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Foreword

This revision of BS 308 : Part 3 has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee; it reflects the established conventions and also takes account of both national and international developments since the 1972 revision, which is now withdrawn.

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 ISO standards, 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.

The UK continues to participate actively in ISO committees on technical drawing for the establishment of international published standards and much of the contents of this standard reflects those agreements reached internationally with which the UK has concurred. Some notes appear in this standard to draw attention to occasional divergence of practice. Appendix A provides information on aspects of engineering drawing practice covered by British and international standards.

The recommendations of this standard have been established having regard to the requirements of microfilming. Drawings prepared in accordance with this standard should be suitable for microfilming and reduced size reproduction techniques.

During the course of this revision particular attention has been paid to developments in computer aided machine draughting and it has been established that computerized draughting machines are currently capable of complying with the recommendations of this standard. Any minor exceptions due to the limitations of a particular system would not be expected to prejudice the understanding of a drawing otherwise claimed to meet this standard.

The 1972 revision was coincidentally undertaken during the main period of transition of UK industry to the metric system and a limited recognition of the imperial system of units was included but this has not been retained in the present revision.

In the ISO committee for technical drawing it is the intention to unify, in one set of standards, the practices and conventions of all disciplines using technical drawings and their standards currently attempt to reflect that policy. In the UK the traditional separations are maintained and it should be carefully noted that BS 308 continues to provide recommendations for engineering drawings in the manufacturing industries associated with mechanical, electrical, electronics, hydraulics, pneumatics and nuclear engineering disciplines, as previously.

The requirements of the building, architectural, civil and structural engineering and construction services industries continue to be covered by BS 1192. BS 308 does not cover special disciplines such as in naval architecture and aeronautical lofting. There are standards published for some industries using BS 308 as a basis but requiring additional recommendations and conventions particular to the discipline. BS 4301, which gives recommendations for the preparation of drawings for optical elements and systems, and BS 2774, which gives drawing conventions for laboratory glassware, are examples.

BS 5070, dealing with engineering diagram drawing practice, is a companion standard to BS 308 and caters for the same industries, providing recommendations on a wide variety of engineering diagrams. Commonly, as a diagram can be called a 'drawing' and a drawing can be called a 'diagram', it is useful to summarize the difference in the scopes of these standards. BS 308 covers what are commonly accepted to be drawings that define shape, size and form. BS 5070 covers the drawing of diagrams that are normally associated with flow of one sort or another and which relate components (usually indicated by symbols) functionally one to another by the use of lines, but do not depict their shape, size or form; neither do they in general indicate actual connections or locations.

For convenience of use, this revision of BS 308 follows the precedent established in 1972 of publishing in three Parts.

This Part leads on from Part 2 where geometrical tolerancing is referred to in clause 11.

The recommendations are generally in accordance with the following international standards:

ISO 1101
ISO 2692
ISO 5458
ISO 5459

Part 1 of this standard deals with the general principles of engineering drawing practice.

Part 2 of this standard deals with dimensioning, tolerancing and interpretations and the application of surface roughness symbols.

Particular attention is drawn to clause 11 on interpretation of limits of size for the control of form in BS 308 : Part 2 : 1985, in which, together with a clarification of the traditional interpretation, a new tolerancing concept has been introduced, in which specified dimensional and geometrical requirements are met independently. This principle of independency, as it is known, has been developed internationally and is the subject of ISO 8015, in the drafting of which the UK has collaborated. It is to be noted however that, whereas ISO 8015 essentially specifies the new concept with only concessionary reference to the commonly accepted relationship between tolerances of size and form, the BSI drafting committee has deemed it necessary that BS 308 presents both concepts with equal status.

Compliance with a British Standard does not of itself confer immunity from legal obligations

Notes on the presentation of this standard

NOTE 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.

NOTE 2. Linear dimensions shown in the figures are in millimetres.

NOTE 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.

NOTE 4. In the illustrations to this standard, a convention is adopted of using capital letters for notes that would appear as part of the drawing and lower case letters are used for notes explaining the point under consideration in relation to the text.

NOTE 5. This standard recognizes both the first and third angle projection methods as having equal status, see clause 7 of BS 308 : Part 1 : 1984, as does ISO 128. The first angle projection method is that normally used for British Standards and is thus used in this publication in the interests of uniformity of presentation.

NOTE 6. Due to the limitations of size of the figures in this standard, the sizes of arrowheads may not conform to the recommendations of 5.4 in BS 308 : Part 1 : 1984.

Section one. General principles and methods of indication

1 Scope

This Part of BS 308 gives recommendations for the general principles, definitions and the methods of indication of geometrical tolerances on engineering drawings*.

The concept of datum targets is included.

The size and proportions of symbols for geometrical tolerancing are given in appendix B.

NOTE 1. The titles of the publications referred to in this standard are listed on the inside back cover.

NOTE 2. A recommendation on marking is given in 2.3.

2 Definitions, general and marking

2.1 Definitions

For the purposes of this Part of BS 308, the definitions in BS 308 : Part 2 apply, together with those given in 12.2 and 17.2, and the following.

2.1.1 geometrical tolerancing. The system used to control deviations in geometry†.

2.1.2 geometrical reference frame. An interpretive diagram constructed from dimensions which define the theoretically exact positional relationships between the features in any one group (see figure 1).

NOTE. Whilst a geometrical reference frame is not intended to appear on a drawing it may aid the interpretation of complex positional tolerancing requirements.

2.2 General

2.2.1 Geometrical tolerancing can be interpreted in one of two ways, depending on which of the two interpretations of limits of size for control of form is used (see clause 11 of BS 308 : Part 2 : 1985). Therefore it is essential to know which alternative is to be applied before using geometrical tolerances.

2.2.2 A geometrical tolerance defines the form and size of a tolerance zone within which a feature (see 2.1 of BS 308 : Part 2 : 1985) is to be contained.

2.2.3 Depending on the characteristic which is to be geometrically tolerated and the manner in which the feature is dimensioned, the tolerance zone may be one of the following:

- (a) the area within a circle;
- (b) the area between two concentric circles;
- (c) the area between two parallel lines;
- (d) the space within a cylinder;
- (e) the space between two coaxial cylinders;
- (f) the space between two parallel surfaces or two parallel planes;
- (g) the space within a parallelepiped.

2.2.4 The tolerated feature may be of any form or orientation within the tolerance zone, unless a more restrictive indication is given, e.g. by an appended note (see figure 2(e)).

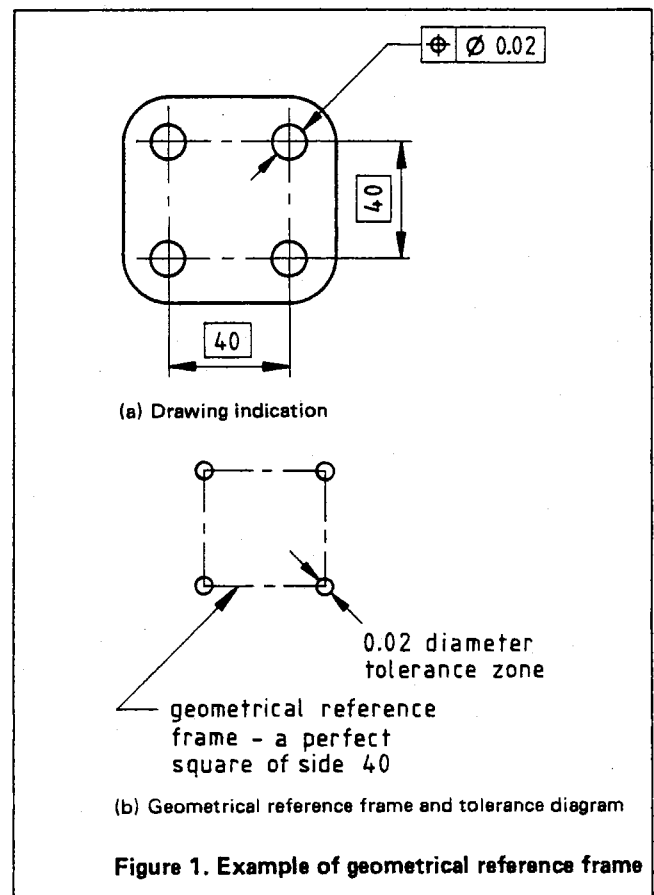
2.2.5 The tolerance should apply for the whole length or surface of the feature, unless otherwise specified.

2.2.6 Geometrical tolerances which are specified for related features (see table 1) do not limit the deviations of geometrical form of the datum feature. It may therefore be necessary to specify tolerances of form for a datum feature so as to ensure that it is sufficiently accurate for its purpose.

2.2.7 Some geometrical tolerances control deviations of more than one characteristic. For example, a parallelism or a perpendicularity tolerance applied to a flat surface also controls flatness deviations of that surface; however, a flatness tolerance does not control parallelism or perpendicularity deviations. Similarly, a symmetry tolerance limits flatness and parallelism deviations and a coaxiality tolerance limits deviation from straightness of the feature to which it is applied. Therefore, when two characteristics of a feature need to be controlled, it may be sufficient to apply only one geometrical tolerance which will keep both characteristics within the desired limits.

2.3 Marking

Drawings produced according to the recommendations of this standard should bear a statement to that effect, e.g. 'drawn to BS 308'. See also clause 14 of BS 308 : Part 2 : 1985.



*Civil and structural engineering and construction services drawings are excluded (see BS 1192). The special discipline aspects of naval architecture and aeronautical lofting are not included.

†PD 7304 gives a fuller introduction to geometrical tolerancing.

3 Symbols

Symbols to indicate characteristics to be tolerated are given in table 1. The symbols given in table 2 identify and qualify tolerated features, datums, zones and dimensions. The uses for these symbols are given in the relevant clauses (see also appendix B).

Table 1. Symbols for tolerated characteristics

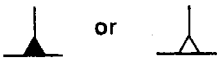
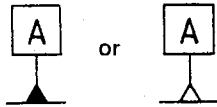
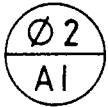
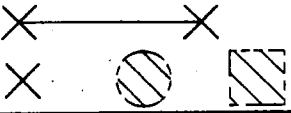
Feature and type of tolerance		Toleranced characteristic	Symbol	Clause
Single feature	Form tolerance	Straightness	—	10.2
		Flatness		10.3
		Circularity*		10.4
		Cylindricity		10.5
Single or related feature		Profile of any line†		10.6
		Profile of any surface†		10.7
Related feature	Orientation tolerance	Parallelism		10.8
		Perpendicularity‡		10.9
		Angularity		10.10
	Location tolerance	Position		10.11
		Concentricity and coaxiality §		10.12
		Symmetry		10.13
	Run-out tolerance	Circular run-out		10.14
		Total run-out		10.15

* Known also as roundness.

† A profile may be related to datum when it is necessary to control position in addition to form.

‡ Perpendicularity is synonymous with normal and is also known as squareness.

§ Concentricity is the state of having the same centre. Coaxiality is the state of having the same axis.

Table 2. Symbols that indicate, identify and qualify		
Description	Symbol	Clause
Tolerance frame		4
Toleranced feature indications	direct 	5
	identification by letter 	6.4
Datum feature indications	direct 	13.1
	identification by letter 	13.1
Theoretically exact dimension		8
Projected tolerance zone		9.2
Maximum material condition qualification		Section three
Envelope requirement		11.1
Datum target frame		16.2.2
Datum target indications		16.2.3

4 Tolerance frame

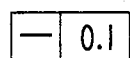
4.1 A tolerance frame is a rectangular symbol which contains indications that define the geometrical tolerance for a feature (see figure 2). The frame should be divided into compartments, containing from left to right:

- the symbol for the characteristic to be tolerated;
- the tolerance value in the unit used for linear dimensions; this value should be preceded by the diameter symbol if the tolerance zone is circular or cylindrical;
- the letter or letters identifying the datum feature or features, where appropriate.

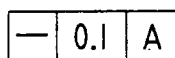
NOTE. (P) and (M) may appear in the tolerance frame as appropriate; see 9.2 and section three.

4.2 Other information concerning the tolerated feature should be placed above the tolerance frame as in figure 2(d), but information qualifying the form of the feature within the tolerance zone should be placed after the tolerance frame as in figure 2(e).

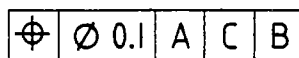
4.3 When it is necessary to specify more than one tolerated characteristic for a feature, the tolerance specifications should be positioned as shown in figure 2(f). Datums (figure 2(g)), tolerated characteristics (figure 2(h)) and tolerance values (figure 2(i)) which are common to two or more combined tolerance frames need be stated only once.



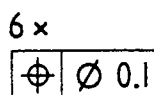
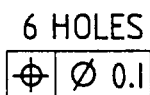
(a)



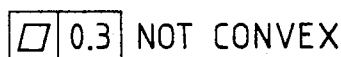
(b)



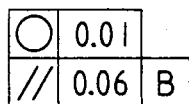
(c)



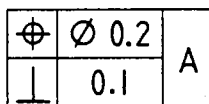
(d)



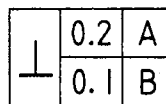
(e)



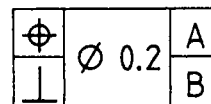
(f)



(g)



(h)



(i)

Figure 2. Tolerance frames

5 Toleranced features

The tolerance frame should be connected to the toleranced feature by a leader line which, in general, is aligned perpendicular to the toleranced feature. At the toleranced feature the leader line should be terminated by an arrowhead which is positioned as follows:

- (a) on the outline of the feature or an extension of the outline, *but not at a dimension line*, when the tolerance refers to the outline itself or to the surface represented by that outline as in figure 3(a) and (b);
- (b) as an extension of a dimension line when the tolerance refers to the axis (figure 3(c) and (d)) or median plane (figure 3(e)) of the feature so dimensioned;
- (c) on the axis or median plane when the tolerance refers to the common axis or median plane of all features lying on that axis or median plane (figure 3(f), (g), (h), (i)).

NOTE 1. Whether a tolerance should be applied to the surface of a cylindrical or symmetrical feature or to its axis or median plane depends on the functional requirements.

NOTE 2. Figures 3(c) and (f) are alternative methods of expressing the same requirement on a single-feature part.

6 Tolerance zones

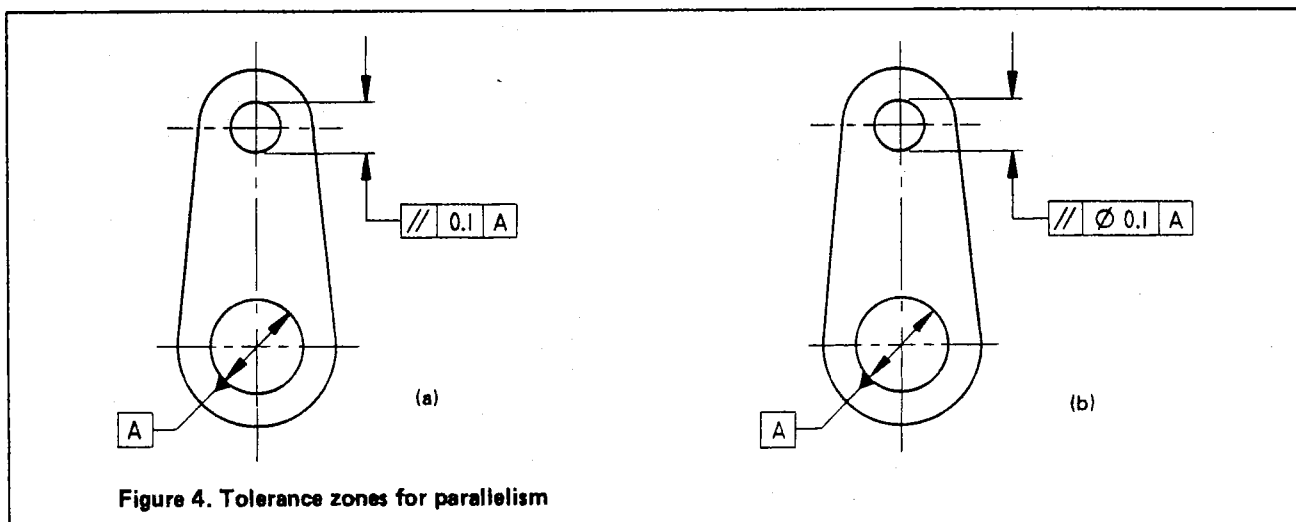
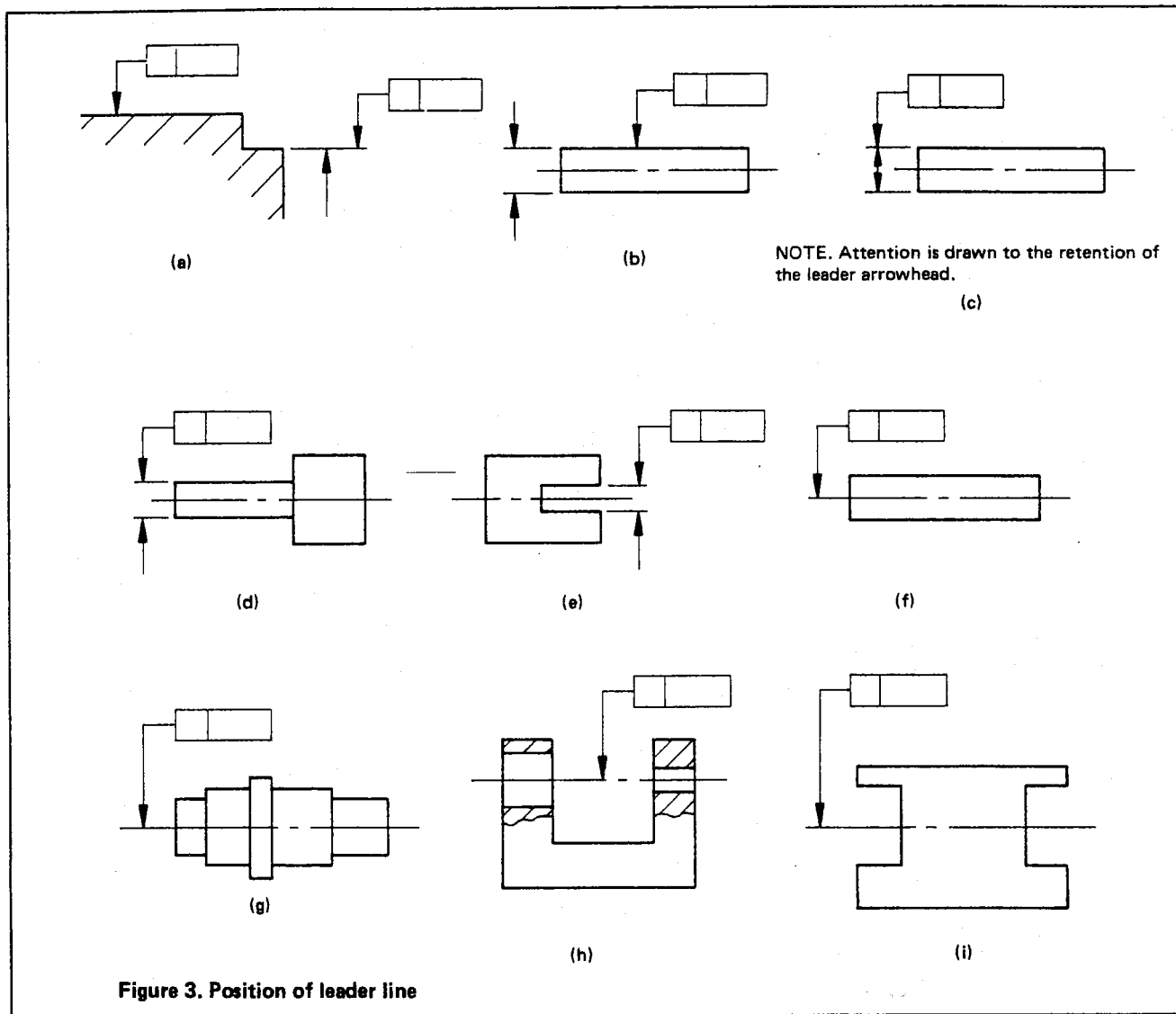
6.1 The width of the tolerance zone is indicated by the direction of the arrow of the leader line joining the tolerance frame to the feature which is toleranced (see figure 4(a)), unless the tolerance value is preceded by the diameter symbol (see figure 4(b), and 10.8.1).

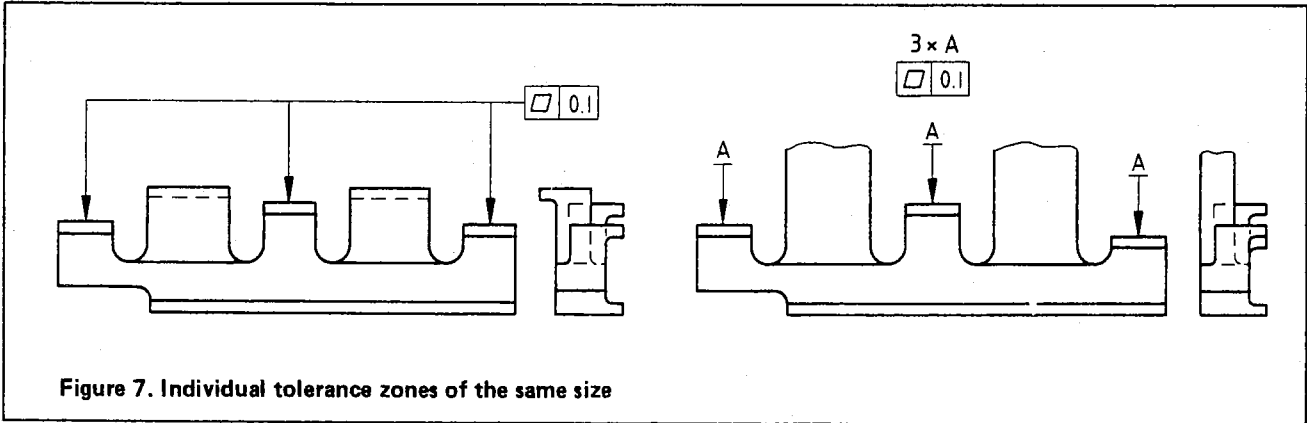
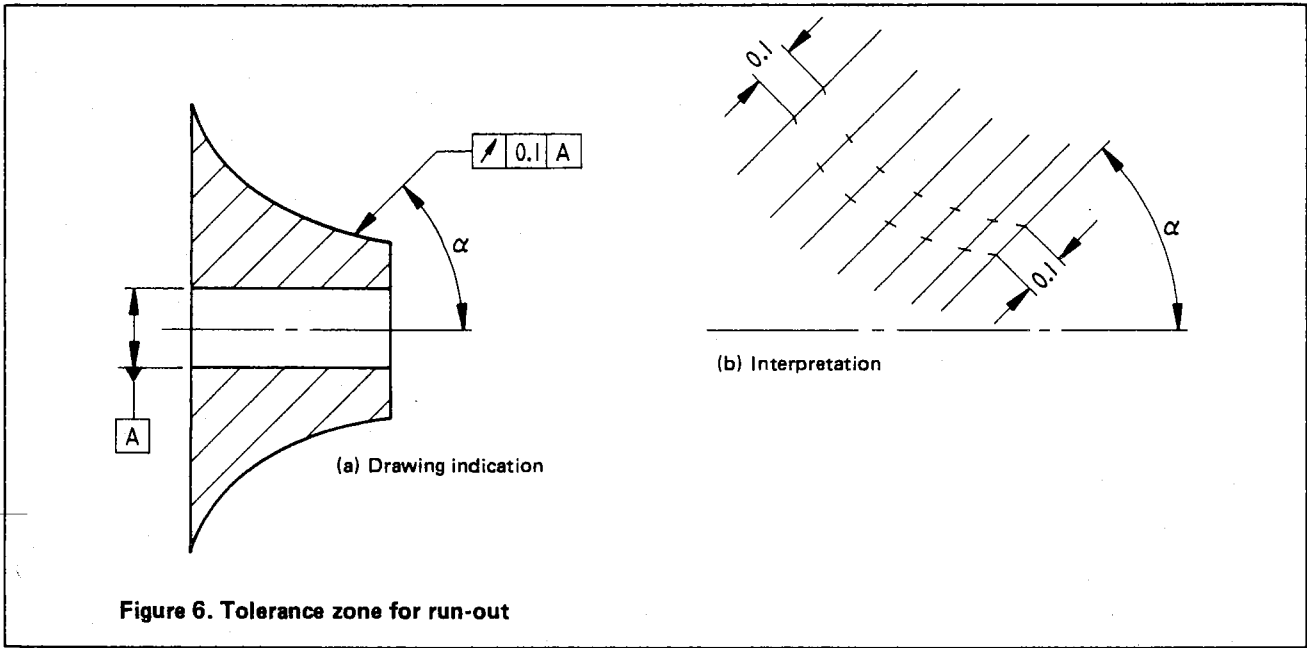
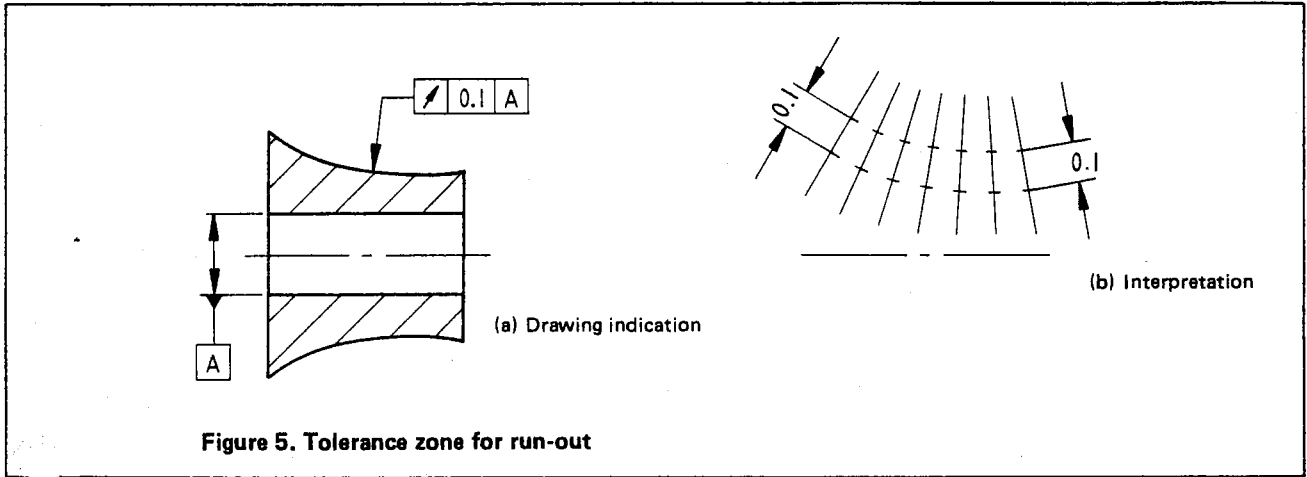
6.2 The direction of the width of the tolerance zone is perpendicular to the specified profile of the toleranced feature (see figure 5), unless otherwise indicated.

6.3 It is essential that the direction of the width of the tolerance zone is indicated when it is required to apply in a direction other than perpendicular to the specified geometry of the part (see figure 6).

6.4 When individual tolerance zones of the same size are applied to several separate features they may be indicated as shown in figure 7.

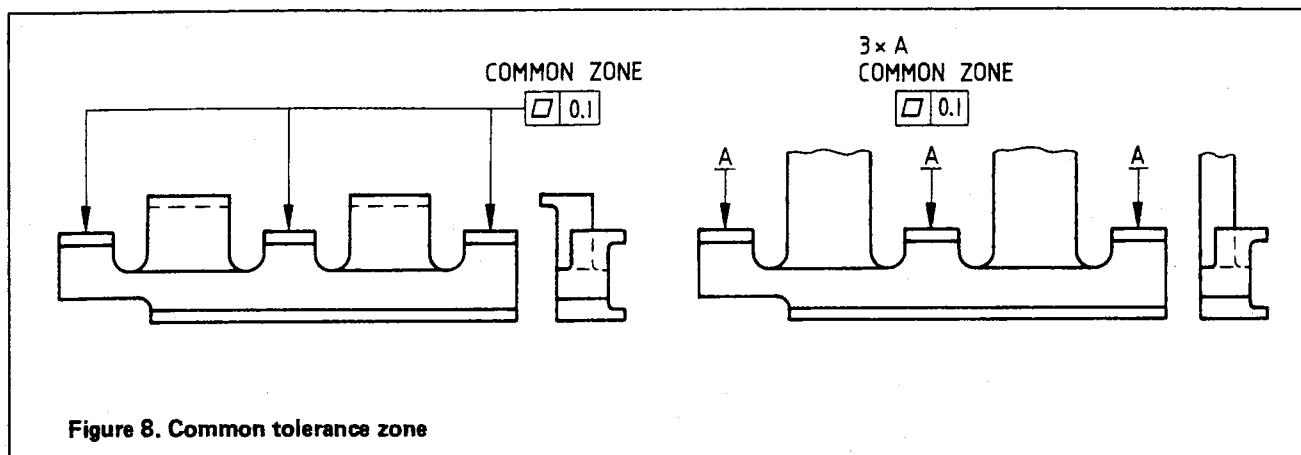
6.5 When a common tolerance zone is applied to several separate features, the requirement should be indicated by the words 'common zone' above the tolerance frame (see figure 8).





7 Tolerance applicable to restricted lengths of features

7.1 When a tolerance is to be applied only to a particular part of a feature, that part should be indicated as in figure 9(a), using a type J line (see table 2 of BS 308 : Part 1 : 1984).

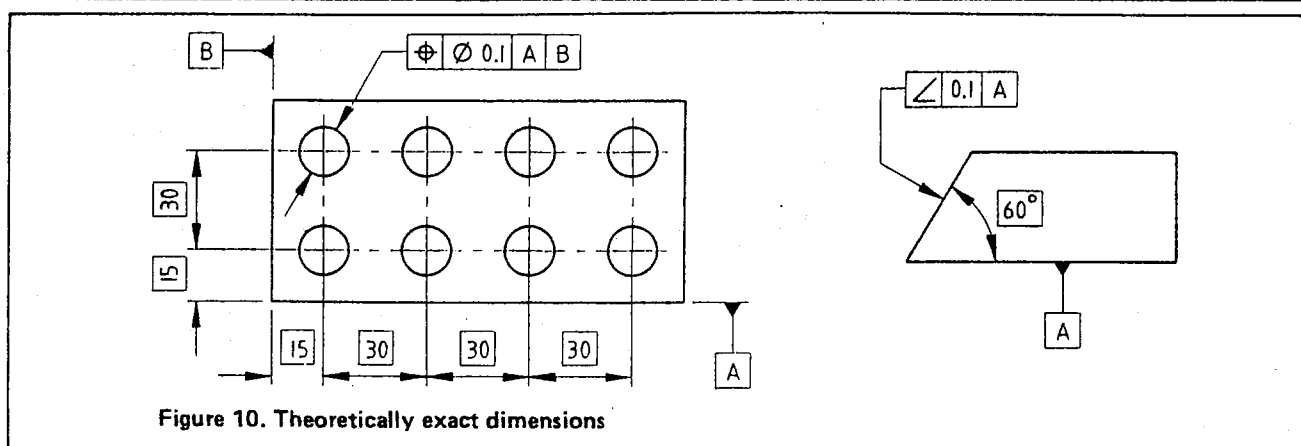
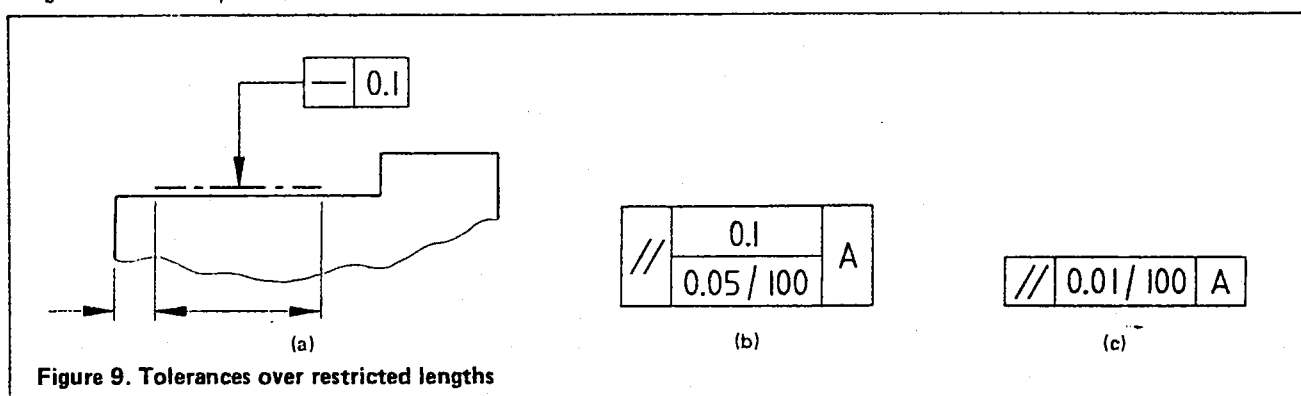


7.2 When the tolerance value over the whole of the considered length or surface is to be qualified by a smaller tolerance on a specified shorter length lying anywhere within it, this should be expressed as in figure 9(b) where the tolerance value 0.05 applies to any length 100. When this convention is used for a feature which is a surface the tolerance value is applicable to all lines of the specified length in any position and in any direction on the surface.

7.3 When the tolerance is only specified in the form of a tolerance value applicable to a specified length as in figure 9(c), an accumulation of tolerance over the whole length or surface is permitted.

8 Theoretically exact dimensions

When tolerances of position, profile or angularity are specified for a feature, the ideal position, profile or angle is defined by theoretically exact dimensions*, these are indicated by being enclosed in a rectangular frame known as a 'box' thus: $\boxed{30}^{\dagger}$. The corresponding actual dimensions of the feature are subject only to the positional tolerance, profile tolerance or angularity tolerance specified in the tolerance frame (see two examples in figure 10).



*Previously known as true positions '(TP)'.

†Boxes can also enclose lettering where relevant. See figure 22.

9 Projected tolerance zone

9.1 General

A cylindrical tolerance zone that limits deviations from the theoretically exact position of a hole axis also limits perpendicularity deviations of the axis relative to the face at one end of the hole (the primary datum) (see clause 22).

When the hole is to be used to secure a fixed fastener*, the maximum perpendicularity deviation of the hole axis could cause the fastener to interfere with the clearance hole in the mating part (see figure 11). A projected

tolerance zone should be specified in order to avoid such interference. The projected tolerance zone applies only to the external projection of the axis of the securing hole from the primary datum (see figure 12).

