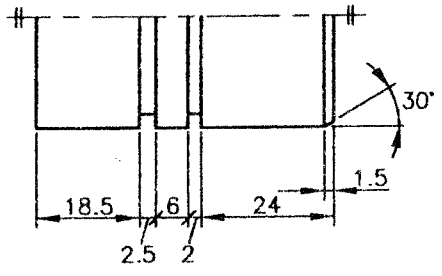


FIGURE 22 - Dimensioning where space is limited

c) at the end of a leader line which terminates on a dimension line that is too short for the dimensional value to be indicated in the usual way (see Figure **22**).

d) above a horizontal extension of a dimension line where space does not allow placement at the interruption of a non-horizontal dimension line (see Figure **23**).

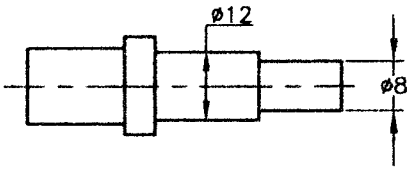


FIGURE 23 - Dimensioning where space is limited

5.4.3 Values for dimensions out-of scale (except where break lines are used)shall be underlined with a straight thick line (see Figure **24**.)

NOTE : *Dimensions out-of-scale can result from a feature size modification where the modification does not warrant an extensive drawing revision to correct the feature scale.*

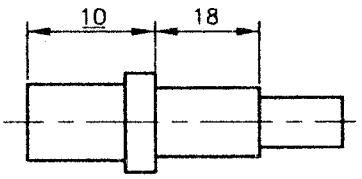


FIGURE 24 - Out-of-scale dimensioning

5.4.4 The following indications are used with dimensions to show applicable shape identification and to improve drawing interpretation. The square symbol may be omitted where the shape is clearly indicated. The applicable indication (symbol) shall precede the value for the dimension (see Figure **25**).

∅: Diameter
: Square
S∅: Spherical diameter
R : Radius
SR : Spherical radius

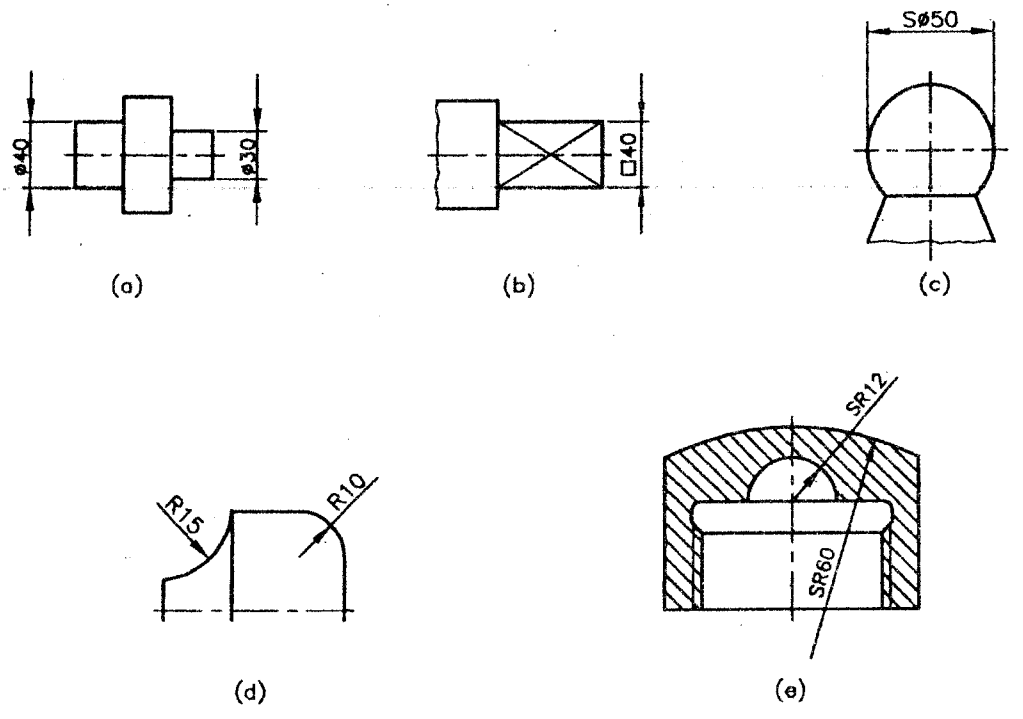


FIGURE 25 - Dimensioning to show applicable shapes identification

6 ARRANGEMENT AND INDICATION OF DIMENSIONS

The arrangement of dimensioning on a drawing shall indicate clearly the design purpose. Generally the arrangement of dimensions is the result of a combination of various design requirements.

6.1 Chain dimensioning

Chains of single dimensions (see Figure **26**) should be used only where the possible accumulation of tolerances does not affect on the functional requirements of the part. Any termination may be used for chain dimensioning except the 90^0 arrowhead as shown in Figure **13 (a).**

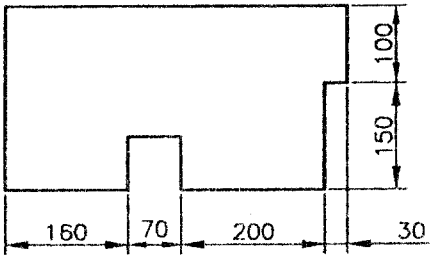


FIGURE 26 - Chain dimensioning

6.2 Dimensioning from a common feature

This method of dimensioning is used where a number of dimensions of the same direction relate to a common origin.

Dimensioning from a common feature may be executed as parallel dimensioning or as superimposed running dimensioning.

6.2.1 Parallel dimensioning is the placement of a number of single dimension lines parallel to one another and spaced out so that the dimensional value can easily be added in as shown in Figure **27** and **34(a)**.

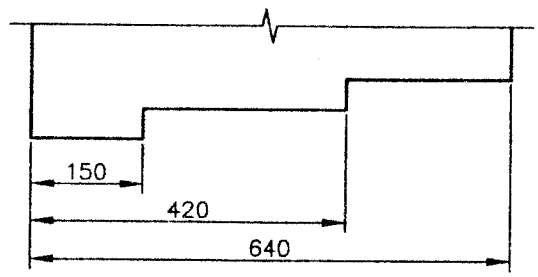


FIGURE 27 - Parallel dimensioning

6.2.2 Superimposed running dimensioning is simplified parallel dimensioning and may be used when there are space limitations and where no legibility problems would occur (see Figure **28**)

The origin indication (see Figure **14**) is placed appropriately and the opposite ends of each dimension line shall be terminated only with an arrowhead.

Dimensional values may be placed, where there is no risk of confusion, either
a) near the arrowhead, in line with the corresponding projection line as in Figure **28(a)**, or
b) near the arrowhead, above and clear of the dimension line as in Figure **28(b)**.

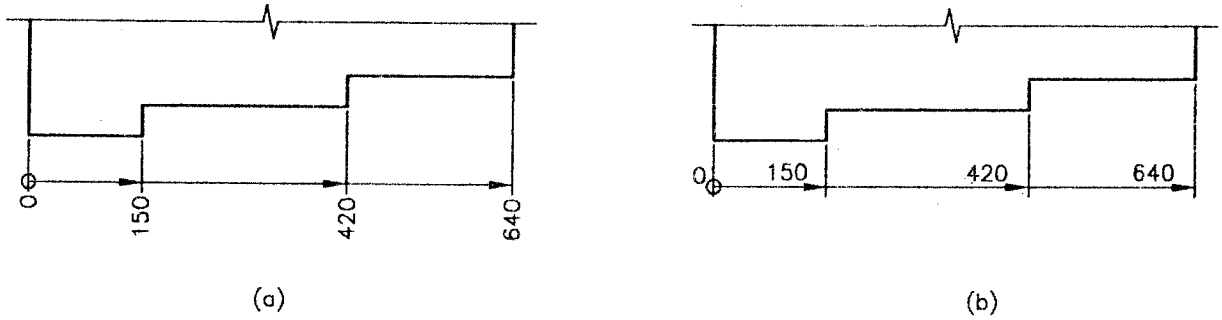


FIGURE 28 - Superimposed running dimensioning

6.2.3 It may be advantageous to use superimposed running dimensioning in two directions. In such a case, the origins may be as shown in Figure **29.**

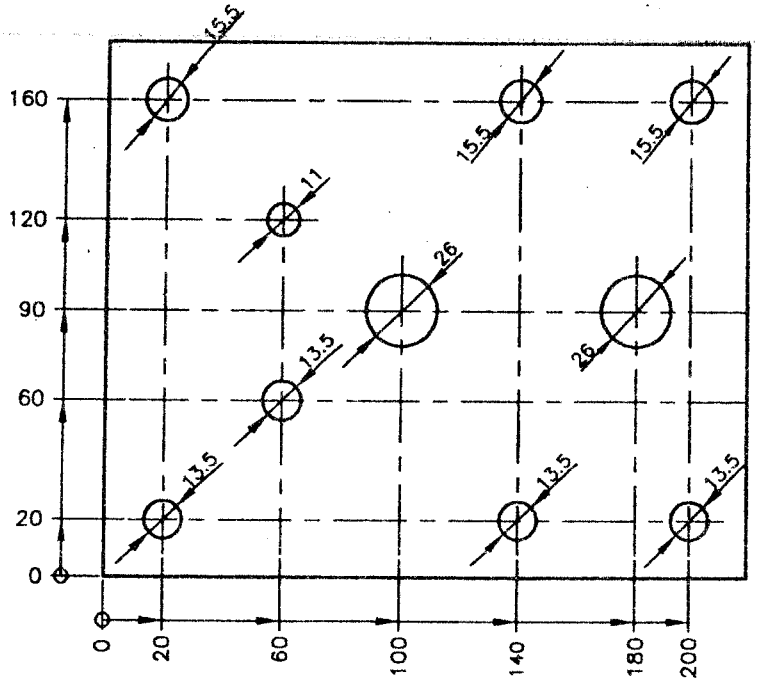
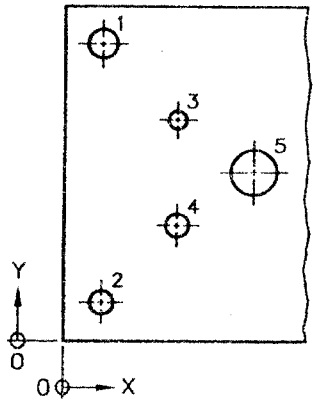


FIGURE 29 - Superimposed running dimensioning in two directions

6.3 Dimensioning by coordinates

6.3.1 It may be useful, instead of dimensioning as shown in Figure 29 to tabulate dimensional values as shown in Figure **30.**



	X	Y	ø
1	20	160	15.5
2	20	20	13.5
3	60	120	11
4	60	60	13.5
5	100	90	26
6			
7			
8			
9			
10			

FIGURE 30 - Dimensioning by coordinates- Method 1

6.3.2 Coordinates for intersections in grids on block plans (site plans) are indicated as shown in Figure **31**.

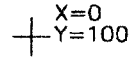


FIGURE 31 - Dimensioning by coordinates- Method 2

6.3.3 Coordinates for arbitrary points of reference without a grid shall appear adjacent to each point (see Figure **32**) or in tabular form (see Figure **33**).

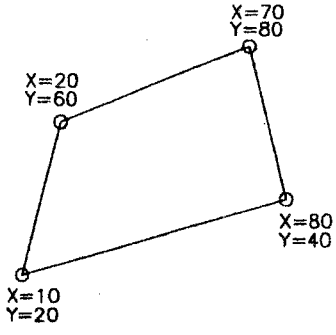
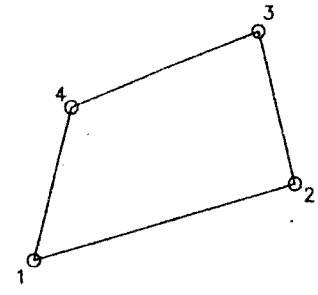


FIGURE 32 - Dimensioning by coordinates Method 3



	X	Y
1	10	20
2	80	40
3	70	80
4	20	60

FIGURE 33 - Dimensioning by coordinates Method 4

6.4 Combined dimensioning

Single dimensions, chain dimensioning and dimensioning from common feature may be combined on a drawing, if necessary (See Figure **34**).

