

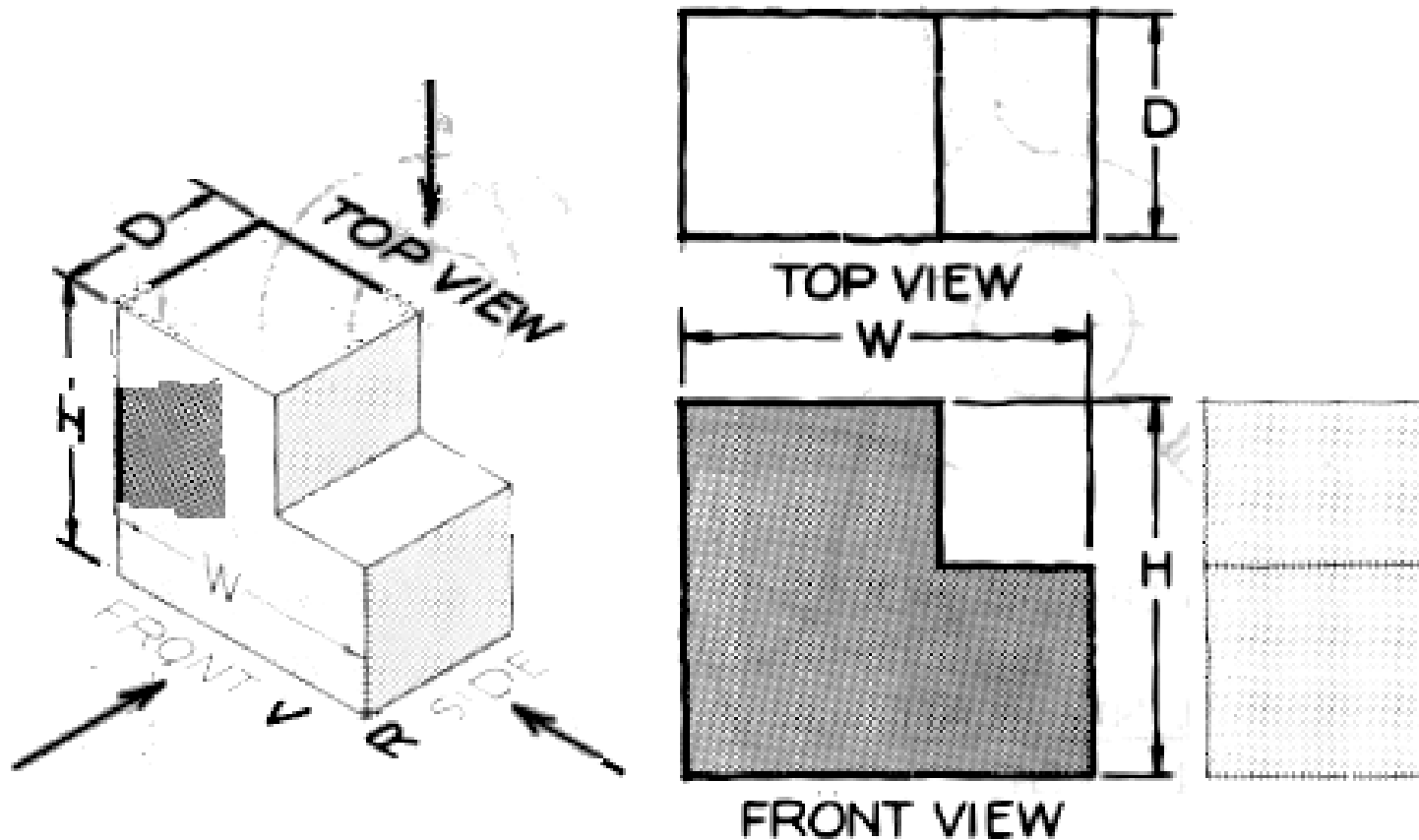
# Technical Drawings

- Models
  - Used for design and analysis
  - SolidWorks, I-DEAS, Pro-E, ...
- Component Drawings
  - Used to specify fabrication or procurement of parts
  - AutoCad, Pro-E, Solid Works ...
- Assembly Drawings
  - Used to specify assembly of parts
  - AutoCad, Pro-E, SolidWorks ...
- **This lecture covers component drawings and tolerances**
- References
  - Earle, J. H., *Engineering Design Graphics* (Addison-Wesley, 1983)
  - ASME Y14.5M Dimensioning and tolerancing

# Component Drawings

- Orthographic projection
- Isometric layout
- Dimensioning
- Tolerancing

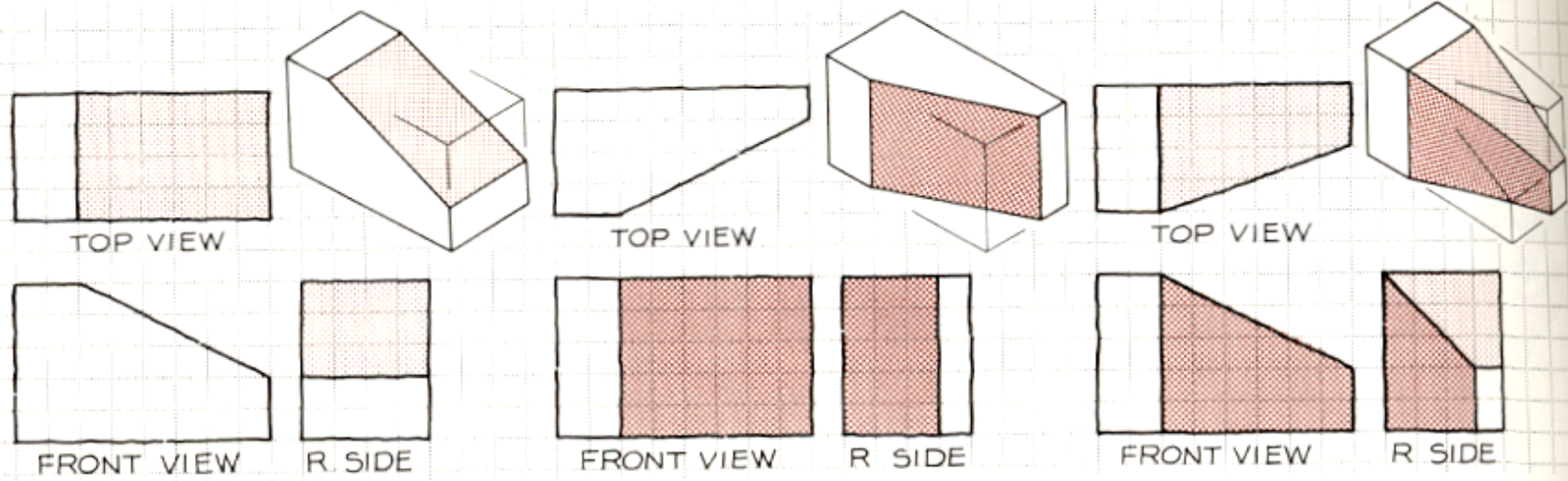
# 3-view orthographic projection



**Fig. 13.1** Three views of an object can be found by looking at the object in this manner. The three views—the top, front, and right side—describe the object.

# Inclined planes

Fig. 13.10 Views of planes



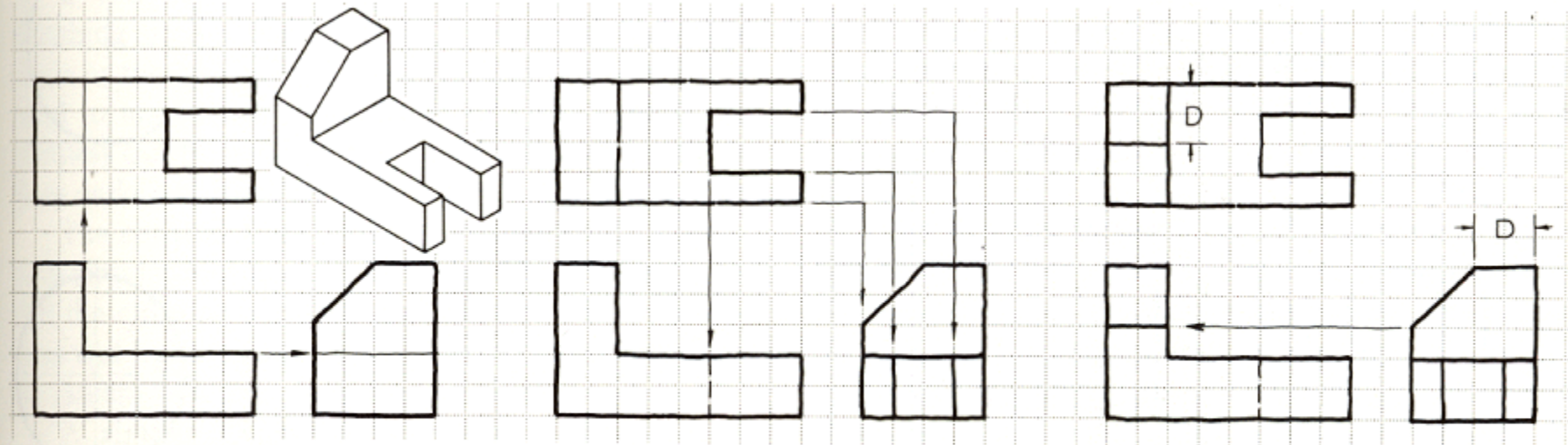
A. The plane appears as an edge in the front view and it is foreshortened in the top and side views.

B. The plane is an edge in the top view and it is foreshortened in the front and side views.

C. These two planes appear foreshortened in the right-side view. Each appears as an edge in either the top or front views.

# Hidden lines

Fig. 13.13 Missing lines

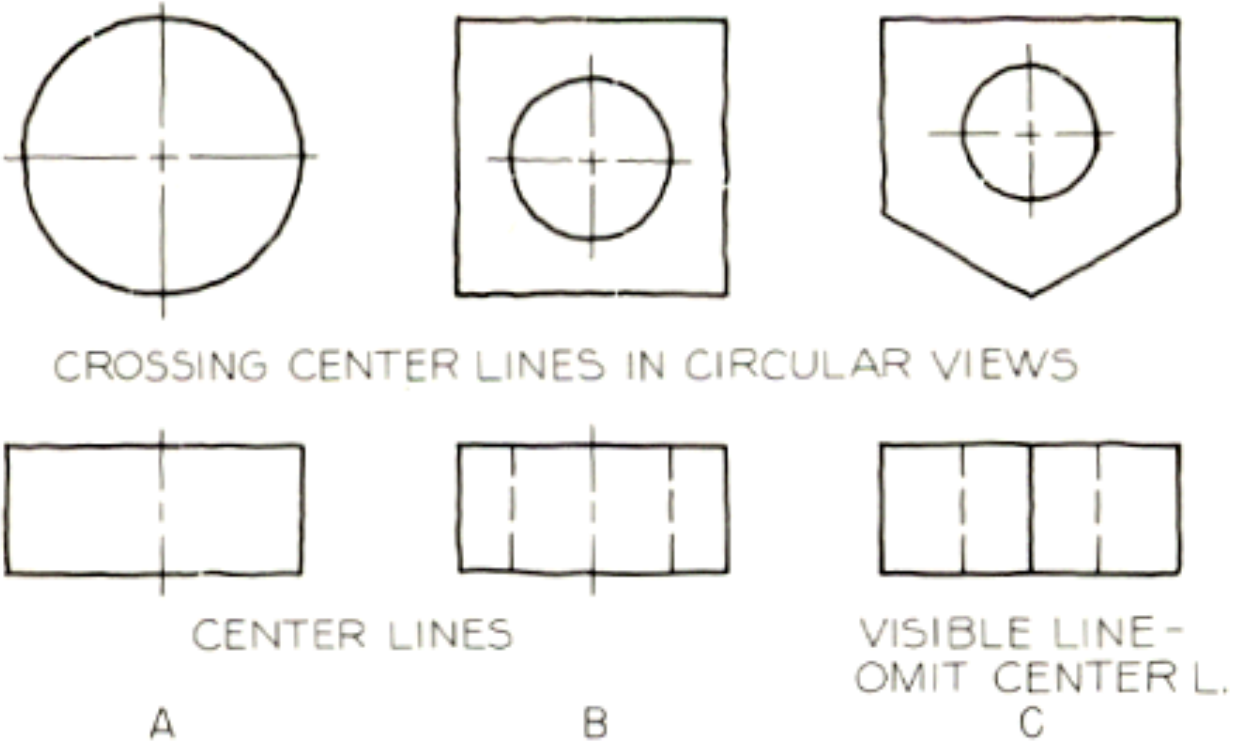


**Step 1** Lines may be missing in all views in this type of problem. The first missing line is found by projecting the edges of the planes from the front to the top and side views.

**Step 2** The notch in the top view is projected to the front and side views. The line in the front view is a hidden line.

**Step 3** The line formed by the beveled surface is found in the front view by projecting from the side view.

# Holes and cylinders



**Fig. 13.14** Center lines are used to indicate the centers of circles and the axes of cylinders. These are drawn as very thin lines. When they coincide with visible or hidden lines, center lines are omitted.

# Concentric cylinders

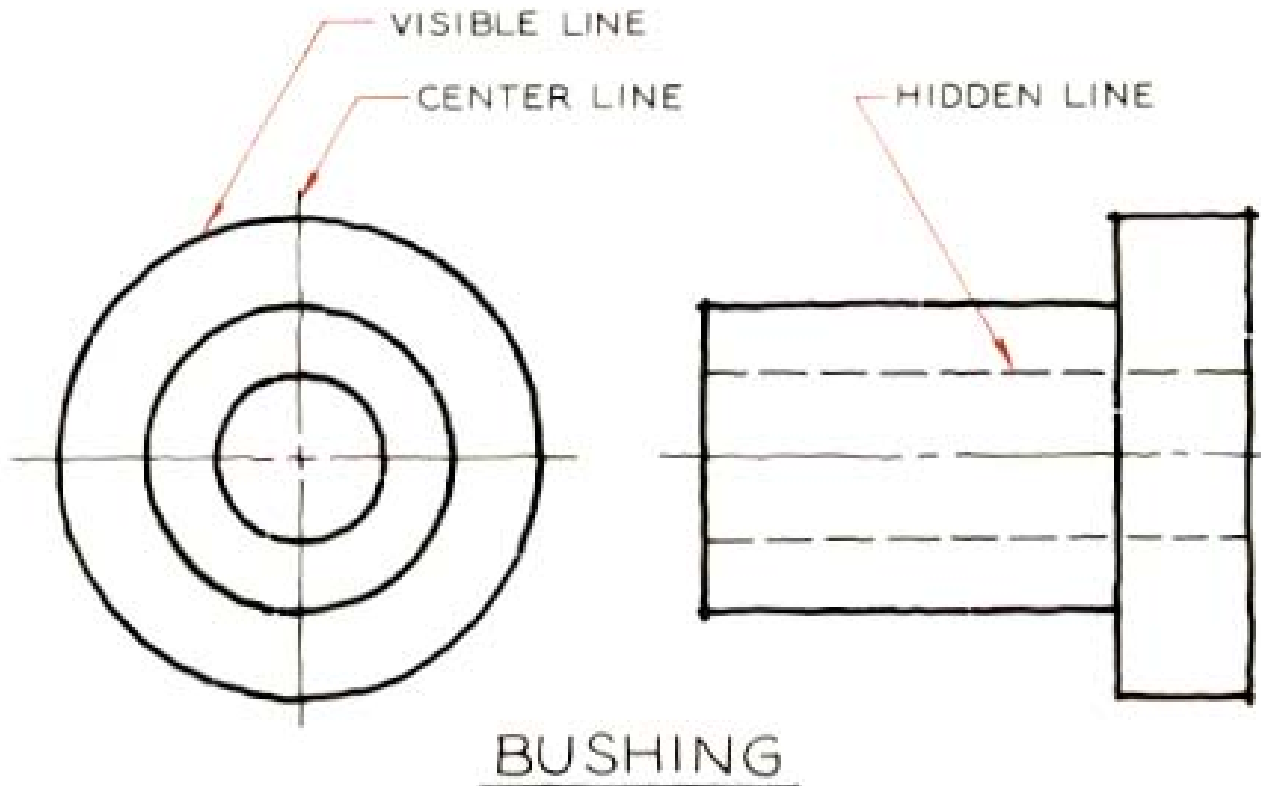
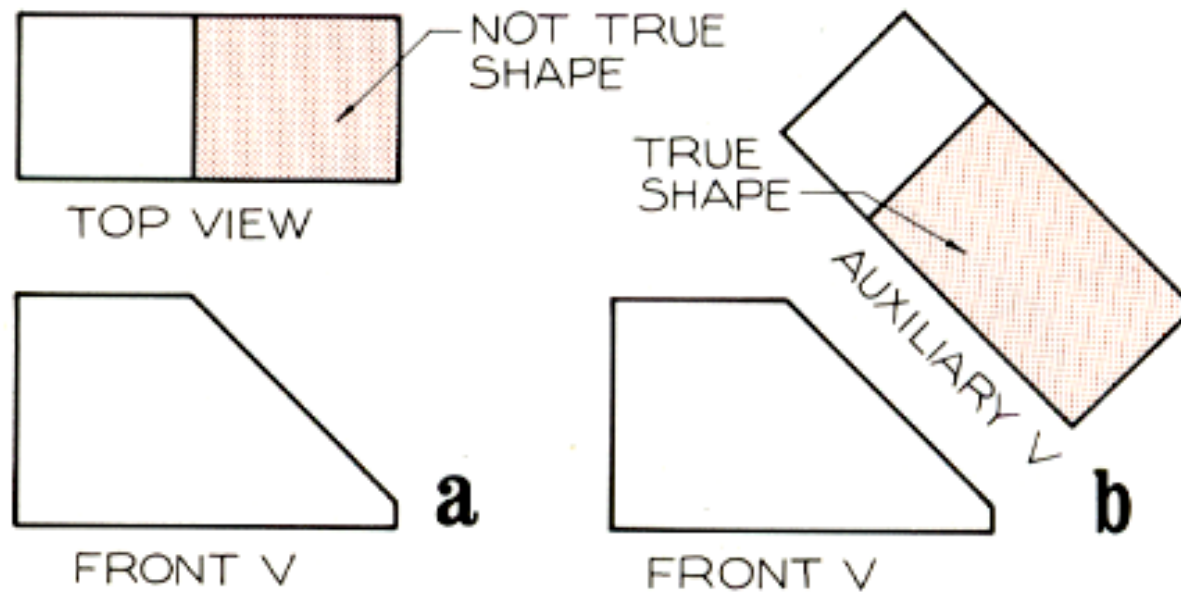