It should be noted that it is the perpendicularity deviation of the portion of the fastener passing through the clearance hole that is significant. Therefore the projected tolerance zone is specified for the axis of the hole into which the fastener is assembled. The location and perpendicularity of this hole is of importance only to the extent that it affects the projecting portion of the engaging fastener.

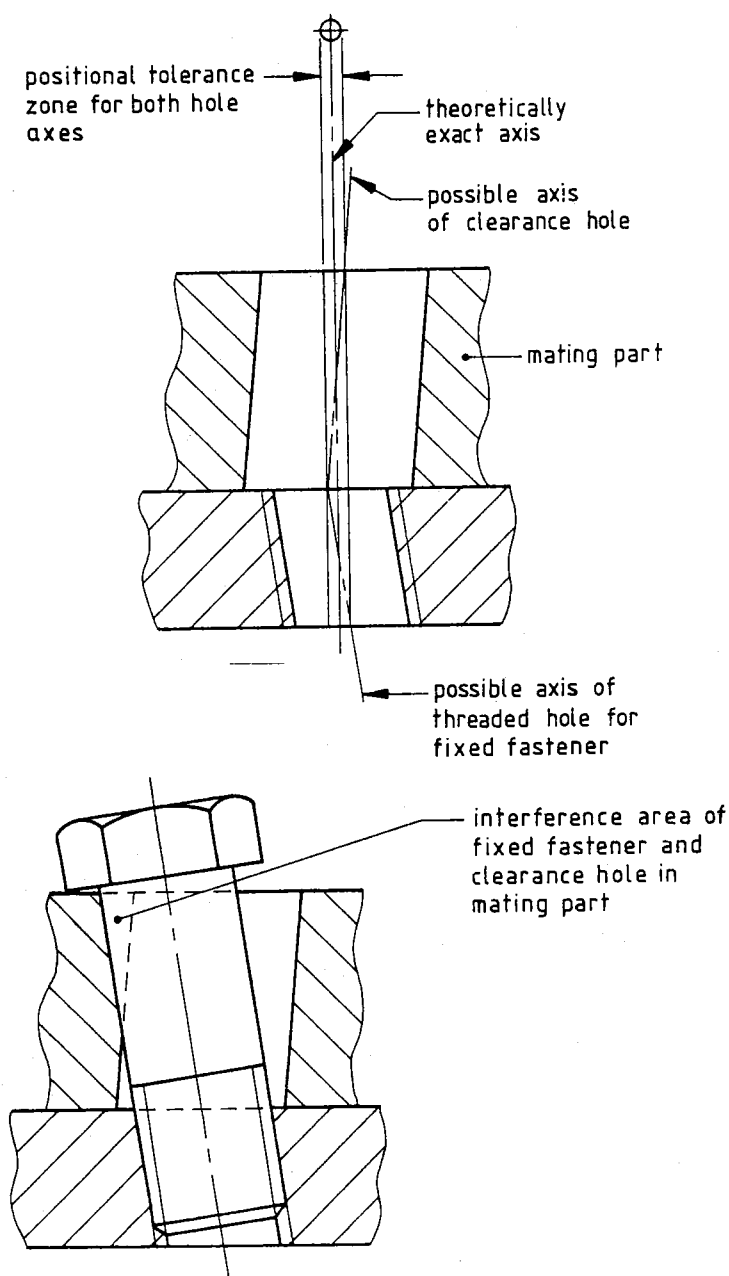


Figure 11. Possible interference between parts if projected tolerance zone is not used

*In this context a stud, screw or press-fit pin would be classified as a fixed fastener and a bolt and nut would be classified as a floating fastener.

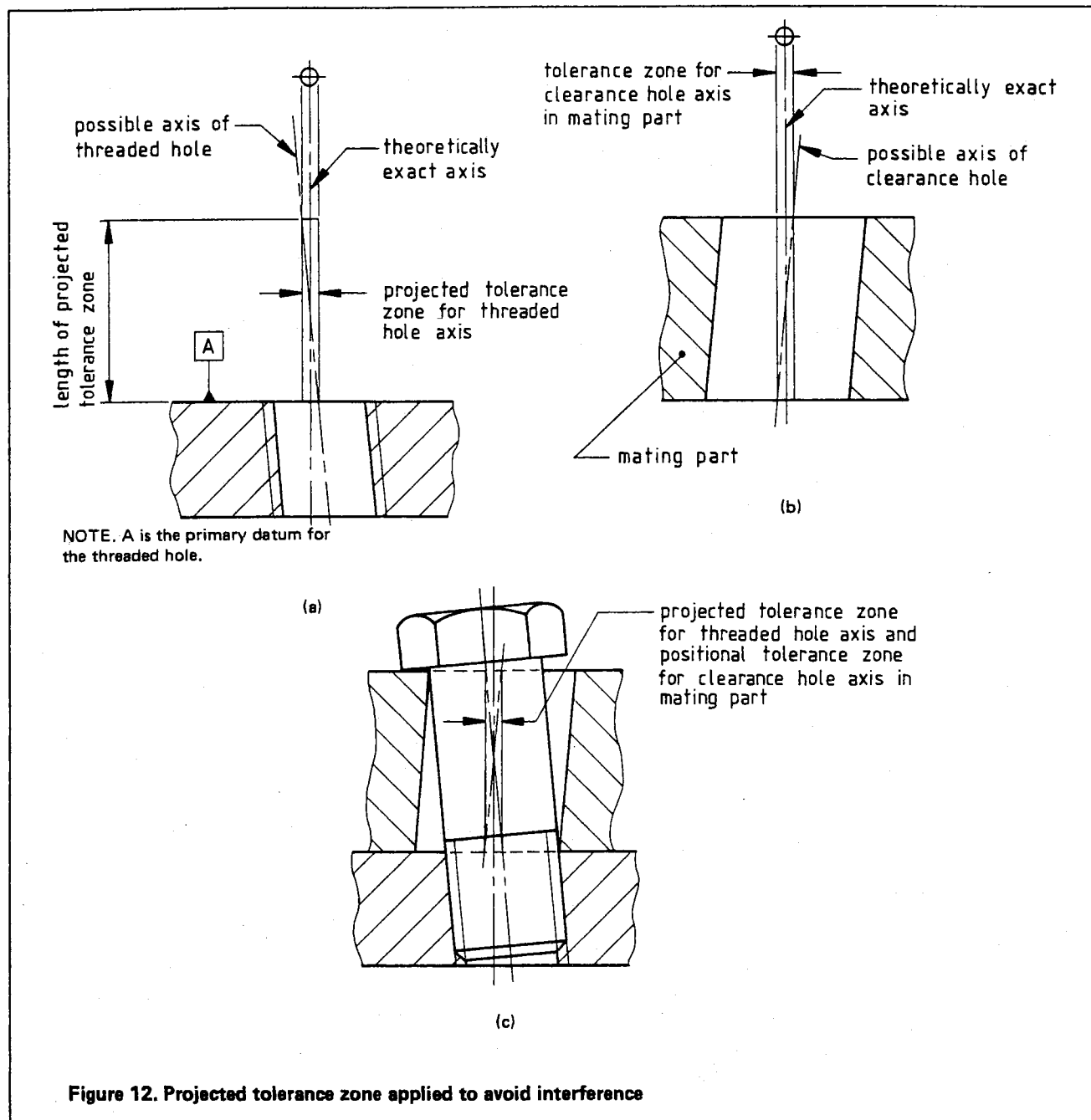


Figure 12. Projected tolerance zone applied to avoid interference

9.2 Indication

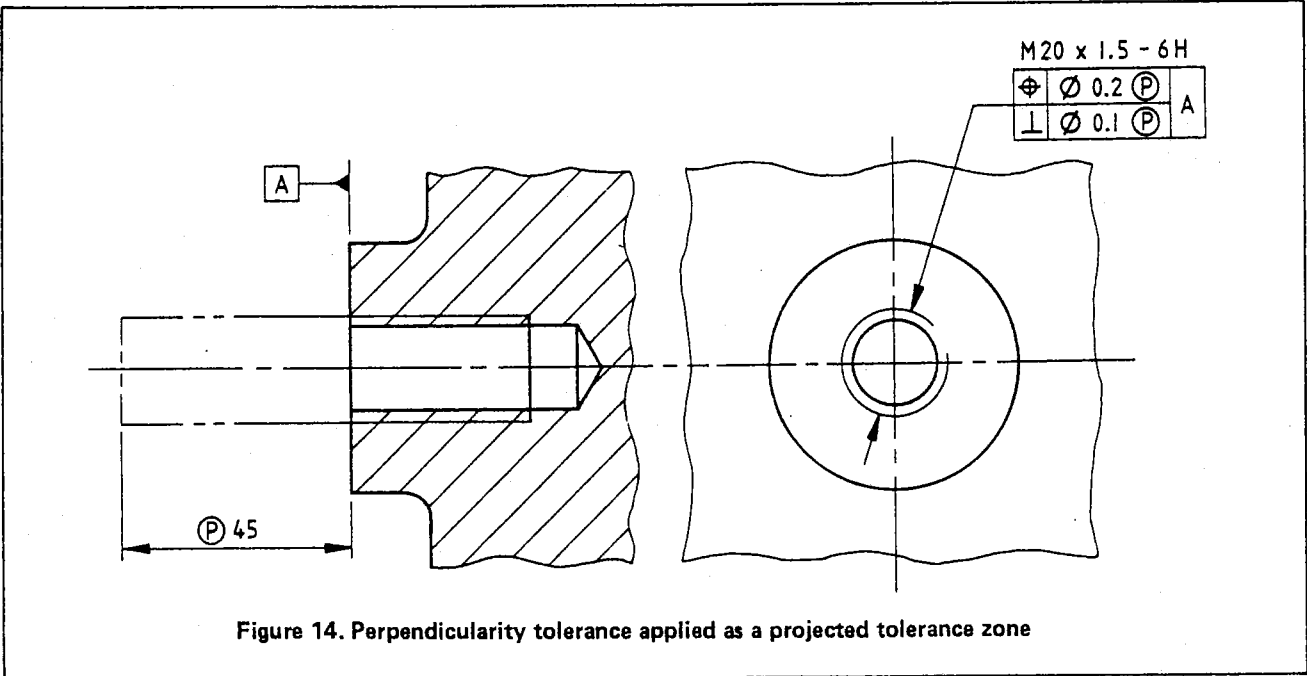
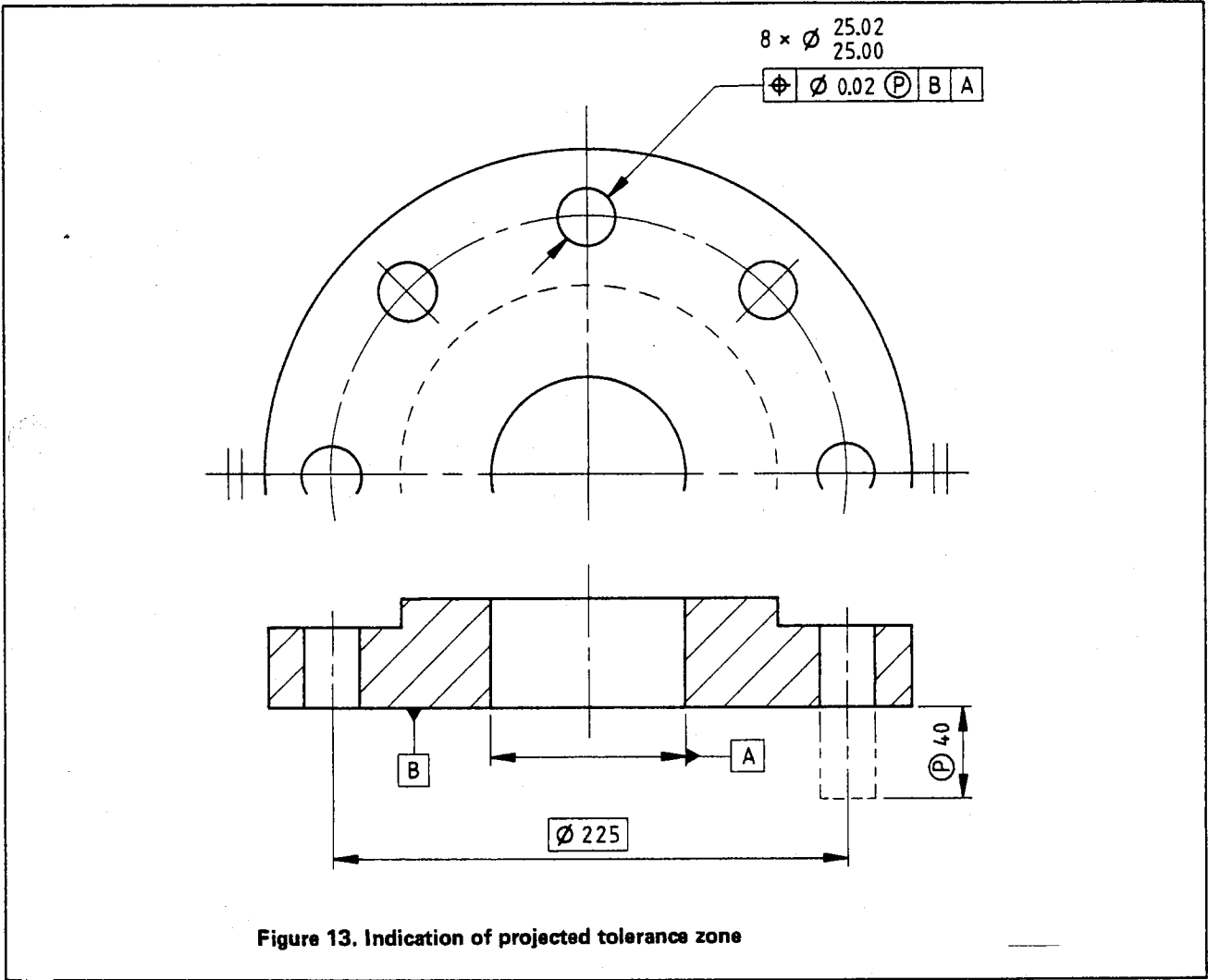
A projected tolerance zone should be indicated by the symbol $\textcircled{P}$ in the two positions as follows (see also figure 13):

- after the value of the tolerance in the tolerance frame that applies to the feature concerned;
- before the dimensioned length of the projected tolerance zone in an appropriate view. In this view the feature concerned should be extended to the specified length of the projected tolerance zone using type K lines (see table 2 of BS 308 : Part 1 : 1984).

9.3 Specified length of projected tolerance zone

The specified length of a projected tolerance zone is a minimum. Where the fixed fastener is a screw the minimum specified length is the maximum permissible thickness of the mating part(s). Where the fixed fastener is a stud or press-fit pin the minimum specified length is the maximum length of the projecting portion of the stud or pin.

Where studs or press-fit pins are toleranced for position on an assembly drawing the specified positional tolerance applies only to the length of the projecting portion of the stud or pin after assembly. Therefore it is unnecessary to specify a projected tolerance zone.



9.4 Perpendicularity tolerance applied as a projected tolerance zone

Where design considerations require a closer control of the perpendicularity of a hole axis than that allowed by the required positional tolerance, a perpendicularity tolerance applied as a projected tolerance zone may be specified. In figure 14 the axis of the threaded portion of the hole is to lie within a cylindrical tolerance zone 0.1 diameter perpendicular to and projecting from datum plane A for the 45 specified height. Additionally, the axis is to lie within the positional tolerance zone 0.2 diameter over the 45 specified height.

However, as explained in 23.1 (b), the axis of the 0.1 diameter tolerance zone may lie on the circumference of the 0.2 diameter tolerance zone. Therefore, the axis of the threaded portion of the hole may lie outside the 0.2 diameter tolerance zone and still be acceptable.

10 Definition, indication and interpretation of tolerance zones

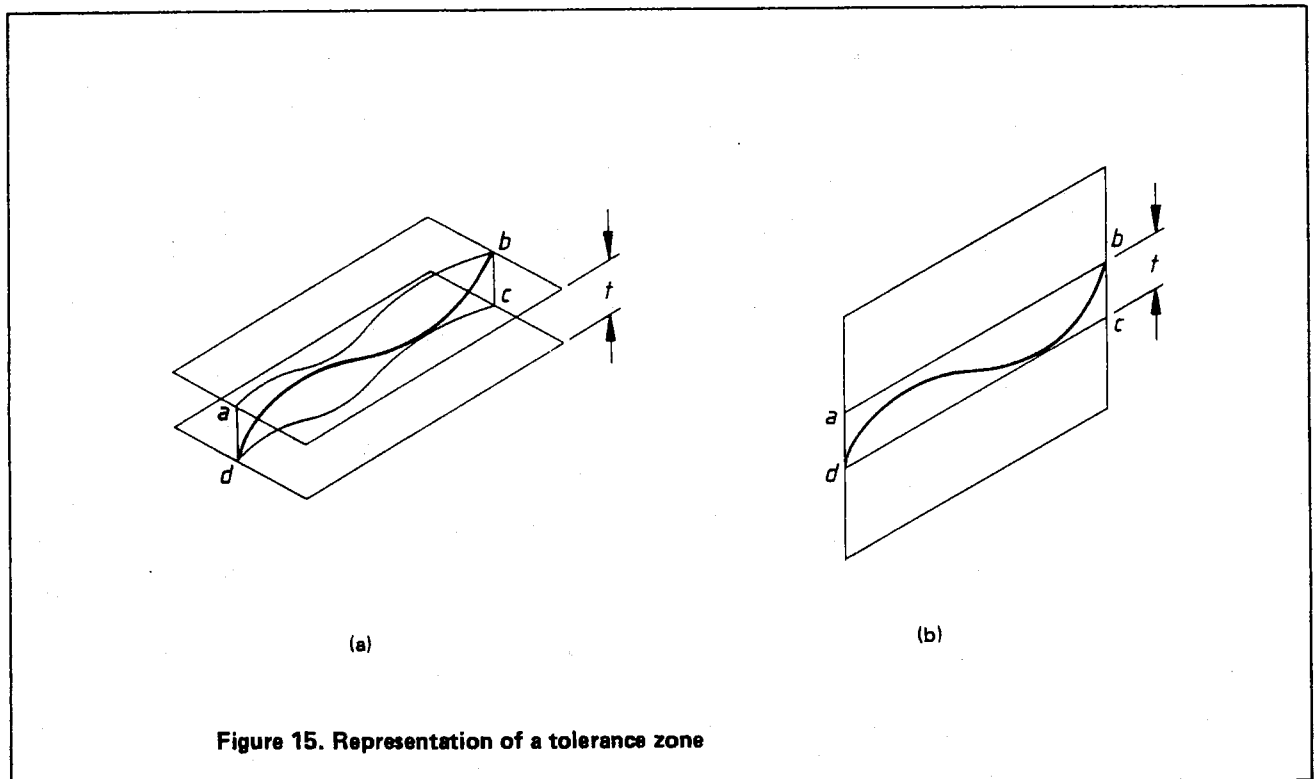
10.1 General

There are two possible methods of graphical representation for some tolerance zones (for example, straightness of a line or axis controlled in one direction only):

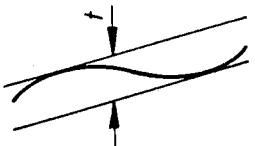
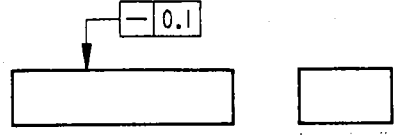
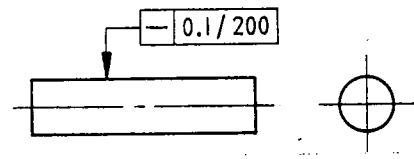
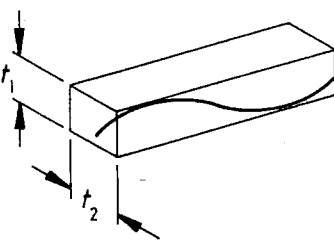
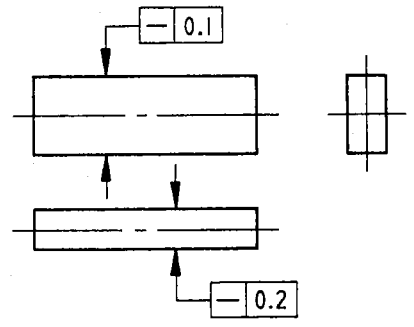
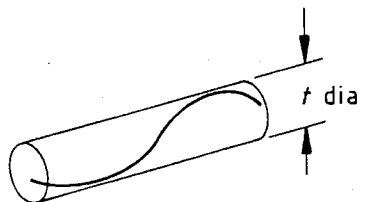
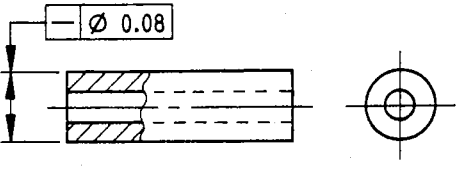
(a) by two parallel planes a distance t apart as shown in figure 15(a);

(b) by two parallel straight lines a distance t apart as shown in figure 15(b).

Figure 15(a) shows a three-dimensional representation of a tolerance zone and figure 15(b) its projection on a plane. There is no difference in the meaning of the two representations, for such a tolerance does not restrict the deviation in any direction perpendicular to the tolerance zone.*



*The simpler method as shown in figure 15(b) has normally been used in this standard.

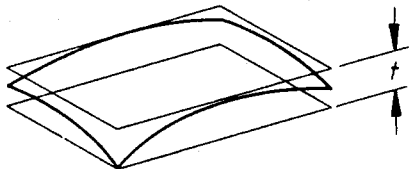
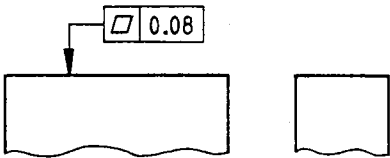
Symbol	Definition of the tolerance zone	Indication and interpretation
10.2 Straightness tolerance*		
	When projected on a plane the tolerance zone is limited by two parallel straight lines a distance t apart. 	 Any line on the upper surface parallel to the plane of projection in which the indication is shown is to be contained between two parallel straight lines 0.1 apart.  Any portion of length 200 of any generator of the cylindrical surface indicated by the arrow is to be contained between two parallel straight lines 0.1 apart in a plane containing the axis.
—	When the tolerance is specified in two directions perpendicular to each other the tolerance zone is limited by a parallelepiped of section $t_1 \times t_2$. 	 The centre line of the bar is to be contained within a parallelepipedic zone of width 0.1 vertically and 0.2 horizontally.
	When the tolerance value is preceded by the diameter symbol the tolerance zone is limited by a cylinder of diameter t. 	 The axis of the cylinder to which the tolerance frame is connected is to be contained within a cylindrical zone of diameter 0.08.†

*See also appendix C.

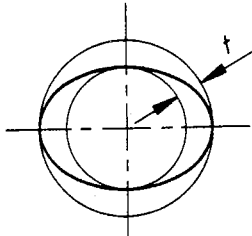
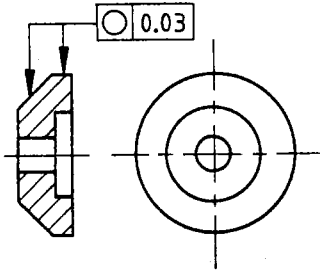
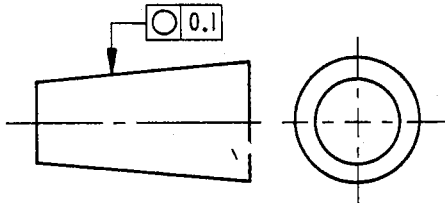
†The straightness tolerance of an axis with dependency of size and form is not a limiting value as defined in clause 11 of BS 308 : Part 2 : 1985. See also 20.2.2.

Symbol	Definition of the tolerance zone	Indication and interpretation
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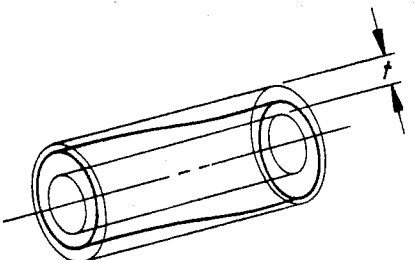
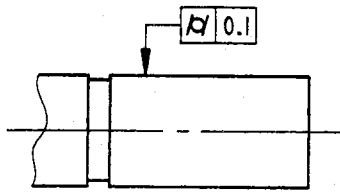
10.3 Flatness tolerance*

	The tolerance zone is limited by two parallel planes a distance t apart. 	 The surface is to be contained between two parallel planes 0.08 apart.
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10.4 Circularity tolerance (roundness)*

	The tolerance zone in the considered plane is limited by two concentric circles a distance t apart. 	 The circumference of each cross-section of the outer profile is to be contained between two co-planar concentric circles 0.03 apart.  The circumference of each cross-section is to be contained between two co-planar concentric circles 0.1 apart.
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10.5 Cylindricity tolerance*

	The tolerance zone is limited by two coaxial cylinders a distance t apart. 	 The considered surface is to be contained between two coaxial cylinders 0.1 apart.
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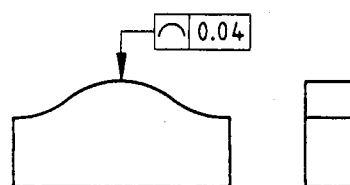
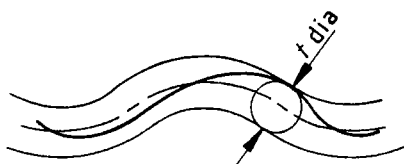
*See also appendix C.

Symbol	Definition of the tolerance zone	Indication and interpretation
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10.6 Profile tolerance of any line

(a) *Bilateral*

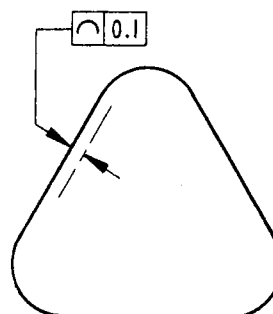
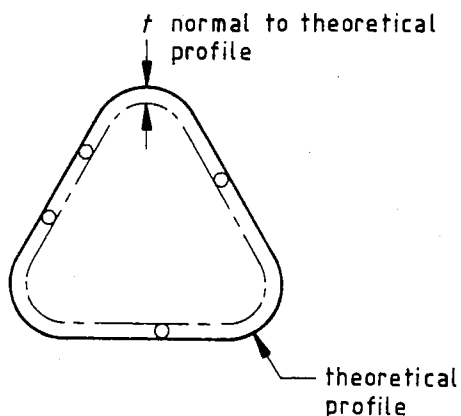
The tolerance zone is limited by two lines enveloping circles of diameter t , the centres of which are situated on a line having the theoretically exact geometrical form.



In each section parallel to the plane of projection the considered profile is to be contained between two lines enveloping circles of diameter 0.04, the centres of which are situated on a line of theoretically exact geometrical profile.

(b) *Unilateral*

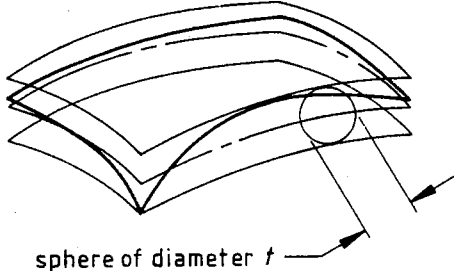
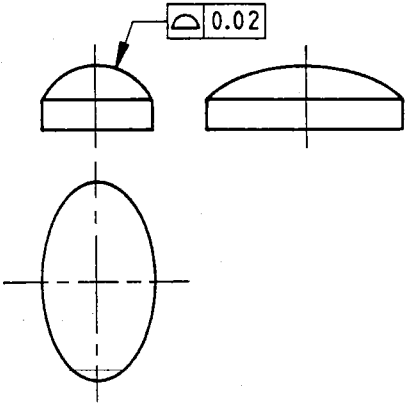
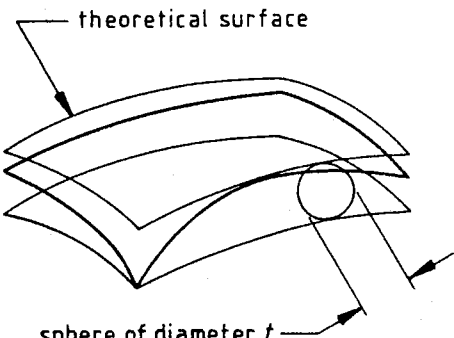
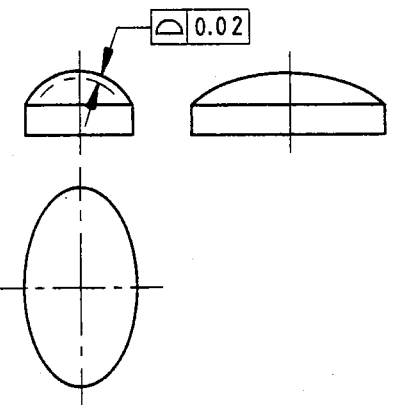
The tolerance zone is limited by two lines enveloping circles of diameter t , one line being the theoretically exact profile.



In any section parallel to the plane of projection of the drawing, the actual profile is to lie between the theoretical profile and a line which envelops a series of circles 0.1 diameter.

Symbol	Definition of the tolerance zone	Indication and interpretation
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10.7 Profile tolerance of any surface

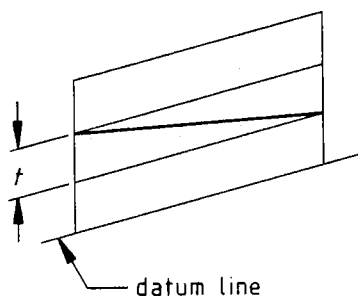
	(a) Bilateral The tolerance zone is limited by two surfaces enveloping spheres of diameter t, the centres of which are situated on a surface having the theoretically exact geometrical form.  sphere of diameter t	 The considered surface is to be contained between two surfaces enveloping spheres of diameter 0.02, the centres of which are situated on a surface of theoretically exact geometrical form.
	(b) Unilateral The tolerance zone is limited by two surfaces enveloping spheres of diameter t, one being the theoretically exact profile.  theoretical surface sphere of diameter t	 The considered surface is to lie between two surfaces which envelop a series of spheres, 0.02 diameter, one surface being theoretically exact.

Symbol	Definition of the tolerance zone	Indication and interpretation
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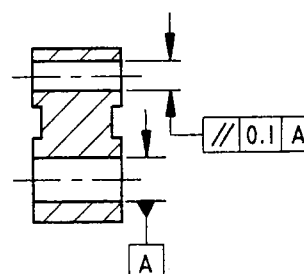
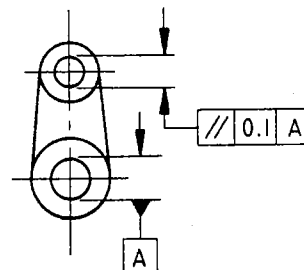
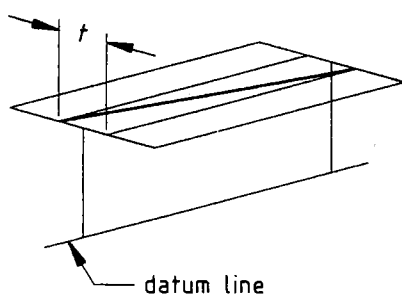
10.8 Parallelism tolerance

10.8.1 Parallelism tolerance of a line with reference to a datum line

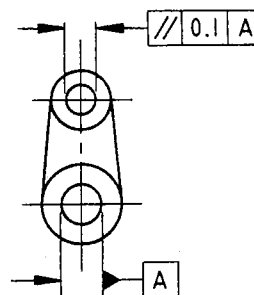
When the tolerance is specified in one direction only the tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart and parallel to the datum line.



//



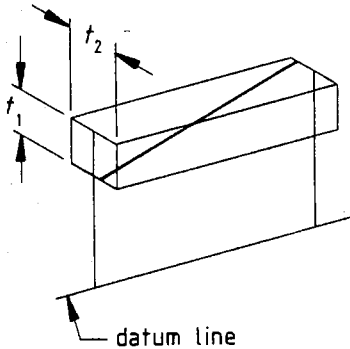
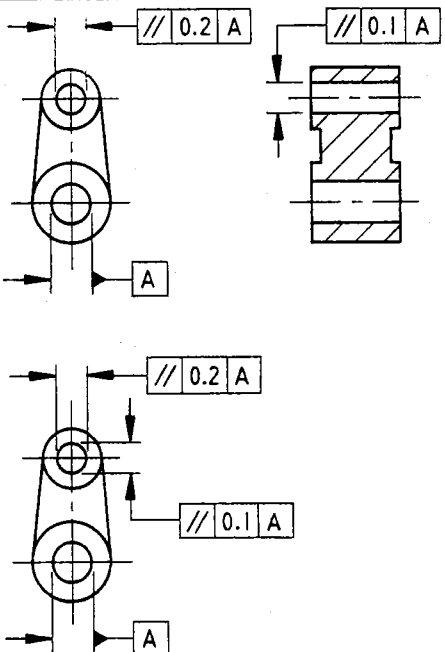
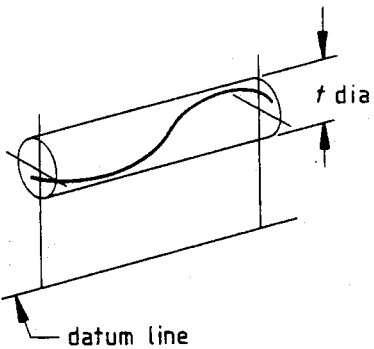
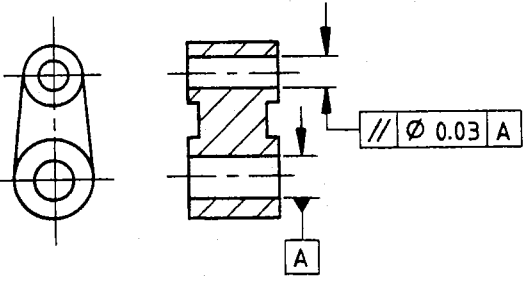
The tolerated axis is to be contained between two straight lines 0.1 apart, which are parallel to the datum axis A and lie in the vertical direction.



The tolerated axis is to be contained between two straight lines 0.1 apart, which are parallel to, and symmetrically disposed about, the datum axis A and lie in the horizontal direction.

