ENGINEERING DRAWING

P.RADHAKRISHNAN
CIPET-HYDERABAD

UNIT I

IMPORTANCE OF ENGINEERING GRAPHICS

- Engineering drawings serve the purpose of communicating ideas to others.
- These are used by all technical people, in addition to engineers.
- Engineering drawings are prepared by the draughtsmen, under the supervision of engineers.
- Drawings should be prepared correctly based on the standards.

CLASSIFICATION OF ENGINEERING DRAWINGS

- Machine Drawing
- Production Drawing
- Assembly Drawing

Contents

Attention to Detail

The engineering drawing is the specification for the component or assembly and is an important contractual document with many legal implications, every line and every comment is important.

Part and Assembly Drawings

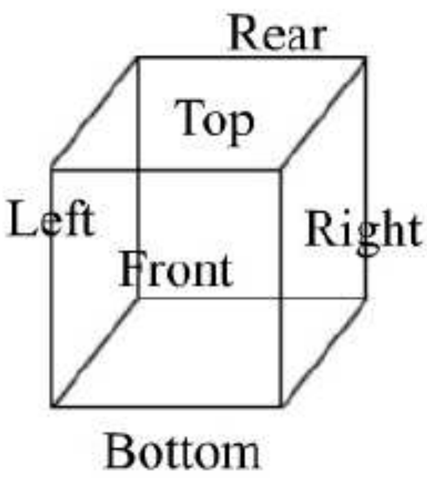
Part Drawings:

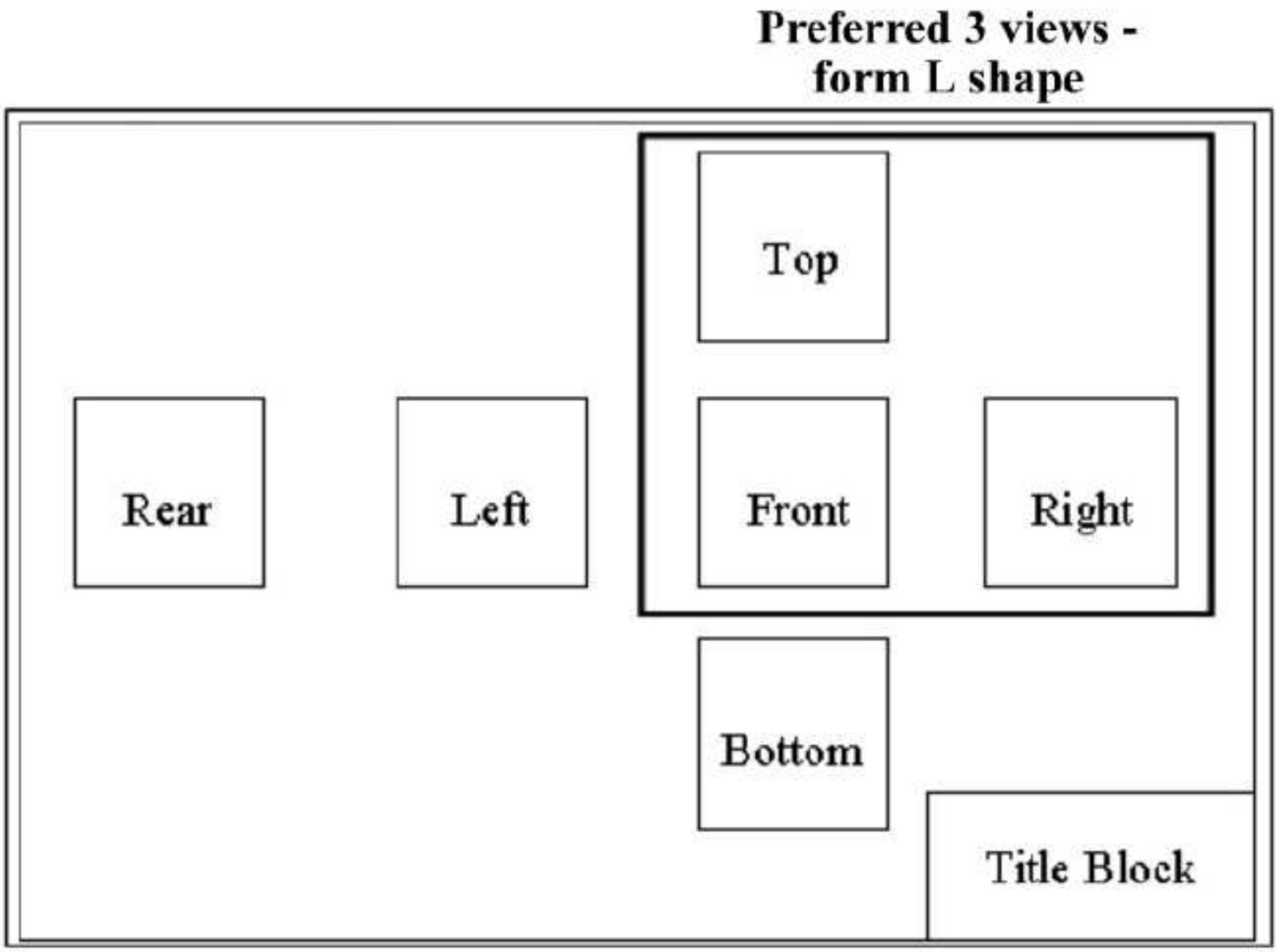
- **Detail drawings completely describe a single part with multiview orthographic projections.**
- **Should provide all the information necessary to economically manufacture a high quality part.**

Assembly Drawings:

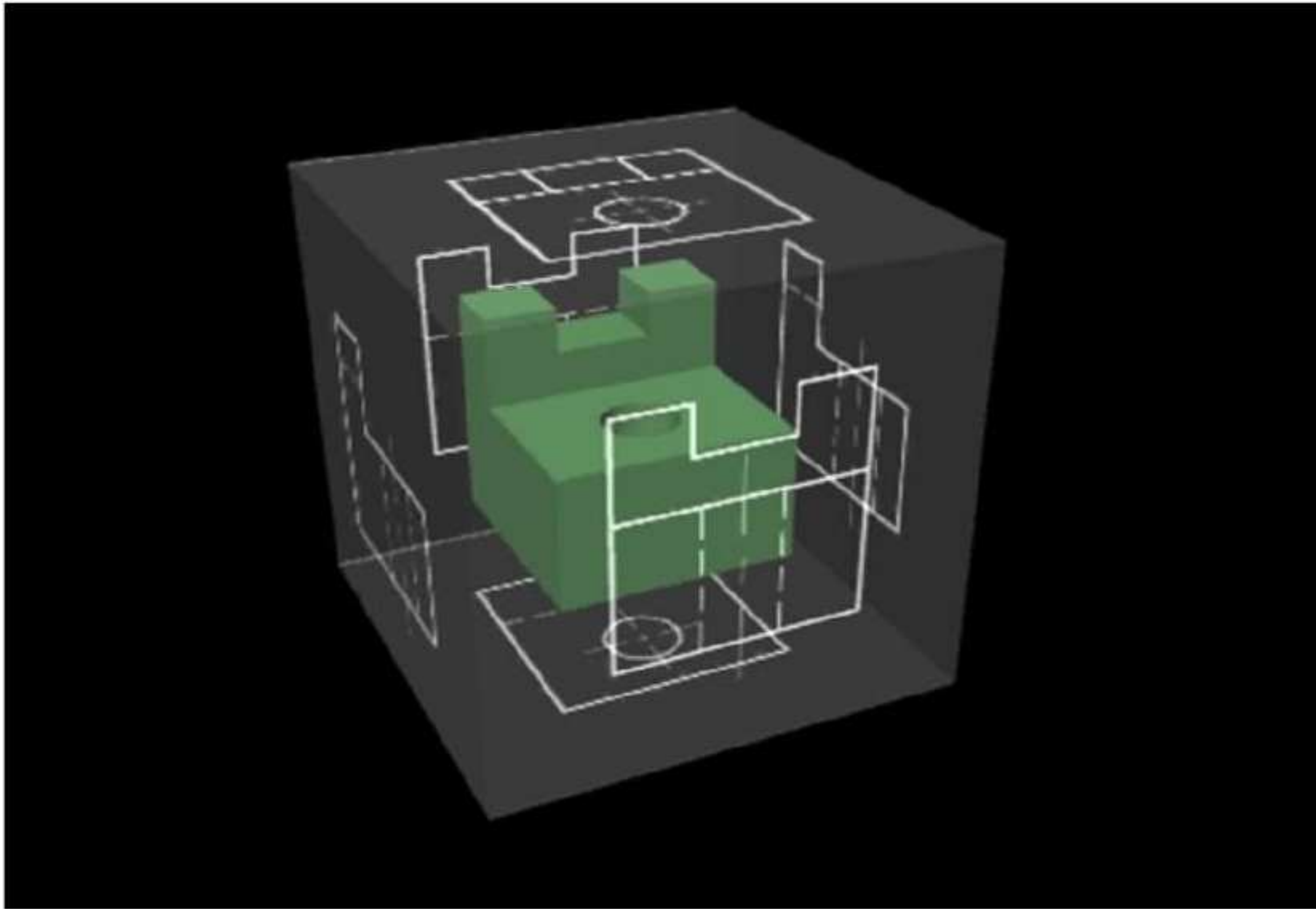
- **Assembly drawings are used to show the position and functional relationship of parts in an assembly, also via multiview orthographic projections.**
- **Generally they have no dimensions on them.**
- **Parts are 'balloon' identified and referenced to either detail drawing numbers or catalog numbers, via a Bill of Materials (BOM)**