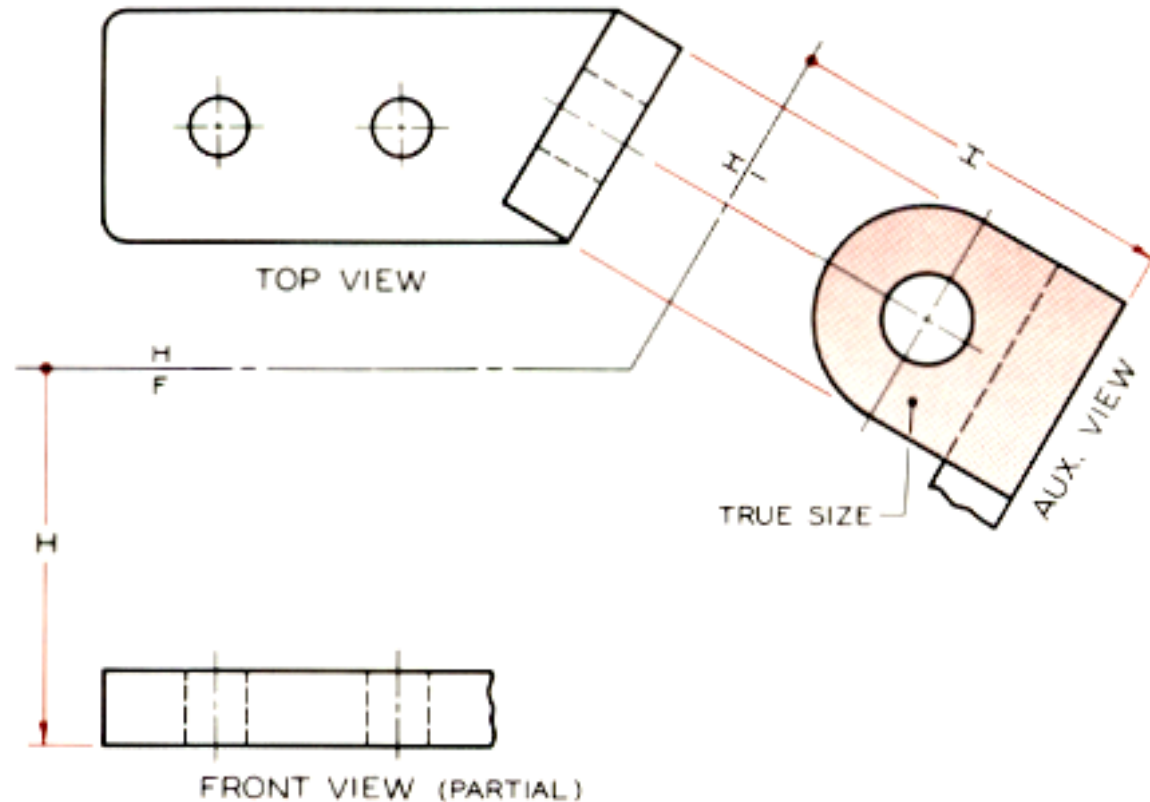
Fig. 13.16 Here you can see the application of center lines of concentric cylinders, and the relative weight of hidden, visible, and center lines.

# Auxiliary views



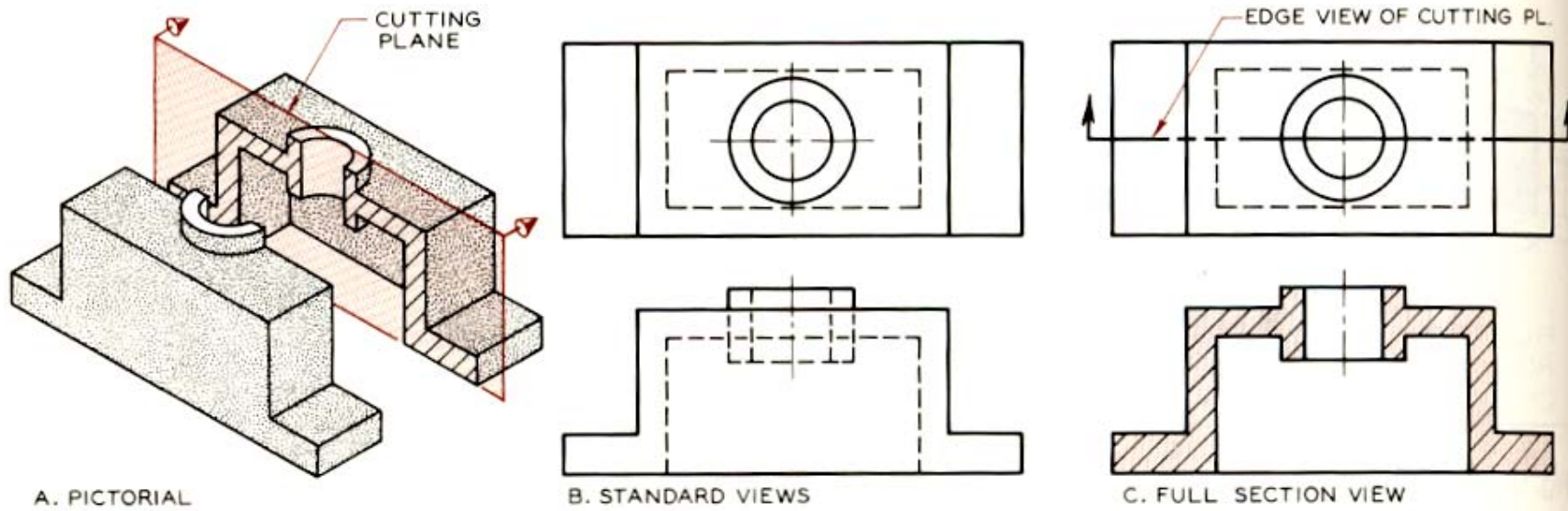
**Fig. 15.1** When a surface appears as an inclined edge in a principal view, it can be found true size by an auxiliary view. The top view at a is foreshortened, but this plane is true size in an auxiliary view at b.

# Auxiliary views



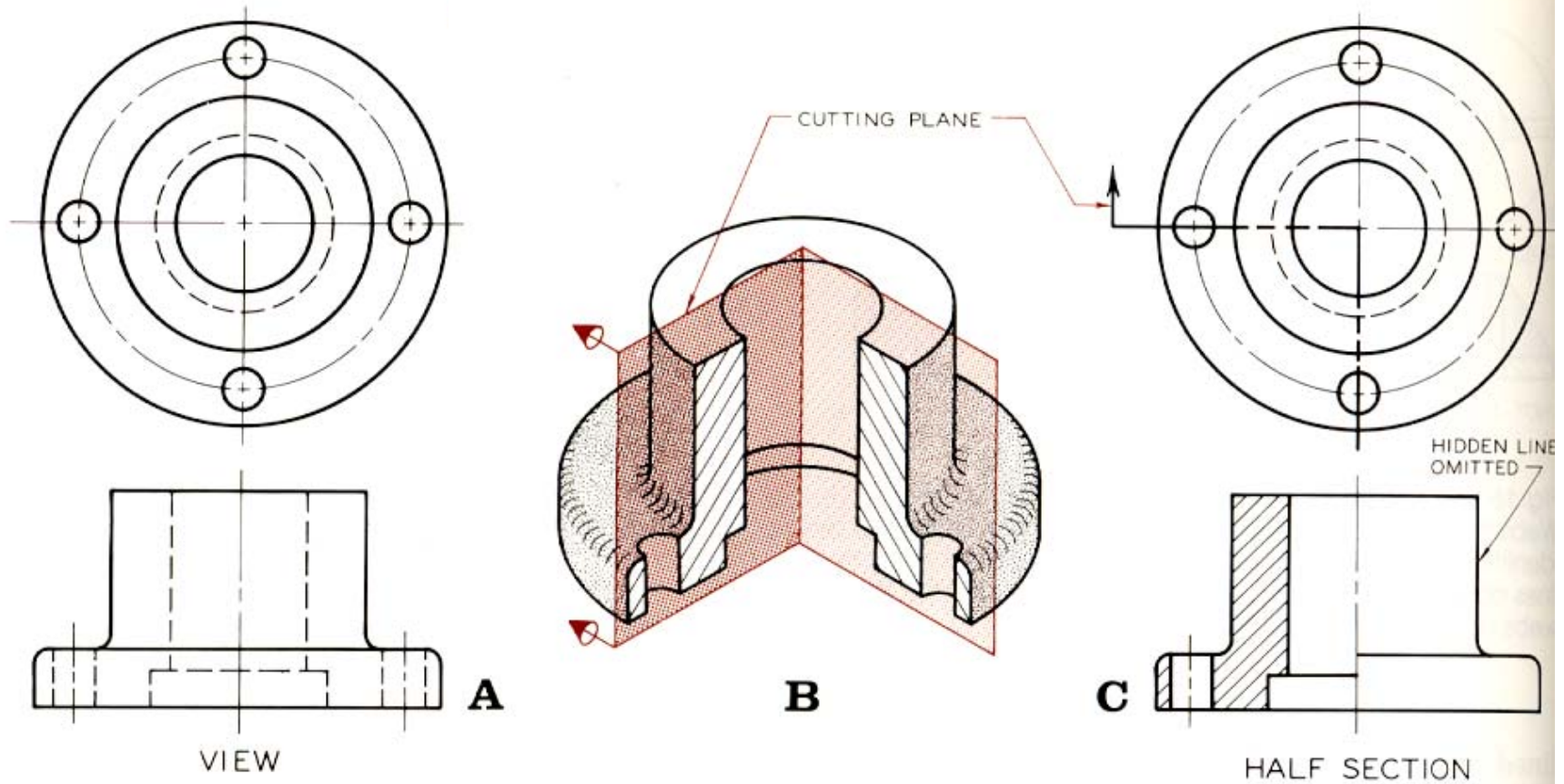
**Fig. 15.6** When the object is drawn on a sheet of paper, it would be laid out in this manner. The front view is drawn as a partial view since the omitted part is shown true size in the auxiliary view.

# Section views



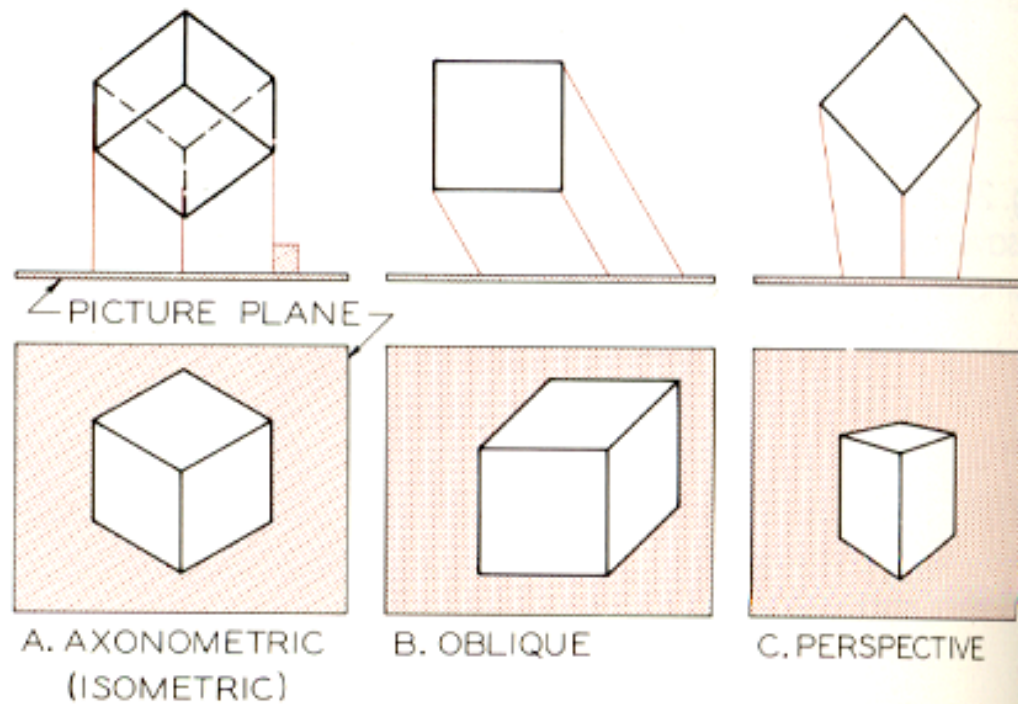
**Fig. 16.1** A comparison of a regular orthographic view with a full-section view of the same object to show the internal features as well as the external features.

# Half section views



**Fig. 16.19** The cutting plane of a half-section passes halfway through the object, which results in a sectional view that shows half of the outside and half of the inside of the object. Hidden lines are omitted unless they are necessary to clarify the view.

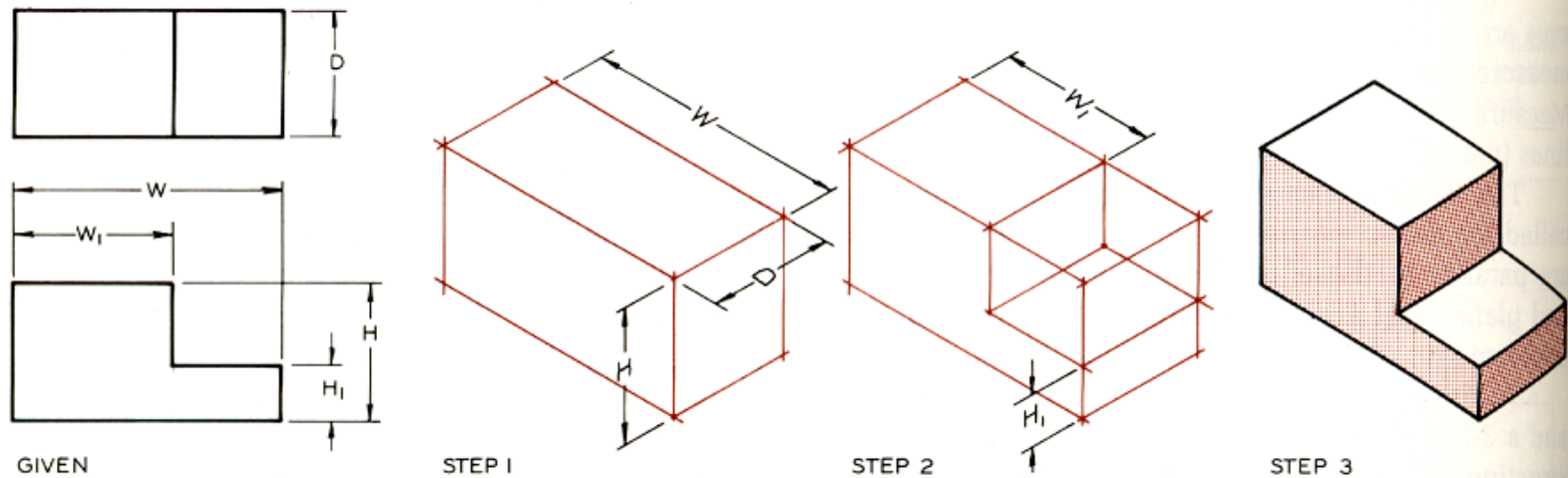
# Pictorial (3D) drawings



**Fig. 25.2** Types of projection systems for pictorials. (A) Axonometric pictorials are formed by parallel projectors that are perpendicular to the picture plane. (B) Obliques are formed by parallel projectors that are oblique to the picture plane. (C) Perspectives are formed by converging projectors that make varying angles with the picture plane.