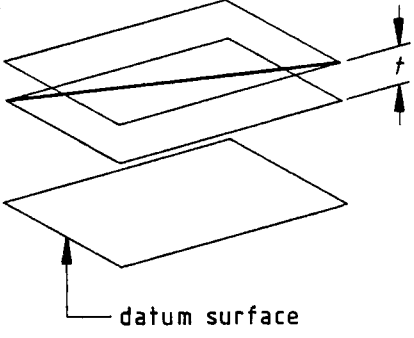
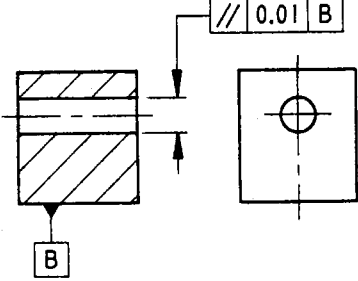
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.8.1 Parallelism tolerance of a line with reference to a datum line (concluded)

//	When the tolerance is specified in two planes perpendicular to each other the tolerance zone is limited by a parallelepiped of section $t_1 \times t_2$ parallel to the datum line.  datum line	 The tolerated axis is to be contained within a parallelepipedic tolerance zone having a width of 0.2 in the horizontal and 0.1 in the vertical direction and which is parallel to the datum axis A.
	When the tolerance value is preceded by the diameter symbol the tolerance zone is limited by a cylinder of diameter t parallel to the datum line.  datum line	 The tolerated axis is to be contained within a cylindrical zone of diameter 0.03 parallel to the datum axis A (datum line).

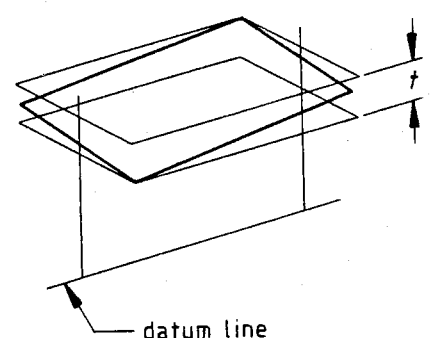
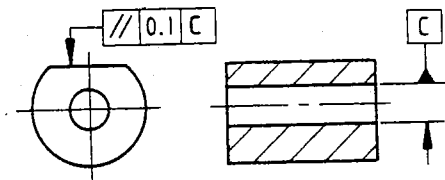
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.8.2 Parallelism tolerance of a line with reference to a datum surface

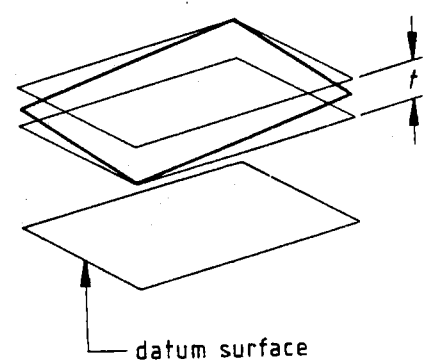
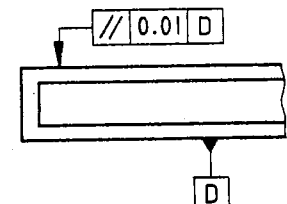
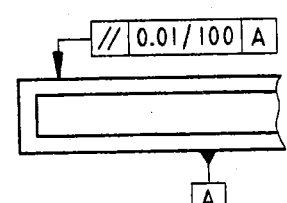
	The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum surface.  datum surface	 The axis of the hole is to be contained between two planes 0.01 apart which are parallel to the datum surface B.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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10.8.3 Parallelism tolerance of a surface with reference to a datum line

//	The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum line.  datum line	 The tolerated surface is to be contained between two planes 0.1 apart which are parallel to the datum axis C of the hole.
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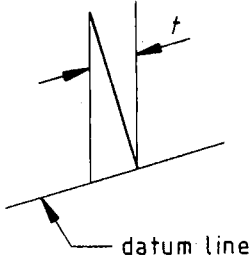
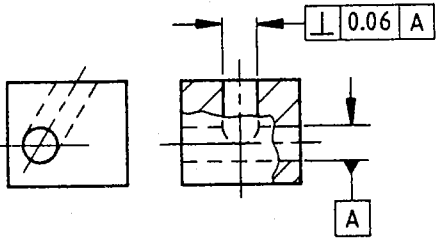
10.8.4 Parallelism tolerance of a surface with reference to a datum surface

//	The tolerance zone is limited by two parallel planes a distance t apart and parallel to the datum surface.  datum surface	 The tolerated surface is to be contained between two parallel planes 0.01 apart which are parallel to the datum surface D.  All the points on the tolerated surface in a length of 100, placed anywhere on this surface, are to be contained between two parallel planes 0.01 apart which are parallel to the datum surface A.
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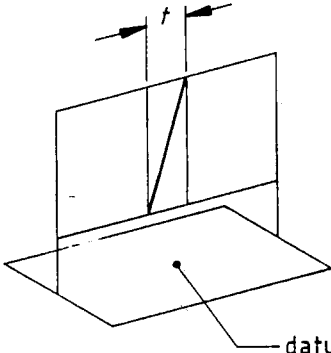
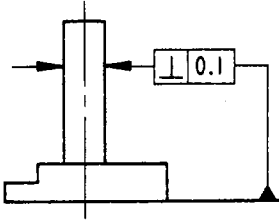
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.9 Perpendicularity tolerance (squareness)

10.9.1 Perpendicularity tolerance of a line with reference to a datum line

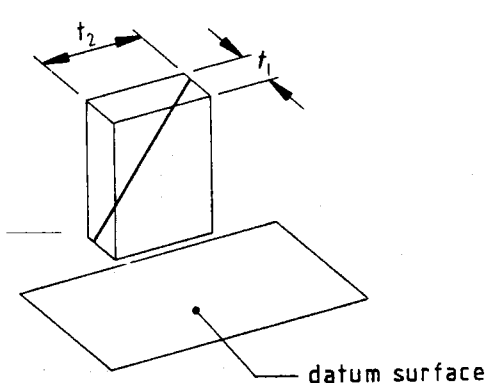
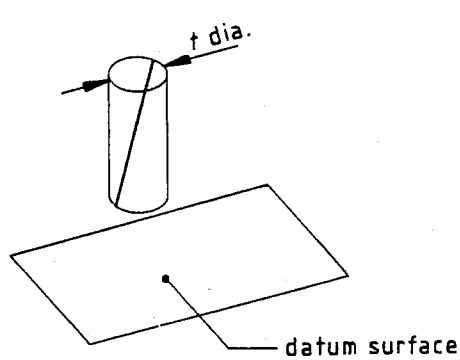
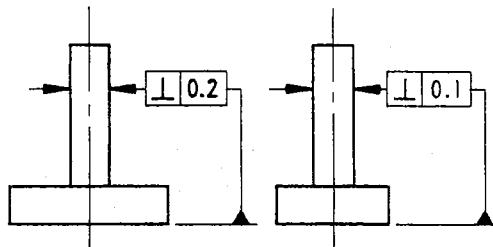
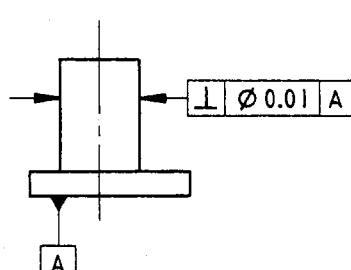
	The tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart and perpendicular to the datum line.  datum line	 The axis of the inclined hole is to be contained between two parallel planes 0.06 apart which are perpendicular to the axis of the horizontal datum hole A.
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10.9.2 Perpendicularity tolerance of a line with reference to a datum surface

	When the tolerance is specified in one direction only the tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart and perpendicular to the datum surface.  datum surface	 The axis of the cylinder is to be contained between two parallel planes 0.1 apart, perpendicular to the datum surface.
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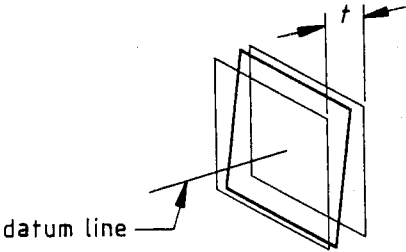
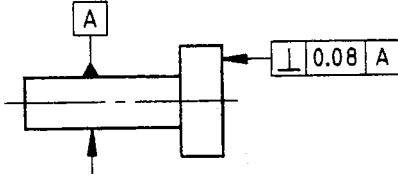
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.9.2 Perpendicularity tolerance of a line with reference to a datum surface (concluded)

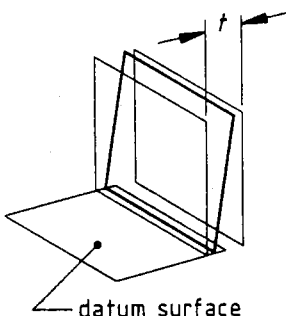
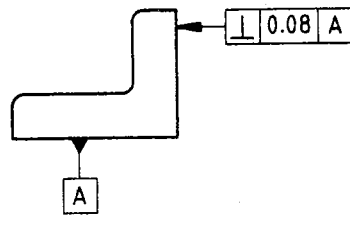
	When the tolerance is specified in two directions perpendicular to each other the tolerance zone is limited by a parallelepiped of section $t_1 \times t_2$ and perpendicular to the datum surface.  datum surface $\perp$ When the tolerance value is preceded by the diameter symbol the tolerance zone is limited by a cylinder of diameter t perpendicular to the datum surface.  datum surface	 The axis of the cylinder is to be contained within a parallelepipedic zone of 0.1×0.2 which is perpendicular to the datum surface.  The axis of the cylinder is to be contained within a cylindrical zone of diameter 0.01 perpendicular to the datum surface A.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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10.9.3 Perpendicularity tolerance of a surface with reference to a datum line

	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum line.  datum line	 The tolerated face is to be contained between two parallel planes 0.08 apart which are perpendicular to the datum axis A.
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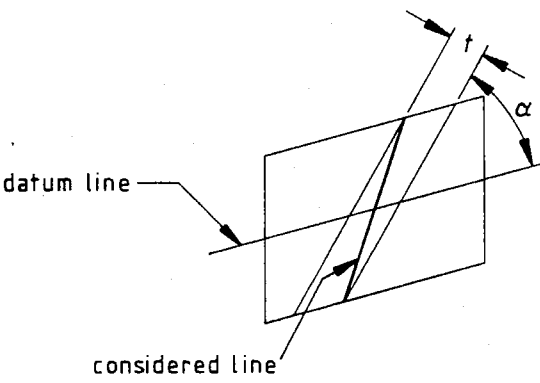
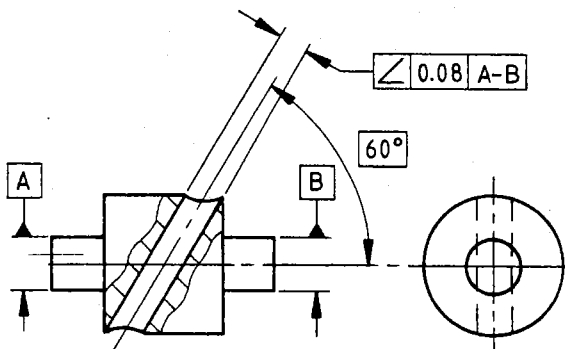
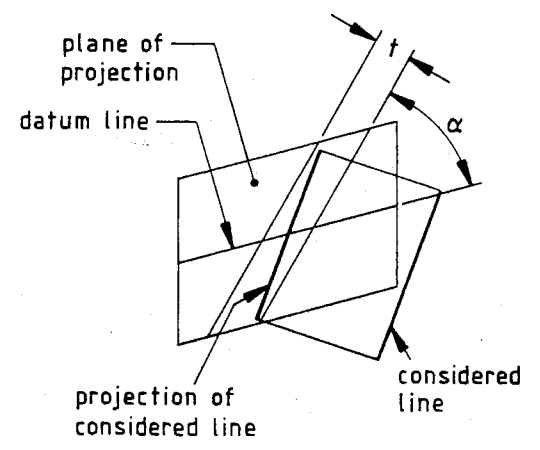
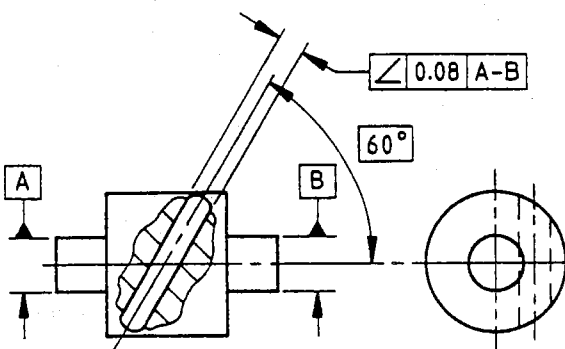
10.9.4 Perpendicularity tolerance of a surface with reference to a datum surface

	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum surface.  datum surface	 The tolerated surface is to be contained between two parallel planes 0.08 apart which are perpendicular to the horizontal datum surface A.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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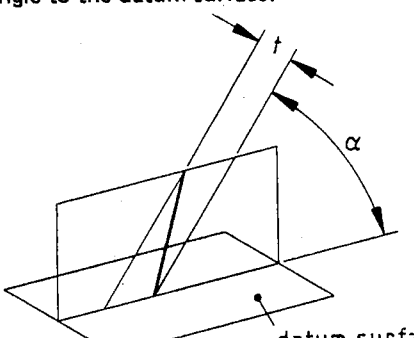
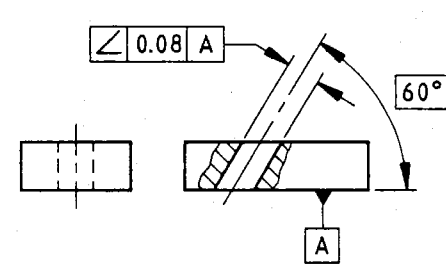
10.10 Angularity tolerance

10.10.1 Angularity tolerance of a line with reference to a datum line

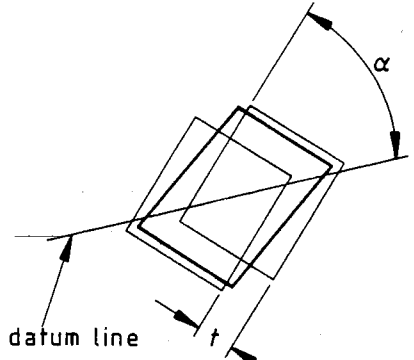
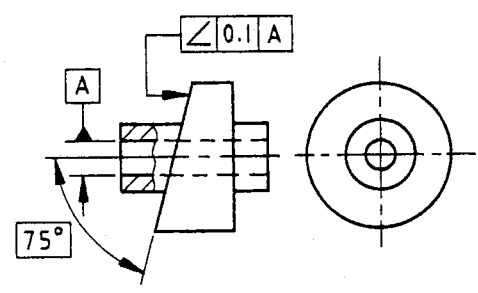
	(a) <i>Line and datum line in the same plane</i> The tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart and inclined at the specified angle to the datum line. 	 The axis of the hole is to be contained between two parallel planes 0.08 apart which are inclined at 60° to the horizontal datum axis A-B.
	(b) <i>Line and datum line in different planes</i> The tolerance zone is applied to the projection of the considered line on the plane containing the datum line and parallel to the considered line. 	 The axis of the hole, projected on a plane containing the datum axis, is to be contained between two parallel straight lines 0.08 apart which are inclined at 60° to the horizontal datum axis A-B.

Symbol	Definition of the tolerance zone	Indication and interpretation
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10.10.2 Angularity tolerance of a line with reference to a datum surface

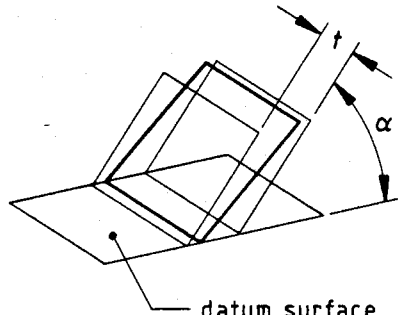
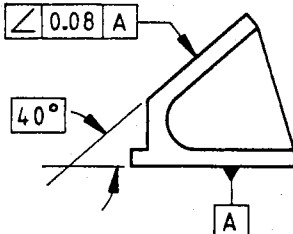
	The tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart and inclined at the specified angle to the datum surface.  datum surface	 The axis of the hole is to be contained between two parallel planes 0.08 apart which are inclined at 60° to datum surface A.
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10.10.3 Angularity tolerance of a surface with reference to a datum line

	The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum line.  datum line	 The inclined surface is to be contained between two parallel planes 0.1 apart which are inclined at 75° to datum axis A.
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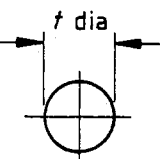
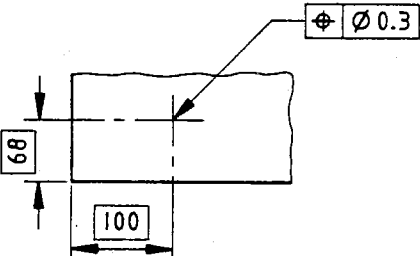
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.10.4 Angularity tolerance of a surface with reference to a datum surface

	The tolerance zone is limited by two parallel planes a distance t apart and inclined at the specified angle to the datum surface.  datum surface	 The inclined surface is to be contained between two parallel planes 0.08 apart which are inclined at 40° to datum surface A.
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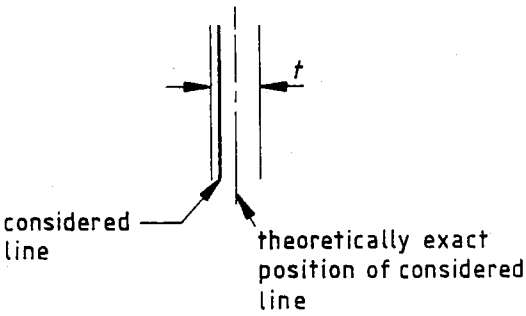
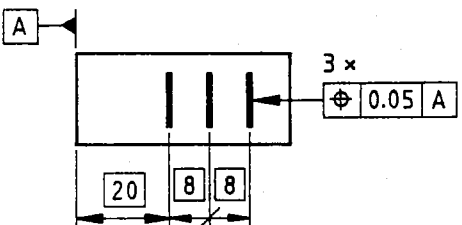
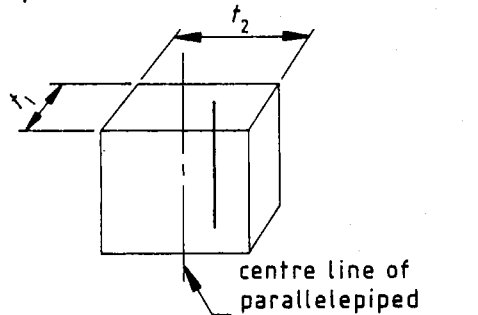
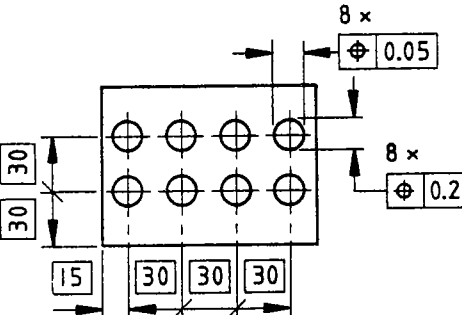
10.11 Positional tolerance

10.11.1 Positional tolerance of a point

	The tolerance zone is limited by a circle of diameter t, the centre of which is in the theoretically exact position of the considered point.  t dia	 The actual point of intersection is to be contained within a circular zone of 0.3 diameter, the centre of which coincides with the theoretically exact position of the considered point of intersection.
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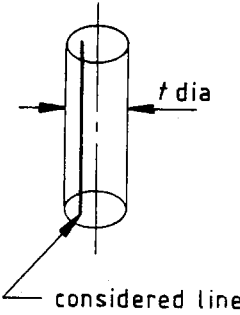
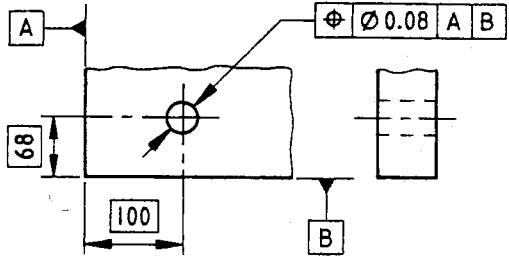
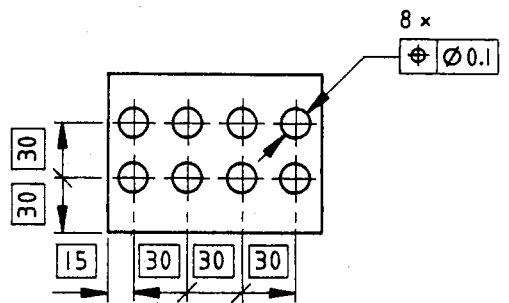
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.11.2 Positional tolerance of a line

	When the tolerance is specified in one direction only the tolerance zone is limited by two parallel straight lines (at a distance t apart) which are disposed symmetrically about the theoretically exact position of the considered line.  considered line theoretically exact position of considered line	 Each of the lines is to be contained between two parallel straight lines 0.05 apart which are symmetrically disposed about the theoretically exact position of the considered line with reference to datum A.
	When the tolerance is specified in two directions perpendicular to each other the tolerance zone is limited by a parallelepiped of section $t_1 \times t_2$ the centre line of which is in the theoretically exact position of the considered line.  centre line of parallelepiped	 Each of the axes of the eight holes is to be contained within a parallelepipedic zone of width 0.05 in the horizontal and 0.2 in the vertical direction the centre line of which is in the theoretically exact position of the considered hole axis.

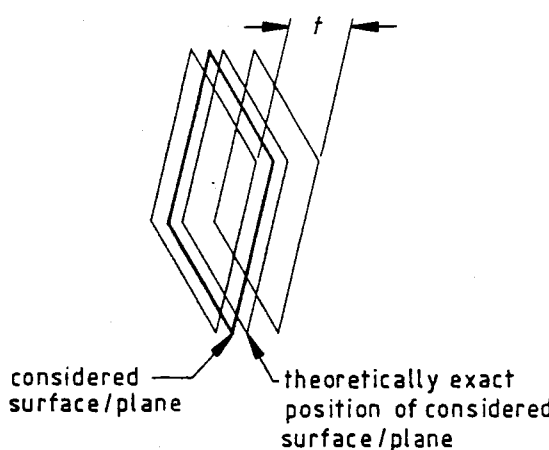
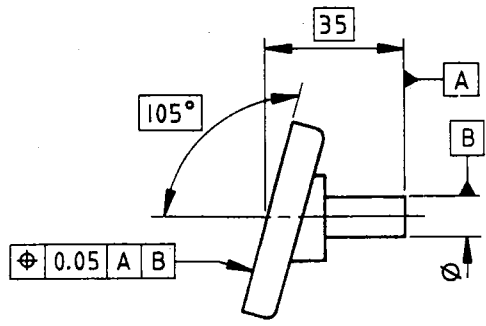
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.11.2 Positional tolerance of a line (concluded)

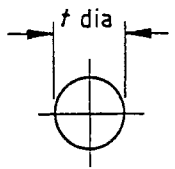
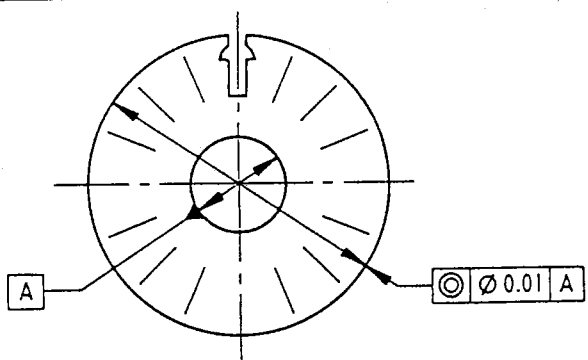
	When the tolerance value is preceded by the diameter symbol the tolerance zone is limited by a cylinder of diameter t the axis of which is in the theoretically exact position of the considered line. 	 The axis of the hole is to be contained within a cylindrical zone of diameter 0.08 the axis of which is in the theoretically exact position of the considered line, with reference to the datum surfaces A and B.  Each of the axes of the eight holes is to be contained within a cylindrical zone of diameter 0.1 the axis of which is in the theoretically exact position of the considered hole axis.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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10.11.3 Positional tolerance of a flat surface or a median plane

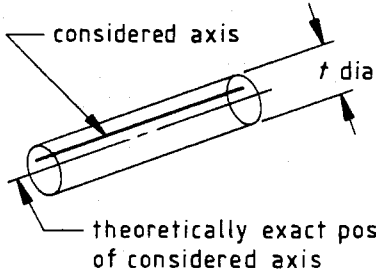
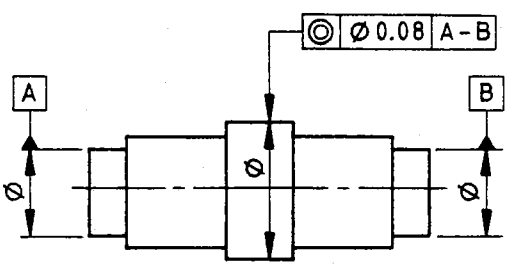
	The tolerance zone is limited by two parallel planes a distance t apart and disposed symmetrically about the theoretically exact position of the considered surface, or plane  considered surface/plane theoretically exact position of considered surface/plane	 The inclined surface is to be contained between two parallel planes which are 0.05 apart and which are symmetrically disposed about the theoretically exact position of the considered surface with reference to datum A and the axis of the datum cylinder B.
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10.12 Concentricity and coaxiality tolerance**10.12.1 Concentricity tolerance of a point**

	The tolerance zone is limited by a circle of diameter t the centre of which coincides with the datum point. 	 The centre of the circle to which the tolerance frame is connected is to be contained within a circular zone of diameter 0.01 concentric with the centre of the datum circle A.
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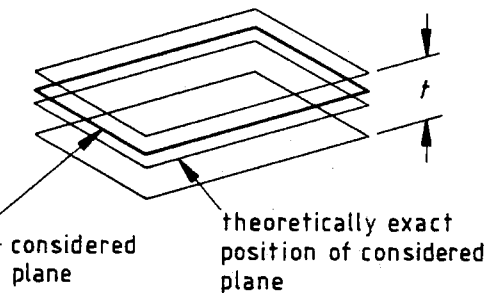
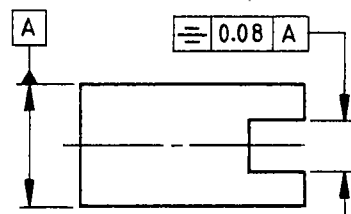
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.12.2 Coaxiality tolerance of an axis

	When the tolerance value is preceded by the diameter symbol the tolerance zone is limited by a cylinder of diameter t, the axis of which coincides with the datum axis. 	 The axis of the cylinder is to be contained within a cylindrical zone of diameter 0.08 coaxial with the datum axis A-B.
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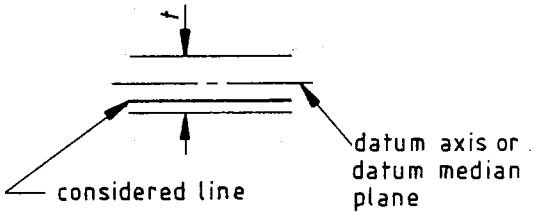
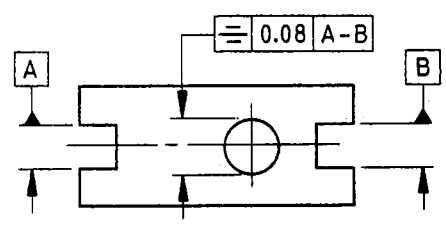
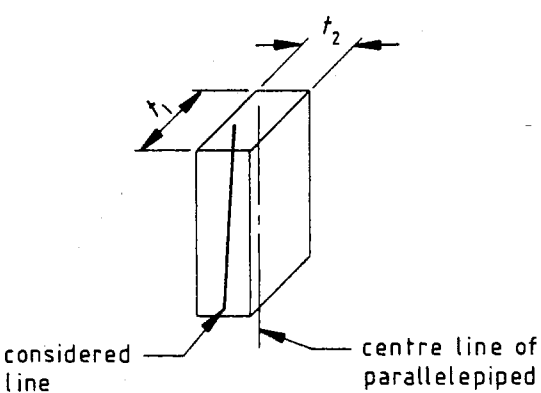
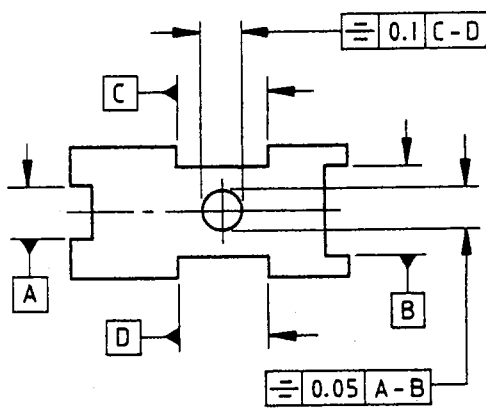
10.13 Symmetry tolerance

10.13.1 Symmetry tolerance of a median plane

	The tolerance zone is limited by two parallel planes a distance t apart and disposed symmetrically about the datum axis or datum median plane. 	 The median plane of the slot is to be contained between two parallel planes which are 0.08 apart and symmetrically disposed about the median plane of the datum feature A.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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10.13.2 Symmetry tolerance of a line or an axis

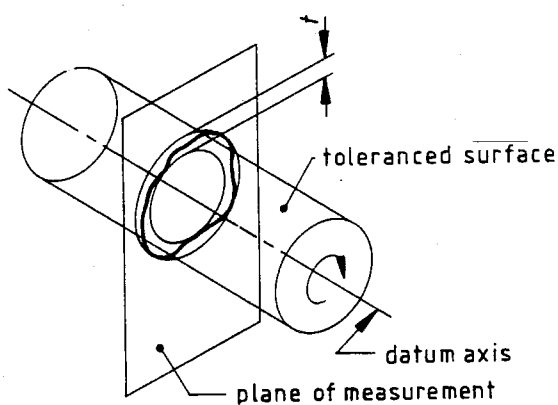
	When the tolerance is specified in one direction only the tolerance zone, when projected on a plane, is limited by two parallel straight lines a distance t apart which are disposed symmetrically about the datum axis or datum median plane. 	 The axis of the hole is to be contained between two parallel planes which are 0.08 apart and symmetrically disposed about the actual common median plane of the datum slots A and B.
	When the tolerance is specified in two directions perpendicular to each other the tolerance zone is limited by a parallelepiped of section $t_1 \times t_2$, the centre line of which coincides with the datum axis. 	 The axis of the hole is to be contained within a parallelepipedic zone of width 0.1 in the horizontal and 0.05 in the vertical direction, the centre line of which coincides with the datum line formed by the intersection of the common median planes A-B and C-D.

Symbol	Definition of the tolerance zone	Indication and interpretation
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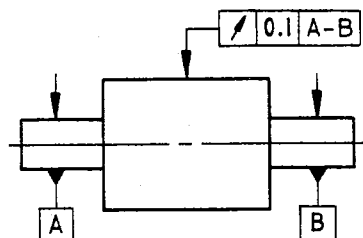
10.14 Circular run-out tolerance

10.14.1 Circular run-out tolerance: radial

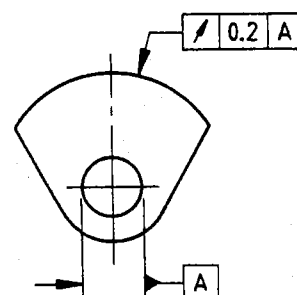
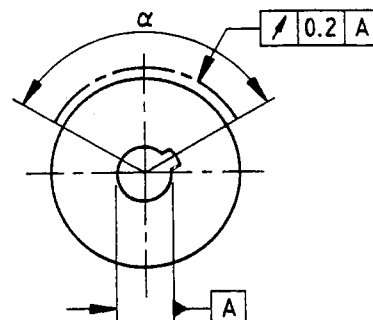
Within any plane of measurement perpendicular to the axis the tolerance zone is limited by two concentric circles a distance t apart, the centre of which coincides with the datum axis.



NOTE. Run-out is usually applied to complete revolutions about the axis unless limited to apply to a part of a revolution.



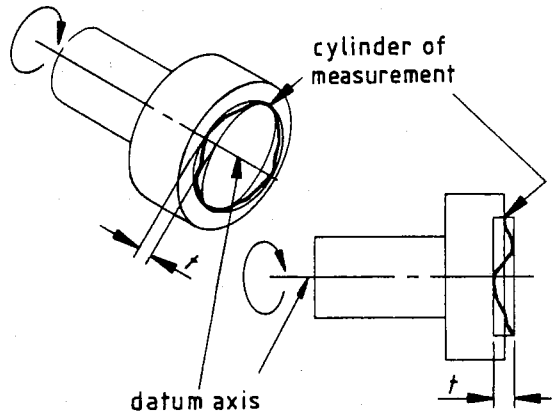
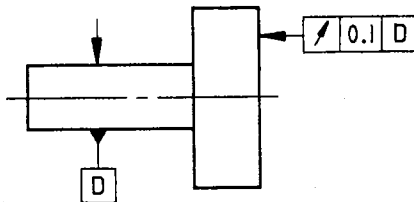
The radial run-out is to be not greater than 0.1 in any plane of measurement during one revolution about the datum axis A-B.



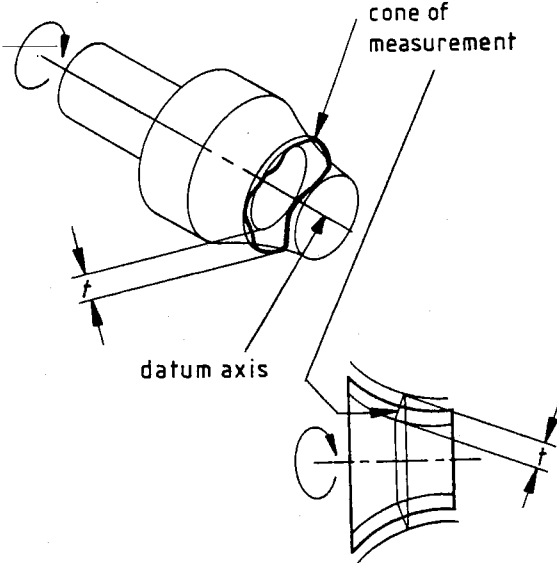
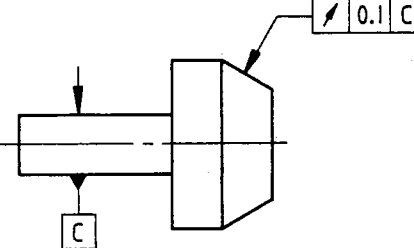
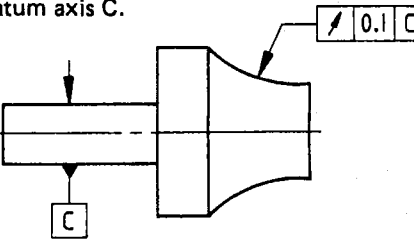
The radial run-out is to be not greater than 0.2 in any plane of measurement when measuring the toleranced part of a revolution about the axis of datum hole A.

