12. 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

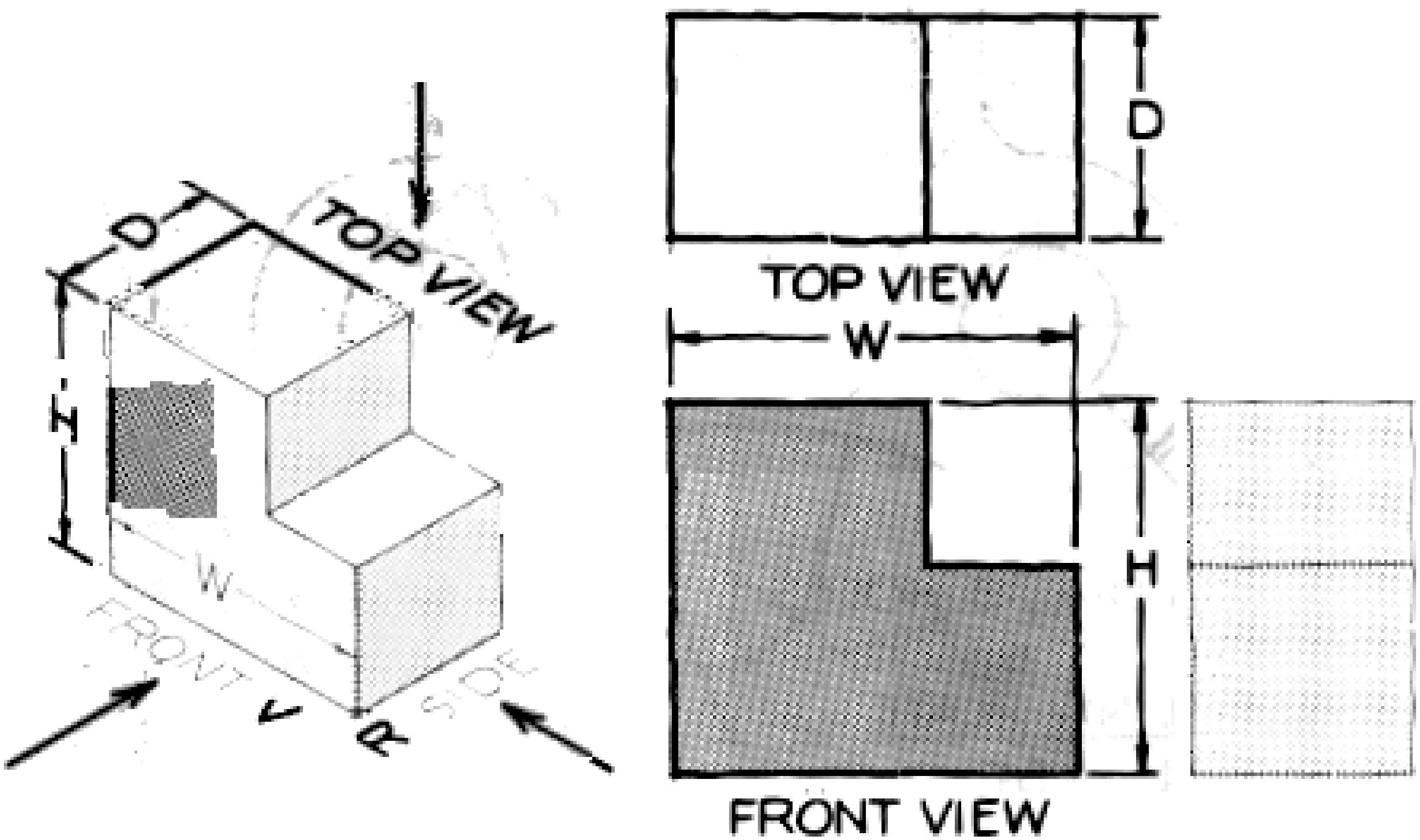
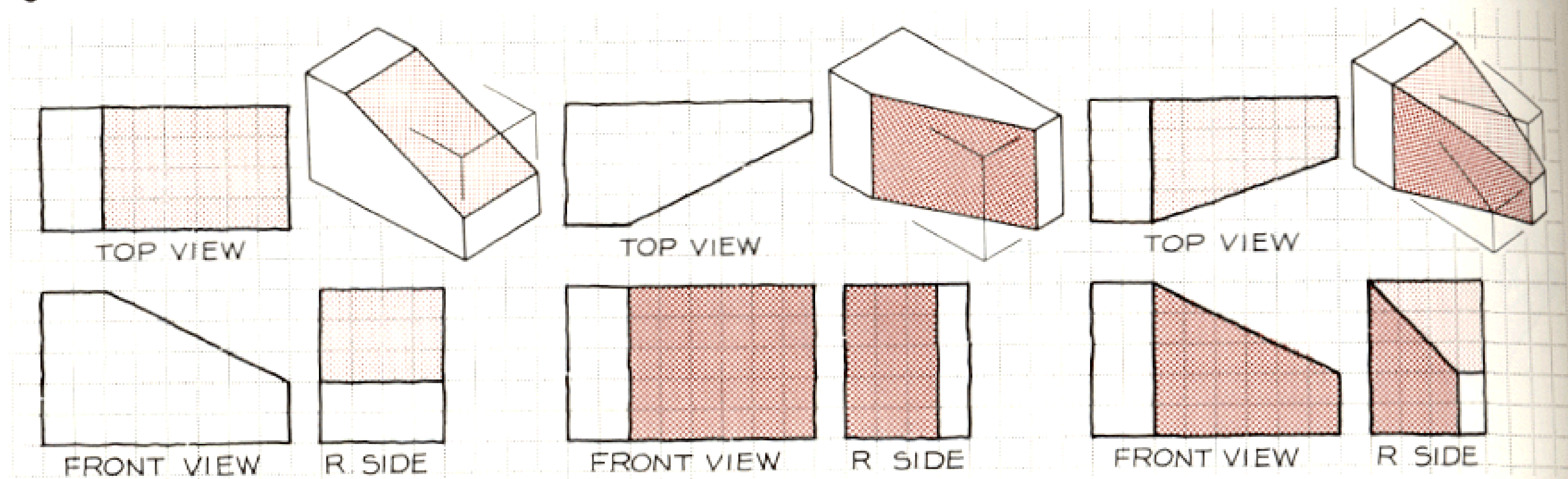


Fig. 13.1 Three views of an object can be found by looking at the object in this manner. The three views· the top, front, and right side—describe the object.

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.

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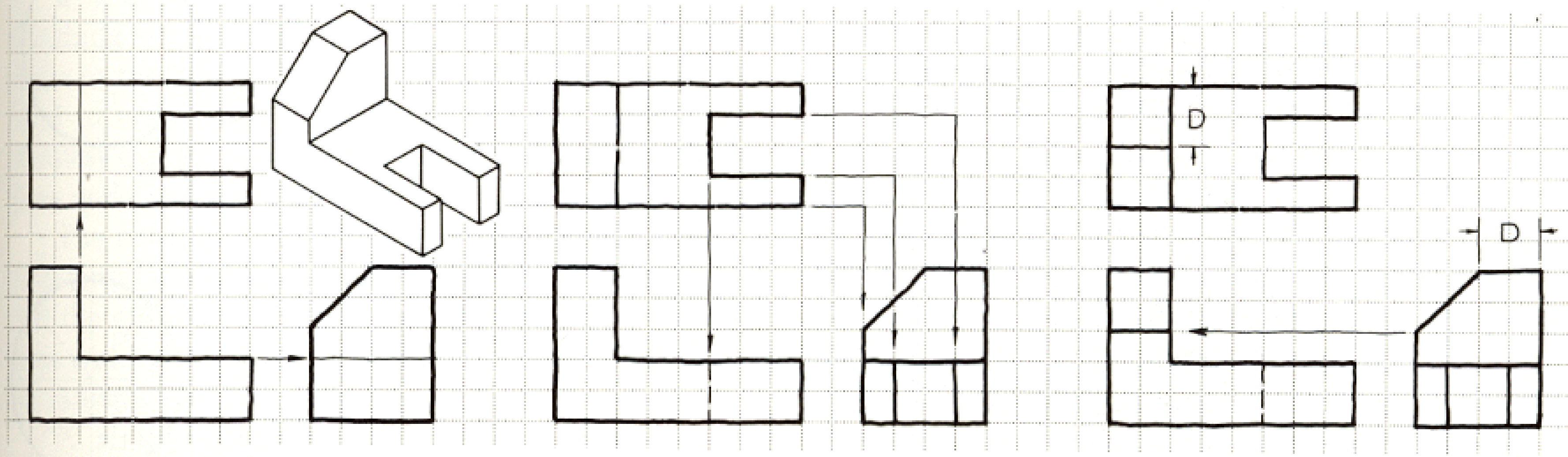
Hidden lines

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

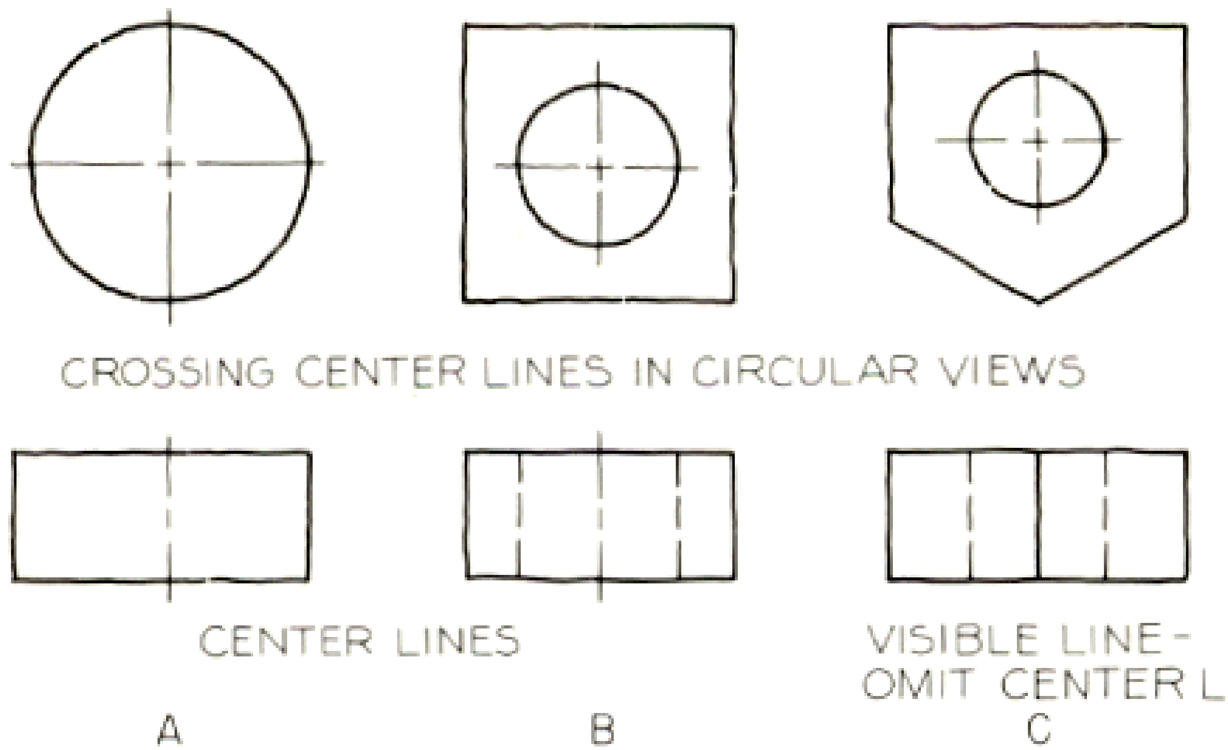


Fig. 13.14 Center lines are used to indicate the centers of circles and the axes of cylinders. These are drawn as very thin lines. When they coincide with visible or hidden lines, center lines are omitted.

Concentric cylinders

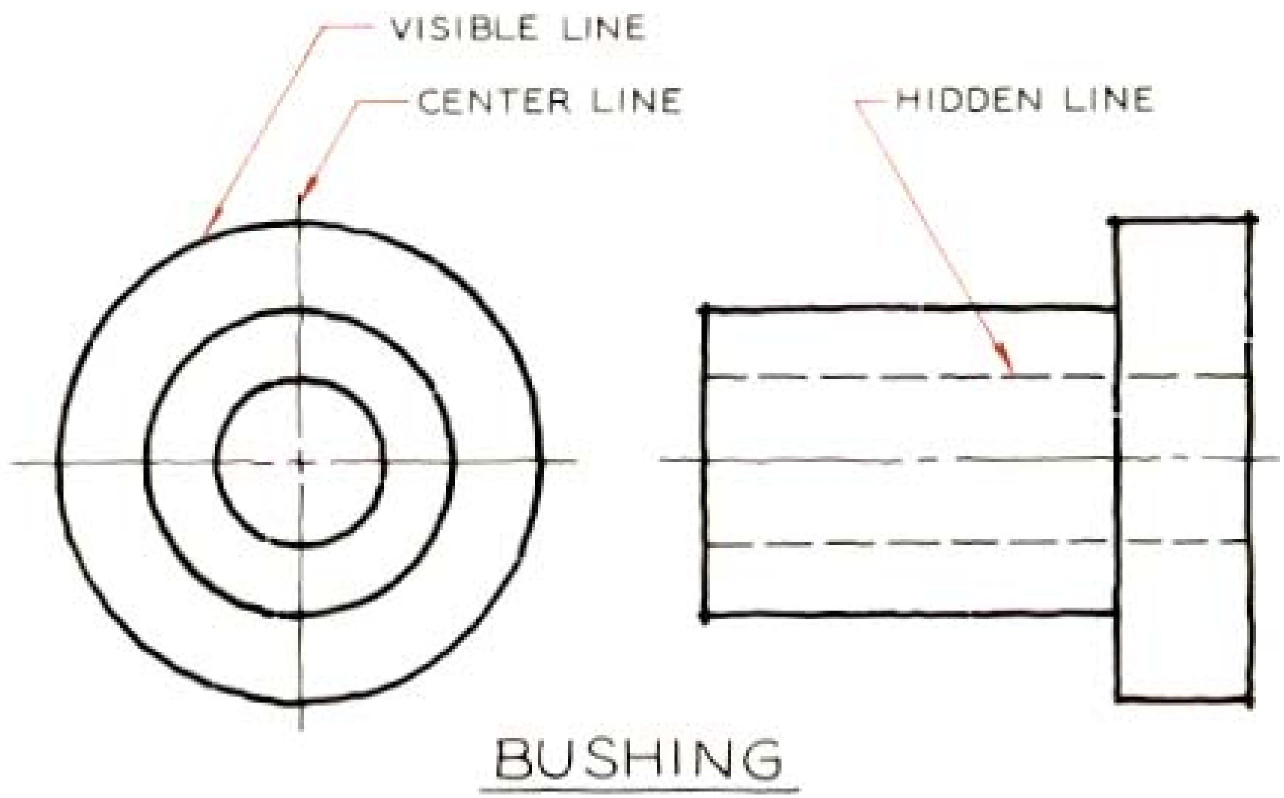


Fig. 13.16 Here you can see the application of center lines of concentric cylinders, and the relative weight of hidden, visible, and center lines.

Auxiliary views

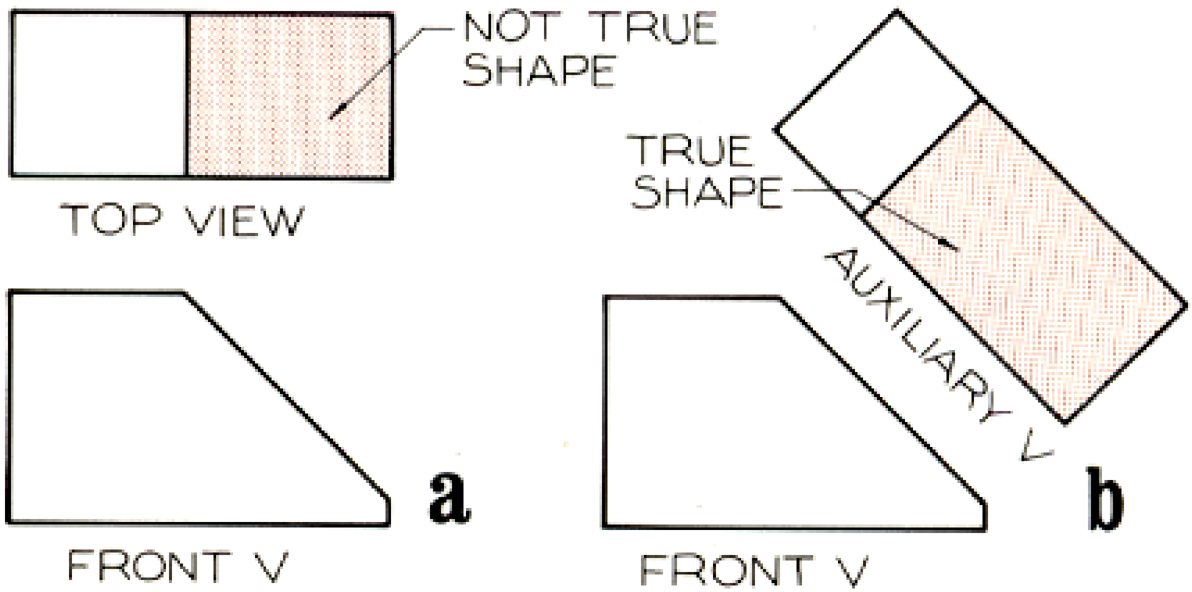


Fig. 15.1 When a surface appears as an inclined edge in a principal view, it can be found true size by an auxiliary view. The top view at a is foreshortened, but this plane is true size in an auxiliary view at b.