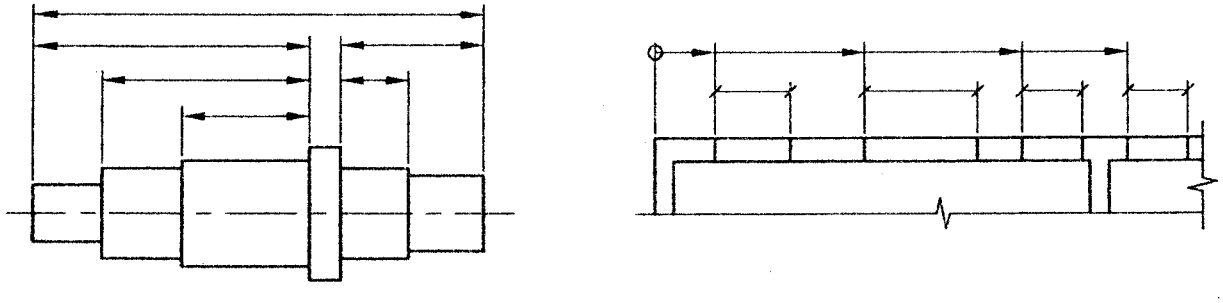


FIGURE 34 -Combined dimensioning

7 SPECIAL INDICATIONS

7.1 Chords, arcs, angles and radii

7.1.1 The dimensioning of chords, arcs and angles shall be as shown in Figures **8, 9** and **10.**

7.1.2 Where the centre of an arc falls outside the limits of the space available, the dimension line of the radius shall be broken or interrupted according to whether or not it is necessary to locate the centre (see Figure **16**).

7.1.3 Where the size of the radius can be derived from other dimensions, it shall be indicated with a radius arrow and the symbol R without an indication of the value (see Figure **35**).

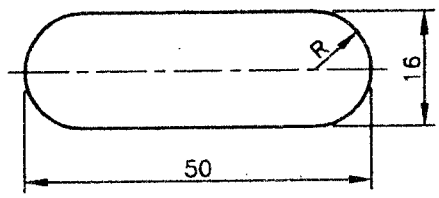


FIGURE 35 - Derived dimensioning

7.2 Equidistant features

Where equidistant features or uniformly arranged elements are part of the drawing specification, dimensioning may be simplified as follows:

7.2.1 Linear spacing may be dimensioned as shown in Figure **36**. If there is any possibility of confusion between the length of the space and the number of spacing, one space shall be dimensioned as shown in Figure **37**.

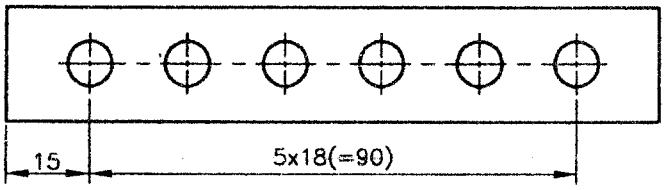


FIGURE 36 - Dimensioning of equidistant features

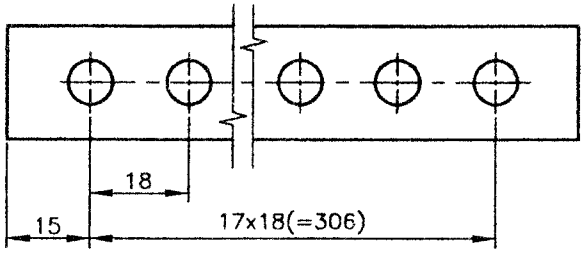


FIGURE 37 - Dimensioning of equidistant features emphasising spacing

7.2.2 Angular spacing of holes and other features may be dimensioned as shown in Figure **38.**

The angles of the spacing may be omitted if their number is evident without confusion (see Figure **39**)

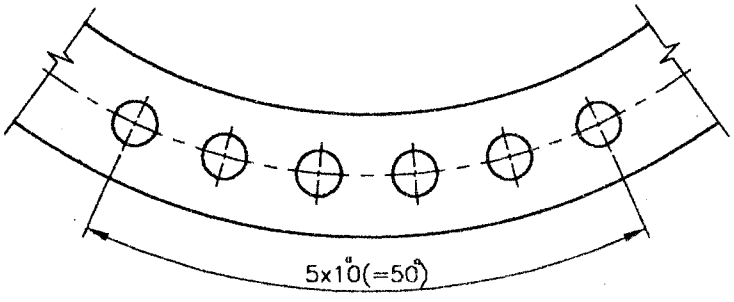


FIGURE 38 - Dimensioning of equidistant features on an arc

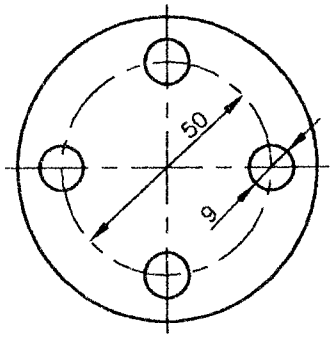


FIGURE 39 - Omission of dimensions of spacing where spacings self evident

7.2.3 Circular spacings may be dimensioned indirectly by giving the number of elements as shown in Figure **40**.

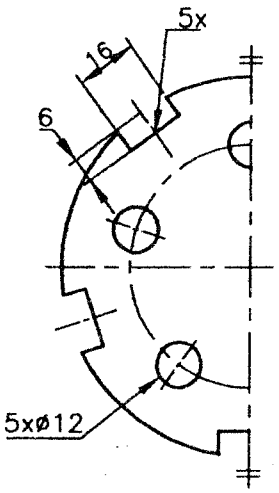
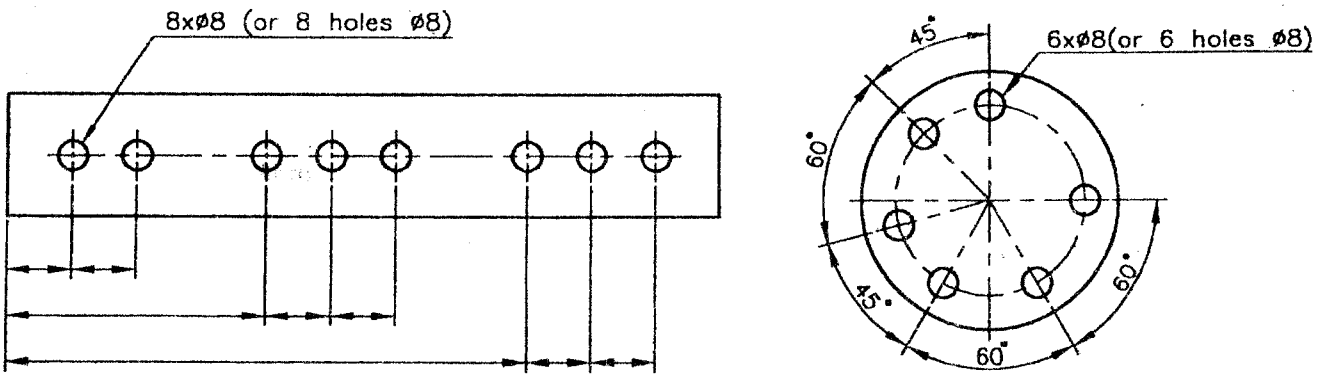


FIGURE 40 - Locating equally spaced features by number required

7.3 Repeated features

If it is possible to define a quantity of elements of the same size so as to avoid repeating the same dimensional value, they may be given by indicating the number and the size of the features once only as shown in Figure **41**.



(a) Linear (b) Angular

FIGURE 41 - Dimensioning repeated features

7.4 Chamfers, countersinks, counterbores and spotfaces

7.4.1 *Chamfers*

Chamfers should be dimensioned as shown in Figure **42**. Where the chamfer angle is 45^0, the indications may be simplified as shown in Figures **43** and **44**.

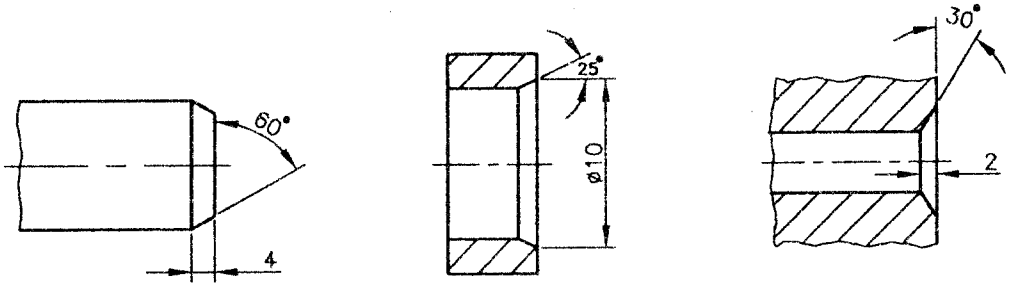


FIGURE 42 - Chamfers at angles other than 45°

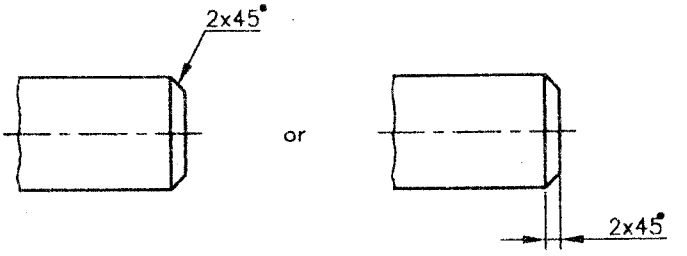


FIGURE 43 - Chamfers (45°) simplified

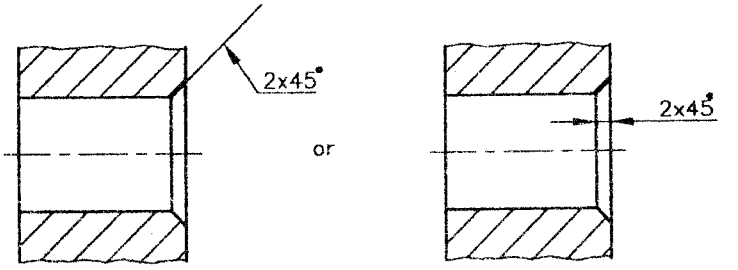


FIGURE 44 - Internal chamfers

7.4.2 *Countersinks*

Countersinks are dimensioned by showing either the required diametral dimension at the surface and the included angle, or the depth and the included angle (see Figure **45**).

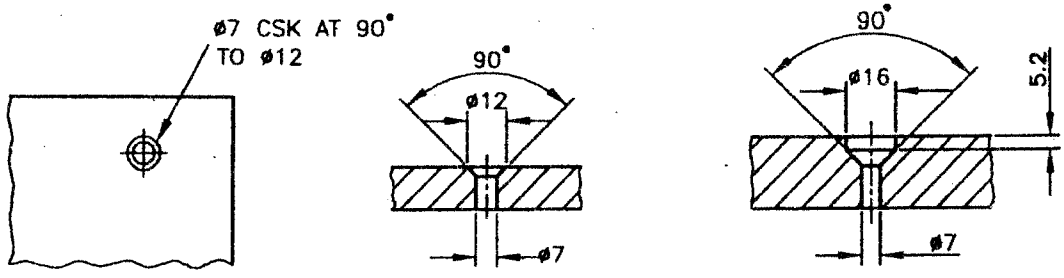


FIGURE 45 - Dimensioning of countersinks

7.4.3 *Counterbores*

Counterbores should be dimensioned by one of the methods shown in Figure **46**.

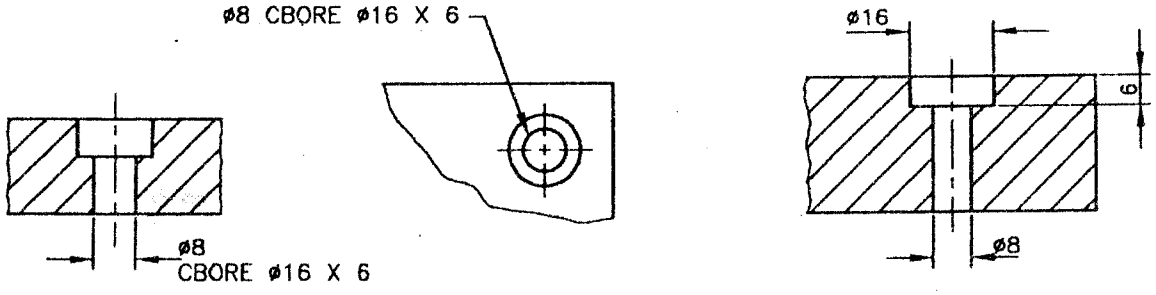


FIGURE 46 - Dimensioning of counterbores

7.4.4 *Spotfaces*

Spotfaces should be dimensioned as shown in Figure **47**. The term 'spotface' implies that the depth is the minimum necessary to provide a completely machined surface of the specified diameter.