# Isometric layout

Fig. 25.28 Layout of an isometric drawing (simple)



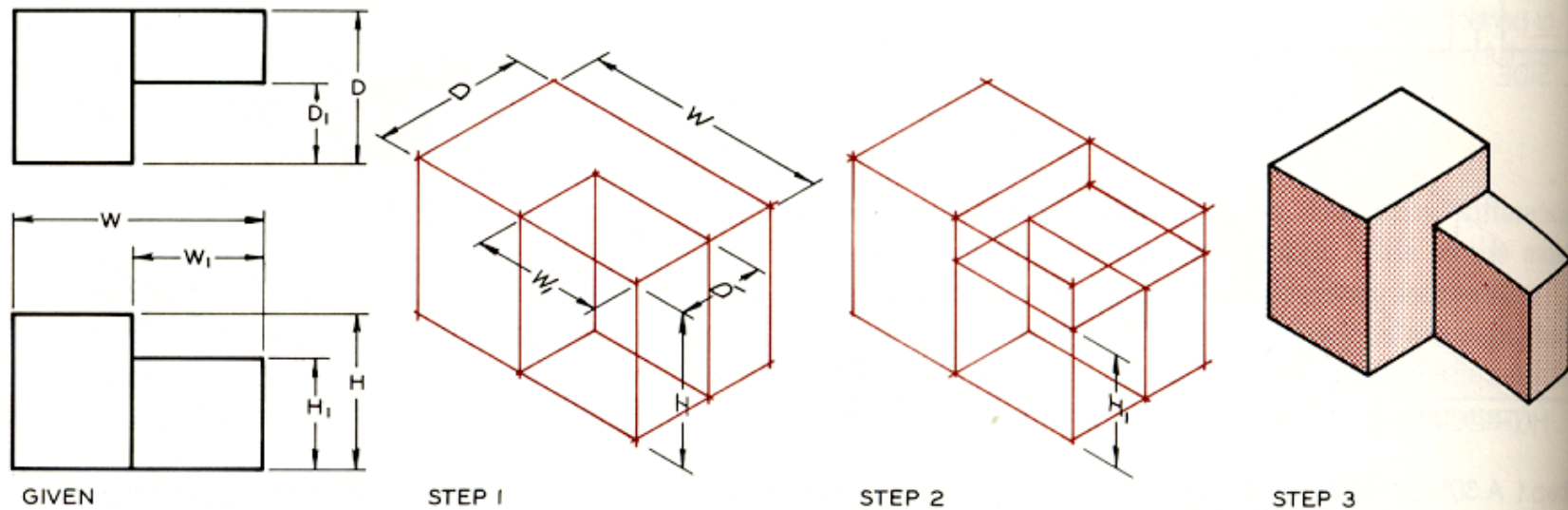
**Step 1** The object is blocked in using the overall dimensions. The notch is removed.

**Step 2** The inclined plane is located by establishing its end points.

**Step 3** The lines are strengthened to complete the drawing.

# Isometric drawings (2)

Fig. 25.29 Layout of an isometric drawing (complex)



**Step 1** The overall dimensions of the object are used to lightly block in the object. One notch is removed by using dimensions taken from the given views.