Auxiliary views

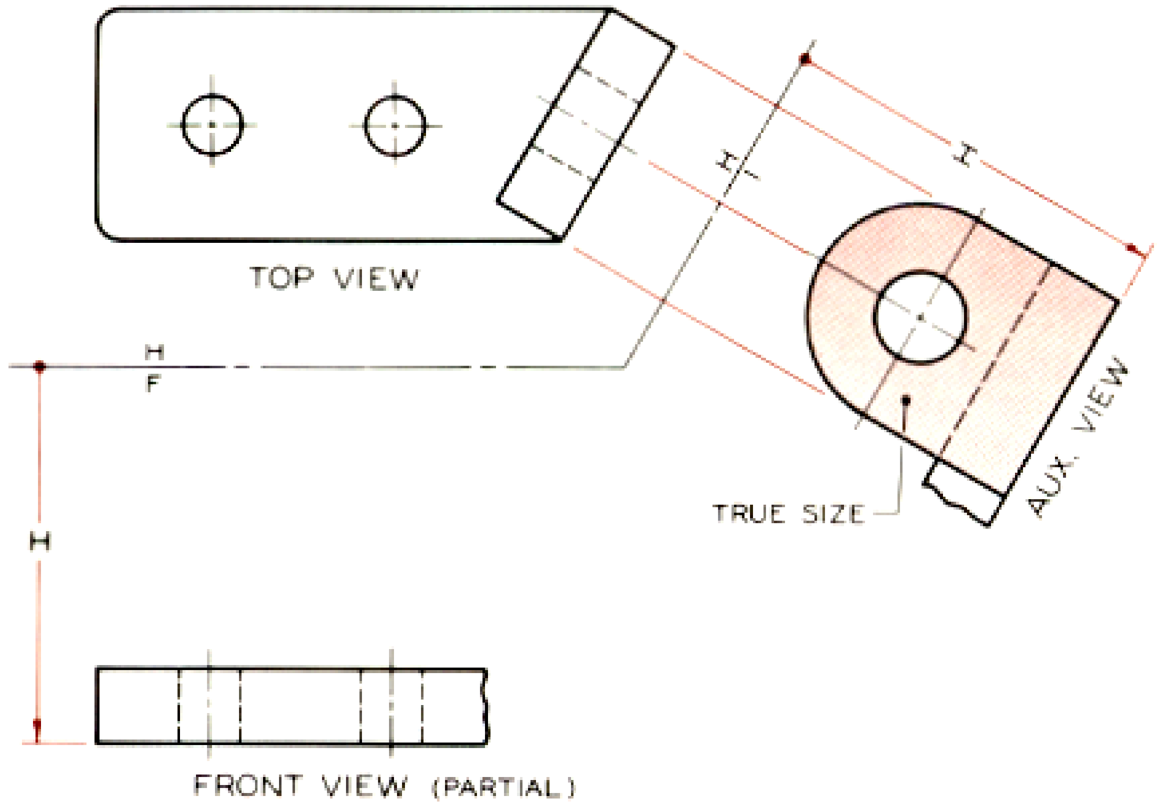


Fig. 15.6 When the object is drawn on a sheet of paper, it would be laid out in this manner. The front view is drawn as a partial view since the omitted part is shown true size in the auxiliary view.

Section views

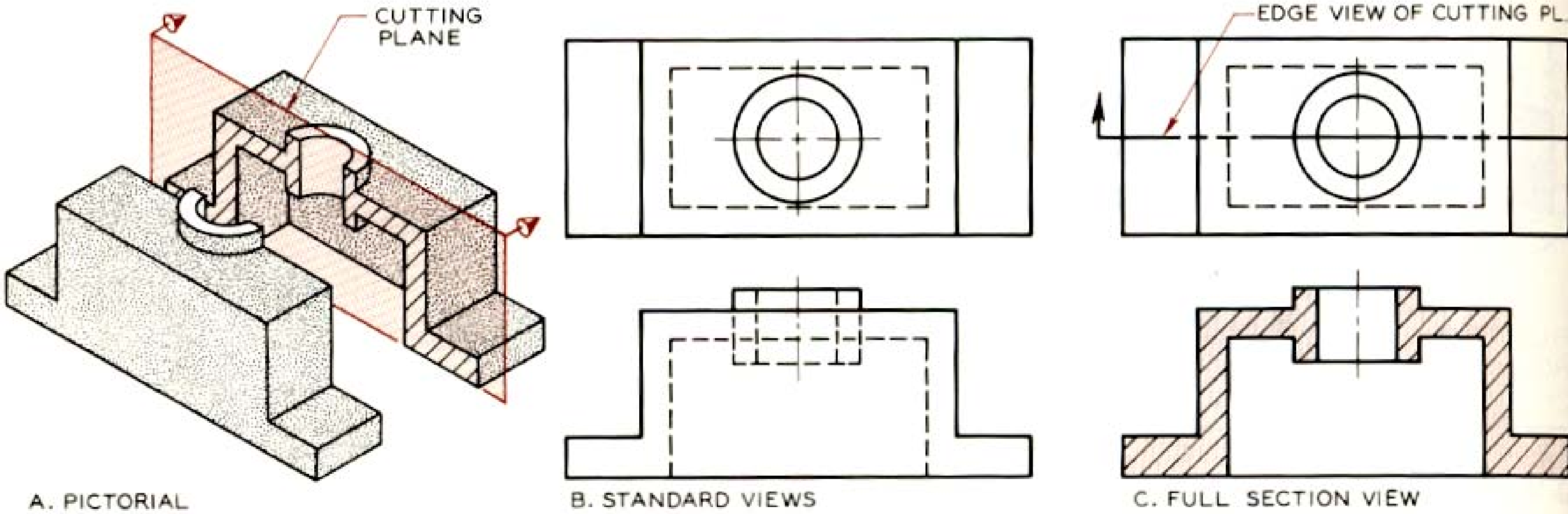


Fig. 16.1 A comparison of a regular orthographic view with a full-section view of the same object to show the internal features as well as the external features.

Half section views

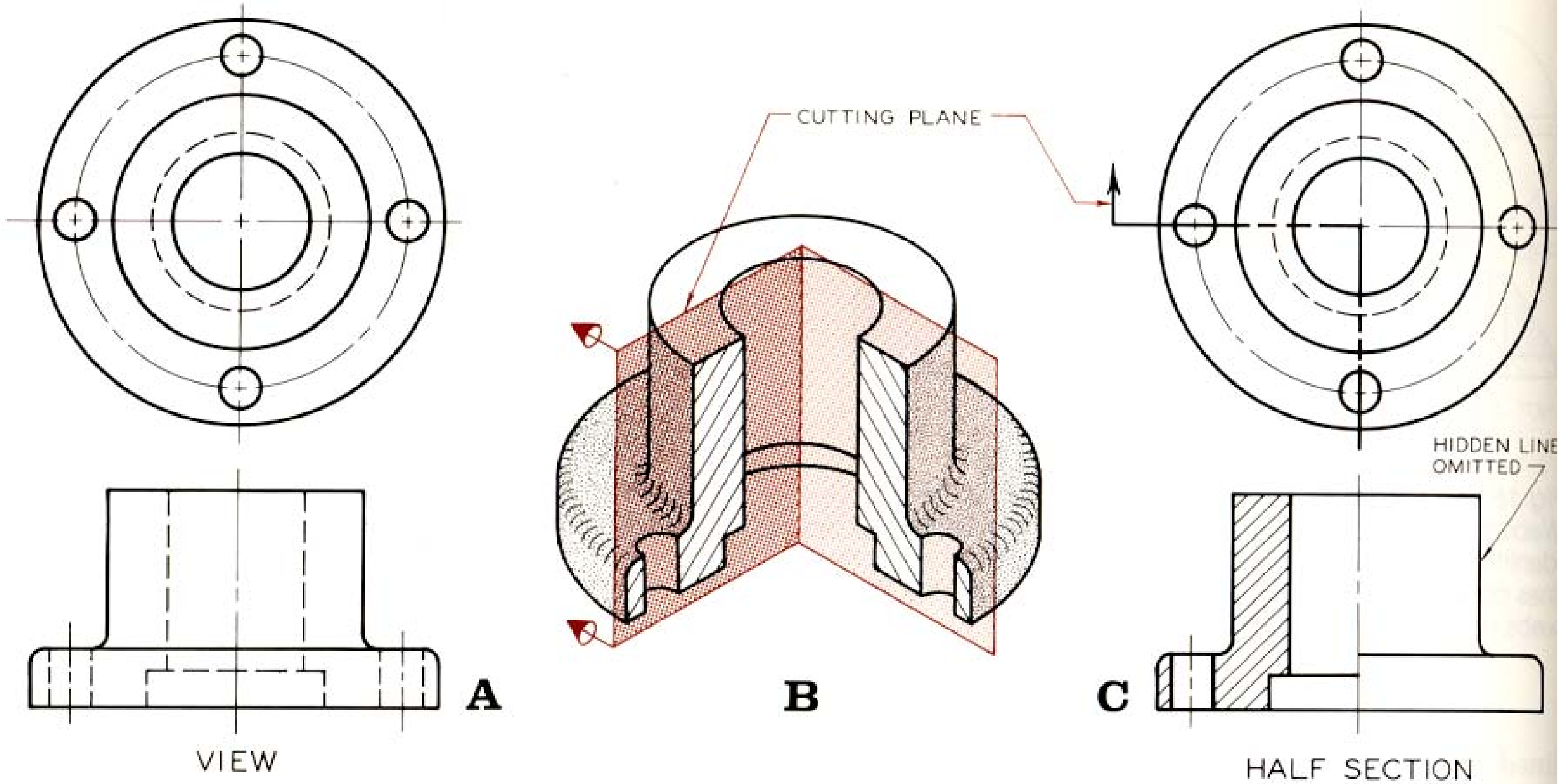


Fig. 16.19 The cutting plane of a half-section passes halfway through the object, which results in a sectional view that shows half of the outside and half of the inside of the object. Hidden lines are omitted unless they are necessary to clarify the view.

Pictorial (3D)drawings

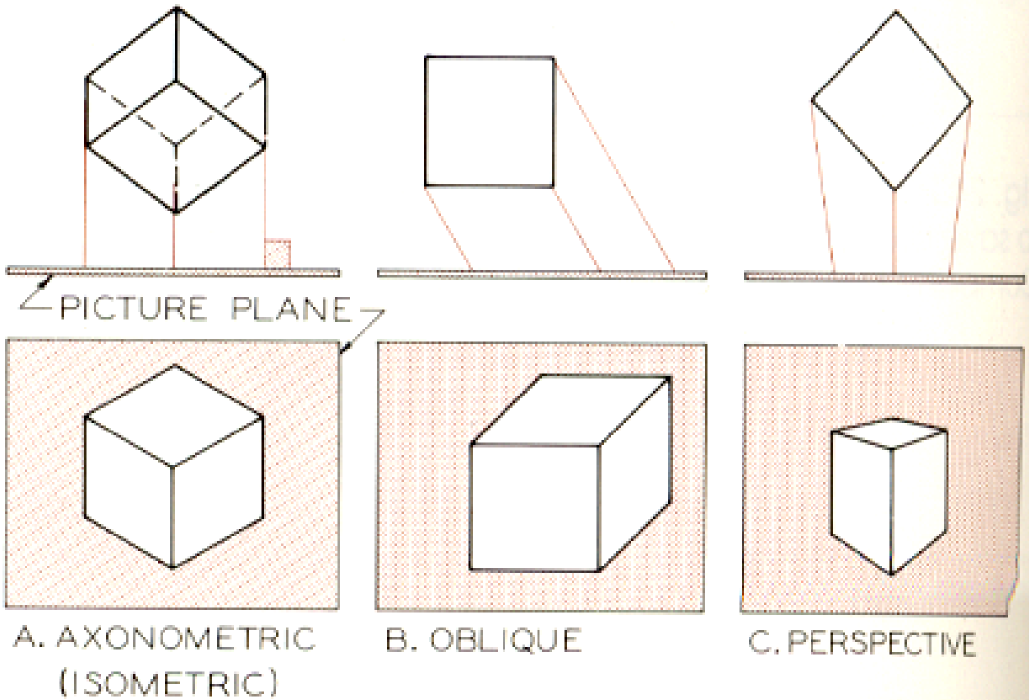


Fig. 25.2 Types of projection systems for pictorials. (A) Axonometric pictorials are formed by parallel projectors that are perpendicular to the picture plane. (B) Obliques are formed by parallel projectors that are oblique to the picture plane. (C) Perspectives are formed by converging projectors that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

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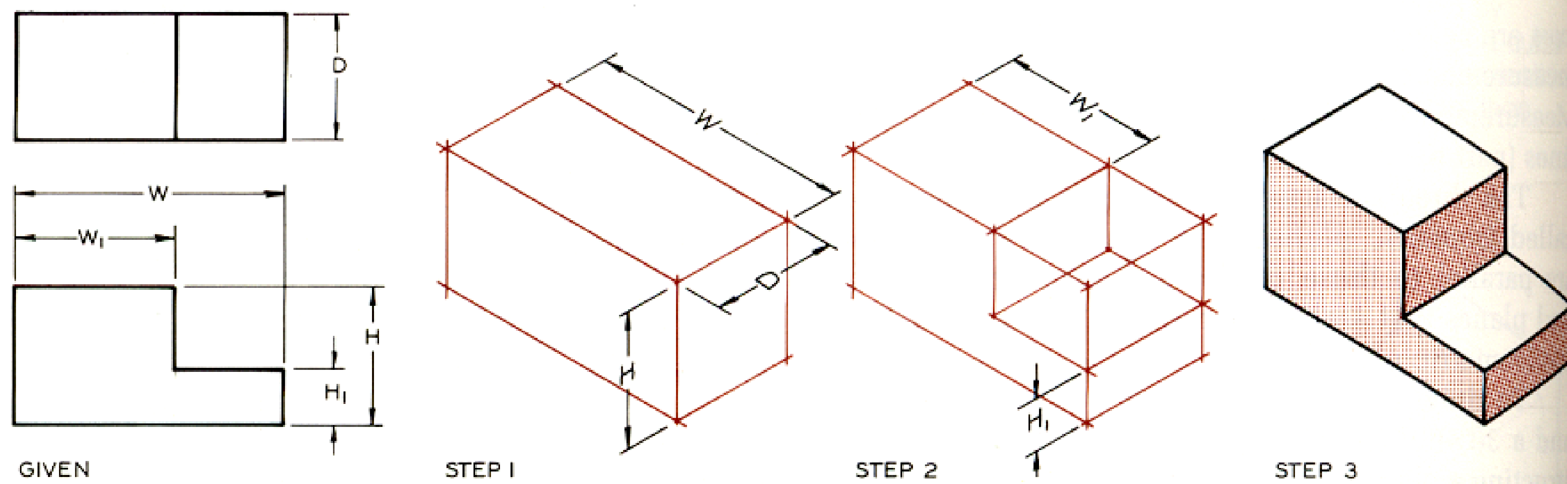
Isometric layout

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.

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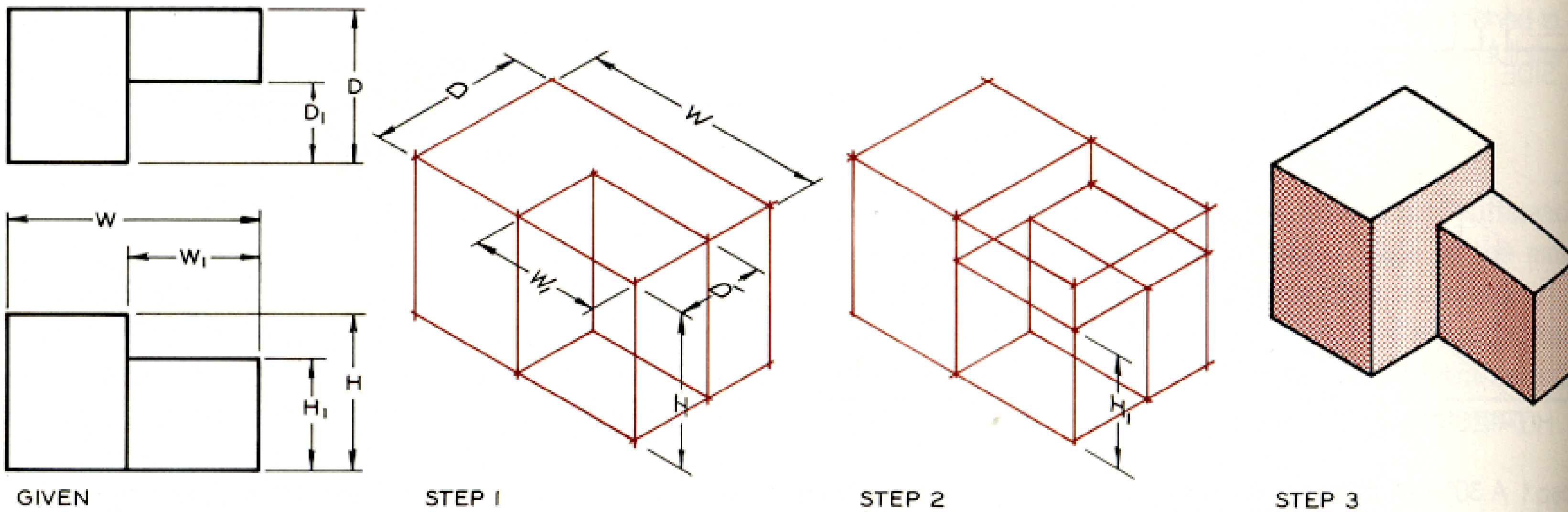
Isometric drawings (2)