Orthographic Views

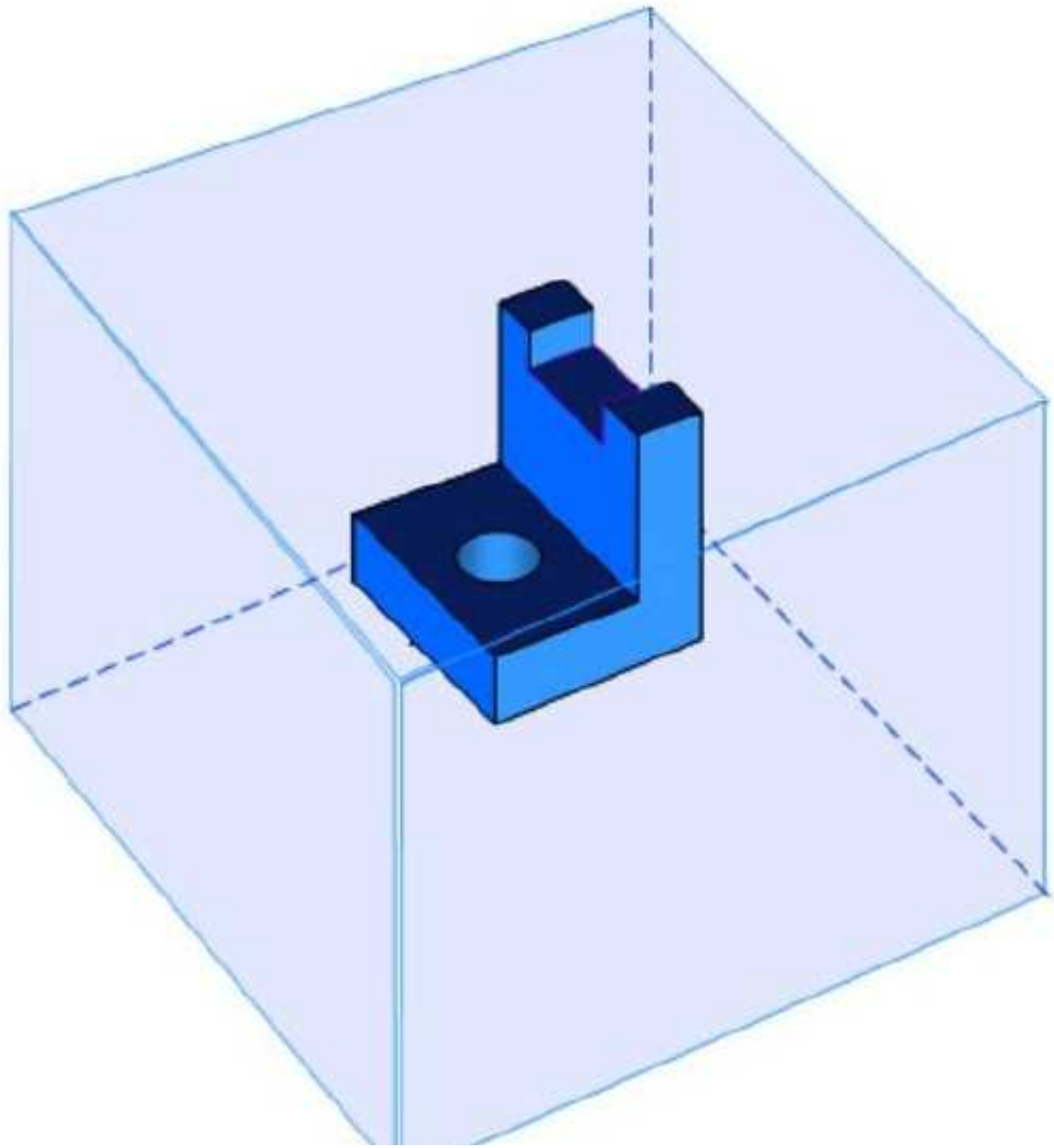




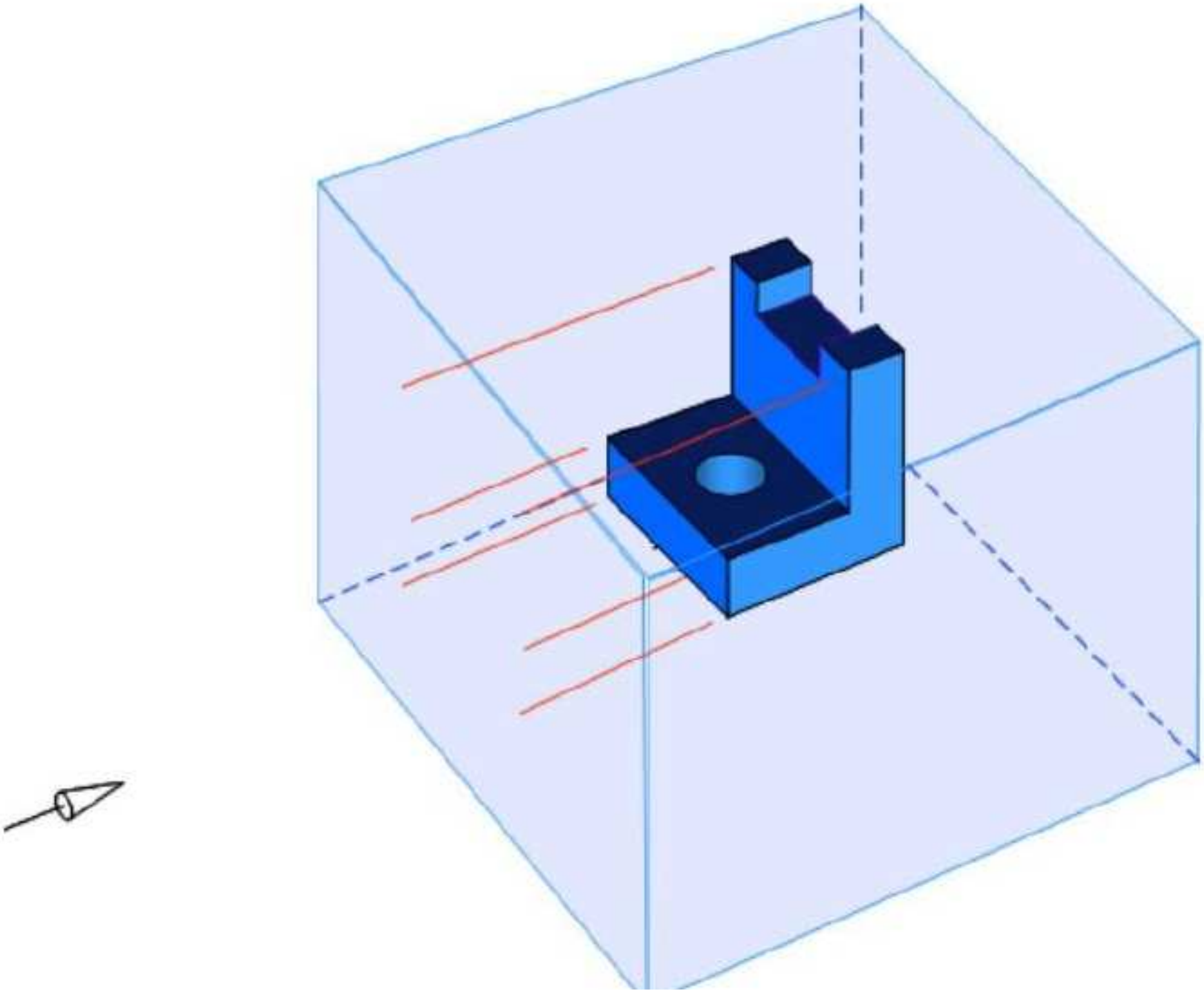
The Glass Box Concept



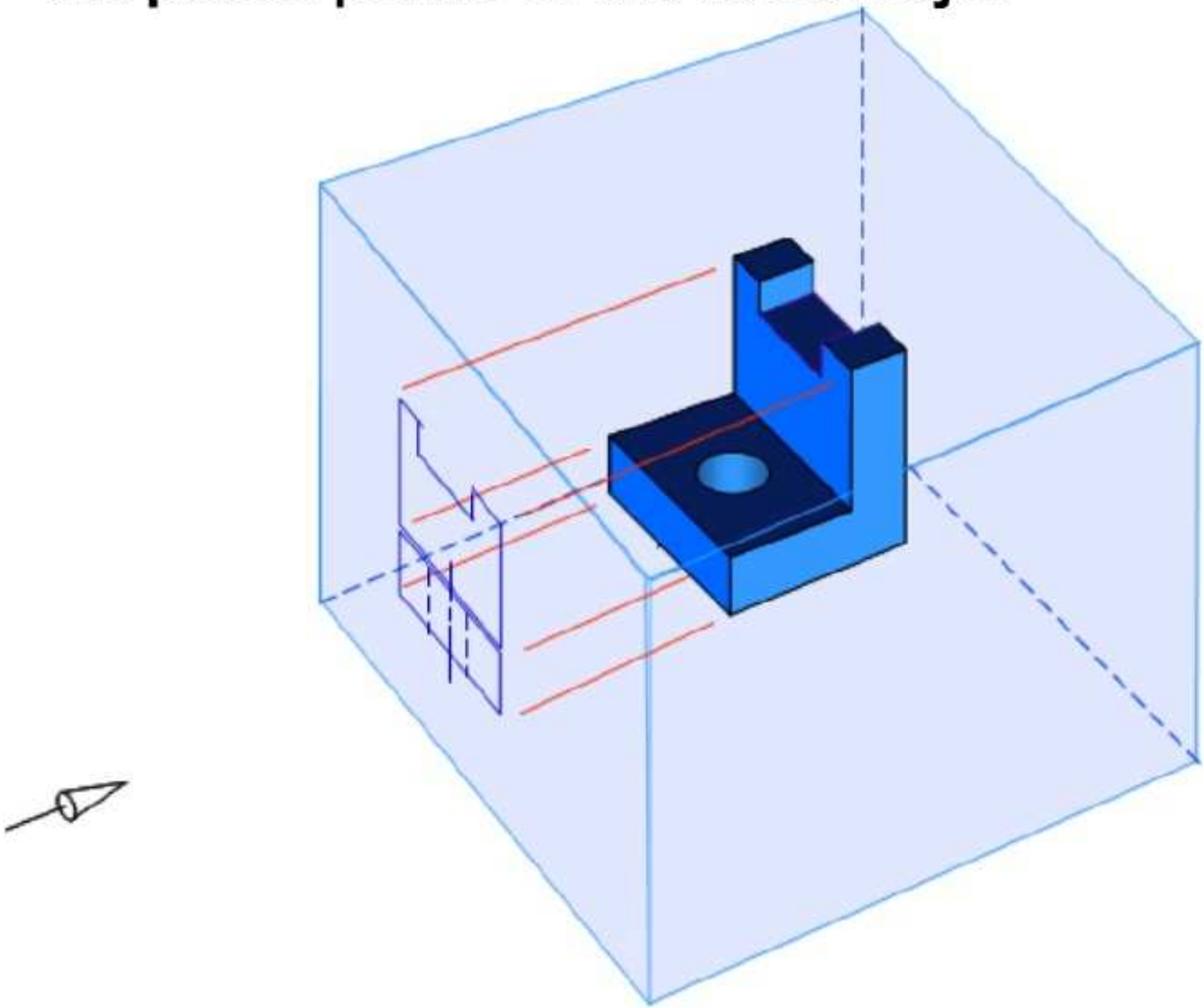
- **The glass box concept theorizes that an object is suspended inside a six-sided glass cube (notice the use of hidden lines on the glass box, depicting lines that would not be visible from the given perspective).**



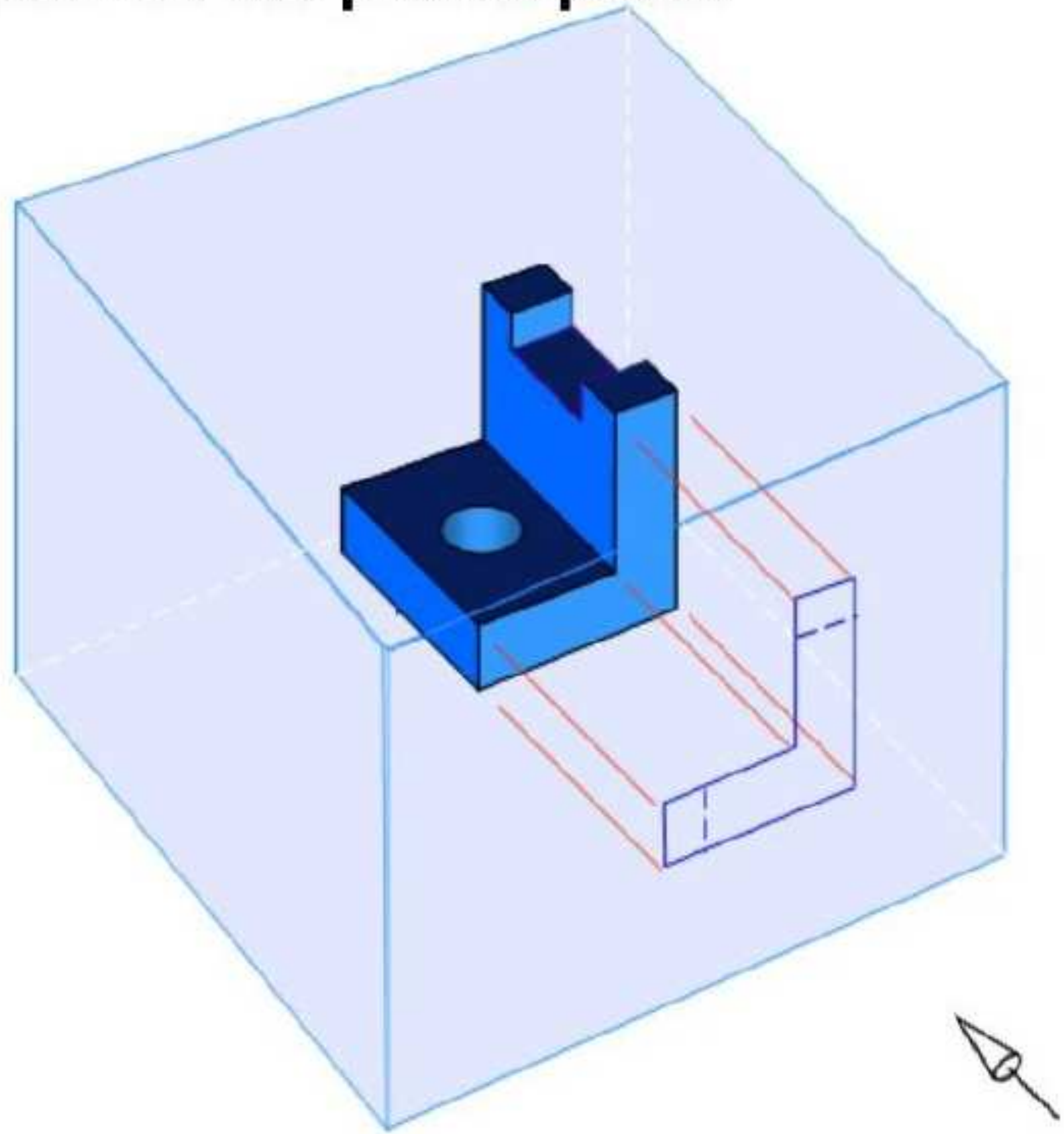
- As the object is viewed from a specific orientation (perpendicular to one of the sides of the cube) visual rays project from the object to the projection plane. These projectors are *always* parallel to each other.



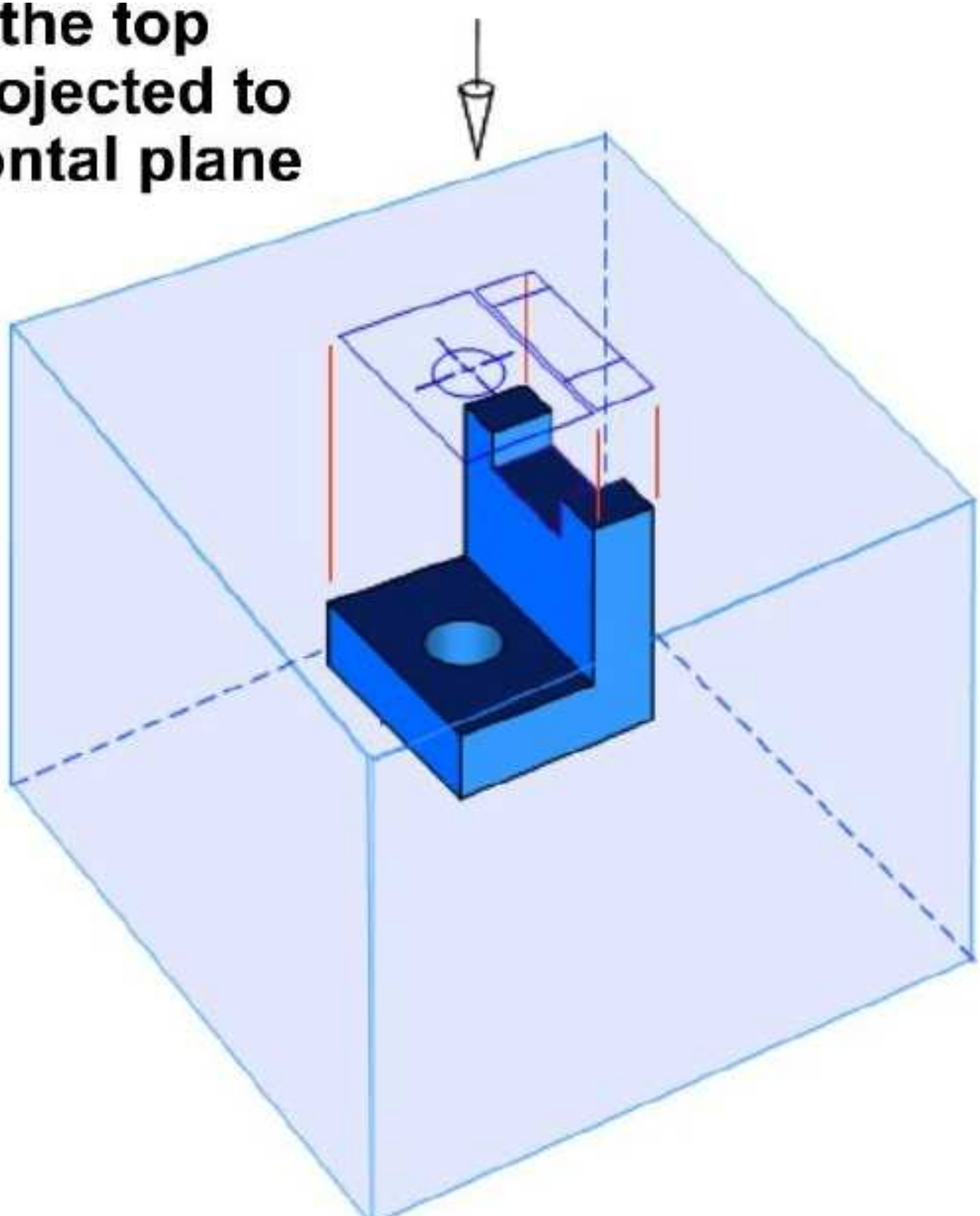
- The object's image is formed on the projection plane by the pierce points of the visual rays.