**Step 2** The second notch is removed using dimension  $H_1$ .

**Step 3** The final lines of the isometric are strengthened.

# Cylinders in isometric

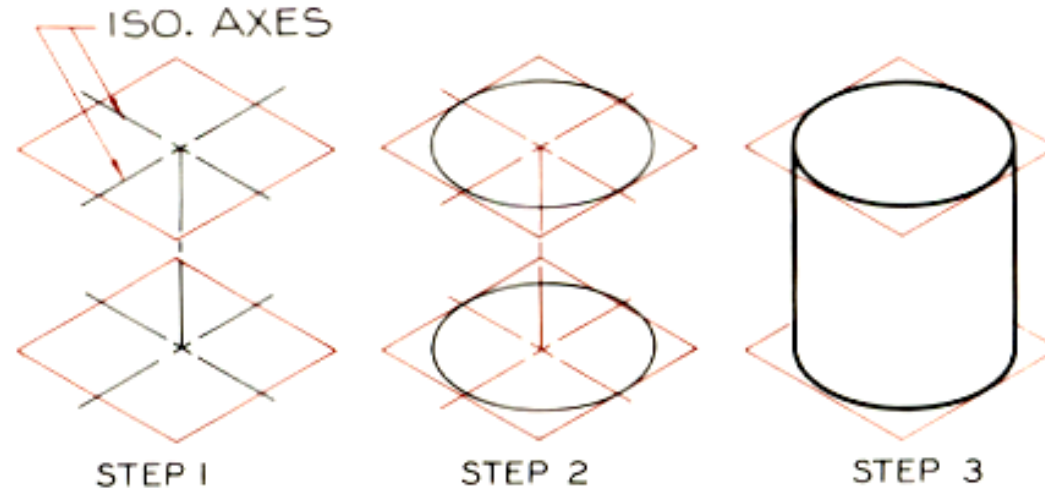


Fig. 25.40 Cylinder: four-center method

**Step 1** A rhombus is drawn in isometric at each end of the cylinder's axis.

**Step 2** A four-center ellipse is drawn within each rhombus.

**Step 3** Lines are drawn tangent to each rhombus to complete the isometric drawing.

# Linear dimensions

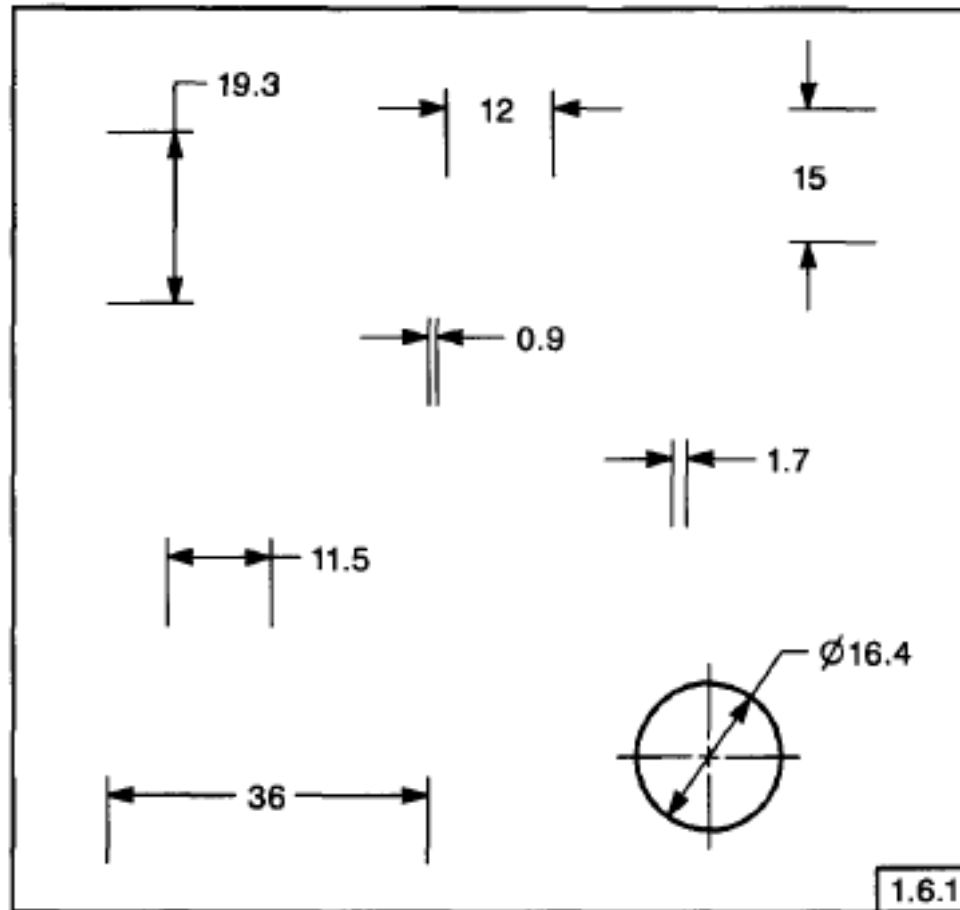


FIG. 1-2 MILLIMETER DIMENSIONS

# Angular dimensions

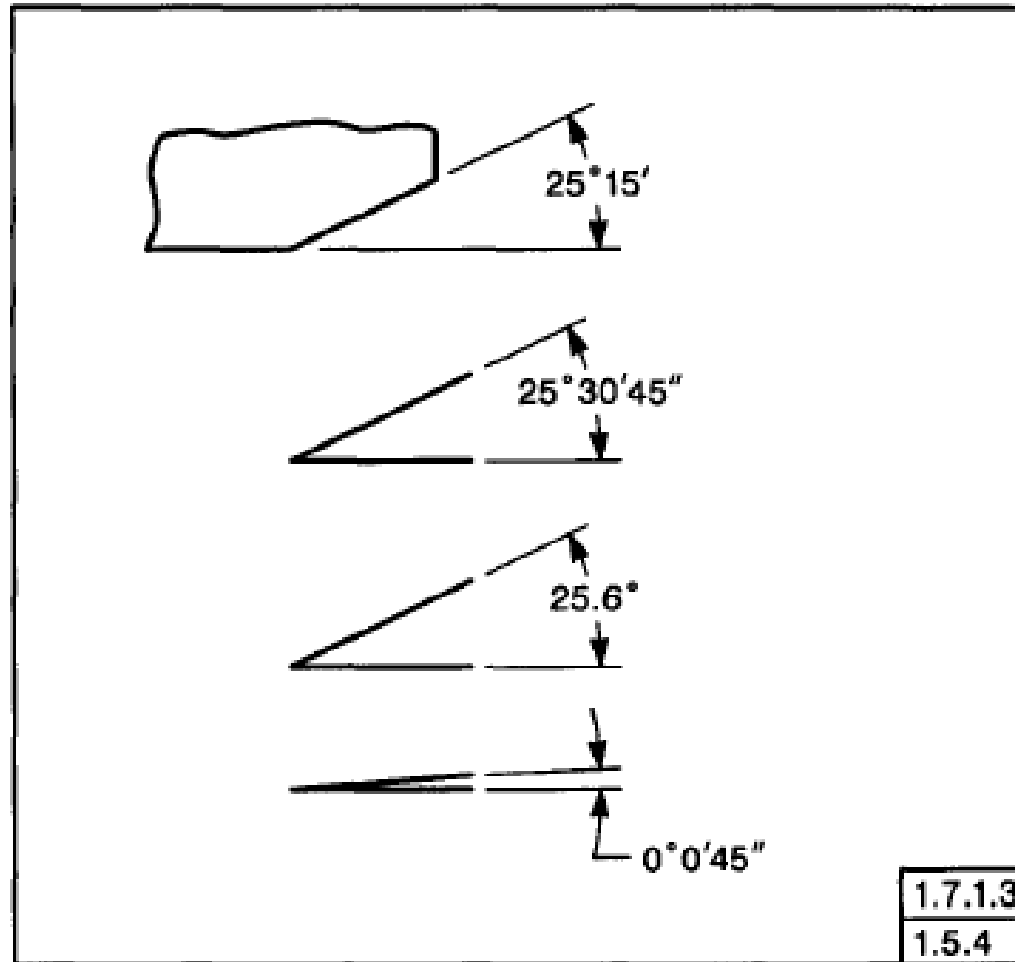


FIG. 1-1 ANGULAR UNITS

# Grouping of dimensions

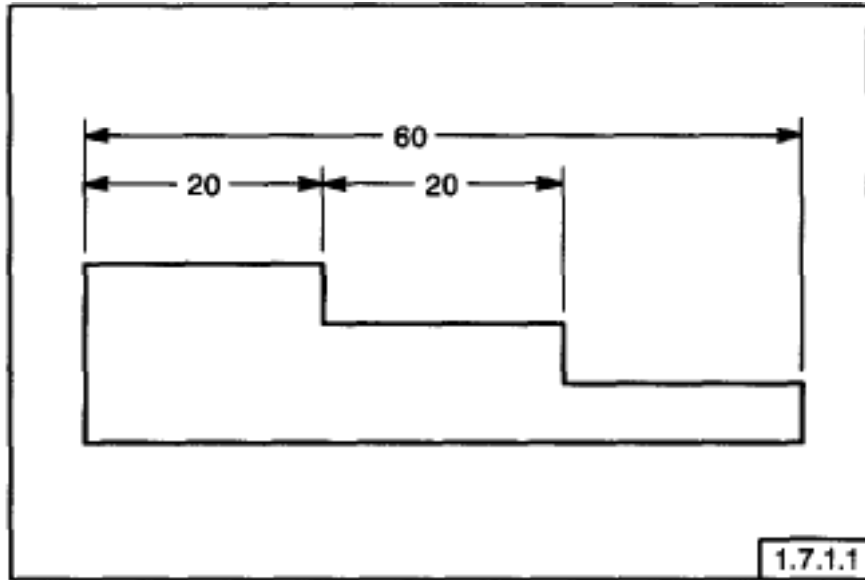


FIG. 1-5 GROUPING OF DIMENSIONS

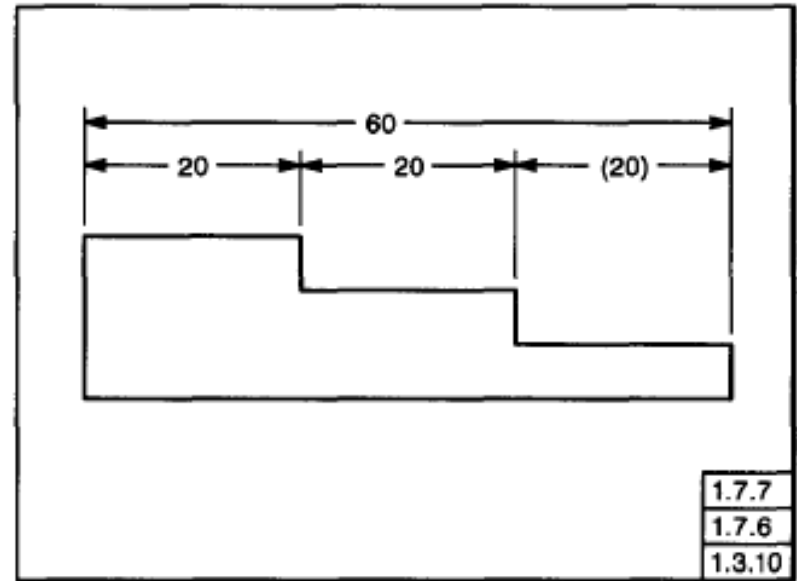


FIG. 1-17 INTERMEDIATE REFERENCE DIMENSION

# Application of dimensions

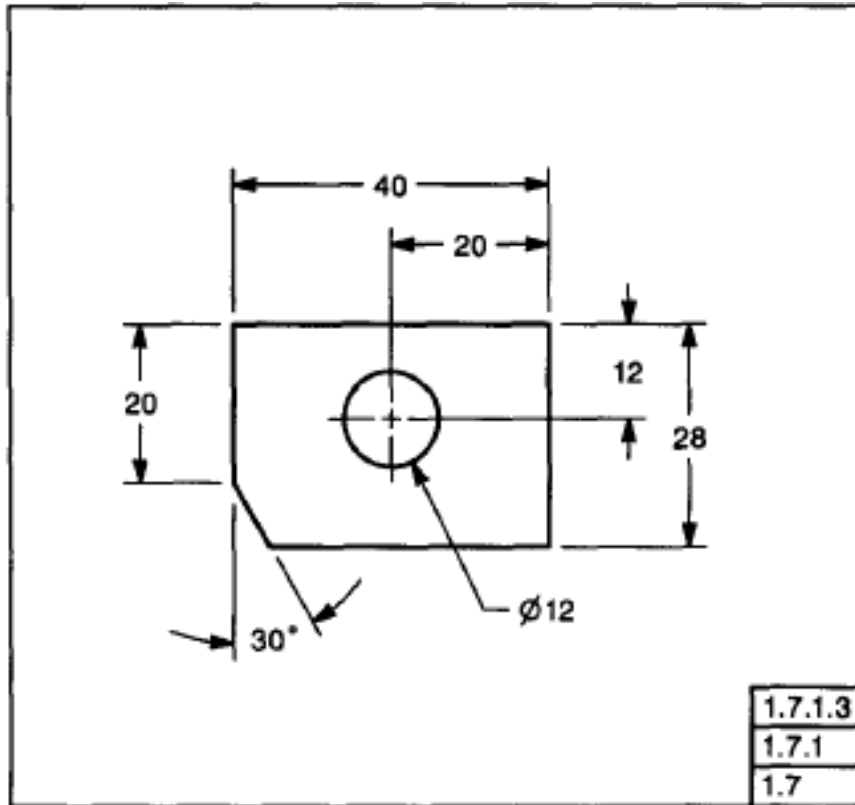


FIG. 1-4 APPLICATION OF DIMENSIONS

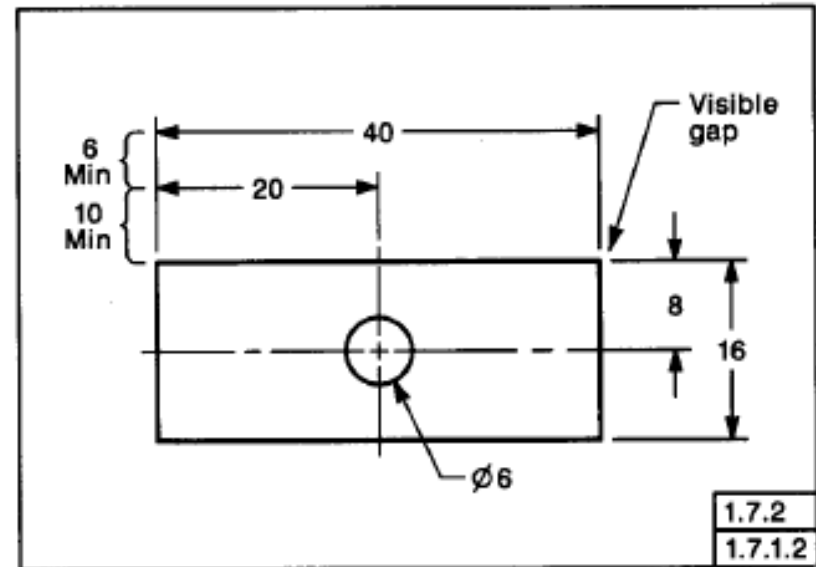


FIG. 1-6 SPACING OF DIMENSION LINES

# Staggered dimensions

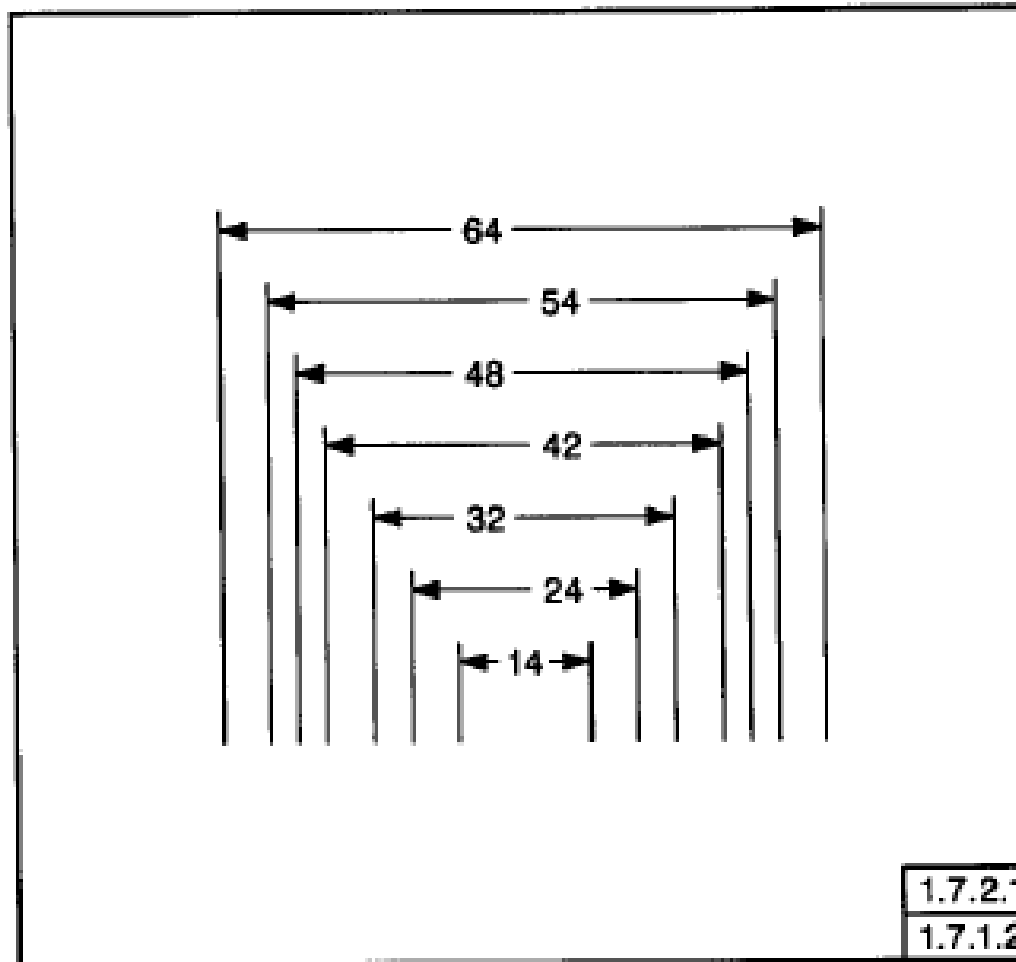


FIG. 1-7 STAGGERED DIMENSIONS

# Leaders

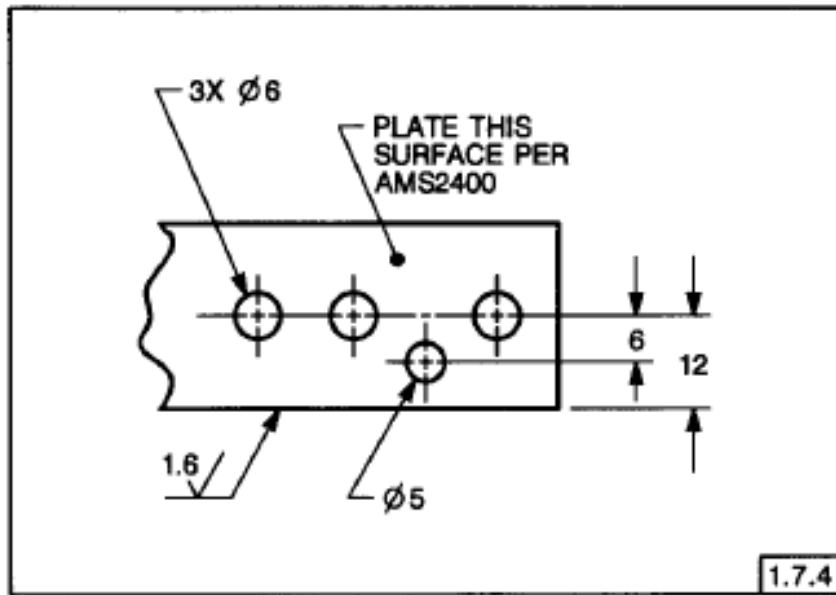


FIG. 1-12 LEADERS

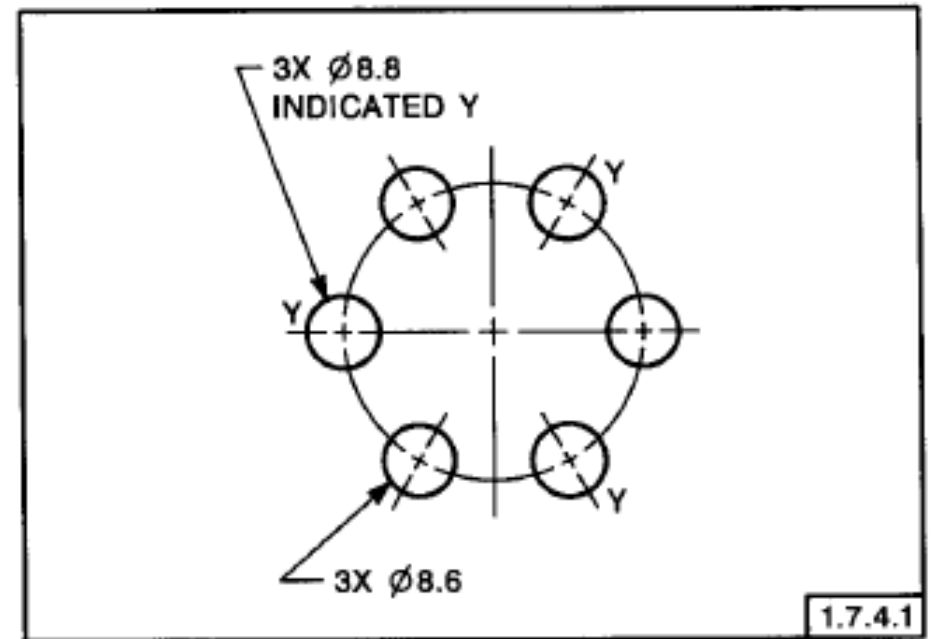


FIG. 1-14 MINIMIZING LEADERS

# Diameters, radii

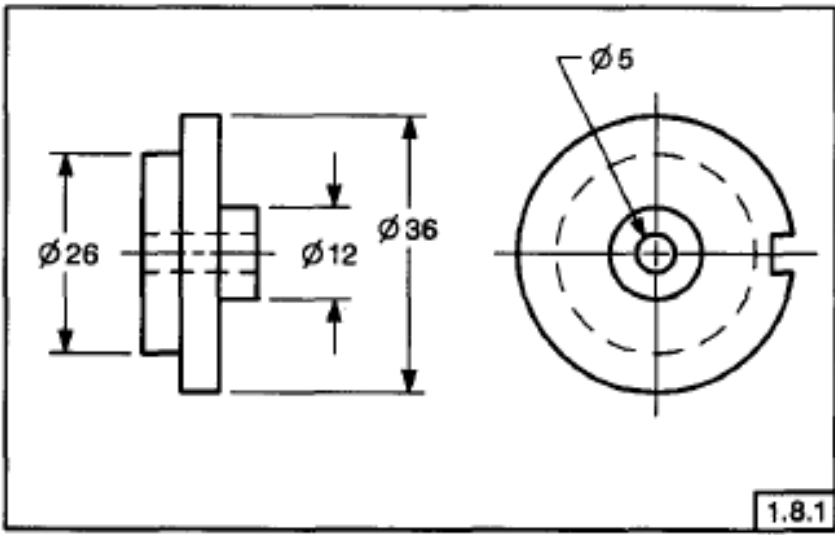


FIG. 1-19 DIAMETERS

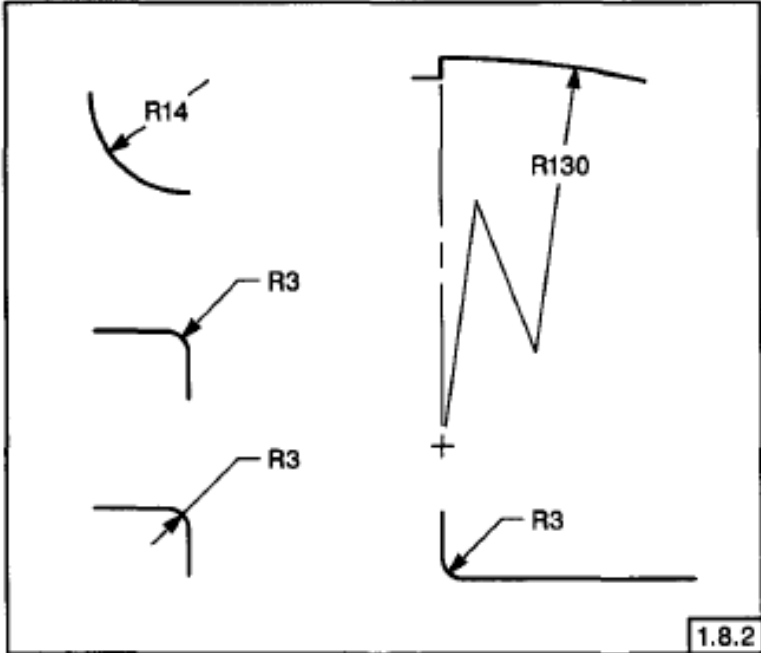
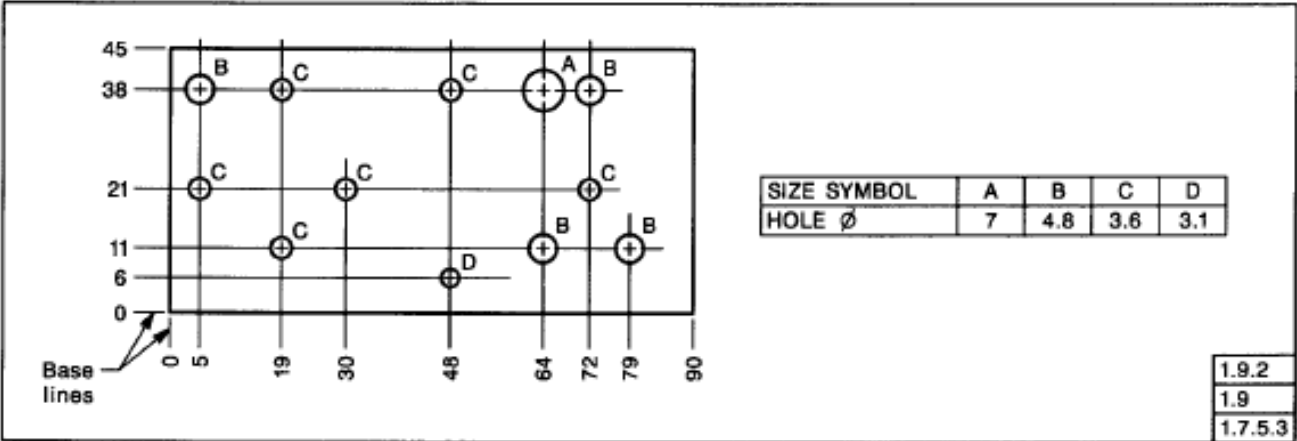
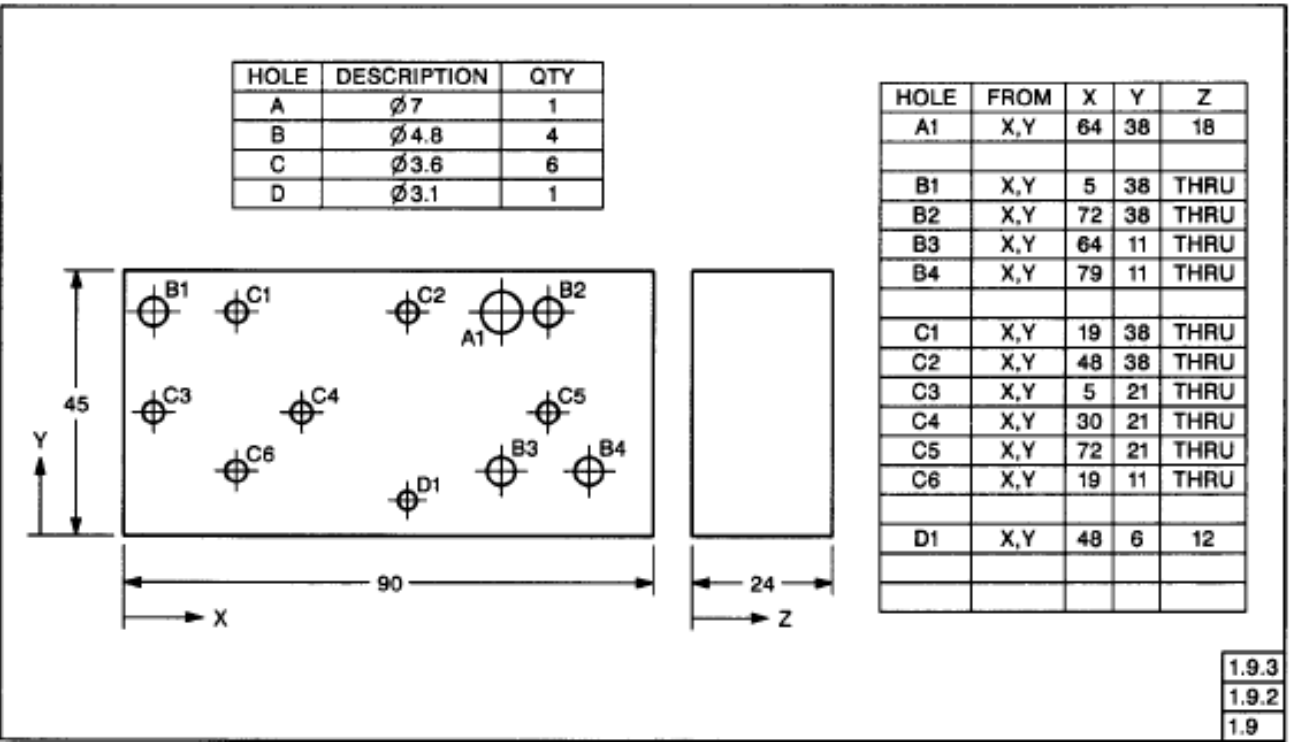


FIG. 1-20 RADII

# Tabular dimensions



1.9.2  
1.9  
1.7.5.3



1.9.3  
1.9.2  
1.9

# Tolerances

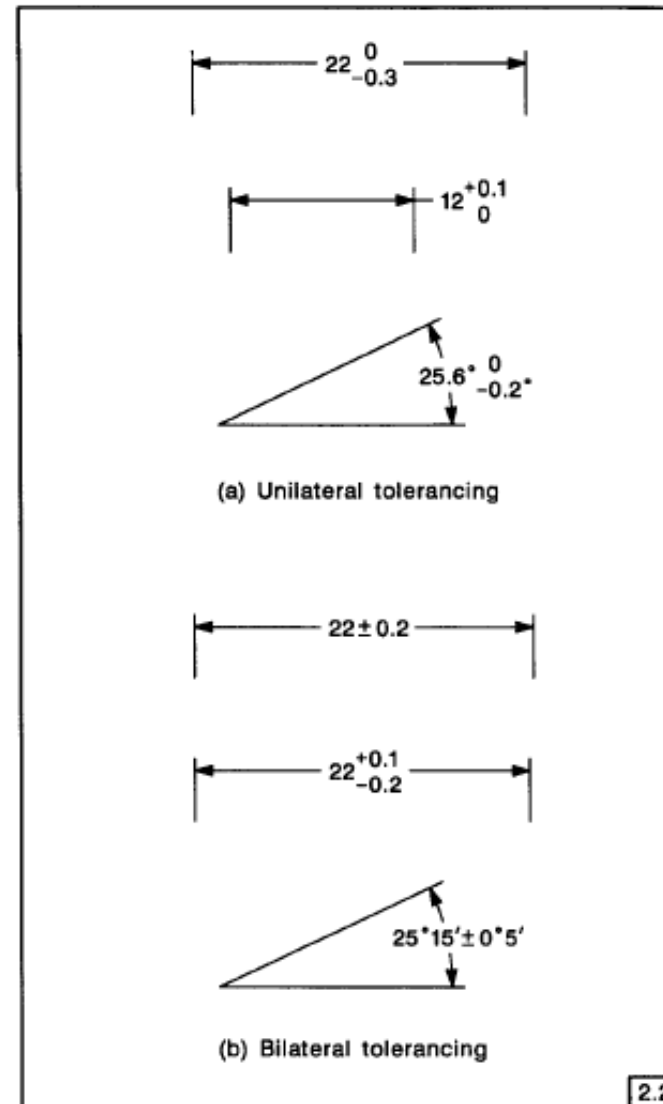
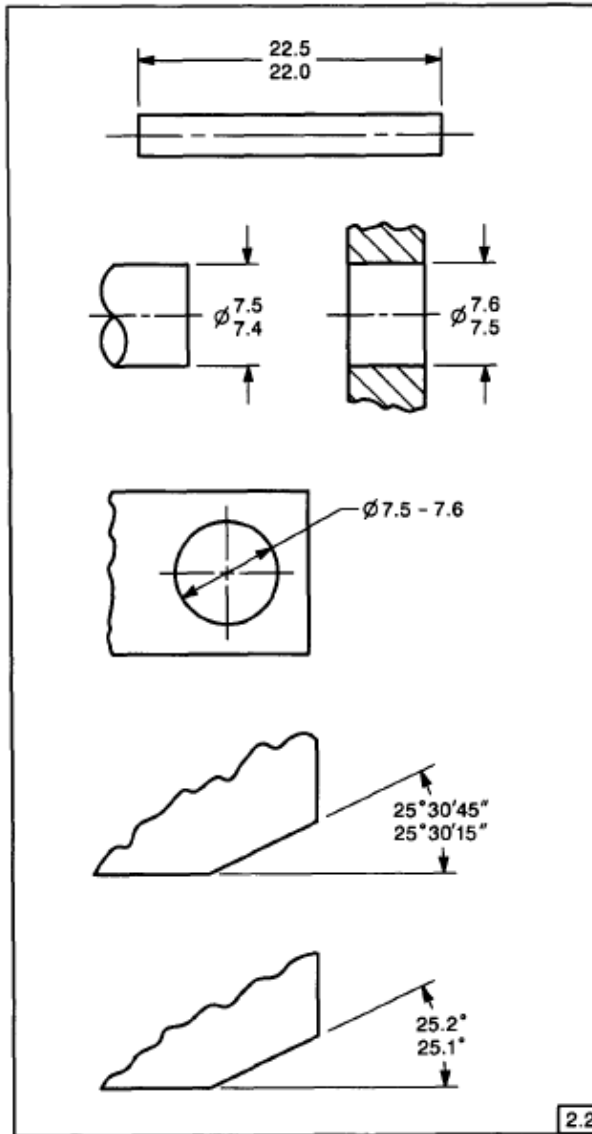
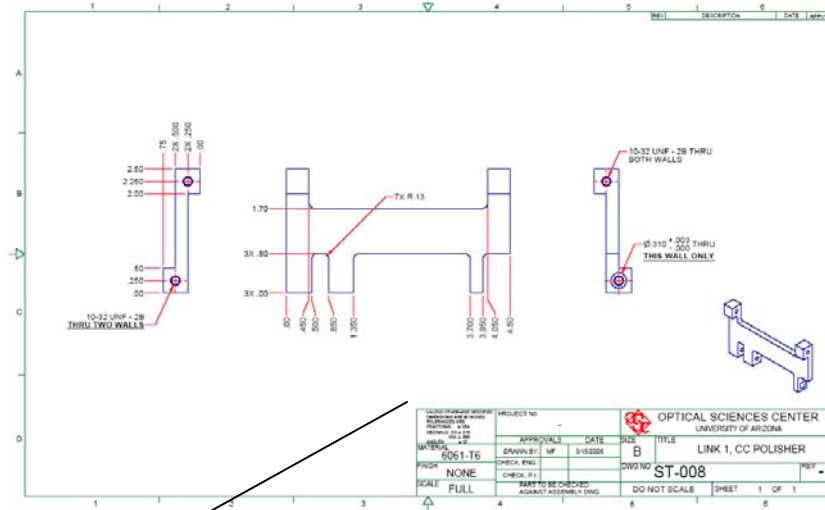