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

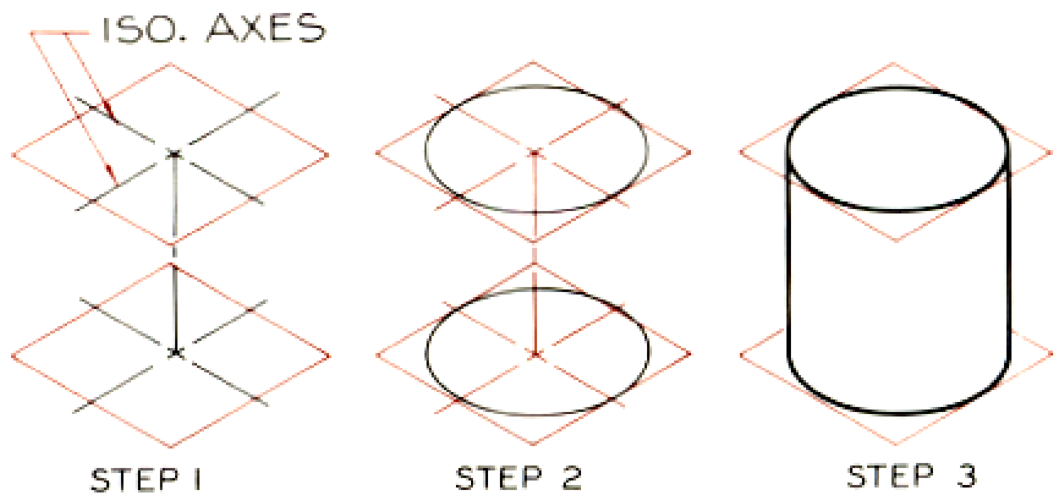


Fig. 25.40 Cylinder: four-center method

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

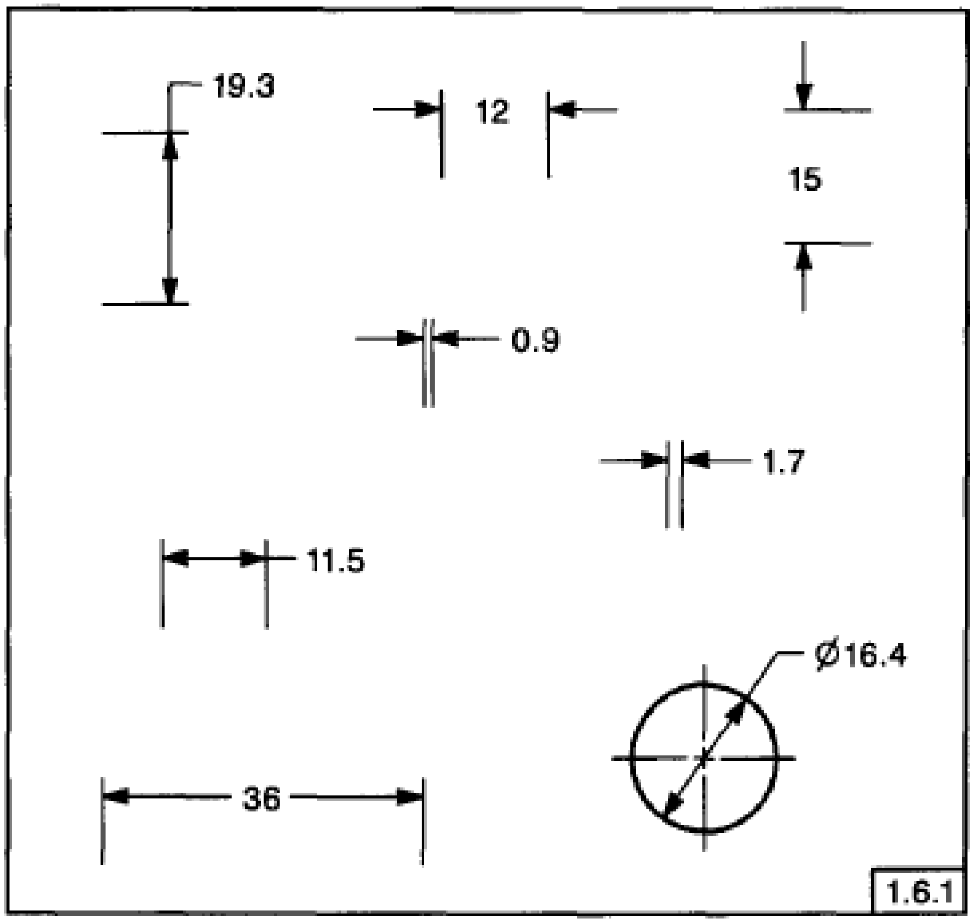


FIG. 1-2 MILLIMETER DIMENSIONS

Angular dimensions

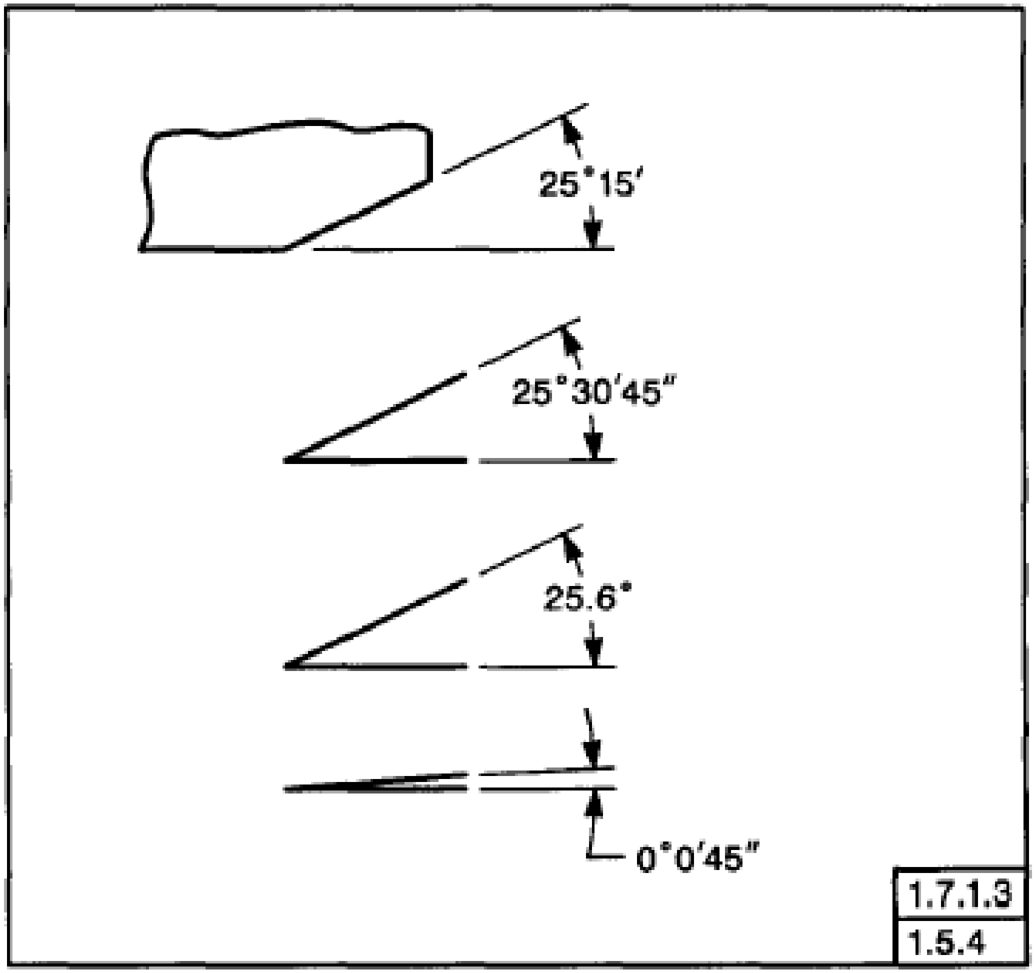


FIG. 1-1 ANGULAR UNITS

Grouping of dimensions

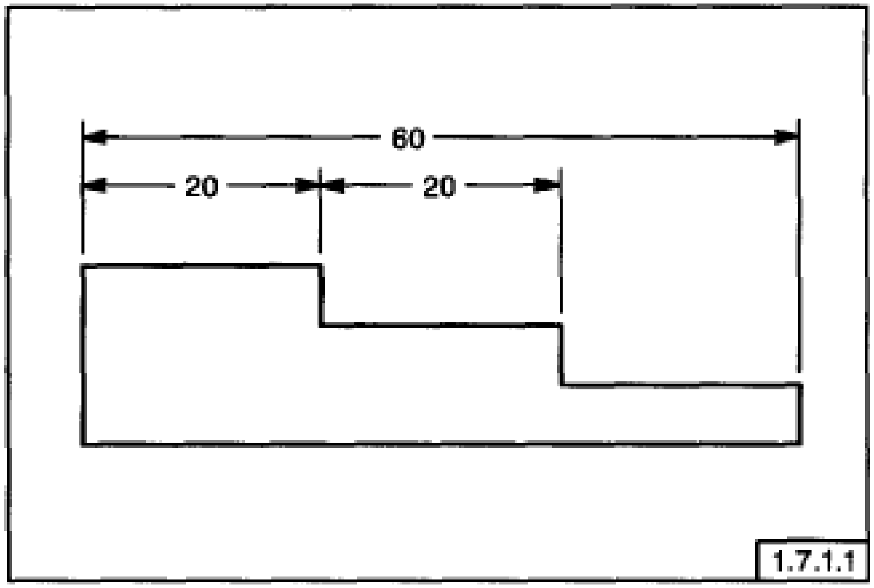


FIG. 1-5 GROUPING OF DIMENSIONS

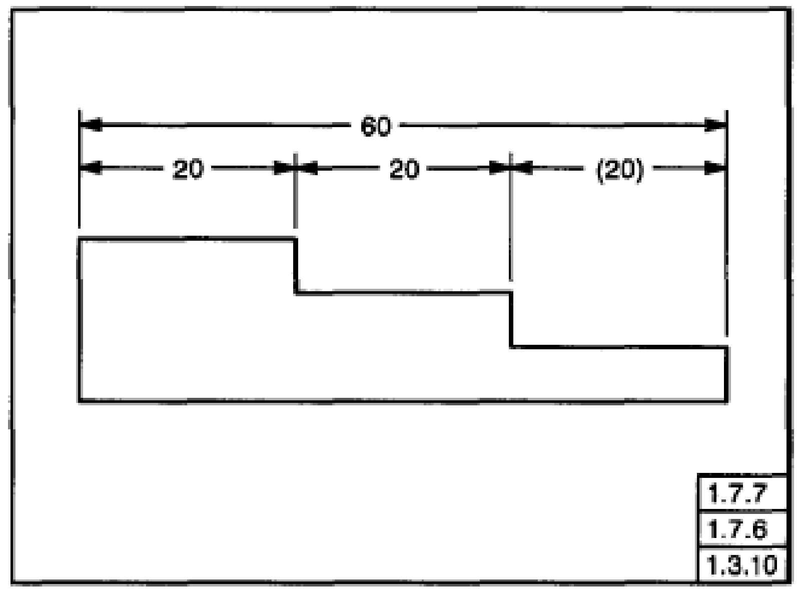


FIG. 1-17 INTERMEDIATE REFERENCE DIMENSION

Application of dimensions

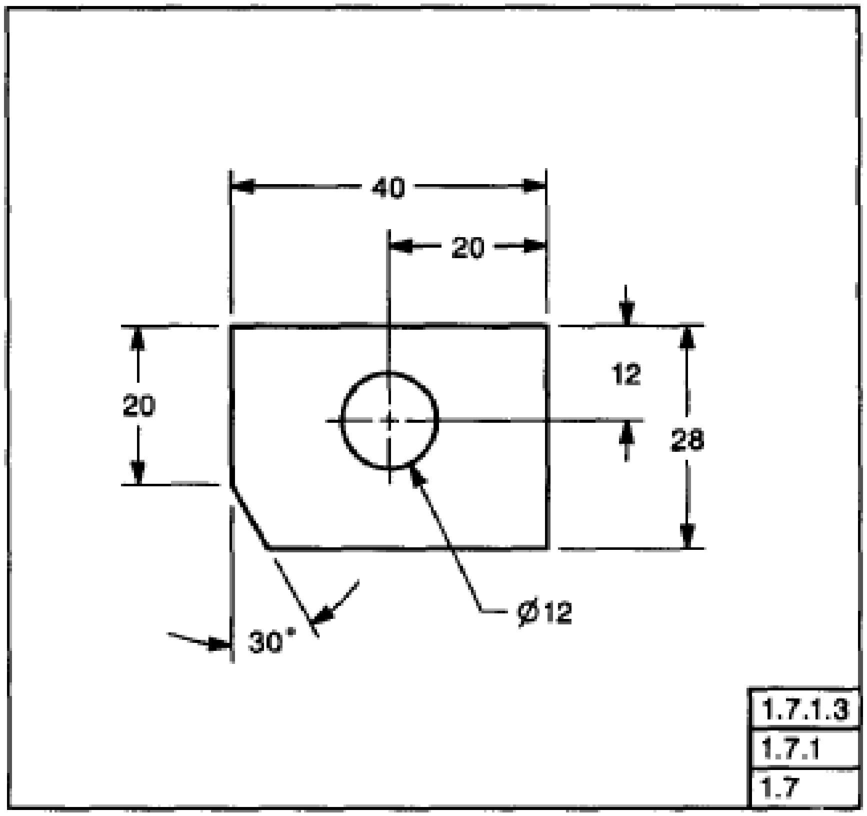


FIG. 1-4 APPLICATION OF DIMENSIONS

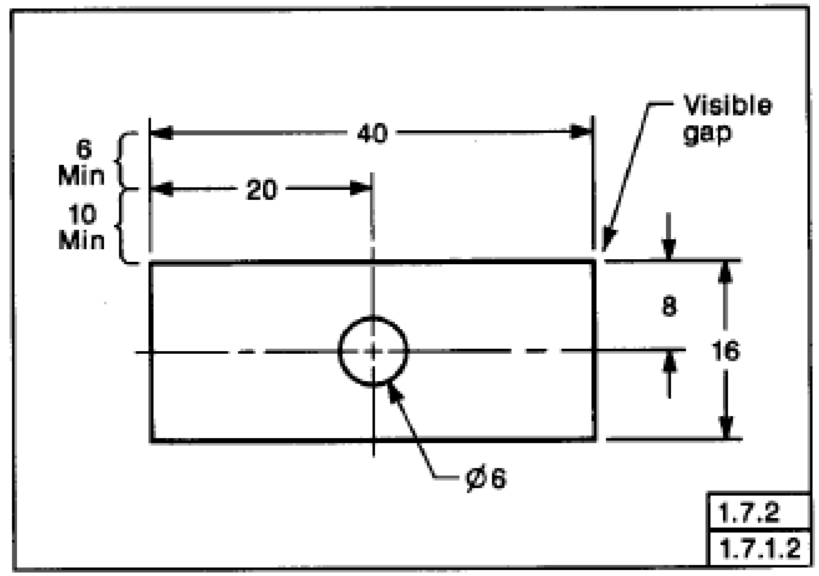


FIG. 1-6 SPACING OF DIMENSION LINES

Staggered dimensions

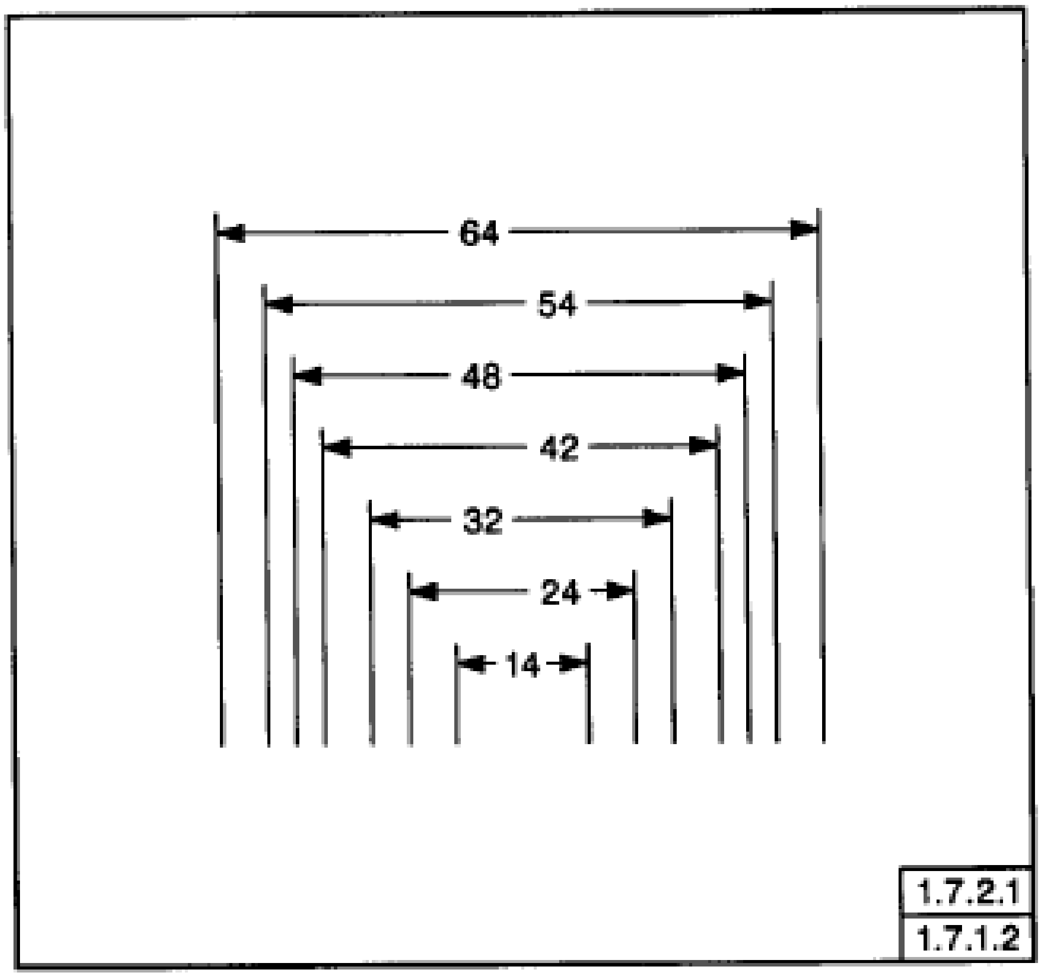


FIG. 1-7 STAGGERED DIMENSIONS

Leaders

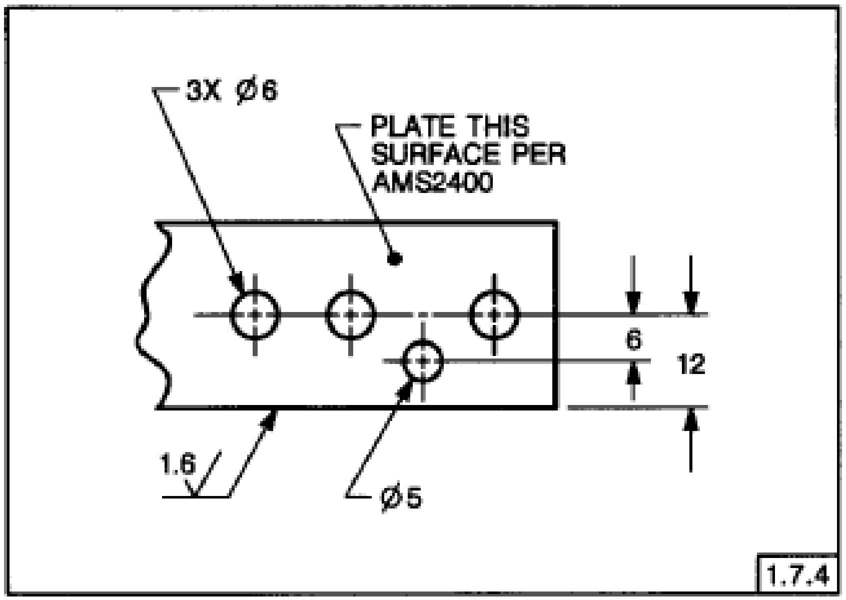


FIG. 1-12 LEADERS