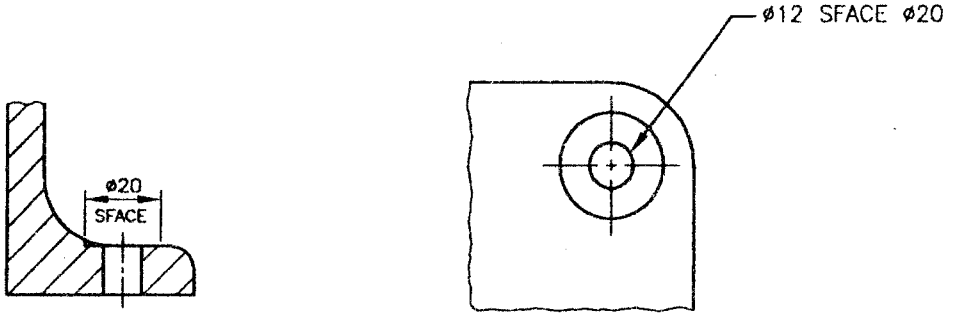


FIGURE 47 - Dimensioning of spotfaces

7.5 Other indications

7.5.1 Where necessary, 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 **48**). Leader lines may be omitted.

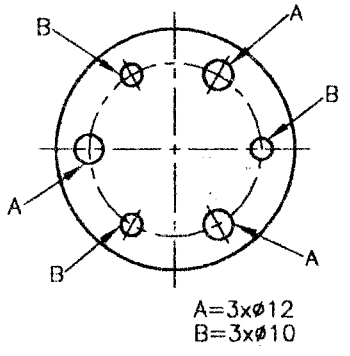


FIGURE 48 - Dimensioning to avoid long leader lines and repeating values

7.5.2 Where several parts are drawn and dimensioned in an assembly, the groups of dimensions related to each part should be kept as separate as possible (see Figure **49**).

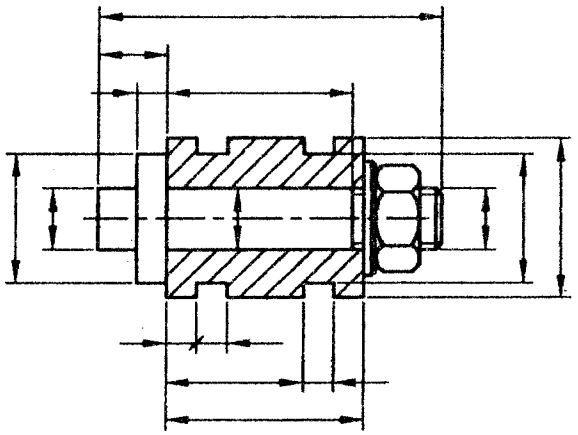


FIGURE 49 - Dimensioning an assembly

7.5.3 Sometimes it is necessary to dimension a limited area or length of a surface to indicate a special condition. In such instances, the area or length and its location are indicated by a thick chain line,(Type J1) drawn adjacent and parallel to the surface and at a short distance from it.

If the special requirement is applied to an element of revolution, the indication shall be shown on one side only as shown in Figure **50 (a)**.

Where the location and extent of the special requirement requires identification, the appropriate dimensioning is necessary. However, where the drawing clearly shows the extent of the indication, dimensioning is not necessary as shown in Figure **50 (b)**.

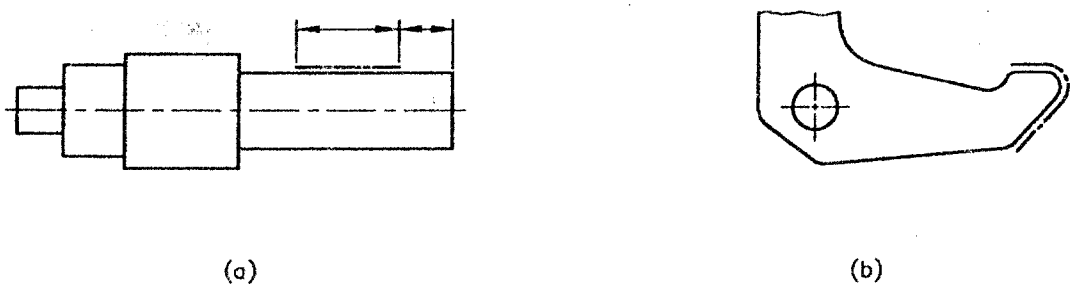


FIGURE 50 - Indication of special requirement

8 DIMENSIONING OF PROFILE

Profiles may be dimensioned by either of the methods described in **8.1** and **8.2**

8.1 The successive radii of curvature and sufficient dimensions shall be given to locate the corresponding elements of the curve (See Figure **51**)

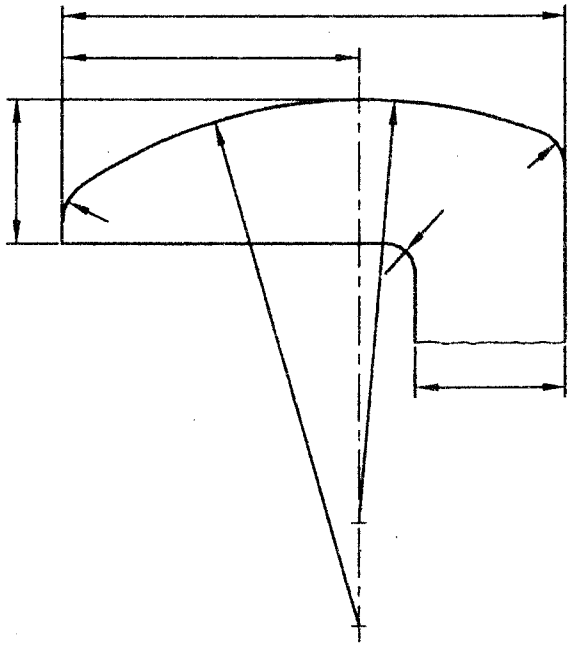


FIGURE 51 - Dimensioning curves by means of radii

8.2 Linear or polar coordinates of a series of points through which the profile passes shall be given (See Figure **52**).

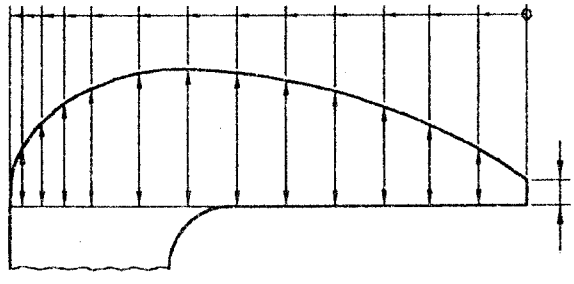
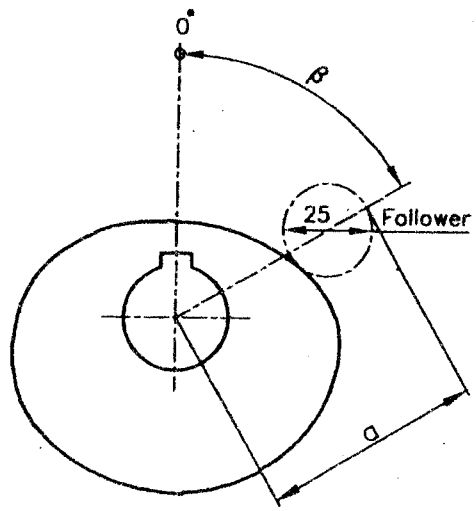


FIGURE 52 - Dimensioning curves by means of coordinates

8.3 With either of the methods described in **8.1** or **87.2** it may be necessary to specify dimensions in association with a follower, the dimension, "a" shall then be indicated on the drawing. (See Figure 53).



β	0°	20°	40°	60°	80°	100°	120° to210°	230°	260°	280°	300°	320°	340°
a	50	52.5	57	63.5	70	74.5	76	75	70	65	59.5	55	52

FIGURE 53 - Dimensioning curves in association with a follower

9 INDICATION AND DIMENSIONING OF THREADED PARTS

9.1 Designation.

The type of screw thread and its dimensions shall be indicated by means of the designation specified in the relevant international standards for threads **(ISO 6410-1, ISO 6410-2, ISO 6410-3)**.

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 millimetres;
- the pitch (P), in millimetres;
- the direction of Lead (see 8.4);

as well as additional indications, such as
- the tolerance class according to the relevant standards;
- thread engagement (S-short, L-long, N-normal);
- the number of starts.

If the thread is coarse, the designation of the pitch, P may be omitted.

EXAMPLES
a) M 20 x 2 -6G/6h - LH
b) M 20 x L 3 - P 1.5 - 6H - S
c) G 1/2 A
d) Tr 40 x 7
e) HA 4.5

9.2 Dimensioning

9.2.1 The nominal diameter, d, always refers to the crest[1)] of the external thread as shown in Figures **54 (a)** and **54 (c)** or the root[2)] of the internal thread as shown in Figure **54 (b)**.

The dimension of the thread length normally refers to the length of the full depth thread as shown in Figure **54 (a)** unless the run-out is functionally necessary (e.g. studs) and therefore specifically drawn (see Figure **54 (c)** and Part 1 Figure **58a**). Ends of bolts should be included in the length of full depth thread (b) or (*l*) as shown in Figure **54 (c)**.

1

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.

9.3 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 as in Figure **54 (d)**. A short designation as shown in Figure **54 (e)** may also be used.

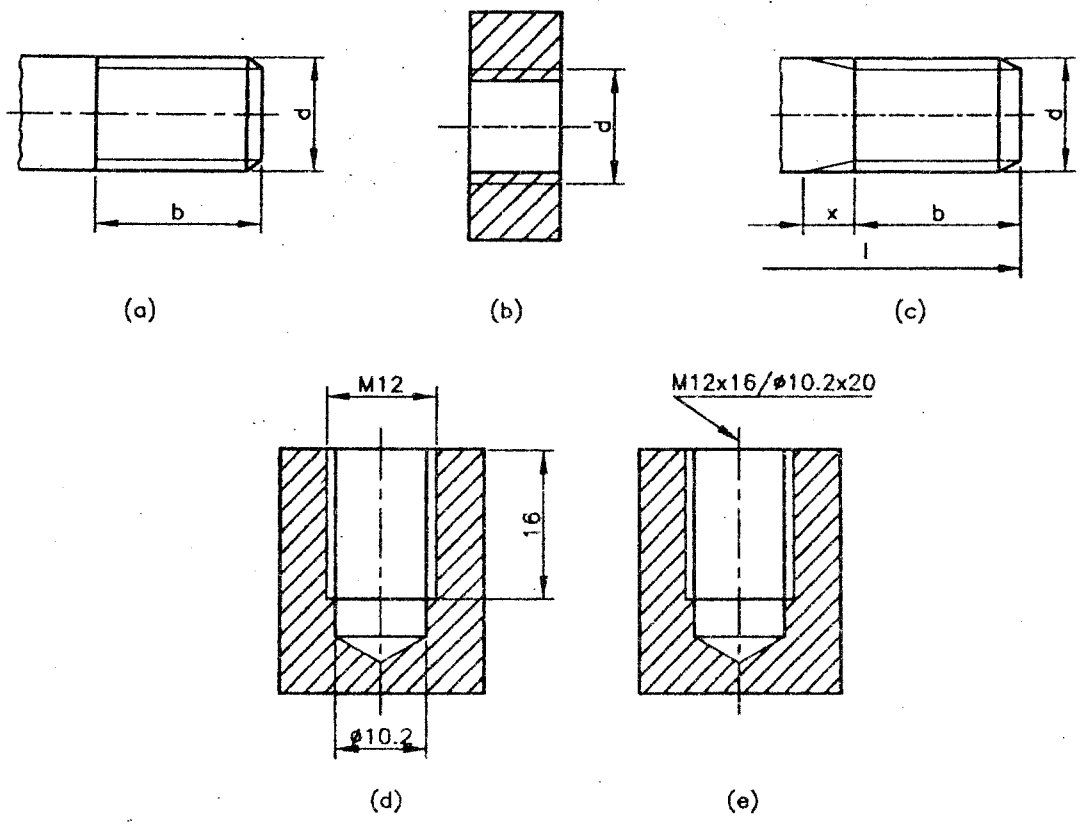


FIGURE 54 - Dimensioning of threaded elements

9.4 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.

9.5 Small diameter threads

It is permissible to simplify the representation and/or the indication of dimensions if,

- the diameter (on the drawing) is < 6 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 leader line which points to the centre-line of the hole and terminates in an arrowhead (See Figure 55).