Symbol	Definition of the tolerance zone	Indication and interpretation
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10.14.2 Circular run-out tolerance : axial

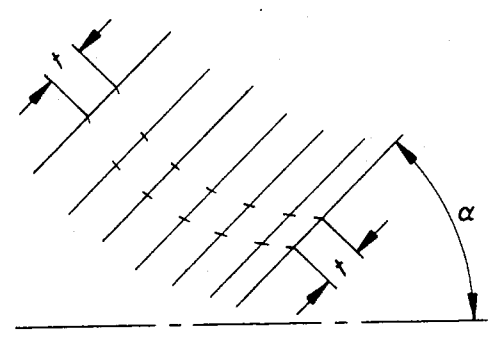
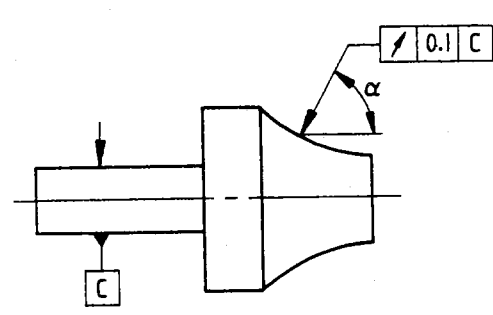
	At any radial position the tolerance zone is limited by two circles a distance t apart lying in a cylinder of measurement, the axis of which coincides with the datum axis. cylinder of measurement datum axis	 The axial run-out is to be not greater than 0.1 at any position of measurement during one revolution about the datum axis D.
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10.14.3 Circular run-out tolerance in any direction

	Within any cone of measurement the tolerance zone is limited by two circles a distance t apart. The axis of the cone of measurement coincides with the datum axis. Unless otherwise specified the direction of measurement is perpendicular to the surface. cone of measurement datum axis	 The run-out in the direction indicated by the arrow is to be not greater than 0.1 in any cone of measurement during one revolution about the datum axis C.  The run-out in the direction perpendicular to the tangent of the curved surface is to be not greater than 0.1 in any cone of measurement during one revolution about the datum axis C.
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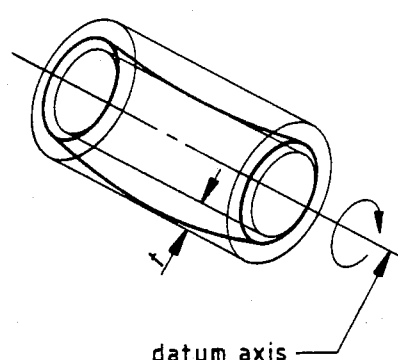
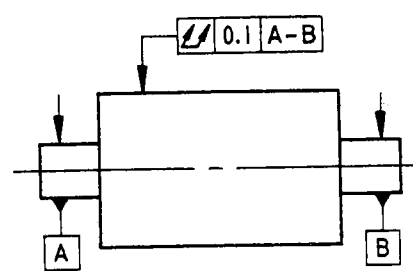
Symbol	Definition of the tolerance zone	Indication and interpretation
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10.14.4 Circular run-out tolerance in a specified direction

	Within any cone of measurement of the specified angle the tolerance zone is limited by two circles a distance t apart. The axis of the cone of measurement coincides with the datum axis. 	 The run-out in the specified direction is to be not greater than 0.1 in any cone of measurement during one revolution about the datum axis C.
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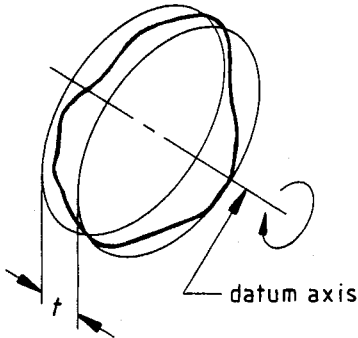
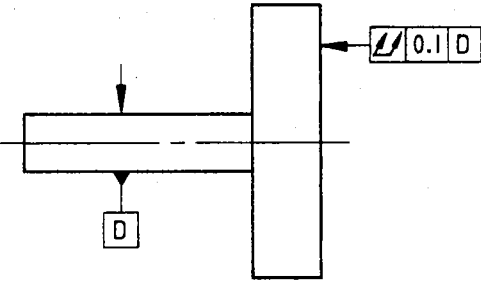
10.15 Total run-out tolerance

10.15.1 Total radial run-out tolerance

	The tolerance zone is limited by two coaxial cylinders a distance t apart, the axes of which coincide with the datum axis.  datum axis	 The total radial run-out is to be not greater than 0.1 at any point on the specified surface whilst revolving about the datum axis A-B, and with relative axial movement between workpiece and measuring instrument. With relative movement the measuring instrument or the workpiece is to be guided along a line having the theoretically exact form of the contour and being in its correct position relative to the datum axis.
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Symbol	Definition of the tolerance zone	Indication and interpretation
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10.15.2 Total axial run-out tolerance

	The tolerance zone is limited by two parallel planes a distance t apart and perpendicular to the datum axis. 	 The total run-out is to be not greater than 0.1 at any point on the specified surface whilst revolving about the datum axis D and with relative radial movement between the measuring instrument and the workpiece. With relative movement the measuring instrument or the workpiece is to be guided along a line having the theoretically exact form of the contour and being in its correct position relative to the datum axis.
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11 Envelope requirement

11.1 General

When tolerancing with independency of size and form is used (see clause 11 of BS 308 : Part 2 : 1985), the envelope requirement may be locally applied to a single feature-of-size (either a cylindrical surface or a feature established by two plane parallel surfaces). The requirement means that the boundary of perfect form at maximum material size (see section three) of the feature-of-size is not to be violated.

The envelope requirement is indicated by the symbol $\textcircled{E}$ placed after the size dimension as shown in figure 16(a).

11.2 Envelope requirement applied to a cylindrical feature

11.2.1 Drawing indication. The drawing indication is shown in figure 16(a).

11.2.2 Functional requirements. The drawing in figure 16(a) indicates the following functional requirements.

- (a) The surface of the cylindrical feature is not to extend beyond the envelope of perfect form at the maximum material size of 150 diameter.
- (b) No actual local size is to be less than 149.96 diameter.

11.2.3 Interpretation. The actual part is to meet the following requirements.

- (a) Each actual local diameter of the cylindrical feature is to remain within the size tolerance of 0.04 and, therefore, may vary between 150 diameter and 149.96 diameter (see figure 16(b)).
- (b) The entire cylindrical feature is to remain within the boundary of the enveloping cylinder of perfect form of 150 diameter (see figures 16(c) and (d)).

It follows that the feature is to be exactly cylindrical when all actual local diameters are at the maximum material size of 150 diameter (see figure 16(e)).

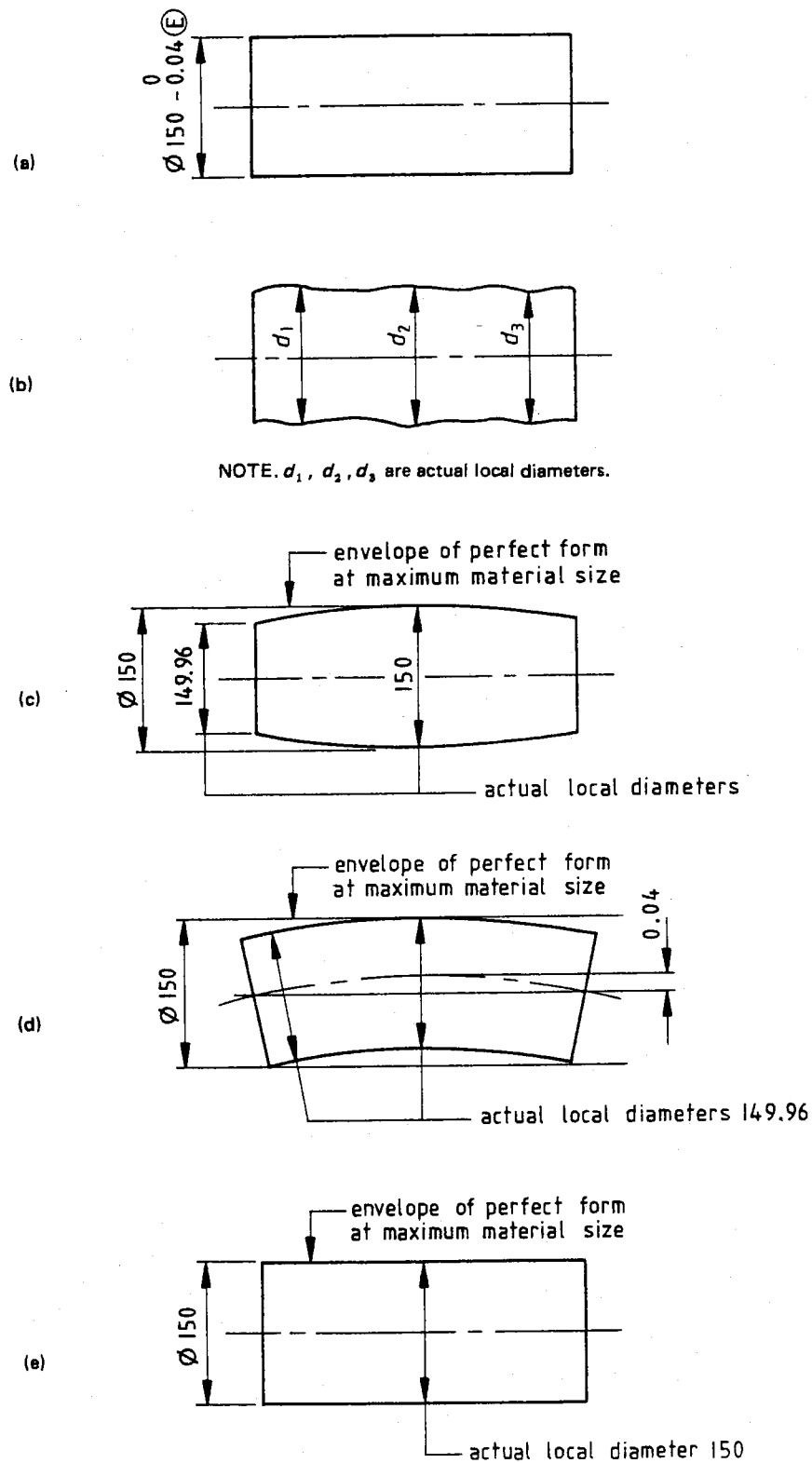


Figure 16. Envelope requirement applied to a cylindrical feature

Section two. Datums and datum systems

12 Introduction

12.1 General

Datums and datum systems are used to establish the relationship of geometrically tolerated features.

It is usually impracticable to measure from theoretical datum planes or axes. The planes or axes are therefore assumed to exist, not in the part itself, but in precisely made manufacturing fixtures or inspection equipment, the surfaces of which are of such a high quality that they are deemed to simulate perfect planes or to define axes.

12.2 Definitions

12.2.1 datum. A theoretically exact geometric reference such as an axis, plane, straight line, etc., to which tolerated features are related.*

NOTE. A datum is established by one or more datum features of a part.

12.2.2 datum feature. A real feature of a part (such as an edge, or a flat or a cylindrical surface) which is used to establish the location of a datum (see clause 14).

NOTE. As datum features are subject to manufacturing variations, it may be necessary to specify geometrical tolerances for them.

12.2.3 datum system. A group of two or more datums used as a reference for a tolerated feature.

12.2.4 simulated datum. A real surface of adequately precise form such as a surface plate, bearing, mandrel, etc. or a surface within a precise fixture, piece of equipment or machine which, when placed in contact with a datum feature, establishes that datum.

NOTE. A simulated datum is used as the practical embodiment of the specified datum during manufacture and inspection and is considered to be perfect.

12.2.5 datum target. A point, line or limited area of defined size and location specified on a datum feature to ensure repeatable contact with a simulated datum (see clause 16).

13 Indication of datums and datum systems

13.1 Indication of datums and datum features

A datum should be indicated by an equilateral triangular symbol (see table 2 and figure 17).

The datum should be identified by a capital letter enclosed in a frame connected to a datum symbol (see table 2).

When a tolerated feature is related to a datum, the same letter which defines the datum should be repeated in the tolerance frame. A different letter should be used for each datum identification.

NOTE. Where there is likelihood of confusion with the numerals 0 and 1 and the symbols $\textcircled{M}$, $\textcircled{P}$ and $\textcircled{E}$ the letters E, I, O, M, P and Q and other letters already in use for sections should be avoided.

The datum symbol should be placed as follows:

- on the outline of the feature or an extension of the outline (but clearly separated from any dimension line), when the datum feature is the line or surface itself (see figure 17(a));
- as an extension of the diameter dimension line when the datum is an axis or as an extension of a width dimension line when the datum is a median plane (see figures 17(b), (c) and (d));
- on the centre line of the feature when the datum is one of the following:
 - the common axis or median plane of two features (see figure 17(e));
 - the axis of a single feature, e.g. a cylinder.

When the tolerance frame can be directly connected in a clear and simple manner with the datum symbol by a leader line, the datum letter may be omitted (see figure 18).

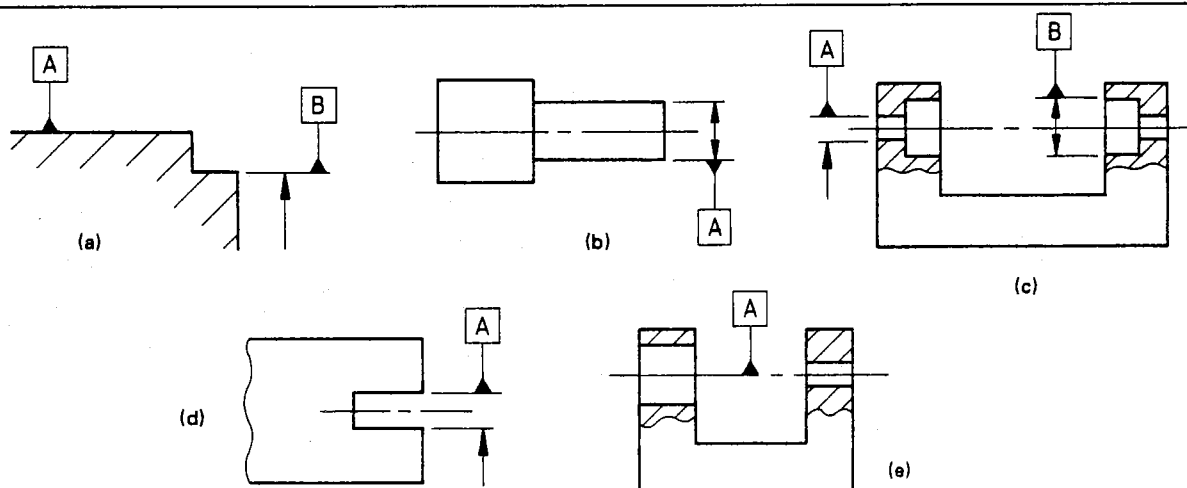
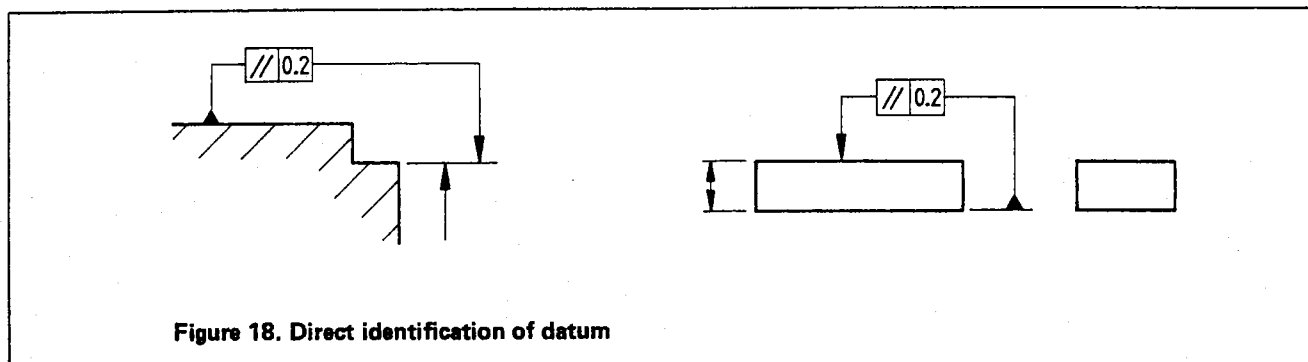


Figure 17. Indication of datums and datum features

*This definition is repeated from BS 308 : Part 2 : 1985.



13.2 The indication of datums and datum systems within a tolerance frame

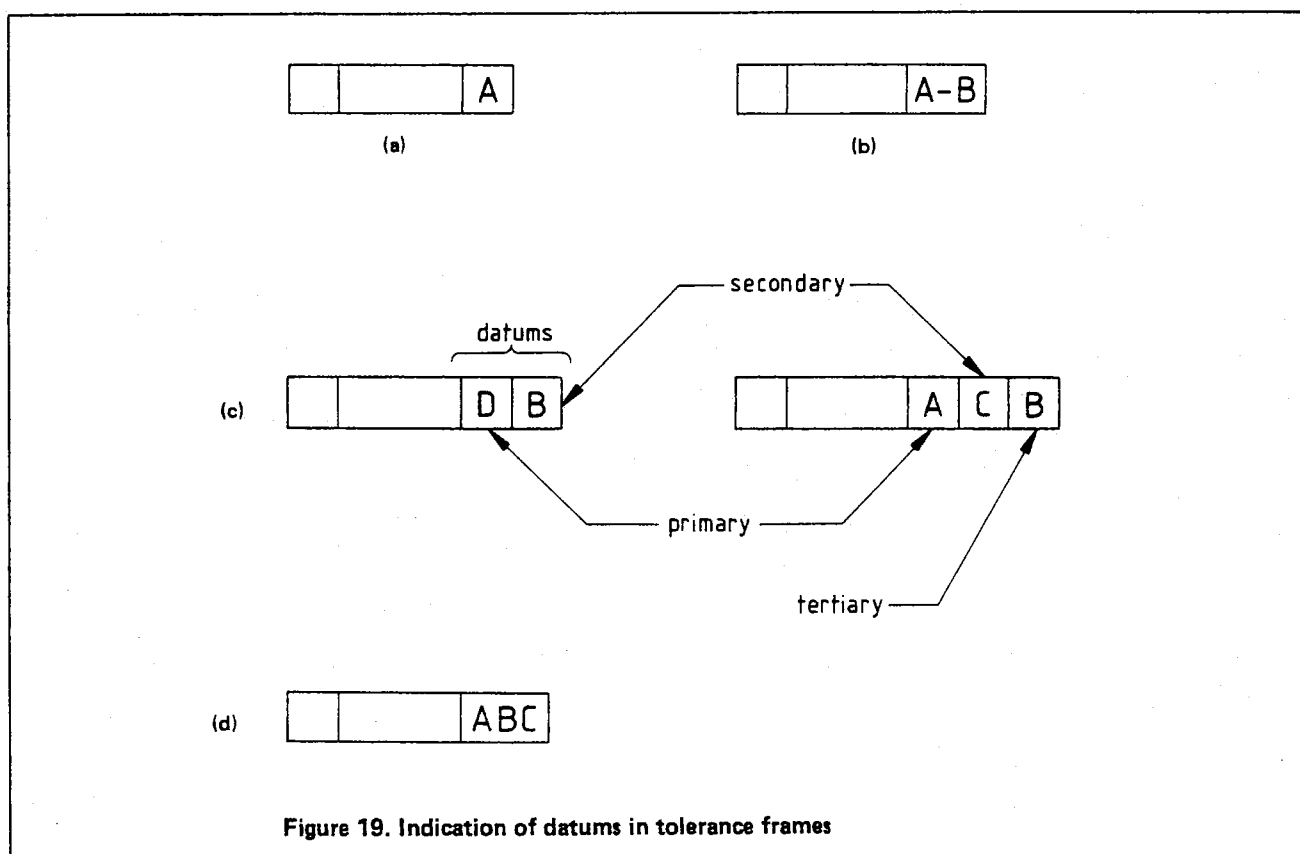
13.2.1 Datum established by a single feature. Where the datum is established by a single feature, it should be indicated by a letter in the third compartment of the tolerance frame (see figure 19(a)).

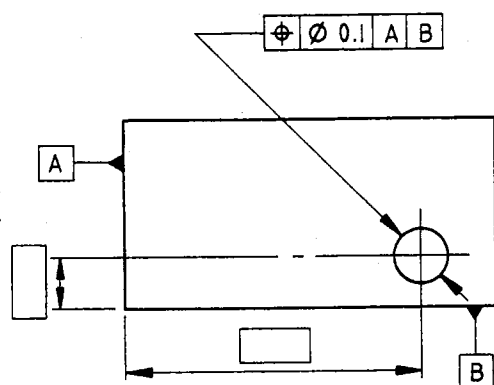
13.2.2 A common datum established by two features. Where a common datum is established by two features, it should be indicated in the third compartment of the tolerance frame by two letters separated by a hyphen (see figure 19(b)).

13.2.3 Datum system established by two or more datum features

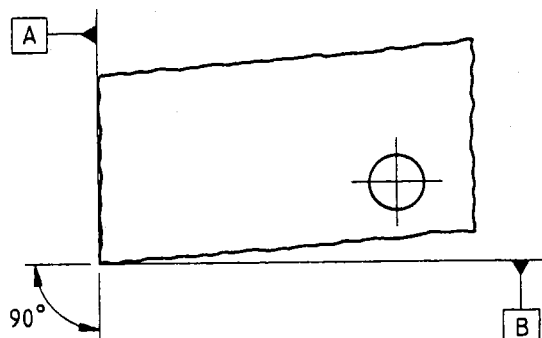
13.2.3.1 Where the order of priority of the datums is significant, the letters identifying the datums should be placed in separate compartments as shown in figure 19(c), where the sequence from left to right indicates the order of priority.

13.2.3.2 The choice of sequence of the datums can have considerable influence on the result obtained (see figure 20), but where the order of priority of the datums is not significant, the letters identifying the datums should be placed together in the third compartment of the tolerance frame (see figure 19(d)).



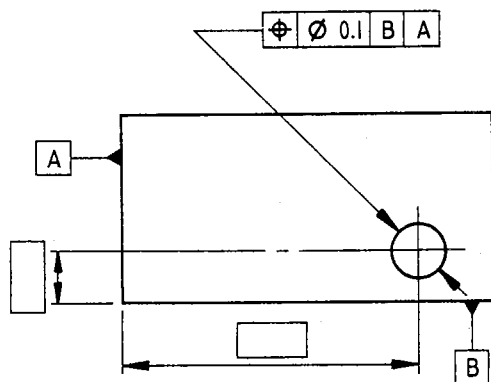


Drawing indication

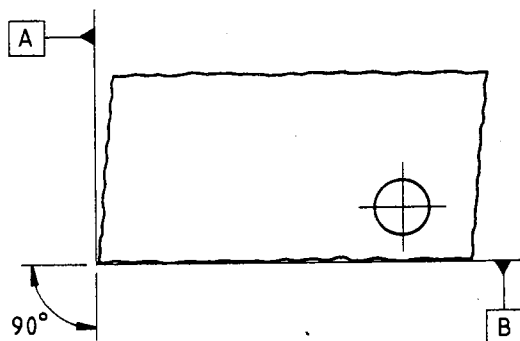


Resulting position of hole

NOTE. A is primary datum
B is secondary datum



Drawing indication



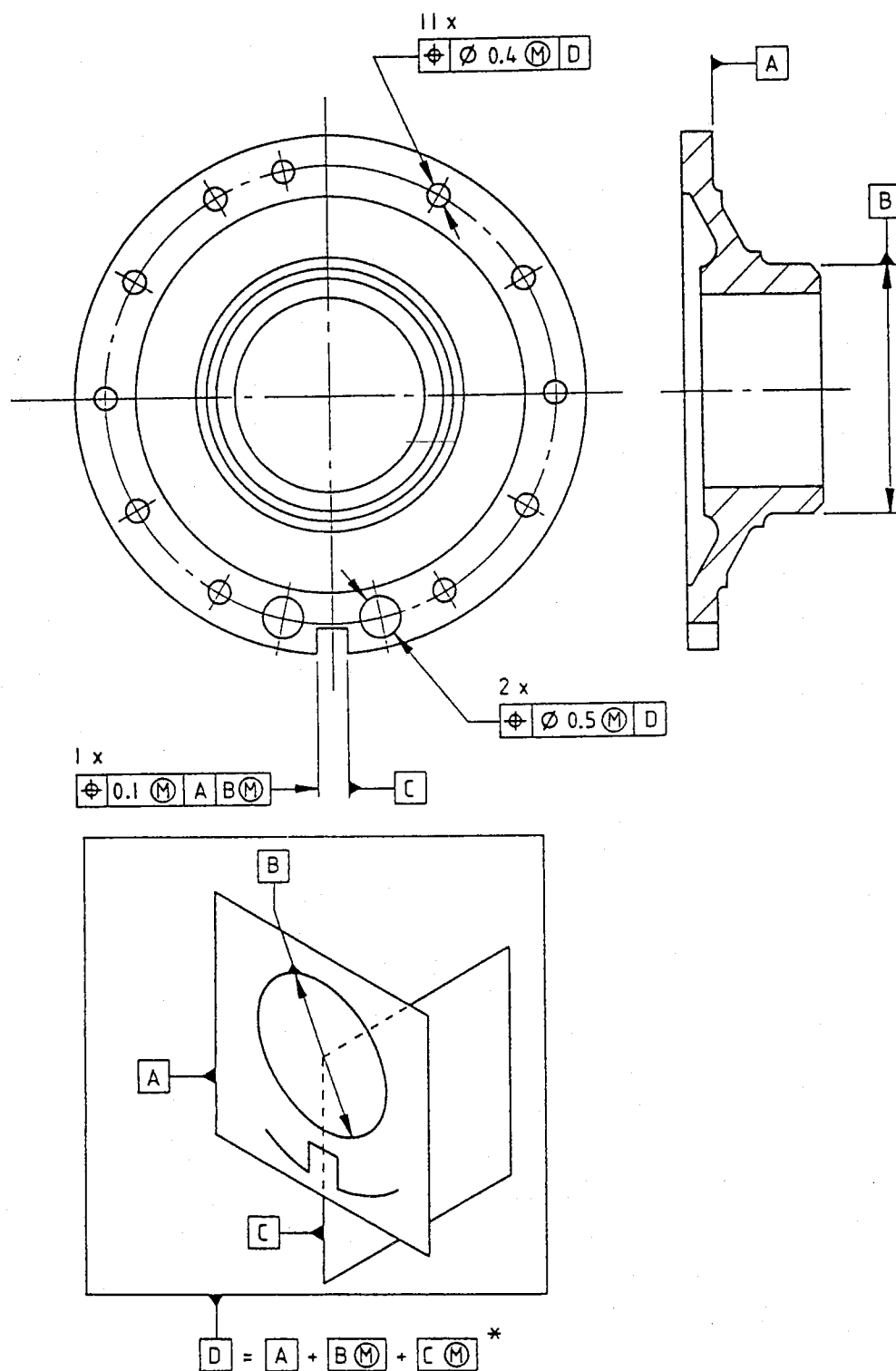
Resulting position of hole

NOTE. B is primary datum
A is secondary datum

Figure 20. Datum sequence interpretation

13.2.3.3 Where the datum system is complex it may be identified by a single letter (see figure 21).

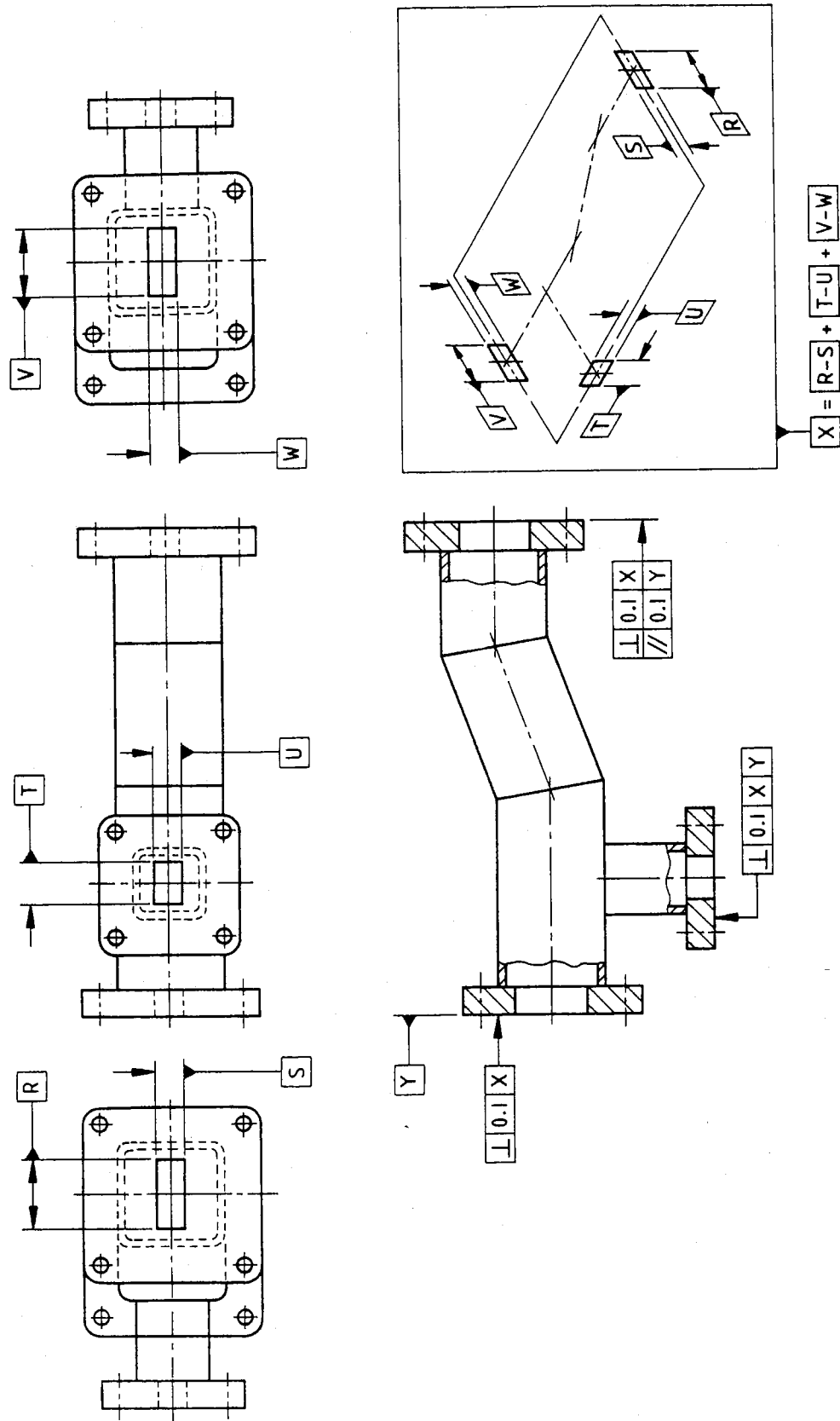
An additional explanatory drawing should be added to the drawing showing the datums which make up the multiple datum system. The single letter in the tolerance frame is related to the datums by a datum equation applied to the explanatory drawing. The sequence of datums from left to right in the datum equation indicates the order of priority.



* Note this equation has the same meaning as $\boxed{} \text{ A B (M) C (M)}$

(a) Housing

Figure 21. Examples of a datum system identified by a single letter

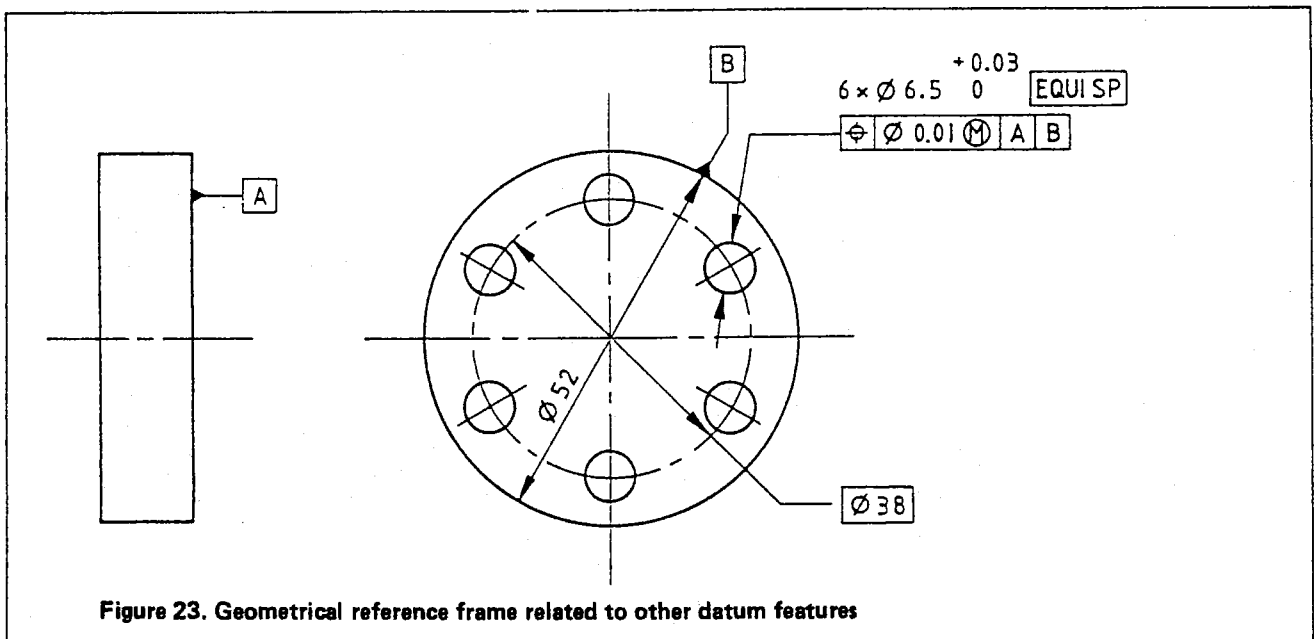
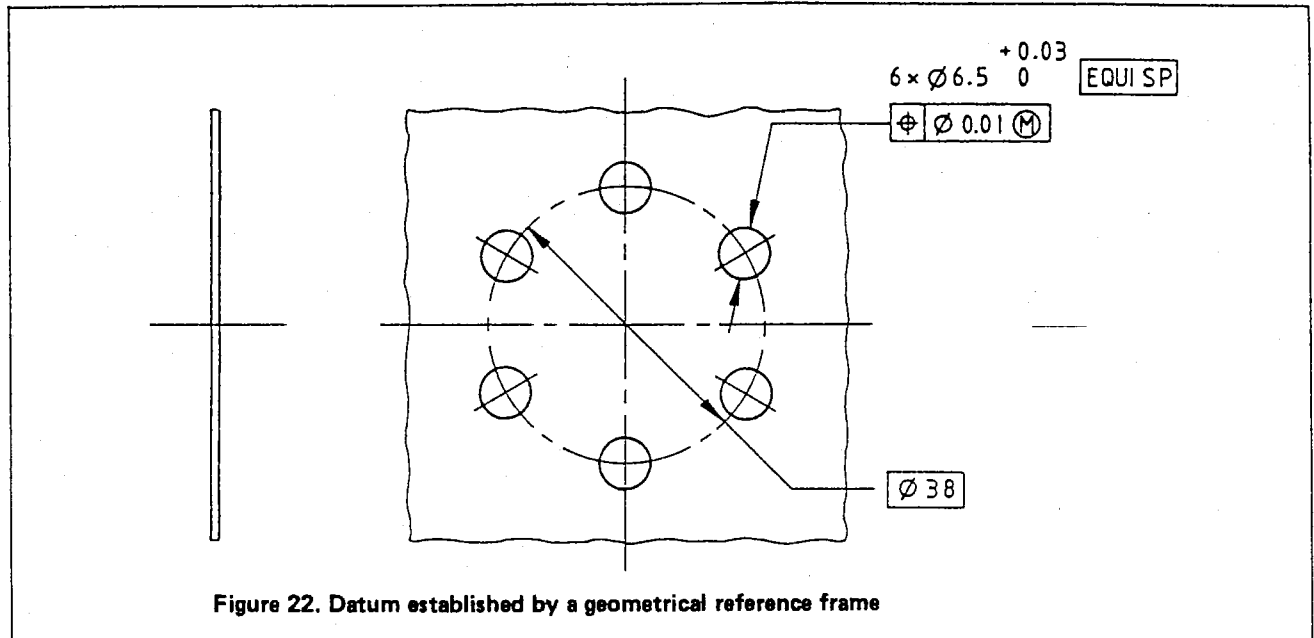


(b) Rectangular tube assembly

Figure 21. Examples of a datum system identified by a single letter (concluded)

13.2.4 Datum established by a geometrical reference frame.
If a positional tolerance is specified for the individual features of a group, in relation to their true positions within the group, without nominating any one feature as a datum, the datum is the geometrical reference frame of the group (see figure 22).