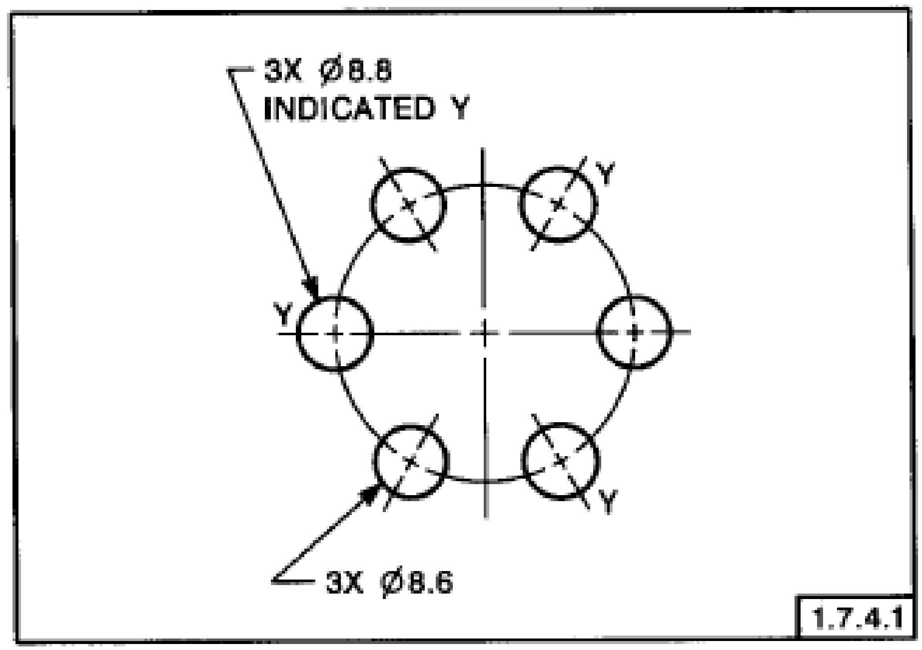


FIG. 1-14 MINIMIZING LEADERS

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Diameters, radii

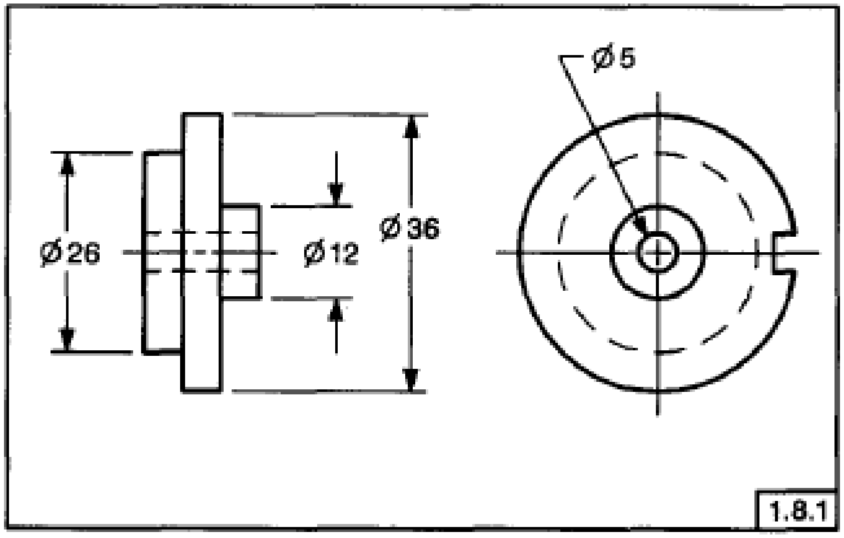


FIG. 1-19 DIAMETERS

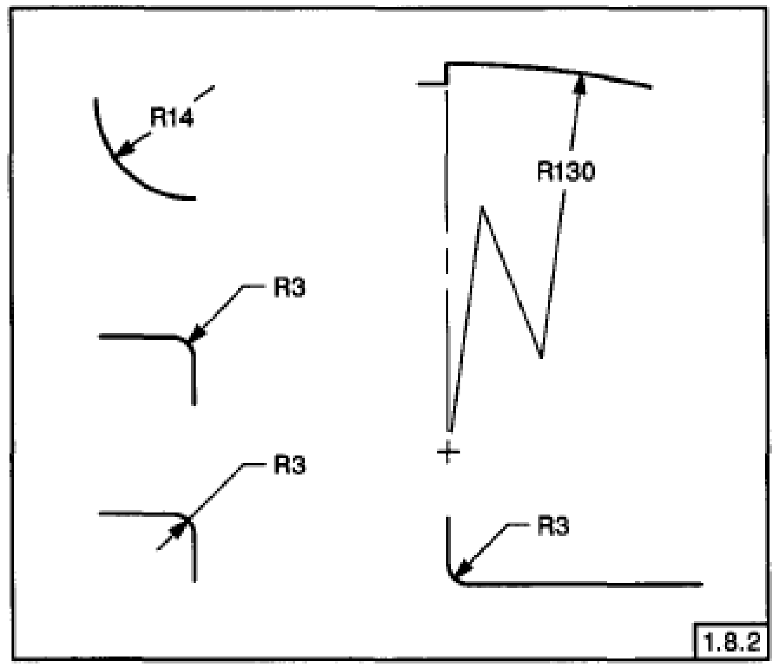
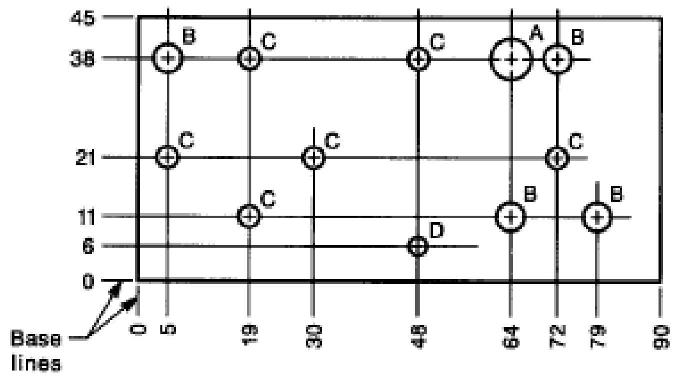


FIG. 1-20 RADII

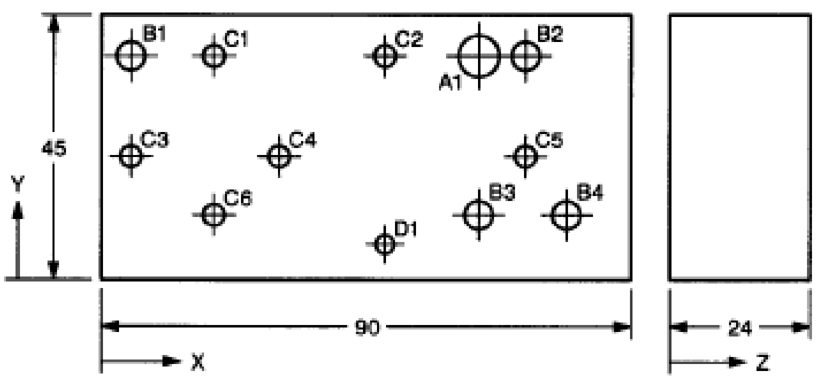
Tabular dimensions



SIZE SYMBOL	A	B	C	D
HOLE Ø	7	4.8	3.6	3.1

1.9.2
1.9
1.7.5.3

HOLE	DESCRIPTION	QTY
A	Ø7	1
B	Ø4.8	4
C	Ø3.6	6
D	Ø3.1	1



HOLE	FROM	X	Y	Z
A1	X,Y	64	38	18
B1	X,Y	5	38	THRU
B2	X,Y	72	38	THRU
B3	X,Y	64	11	THRU
B4	X,Y	79	11	THRU
C1	X,Y	19	38	THRU
C2	X,Y	48	38	THRU
C3	X,Y	5	21	THRU
C4	X,Y	30	21	THRU
C5	X,Y	72	21	THRU
C6	X,Y	19	11	THRU
D1	X,Y	48	6	12

1.9.3
1.9.2
1.9

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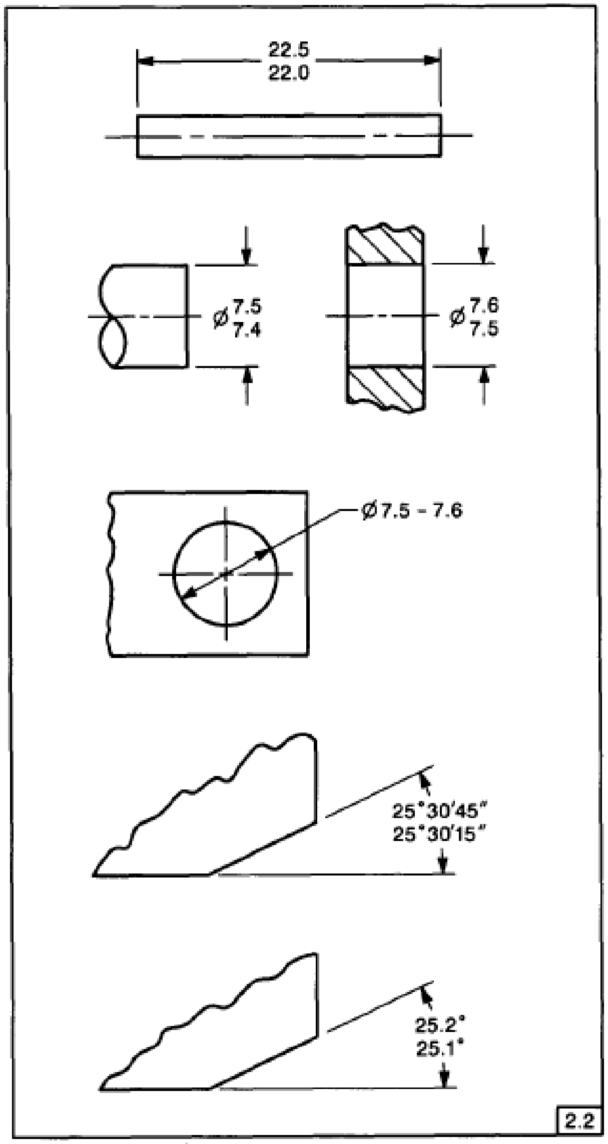
Tolerances



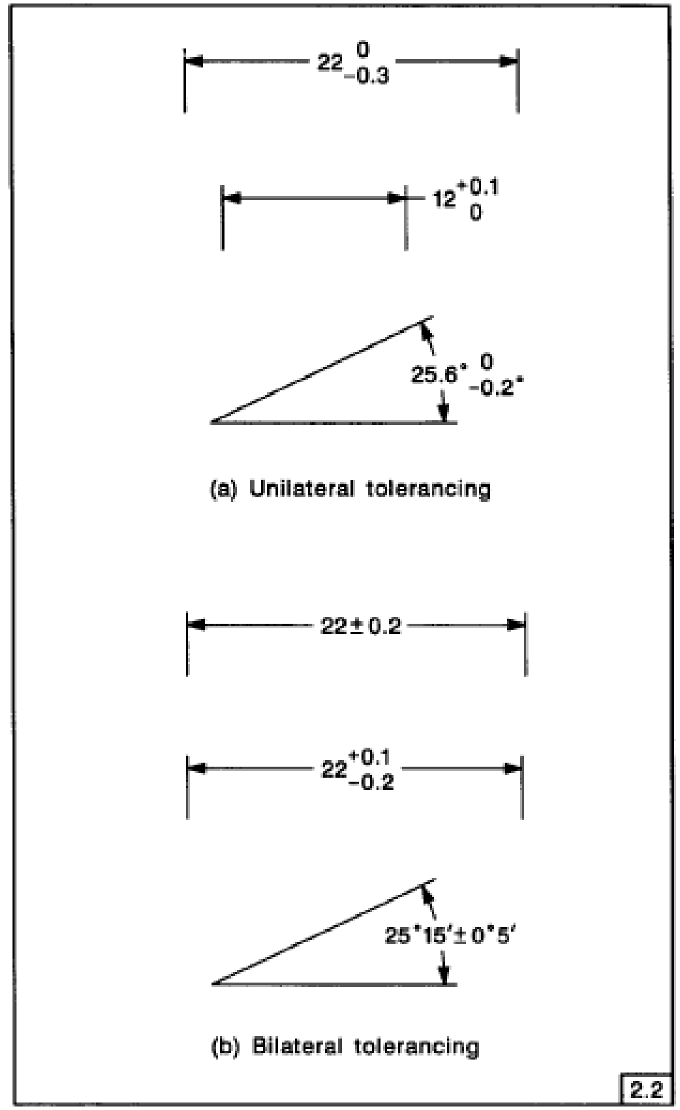
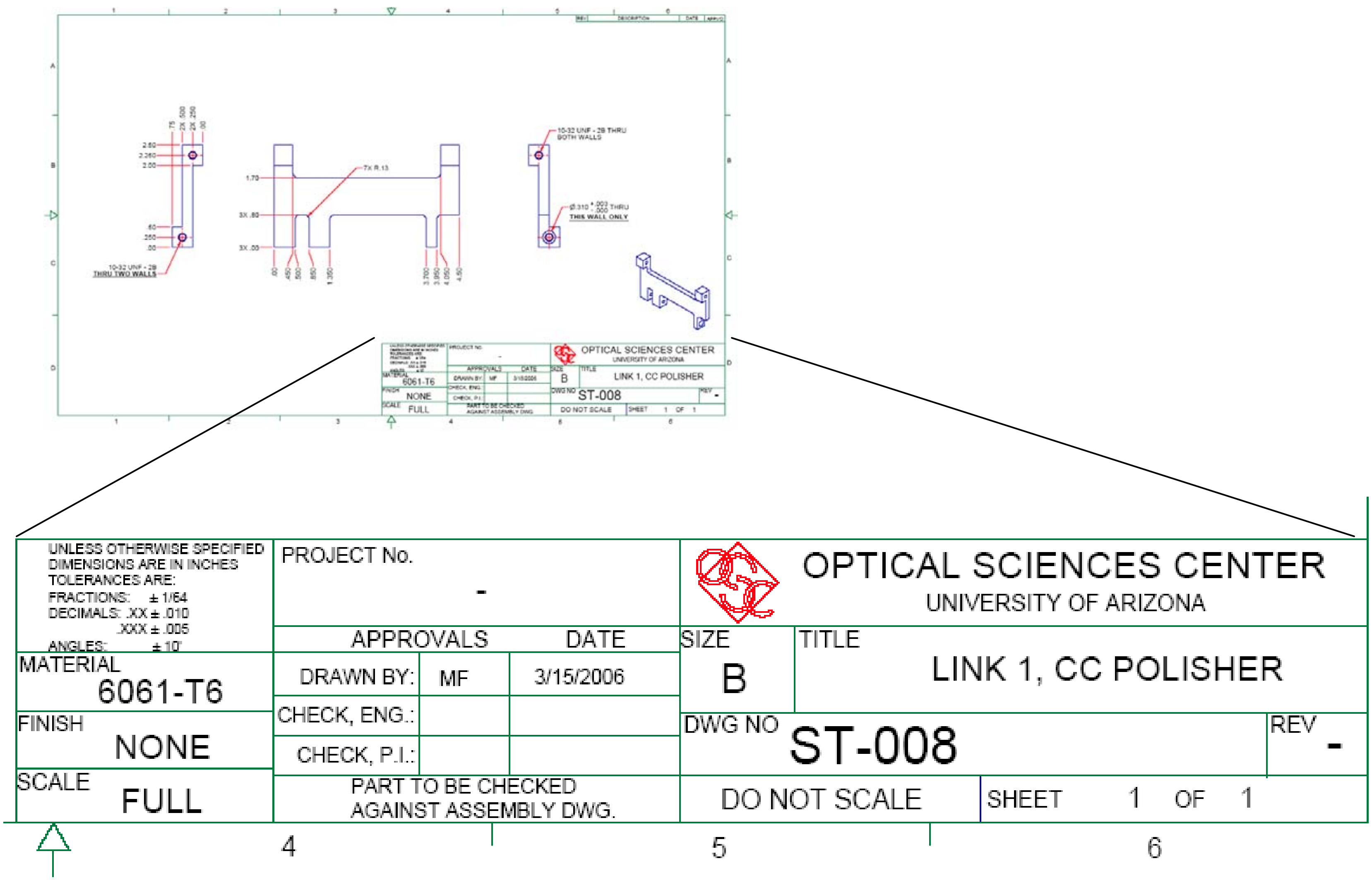