FIG. 2-2 PLUS AND MINUS TOLERANCING

# Default tolerances

Can be specified in Title Block of drawing



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS: $\pm 1/64$ DECIMALS: $.XX \pm .010$ $.XXX \pm .005$ ANGLES: $\pm 10'$	PROJECT No.		-		 <b>OPTICAL SCIENCES CENTER</b> UNIVERSITY OF ARIZONA
	APPROVALS		DATE	SIZE	
MATERIAL	DRAWN BY:	MF	3/15/2006	B	LINK 1, CC POLISHER
FINISH	CHECK, ENG.:			DWG NO	ST-008
SCALE	CHECK, P.I.:			REV	-
	PART TO BE CHECKED AGAINST ASSEMBLY DWG.		DO NOT SCALE	SHEET	1 OF 1

# Specification of datum

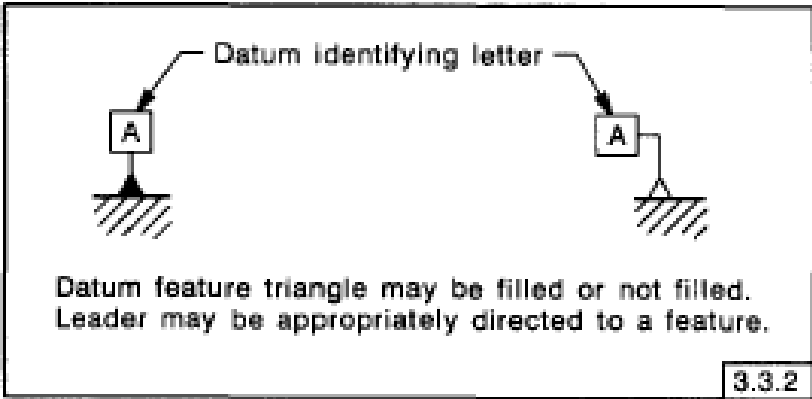


FIG. 3-2 DATUM FEATURE SYMBOL

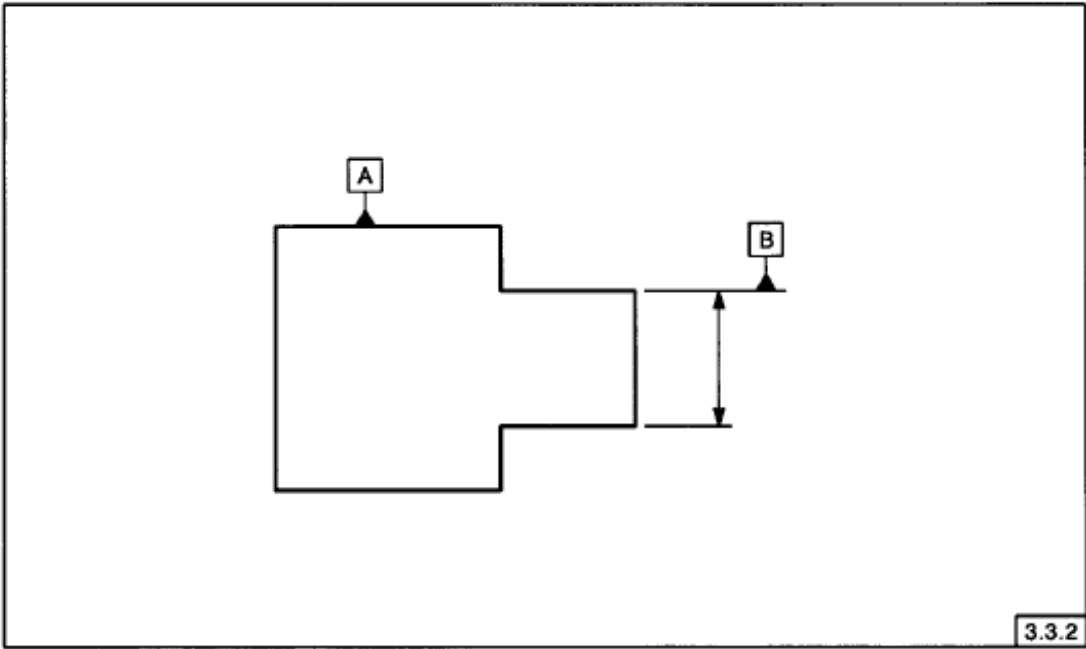


FIG. 3-3 DATUM FEATURE SYMBOLS ON A FEATURE SURFACE AND AN EXTENSION LINE

# Datum reference frame

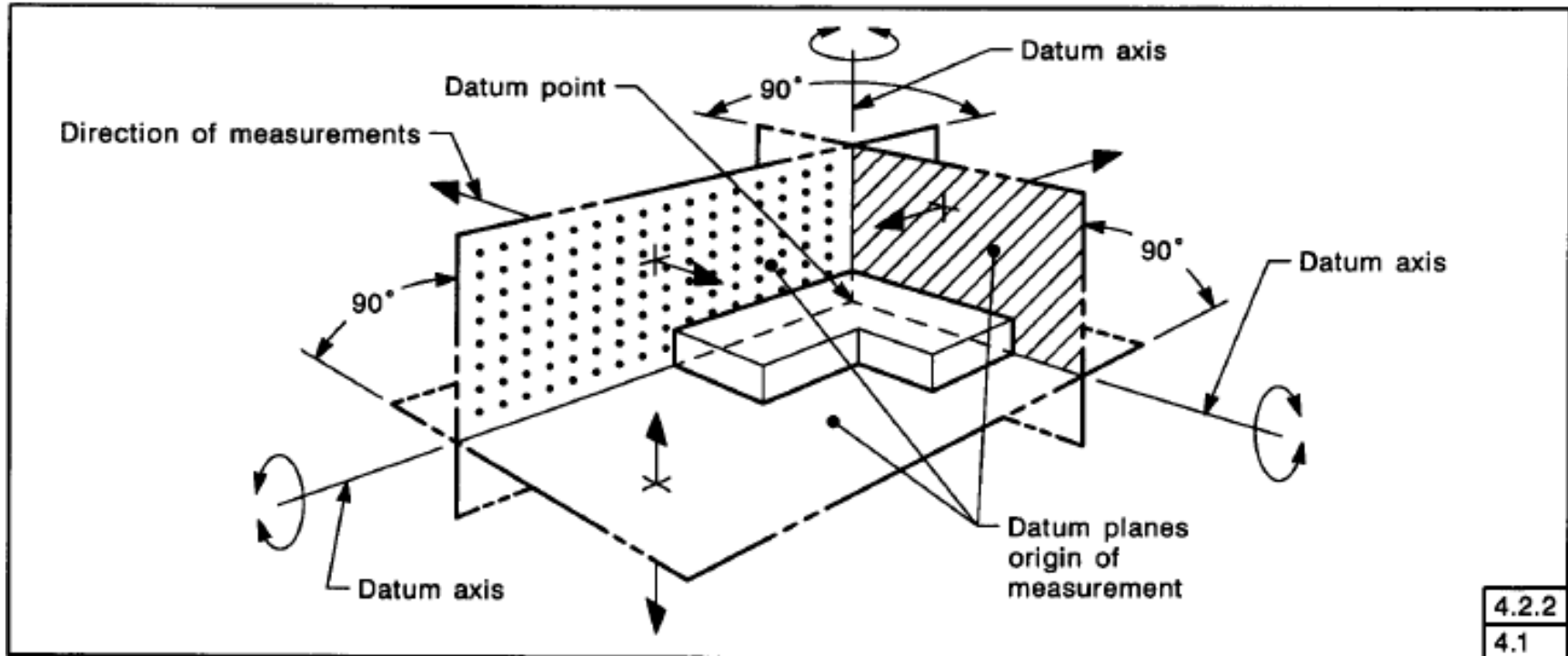


FIG. 4-1 DATUM REFERENCE FRAME

# Reference to datum

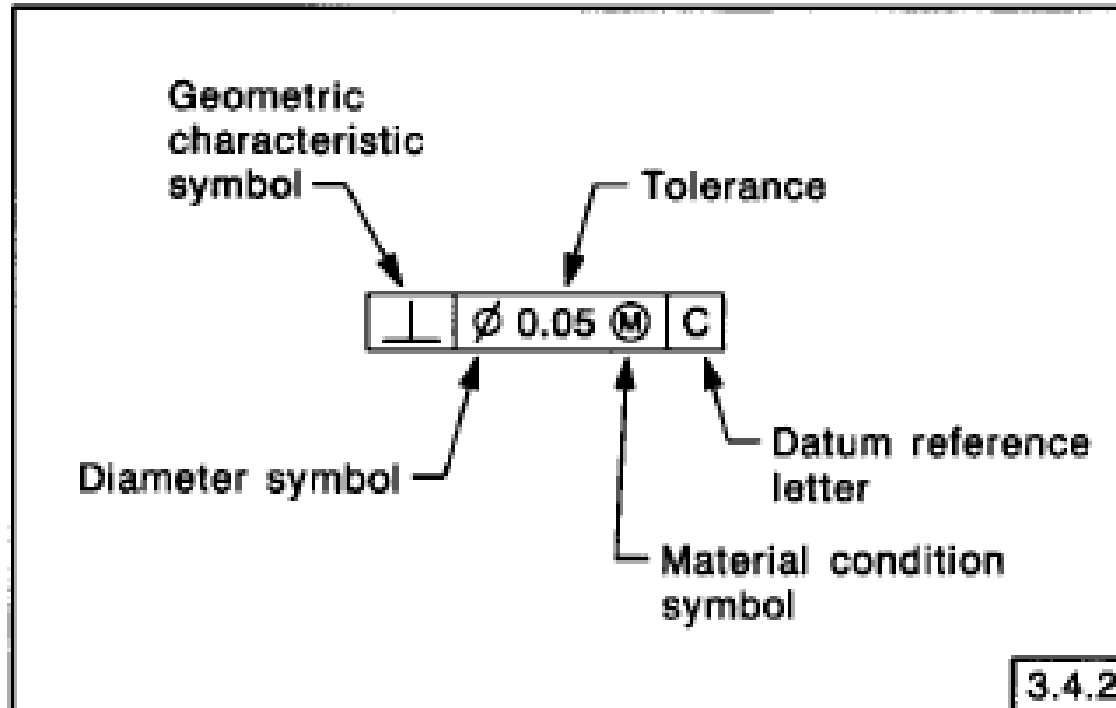


FIG. 3-20 FEATURE CONTROL FRAME INCORPORATING A DATUM REFERENCE

MMC = Maximum Material Condition

LMC = Least Material Condition

# Geometric reference symbols

	TYPE OF TOLERANCE	CHARACTERISTIC	SYMBOL	SEE:
FOR INDIVIDUAL FEATURES	FORM	STRAIGHTNESS	—	6.4.1
		FLATNESS		6.4.2
		CIRCULARITY (ROUNDNESS)		6.4.3
		CYLINDRICITY		6.4.4
FOR INDIVIDUAL OR RELATED FEATURES	PROFILE	PROFILE OF A LINE		6.5.2 (b)
		PROFILE OF A SURFACE		6.5.2 (a)
FOR RELATED FEATURES	ORIENTATION	ANGULARITY		6.6.2
		PERPENDICULARITY		6.6.4
		PARALLELISM		6.6.3
	LOCATION	POSITION		5.2
		CONCENTRICITY		5.11.3
		SYMMETRY		5.13
	RUNOUT	CIRCULAR RUNOUT		6.7.1.2.1
		TOTAL RUNOUT		6.7.1.2.2
* ARROWHEADS MAY BE FILLED OR NOT FILLED				3.3.1