13.2.5 Datum for a geometrical reference frame. Where a geometrical reference frame is related to another feature or features, the datum features should be indicated as in figure 23.



13.2.6 Datum established by a group of geometrically tolerated features. When a group of features which is subject to a geometrical tolerance is to be used as a datum, as with the six holes and datum C in figure 24, the datum identifying frame should be attached to the geometrical tolerance frame that applies to the group of features.

Datum C in practice is the axes of the six holes forming the group. The axes are in their theoretically exact positions as defined by their geometrical reference frame. The length of the axes is the length of the holes and the axes are perpendicular to the primary datum. The geometrical reference frame lies on the primary datum.

When a datum identifying frame is attached to a geometrical tolerance frame the datum indicated in the datum identifying frame does not include the datums indicated in the geometrical tolerance frame. Thus, in figure 24, datum C does not include datum A and datum B.

14 The establishment of datums from datum features

14.1 General

When establishing datums, the following methods may be used to allow for manufacturing imperfections of the datum feature(s).

14.2 Datum being a straight line or a plane

The datum feature should be arranged in such a way that the maximum distance between it and the simulated datum feature has the least possible value, as in appendix C.

14.3 Datum being the axis of a cylinder

The datum should be the axis of the largest inscribed cylinder (simulated datum feature) of a hole (see figure 25), or the smallest circumscribed cylinder of a shaft, so orientated that any possible angular movement of the cylinder in any plane is equalized.

14.4 Datum being a common axis or common median plane

In figure 26 the datum is the common axis of the two smallest circumscribed coaxial cylinders.

NOTE. Depending on circumstances the position and length of the simulated datum may need to be indicated as less than the overall length of the datum feature.

14.5 Datums being the axis of a cylinder and a perpendicular plane

In figure 27 primary datum A is the plane represented by the contacting flat surface. Secondary datum B is the axis of the largest inscribed cylinder, perpendicular to datum A.

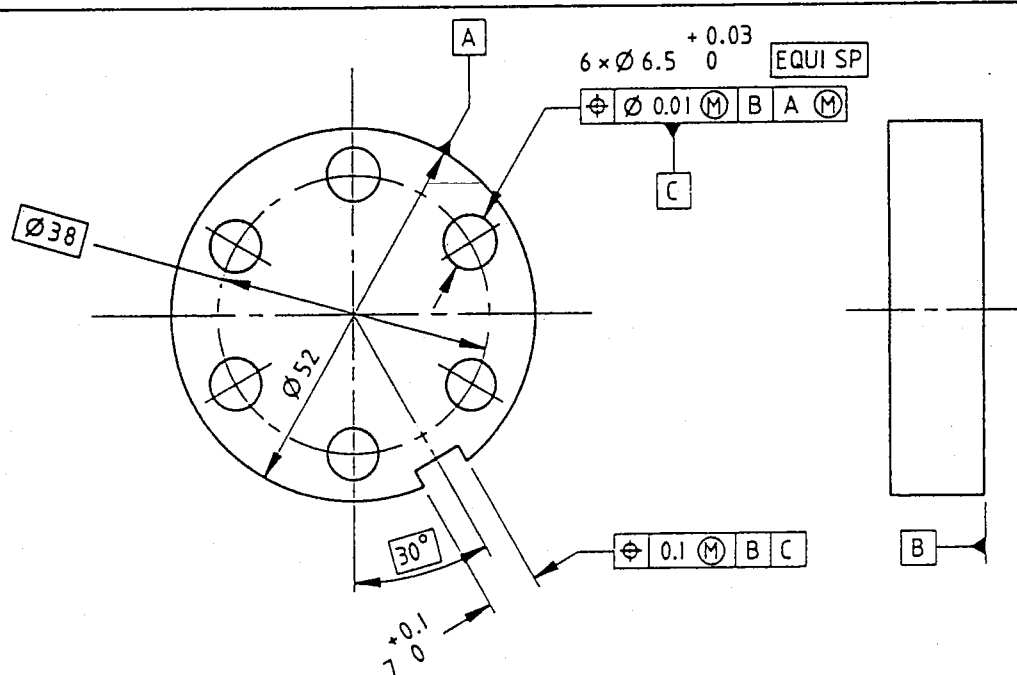
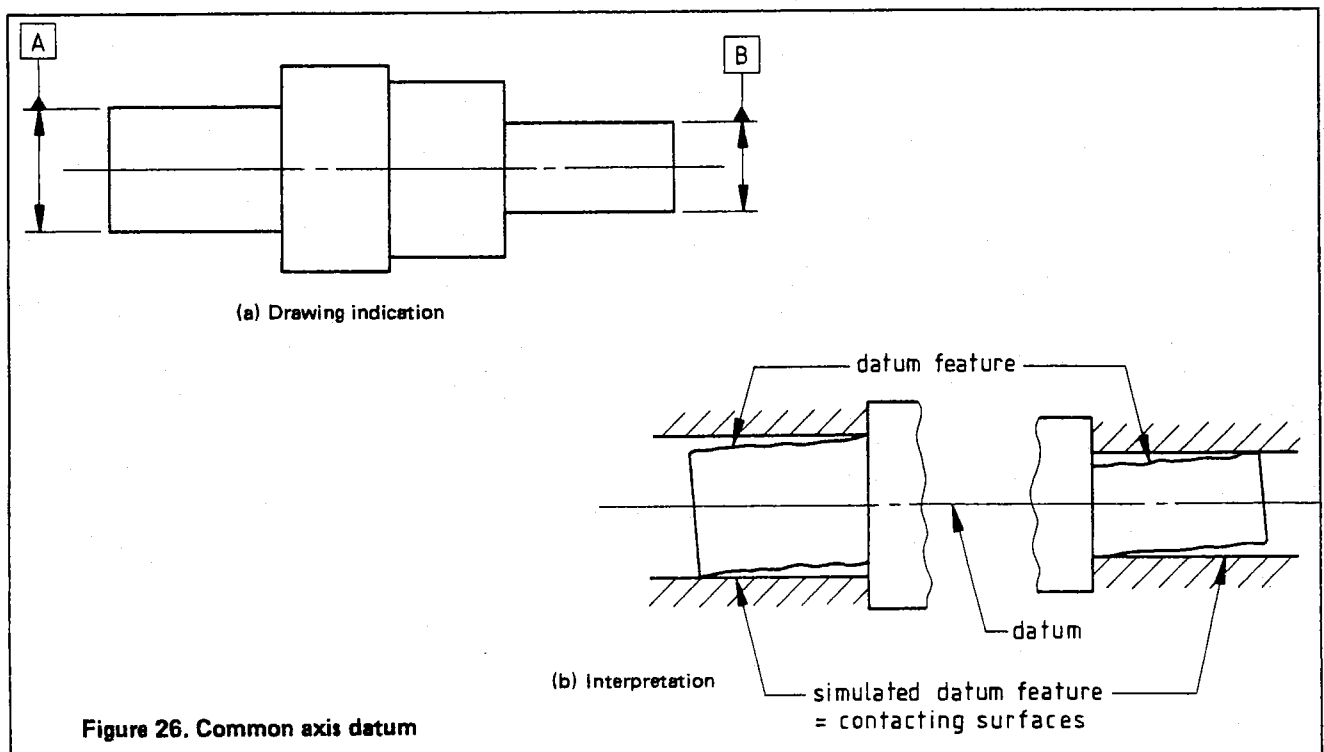
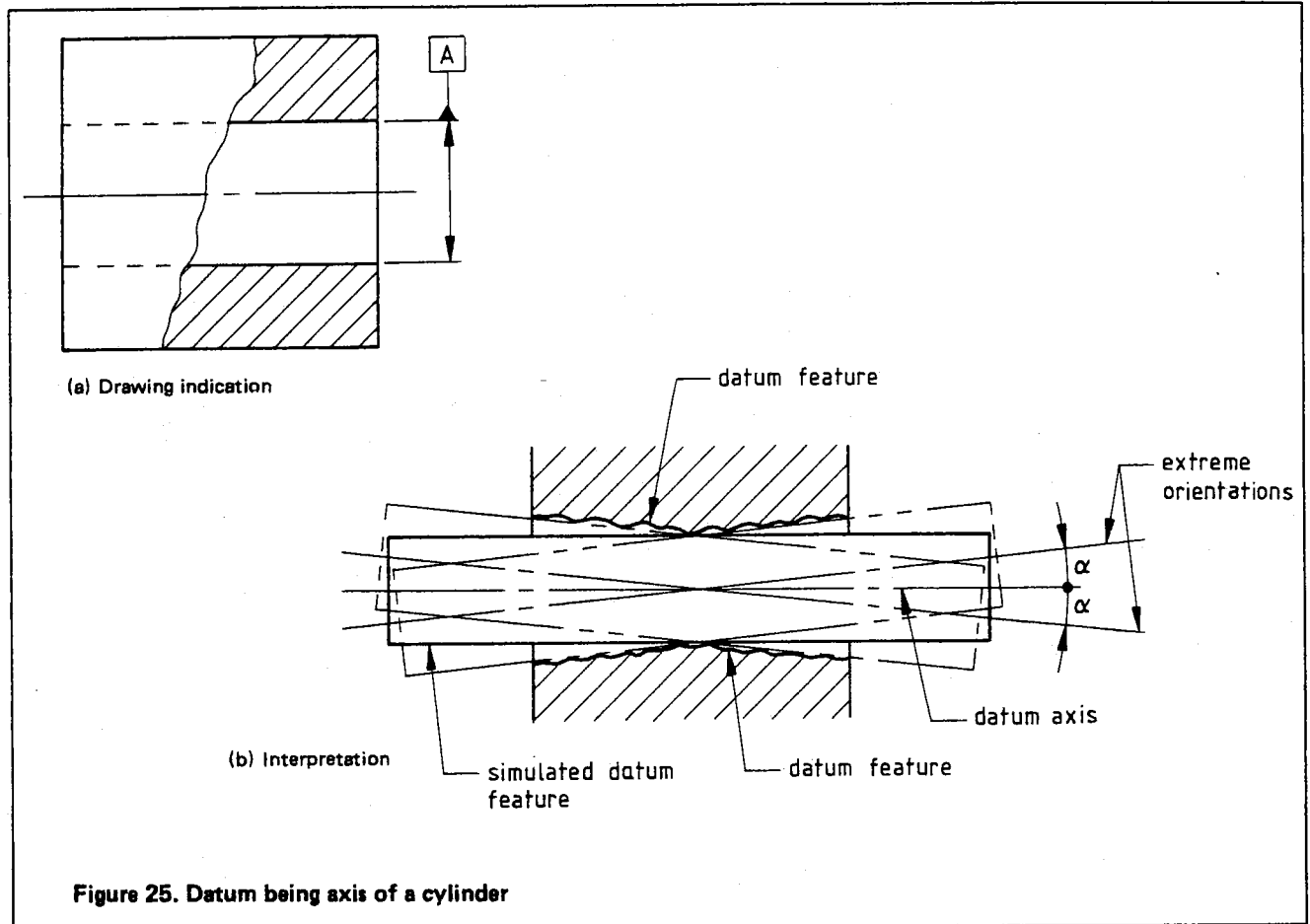
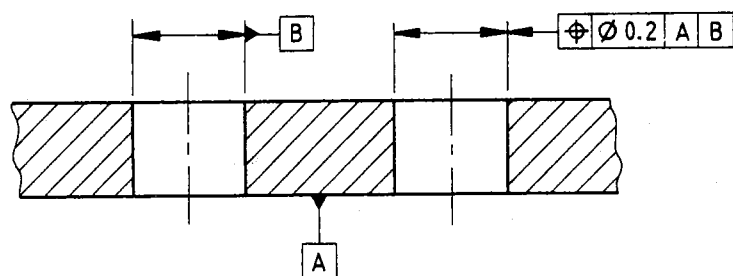
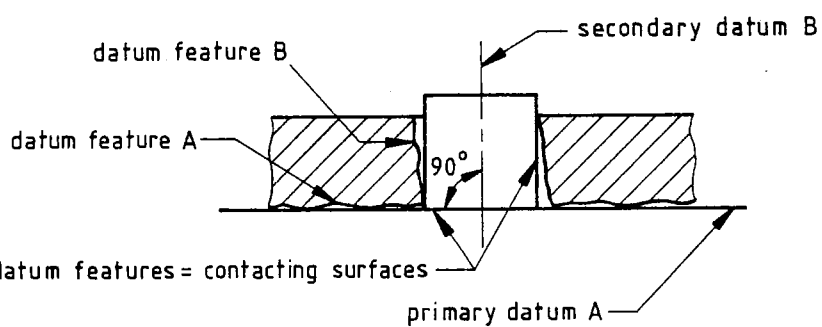


Figure 24. Group of geometrically tolerated features as datum





(a) Drawing indication



(b) Interpretation of datum hole

Figure 27. Datums being axis of cylinder and perpendicular plane

15 Application of datums

Table 3 shows examples of:

- (a) the indication of datums;
- (b) the datum features;
- (c) how datums are established by means of simulated datum features.

Table 3. Examples of application of datums

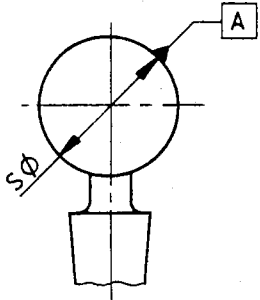
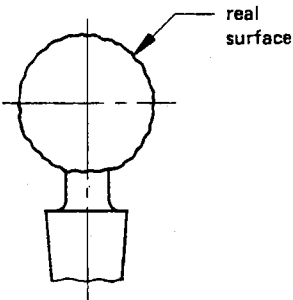
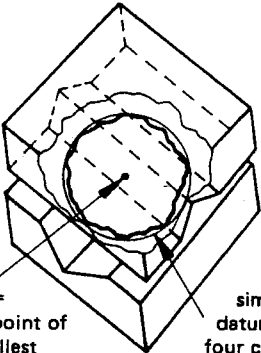
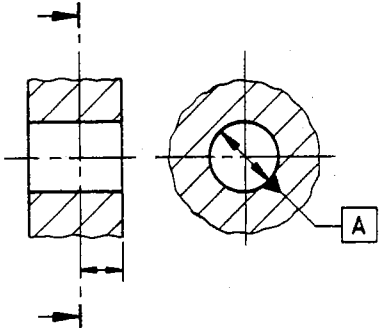
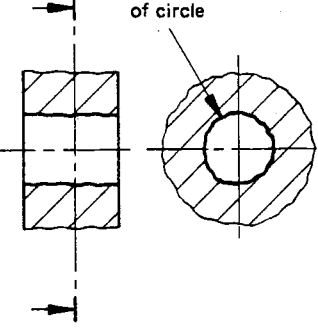
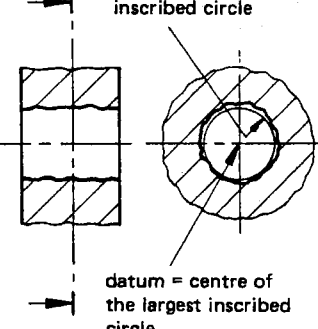
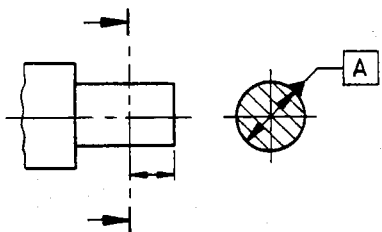
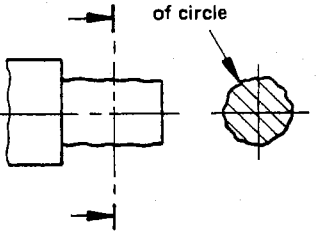
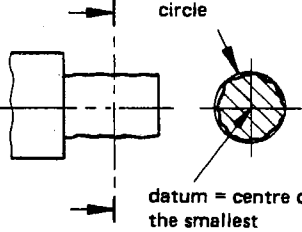
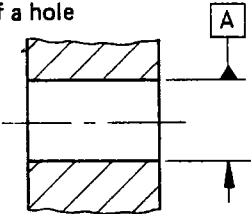
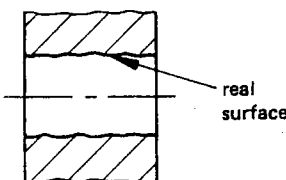
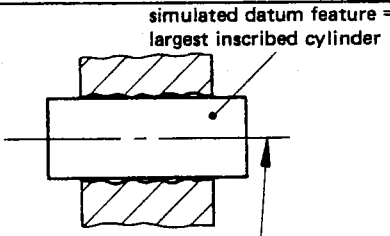
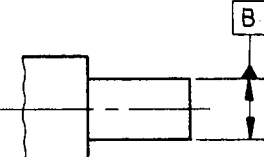
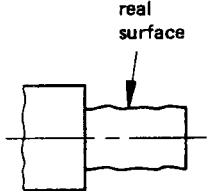
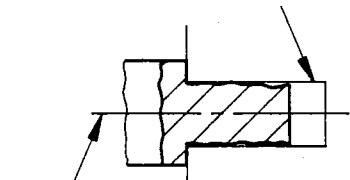
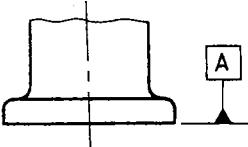
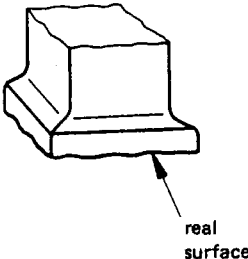
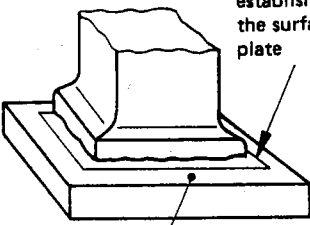
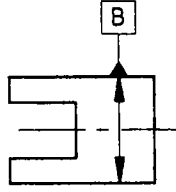
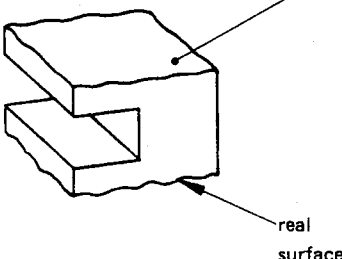
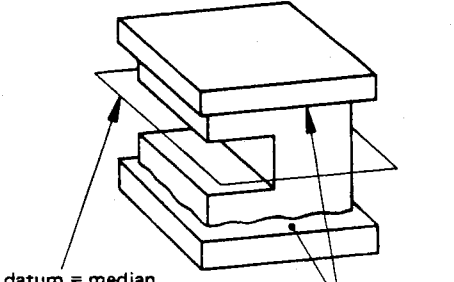
Drawing indication of datum	Datum feature	Establishment of datum
(a) Datum: centre-point		
Centre-point of a sphere 	 real surface	 datum = centre-point of the smallest circumscribed sphere simulated datum feature = four contacting points (representing the smallest circumscribed sphere) on the vee-block
Centre-point of a circle 	 real profile of circle	 simulated datum feature = largest inscribed circle datum = centre of the largest inscribed circle
Centre-point of a circle 	 real profile of circle	 simulated datum feature = smallest circumscribed circle datum = centre of the smallest circumscribed circle

Table 3. Examples of application of datums (concluded)		
Drawing indication of datum	Datum feature	Establishment of datum
(b) Datum: line		
Axis of a hole 	 real surface	 simulated datum feature = largest inscribed cylinder datum = axis of the largest inscribed cylinder
Axis of a shaft 	 real surface	 simulated datum feature = smallest circumscribed cylinder datum = axis of the smallest circumscribed cylinder
(c) Datum: plane		
Surface of a part 	 real surface	 datum = plane established by the surface plate simulated datum feature = surface of the surface plate
(d) Datum: median plane		
Median plane of the two surfaces of a part 	 real surface real surface	 datum = median plane established by the two contacting flat surfaces simulated datum feature = contacting flat surfaces

16 Datum targets

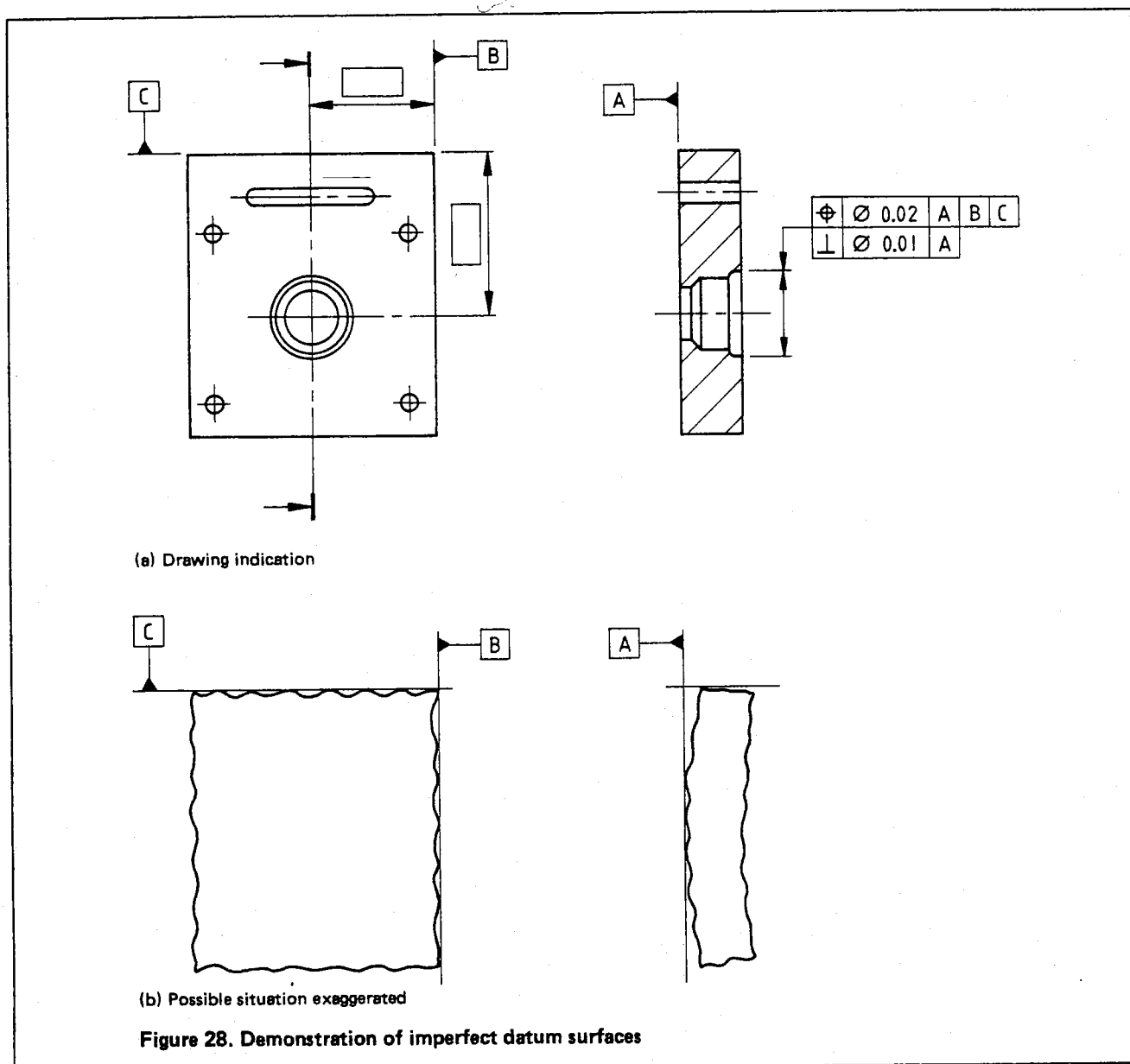
16.1 General

All datum features no matter how produced are subject to deviation (see figure 28). It may be impractical to designate an entire surface as a datum feature because accurate and repeatable measurements may not be possible. In order to establish practical datums, suitable locations called datum targets may be selected and indicated on the drawing. A datum target may be a point, a line, or an area.

The positions of these datum targets should be specified by toleranced linear dimensions.

All toleranced dimensions to a feature from a surface containing datum targets should be taken as being dimensioned from the plane of those datum targets only and not from the entire surface.

Before specifying the datum targets, it is necessary to consider whether the functioning of the part might be endangered by specifying limited datum locations only instead of the whole surface.



16.2 Indication of datum targets

- 16.2.1 *General.* A datum target should be indicated by a datum target frame and a datum target symbol.
- 16.2.2 *Datum target frame.* The datum target frame should be a circle divided into two compartments by the horizontal diameter.

The lower compartment should contain a datum target identification consisting of the datum identifying letter and a numeral. The numeral should distinguish the datum target from others for the same datum feature (see figure 29).

The upper compartment should contain the dimension(s) of the target area as appropriate (see figure 29(a) and (b)). If there is not sufficient space within the compartment, the information may be placed outside and connected to the compartment by a leader line (see figure 29(c)). Where the datum target is a point or a line, the upper compartment should be empty.

- 16.2.3 *Datum target symbols.* When the datum target is a point, it should be indicated by a cross, see figure 30(a); when it is a line it should be indicated by a line terminated by crosses, see figure 30(b); and when it is an area, it should be indicated by a hatched area bounded by a type K line (see BS 308 : Part 1 and figure 30(c)).
- The symbols should be placed and dimensioned on that view which shows most clearly the locations of the datum targets (see figure 31).

NOTE. Theoretically exact (boxed) dimensions should not be used.

16.2.4 *Leaders.* A leader from the datum target frame terminating in an arrowhead should point towards the datum target symbol (see figure 31). In the case of a datum target line the leader line should be directed towards the centre of the line.

- 16.2.5 *Datum target equations.* The primary, secondary and tertiary datums should be identified on the drawing by the appropriate datum target equations, e.g. $A = A1 + A2 + \dots$ etc. (see figures 32 and 33).

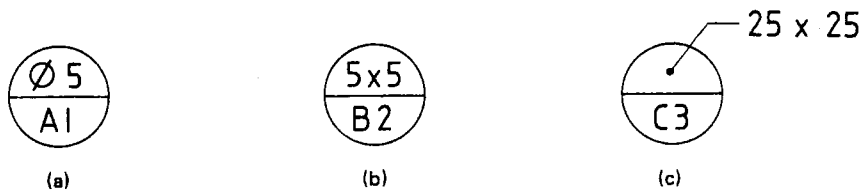


Figure 29. Datum target frame

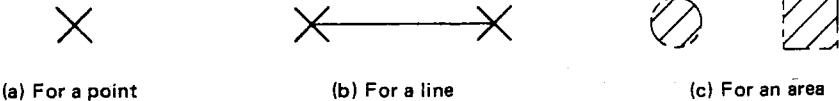
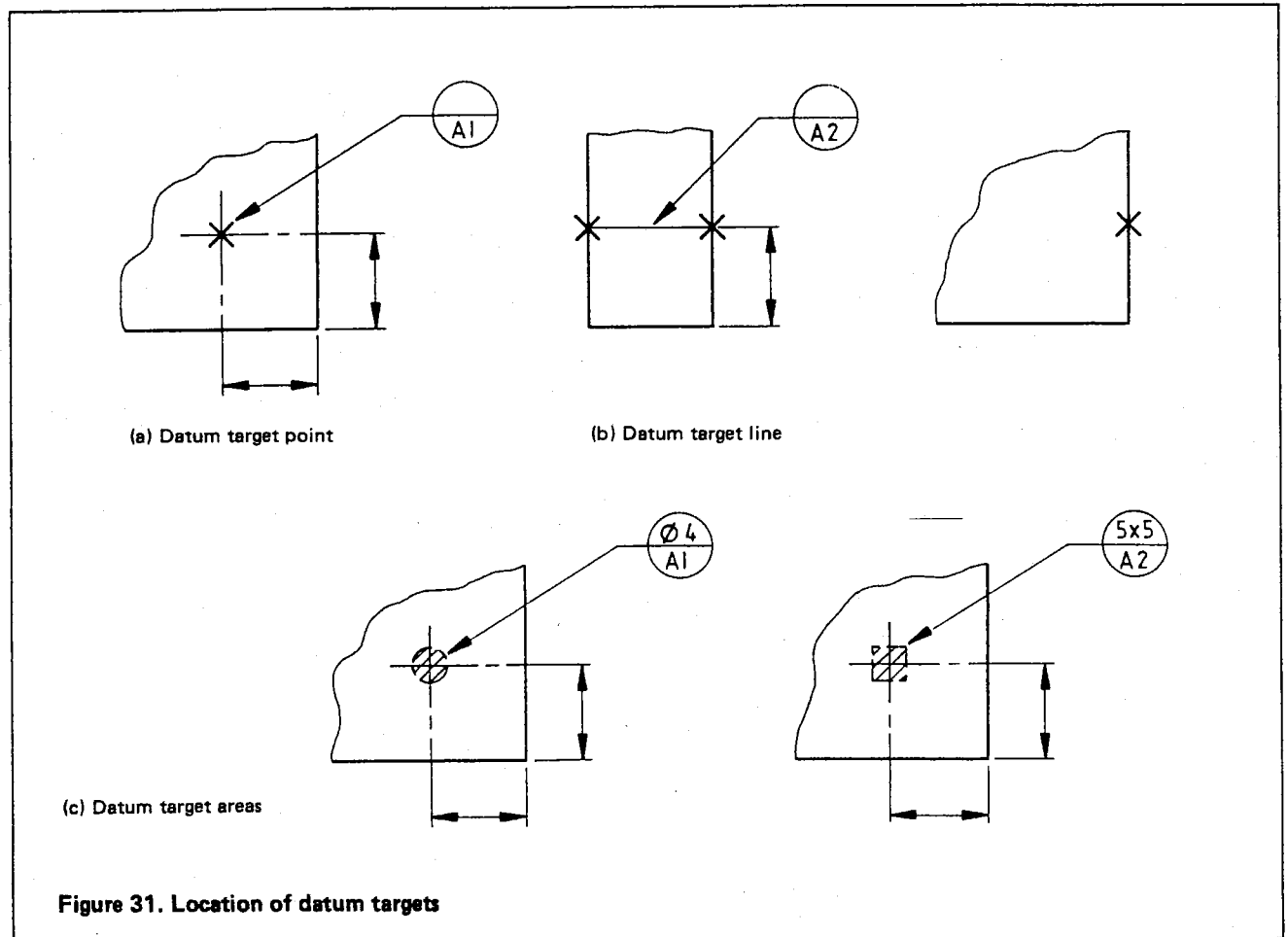
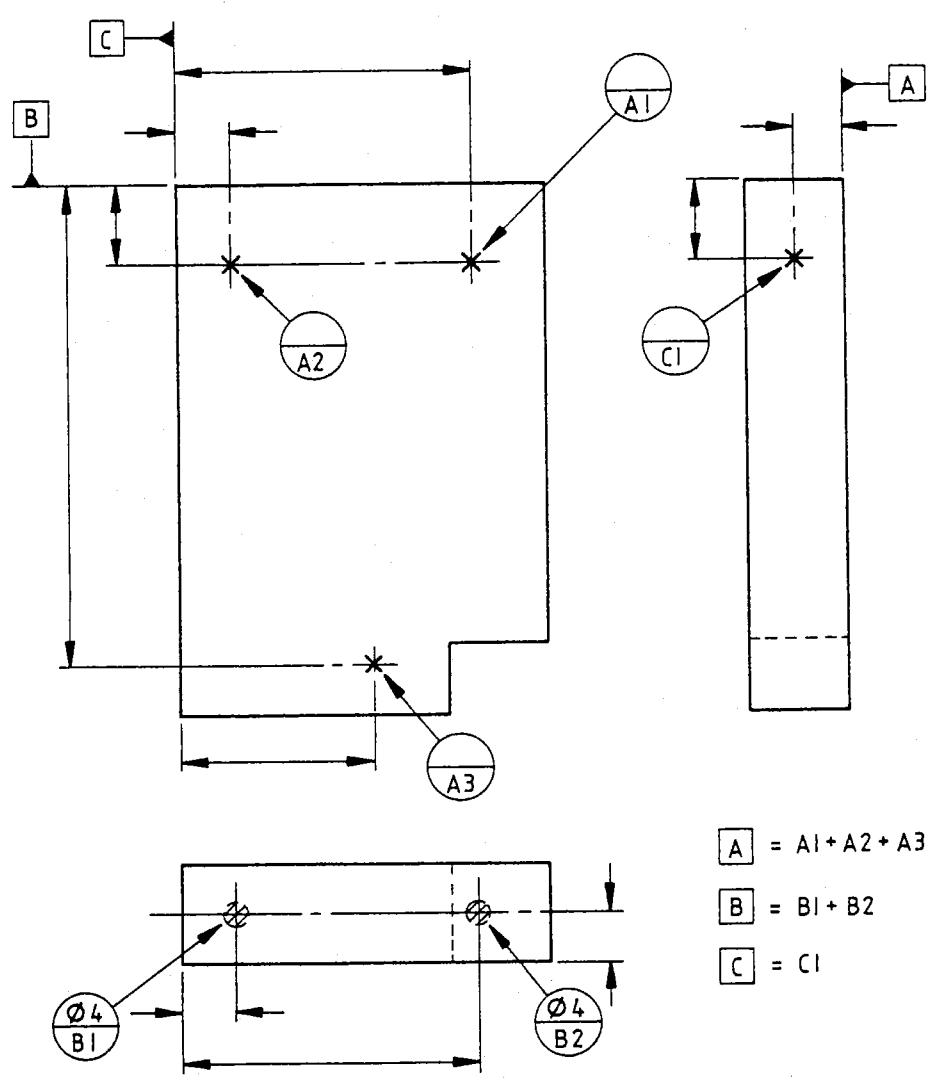