FIG. 2-2 PLUS AND MINUS TOLERANCING

Default tolerances

Can be specified in Title Block of drawing



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Specification of datum

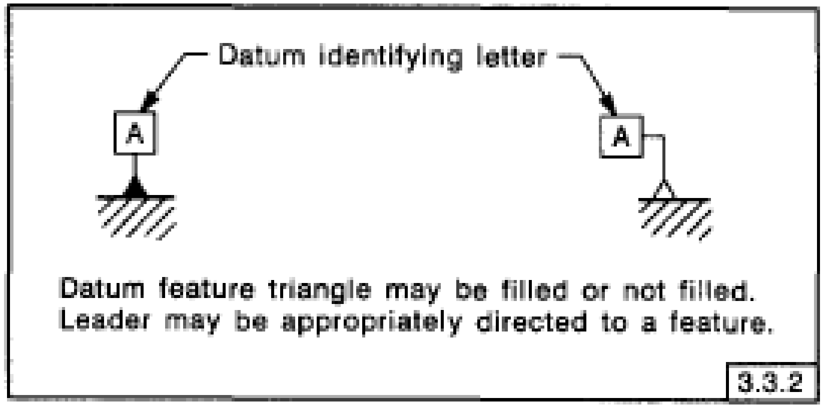

FIG. 3-2 DATUM FEATURE SYMBOL

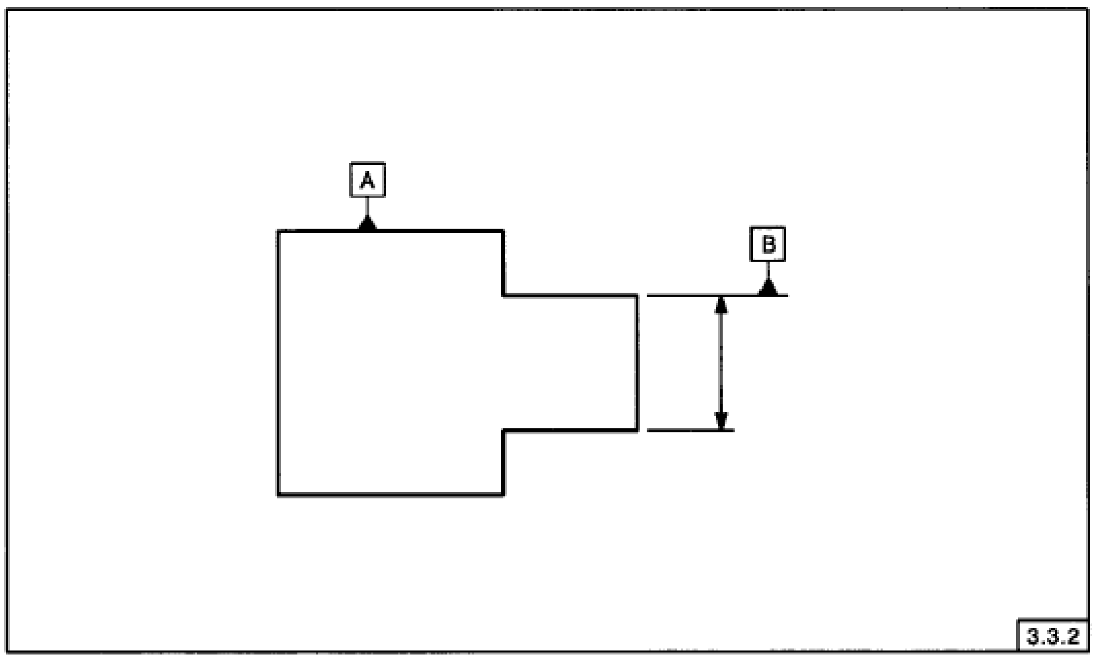

FIG. 3-3 DATUM FEATURE SYMBOLS ON A FEATURE SURFACE AND AN EXTENSION LINE

Datum reference frame

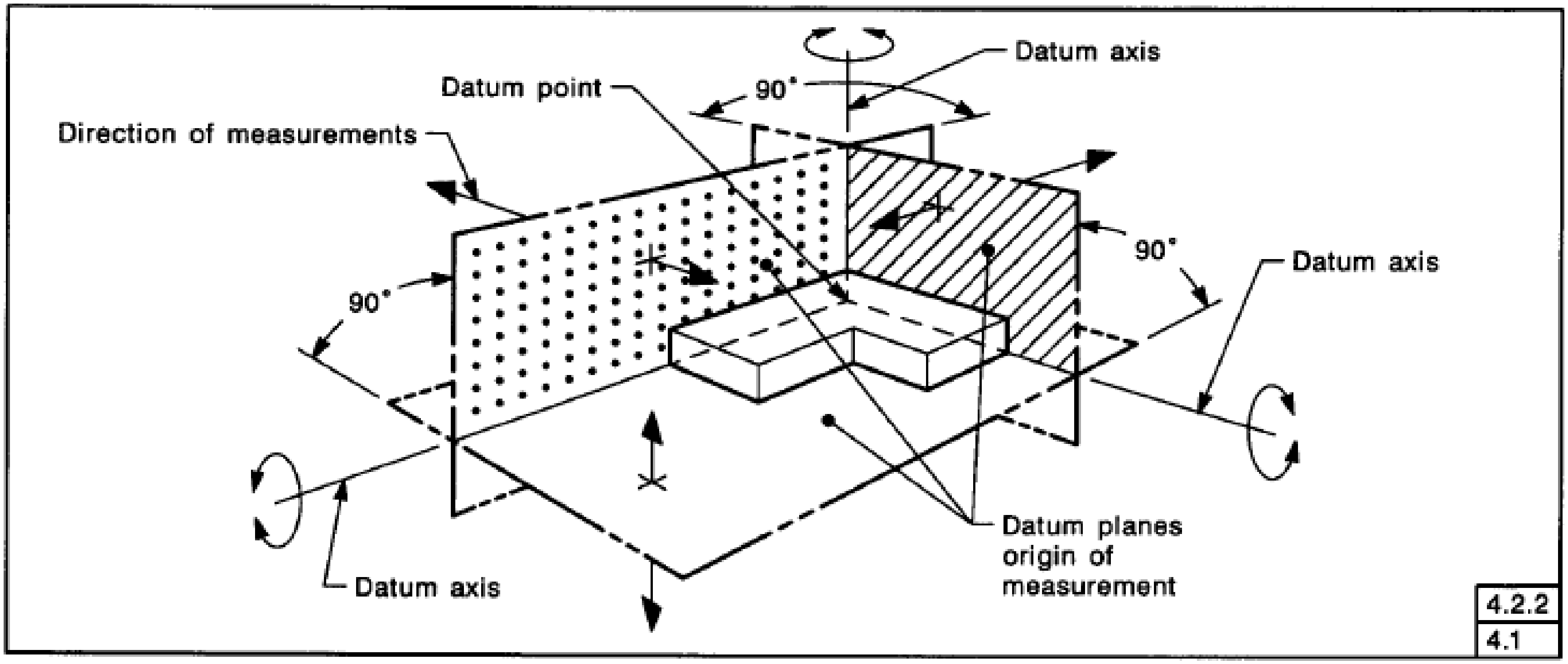

FIG. 4-1 DATUM REFERENCE FRAME

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Reference to datum

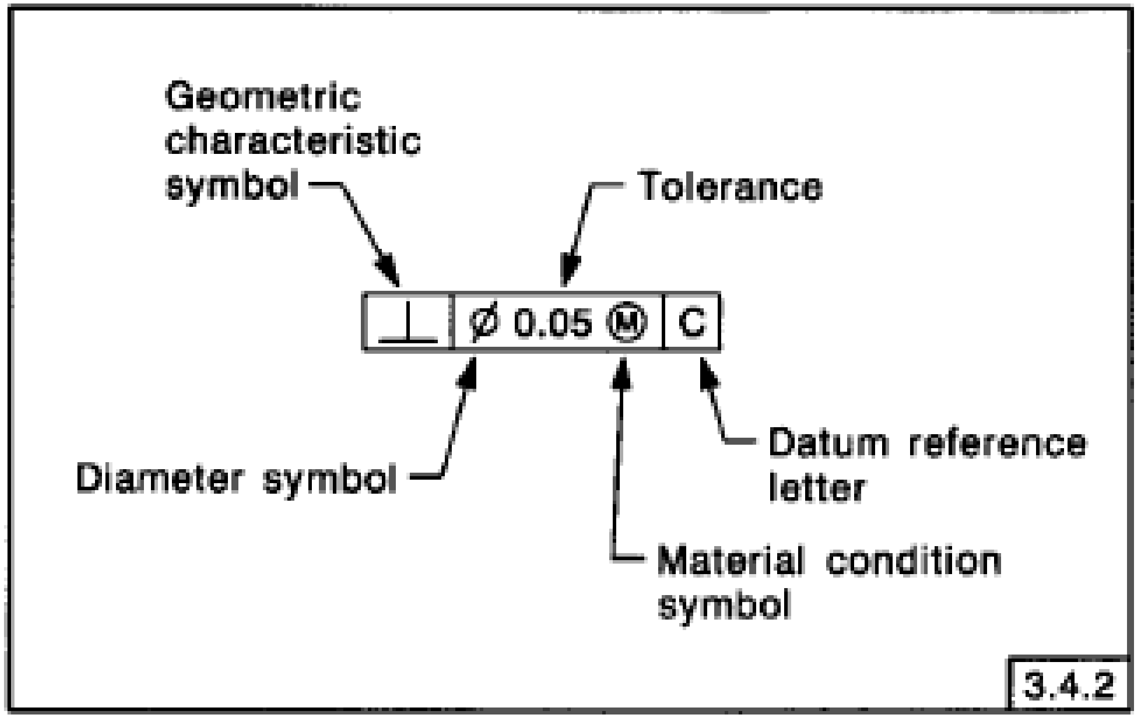

FIG. 3-20 FEATURE CONTROL FRAME INCORPORATING A DATUM REFERENCE

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

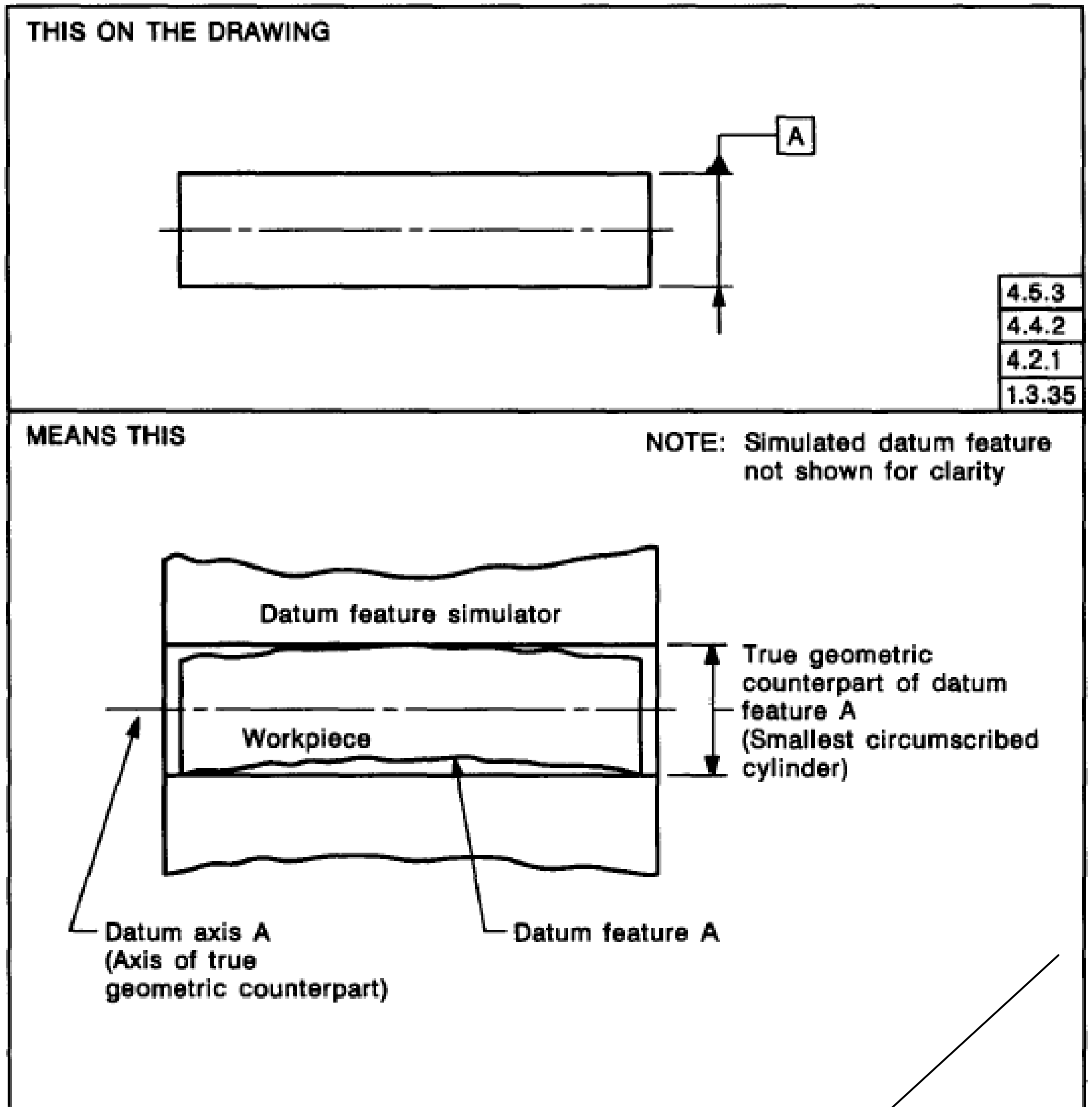

FIG. 4-11 PRIMARY EXTERNAL DATUM DIAMETER — RFS

RFS: regardless of Feature Size

Definition of cylindrical ID datum

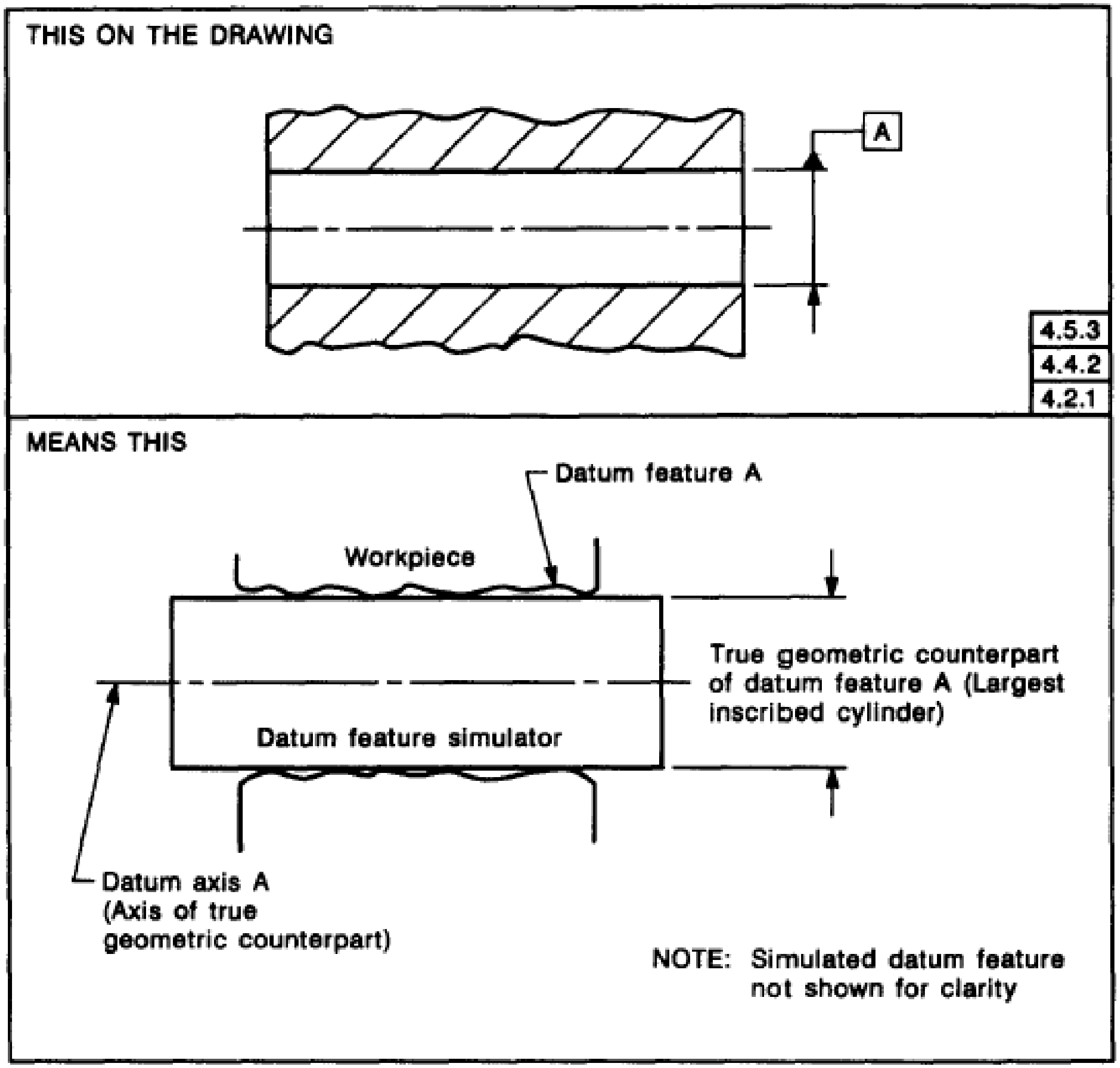

FIG. 4-12 PRIMARY INTERNAL DATUM DIAMETER — RFS

Concentricity

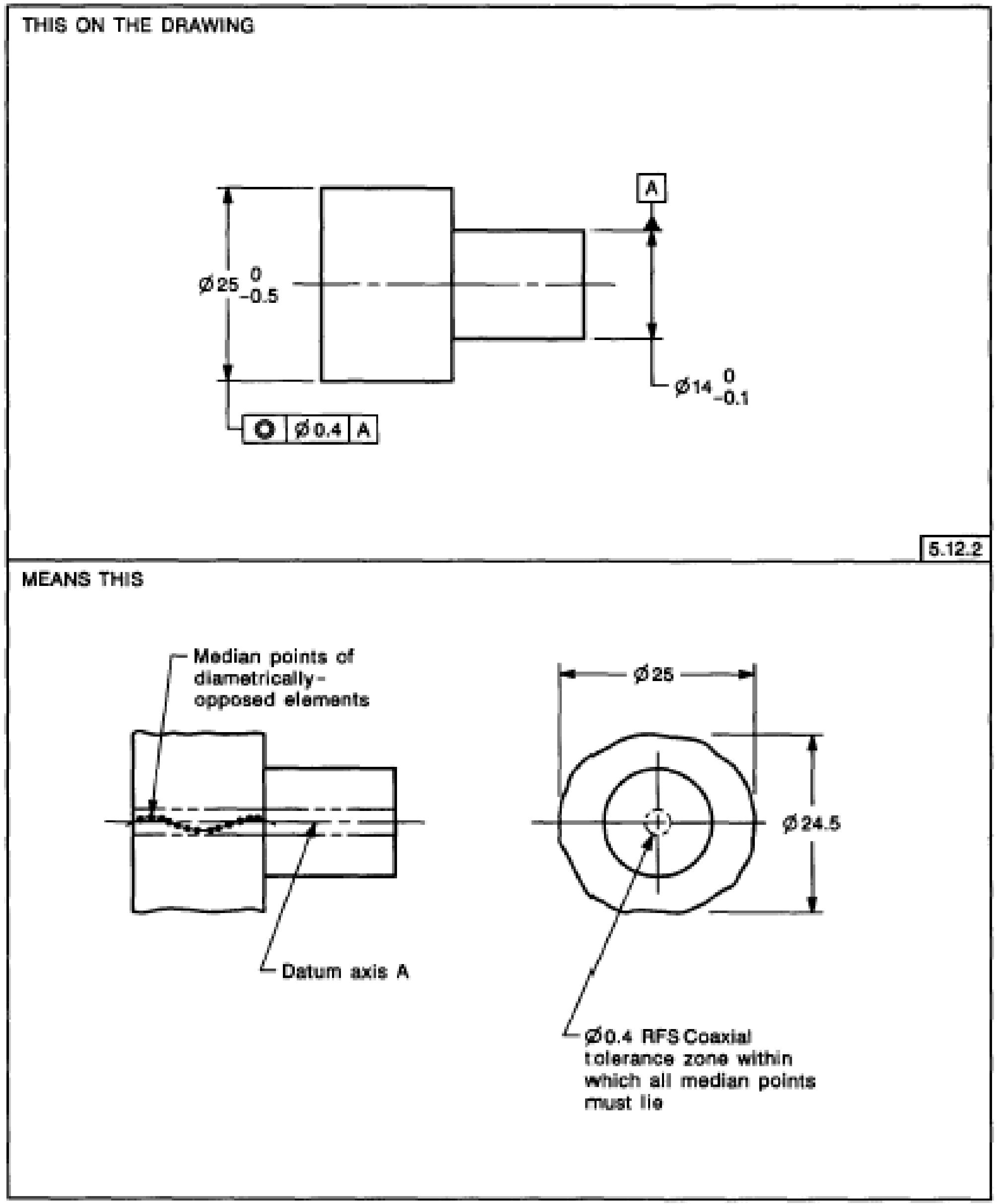

FIG. 5-58 ITEM DEPICTED IN FIG. 5-55 CONTROLLED FOR CONCENTRICITY

Surface flatness

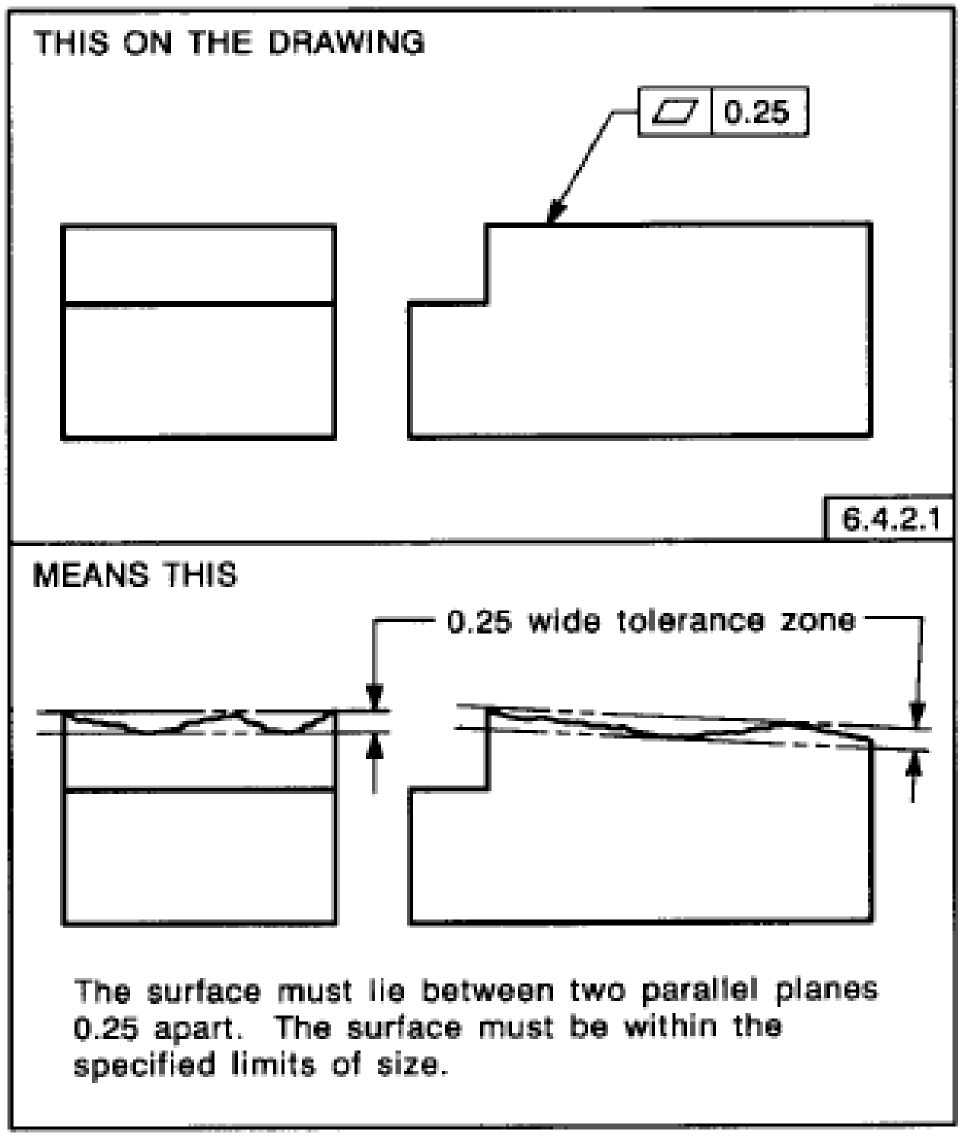

FIG. 6-7 SPECIFYING FLATNESS

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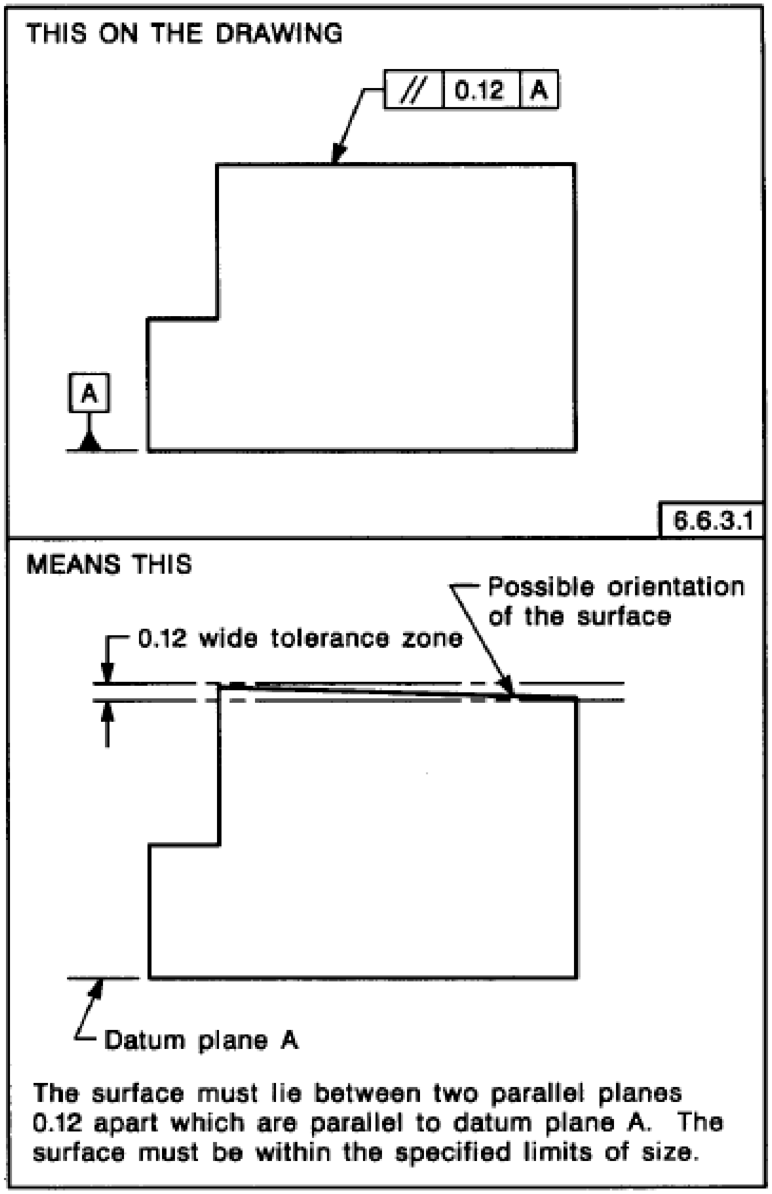
Surface parallelism