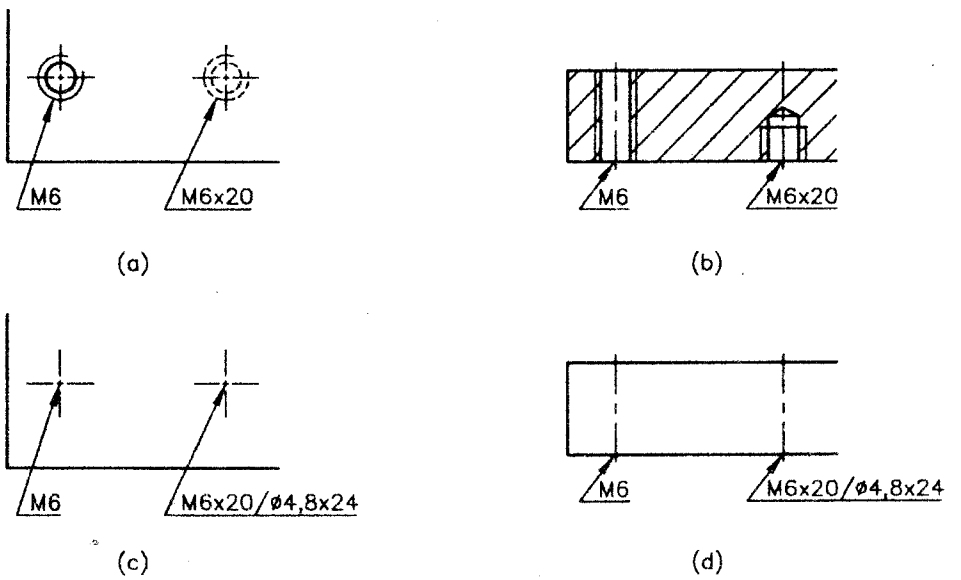


FIGURE 55 - Dimensioning of small diameter threads

9.6 Screw thread inserts

9.6.1 *Designation and dimensioning*

Screw thread inserts shall be designated as given in the relevant standards. If such standards are not available the designation shall consist of the designation for the thread, d x p (screw thread for which the screw thread insert is intended) followed by the letters INS (for insert).

Example

M 30 x 1.5 INS

NOTE : *For more details refer **ISO 6410-2 : 1993.***

10 DIMENSIONING CONES

10.1 Definition

For the purpose of this standard, the following definition applies.

The term "cone" relates to right angle circular cones only.

rate of taper C: Ratio of the difference in the diameters of two sections of a cone to the distance between them. It is expressed by the following formula (see Figure **56**)

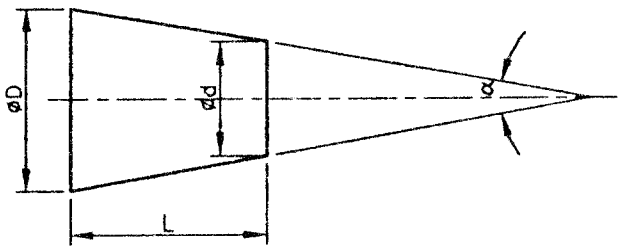
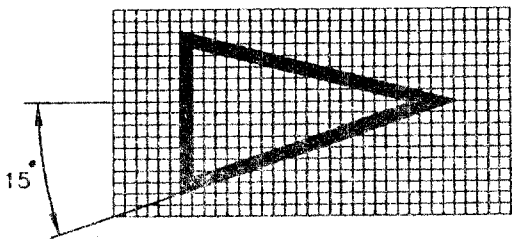


FIGURE 56 - Dimensioning cones

10.2 Graphical symbol for a cone

A cone shall be indicated using the graphical symbol illustrated in Figure **57** positioned on a reference line (see Figure **59**). The orientation of the graphical symbol shall coincide with that of the cone (see Figure **59** and Figure **60**).



NOTE : *For the size and line thickness of the graphical symbol, see ISO3461-2*

FIGURE 57 - Graphical symbol for a cone

10.3 Dimensioning of cones

10.3.1 *Characteristics of cones*

In order to define a cone, the characteristics and dimensions shown in Table 1 may be used in those combinations most appropriate for the function of the cone

TABLE 1 - Characteristics and dimensions of cones

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	α	35^0	0.6 rad
Cone diameter			
- at the larger end	D		
- at the smaller end	d		
- at the selected cross -section	D_x		
Length			
Cone Length	L		
Length including cone length	L'		
Length locating a cross-section at which D is specified	L_x		

No more dimensions than are necessary shall be specified. However, additional dimensions (for example, half the included angle) may be given as 'auxiliary' or 'reference' dimensions in brackets for information.

Typical combinations of cone characteristics and dimensions are shown in Figure **58**.

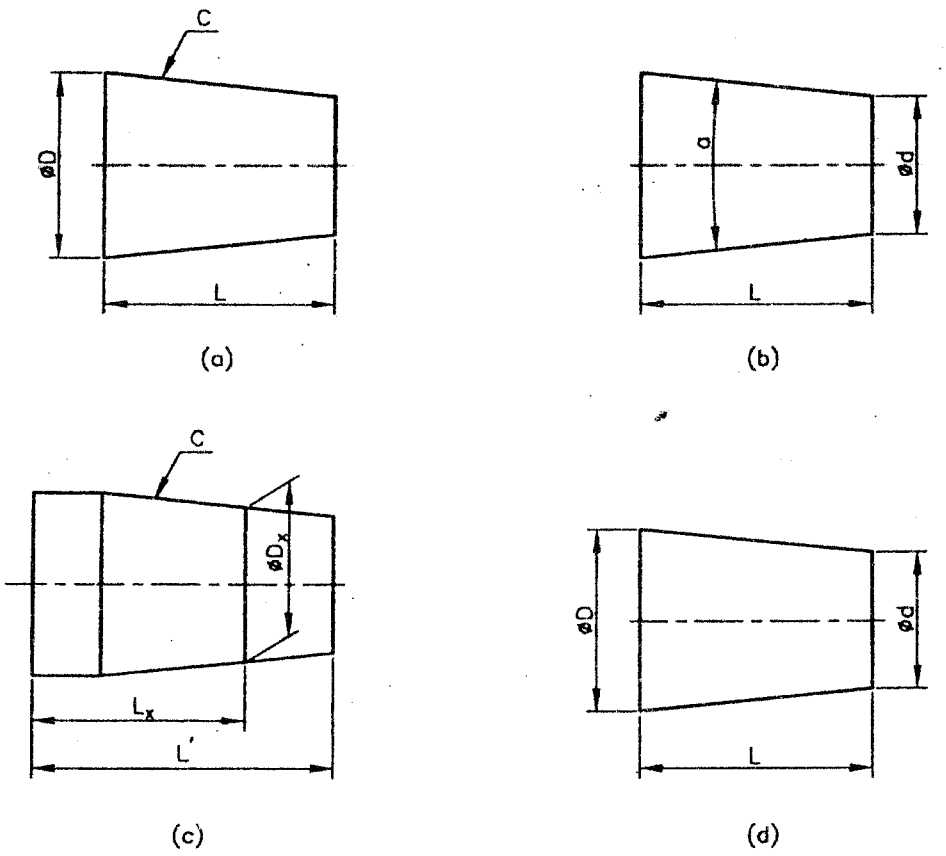


FIGURE 58 - Cone characteristics and dimensions

10.3.2 *Indication of rate of taper on drawings*

The graphical symbol and the rate of taper of a cone shall be indicated near to the feature, and the reference line shall be connected to the outline of the cone by a leader line as shown in Figure **59**. The reference line shall be drawn parallel to the centre-line of the cone, and the orientation of the graphical symbol shall coincide with that of the cone.

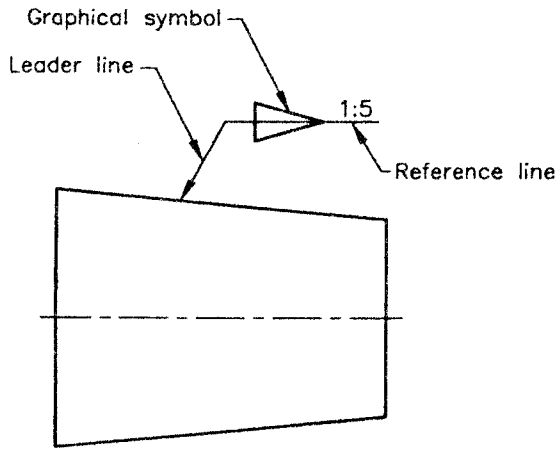


FIGURE 59 - Indication of rate of taper

10.3.3 *Standardized series of cones*

When the taper to be indicated is one of a standardized series of conical taper (in particular Morse or metric taper), the tapered feature may be designated by specifying the standard series (see **ISO 1119**) and appropriate number (see Figure **60**).

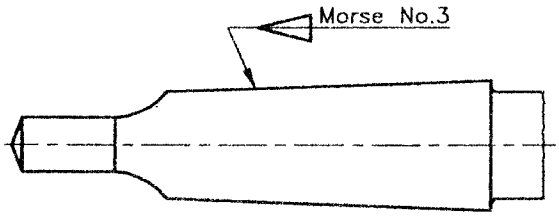


FIGURE 60 - Indication of standard series of cones

11 KEYWAYS

Keyways in hubs and shafts should be dimensioned by one of the methods shown in Figure 61.

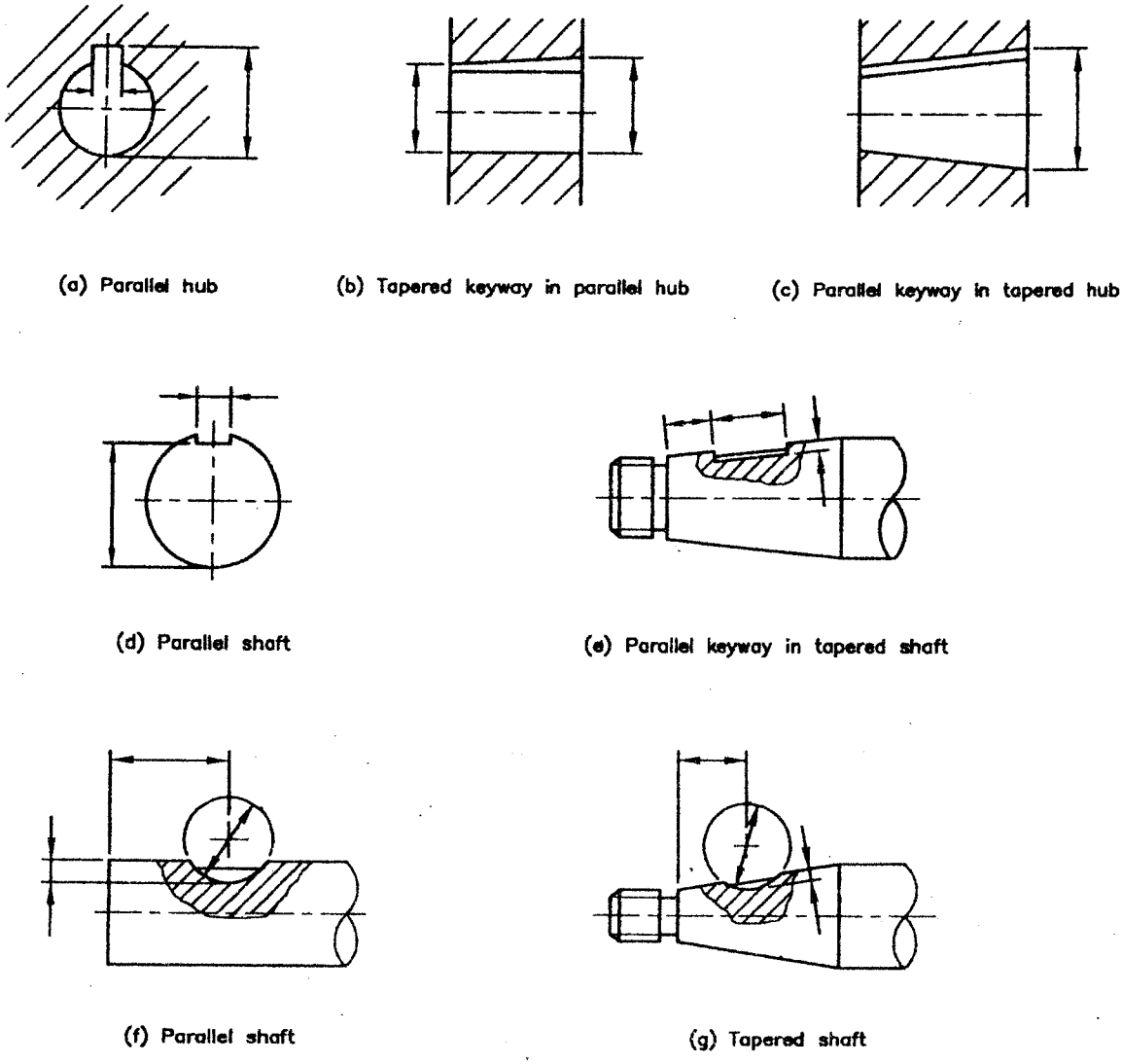


FIGURE 61 - Dimensioning of keyways

12 SPLINES AND SERRATIONS

Method for indicating designation

The designation should be indicated near the feature but always connected to the contour of the splines by a leader line. (See Figure **62**).