FIG. 3-1 GEOMETRIC CHARACTERISTIC SYMBOLS

# Definition of cylindrical OD datum

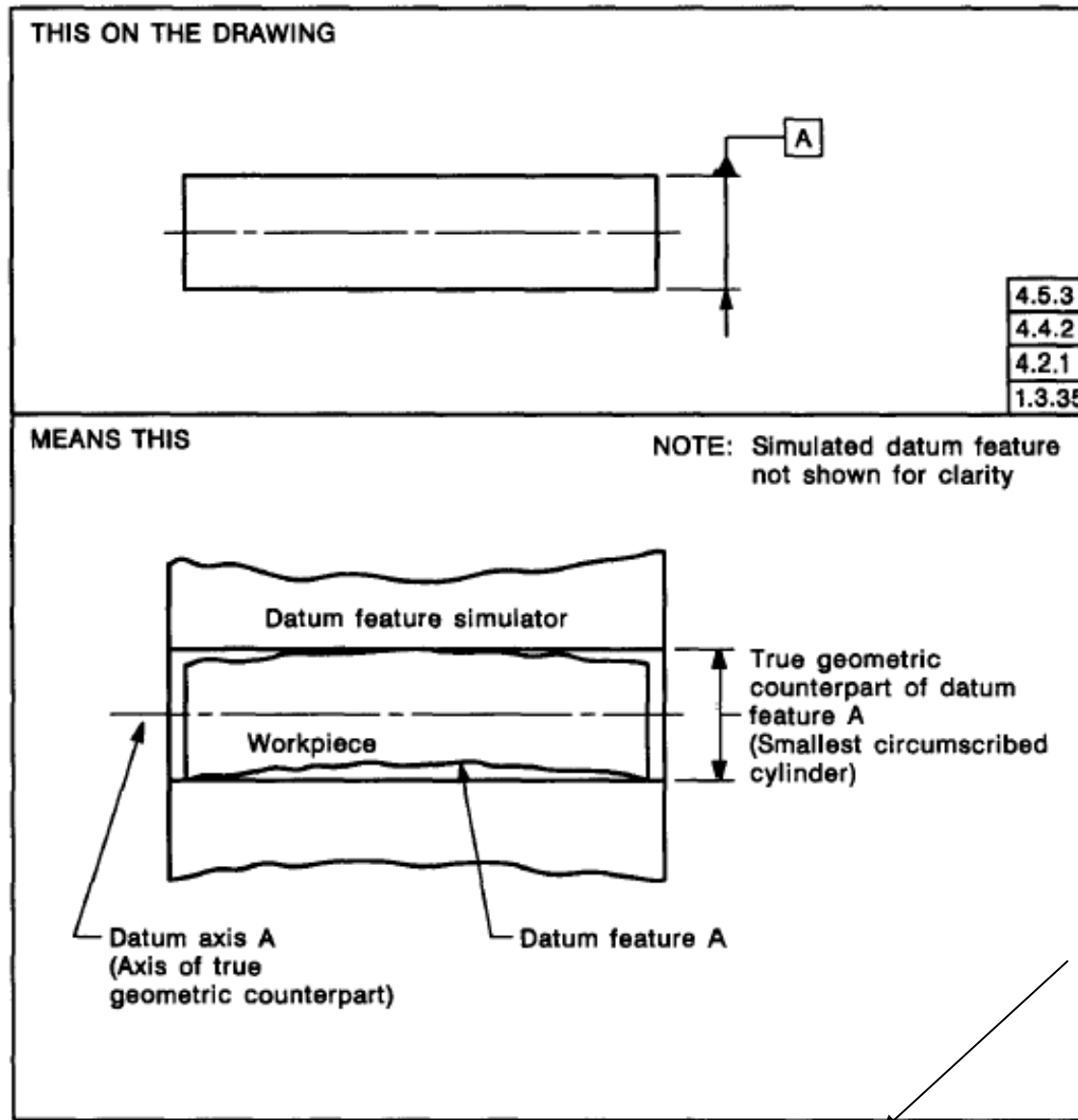


FIG. 4-11 PRIMARY EXTERNAL DATUM DIAMETER — RFS

# Definition of cylindrical ID datum

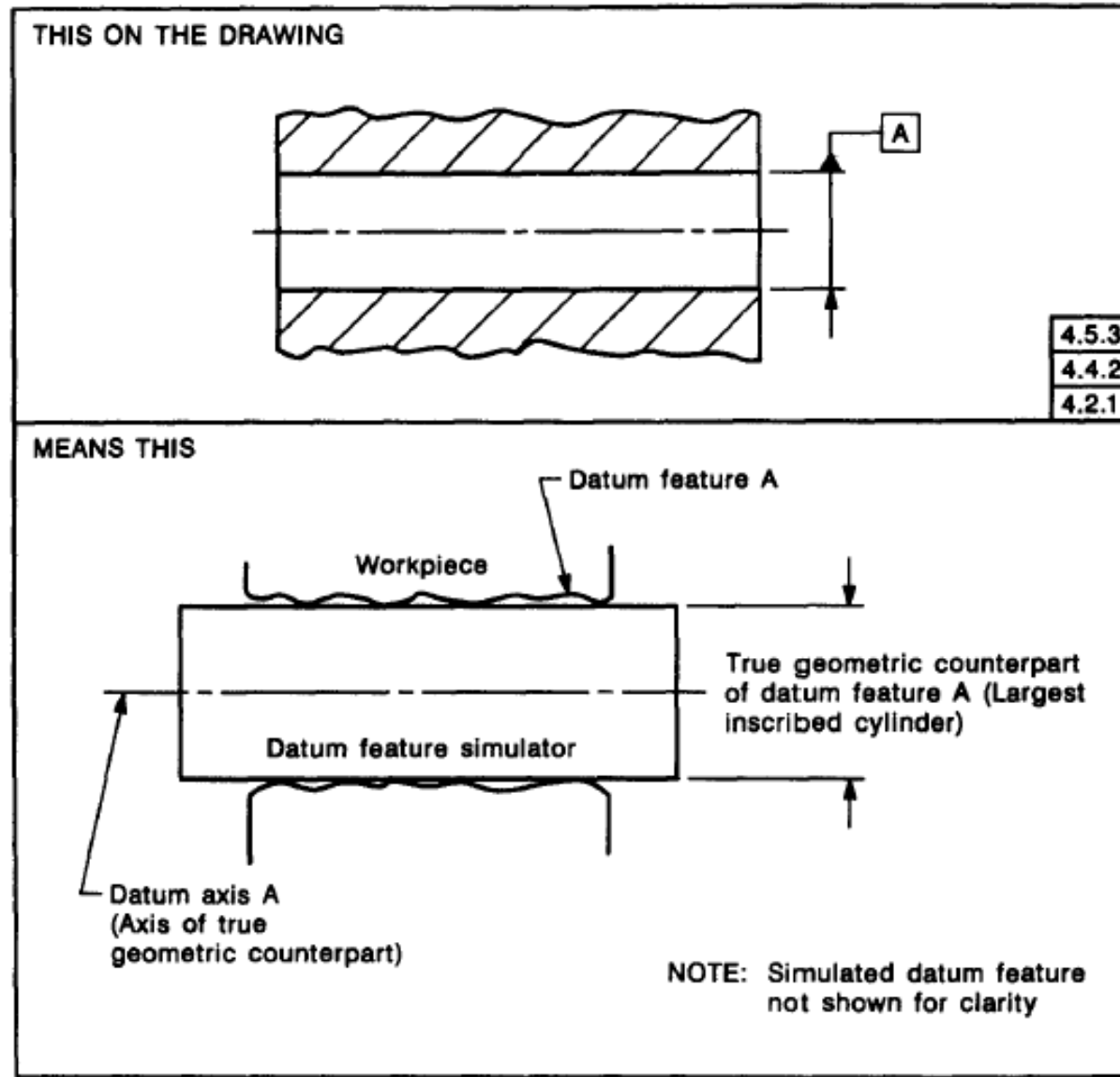


FIG. 4-12 PRIMARY INTERNAL DATUM DIAMETER — RFS

# Concentricity

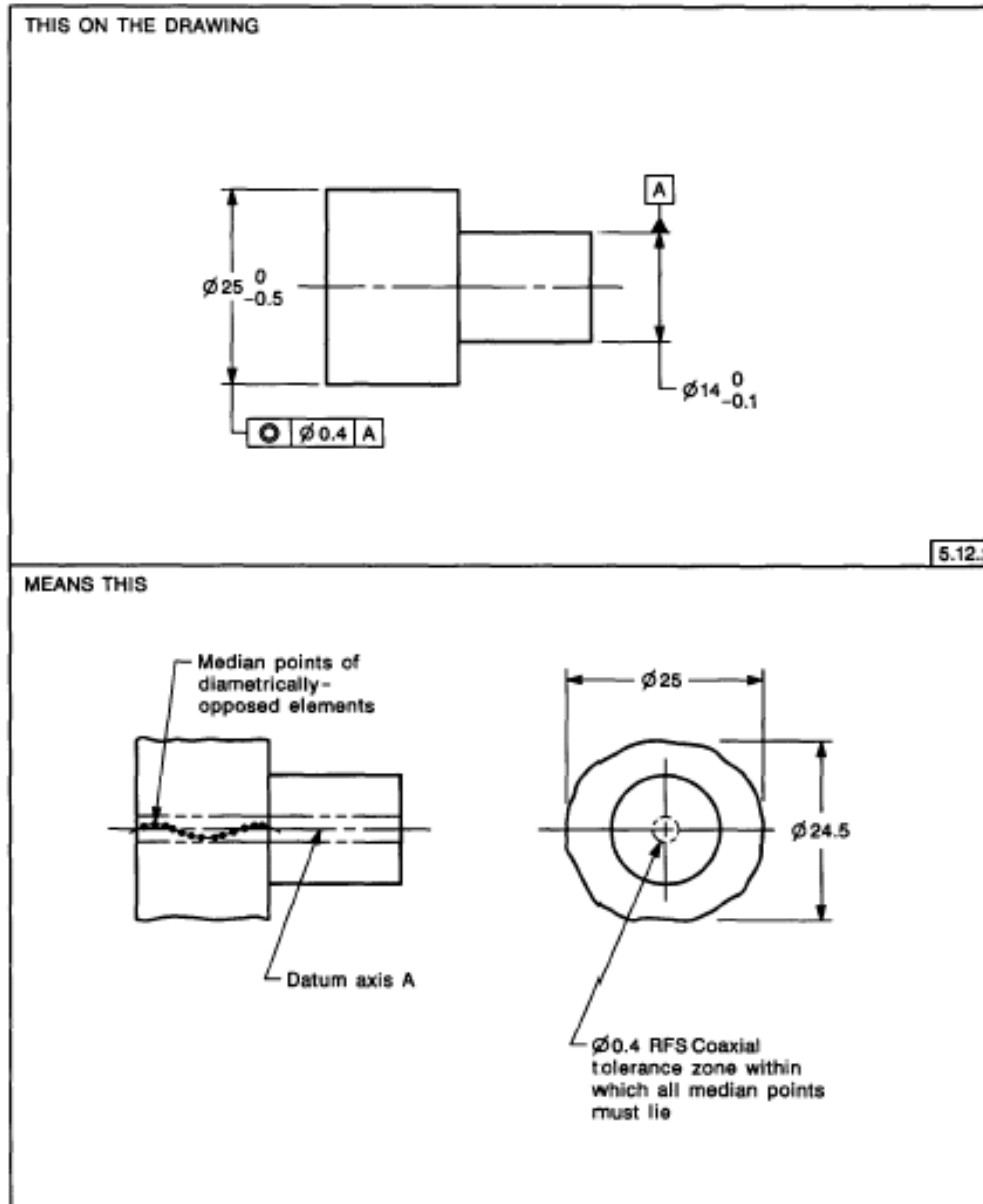


FIG. 5-58 ITEM DEPICTED IN FIG. 5-55 CONTROLLED FOR CONCENTRICITY

# Surface flatness

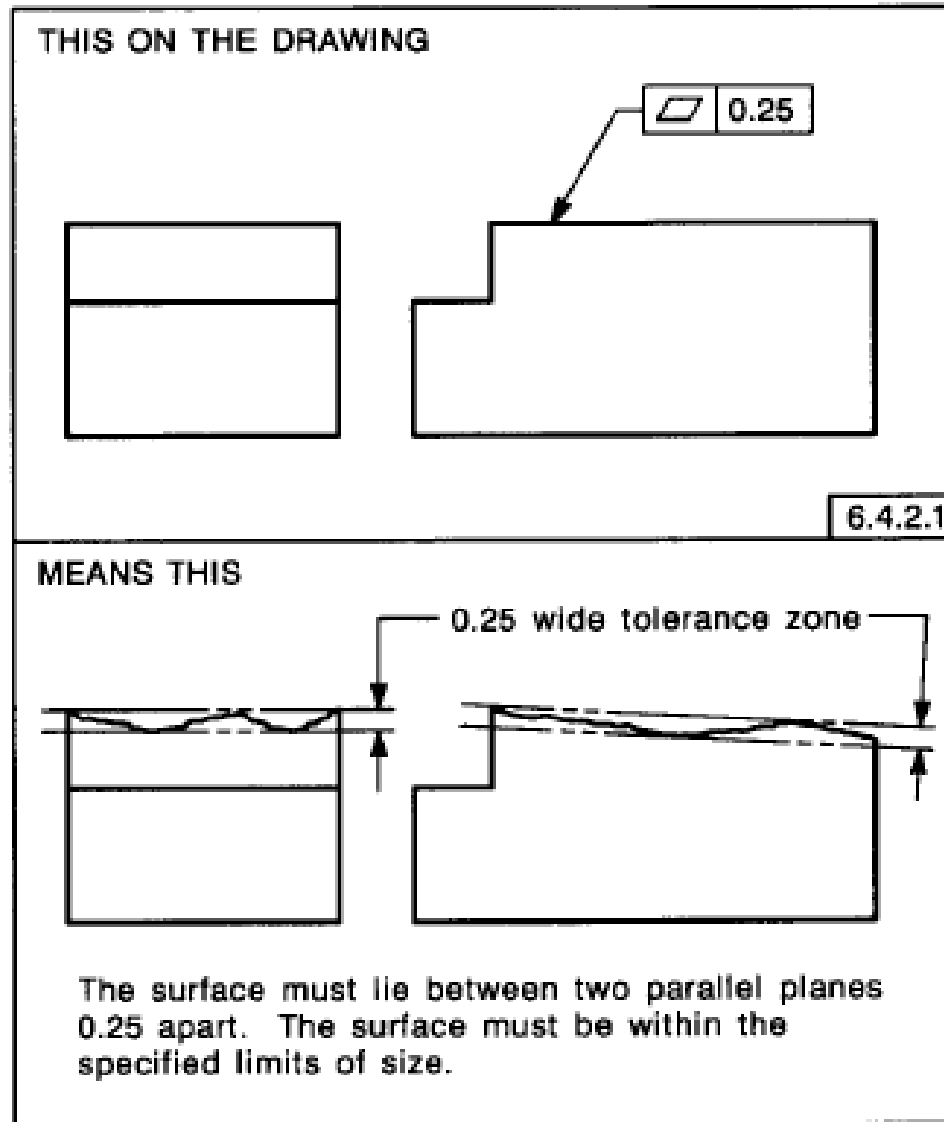
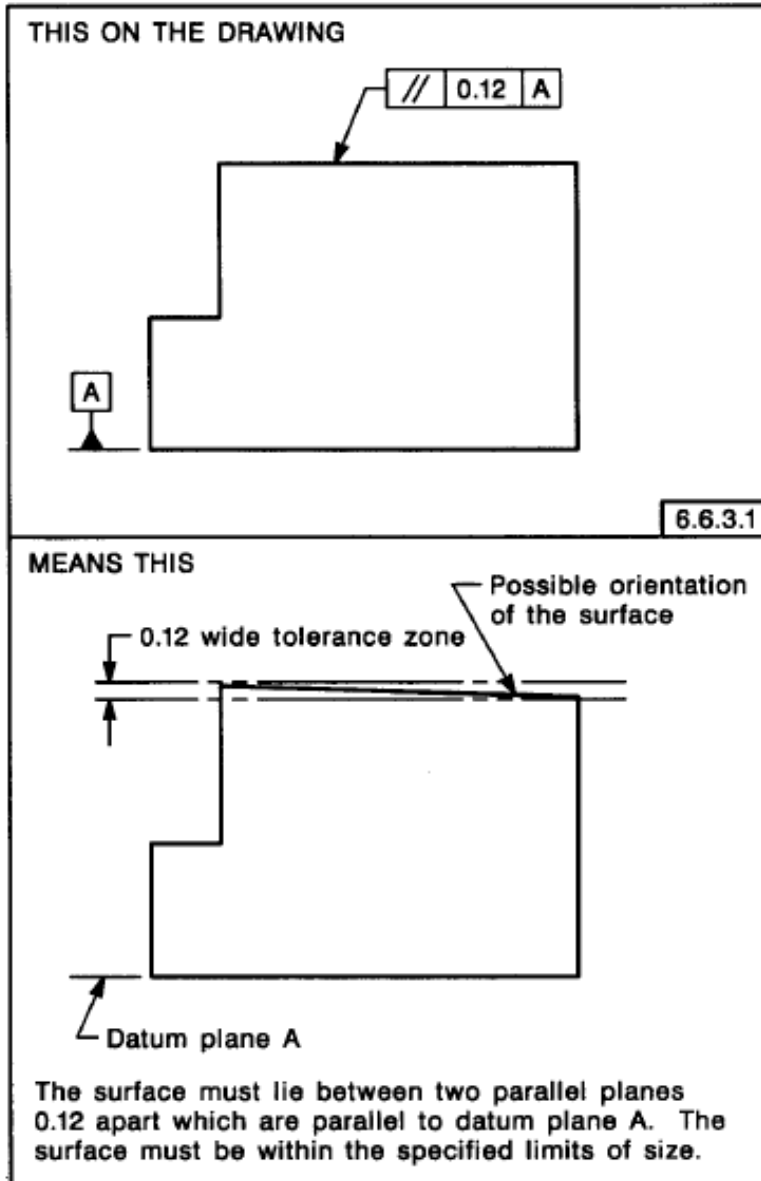