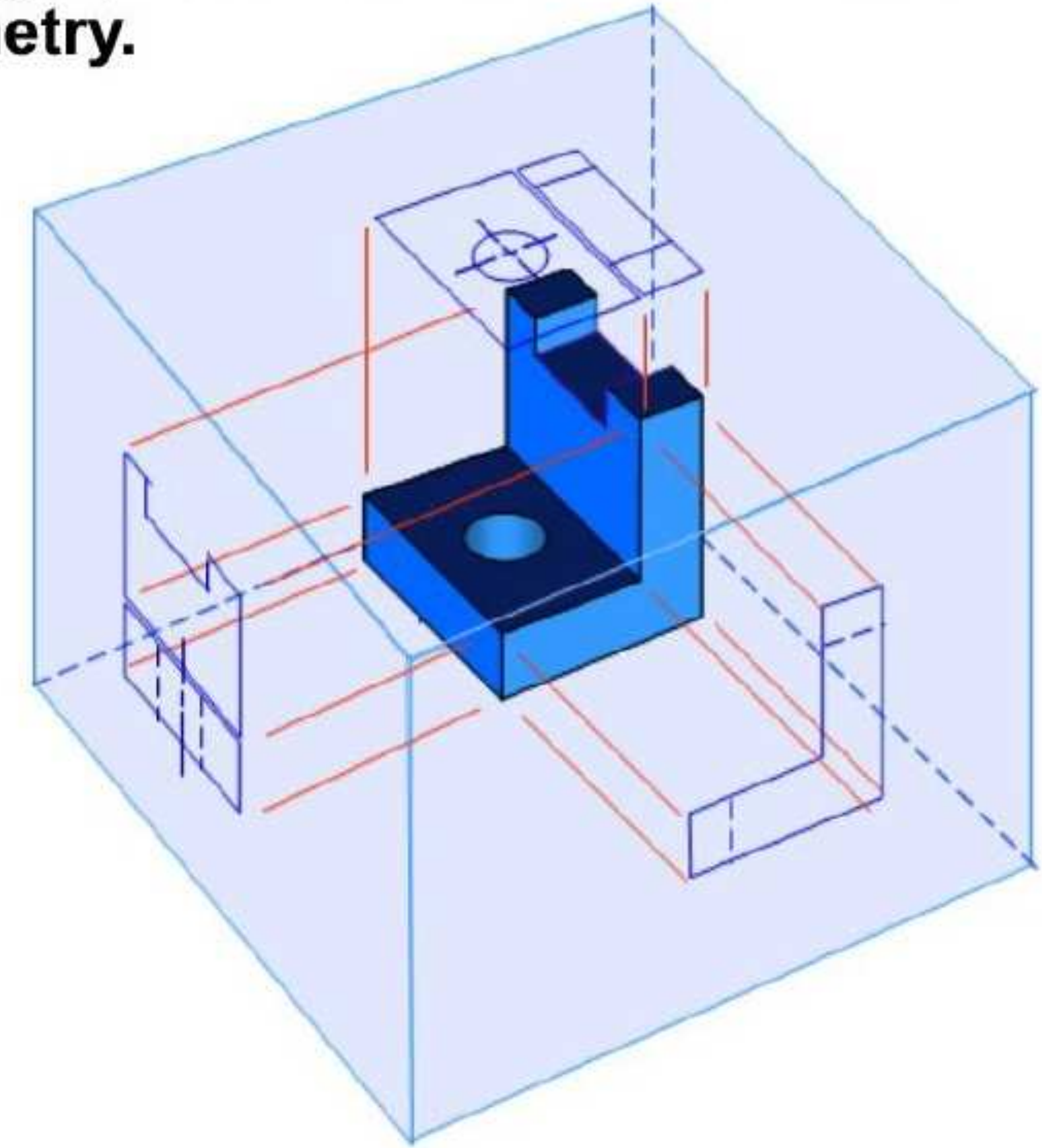
- **The process is repeated to construct the right side view on the profile plane**



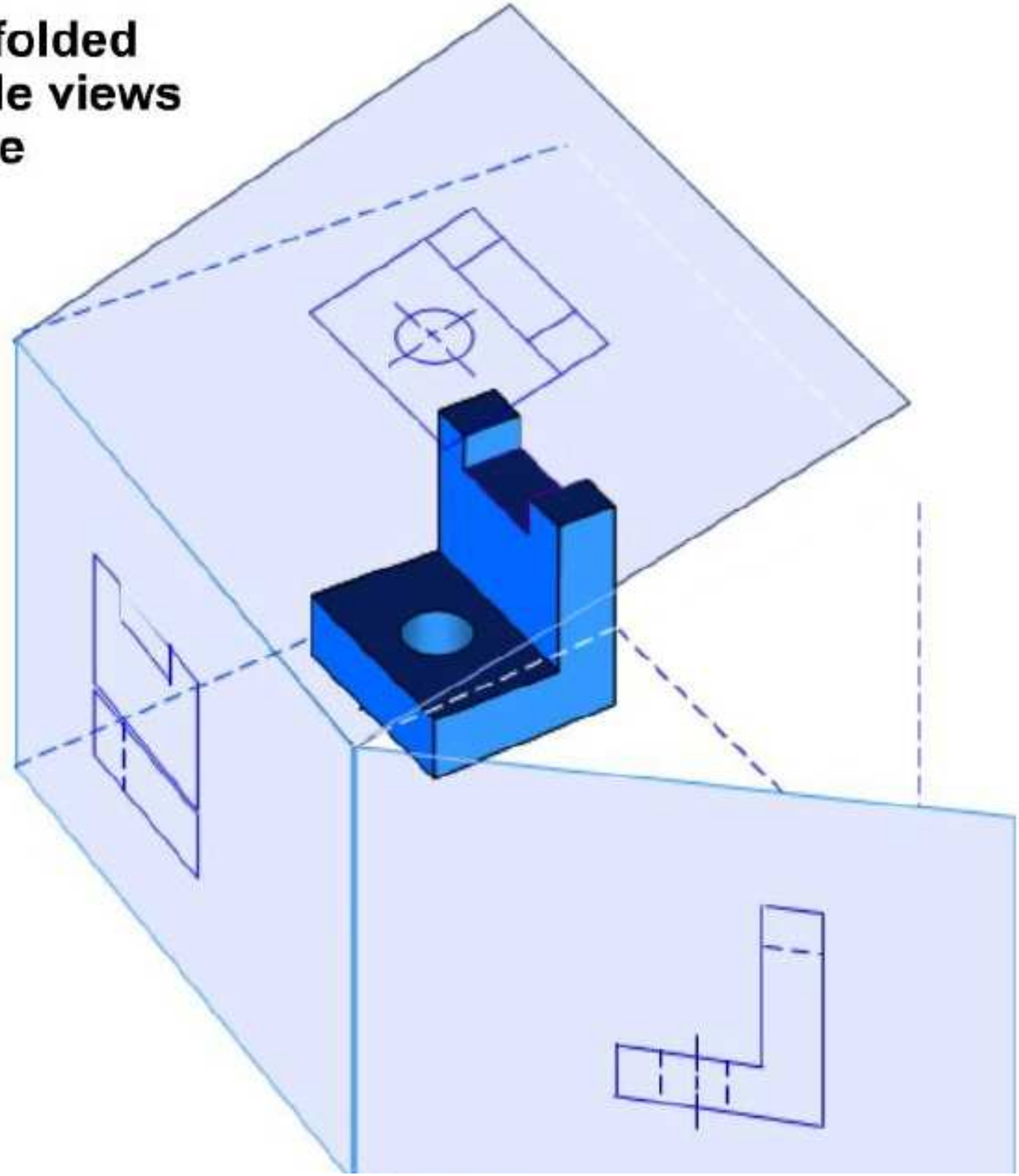
- **Similarly, the top view is projected to the horizontal plane**

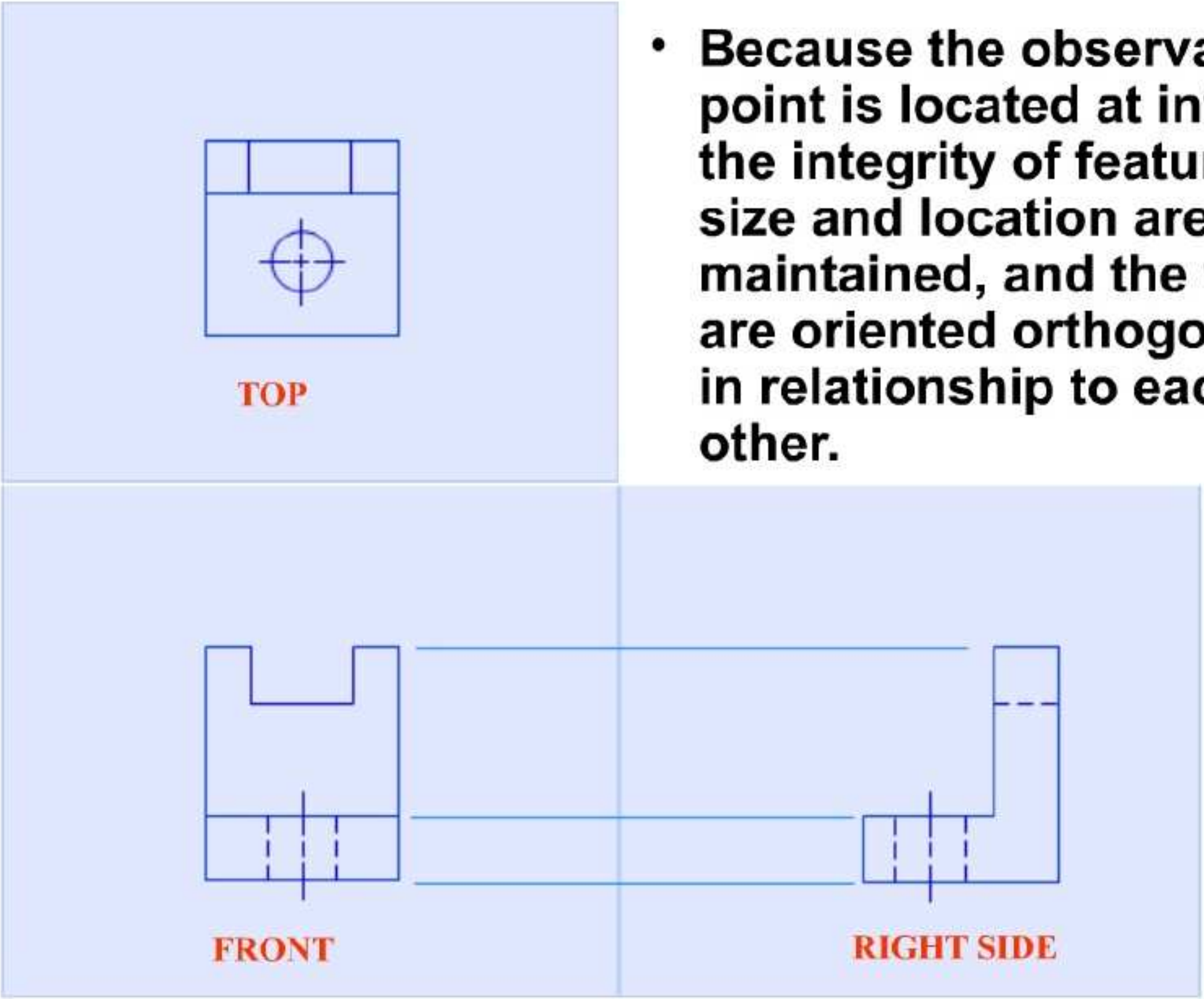


- For many three-dimensional objects, two to three orthographic views are sufficient to describe their geometry.