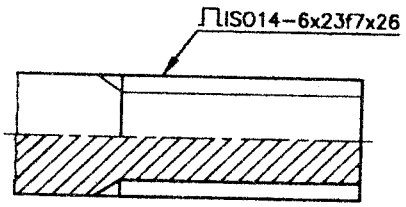


FIGURE 62 - Designations

Where splines are not in accordance with a standard as mentioned above, or where the requirement is modified, the necessary data shall be tabulated on the drawing or any other associated document and shall be cross-referenced by a leader line and graphical symbol to the applicable contour.

In assembly drawings, the designations of both parts (hub and shaft) shall be combined as shown in Figure **63**. For more details of representation of splines and serrations (See **ISO 6413**).

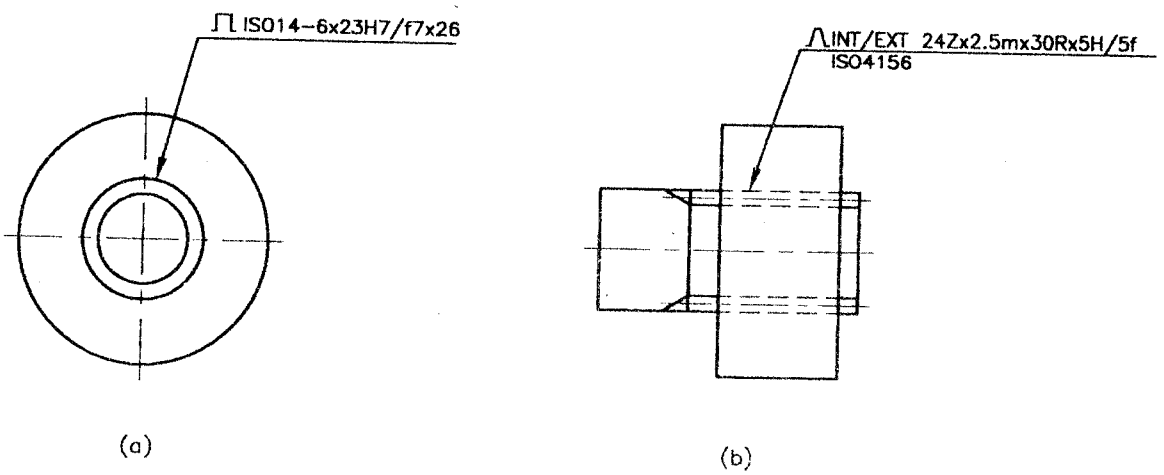


FIGURE 63 - Designation of splines assembly

13 TOLERANCING OF SIZE

All dimensions and tolerances on the drawings are stenciled in upright lettering. These indications could have also been written in vertical or inclined (italic) lettering without altering the meaning of the indications.

NOTE : *This Clause covers the indication of tolerances for linear and angular dimensions on technical drawings. Indicating such tolerances does not necessarily imply the use of any particular method of production, measurement or gauging.*

13.1 Units

Deviations shall be expressed in the same unit as the basic size.

If two deviations relating to the same dimension have to be shown, both shall be expressed to the same number of decimal places as shown in figure **64(b)**, except if one of the deviations is zero as shown in Figure **65(b)**.

13.2 Indication of the components of a linear dimension

13.2.1 *Components and symbols*

The components of the toleranced dimension shall be indicated in the following order:

a) the basic size ;
b) the tolerance symbol.

If, in addition to the symbols as shown in Figure **64(a)**, it is necessary to express the values of the deviations as shown in Figure **64(b)** or the limits of size as shown in Figure **64(c)**, the additional information shall be shown in parentheses.

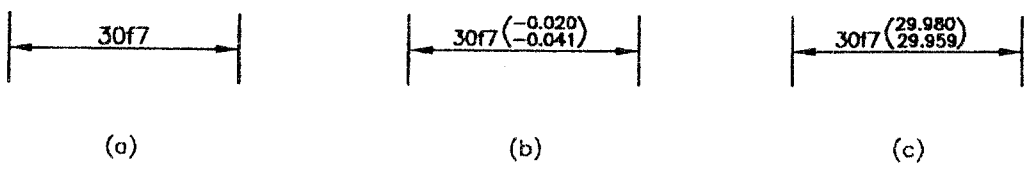


FIGURE 64 - Tolerancing with symbols

13.2.2 *Permissible deviations*

The toleranced dimension shall be indicated in the following order (See Figure **65**);

a) the basic size;
b) the values of the deviations as in Figure **65(a)**.

If one of two deviations is zero, this should be expressed by the digit zero as in Figure **65(b)**.

If the tolerance is symmetrical in relation to the basic size, the value of the deviations should be indicated once only, preceded by the sign ± as shown in Figure **65(c).**

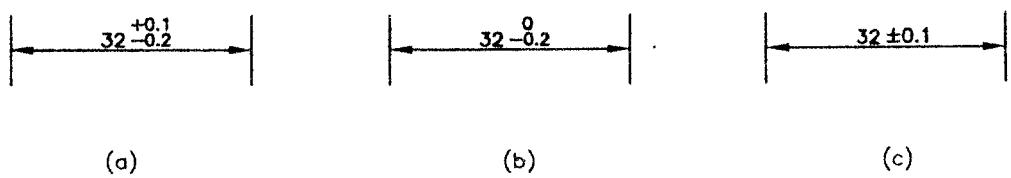


FIGURE 65 - Tolerancing with deviations

13.2.3 *Limits of size*

The limits of size may be indicated by an upper and lower dimension (See Figure **66**).

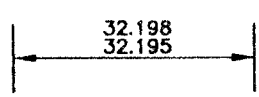


FIGURE 66 - Limits of size with upper and lower dimension (Bilateral tolerancing)

13.2.4 *Limits of size in one direction*

If a dimension needs to be limited in one direction only, this should be indicated by adding "min" or "max" to the dimension (See Figure **67**).

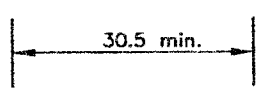


FIGURE 67 - Limits of size in one direction (Unilateral tolerancing)

13.3 Order of indication of deviations and limits of size

The upper deviation or the upper limit of size shall be written in the upper position and the lower deviation or the lower limit of size in the lower position, irrespective of whether a hole or a shaft is toleranced.

13.4 Indication of tolerances on drawings of assembled parts

13.4.1 *Symbols*

The tolerance symbol for the hole shall be placed before that for the shaft as in Figure **68(a)** or above it as in Figure **68(b)**, the symbols being preceded by the basic size indicated once only.

If it is also necessary to specify the numerical values of the deviations, they should be written in parentheses as in Figure **68(c)**.

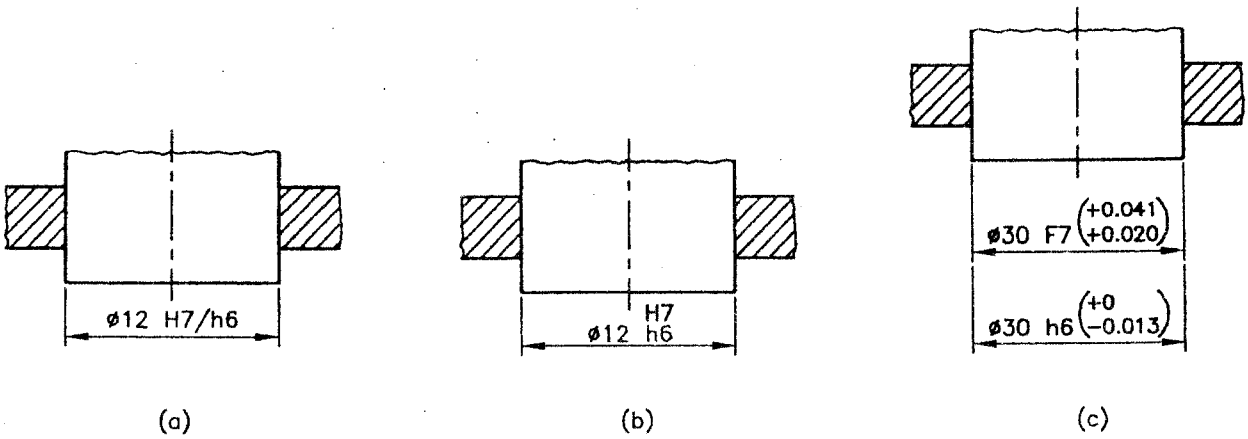


FIGURE 68 - Tolerancing assembled features

For the sake of simplicity, dimensioning with only one dimension line may be used as in Figure **69(a)**.

13.4.2 *Values by digits*

The dimension for each of the components of the assembled parts shall be preceded by the name as in Figure **69(a)** or item reference as in Figure **69(b)** of the components, the dimension for the hole being placed in both cases above that for the shaft.

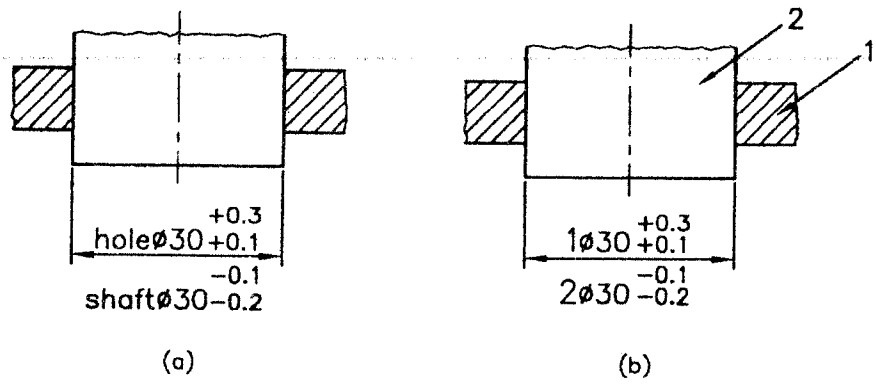


FIGURE 69 - Tolerancing assembled features with deviations

NOTE : *For more details on limits and fits refer ISO 286-1 and 2.*

13.5 Indication of the components of an angular dimension

An angular tolerance, specified in angular units, controls only the general orientation of lines or line elements of surfaces, by not their form deviations . The general orientation of the line derived from the actual surface is the orientation of the contacting line of ideal geometrical form the maximum distance between the contacting line and the actual line shall be the least possible value (see figure 70)

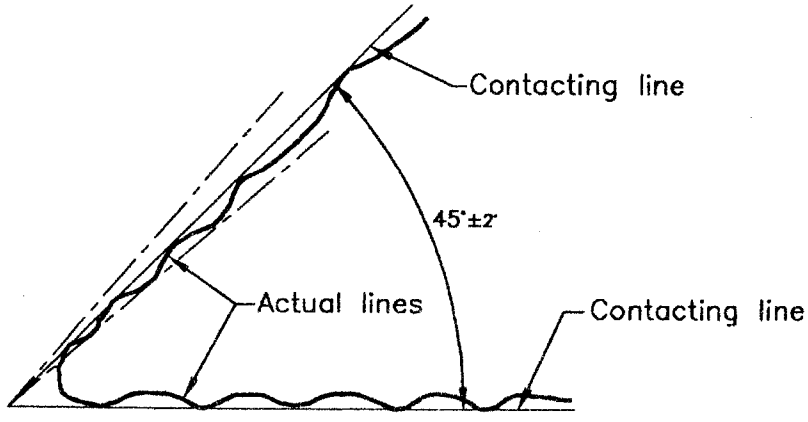


FIGURE 70 - Interpretation of angular tolerances

The rules given for the indication of tolerances on linear dimensions are equally applicable to angular dimensions, except that the units of the basic angle and the fractions thereof, as well as the deviations, shall always be indicated (see Figure 71). If the angular deviation is expressed in either minutes of degree or seconds of a minute of a degree, the value of the minute or second shall be preceded by 0^0 or 0^0 $0'$ as applicable.