Figure 30. Datum target symbols



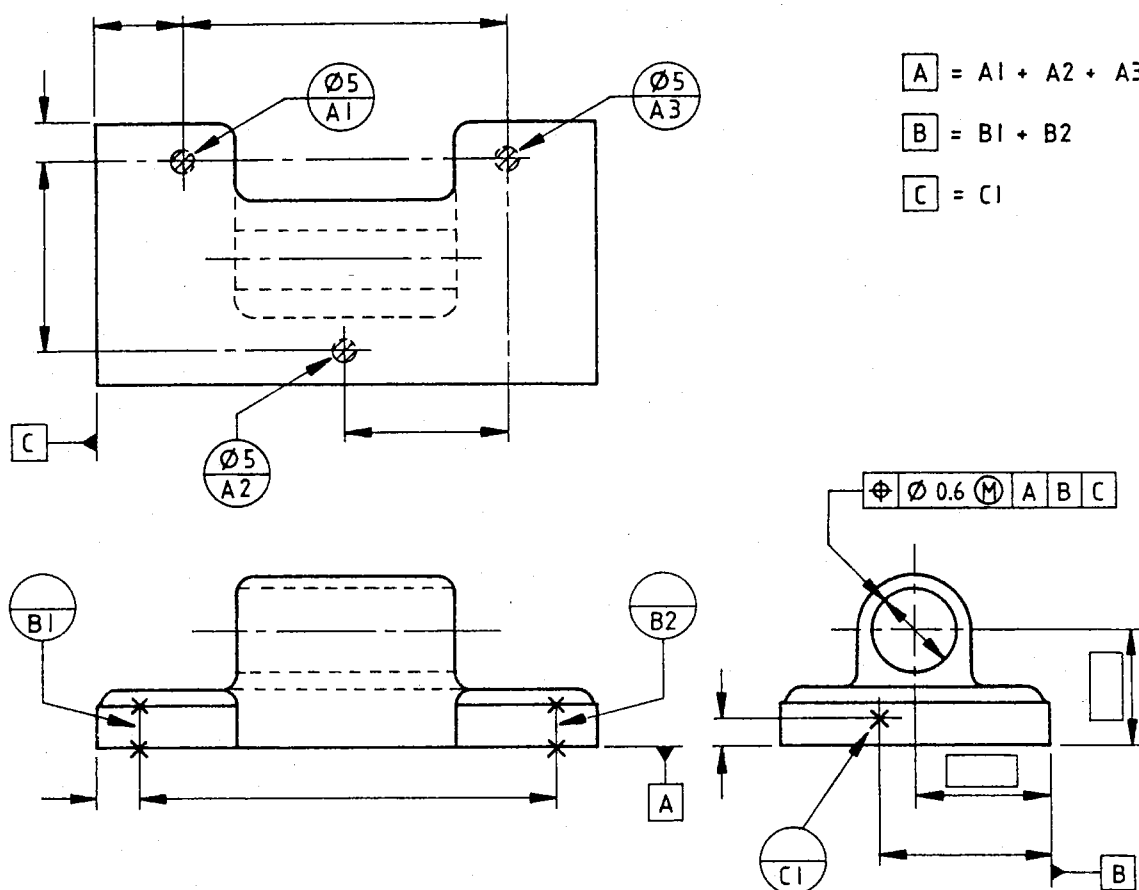


$A = A1 + A2 + A3$
 $B = B1 + B2$
 $C = C1$

Interpretation

Datum targets A1, A2 and A3 establish datum A
Datum targets B1 and B2 establish datum B
Datum target C1 establishes datum C

Figure 32. Application of datum targets



Interpretation

Datum targets A1, A2 and A3 establish datum A
Datum targets B1 and B2 establish datum B
Datum target C1 establishes datum C

Figure 33. Application of datum targets

Section three. Maximum material principle

17 Introduction

17.1 General

The satisfactory assembly of features which fit together (such as the securing bolts and bolt holes in two flanges) depends on the actual sizes and actual geometrical deviations of the features being fitted together.

The minimum assembly clearance occurs when each of the mating features is at its maximum material size, e.g. largest bolt and smallest hole, and when geometrical deviations, e.g. positional deviation, are also at their indicated maxima. Conversely, the maximum assembly clearance occurs when each of the features is at its least material size, e.g. smallest bolt and largest hole, and the geometrical deviations are nil.

However, when the actual size of one feature does not reach its maximum material size, the indicated geometrical tolerance for that feature could be correspondingly exceeded without endangering assembly with the mating feature. This concept is known as the maximum material principle.

The maximum material principle is applied to one part of the assembly without reference to the mating part. Assembly will always be possible even when the mating part is manufactured on the extreme limits of the tolerance in the direction most unfavourable for the assembly.

In general, the use of the maximum material principle thus facilitates manufacture without affecting the assembly of parts.

17.2 Definitions

17.2.1 actual local size. An actual two-point measurement of a dimensioned feature*.

17.2.2 maximum material condition (MMC). The state of the considered feature wherein it is everywhere at that limit of size where the material of the feature is at its maximum (see figure 34).

17.2.3 maximum material size. The dimension defining the maximum permitted size of a male feature, e.g. maximum shaft diameter, and the minimum permitted size of a female feature, e.g. minimum hole diameter.

17.2.4 least material size. The dimension defining the minimum permitted size of a male feature, e.g. minimum shaft diameter, and the maximum permitted size of a female feature, e.g. maximum hole size.

17.2.5 virtual condition. The limiting boundary of perfect form generated by the collective effects of the specified maximum material limit of size of a feature and any applicable geometrical tolerances.

NOTE. When the maximum material principle is applied, only those geometrical tolerances followed by the symbol (M) are to be taken into account when determining the virtual condition (see figure 34).

17.2.6 virtual size. The size of the virtual condition.

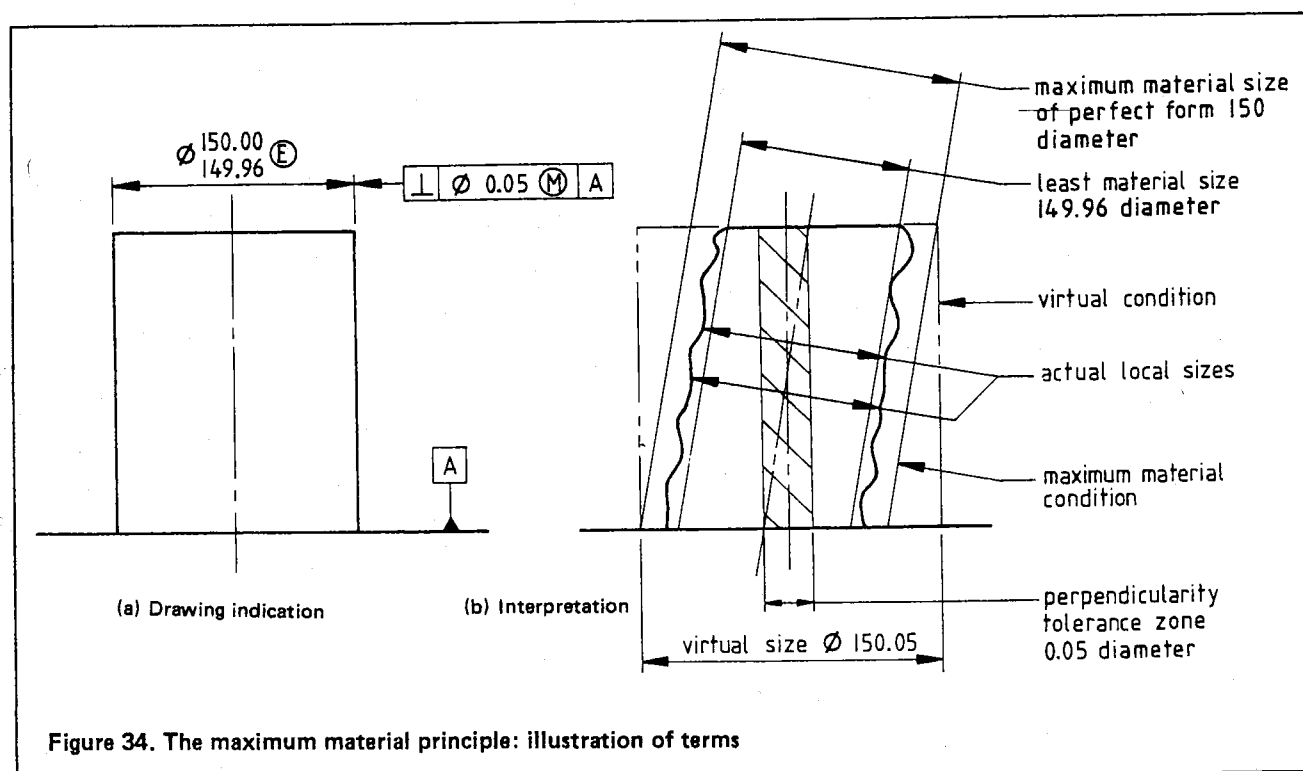
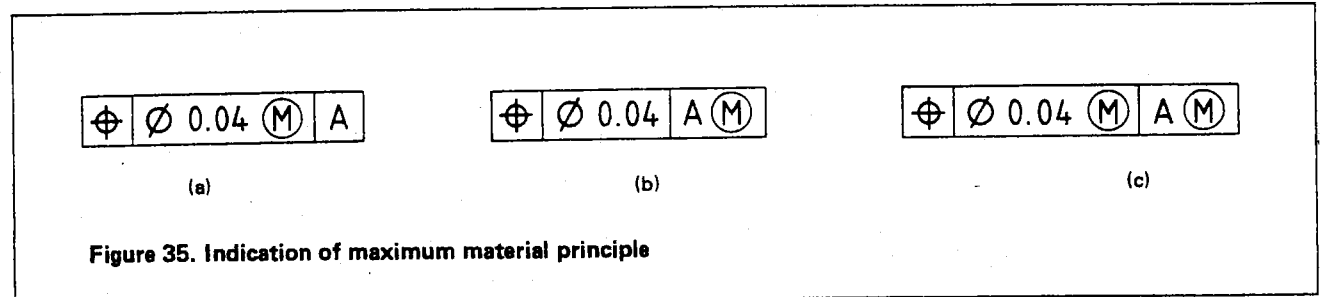


Figure 34. The maximum material principle: illustration of terms

*This definition is repeated from BS 308 : Part 2 : 1985.

18 Methods of indication

When the maximum material principle is to be applied to a toleranced feature the symbol $\textcircled{M}$ should be positioned after the tolerance value in the tolerance frame (see figure 35(a)). When the maximum material principle is to be applied to a datum feature the symbol $\textcircled{M}$ should be positioned after the datum identifying letter in the tolerance frame (see figure 35(b)). When both conditions apply, this should be indicated as in figure 35(c).



19 Application of the maximum material principle

19.1 General

The principle should be applied only to the axes or median planes of features-of-size and takes into account the dependency of the geometrical tolerance and the size tolerance concerned.

When applied to a toleranced feature, the maximum material principle requires the indicated geometrical tolerance to be enforced rigorously only when the feature is at its maximum material size. When the feature is finished away from its maximum material size the principle permits the indicated geometrical tolerance to be exceeded, provided that the feature does not violate its virtual condition. The increase in the geometrical tolerance is equal to the difference between the actual finished size of the feature and its maximum material size (see 17.1).

The maximum material principle may be applied to datum features as well as, or instead of, to toleranced features, depending on the functional requirements of the part, as follows.

- (a) When a single toleranced feature is related to a datum feature to which the maximum material principle is applied, the principle permits the indicated geometrical tolerance for the single feature to be exceeded by the difference between the actual finished size of datum feature and its maximum material size (see 20.3).
- (b) When a group of toleranced features is related to a datum feature to which the maximum material principle is applied, the principle permits the geometrical reference frame of the group of toleranced features to move bodily relative to the actual axis or median plane of the datum feature. The movement is equal to half the difference between the actual size of the datum feature and its maximum material size (see 20.4). However the maximum material principle permits no increase in the geometrical tolerance of the individual features of the group relative to the geometrical reference frame for the group.

Whenever the maximum material principle is to be applied, the functional requirements of the part should be considered, to establish whether the permitted increase in the geometrical tolerance and the permitted movement of any datum axis or datum median plane can be accepted.

These movements can generally be accepted in the positional tolerancing of such features as clearance holes for bolts, studs, etc. They may not be acceptable in the positional tolerancing of the pivots in kinematic linkages, the axes of the supporting bores for gears, threaded holes, interference fit holes, etc.

19.2 Relationship to geometrical form

Since the maximum material principle involves a relationship between size and form, or size and position, it can only be applied to those features where this relationship is possible. The feature may be the feature being toleranced and/or the datum feature depending on the design requirement. In effect this limits its application to features-of-size incorporating an axis or a median plane with the following tolerated characteristics:

- (a) straightness;
- (b) parallelism;
- (c) perpendicularity;
- (d) angularity;
- (e) position;
- (f) concentricity;
- (g) symmetry.

The principle cannot be applied to a plane surface or a line on a surface.

20 Examples of the application of the maximum material principle

20.1 Positional tolerance for groups of holes and fixed mating pins

20.1.1 General. Drawing indications for a group of four holes and four fixed pins which are to assemble with the holes are shown in figure 36(a) and (c). The maximum material size is 8.1 diameter for the holes and 7.9 diameter for the pins.

The difference between these maximum material sizes (0.2) may be used as positional tolerance for the holes and pins, see figure 36(b) and (d). In this example the difference has been distributed equally between holes and pins, giving positional tolerance zones for each of 0.1 diameter, but any values totalling 0.2 could have been used.

The axes of the tolerance zones are at the theoretically exact positions of the axes of the holes and pins.

When any hole in the group is finished away from its maximum material size, the clearance between it and its mating pin will increase. This increase in clearance may be used as additional positional tolerance for that hole, because the maximum material principle has been applied to the group of holes.

Similarly, when any pin is finished away from its maximum material size, the clearance between it and its mating hole will increase. The application of the maximum material principle to the group of pins permits the increase in clearance to be used as additional positional tolerance for that pin.

The permitted increase in positional tolerance depends on the actual finished size of the hole or pin. It may therefore be different for each hole and each pin but is a maximum when a hole or pin is at its least material size.

For a hole, the maximum permitted increase in positional tolerance is the difference between its least material size and maximum material size, e.g. in figure 36, $8.2 - 8.1 = 0.1$. Therefore, the diameter of the tolerance zone for the axis of a hole at least material size is permitted to be 0.2.

Similarly, when a pin is at its least material size of 7.8, the diameter of the tolerance zone for its axis is permitted to be 0.2.

Figure 37 shows that a feature (hole or pin) at least material size with the maximum permitted positional tolerance will assemble with a mating feature at maximum material size and specified positional tolerance under the most unfavourable conditions. The groups of holes and pins will still assemble when similar unfavourable conditions exist for all four pairs of mating features.

20.1.2 Virtual condition and virtual size of the holes and pins

NOTE. In this subclause, virtual sizes have been calculated assuming that when the holes and pins are at their maximum material sizes they are of perfect form.

When the axis of a hole or pin deviates from its theoretically exact position (within its tolerance zone), the size of the hole or pin is virtually altered: the size of a hole is virtually reduced and the size of a pin is virtually increased.

One of the holes in figure 36(a) is shown enlarged in figure 38(a). The hole is at its maximum material size of 8.1 diameter and the tolerance zone diameter for its axis is the specified value of 0.1. Four possible extreme positions

of the hole axis within the tolerance zone are shown at H, J, K and L. Part of the surface of an 8.1 diameter hole is shown for each position of the axis.

In figure 38(b) a circle is inscribed in the surfaces of the 8.1 diameter holes. This circle is the end view of a cylinder which inscribes the surfaces of all holes of 8.1 diameter which have their axes on the surface of the 0.1 diameter cylindrical tolerance zone.

This inscribed cylinder, which is perfect in form, is the virtual condition of the hole and its diameter is the virtual size of the hole. The diameter is $8.1 - 0.1 = 8$, i.e. the maximum material size of the hole minus the specified positional tolerance of 0.1. A similar virtual condition cylinder exists for each of the four holes in the group. The axis of each virtual condition cylinder is at the theoretically exact position of the corresponding hole axis.

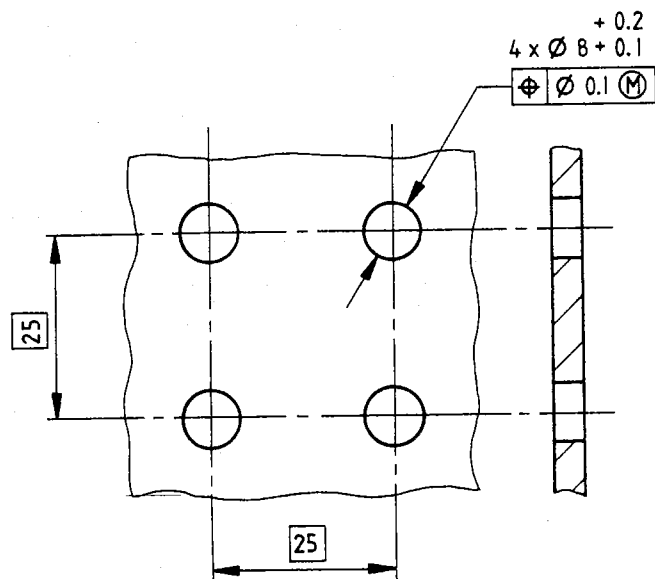
Figure 38(c) shows one hole at its maximum material size and the virtual condition of the hole. The axis of the hole is at an extreme position within its tolerance zone. When all four holes are at their maximum material size and their axes are at any extreme positions within their tolerance zones, the four mating pins will assemble with the holes because the hole surfaces do not violate the surfaces of the virtual conditions.

One of the pins in figure 36(c) is shown enlarged in figure 39(a). The pin is at its maximum size of 7.9 diameter and the diameter of the tolerance zone for its axis is the specified value of 0.1. Four possible extreme positions of the pin axis within the tolerance zone are shown at M, N, O and P. For each position of the axis, part of the surface of a 7.9 diameter pin is shown.

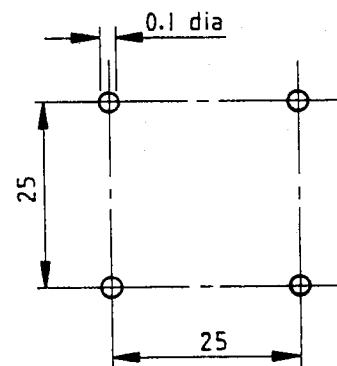
Figure 39(b) shows a circle circumscribing the surfaces of the 7.9 diameter pins. This circle represents the virtual condition cylinder of the pin and envelops all 7.9 diameter pins which have their axes at extreme positions within the 0.1 diameter cylindrical tolerance zone. The virtual condition cylinder is perfect in form and its diameter is the virtual size of the pin. The diameter is $7.9 + 0.1 = 8$, i.e. the maximum material size of the pin plus the specified positional tolerance of 0.1. Each pin in the group has a similar virtual condition cylinder which has its axis at the theoretically exact position of the corresponding pin axis.

Figure 39(c) shows the virtual condition of one pin together with the pin at its maximum material size. The axis of the pin is at an extreme position within its tolerance zone. When all four pins are at their maximum material size and their axes are at any extreme positions within their tolerance zones, the four mating holes will assemble with the pins because the pin surfaces do not violate the surfaces of the virtual conditions.

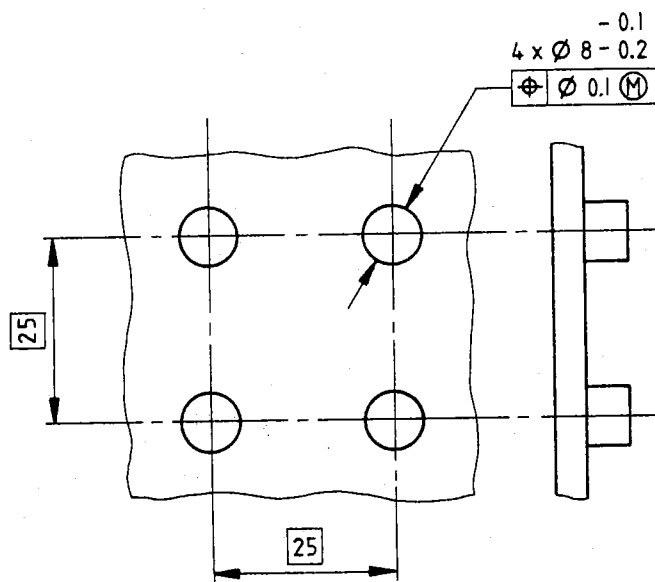
In general, groups of mating features will always assemble if the virtual size of the female features is equal to or greater than the virtual size of the male features.



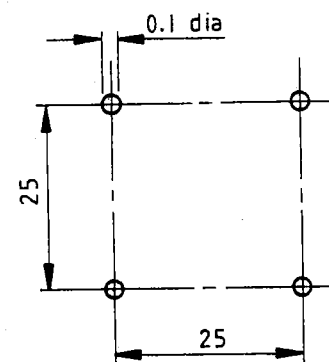
(a) Drawing indication for holes



(b) Tolerance diagram for the axes of the holes at maximum material size

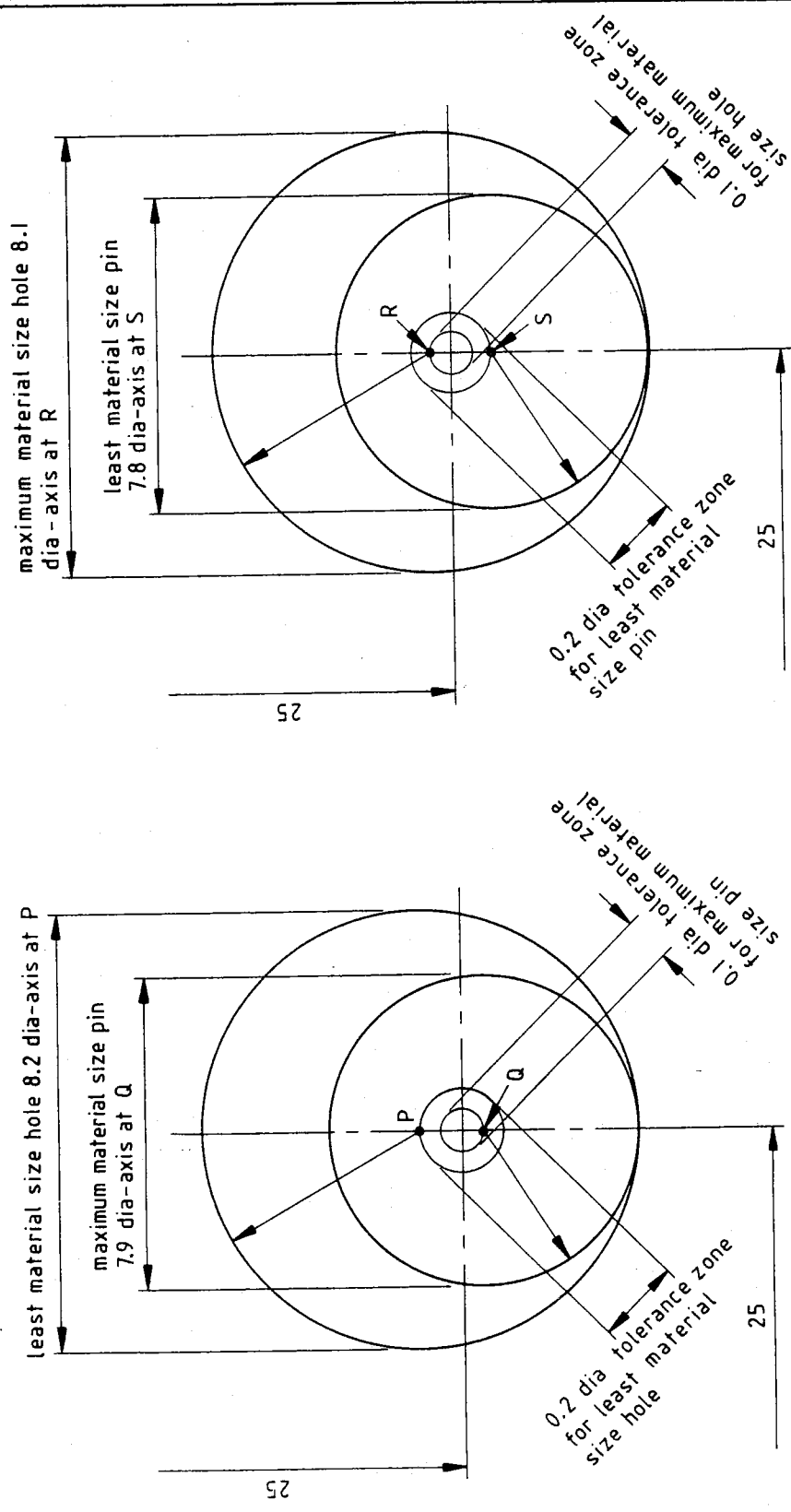


(c) Drawing indication for fixed pins



(d) Tolerance diagram for the axes of the pins at maximum material size

Figure 36. Positional tolerancing of a group of holes and a group of fixed mating pins



(a) Maximum material size pin assembled in least material size hole
(b) Least material size pin assembled in maximum material size hole

Figure 37. Assembly of holes and pins under the most unfavourable conditions

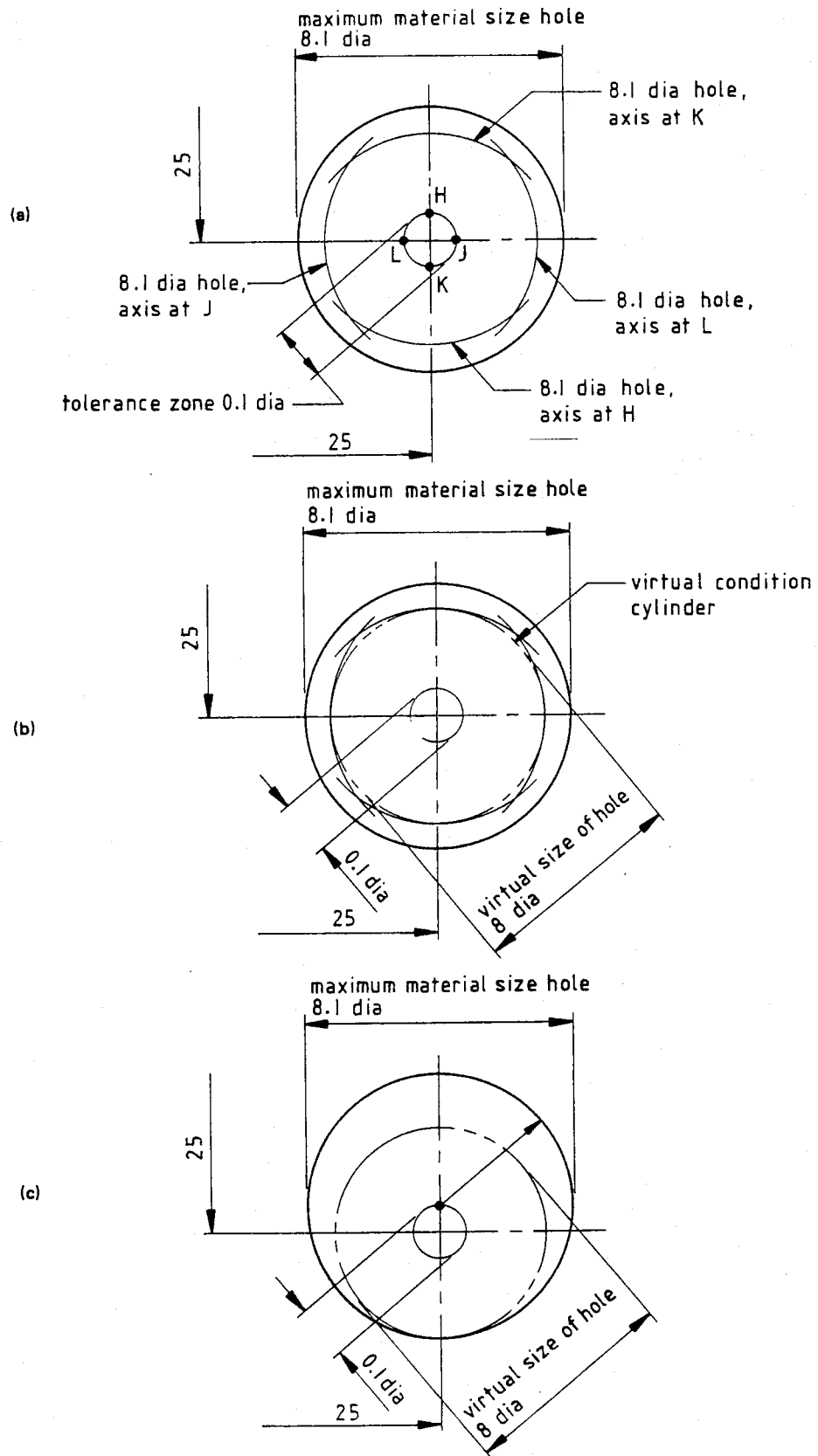


Figure 38. Virtual condition and virtual size of the holes in figure 36(a)

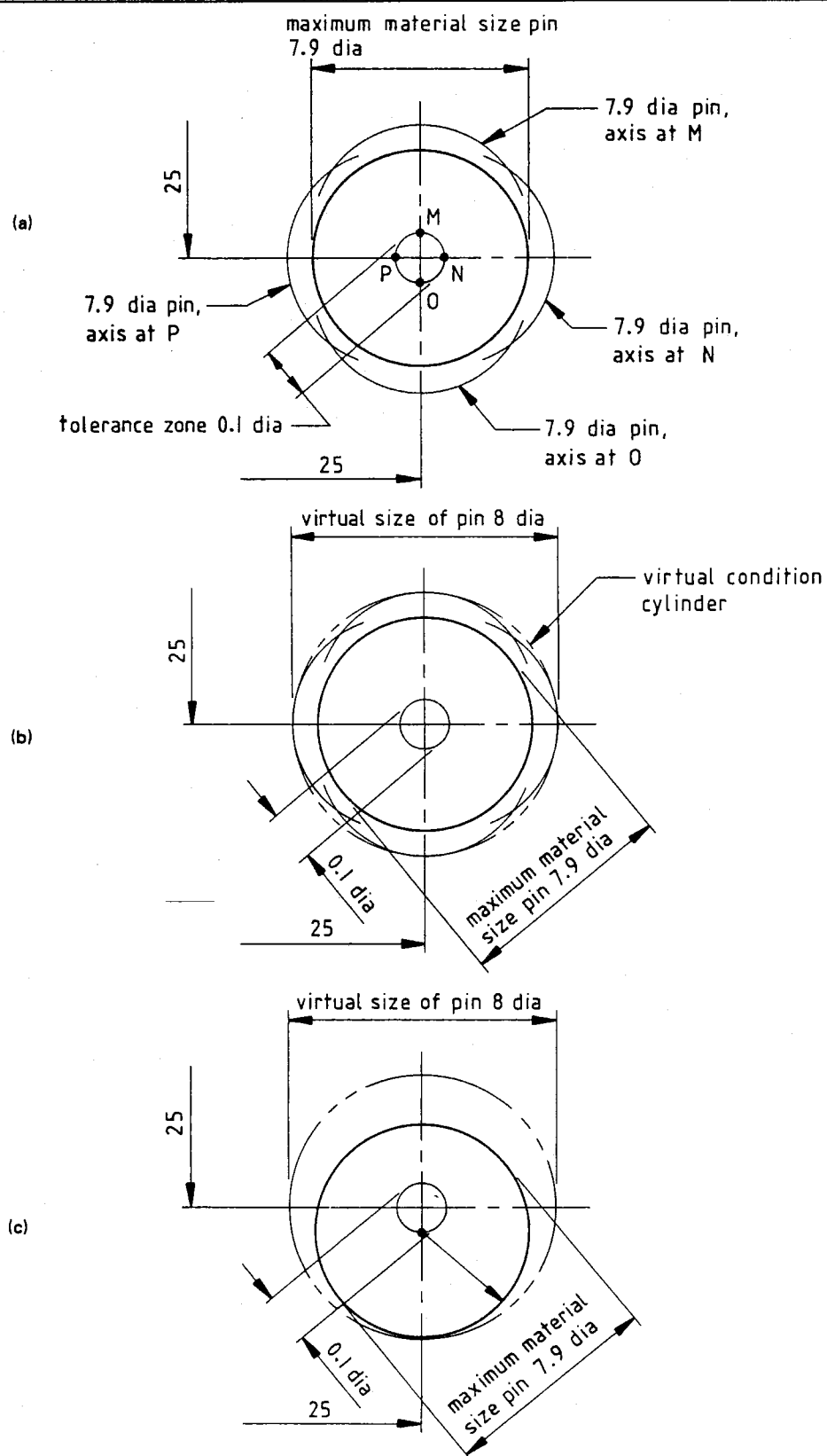


Figure 39. Virtual condition and virtual size of the pins in figure 36(c)

20.2 Straightness tolerance of an axis

20.2.1 Tolerancing with independency of size and form (see 11.3 of BS 308 : Part 2 : 1985). A shaft, the axis of which is tolerated as in figure 40(a), has to meet the following conditions.