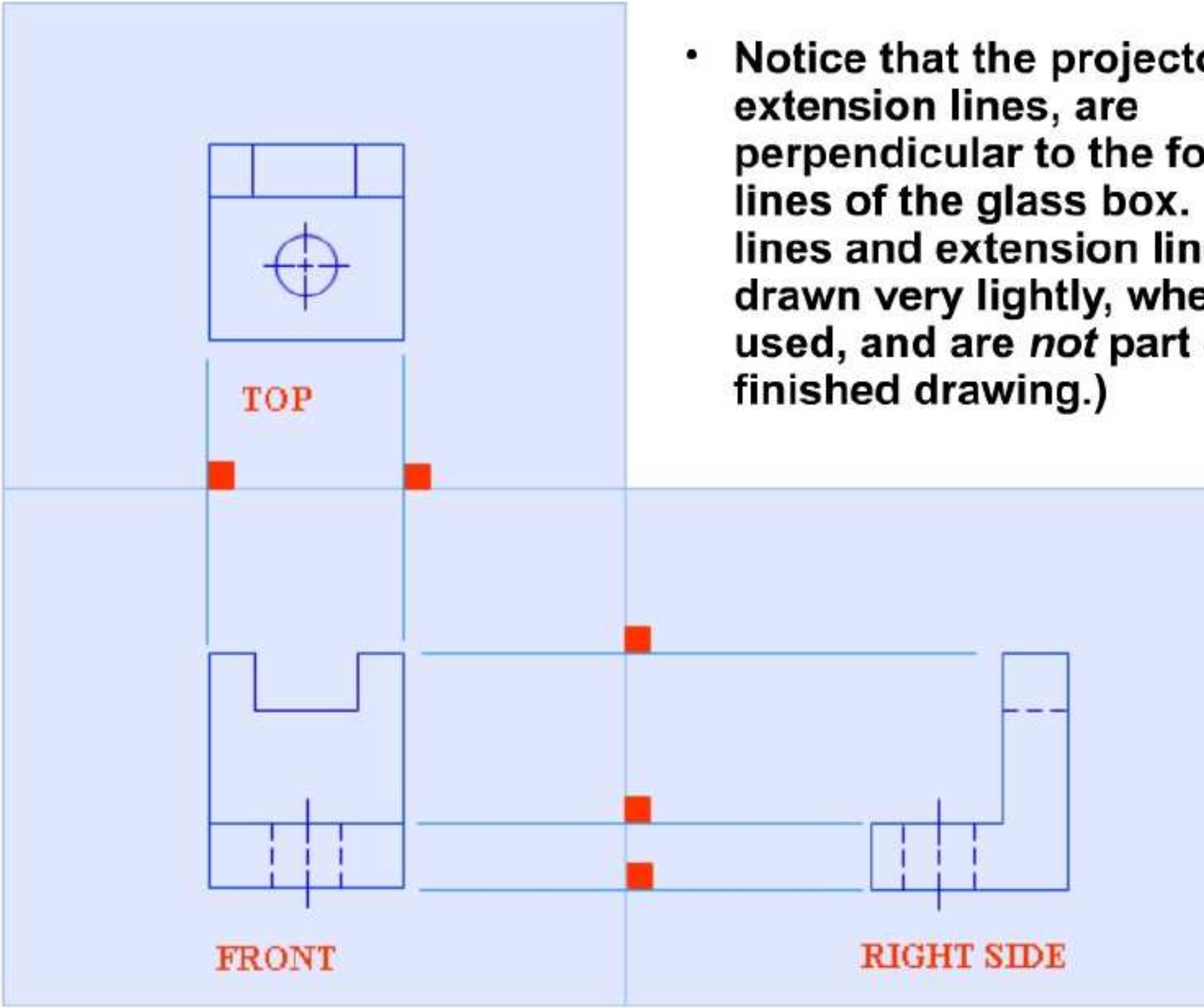


- **The box can be unfolded to show the multiple views in a single x-y plane**





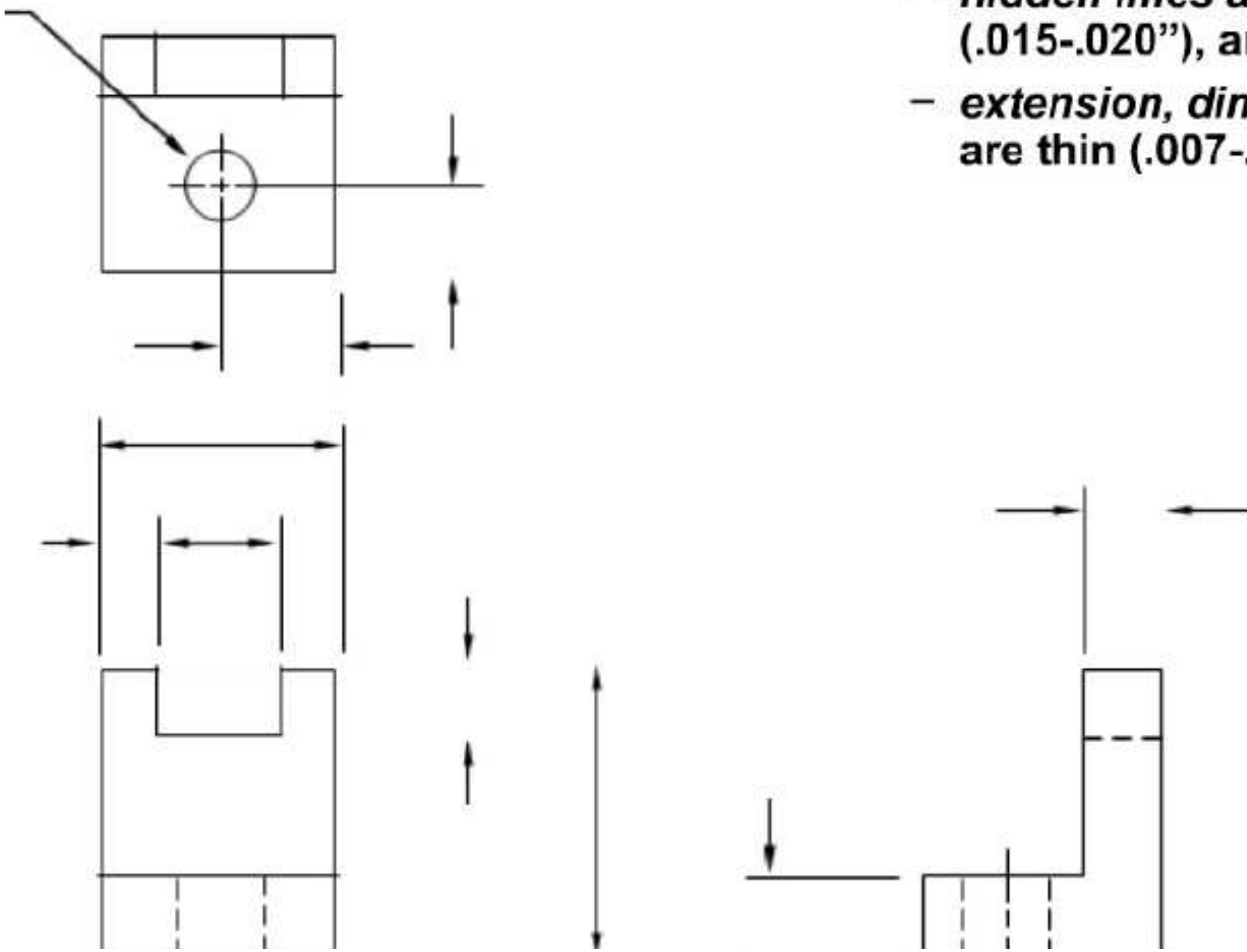
- Because the observation point is located at infinity, the integrity of feature size and location are maintained, and the views are oriented orthogonally in relationship to each other.

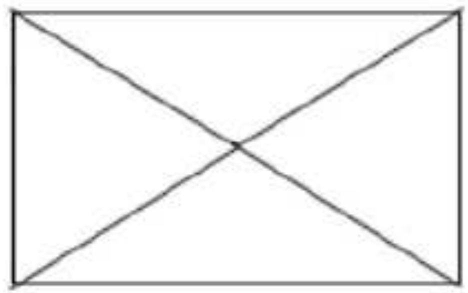


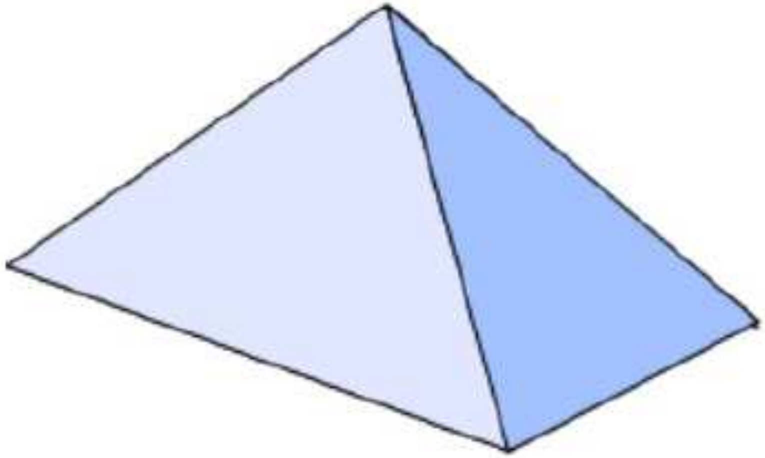
- **Notice that the projectors or extension lines, are perpendicular to the folding lines of the glass box. (Fold lines and extension lines are drawn very lightly, when used, and are *not* part of the finished drawing.)**

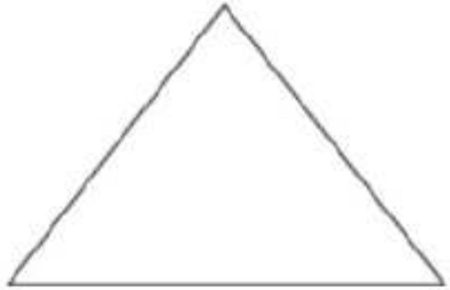
Dimensional Data can then be added to the drawing

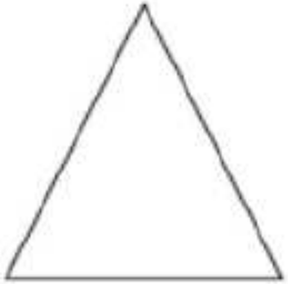
- There are 3 distinct line weights to be aware of:
  - *object lines* are thick (approximately .030-.040" thick),
  - *hidden lines* are a medium thickness (.015-.020"), and
  - *extension, dimension, and center lines* are thin (.007-.010").



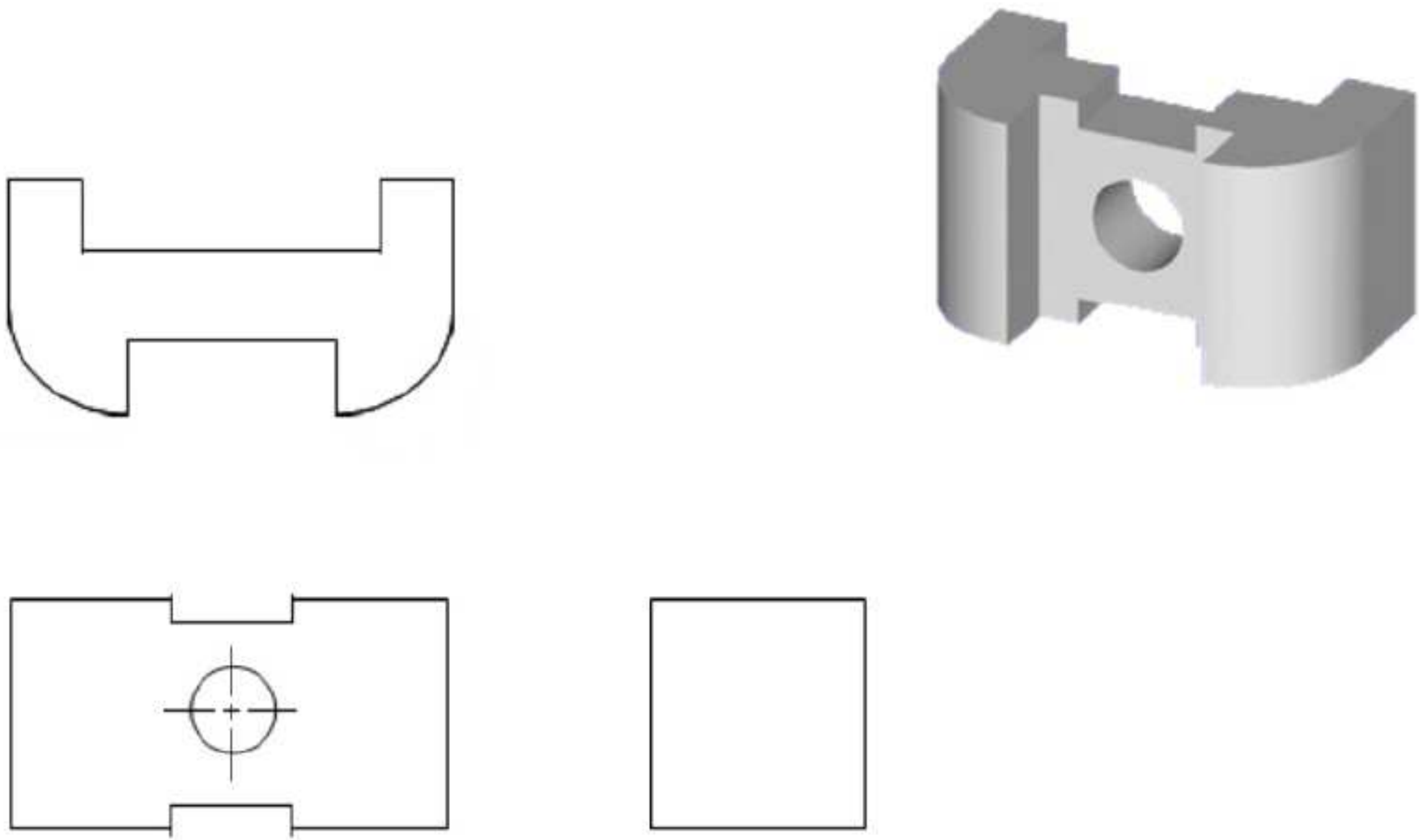




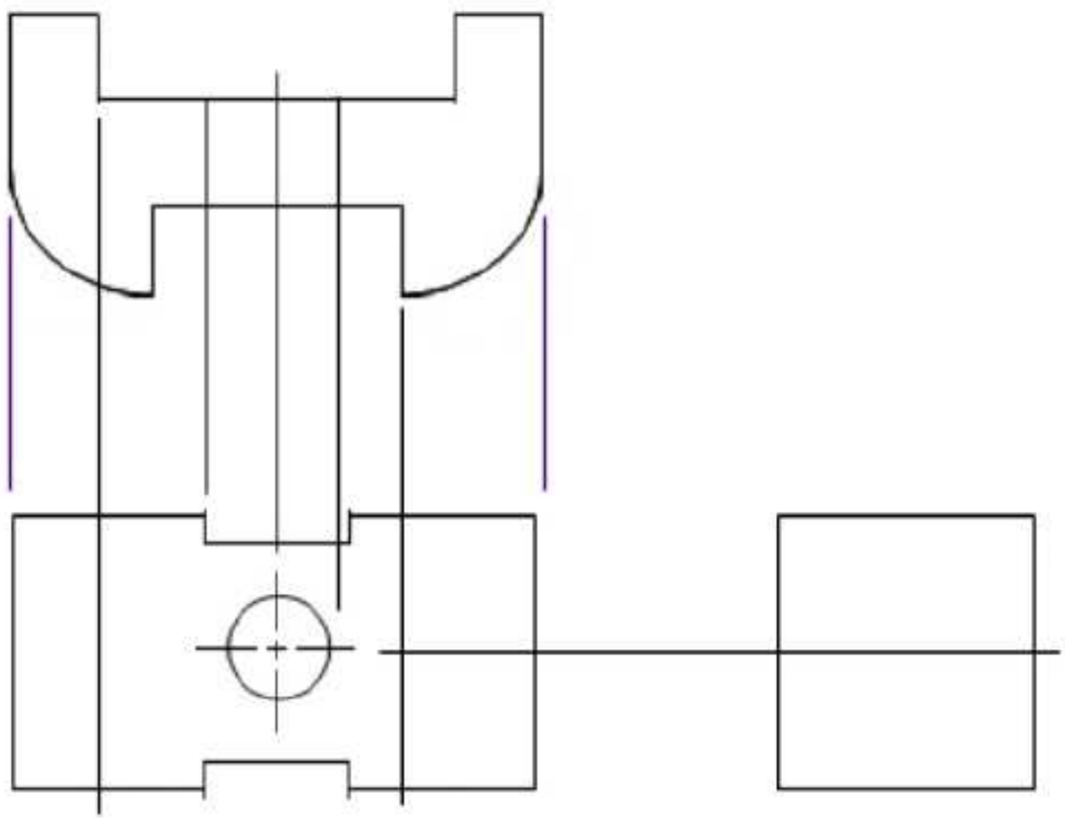


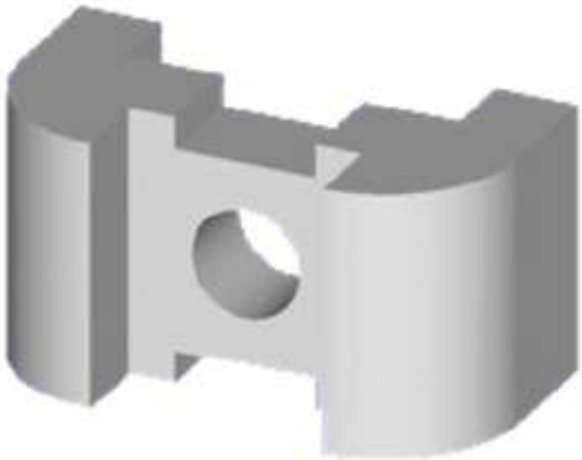


Complete the 3 view drawing (without dimensions for now). Begin by projecting all of the known information between the views.