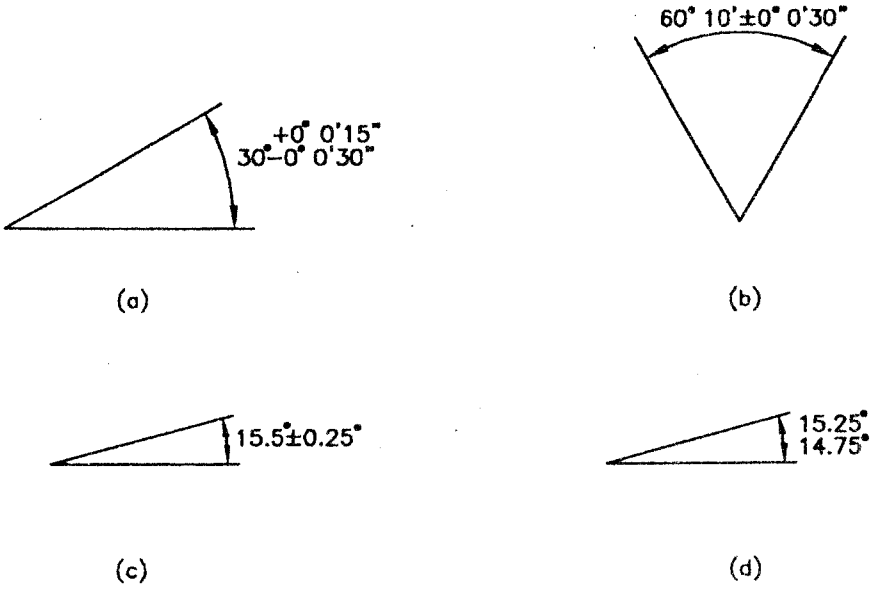


FIGURE 71 - Indication of Tolerances for angular dimension

13.6 Tolerancing of cones

Cones shall be toleranced (both size and conical surface) in accordance with the methods given in **13.6.1** to **13.6.5** (see **10**)

The letter symbol *t* is used to define the width of the tolerance zone.

NOTE : *Other methods of tolerancing using only dimensional tolerances do not give adequate indication with regard to the shape of the surface.*

13.6.1 Tolerancing of cone, cone angle specified

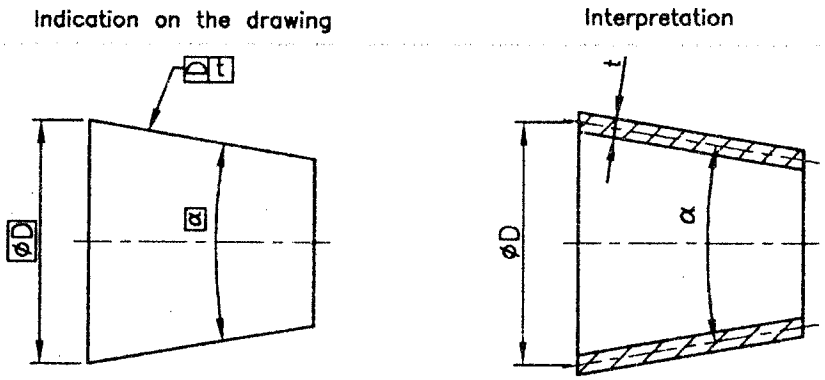


FIGURE 72 - Tolerancing of cone specifying cone angle

13.6.2 Tolerancing of cone, rate of taper specified

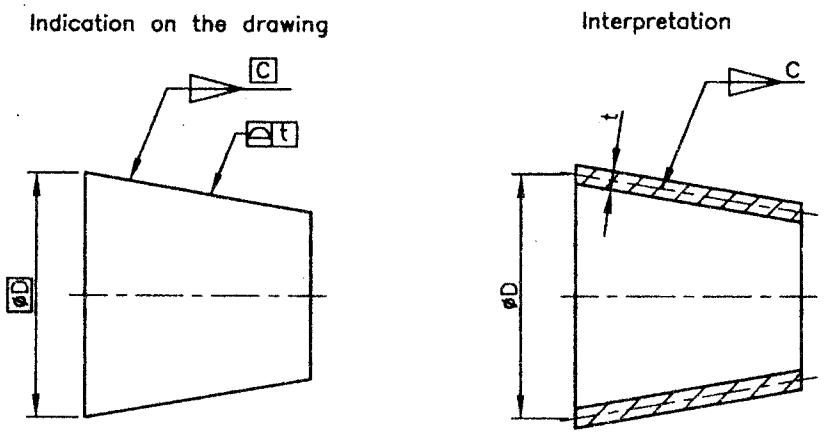


FIGURE 73 - Tolerancing of cone specifying rate of taper

13.6.3 Tolerancing zone of cone defining simultaneously the axial location of the cone.

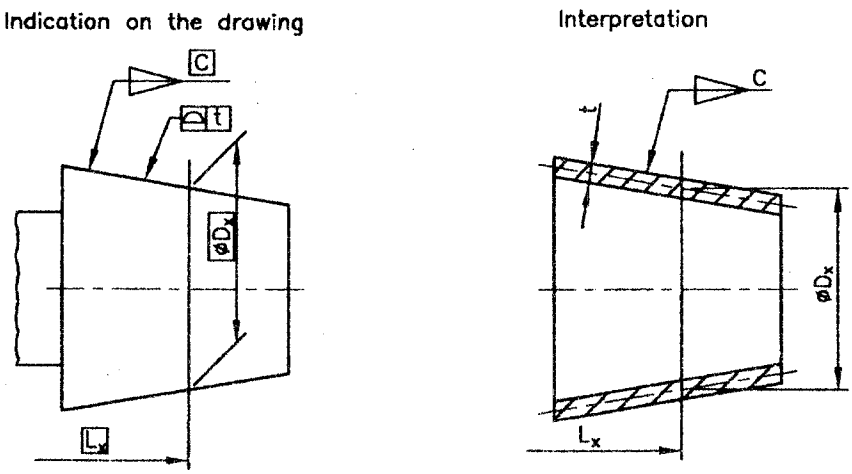


FIGURE 74 - Tolerancing zone of cone

13.6.4 Tollerancing of cone separate from the tolerance of the axial location of the cone

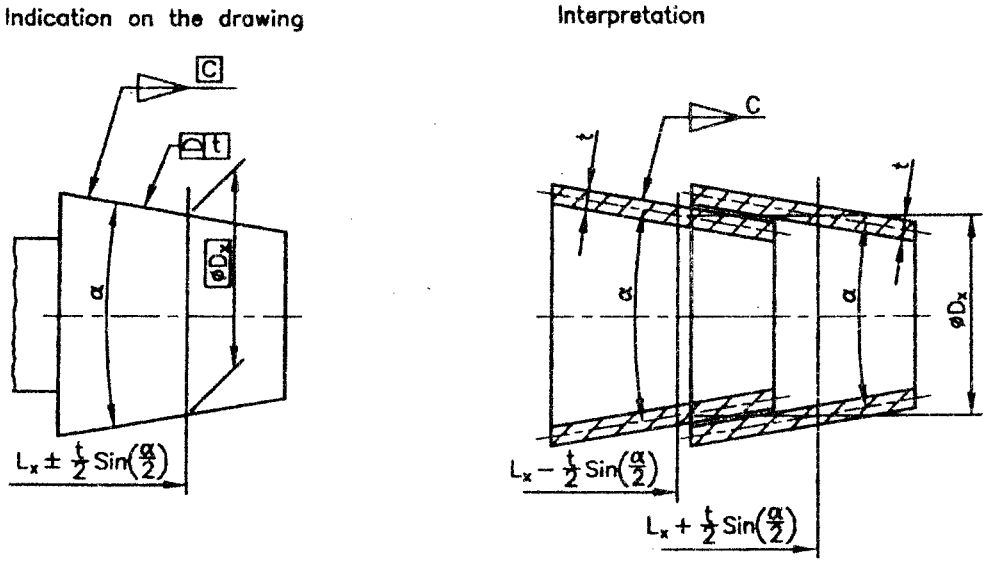


FIGURE 75 - Tolerancing of cone with axial location

13.6.5 Tolerancing of cone related to a datum (simultaneously defining coaxiality).

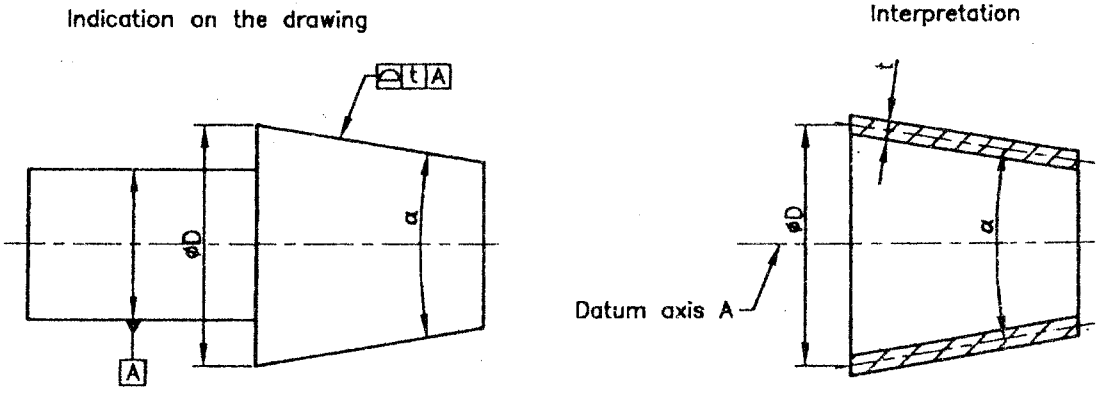


FIGURE 76 - Datum related tolerancing of cone

13.7 Tolerancing of threads and threaded parts.

For tolerancing threads, threaded parts and threaded assemblies refer **ISO 965** and **ISO 4759.**

14 METHOD OF INDICATING SURFACE TEXTURE ON DRAWINGS

This clause specifies graphical symbols and additional indications of surface texture to be used on technical drawings. It should not be taken as prescribing rules for the choice of surface roughness parameters suitable in any given case.

14.1 Graphical symbols used for indication of surface texture

14.1.1 The basic graphical symbol consists of two straight lines of unequal length inclined at approximately 60^0 to the line representing the considered surface, as shown in Figure 77.

This graphical symbol in isolation means "the surface under consideration" and prescribes no requirement for surface roughness.

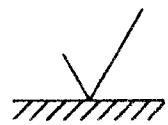


FIGURE 77 - Basic graphical symbol

14.1.2 If the removal of material by machining is required, a bar shall be added to the basic graphical symbol, as shown in Figure **78**.

FIGURE 78 - Symbol indicating machining

This graphical symbol in isolation means "a surface to be machined" and prescribes no requirement for surface roughness.

14.1.3 If the removal of material is not permitted, a circle is added to the basic graphical symbol, as shown in Figure **79**.

FIGURE 79 - Symbol when removal of material is not permitted

14.1.4 The graphical symbol shown in Figure **79** may also be used in a drawing relating to a production process to indicate that a surface is to be left in the state resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise.

In this case, none of the indication given in **14.3** is added to the graphical symbol.

14.1.5 When special surface texture characteristics have to be indicated (see **14.3.3**) a line is added to the longer arm of any of the graphical symbols illustrated in Figures 77 to 79, as shown in Figure **80**.

FIGURE 80 - Symbol for indicating special surface characteristics

14.1.6 When the same surface texture is required on all surfaces around a part, a circle is added to the graphical symbol illustrated in Figure 80, as shown in Figure 81.

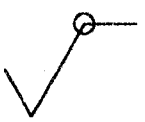


FIGURE 81 - Indication of same surface texture on all the surfaces

14. 2 Interpretation of drawing indication of surface roughness values

The interpretation of surface roughness parameters, indicated by means of upper and/or lower limits or designed as maximum (max.) and/or minimum (min.) values respectively, for the purposes of inspection of the surface finish of a workpiece is described in **ISO 4288.**

14.3 Indication of surface texture

14.3.1 *Indications added to the graphical symbols*

The indications of surface texture shall be placed relative to the graphical symbol as shown in Figure **82.**

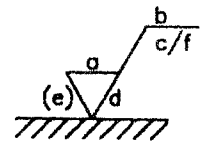


FIGURE 82 - Indication of surface texture in the symbol

Key

a roughness value(s) R_a in micrometers, preceded by the parameter symbol Ra (see **14.3.2.1**), or other roughness parameter symbol(s) together with its (their) value(s) in micrometers (**see 14.3.2.1**) roughness.

b production method, treatment, coating or other requirements concerning the production process, etc.

c waviness height in micrometers, preceded by the corresponding parameter symbol, or sampling length in millimeters.

d surface pattern (see **14.3.4**)

e machining allowance

f roughness value(s) other than R_a in micrometers, preceded by the parameter symbol (e.g Ry 0.4) (see 14.3.2.1).

FIGURE 82 - Indication of surface texture in the symbol

14.3.2 *Indication of surface roughness/waviness*

14.3.2.1 The value or values of the arithmetical mean deviation R_a are added to the graphical symbols given in Figure **77** to **79** as shown in Figure **83**.

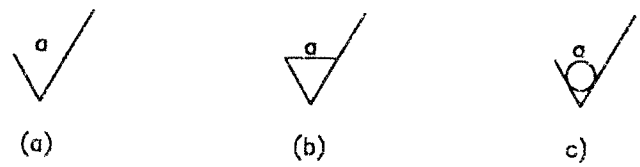


FIGURE 83 - Indication of surface roughness values

The interpretations of the indications in Figure **83** are as follows. The surface texture specified in Figure **83** (**a**) may be obtained by any production method (removal of material by machining is optional) (see **14.1.1**), that specified in Figure **83** (b) shall be obtained by removal of material

by machining (obligatory) (see **14.1.2**), and that specified in Figure **83** © shall be obtained by a procedure other than removal of material (see **14.1.3**).