FIG. 6-7 SPECIFYING FLATNESS

# Surface parallelism

## General



## Using tangent plane

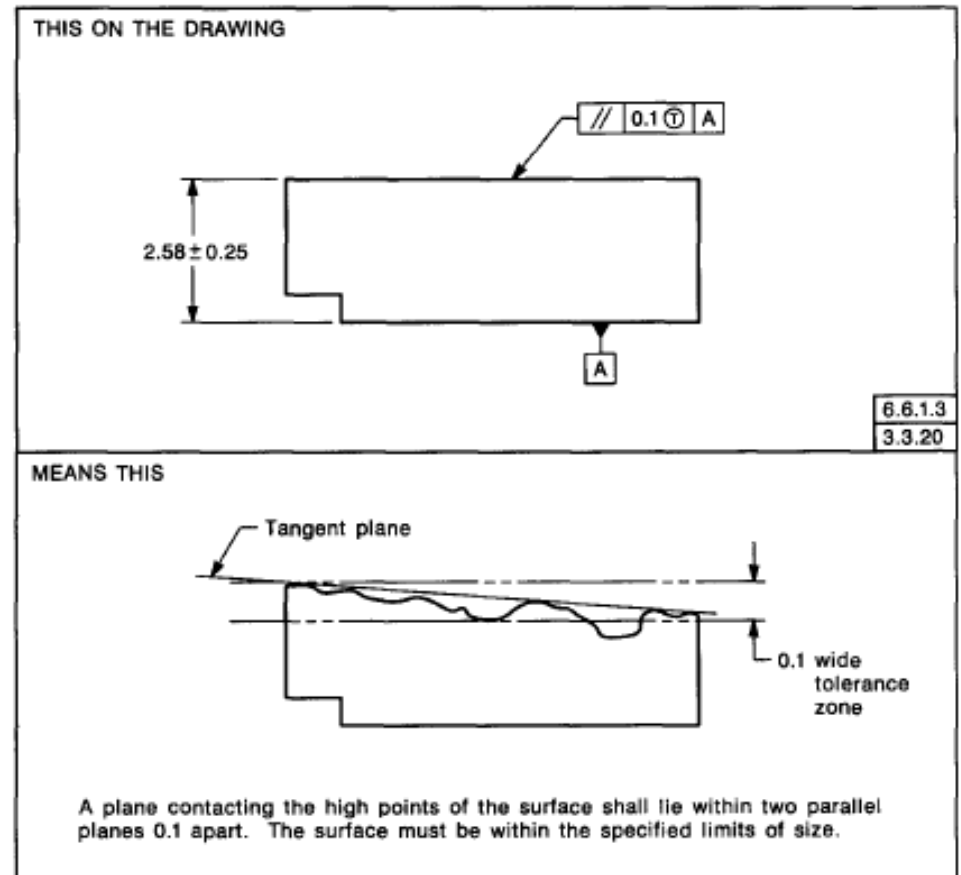


FIG. 6-43 SPECIFYING A TANGENT PLANE

# Perpendicularity

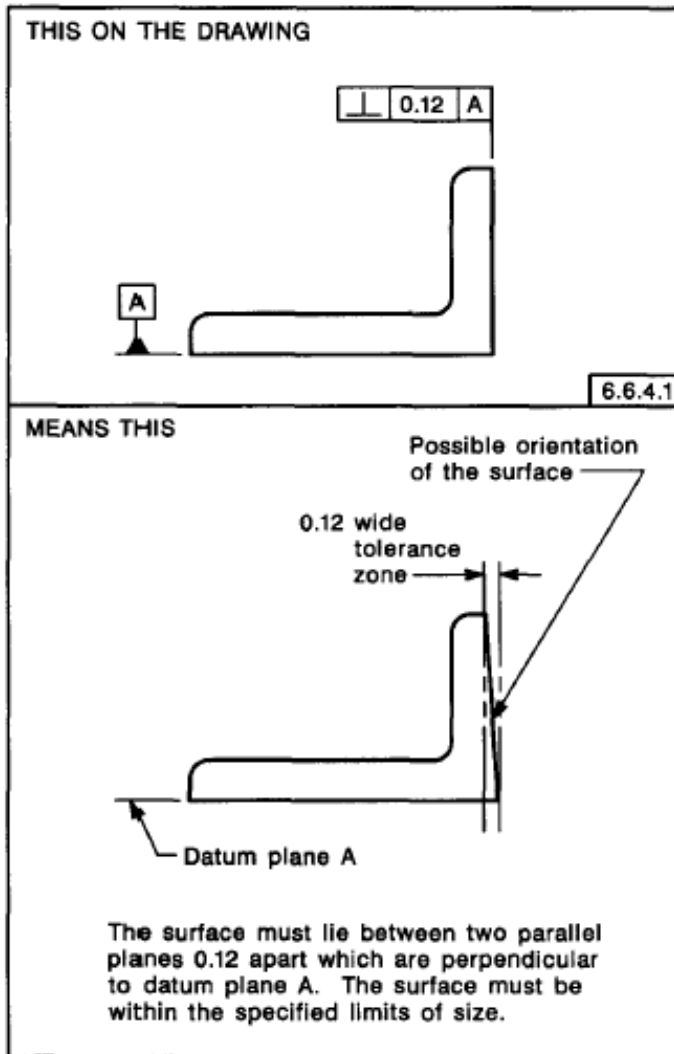


FIG. 6-34 SPECIFYING PERPENDICULARITY FOR A PLANE SURFACE

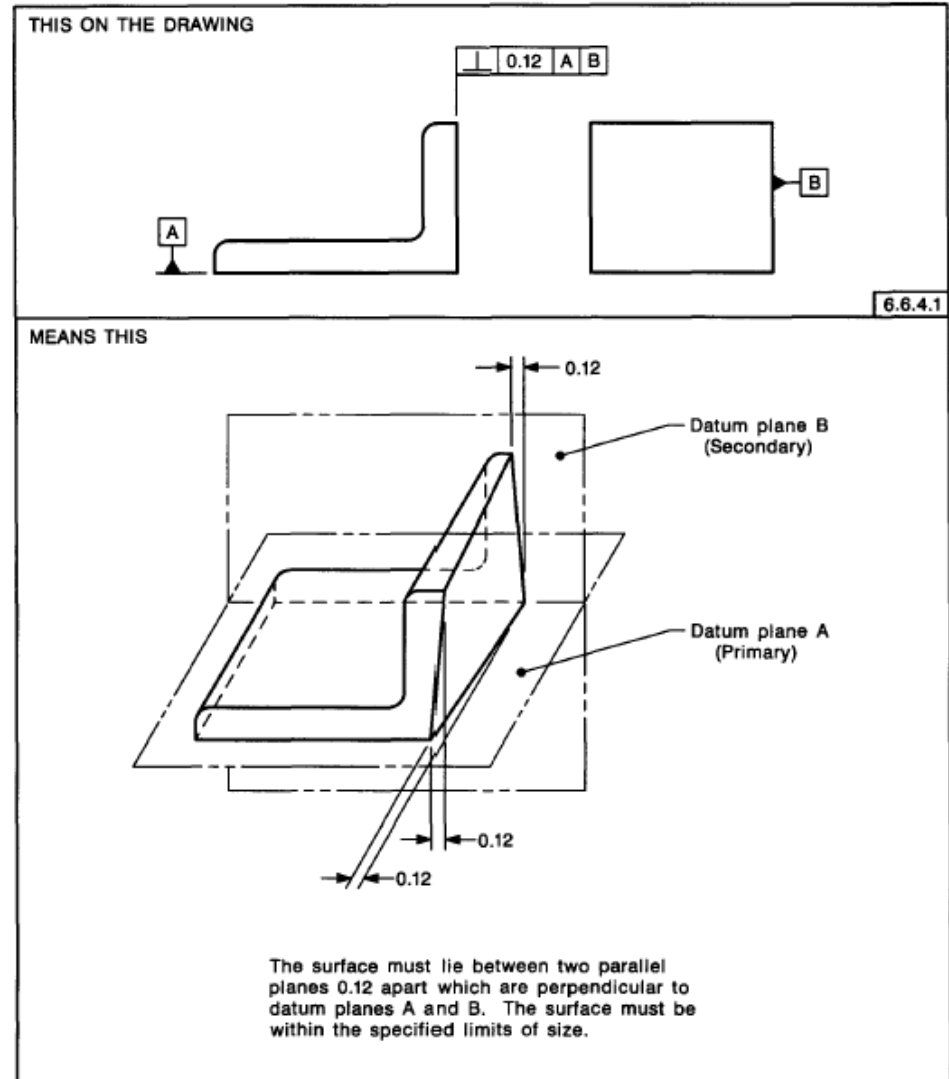


FIG. 6-35 SPECIFYING PERPENDICULARITY FOR A PLANE SURFACE RELATIVE TO TWO DATUMS

# Parallelism for axis

THIS ON THE DRAWING

6.6.3.1

MEANS THIS

0.12 wide tolerance zone

Possible orientation of feature axis

Datum plane A

Regardless of feature size, the feature axis must lie between two parallel planes 0.12 apart which are parallel to datum plane A. The feature axis must be within the specified tolerance of location.

THIS ON THE DRAWING

6.6.3.1

MEANS THIS

Feature size	Diameter tolerance zone allowed
10.000	0.05
10.001	0.051
10.002	0.052
↓	↓
10.021	0.071
10.022	0.072

Where the feature is at maximum material condition (10.00), the maximum parallelism tolerance is 0.05 diameter. Where the feature departs from its MMC size, an increase in the parallelism tolerance is allowed which is equal to the amount of such departure. The feature axis must be within the specified tolerance of location.

# Runout

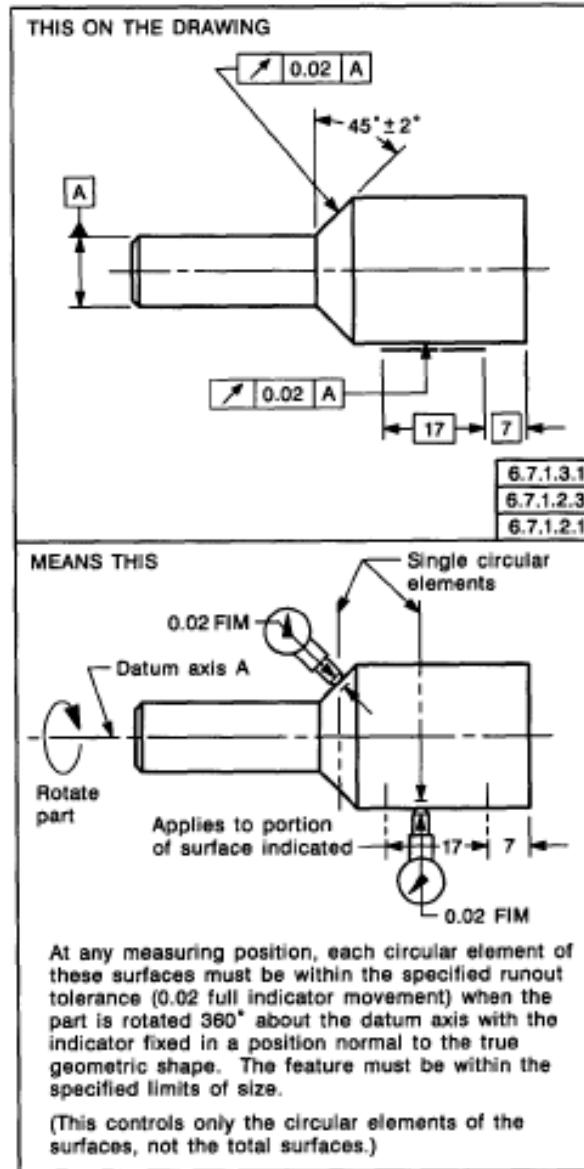


FIG. 6-47 SPECIFYING CIRCULAR RUNOUT RELATIVE TO A DATUM DIAMETER

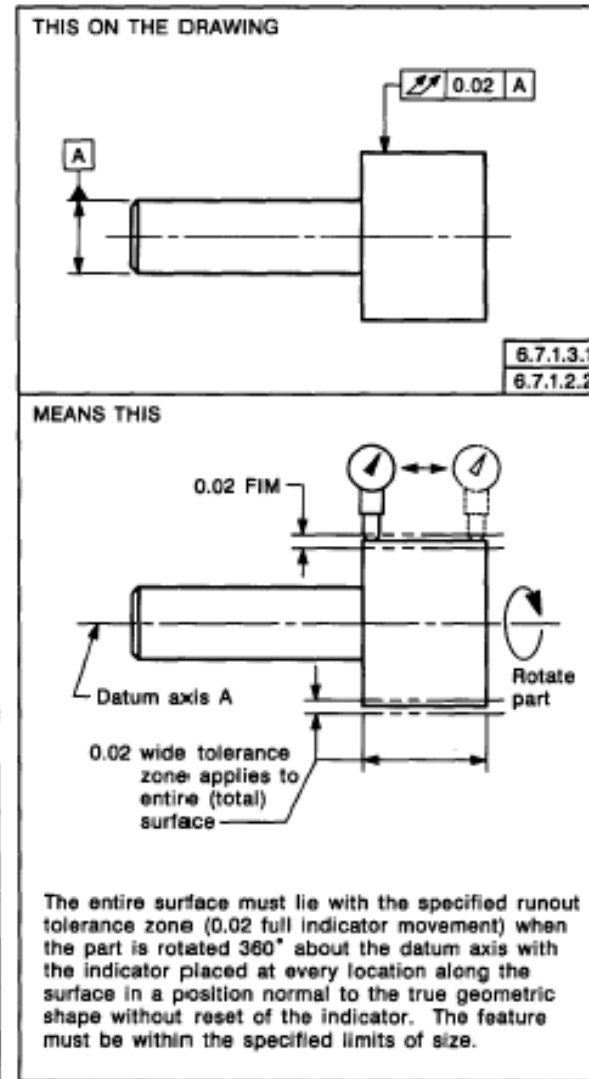


FIG. 6-48 SPECIFYING TOTAL RUNOUT RELATIVE TO A DATUM DIAMETER

# Surface orientation

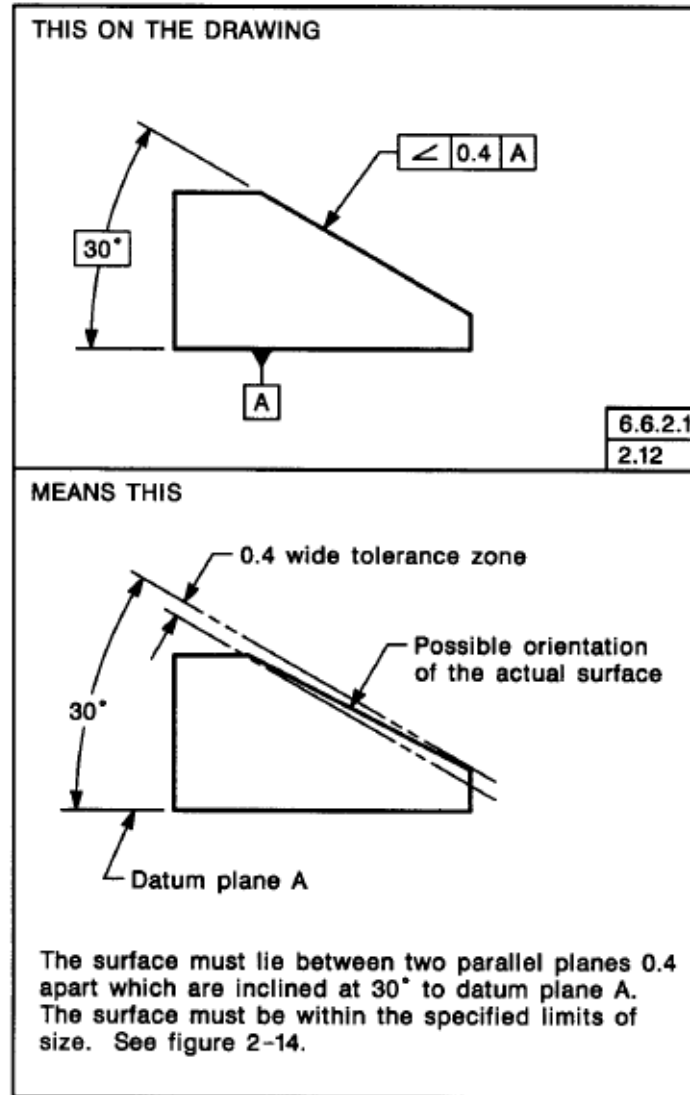


FIG. 6-27 SPECIFYING ANGULARITY FOR A PLANE SURFACE

# Use of feature control frames

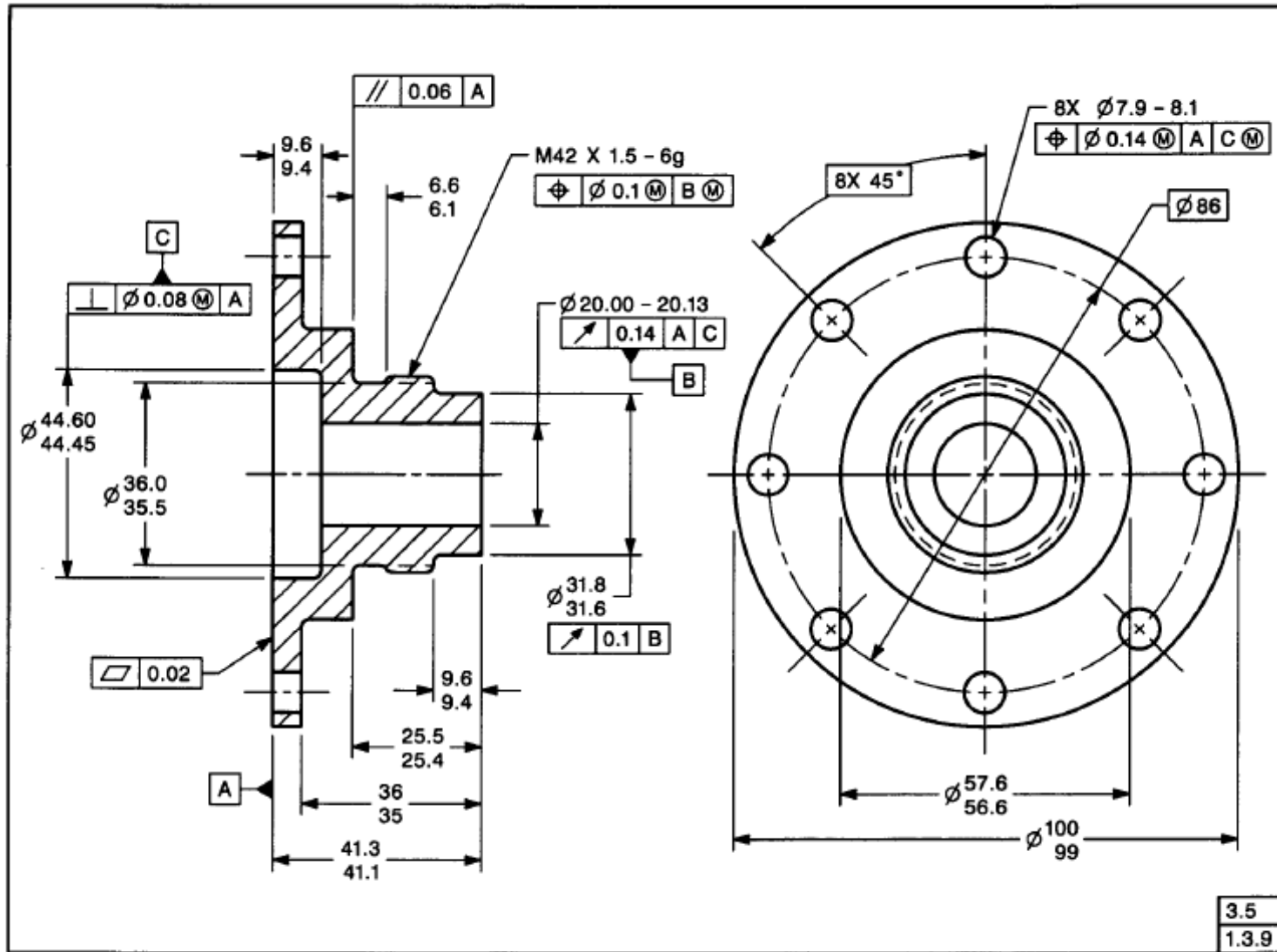
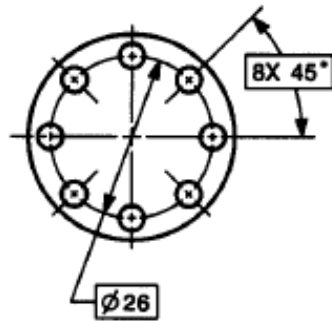
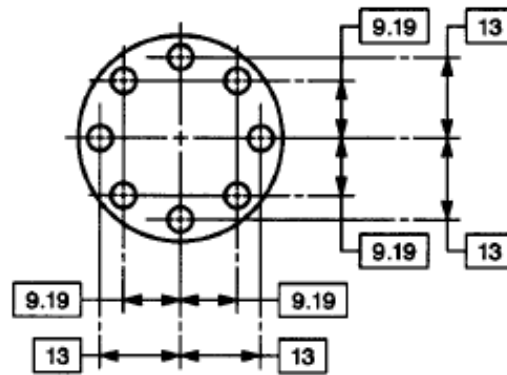


FIG. 3-25 FEATURE CONTROL FRAME PLACEMENT

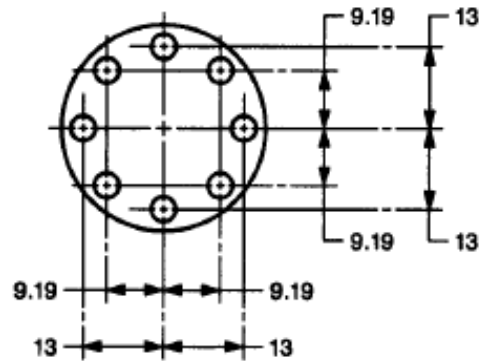
# Basic dimensions



(a) Basic dimensions in polar coordinates.