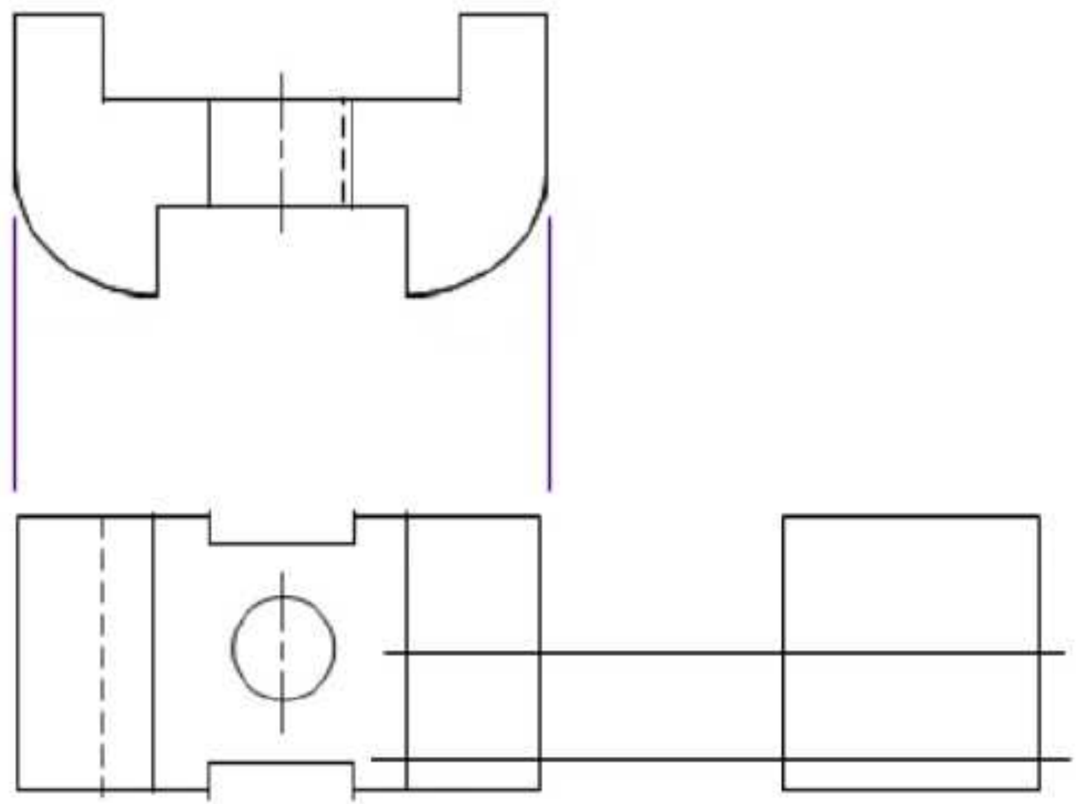


Begin by projecting all of the known information between the views.

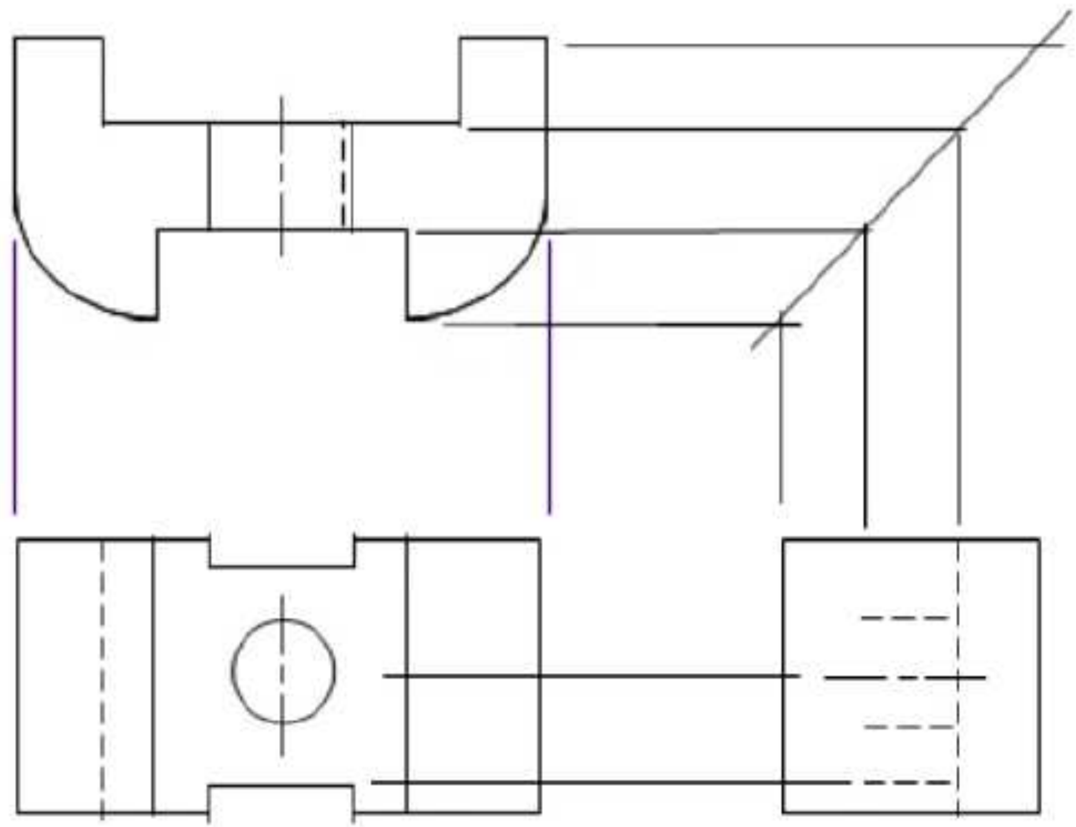




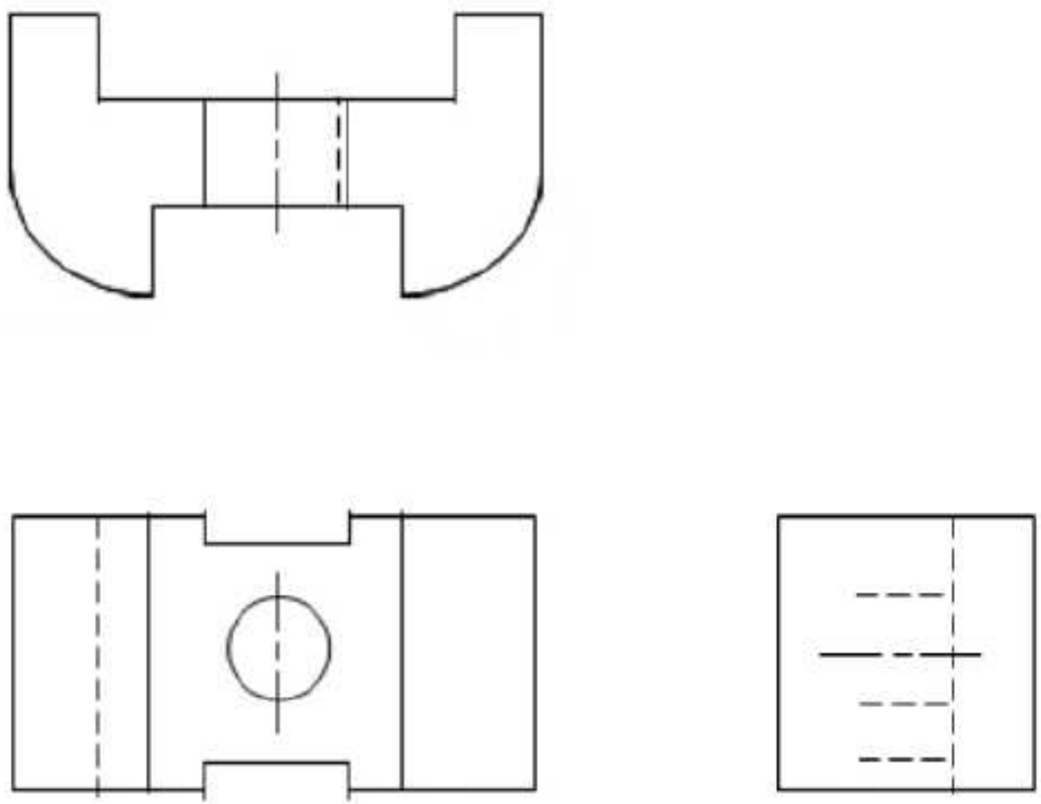
Heavy-up all of the object lines that depict visible object lines, and show surfaces that would not be visible in the specific orientation, using dashed/hidden lines.

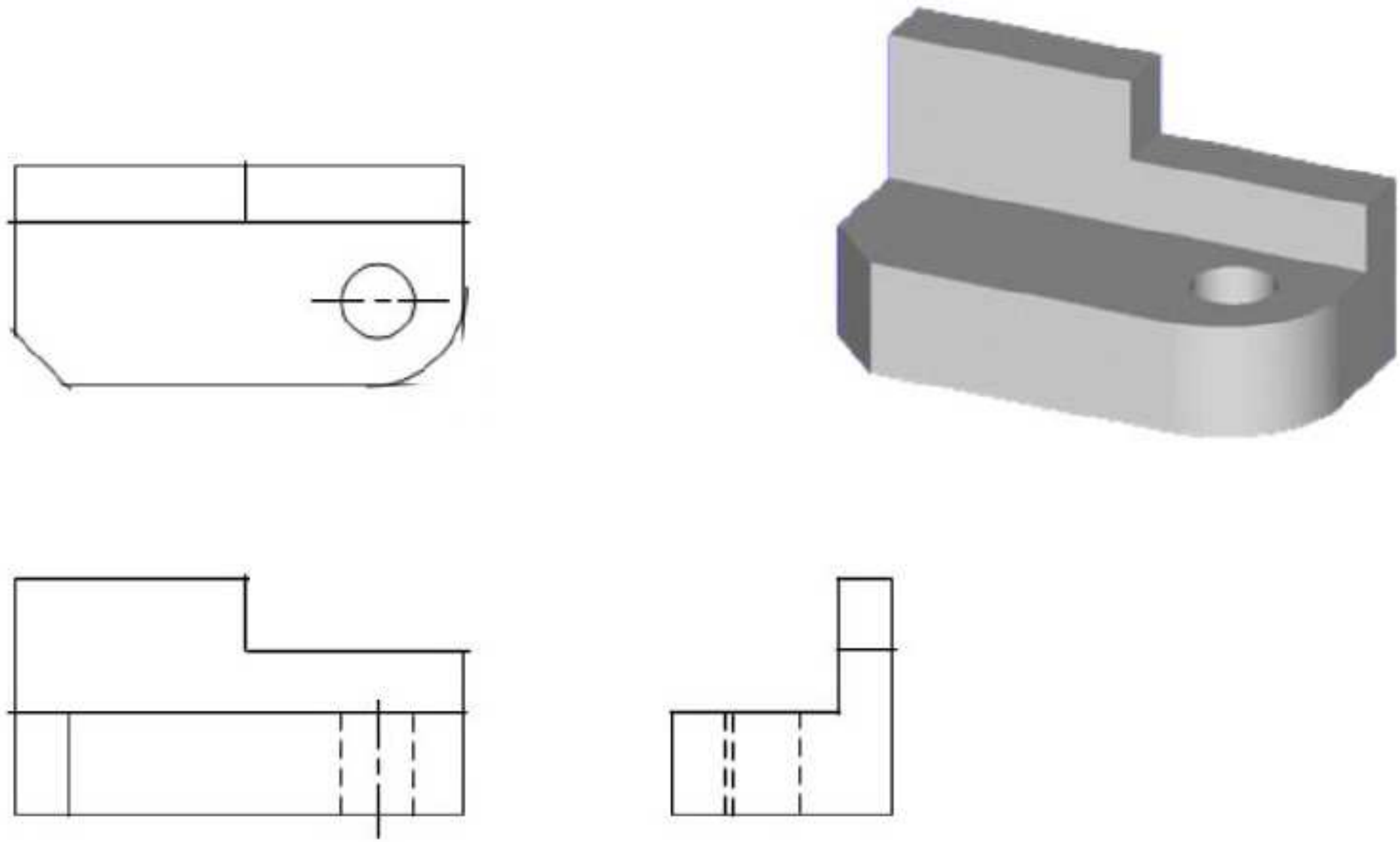


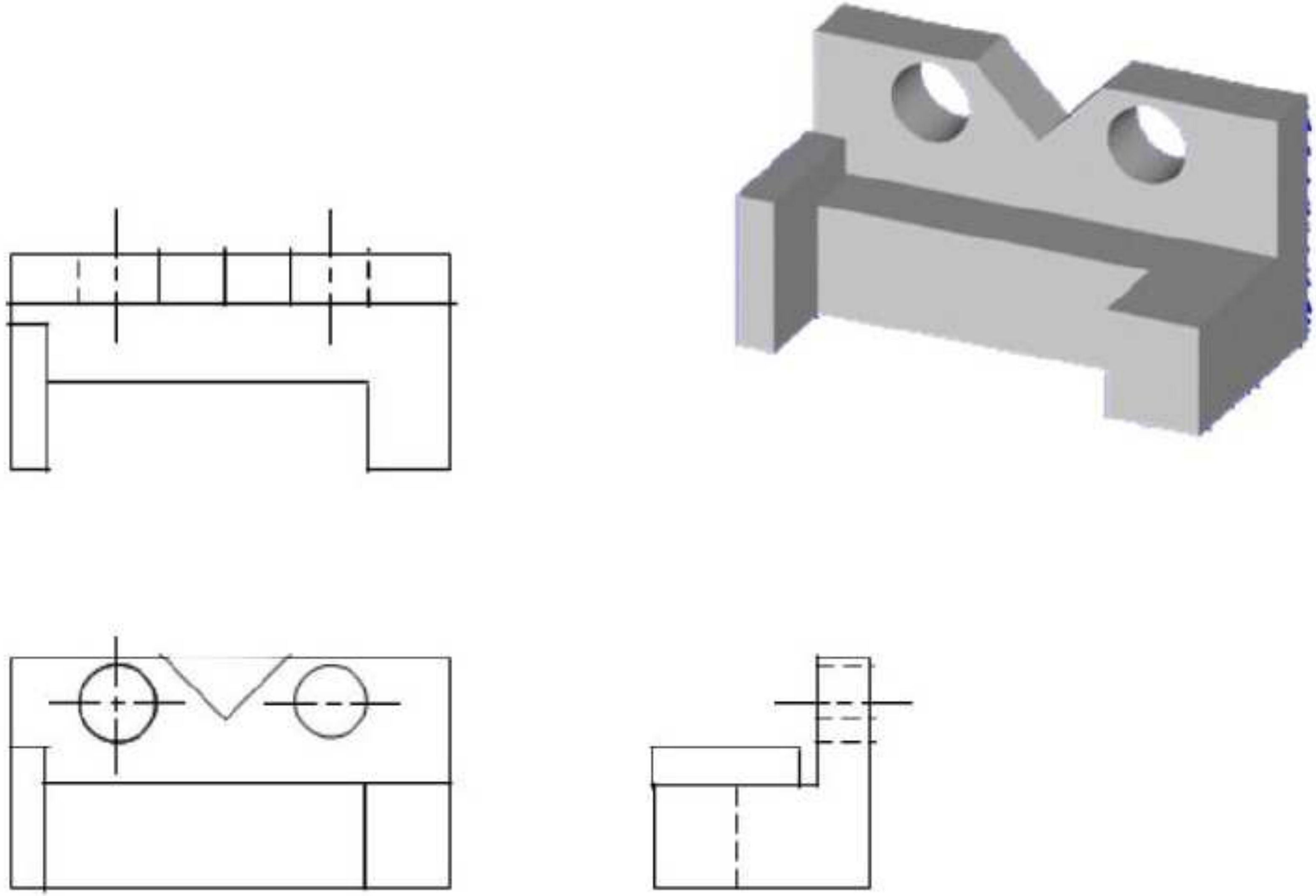
Complete the right side view by projecting all of the relevant lines and points using a 45 degree miter line. Clean up the drawing.