14.3.2.2 When only one value is specified it constitutes the upper limit of the surface roughness parameter.

14.3.2.3 If it is necessary to specify upper and lower limits of the roughness parameter, both values shall be given as illustrated in Figure 84 with the upper limit a_1, above the lower limit a_2.

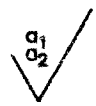


FIGURE 84 - Indication of limits of surface roughness

14.3.2.4 Preferred numerical values for surface roughness parameters (maximum and/or minimum values, upper and/or lower ,limits, or a range of values) shall be selected from **ISO 468**.

14.3.2.5 If it is necessary to specify waviness height, this shall be indicated under a line added to the longer arm of the symbols given in Figures **77** to **79**, as shown in Figure **85.**

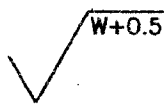


FIGURE 85 - Indication of waviness height

14.3.3 *Indication of special surface texture characteristics*

14.3.3.1 In certain circumstances, for functional reasons, it may be necessary to specify additional special requirements concerning surface texture.

14.3.3.2 When the required surface texture is to be produced by a particular method, that method shall be indicated in works on a line added to the longer arm of the symbols given in Figures **77** to 79, as shown in Figure **86.**

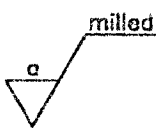


FIGURE 86 - Indication of production method

14.3.3.3 Any indication relating to treatment or coatings shall also be given on this line.

Unless otherwise stated, the numerical value of the roughness applies to the surface texture after treatment or coating.

If it is necessary to define surface texture both before and after treatment, this shall be explained in a note or in accordance with Figure **87.**

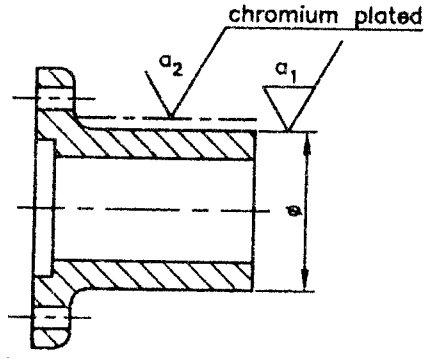


FIGURE 87 - Defining surface texture

14.3.3.4 If it is necessary to indicate the sampling length this shall be selected from the appropriate series given in **ISO 4288** and stated, in millimeters, adjacent to the graphical symbol, as shown in **Figure 88.**

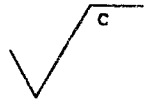


FIGURE 88 - Indication of sampling length

!4.3.4 *Graphical symbols for surface patterns*

14.3.4.1 If it is necessary to specify the surface pattern by working (e.g. tool marks) and, in particular, the direction of lay, the appropriate graphical symbol shall be added to the surface texture symbol, as shown for example in Figure **89.**

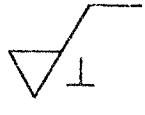
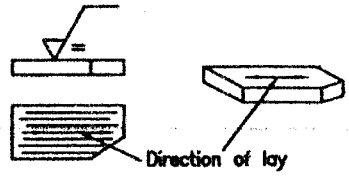
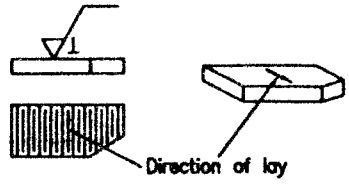
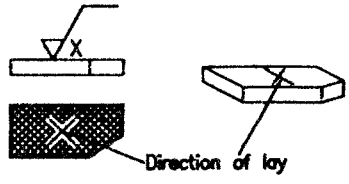
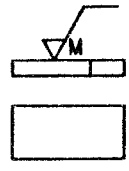
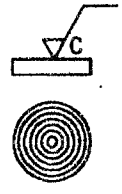
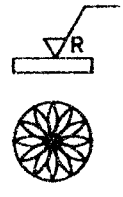
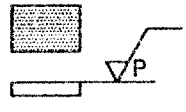


FIGURE 89 - Indication of the direction of lay

NOTE : *The direction of lay is the direction of the predominant surface pattern, usually determined by the production method employed.*

14.3.4.2 The graphical symbols for common surface patterns are specified in Table **2.**

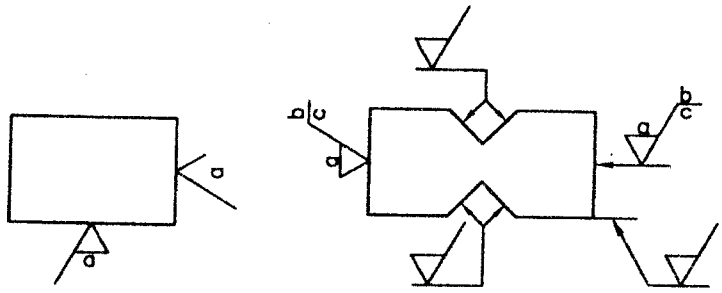
TABLE 2 - Graphical symbols for common surface patterns

Graphical symbol	Interpretation and example
=	Parallel to the plane of projection of the view in which the symbol is used 
⊥	Perpendicular to the plane of projection of the view in which the symbol is used 
X	Crossed in two oblique directions relative to the plane of projection of the view in which the symbol is used 
M	Multi-directional 
C	Approximately circular relative to the centre of the surface to which the symbol applies 
R	Approximately radial relative to the centre of the surface to which the symbol applies 
P	Lay is particulate, non-directional, or protuberant 
NOTE : *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*	

14.4 Indication of drawings

(See also the examples given in Appendix D)

14.4.1 The general rule is that the graphical symbol together with the associated inscriptions shall be oriented so that they can be read from the bottom or the right-hand side of the drawing, in conformity with **5.4** (see Figure 90 (a)).



(a) (b)

FIGURE 90 - Orientation of symbols and inscriptions

However, if it is not practicable to adopt this general rule, the graphical symbol may be drawn in any position, but only if it does not carry any indications of special surface texture characteristics. Nevertheless, in such cases, the inscription defining the value of the arithmetical mean deviation R_a (if present) shall always be written in conformity with the general rule (see Figure 90 (a)).

If necessary, the graphical symbol may be connected to the surface by a leader line terminating in an arrowhead.

As a general rule, the graphical symbol, or the leader line terminating in an arrowhead, shall point from outside the material of the piece either to the line representing the surface, or to an extension of it (see Figure **90 (b)**)

However, if there is no risk of misinterpretation, the surface roughness requirement may be indicated in connection with the dimensions given, as shown in Figure 91.

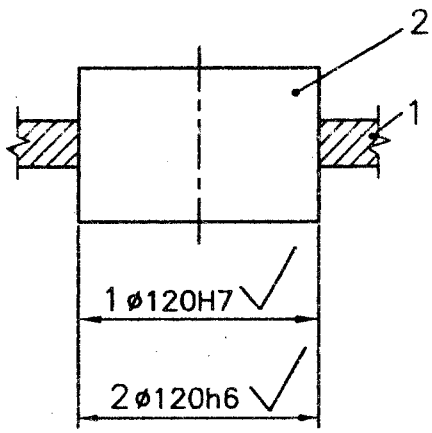


FIGURE 91 - Indication of surface roughness requirement

14.4.2 The graphical symbol shall be used only for a given surface and, if possible, on the same view as the dimensions defining the size or position of the surface. Cylindrical as well as prismatic surfaces need only be specified once if indicated by a centerline (see Figure **92 (a)**). However, each prismatic surface needs to be indicated separately if a different surface texture is required or if particular requirements are applicable (see Figure **92 (b)**).

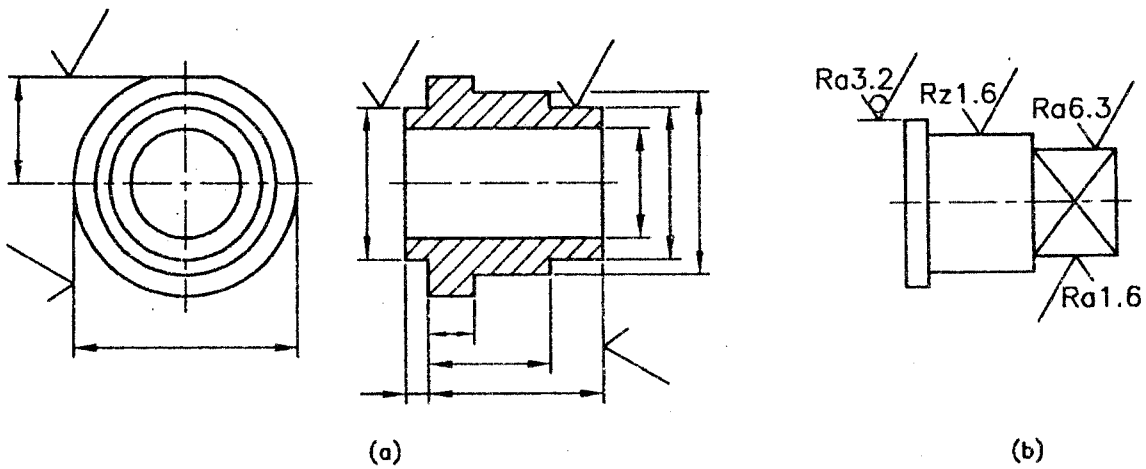


FIGURE 92 - Indication of surface texture in drawing

14.4.3 If the same surface texture is required on the majority of the surface of a part, the general graphical symbol corresponding to this surface texture shall be followed by

- a basic graphical symbol in parentheses without any other indication (see Figure **93 (a)**),
  or

- the graphical symbols in parentheses of the special surface texture or textures (see Figure **93 (b)**).

Symbols for surface texture which are exceptions to the general symbol shall be indicated on the corresponding surfaces.

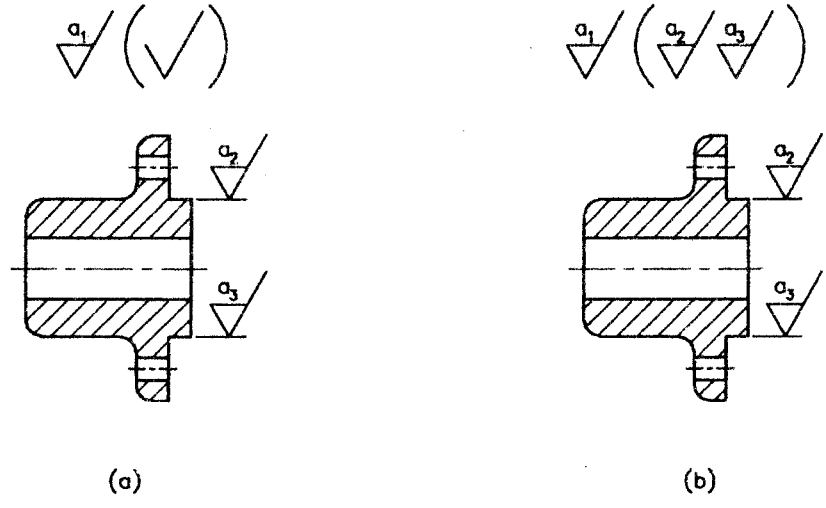


FIGURE 93 - Indication of same surface texture on the majority of surface

14.4.4 To avoid the necessity of repeating a complicated indication a number of times, or where space is limited, a simplified indication may be used on the surface provided that its meaning is explained near the part in question, near the title block or in the space devoted to general notes (see Figure **94**).

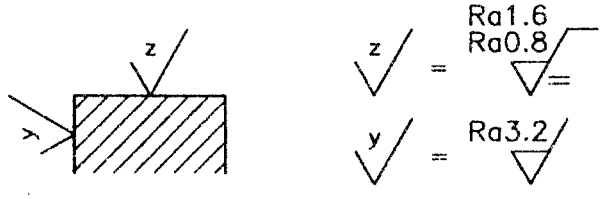


FIGURE 94 - Simplified indication of surface texture

14.4.5 If the same surface texture is required on a large number of surfaces of the part, the corresponding graphical symbol shown in Figure **77, 78** or **79** may be used on the appropriate surfaces and its meaning given on the drawing as shown, for example in Figure **95.**

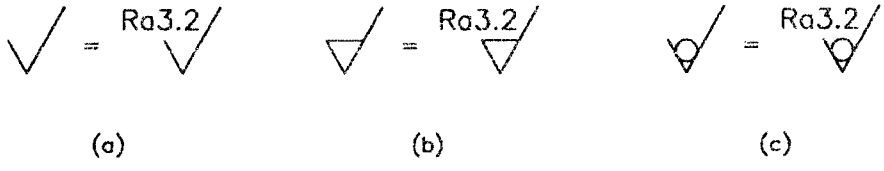


FIGURE 95 - Simplified indication of surface texture

ADDENDIX A

PROPORTIONS AND DIMENSIONS OF GRAPHICAL SYMBOLS

A.1 General requirements

In order to harmonise the size of the symbols specified in this clause with those of the other inscriptions on the technical drawing (dimensions, tolerances, etc.) the rules given in ISO 3461-2 should be observed.