(b) Basic dimensions in rectangular coordinates.



**NOTE: UNTOLERANCED DIMENSIONS LOCATING TRUE POSITION ARE BASIC**

(c) Basic dimensions identified by a note.

5.2.1.1

# Meaning of basic tolerances

## Geometric Dimensioning and Tolerancing

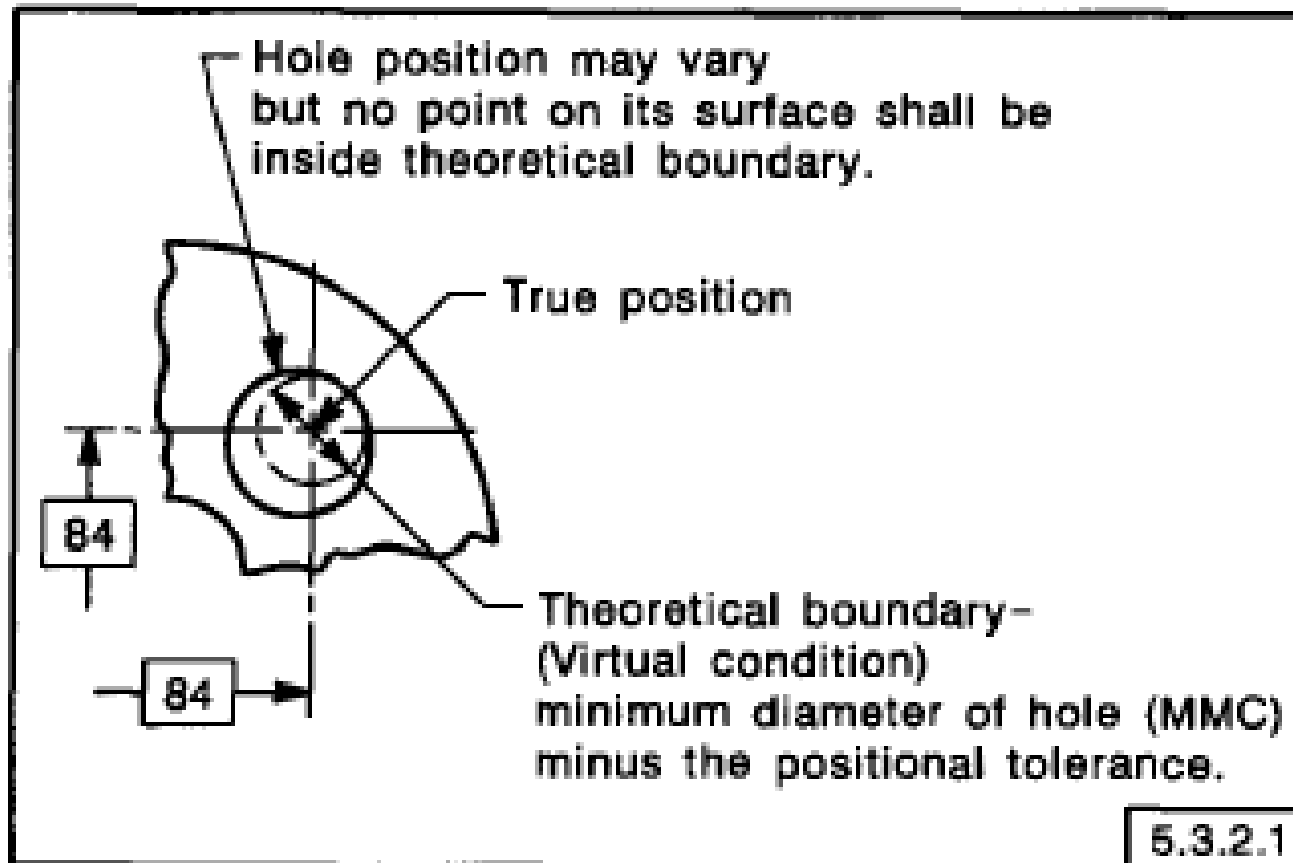


FIG. 5-5 BOUNDARY FOR SURFACE OF HOLE AT MMC

# Tolerancing using basic dimensions

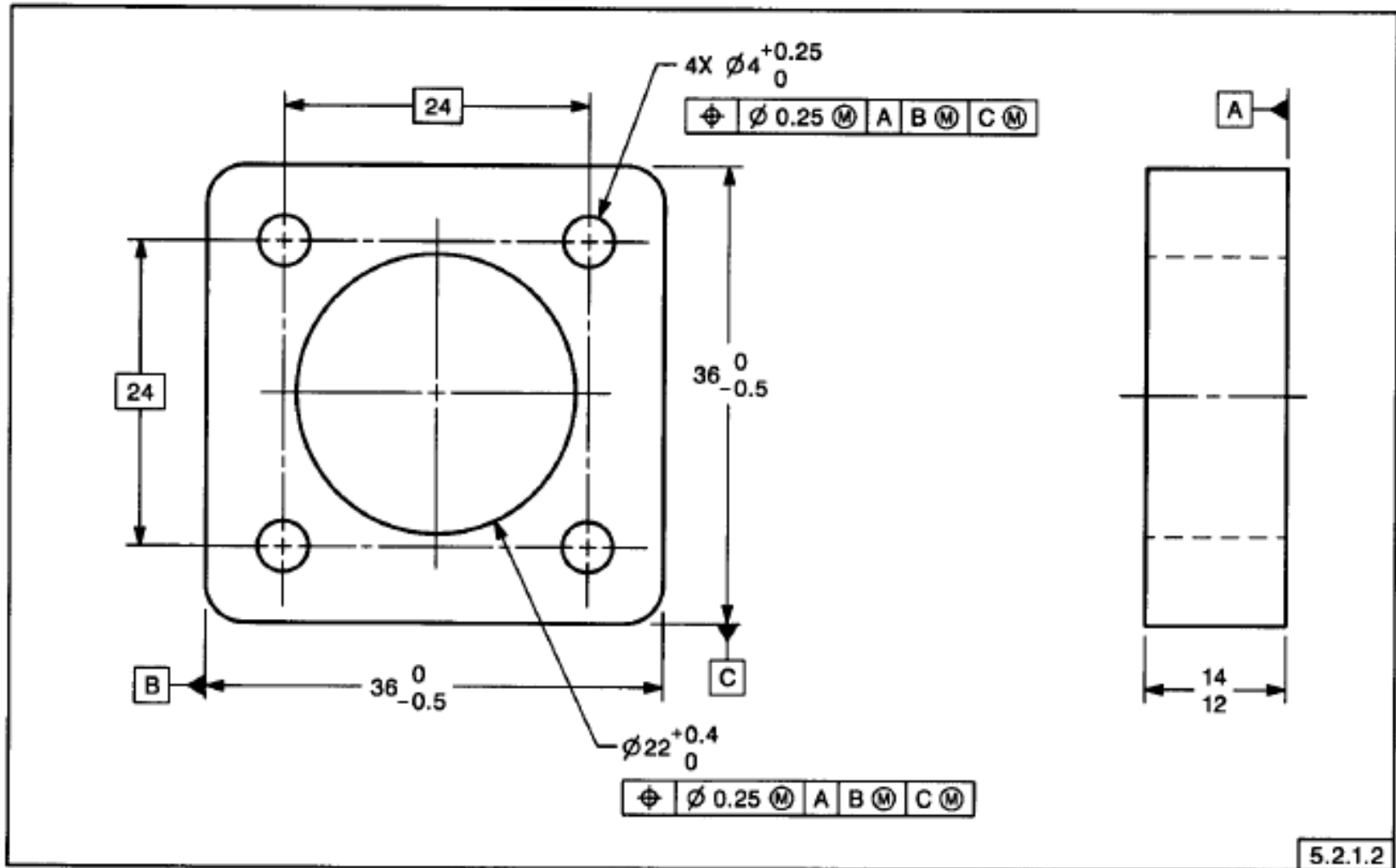


FIG. 5-4 POSITIONAL TOLERANCING AT MMC RELATIVE TO DATUM FEATURE CENTER PLANES

# Example of multiple features

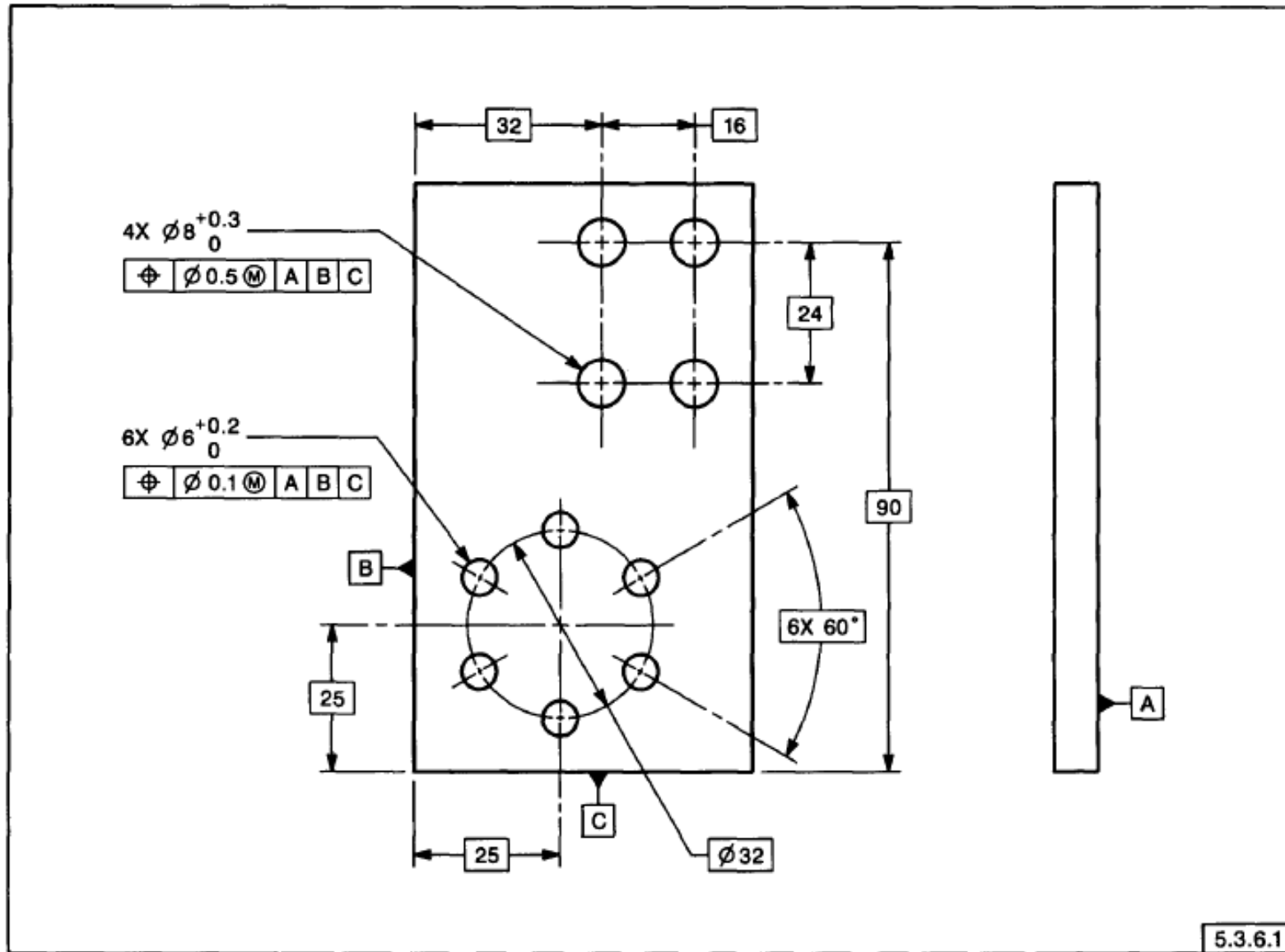
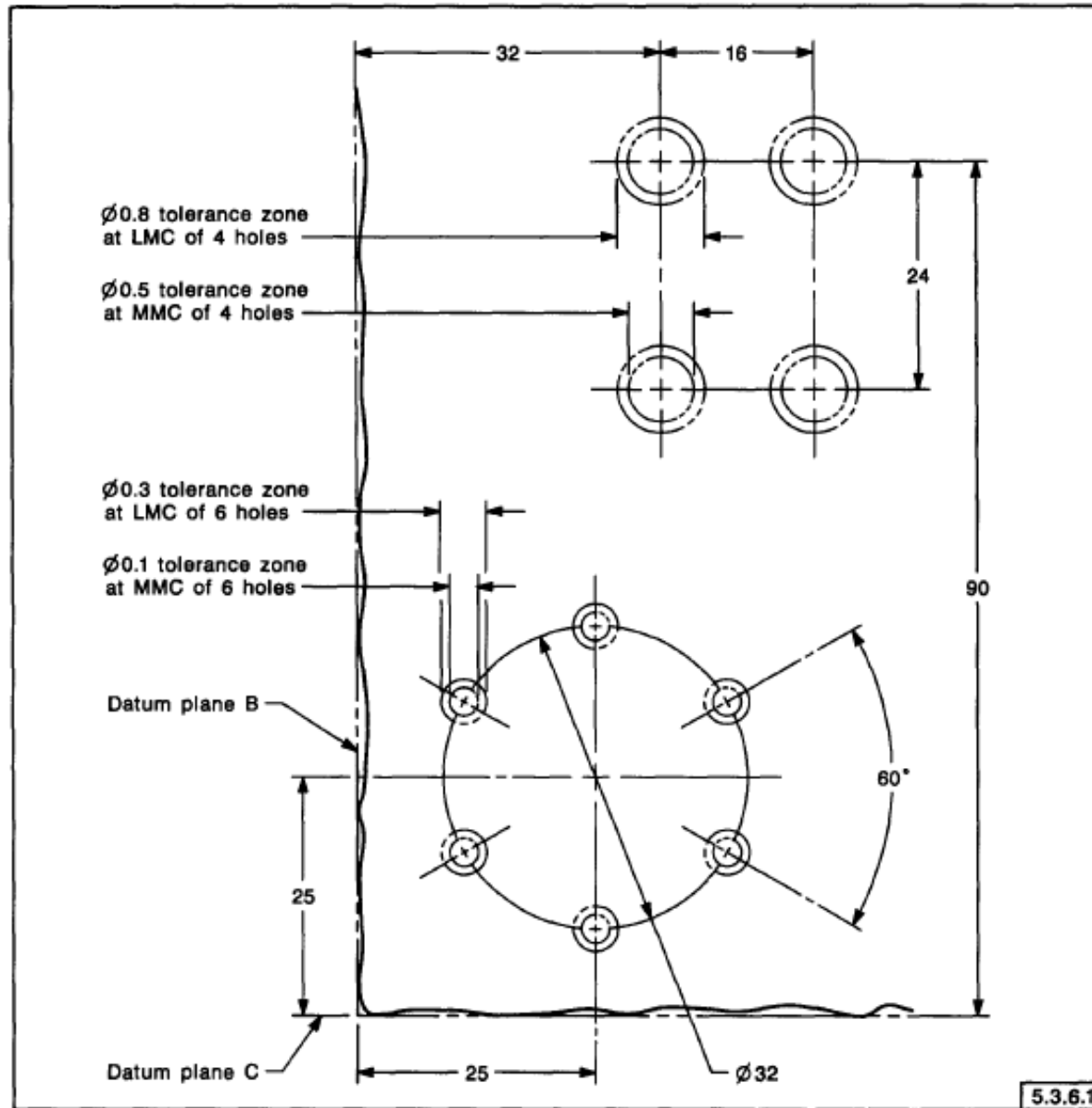


FIG. 5-16 MULTIPLE PATTERNS OF FEATURES

# Tolerance zones



5.3.6.1

FIG. 5-17 TOLERANCE ZONES FOR PATTERNS SHOWN IN FIG. 5-16