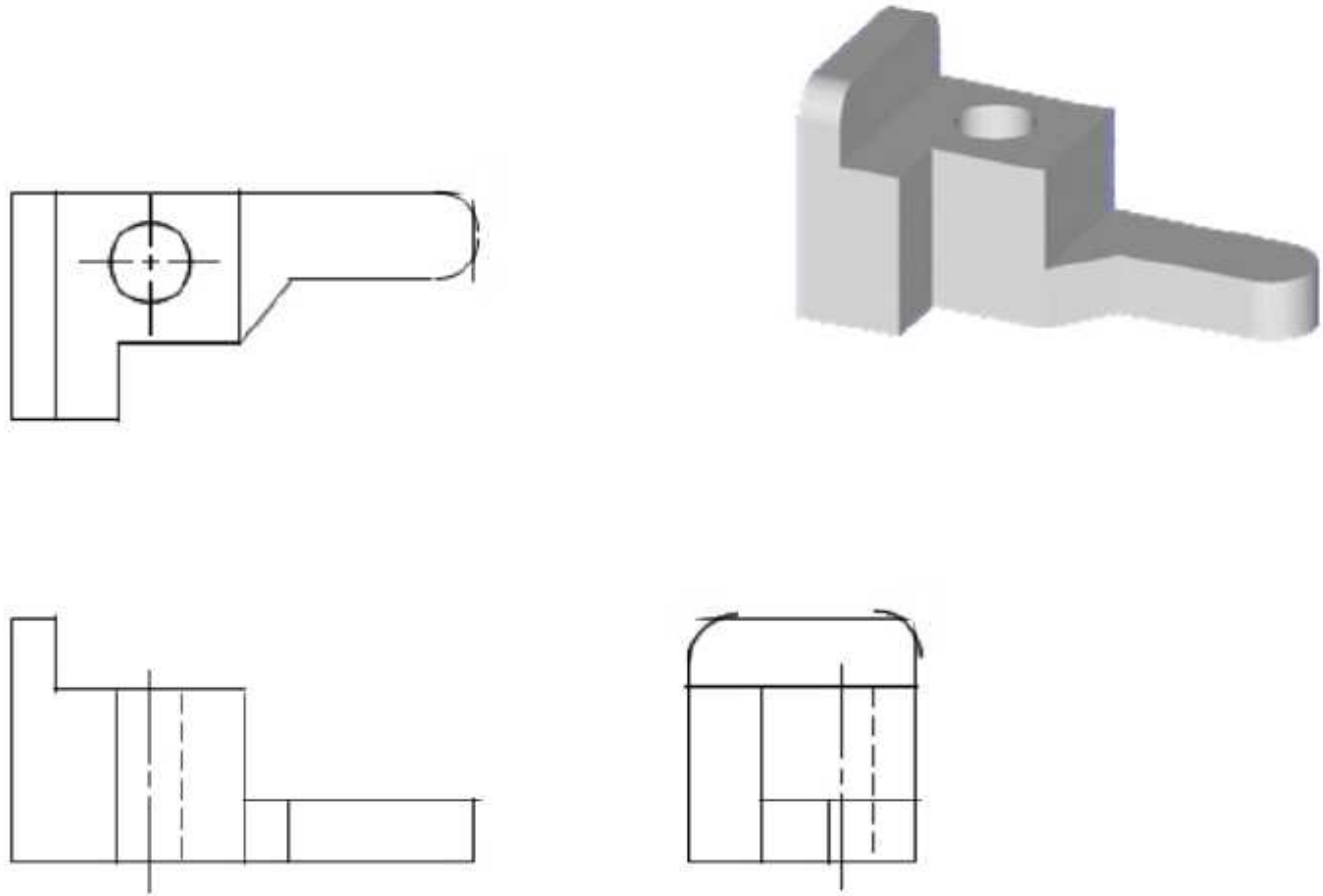


Remove the final construction lines to see the finished drawing



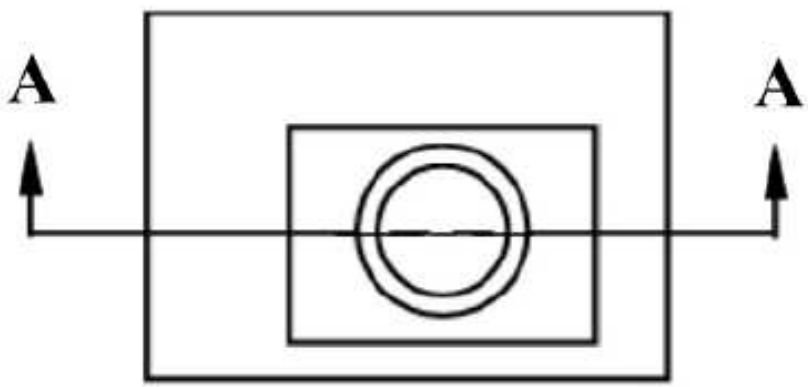


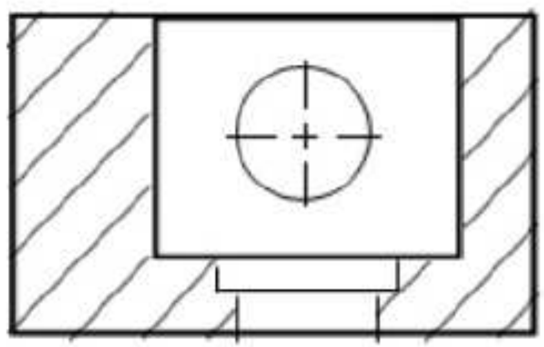




Section Views

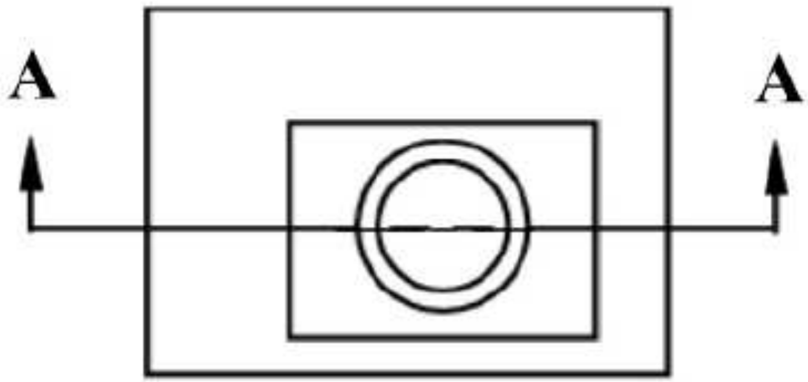
- **Section views are used to clarify internal detail and to avoid dimensioning to hidden lines**

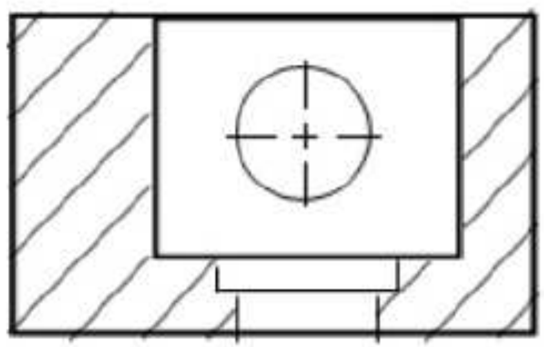




SECTION **A - A**

Section Views

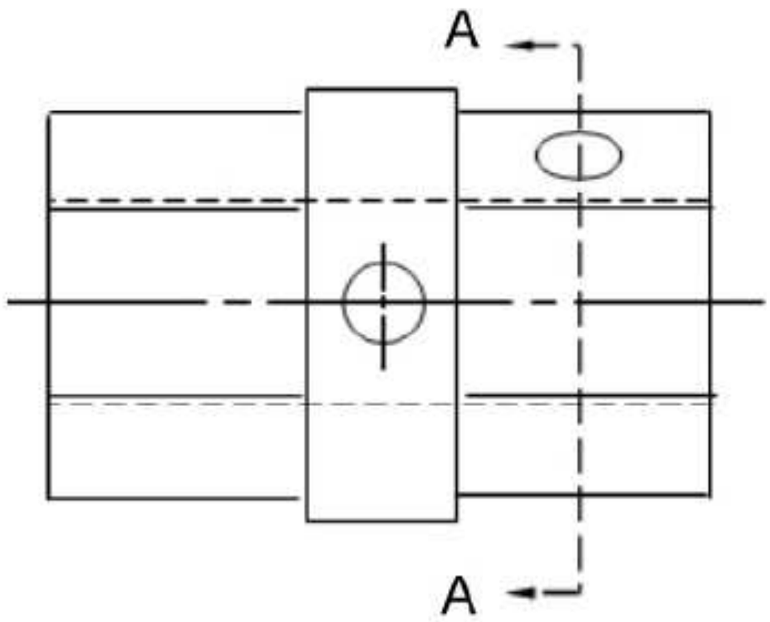


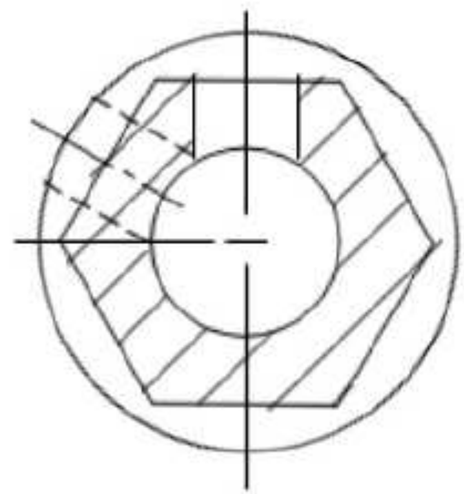


SECTION **A - A**

- **Section views are used to clarify internal detail and to avoid dimensioning to hidden lines**
- **The are established by referencing a cutting plane**
- **Cutting planes depict the exact location on the part from which the section view will be projected, and should have associated arrowheads, indicating the direction *from* which the section view will be observed.**
- **Cutting planes are constructed as an integral feature of the parent view, and cutting plane arrowheads *always* indicate the direction for the observer's *line of sight*.**

Projected Section Views

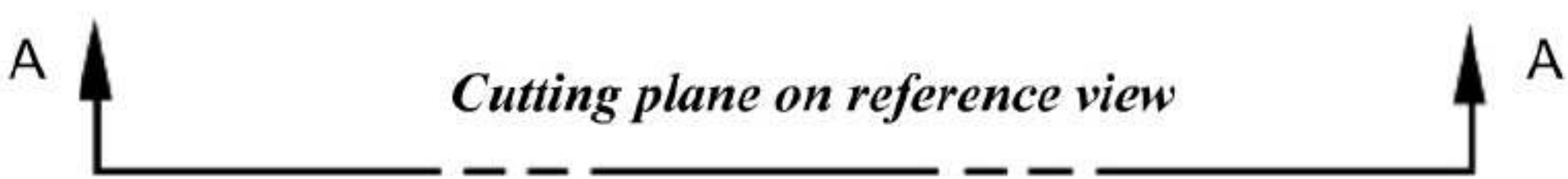




SECTION A – A
ROTATED 30º CLOCKWISE

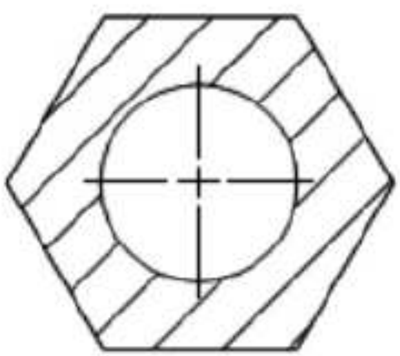
Cutting Plane

- **Alpha Characters A - A, B - B, C – C*, etc., are used to designate the required section view. The characters are placed *near* the arrowheads *and* as a subtitle of the view. There is no “standard” for the location of the section designators, other than near the cutting plane arrowheads—as the examples below illustrate.**
- **When the alphabet has been exhausted, use double characters AA - AA, BB - BB, CC – CC*, etc.**
- ****Section Designators should NOT include the alpha characters I, O, or Q.***

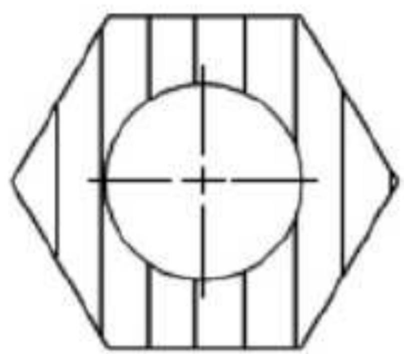


Crosshatching Section Views

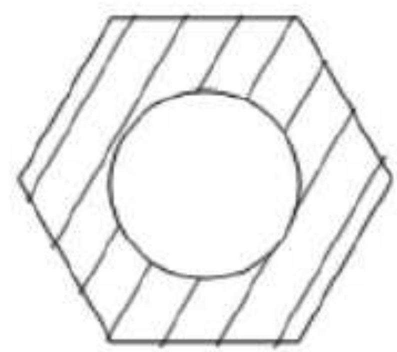
- *Crosshatching,* is a repeating graphic pattern which is applied throughout all areas of the part that would be in *contact* with the cutting plane. Thus, the hole is not crosshatched.
- The recommended angle for the standard crosshatch pattern is 45, 30, or 60 degrees with horizontal. Similarly, crosshatch lines should be *neither parallel nor perpendicular* to the outline of the feature in section—if avoidable (see the examples below).