A.2 Proportions

A.2.1 The basic symbol and its complements (see 14.1) shall be drawn in accordance with figures 96 to 98.

The shape of the symbols in Figures 97© to 97(g) is the same as that of the corresponding capital letters in clause 7 of SLS 409 - Part 1.

For dimensions, see Figure 98.

The length of the horizontal stroke of the symbol in Figure 96(b) depends on the indications associated with it (see 14.3.3 and B.3).

If one roughness value only is to be inscribed, this shall be situated in area a_2 shown in Figure 98.

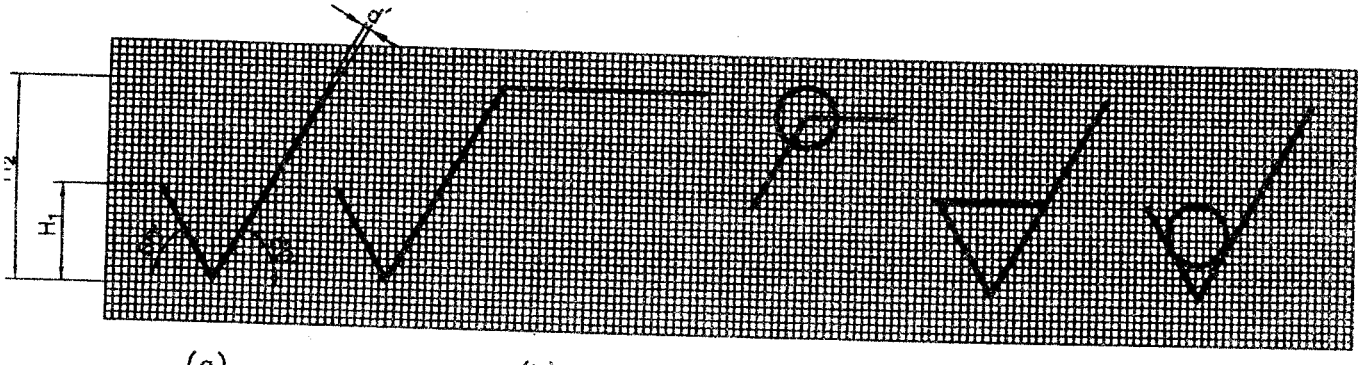


FIGURE 96 - Basic symbol and its complements

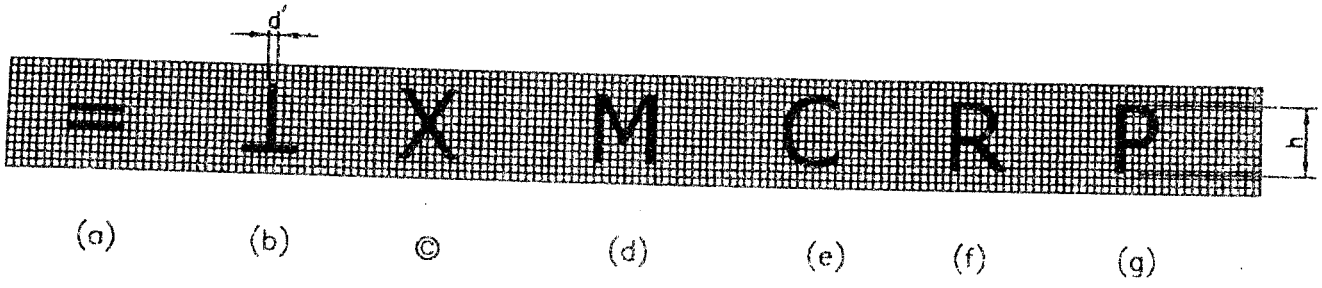
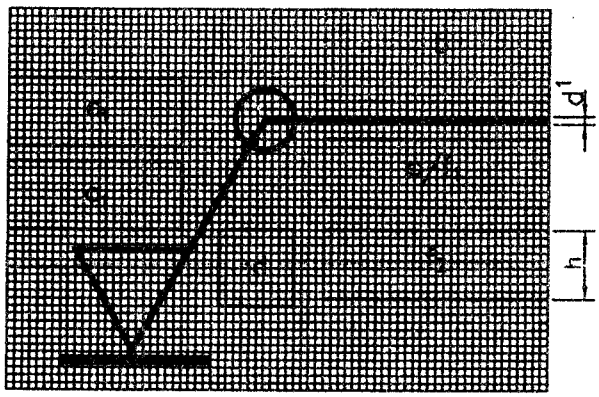


FIGURE 97 - The symbols for indicating the direction of lay



NOTE : *For the meaning of the identifying letters indicating the placing of surface texture specifications in areas a to f, see Figures 82 and 88.*

FIGURE 98 - Other additional indications to be added to the symbol

The height of all lettering in areas a_1, a_2, c and d, (see Figure 98) shall be equal to *h*.

As the lettering in area b, Figure 98, may comprise capital and/or lower-case letters, the height of this area may be greater than *h* to allow for tails of lower-case letters.

The inscription of the roughness value in area a_2 shall be at the same level as that of the sampling length in area c (See Figure 98).

A.3 Dimensions

The dimensions of the graphical symbols and additional indications shall be as specified in Table 3.

Table 3

Dimensions in millimetres

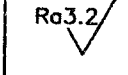
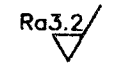
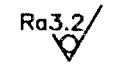
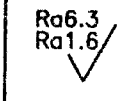
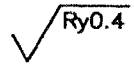
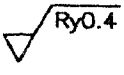
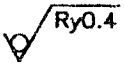
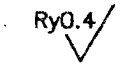
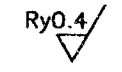
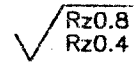
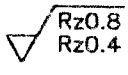
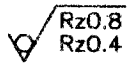
Height of numerals and letters, *h* (See clause 7 of SLS 409-part 1)	2.5	3.5	5	7	10	14	20
Line width for symbols, *d'*	0.25	0.35	0.5	0.7	1	1.4	2
Line width for lettering, *d*							
Height, H_1	3.5	5	7	10	14	20	28
Height, H_2	8	11	15	21	30	42	60

APPENDIX B
SYNOPTIC TABLES

B.1 Graphical symbol with no inscription

Reference No.	Graphical symbol	Meaning
B.1.1		Basic symbol it may be used in isolation only when its meaning is either "the surface under consideration" or explained by a note (see 14.4.3 to 14.4.5)
B.1.2		A machining surface with no indication of any other detail. In isolation this graphical symbol may be used only when its meaning is "a surface to be machined".
B.1.3		A surface from which the removal of material is prohibited. This symbol may also be used in a drawing relating to a production process to indicate that a surface is to be left in the stste resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise.

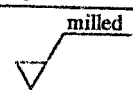
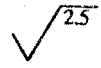
B.2 Graphical symbol with indication of surface texture

Reference No.	Graphical symbol			Meaning
	Removal of material by machining is			
	Optional	Obligatory	Prohibited	
B.2.1				A surface with an upper limit of the surface roughness parameter *Ra* of 3.2μm.
B.2.2				A surface with an upper limit of the surface roughness parameter *Ra* of 6.3μm. and a lower limit of 1.6μm.
B.2.3				A surface with an upper limit of the surface roughness parameter other than *Ra* in this case y=0.4 μm.
B.2.4				A surface with a surface roughness parameter other than *Ra* (see figure 82 and the note to 14.3.2.1)
B.2.5				A surface with a surface roughness parameter other than *Ra* in this case with an upper limit of *Ra*=0.8 μm and a lower limit of *Ra*= 0.4 μm

NOTE: *The surface roughness values ara given as examples only.*

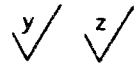
B.3 Graphical symbols with additional indications

(These indications may be used in combination with the appropriate graphical symbol from B2)

Reference No.	Graphical symbol	Meaning
B.3.1		Production method : milled. (see 14.3.3.2)
B.3.2		Sampling length : 2.5mm. (see 14.3.3.4)
B.3.3		Surface pattern : direction of lay perpendicular to the plane of projection of the view. (see 14.3.4)

NOTE : *The production method, sampling, and surface pattern quoted are given as examples only*

B.4 Simplified graphical symbols

Reference No.	Graphical symbol	Meaning
B.4.1		The meaning is defined by text added to the drawing (see 14.4.4 and 14.4.5)
B.4.2		

APPENDIX C

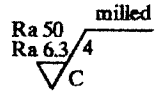
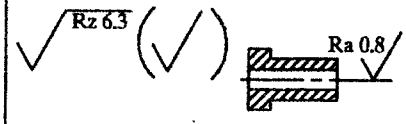
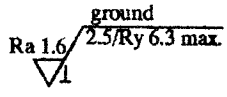
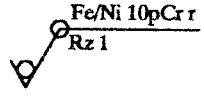
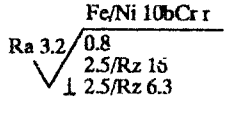
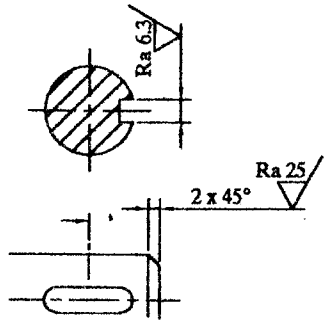
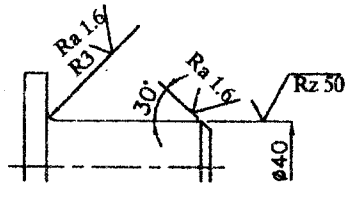
COMPARISON OF ARITHMETICAL MEAN DEVIATION R_a AND ROUGHNESS GRADE NUMBERS

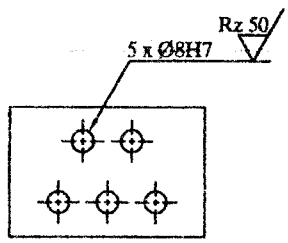
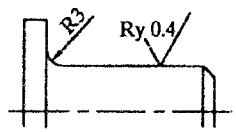
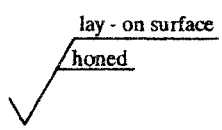
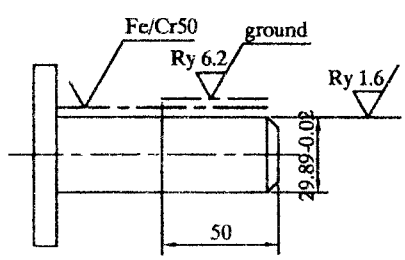
TABLE 4

Roughness values R_a		Roughness grade numbers
μ	μin	
50	2 000	N12
25	1 000	N11
12.5	500	N10
6.3	250	N9
3.2	125	N8
1.6	63	N7
0.8	32	N6
0.4	16	N5
0.2	8	N4
0.1	4	N3
0.05	2	N2
0.025	1	N1

APPENDIX D

Examples

Reference no.	Requirement	Example
D.1	Surface roughness between R_a=50 µm and R_a= 6.3 µm; direction of lay approximately circular relative to the centre; production processmilled; sampling length 4mm	
D.2	Surface roughness R_z = 6.3 µm on all surfaces except for one surface which has a surface roughness R_a = 0.8 µm	
D.3	Surface texture produced by grinding; R_a = 1.6 µmlimited to R_y max. = 6.3 µm ; sampling length 2.5mm; direction of lay approximately perpendicular to the plane of projection	
D.4	Surface trearment without any machining; nickel/chrome plated; roughness R_z = 1 µm on all surfaces	
D.5	surface treatment, electroplated nikel/chrome coating; surface texture R_a = 3.2 µm with a sampling length of 0.8 µm , limited to an $R_z$value between R_z= 16 µm and R_z = 6.3 µm with a sampling length of 2.5mm; direction of lay approximately perpendicular to the plane of projection	
D.6	Indication for surface texture and dimensioning may be combined by using the same dimension line	
D.7	Surface texture and dimensioning may be indicated — together on an extended dimension line or — separated on the respective projection line and dimension line	

Reference no.	Requirement	Example
D.8	Indication for surface texture and dimensioning may be combined by using the same leader line	
D.9	If there is only one roughness indication as shown in the example this is also valid for the extending radii If there is only one roughness indication as shown in the example this is also valid for the extending radii and chamfers may be omitted	
D.10	Other text indication if there is not enough space on the drawing to locate the text on one line	
D.11	Indication for surface texture, dimensioning and treatment	

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