General



Using tangent plane

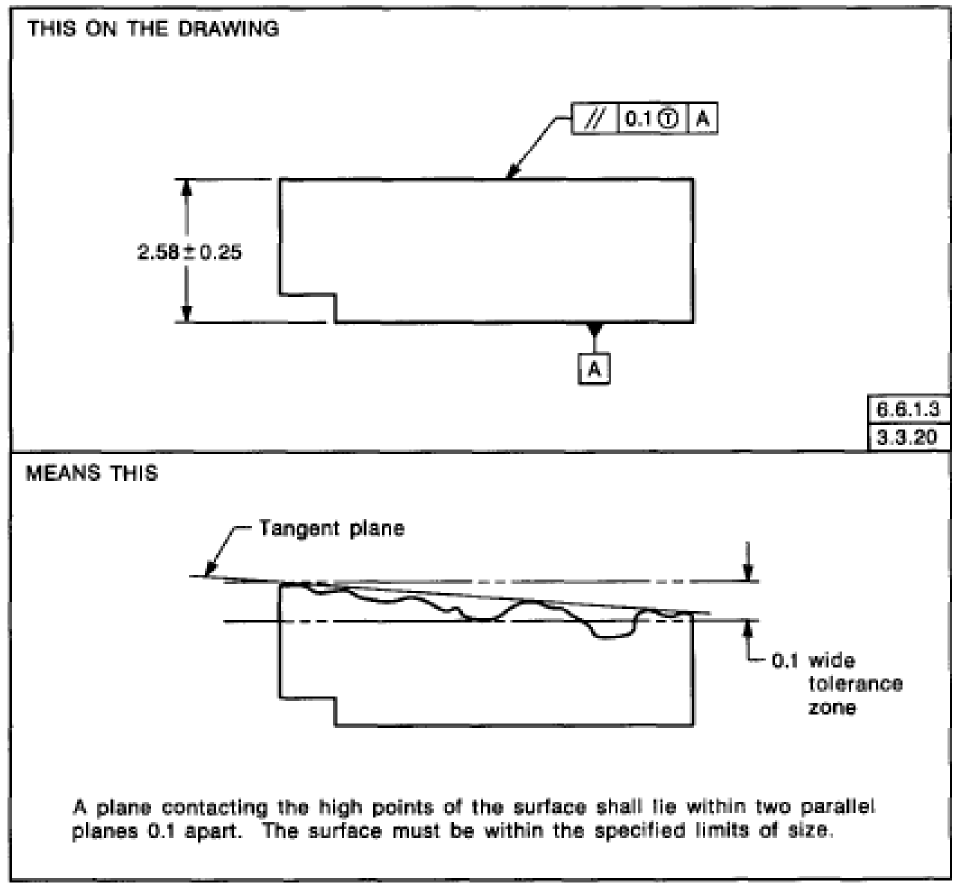


FIG. 6-43 SPECIFYING A TANGENT PLANE

Perpendicularity

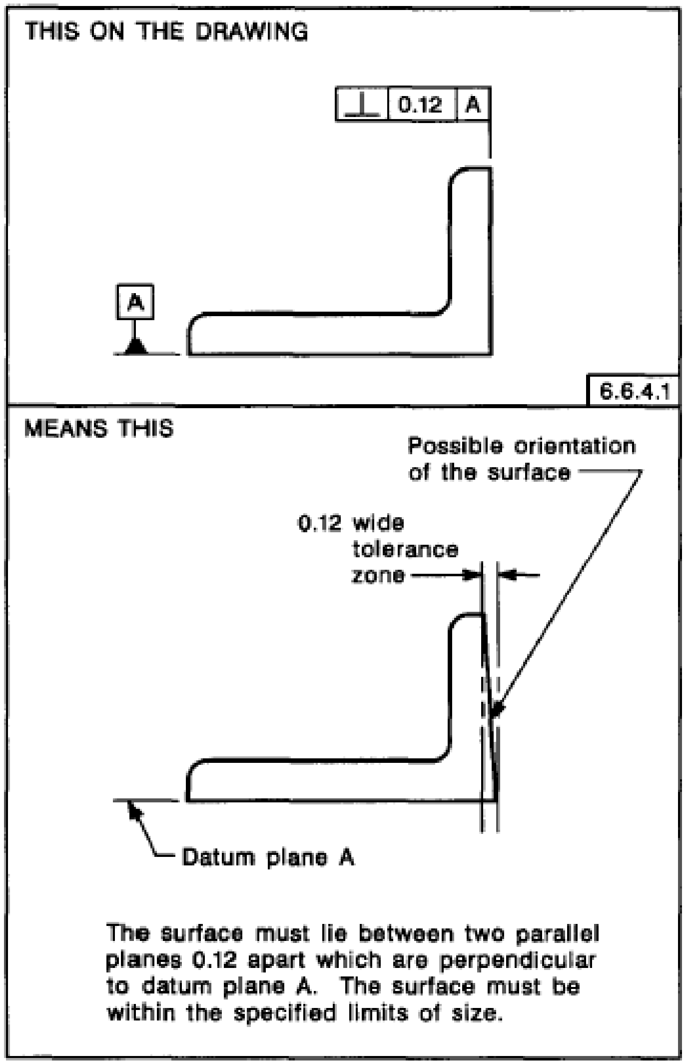


FIG. 6-34 SPECIFYING PERPENDICULARITY FOR A PLANE SURFACE

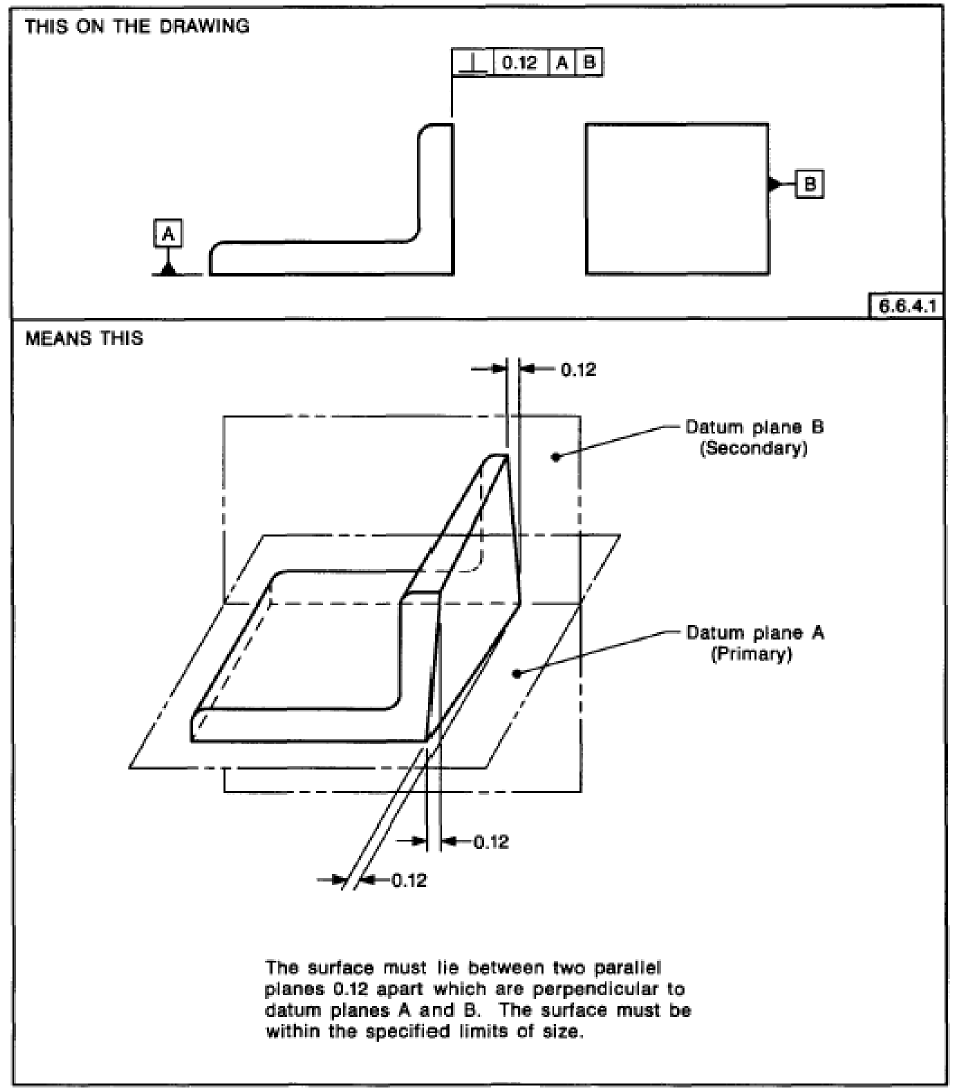
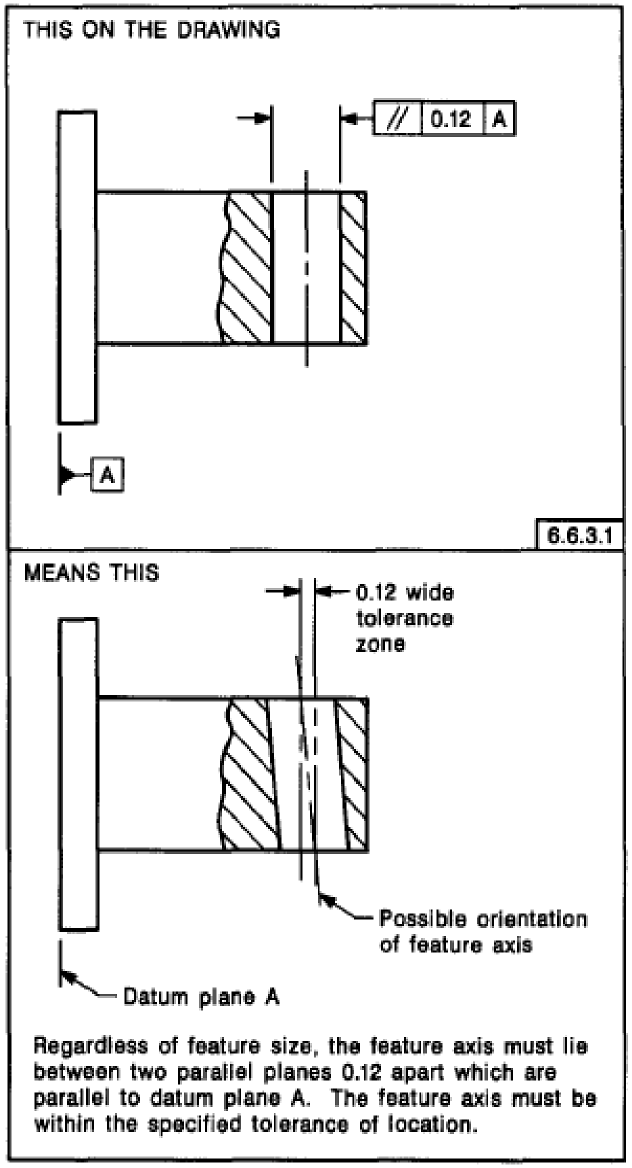
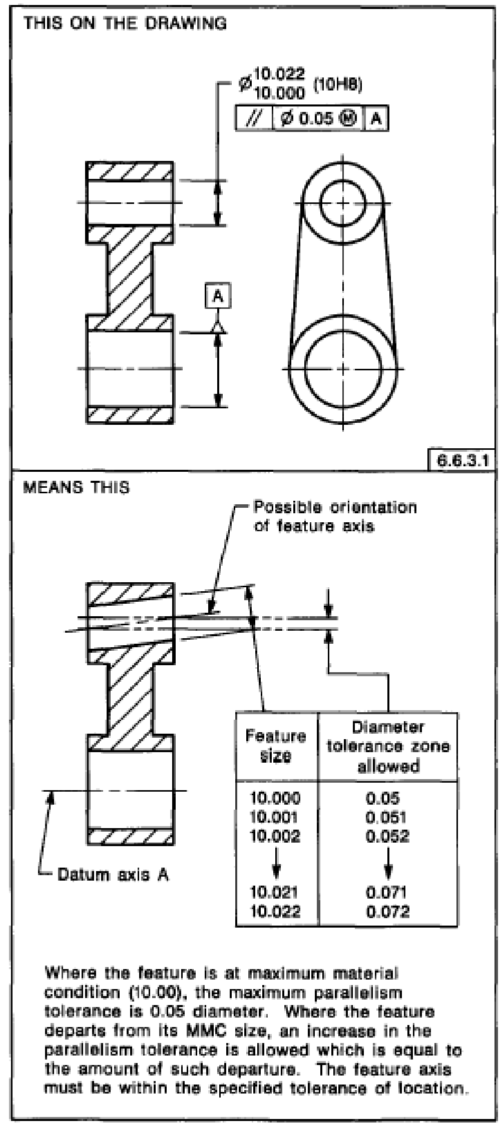