- (a) It is not to violate the virtual condition, i.e. the enveloping cylinder of perfect form having a diameter of $12 + 0.4 = 12.4$.
- (b) All actual local sizes (two-point measurements) are to be within the size tolerance of 0.2 and therefore may vary between 11.8 diameter and 12 diameter. Circularity deviations are permitted at any actual local size up to and including the maximum material size of 12 diameter, provided that they do not cause the shaft to violate the virtual condition.
- (c) When the shaft is everywhere at its maximum material size of 12 diameter, its axis is to be contained in a cylindrical tolerance zone of 0.4 diameter (see figure 40(b)). As the shaft departs from its maximum material size, the diameter of this tolerance zone is permitted to increase by the amount of such departure. Hence when the shaft is everywhere at its least material size of 11.8 diameter, the tolerance zone diameter is a maximum of 0.6, i.e. 0.4 plus the size tolerance (see figure 40(c)).

20.2.2 Tolerancing with dependency of size and form (see 11.2 of BS 308 : Part 2 : 1985). When a feature-of-size, such as a shaft, is tolerated with dependency of size and form, 11.2 of BS 308 : Part 2 : 1985 states that, in general, the shaft is to be perfect in form when it is in its maximum material condition. This means that any specified form tolerances, such as a straightness tolerance applied to the generators of the shaft, are maximum limiting values which will reduce as the shaft approaches its maximum material condition.

However, the application of a straightness tolerance to the axis of the shaft modifies the requirement of perfect form in the maximum material condition, since the axis is permitted to be out of straight when the shaft is in the maximum material condition.

Therefore the shaft in figure 40(a), tolerated with dependency of size and form, has to meet the same conditions as apply when it is tolerated with independency of size and form (see 20.2.1), with one exception: when the shaft is everywhere at its maximum material size of 12 diameter, circularity deviations are not permitted and all cross sections are to be perfectly circular.

When the shaft is in its maximum material condition (all actual local sizes 12 diameter) its axis is to be contained in a cylindrical tolerance zone of 0.4 diameter. The diameter of this tolerance zone is permitted to increase proportionately up to a maximum of 0.6 when the shaft is in its least material condition (all actual local sizes 11.8 diameter).

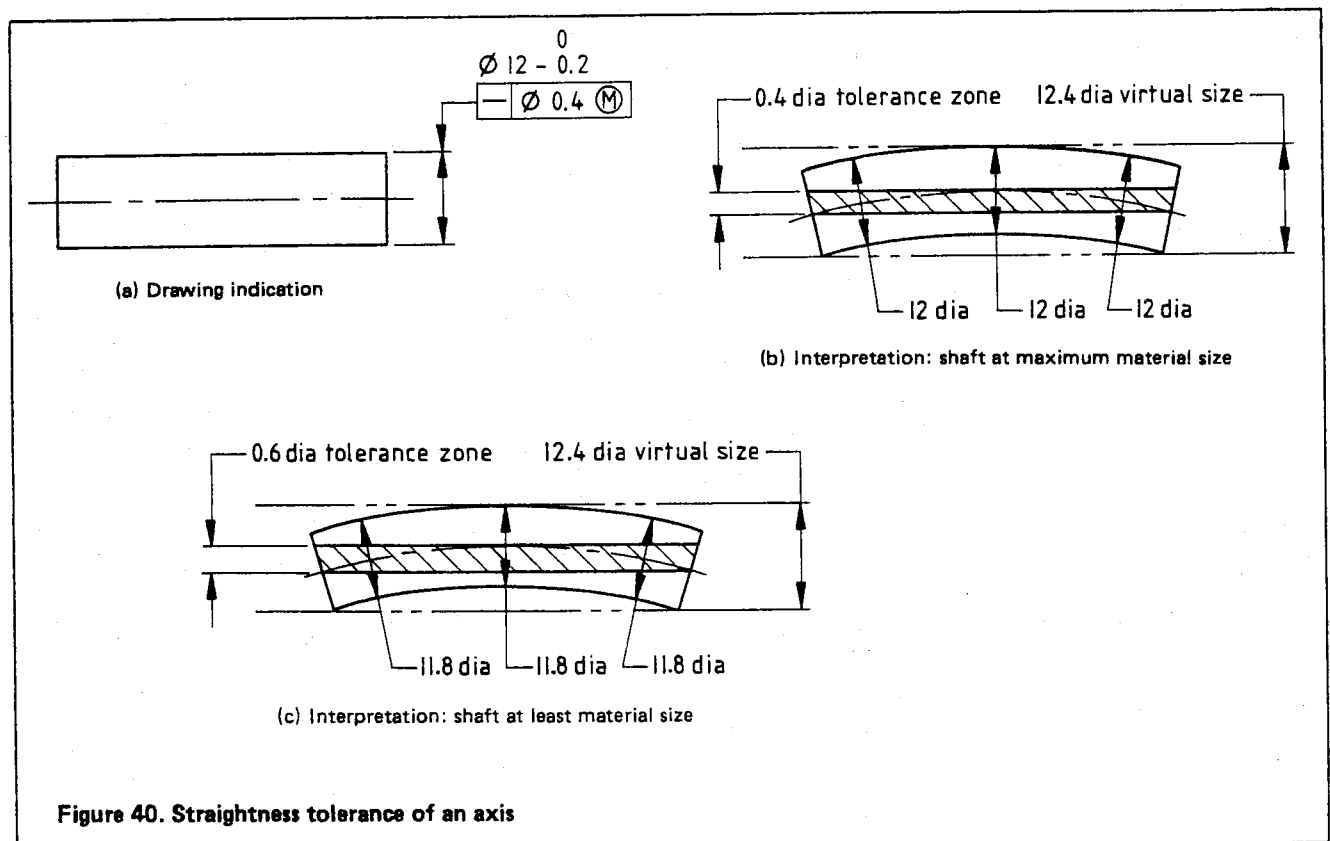


Figure 40. Straightness tolerance of an axis

20.3 Perpendicularity tolerance of a shaft related to a datum plane

20.3.1 Tolerancing with independency of size and form (see 11.3 of BS 308 : Part 2 : 1985). A shaft, the axis of which is toleranced as in figure 41(a) has to meet the conditions shown in figure 41(b), which are as follows.

- (a) It is not to violate the virtual condition, that is, the enveloping cylinder of perfect form which is perpendicular to datum D and has a diameter of 20.2 (20 + 0.2).
- (b) All actual local sizes are to be between 19.9 diameter and 20 diameter. Circularity deviations are permissible at any actual local size provided they do not cause the shaft to violate the virtual condition.

(c) When the shaft is everywhere at its maximum material size of 20 diameter, its axis is to be contained in a cylindrical tolerance zone of 0.2 diameter perpendicular to datum feature D. The diameter of this tolerance zone is permitted to increase by the amount that the shaft departs from its maximum material size. When the shaft is everywhere at its least material size of 19.9 diameter the tolerance zone diameter is a maximum of 0.3.

Therefore, the maximum straightness deviation of the axis or of the generators of the shaft will be as shown in figure 41(c) when the shaft is in its maximum material condition, and as shown in figure 41(d) when the shaft is in its least material condition.

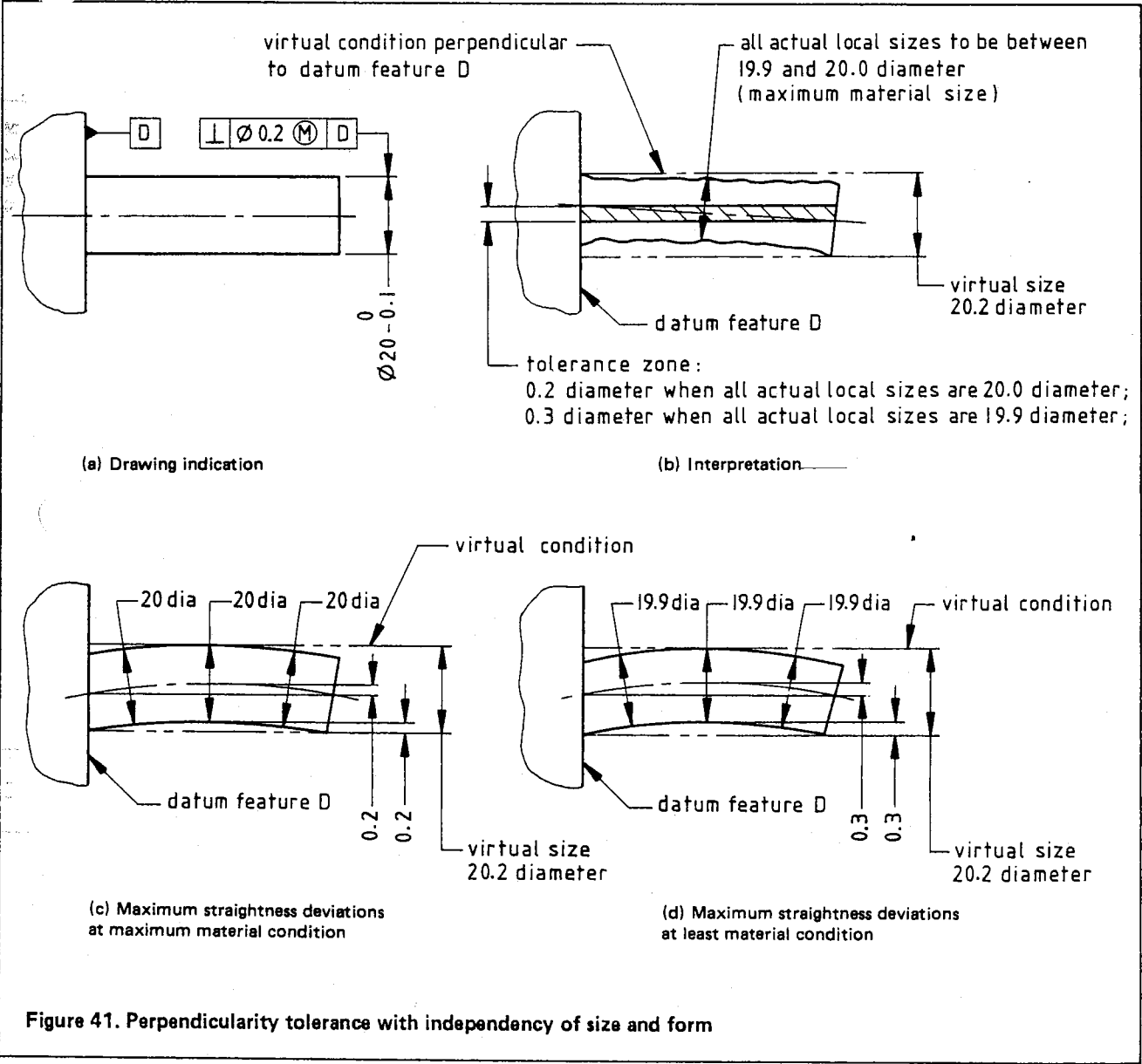


Figure 41. Perpendicularity tolerance with independency of size and form

20.3.2 Envelope requirement specified with the perpendicularity tolerance. The envelope requirement (see clause 11), indicated by the symbol $\textcircled{E}$ is applied to the shaft in figure 42(a), which otherwise is tolerated in the same way as the shaft in figure 41(a).

The envelope requirement restricts the shaft to be contained always within the envelope of perfect form at the maximum material condition, this envelope being a cylinder of 20 diameter. The envelope requirement, which is to be met independently of the perpendicularity tolerance, specifies that the axis of a shaft in the maximum material condition is to be perfectly straight and all cross sections are to be perfectly circular. At the same time the perpendicularity tolerance requires the axis to be contained in a cylindrical tolerance zone of 0.2 diameter, perpendicular to datum feature D. Furthermore, the shaft is not to violate the virtual condition.

Figure 42(b) shows a shaft in its maximum material condition meeting all three of these conditions. The axis of the shaft is in one possible extreme position within the 0.2 diameter tolerance zone.

When the shaft is less than its maximum material size of 20 diameter, straightness and circularity deviations are permissible provided they do not cause the shaft to violate the envelope requirement. This means, for example, that the straightness deviation of the generators or axis, which is zero when the shaft is in the maximum material condition, are not to exceed 0.1 when all actual local sizes are 19.9 diameter.

Since the maximum material principle is applied to the perpendicularity tolerance, perpendicularity deviations of the axis are permitted to increase proportionately from 0.2 to 0.3 as the actual local sizes decrease from 20 diameter to 19.9 diameter.

20.3.3 Tolerancing with dependency of size and form (see 11.2 of BS 308 : Part 2 : 1985). The requirement of perfect form in the maximum material condition is implicit in the tolerancing of a feature-of-size with dependency of size and form. However, for a feature-of-size tolerated with independency of size and form, the requirement has to be specified explicitly, using the envelope requirement.

It follows, therefore, that the conditions to be met by the shaft in figure 41(a), but tolerated with dependency of size and form, are the same as those which apply to the shaft in figure 42(a) which is tolerated with independency of size and form and also has to meet the envelope requirement (see 20.3.2).

20.4 Coaxiality tolerance of a single feature referred to a datum feature

The axis of the outside diameter of the component shown in figure 43 is tolerated for coaxiality in relation to the axis of the bore (the datum feature).

When the outside diameter and the bore are both at their maximum material limits of size, the axis of the outside diameter is to be contained in a cylindrical tolerance zone of 0.01 diameter, the axis of which is coincident with the axis of the bore.

When the outside diameter is less than its maximum material limit of size, the diameter of the tolerance zone is permitted to increase by a maximum of 0.03, the size tolerance of the outside diameter.

An increase in the diameter of the tolerance zone is also permitted when the diameter of the bore is greater than maximum material limit of size. This increase is limited to a maximum of 0.2, the size tolerance of the bore. If the outside diameter and the bore are both at their least

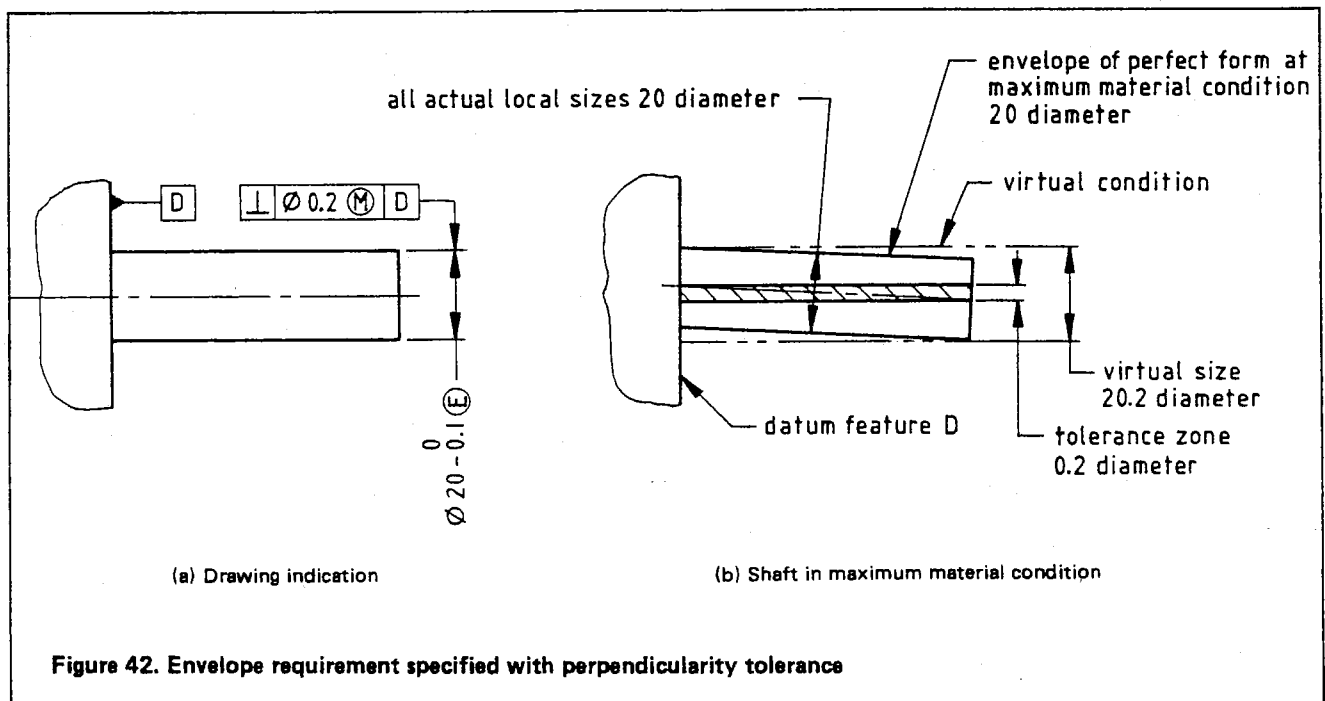


Figure 42. Envelope requirement specified with perpendicularity tolerance

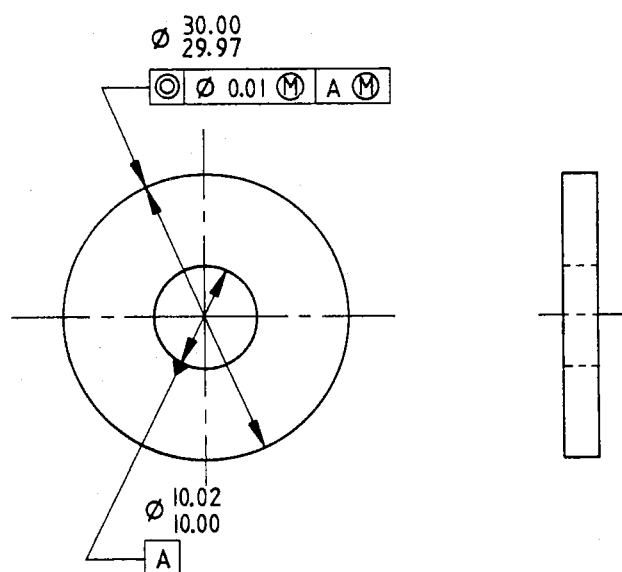


Figure 43. Coaxiality tolerance of a single feature referred to a datum feature

material limit of size, the diameter of the tolerance zone is permitted to be $0.01 + 0.03 + 0.02$ which totals 0.06.

20.5 Positional tolerance of a group of tolerated features referred to datum features

A group of holes tolerated for position in relation to a datum spigot and datum face is shown in figure 44(a). The tolerance diagram in figure 44(b) shows the positional requirements when the holes and datum spigot are all at their maximum material condition. The axes of the eight cylindrical tolerance zones are perpendicular to datum face B and the centre of the geometrical reference frame for the eight holes is to coincide with the axis of the datum spigot.

When any hole is greater than its maximum material limit of size the diameter of its tolerance zone is permitted to increase. The maximum increase is limited to 0.25, the size tolerance of the hole.

Departure of the datum spigot from its maximum material limit of size of 150.05 diameter does not permit any increase in the tolerance zone diameters for the eight holes. Instead, such a departure creates, in effect, a cylindrical tolerance zone for the axis of the datum spigot. The diameter of this tolerance zone is equal to the departure of the spigot from its maximum material limit. The axis of the tolerance zone passes through the centre of the geometrical reference frame for the eight holes and is perpendicular to datum face B, the plane in which the geometrical reference frame lies.

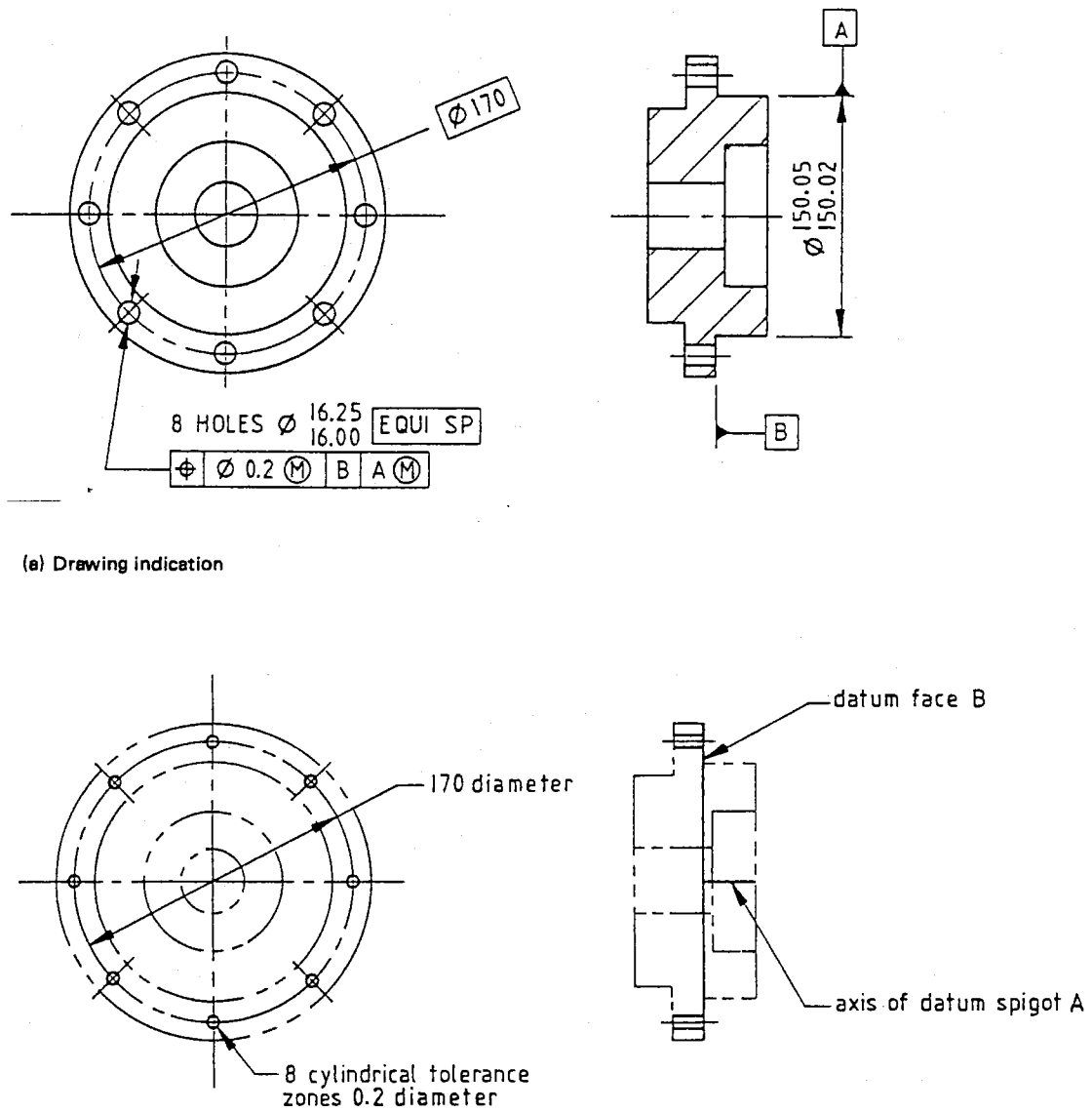


Figure 44. Positional tolerance of a group of tolerated features referred to datum features

21 Zero geometrical tolerance

21.1 Where deviations of straightness, coaxiality, perpendicularity, etc., are required to be contained within the maximum material limits of size of features, the requirement should be indicated as shown in figures 45 and 46. This means that when the features are in the maximum material condition they are required to be geometrically perfect, i.e. truly straight, coaxial, etc. But deviations of form in the toleranced feature are permissible when the features are not at their maximum material limits of size (to an extent permitted by the difference between the actual sizes and the maximum material limits of size) provided that the least material limits of size are everywhere observed. For example, in figure 45 deviation from perfect straightness of the axis required at the maximum material condition can be permitted as the feature tends towards the least material condition.

21.2 When form deviations are to be limited additionally by a specified tolerance, but it is still desired to restrict the feature to being contained within the boundary of perfect form at maximum material condition, the drawing indication should be as shown in figure 47.

21.3 Zero geometrical tolerance should be specified only with the maximum material principle; to do otherwise would be to demand perfection.

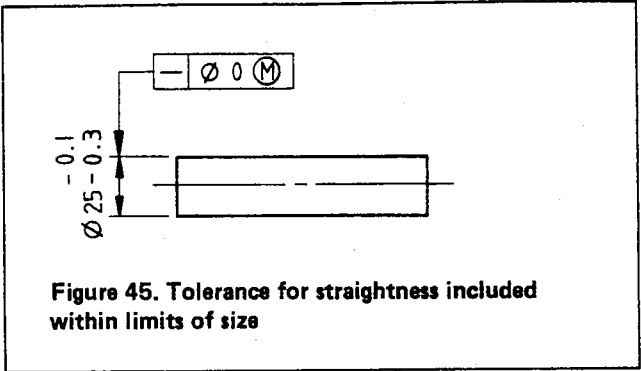


Figure 45. Tolerance for straightness included within limits of size

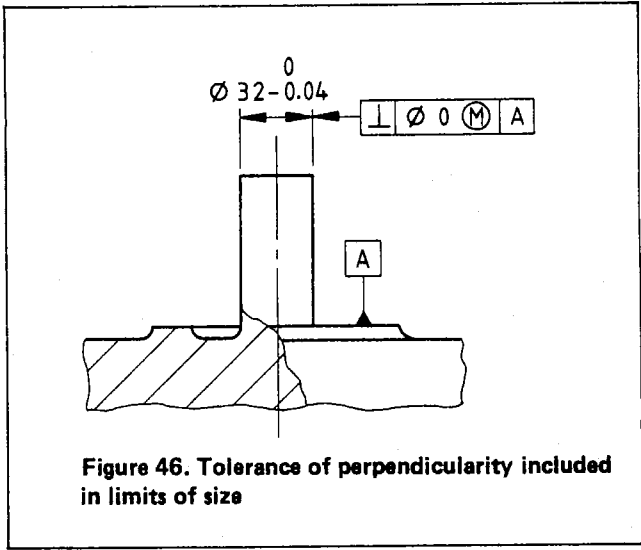


Figure 46. Tolerance of perpendicularity included in limits of size

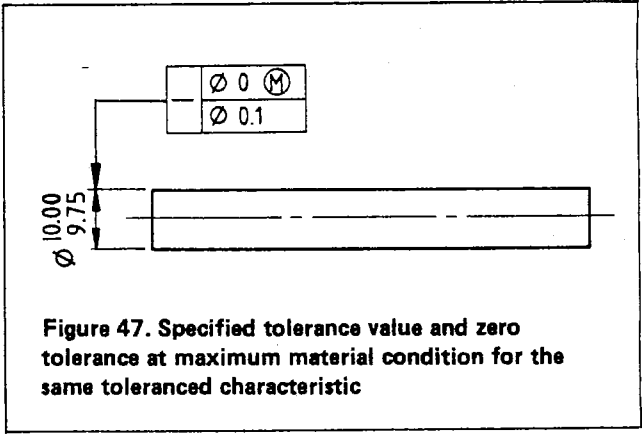


Figure 47. Specified tolerance value and zero tolerance at maximum material condition for the same toleranced characteristic

Section four. Positional tolerancing

22 Establishment of positional tolerances

Theoretically exact dimensions and positional tolerances determine the limits of the location of features, such as points, axes and median planes, relative to each other or to one or more datums.

The positional tolerance zone is symmetrically disposed about the theoretically exact location of the feature and its axis is always perpendicular to the primary datum (see figure 48).

NOTE. For the indication and interpretation of positional tolerancing, see also 10.11.

23 Tolerance combinations: location of groups and the relationship of holes within each group

23.1 Where a group of features is located, as a group, by a positional tolerance, and the features are located individually by a second smaller positional tolerance, each requirement is to be met without reference to the other as follows (see, for example, figure 49).

(a) The upper half of the tolerance frame shown in figure 49(a) indicates the tolerance on the axes of the holes as a group relative to the datums A, Y and Z. The axes of the holes are to be contained within tolerance zones of 0.3 diameter, the axes of which are perpendicular to the primary datum A and located, relative to datums Y and Z, by the boxed dimensions (see figure 49(b)).

(b) The lower half of the tolerance frame locates the hole axes individually within 0.1 diameter tolerance zones. The axes of these tolerance zones are to be perpendicular to the primary datum in the tolerance frame, and also to lie within the 0.3 diameter tolerance zones. Figure 49(c) shows one possible extreme position of the axis of a 0.1 diameter tolerance zone within a 0.3 diameter tolerance zone. The position of a hole the axis of which lies in the hatched portion of the 0.1 diameter tolerance zone would be acceptable even though its axis is outside the 0.3 diameter tolerance zone* (see also 23.3).

23.2 Where the accuracy of location of a group of features is unimportant compared with the accuracy of position within the group, either positional tolerances or a combination of toleranced centre distances and positional tolerances may be used.

NOTE 1. An example of the latter, an instrument panel, is shown in figure 50.

Where such a combination of toleranced centre distances and positional tolerances is used, the toleranced centre distances should be interpreted as referring only to the geometrical reference frame of each group. The axis of each feature may then deviate from its theoretically exact position to the extent permitted by the positional tolerance.

NOTE 2. An alternative tabular form of presentation of the geometrical tolerances of figure 50 is shown in figure 54.

23.3 Figures 51 and 52 each show extreme deviations of position which are permissible when hole patterns are dimensioned as in figure 50 and individual features are in their maximum material condition.

The maximum material principle applied to the 0.2 diameter positional tolerances indicates that if the holes are in any condition other than their maximum material condition a further deviation from the specified position is permissible.

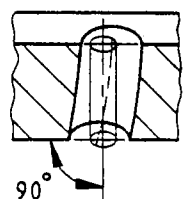
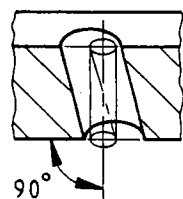
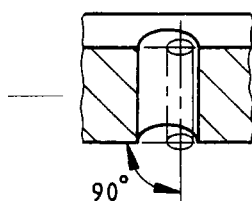
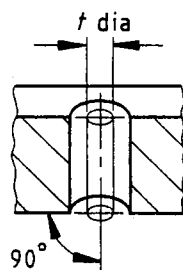
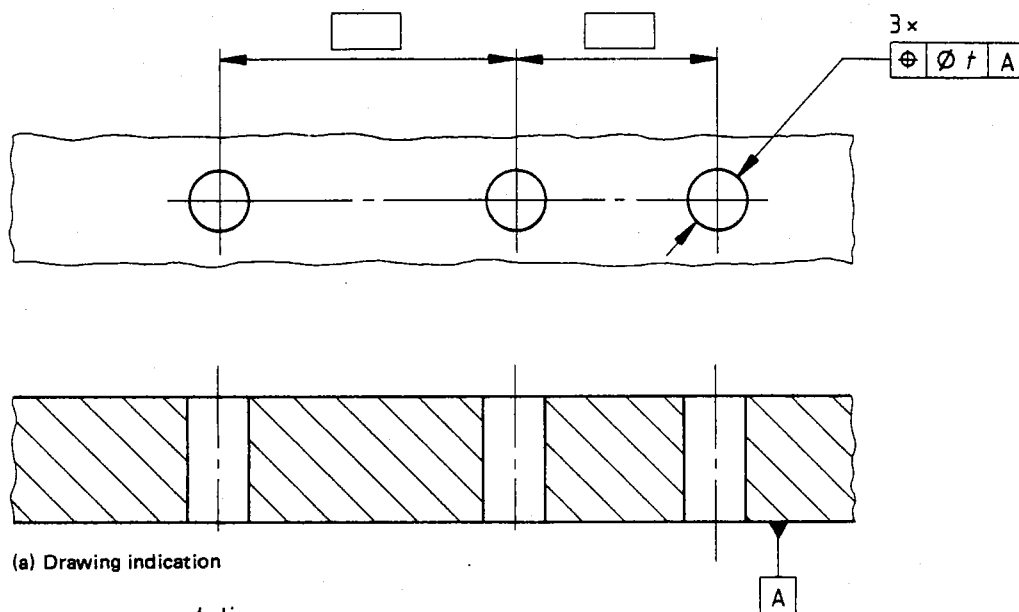
The positional tolerance of the holes relative to the group is, in most cases of this type, small compared to the direct tolerance on the group's location and provides only a minor increase in total tolerance of position. However, a detailed analysis of the interpretation of the method of dimensioning the groups shown in figure 50 is given below and in figures 51 and 52 which show the following.

(a) The boxed dimensions give the theoretical or perfect relationship between the axes of the holes of the group.

(b) Referring to the three hole group in the top left-hand corner of the plate of figure 50, the permitted positions of that reference frame are established by the toleranced dimensions 25 to 26 and 18.5 to 19.5, giving rectangular tolerance zones 1.0×1.0 . The axes of the circular tolerance zones are required to lie within these rectangular zones; therefore holes actually positioned as in figure 51 would be acceptable despite the fact that their axes are outside the 1.0×1.0 tolerance zones.