Good Practice



Poor Practice

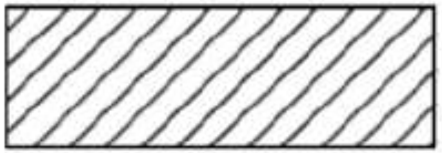


Poor Practice

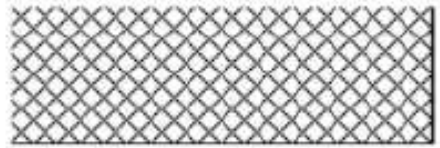
Cross Hatch Standards

- The general purpose cross hatch is used in most individual detail component drawings and in assembly applications where no confusion will result.
- Each of the assembled components are depicted with a different crosshatch *angle* to assist in part differentiation.
- Specific crosshatch symbols are sometimes used to represent each different material type.

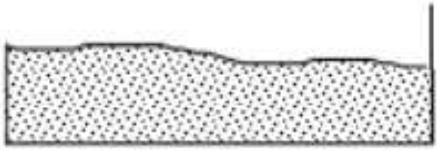
Cross Hatch Symbols



Cast Iron (General Use)



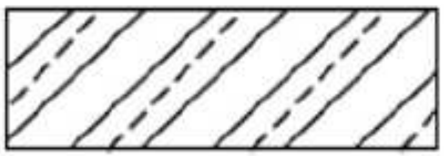
White Metal (Zinc)



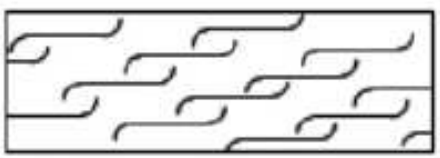
Sand

Steel

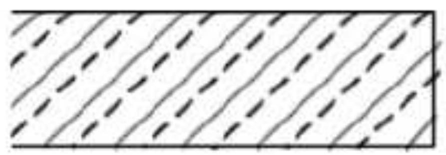
Magnesium, Aluminum



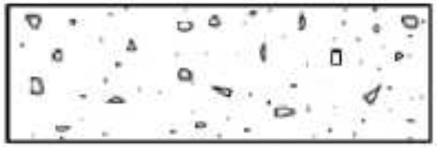
Titanium



Felt, Leather, & Fiber



Bronze, Brass, etc.



Concrete

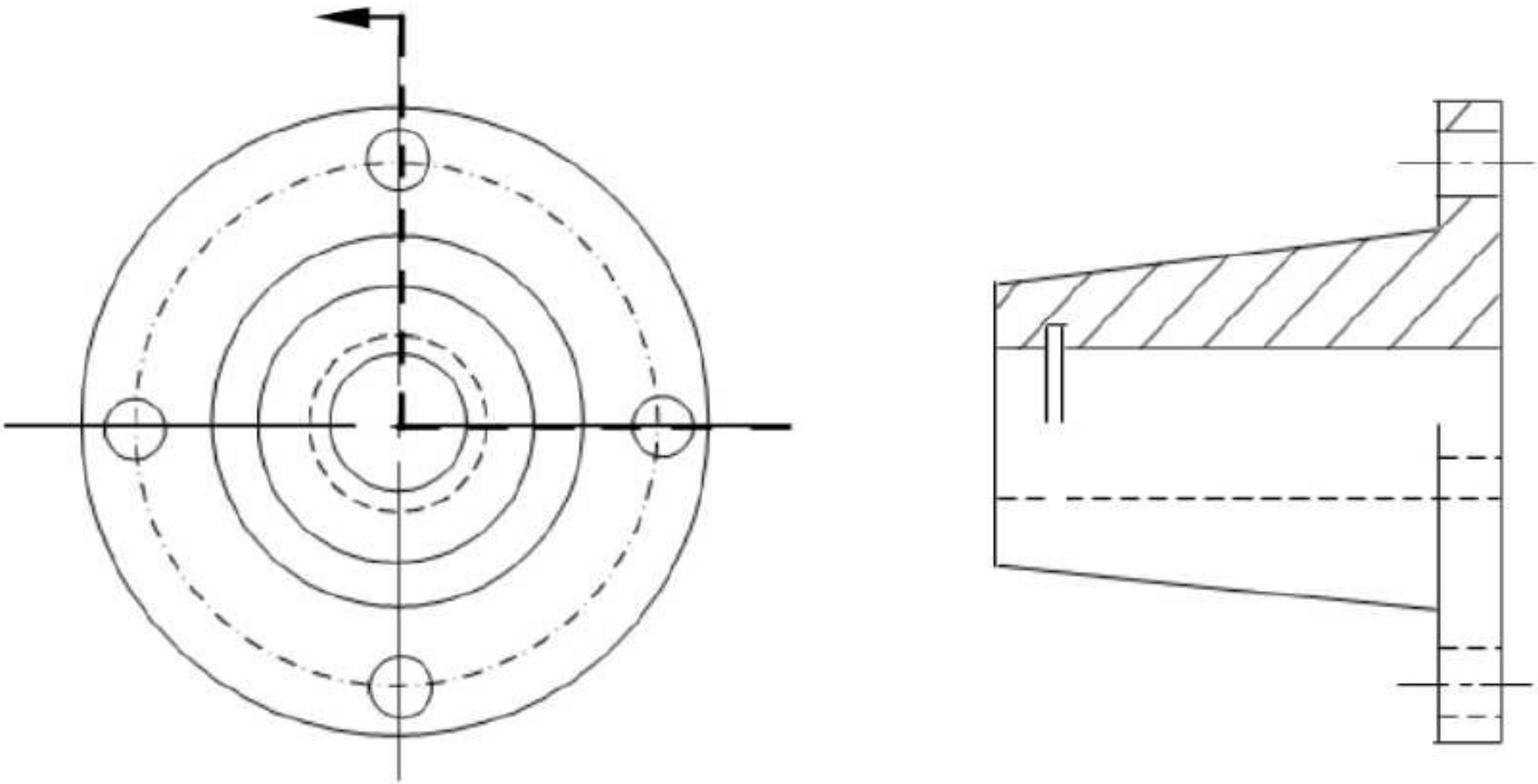
Marble, Slate, Glass, etc.

Water, Liquids

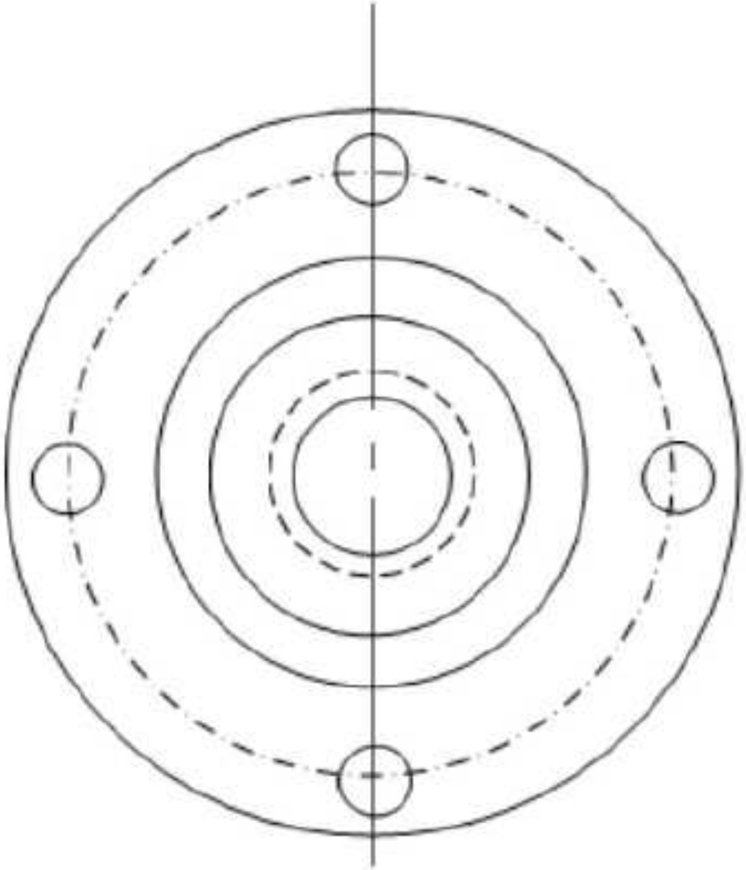
Wood; Cross Grain

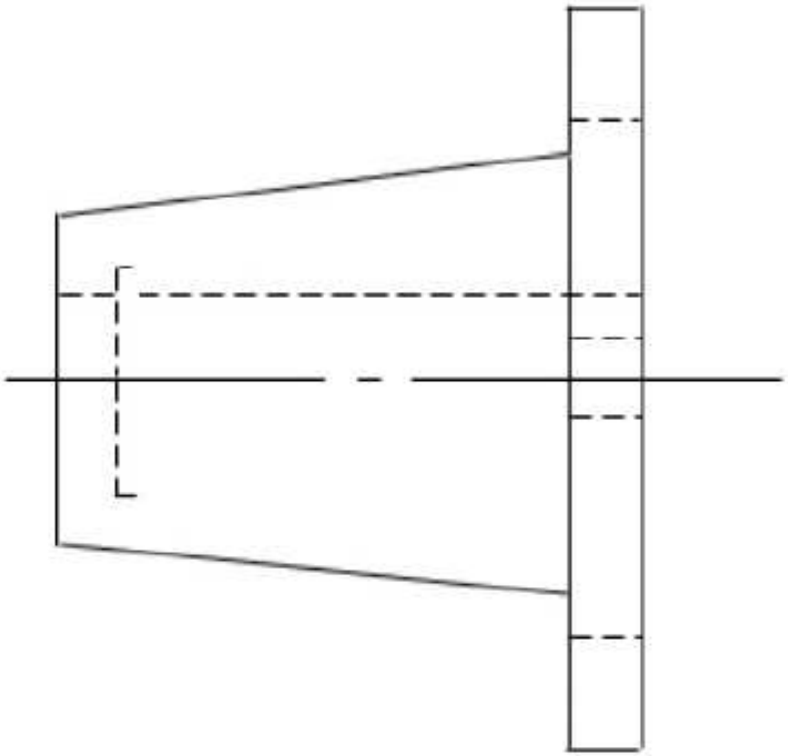
Half Sections

- **Half section views are the result of cutting planes being positioned on parts in such a manner that only *half* of the *resulting* view or projection is shown in section.**



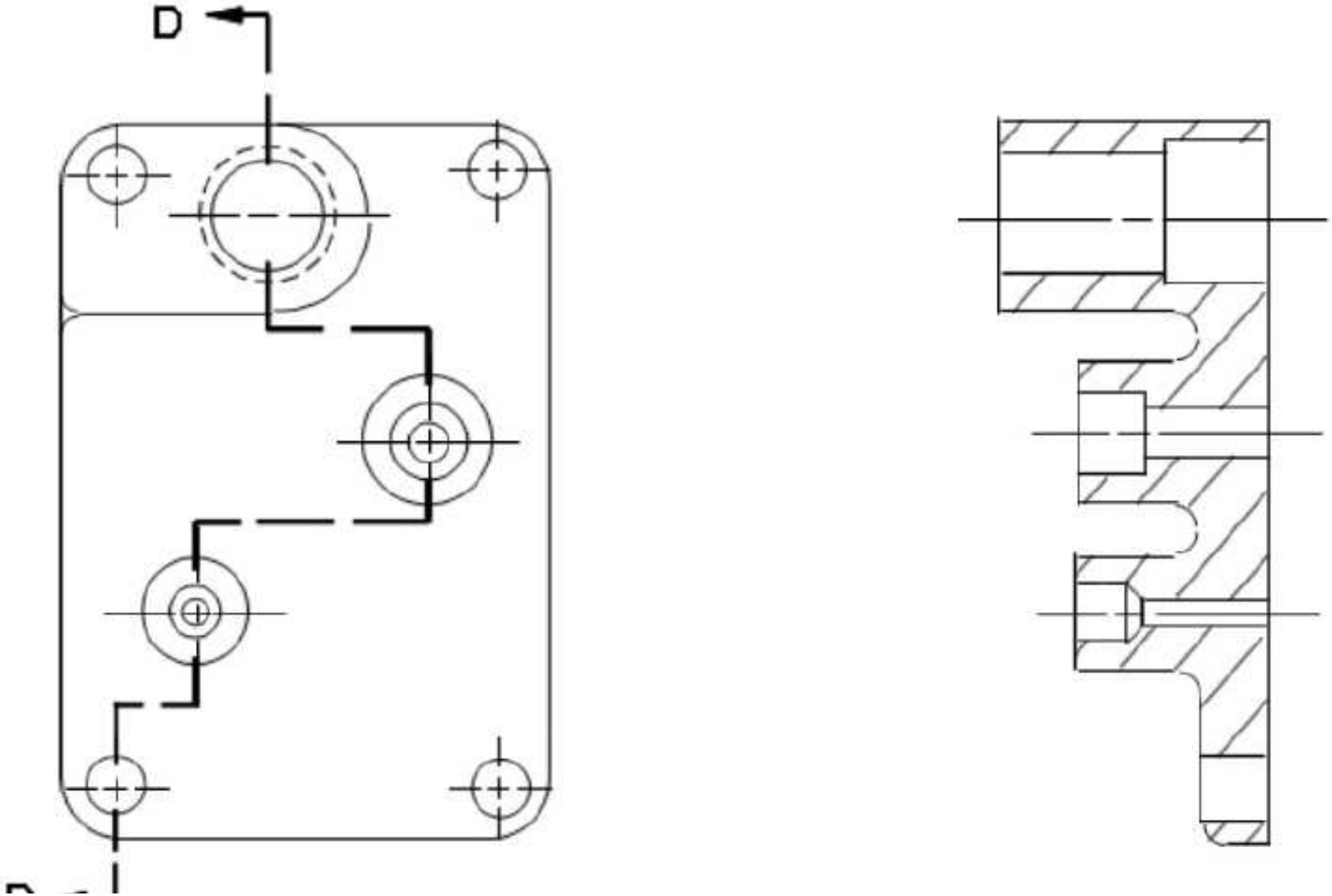
Half Sections





Offset Sections

- **Offset sections allow us to provide greater breadth of detail with fewer section views. All of the features are aligned with the cutting plane.**



Coordinate Dimensioning and Tolerancing

The *collective* process of modeling, defining and describing geometric sizes and feature relationships, and providing all of the required technical information necessary to produce and inspect the part is called *dimensioning and tolerancing*.