FIG. 6-35 SPECIFYING PERPENDICULARITY FOR A PLANE SURFACE RELATIVE TO TWO DATUMS

Parallelism for axis





Runout

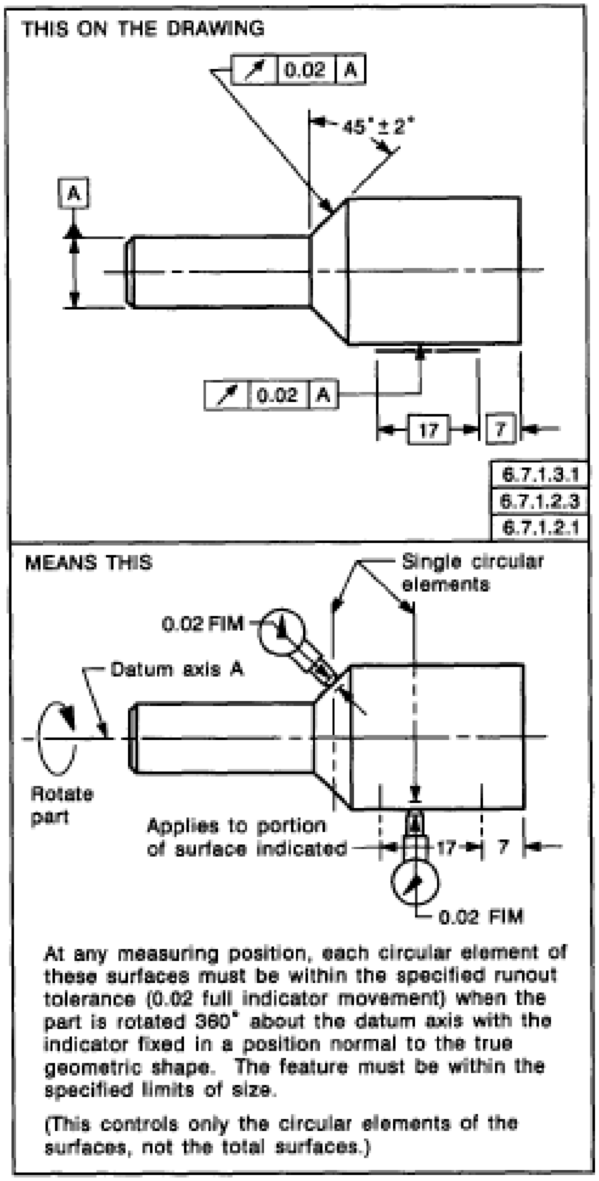


FIG. 6-47 SPECIFYING CIRCULAR RUNOUT RELATIVE TO A DATUM DIAMETER

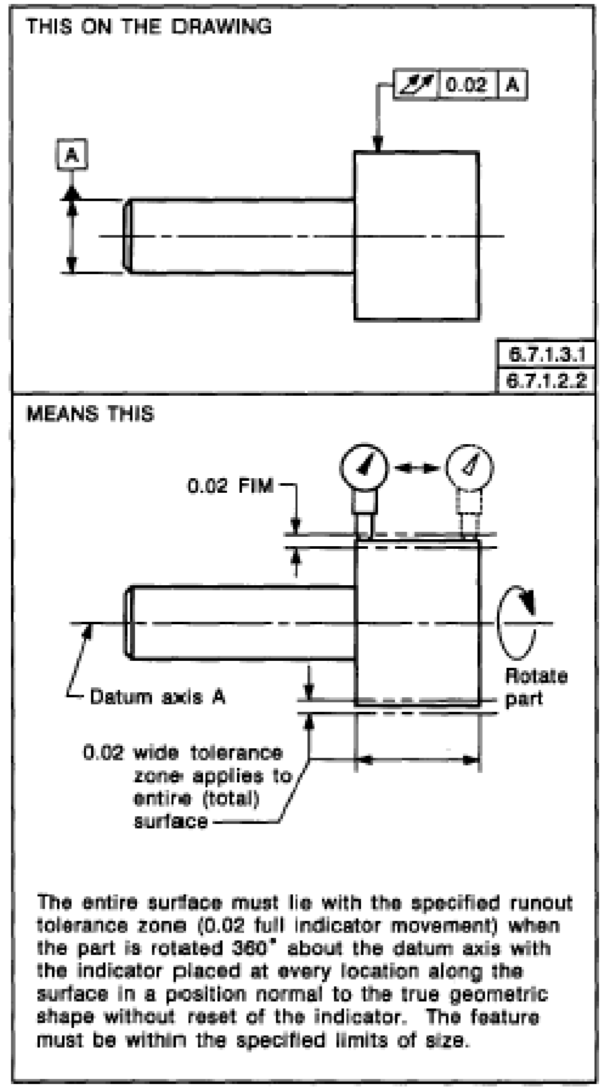


FIG. 6-48 SPECIFYING TOTAL RUNOUT RELATIVE TO A DATUM DIAMETER

Surface orientation

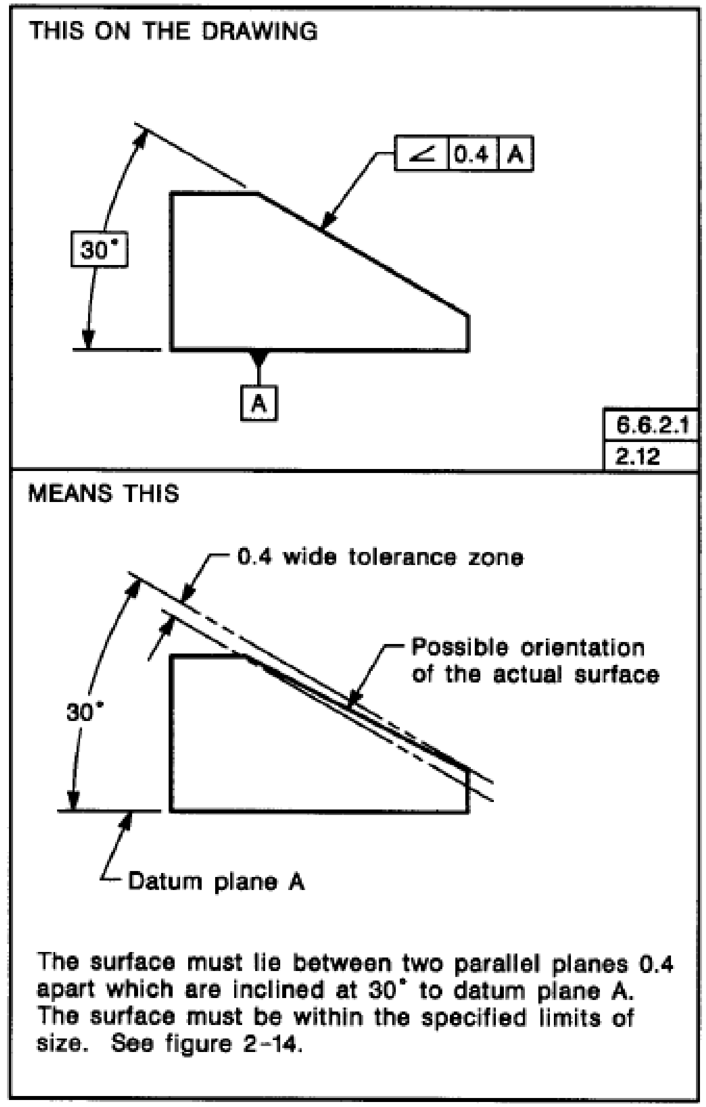


FIG. 6-27 SPECIFYING ANGULARITY FOR A PLANE SURFACE

Use of feature control frames

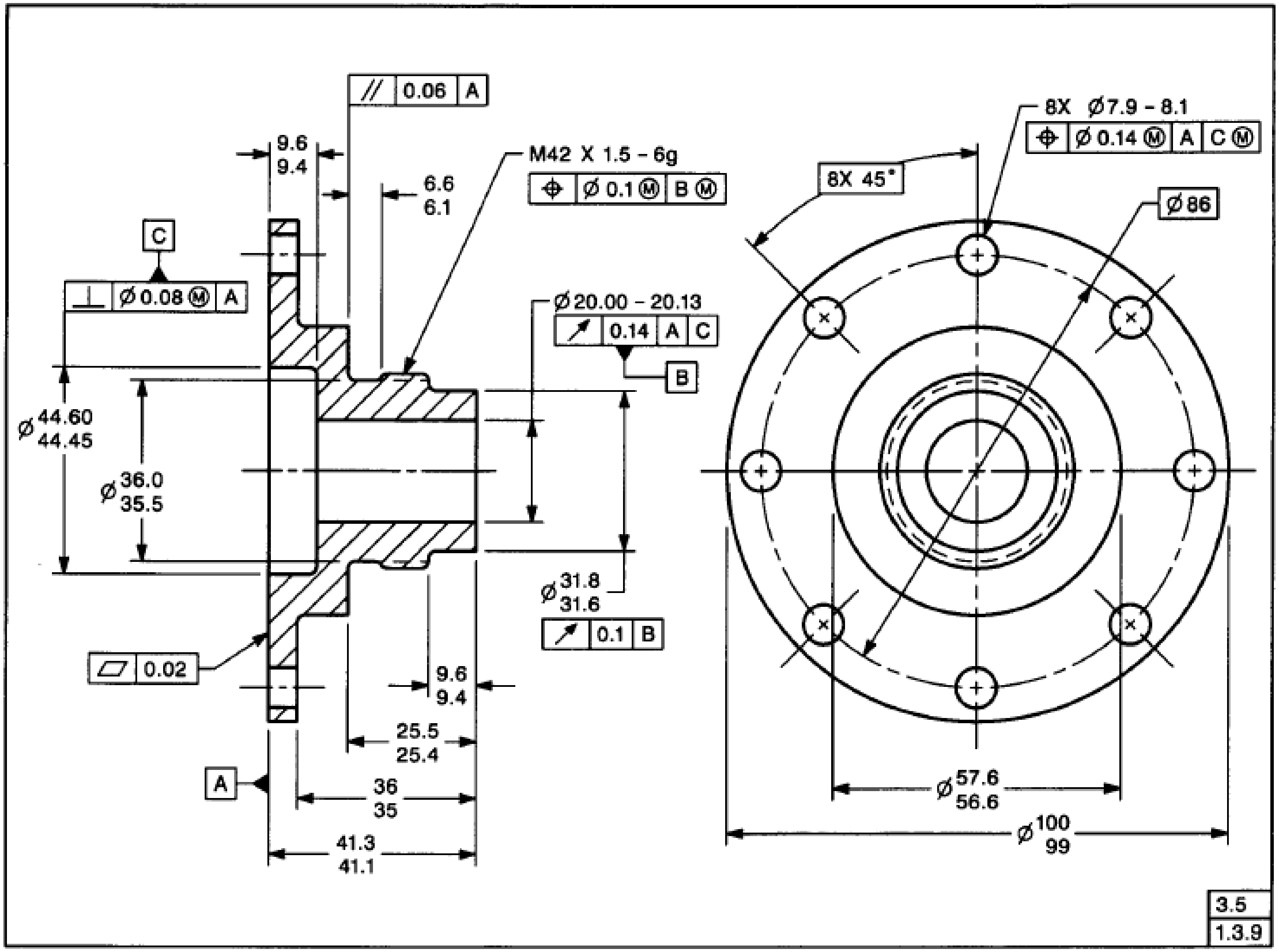


FIG. 3-25 FEATURE CONTROL FRAME PLACEMENT

Basic dimensions

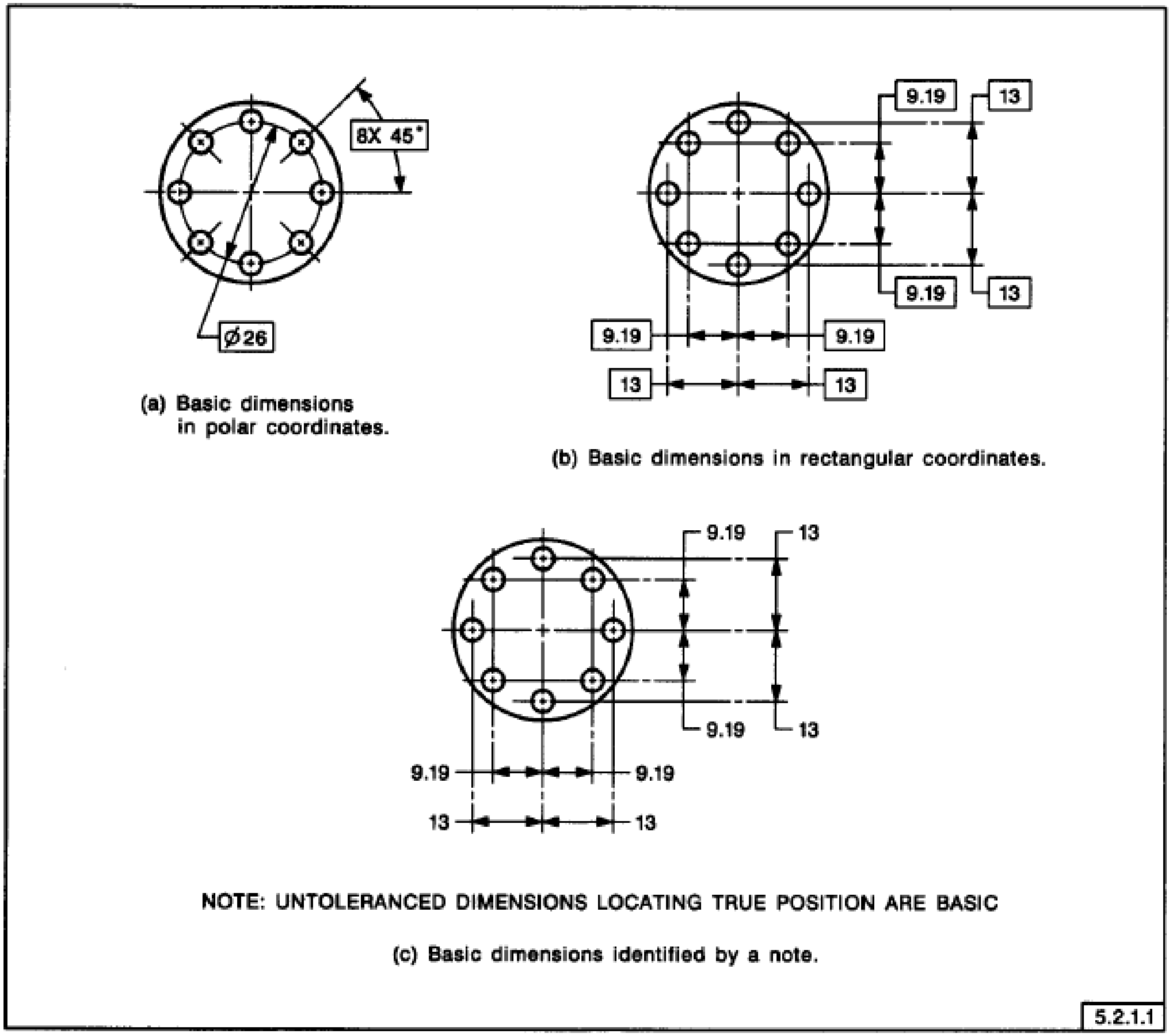