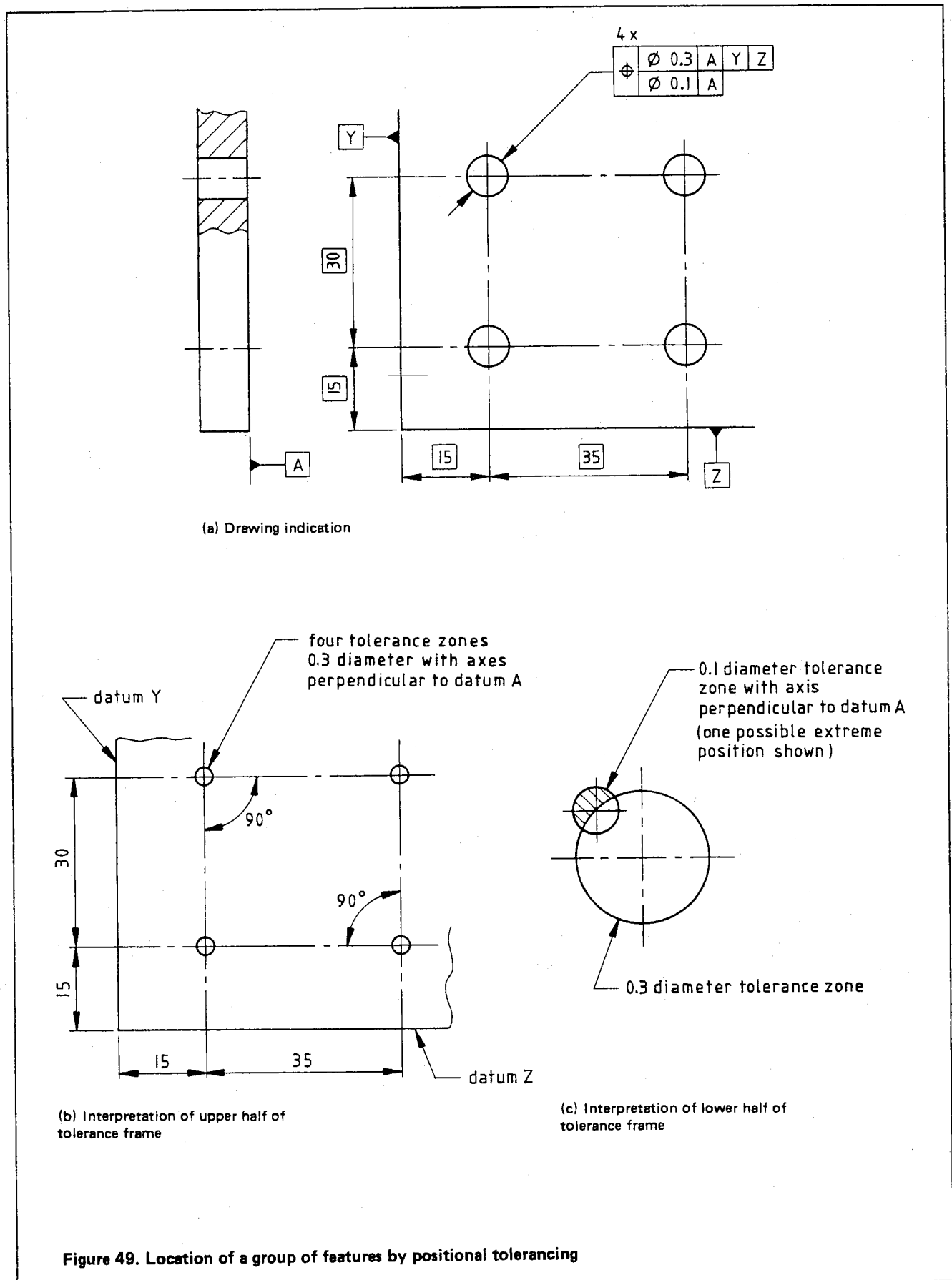
23.4 If one hole of a group is specified as the datum for the remaining holes of the group (as in figure 53) its toleranced locating dimensions are to be observed with no additional freedom other than that given if the maximum material principle is invoked. If, for example, the axis of the top left-hand (6 diameter) hole in figure 50 is specified as the datum for that local group, as shown in figure 53(a), the interpretation is as shown in figure 53(b) when all the holes are in their maximum material condition. The axis of the datum hole is required to lie in, or on the boundary of, a rectangular tolerance zone 1.0×1.0 .

*In ISO 5458 and some other national (e.g. American) standards the interpretation requires the whole of the smaller tolerance zone to lie within the larger tolerance zone.



(b) Interpretations permitted at any individual hole

Figure 48. Positional tolerancing



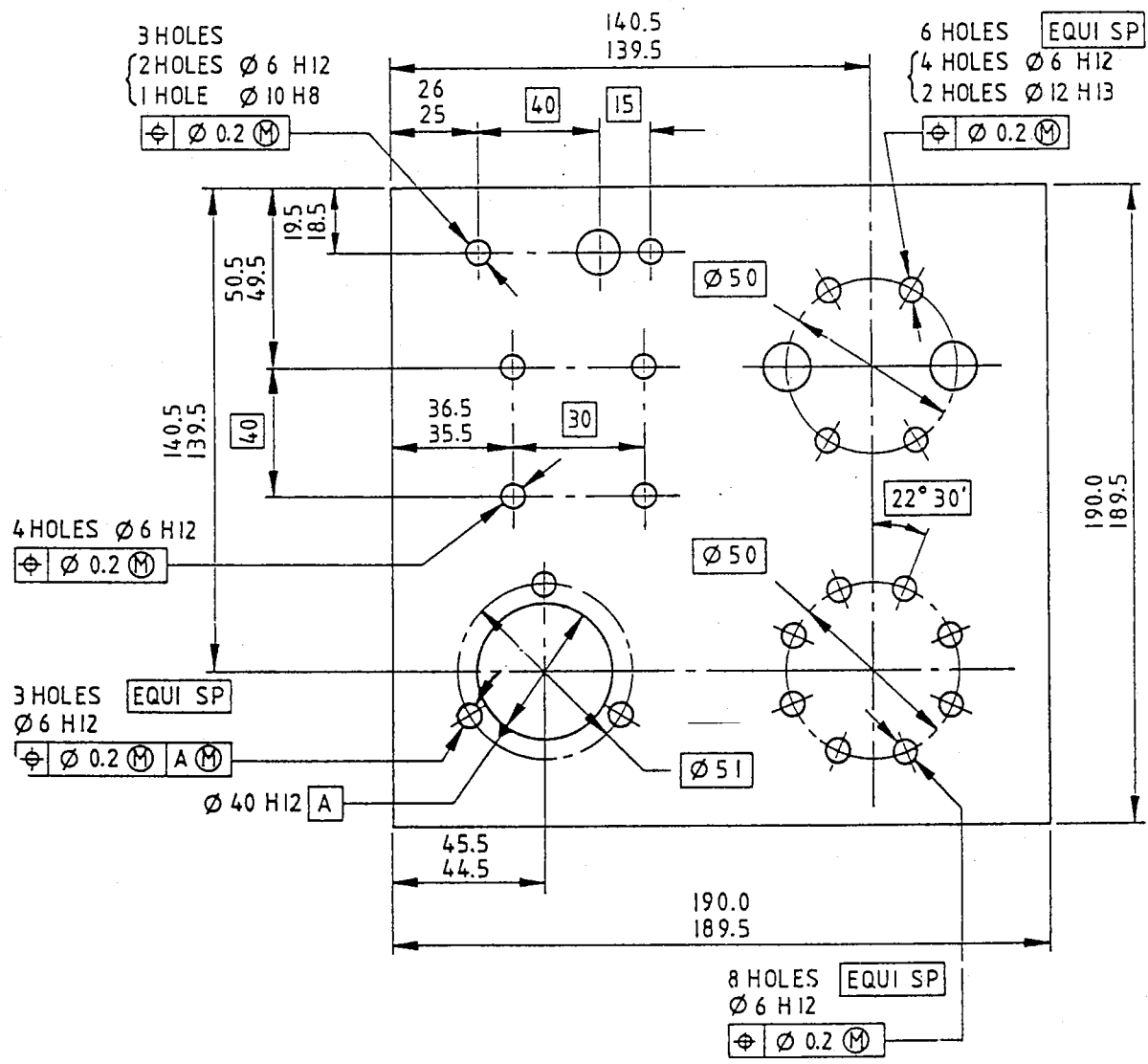
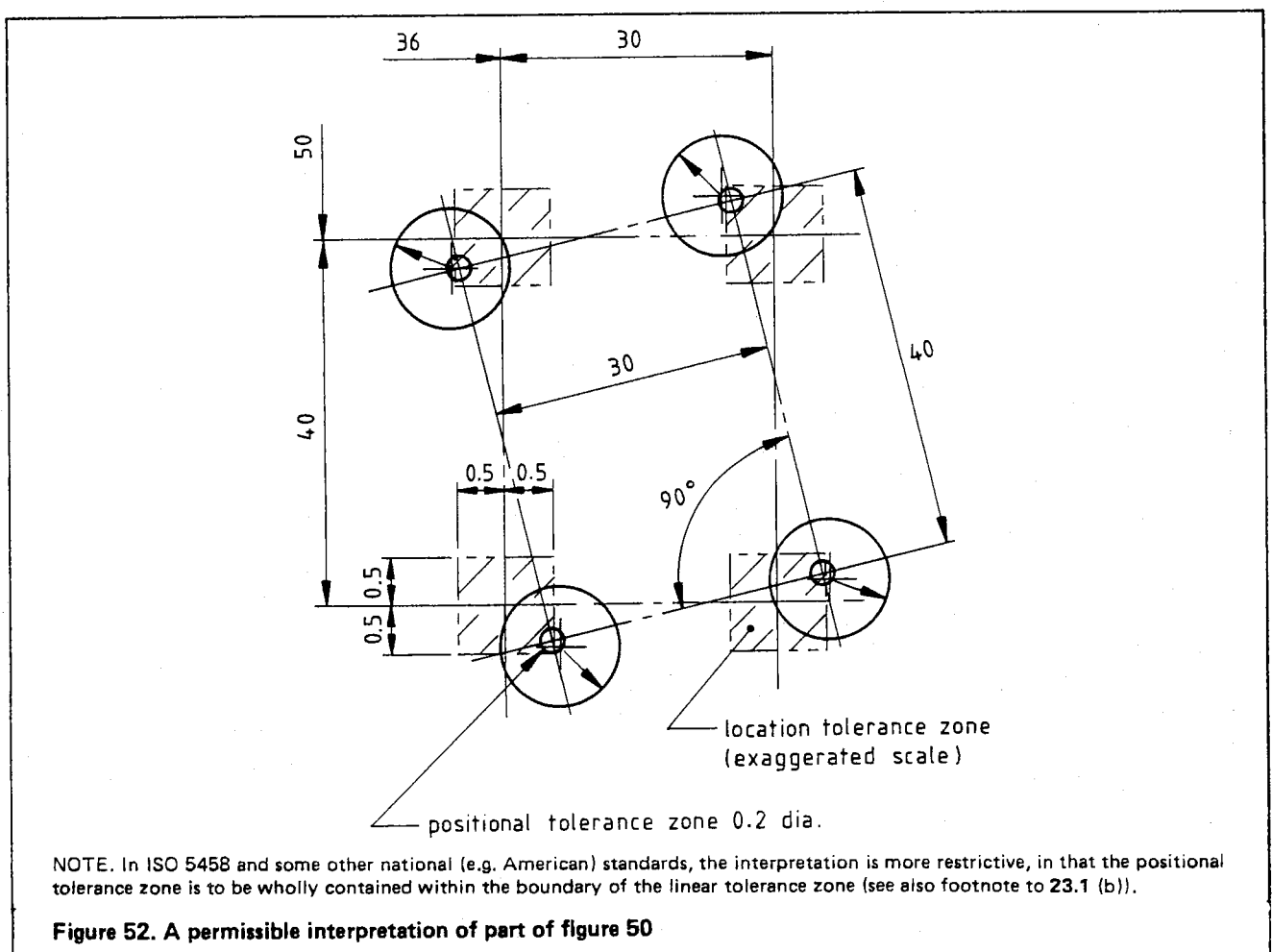
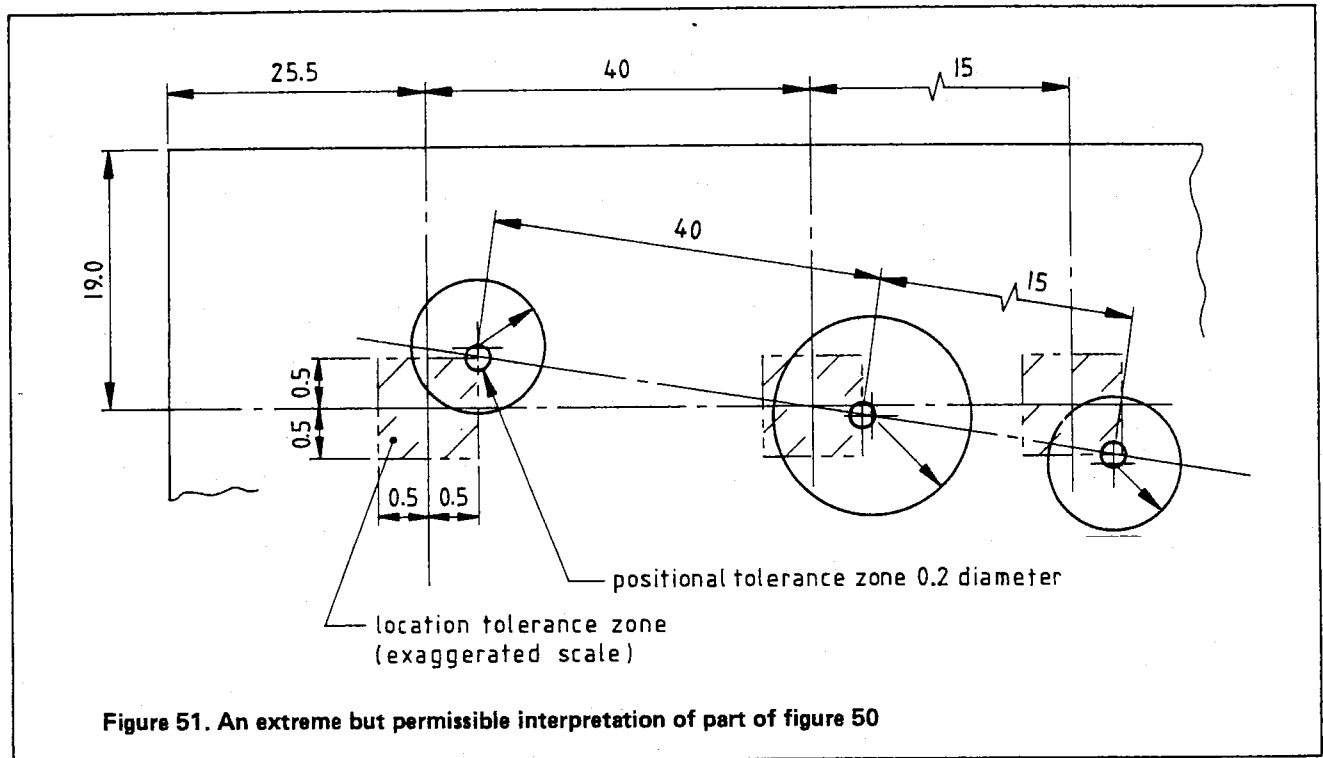


Figure 50. Location of groups by co-ordinate tolerancing



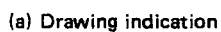
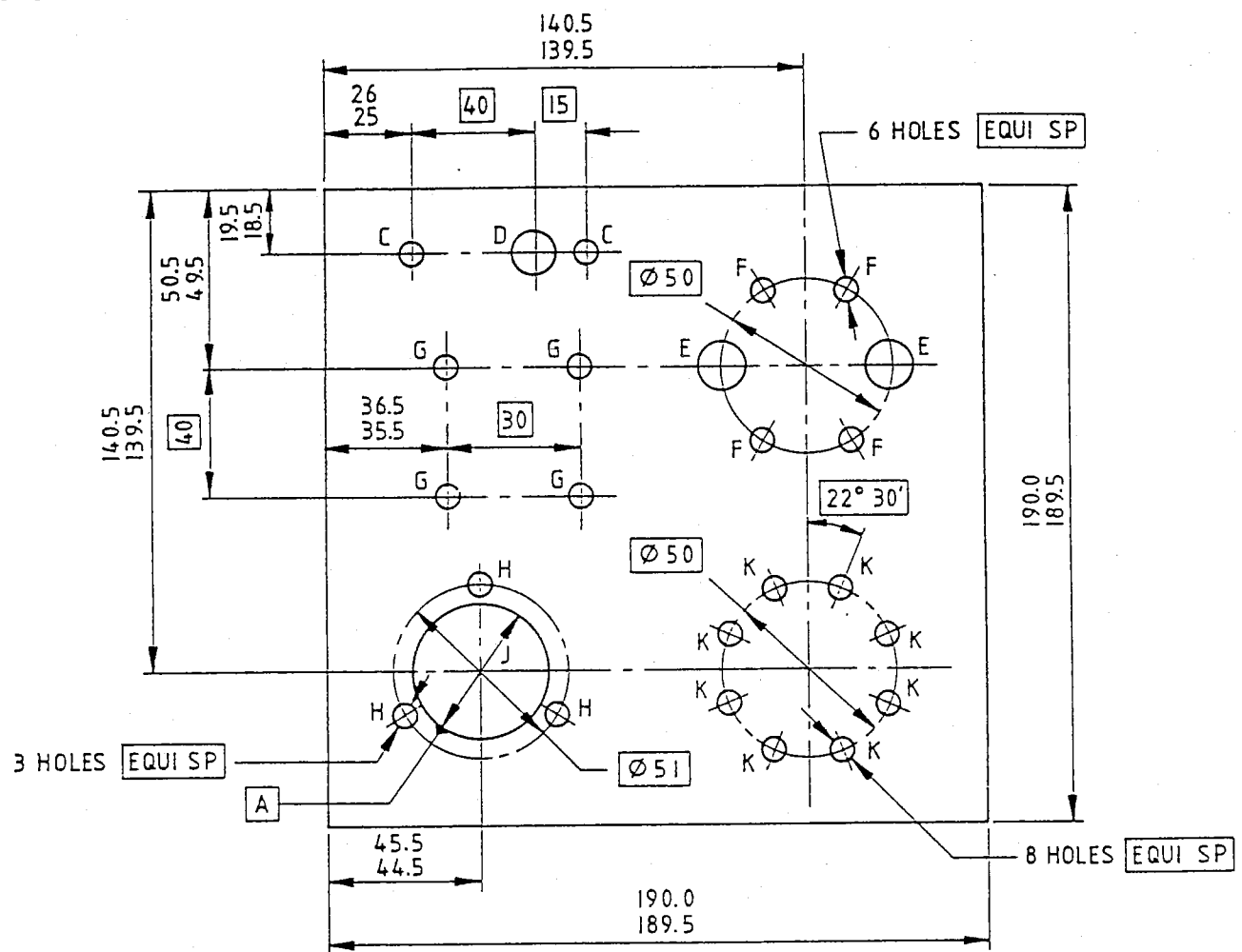


Figure 53. One hole of a group specified as a datum (variation of figure 50)



Group	Feature	Feature size	Quantity	Characteristic	Geometrical tolerance	Datum
1	C	ϕ 6 $\begin{smallmatrix} +0.12 \\ 0 \end{smallmatrix}$	2	$\oplus$	ϕ 0.2 (M)	
	D	ϕ 10 $\begin{smallmatrix} +0.27 \\ 0 \end{smallmatrix}$	1	$\oplus$		
2	E	ϕ 12 $\begin{smallmatrix} +0.27 \\ 0 \end{smallmatrix}$	2	$\oplus$	ϕ 0.2 (M)	
	F	ϕ 6 $\begin{smallmatrix} +0.12 \\ 0 \end{smallmatrix}$	4	$\oplus$		
3	G	ϕ 6 $\begin{smallmatrix} +0.12 \\ 0 \end{smallmatrix}$	4	$\oplus$	ϕ 0.2 (M)	
4	H	ϕ 6 $\begin{smallmatrix} +0.12 \\ 0 \end{smallmatrix}$	3	$\oplus$	ϕ 0.2 (M)	A (M)
	J	ϕ 40 $\begin{smallmatrix} +0.25 \\ 0 \end{smallmatrix}$	1	-	-	
5	K	ϕ 6 $\begin{smallmatrix} +0.12 \\ 0 \end{smallmatrix}$	8	$\oplus$	ϕ 0.2 (M)	

Figure 54. A tabular method of presentation of figure 50

Appendices

Appendix A. Aspects of engineering drawing practice covered by British and International (ISO) Standards

The numbers given merely indicate the standards in which the subjects are dealt and no equivalence is implied.

Subject	BS	ISO
Centre holes: simplified representation	—	6411 : 1982
Conventional representations	308 : Part 1	—
Definitions		
dimensioning and tolerancing	308 : Part 2	129 : 1985
general	308 : Part 1	—
Dimensioning and tolerancing		
cones	—	3040 : 1974*
profiles	—	1660 : 1987
Dimensions	308 : Part 2	129 : 1985
Drawing sheets		
layout	308 : Part 1	5457 : 1980
sizes	3429	5457 : 1980
Drawing types	308 : Part 1	—
Engineering diagrams	5070	—
Folding of drawing prints	1192 : Part 1	†
Gears	308 : Part 1	2203 : 1973
Geometrical tolerancing		
datums	308 : Part 3	5459 : 1981
general	308 : Part 3	1101 : 1983*
maximum material condition	308 : Part 3	2692 : 1988
positional tolerancing	308 : Part 3	5458 : 1987
Indication of surface texture	308 : Part 2	1302 : 1978*
Item lists	—	7573 : 1983
Item reference	308 : Part 1	6433 : 1981
Laboratory glassware	2774‡	6414 : 1982‡
Lettering	308 : Part 1	3098/1 : 1974
Lines	308 : Part 1	128 : 1982
Optical elements and systems	4301	†
Pictorial representations	1192 : Part 1	5456†
Principles of dimensioning	308 : Part 2	129 : 1985
Projection and dimension lines	308 : Part 2	129 : 1985
Projections	308 : Part 1	128 : 1982
Requirements for microcopying	5536	6428 : 1982
Scales	308 : Part 1	5455 : 1979
Sections	308 : Part 1	128 : 1982
Splines and serrations	308 : Part 1	6413 : 1988
Springs	308 : Part 1	2162 : 1973
Symbols		
geometrical tolerances	308 : Part 3	7083 : 1983
welding	499	2553 : 1973
and abbreviations	308 : Part 1	—
Tapered features	308 : Part 2	—
Terminology of dimensions and tolerances	308 : Part 2	5463†
Threaded parts	308 : Part 1	6410 : 1981*
Title block	308 : Part 1	7200 : 1984
Toleranced dimensions	308 : Part 2	129 : 1985 and 406 : 1987
Tolerancing principles	308 : Part 2	8015 : 1985
Views	308 : Part 1	128 : 1982

*Under revision.

†In preparation.

‡This British Standard is identical ('dual-numbered') with the ISO Standard.

Appendix B. Proportions of symbols for geometrical tolerancing

B.1 Symbols for toleranced characteristics and additional symbols are given in tables 1, 2 and 4.

B.2 The heights of symbols are based on the selected lettering line thickness (d), which is in turn related to the height of lettering selected for the drawing.

Proportional heights of symbols are given in table 4.

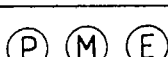
The height of lettering should be $10d$ (see 6.3 of BS 308 : Part 1 : 1984).

B.3 Frames and circles for datum references, tolerances, datum targets, boxed dimensions and encircled symbols are drawn using a B type line (see table 2 of BS 308 : Part 1 : 1984).

B.4 The widths of the compartments of tolerance frames should be as follows:

- (a) first compartment, equal to height of frame;
- (b) second compartment, to suit the length of the inscription;
- (c) third and subsequent compartments, when required, to suit the width(s) of the reference letter(s).

Table 4. Heights of graphic symbols and frames

Description	Symbol *	Height
Straightness	—	d
Flatness		$10d$
Circularity		$14d$
Cylindricity		$14d$, and $8d$ for circle
Profile of any line		$7d$
Profile of any surface		$7d$
Parallelism		$14d$
Perpendicularity		$14d$
Angularity		$14d$
Position		$14d$, and $8d$ for circle
Concentricity and coaxiality		$14d$, and $8d$ for inner circle
Symmetry		$9d$
Circular run-out		$14d$ (60° min.)
Total run-out		$14d$ (60° min.)
Datum triangle (equilateral)		$7d$
Datum reference frame		$20d$ square
Tolerance frame		$20d$
Datum target frame		$40d$
Boxed dimensions frame		$20d$, and $10d$ for value
Encircled letters		$16d$, and $10d$ for letter
* Not shown to scale		

Appendix C. Straightness, flatness, circularity and cylindricity assessment

C.1 The straightness or flatness of a tolerated feature is acceptable when the distance of any point from a superimposed contacting surface of ideal geometrical form is equal to or less than the value of the specified straightness or flatness tolerance. Unless otherwise specified the orientation of the ideal line or surface is chosen so that the maximum distance between it and the actual surface of the feature is the least possible value. Possible orientations of the line or surface in figure 55 are A_1B_1 , A_2B_2 , A_3B_3 , giving corresponding distances of h_1 , h_2 , and h_3 respectively, where $h_1 < h_2 < h_3$. Therefore in figure 55 the optimum orientation of the ideal line or surface is A_1B_1 . The distance h_1 is to be equal to or less than the specified straightness or flatness tolerance.

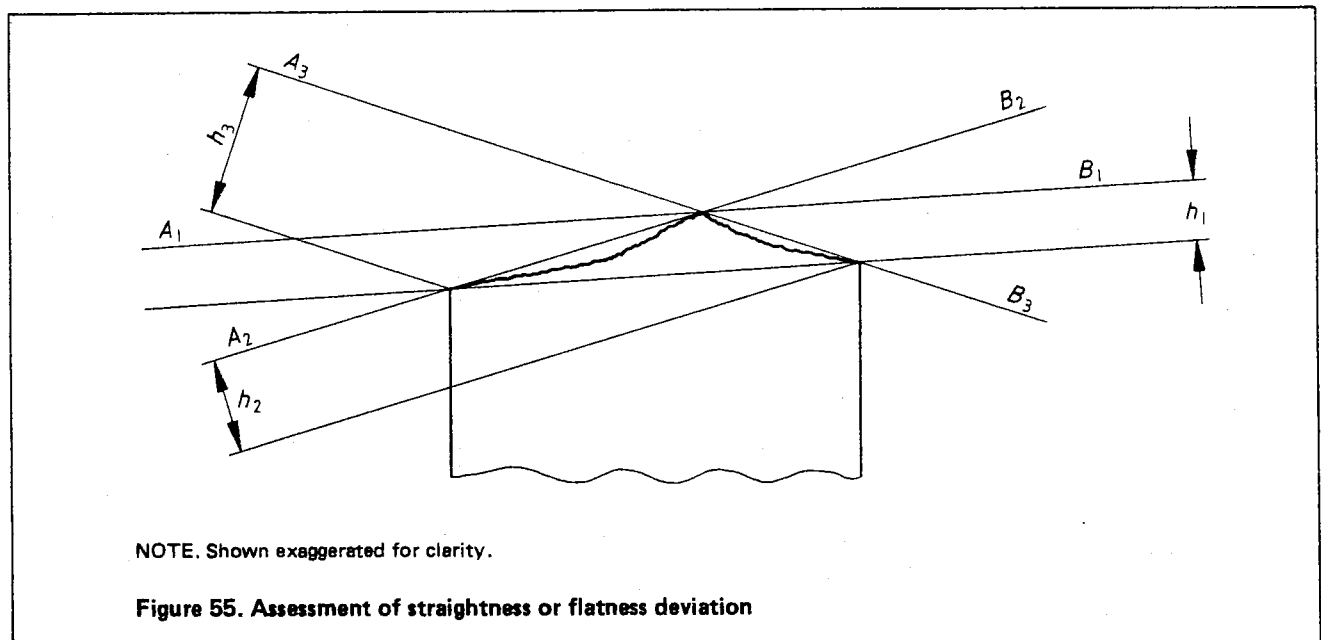
C.2 When assessing circularity and cylindricity, the location of the tolerance zone formed by the two concentric circles

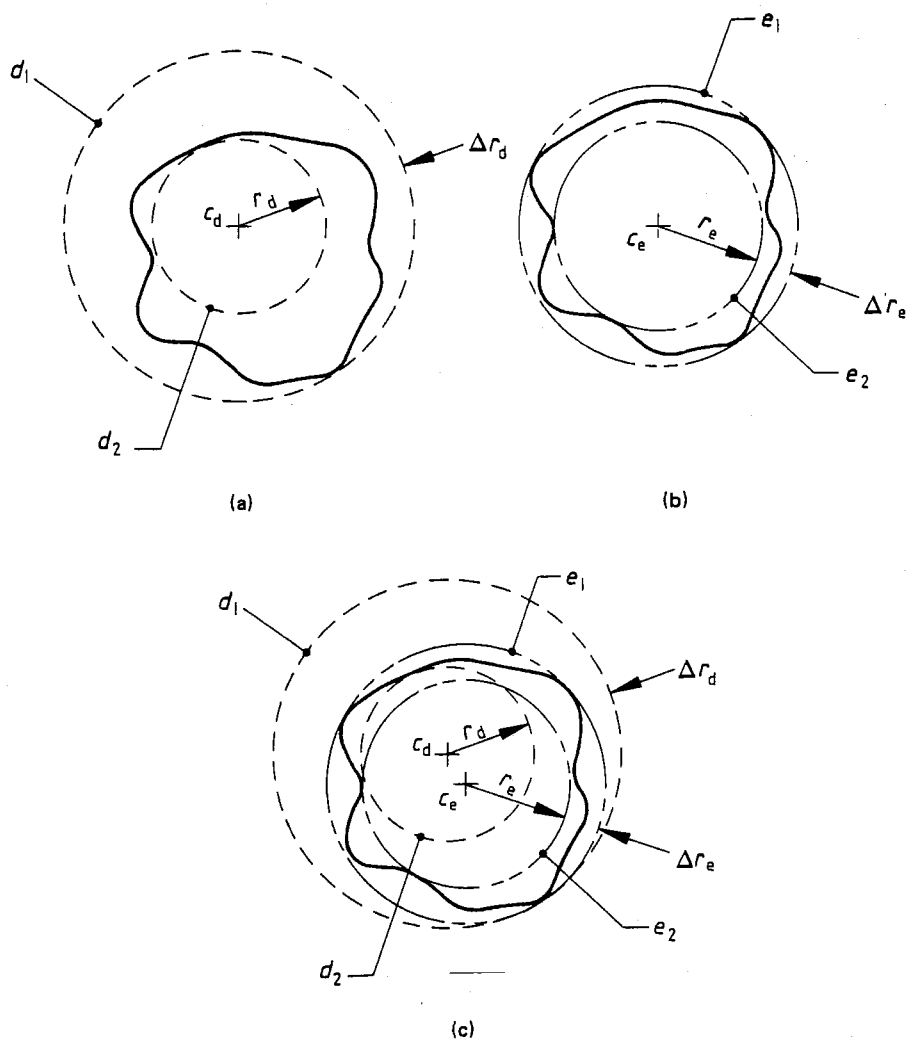
or coaxial cylinders which contain the line or surface is to be chosen so that the radial distance between the circles or cylinders is a minimum.

Figures 56(a) and (c) each show the same two concentric circles or coaxial cylinders d_1 and d_2 with centre or axis c_d which contain the tolerated line or surface. The radial separation of the circles or cylinders is Δr_d .

Figures 56(b) and (c) each show the same two concentric circles or coaxial cylinders e_1 and e_2 with centre or axis c_e . c_e is in a different position from c_d . The circles or cylinders e_1 and e_2 also contain the tolerated line or surface and their radial separation is Δr_e . Δr_e is a minimum and less than Δr_d and the optimum location for the centres of the two concentric circles or coaxial cylinders is c_e . The radial distance Δr_e should be equal to or less than the specified tolerance.

NOTE. This interpretation is equivalent to the minimum zone centre (MZC) case given in appendix A of BS 3730 : Part 2 : 1982.





NOTE 1. (c) shows (a) and (b) in superimposition.

NOTE 2. Shown exaggerated for clarity.

Figure 56. Assessment of circularity and cylindricity deviation

Index

This index is common to all the Parts of BS 308.

	Part	Clause		Part	Clause
Abbreviations	1	11	Decimal marker	2	3.1.8
Actual local size	2	2.9	Dependency of size and form (limits of size)	2	11.2
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Publications referred to

BS 308	Engineering drawing practice Part 1 Recommendations for general principles Part 2 Recommendations for dimensioning and tolerancing of size
BS 499	Welding terms and symbols
BS 1192	Construction drawing practice Part 1 Recommendations for general principles
BS 2774	Specification for drawing conventions for laboratory glass apparatus
BS 3429	Specification for sizes of drawing sheets
BS 3730	Assessment of departures from roundness Part 2 Specification for characteristics of stylus instruments for measuring variations in radius (including guidance on use and calibration)
BS 4301	Recommendations for preparation of drawings for optical elements and systems
BS 5070	Engineering diagram drawing practice
BS 5536	Recommendations for preparation of technical drawings for microfilming
ISO 128	Technical drawings — General principles of presentation
ISO 129	Technical drawings — Dimensioning — General principles, definitions, methods of execution and special indications
ISO 406	Technical drawings — Tolerancing of linear and angular dimensions
ISO 1101*	Technical drawings — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out Generalities, definitions, symbols, indications on drawings
ISO 1302*	Technical drawings — Method of indicating surface texture on drawings
ISO 1660	Technical drawings — Dimensioning and tolerancing of profiles
ISO 2162*	Technical drawings — Representation of springs
ISO 2203	Technical drawings — Conventional representation of gears
ISO 2553	Welds — Symbolic representation on drawings
ISO 2692	Technical drawings — Geometrical tolerancing — Maximum material principle
ISO 3040*	Technical drawings — Dimensioning and tolerancing cones
ISO 3098	Technical drawings — Lettering Part 1 Currently used characters
ISO 5455	Technical drawings — Scales
ISO 5456†	Technical drawings — Pictorial representations
ISO 5457	Technical drawings — Sizes and layout of drawing sheets
ISO 5458	Technical drawings — Geometrical tolerancing — Positional tolerancing
ISO 5459	Technical drawings — Geometrical tolerancing — Datums and datum-systems for geometrical tolerances
ISO 5463†	Technical drawings — Dimensioning and tolerancing — Terminology
ISO 6410	Technical drawings — Conventional representation of threaded parts
ISO 6411	Technical drawings — Simplified representation of centre holes
ISO 6413	Technical drawings — Representation of splines and serrations
ISO 6414	Technical drawings for glassware
ISO 6428	Technical drawings — Requirements for microcopying
ISO 6433	Technical drawings — Item references
ISO 7083	Technical drawings — Symbols for geometrical tolerancing — Proportions and dimensions
ISO 7200	Technical drawings — Title blocks
ISO 7573	Technical drawings — Item list
ISO 8015	Technical drawings — Fundamental tolerancing principle
PD 7304	Introduction to geometrical tolerancing

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†In preparation.

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Engineering drawing practice
Part 3. Recommendations for geometrical tolerancing

Additional text

Foreword

Insert the following text at the end of the Foreword.

This Part of BS 308 is being superseded by the adoption of European implementations of international standards.

The following standard has been published as a British Standard.

European standard	Subject	Deleting action on BS 308 : Part 3
BS EN ISO 7083	G.T symbols	Appendix B

Further ISO standards expected to be adopted include the following.

ISO standard	Subject	Deleting action on BS 308 : Part 3
ISO 1101	G.T - general principles	Clauses 3 to 8, 10, 11
ISO 2692	G.T - maximum material principle	Clauses 17 to 21
ISO 5458	G.T - position	Clauses 22, 23
ISO 5459	G.T - datums	Clauses 12 to 16
ISO 10578	G.T -projected tolerance zone	Clause 9

Because BS 308 does not conflict in its technical recommendations the withdrawal of this Part of the standard is delayed until all the relevant ISO standards have been adopted.

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