FIG. 5-1 IDENTIFYING BASIC DIMENSIONS

Meaning of basic tolerances

Geometric Dimensioning and Tolerancing

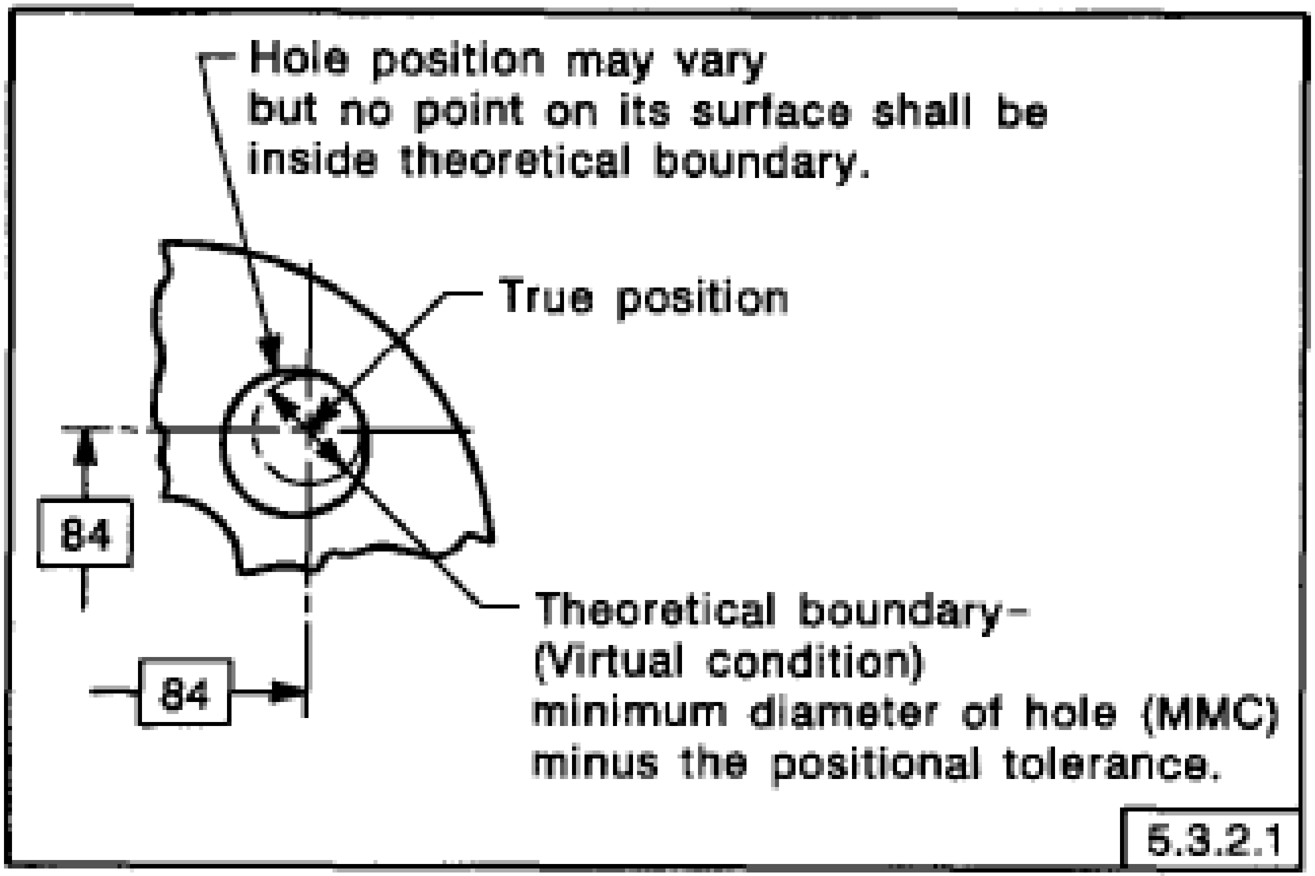


FIG. 5-5 BOUNDARY FOR SURFACE OF HOLE AT MMC

Tolerancing using basic dimensions

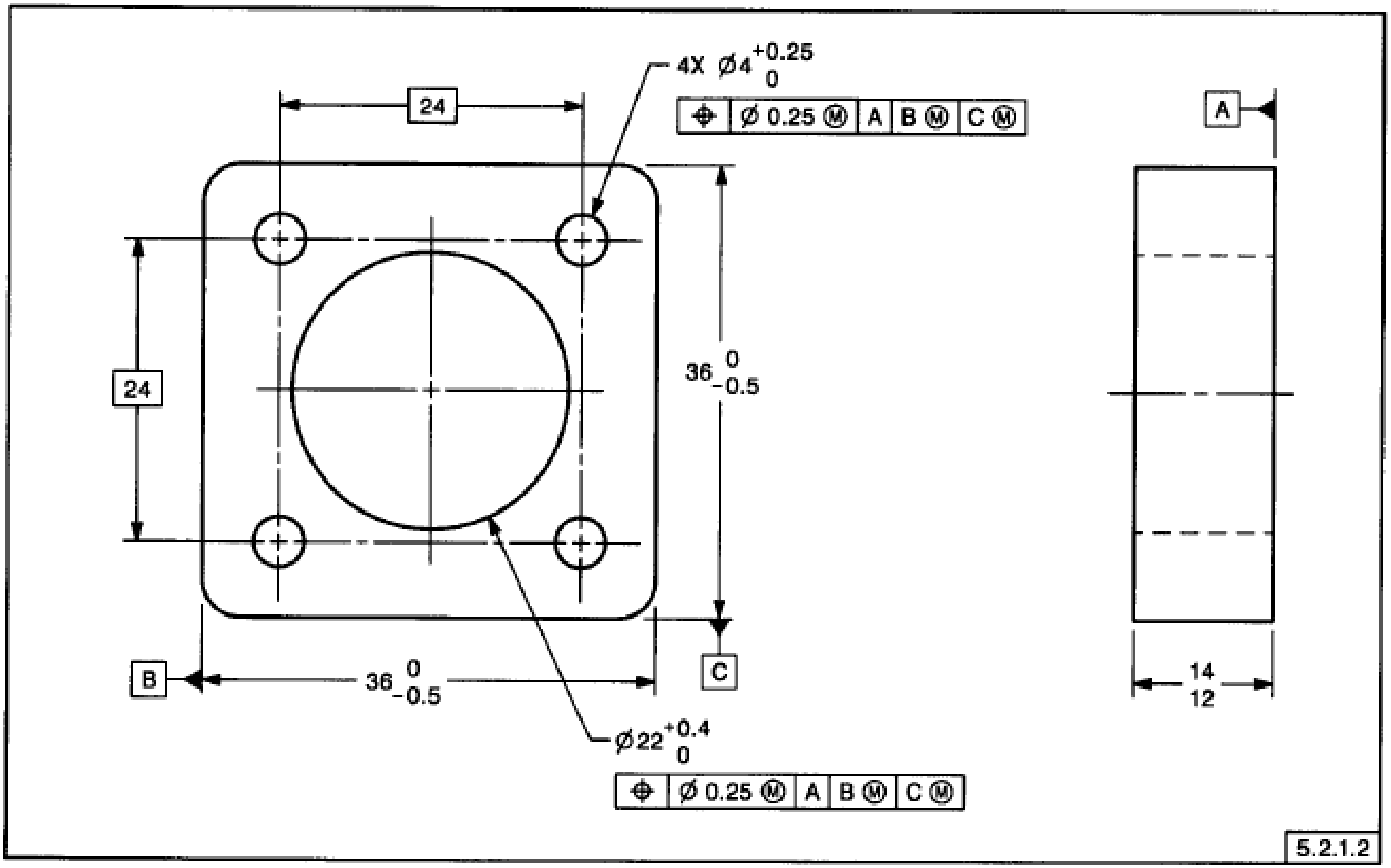


FIG. 5-4 POSITIONAL TOLERANCING AT MMC RELATIVE TO DATUM FEATURE CENTER PLANES

Example of multiple features

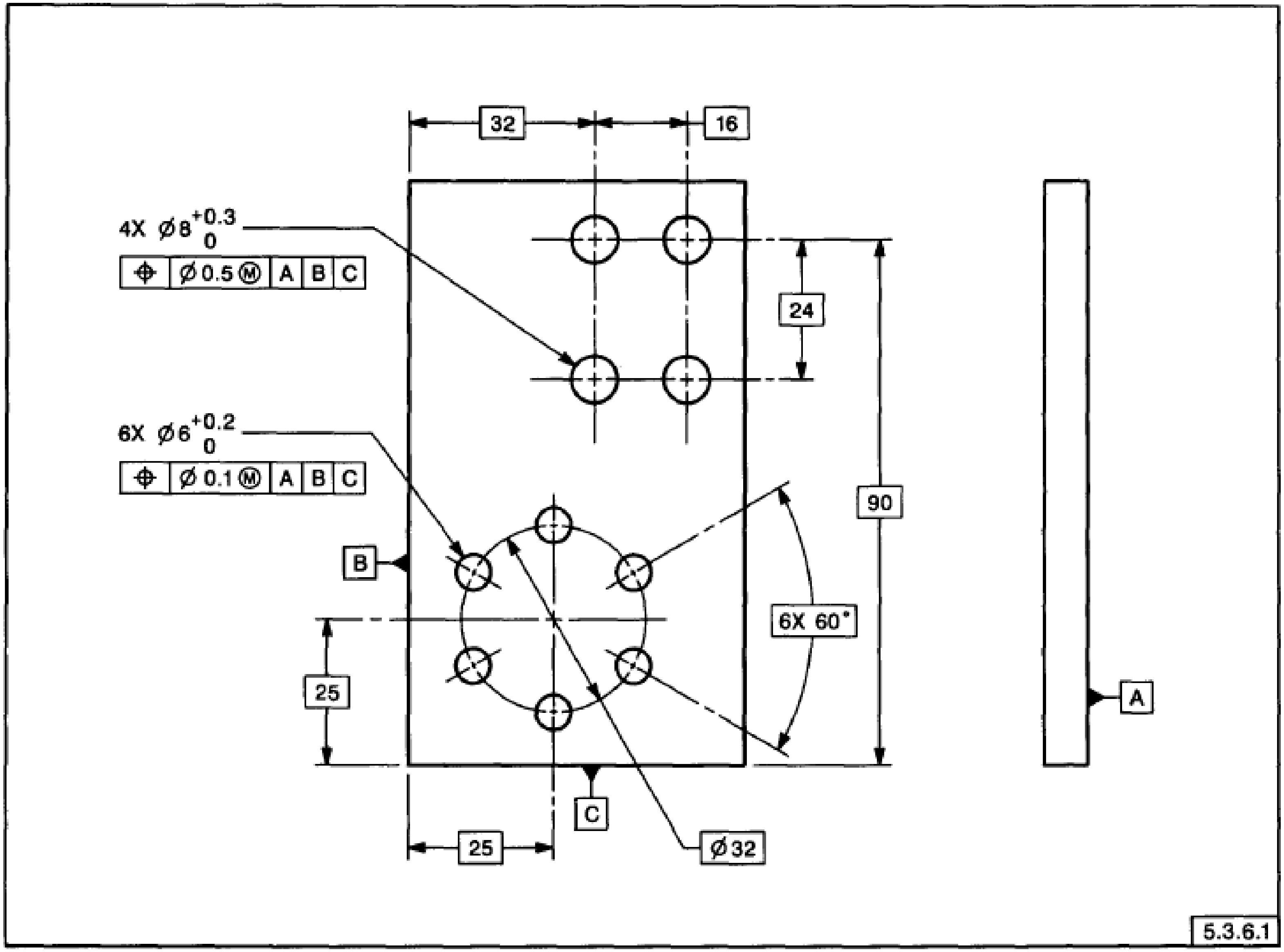


FIG. 5-16 MULTIPLE PATTERNS OF FEATURES

Tolerance zones

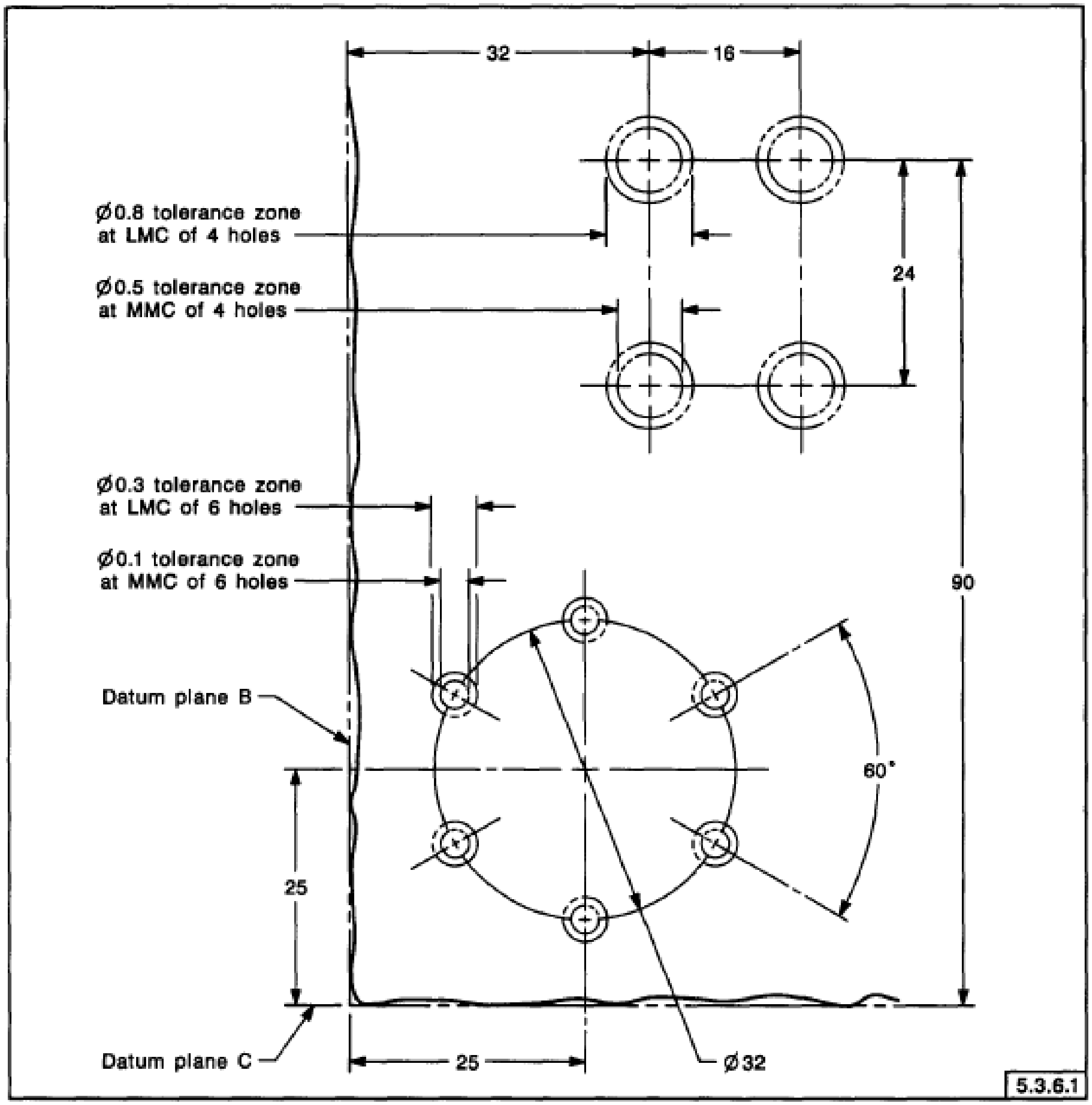


FIG. 5-17 TOLERANCE ZONES FOR PATTERNS SHOWN IN FIG. 5-16