The current National Standard for dimensioning and tolerancing in the United States is ASME Y14.5M - 1994.

DRAWN IN ACCORDANCE WITH ASME Y14.5M - 1994
REMOVE ALL BURRS AND SHARP EDGES
ALL FILLETS AND ROUNDS R .06 UNLESS OTHERWISE SPECIFIED

Drawing Notes

Notes should be concise and specific. They should use appropriate technical language, and be complete and accurate in every detail. They should be authored in such a way as to have *only one possible interpretation*.

General Notes

DRAWN IN ACCORDANCE WITH ASME Y14.5M - 1994
REMOVE ALL BURRS AND SHARP EDGES
ALL FILLETS AND ROUNDS R .06 UNLESS OTHERWISE SPECIFIED

Local Notes

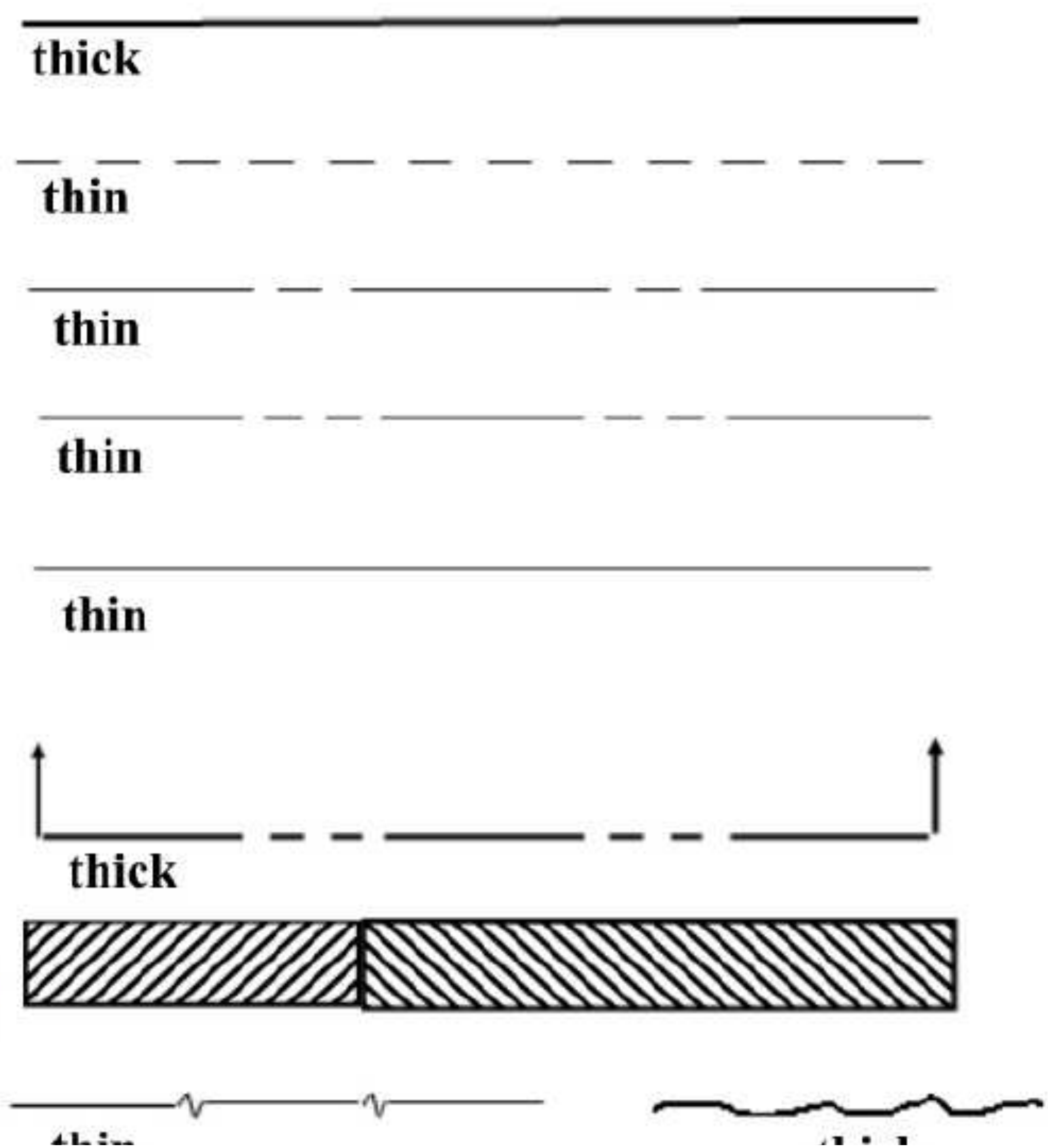
4X ∅8.20 M10 X 1.25

82° CSK ∅10

1.5 X 45° CHAM

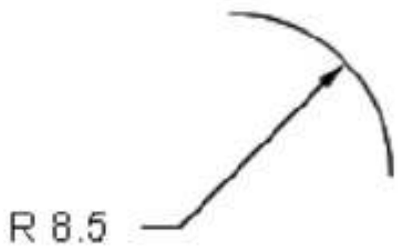
Line Types

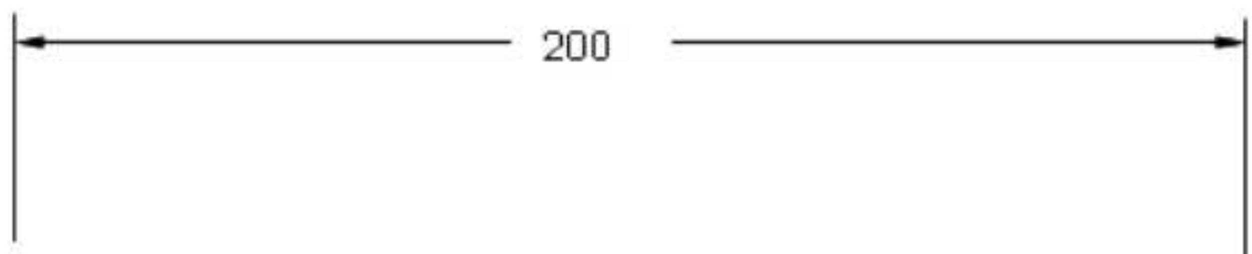
- **Object Lines**
- **Hidden Lines**
- **Center Lines**
- **Phantom Lines**
- **Dimension Lines**
  Extension Lines
  Leader Lines
- **Cutting Plane Line**
- **Sections - Hatching**
- **Break Lines**



Arrowheads

- Arrowheads are used as terminators on dimension lines. The points of the arrowheads on leader lines and dimension lines must make contact with the feature object line or extension lines which represent the feature being dimensioned. The standard size ratio for all arrowheads on mechanical drawings is 3:1 (length to width).



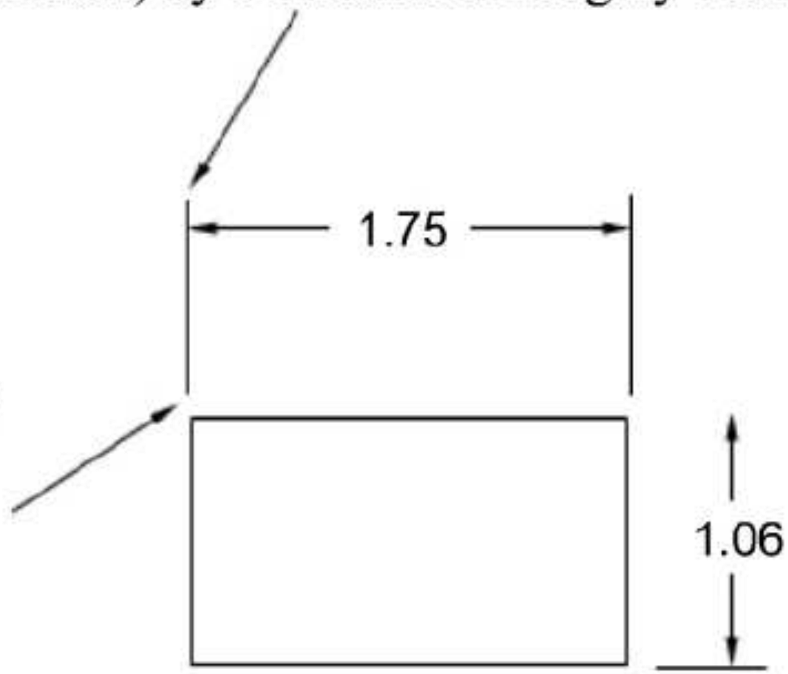


Of the four different arrowhead types that are authorized by the national standard, ASME Y14.2M – 1994, a filled arrowhead is the highest preference.

Dimension Lines and Extension Lines

Extension lines overlap dimension lines (beyond the point of the arrowheads) by a distance of roughly 2-3mm

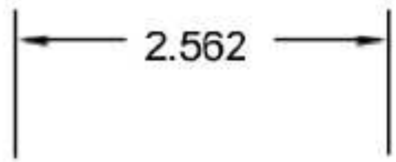
There should be a visible gap (~1.5 mm) between the object lines and the beginning of each extension line.



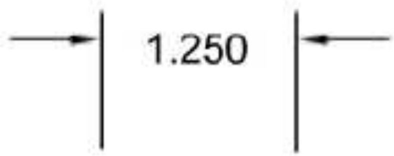
Dimensions should be placed *outside* the actual part outline. Dimensions should not be placed within the part boundaries unless greater clarity would result.

Placement of Linear Dimensions

Order of Preference



Arrows in / dimension in



Arrows out / dimension in

Arrows in / dimension out

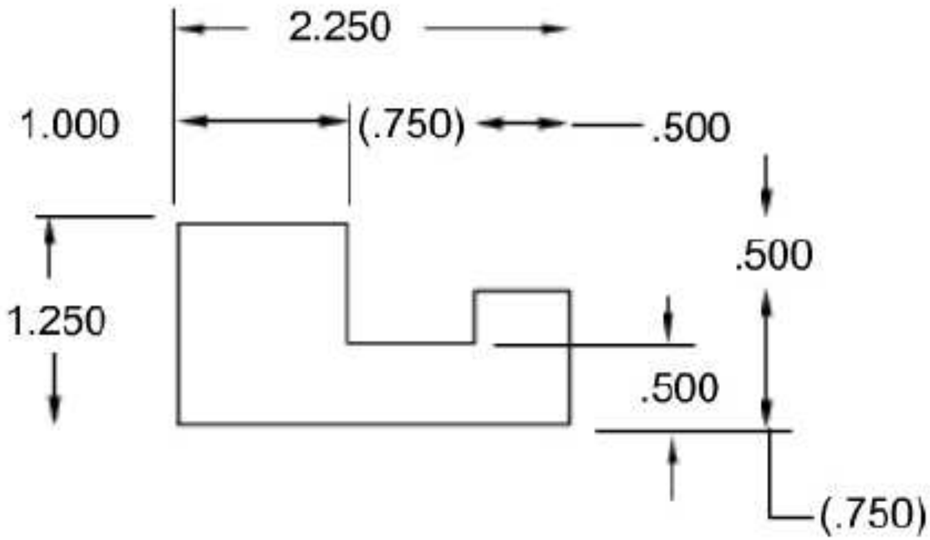
Arrows out / dimension out

When there is not enough room between the extension lines to accommodate either the dimension value or the dimension lines they can be placed outside

Reference Dimensions

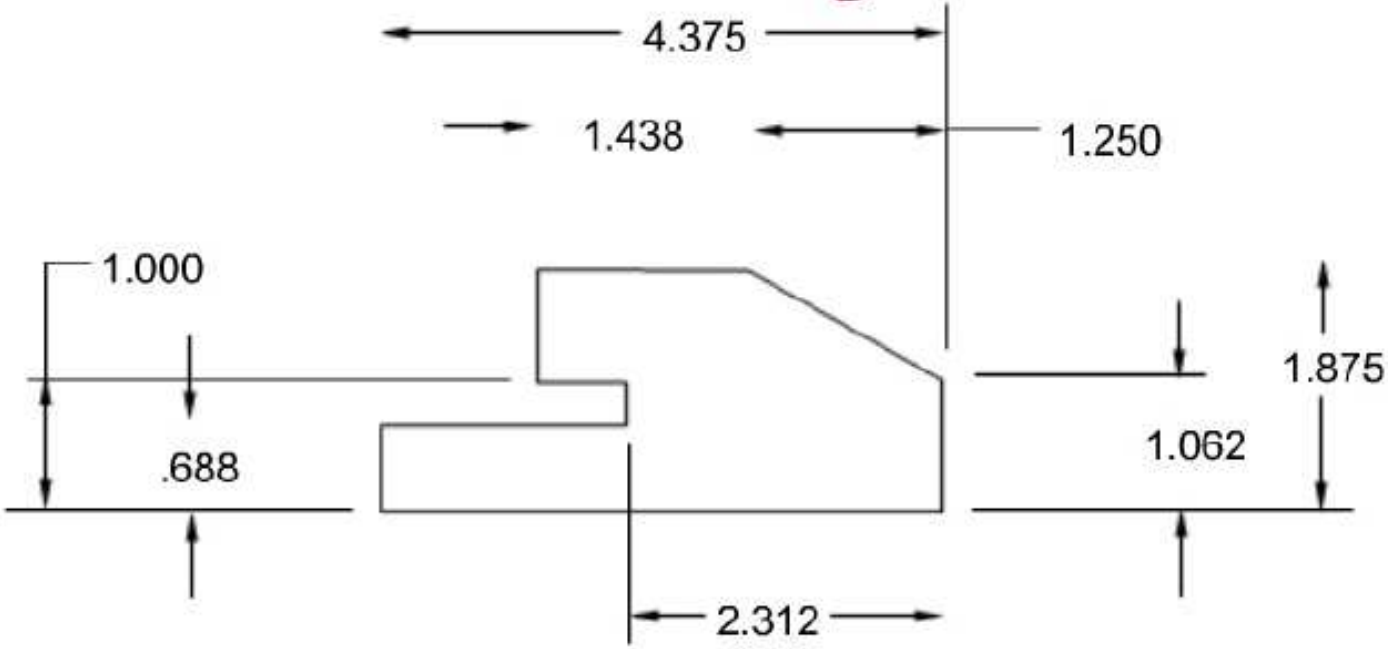
Reference Dimension Symbol (X.XXX)

EXAMPLE

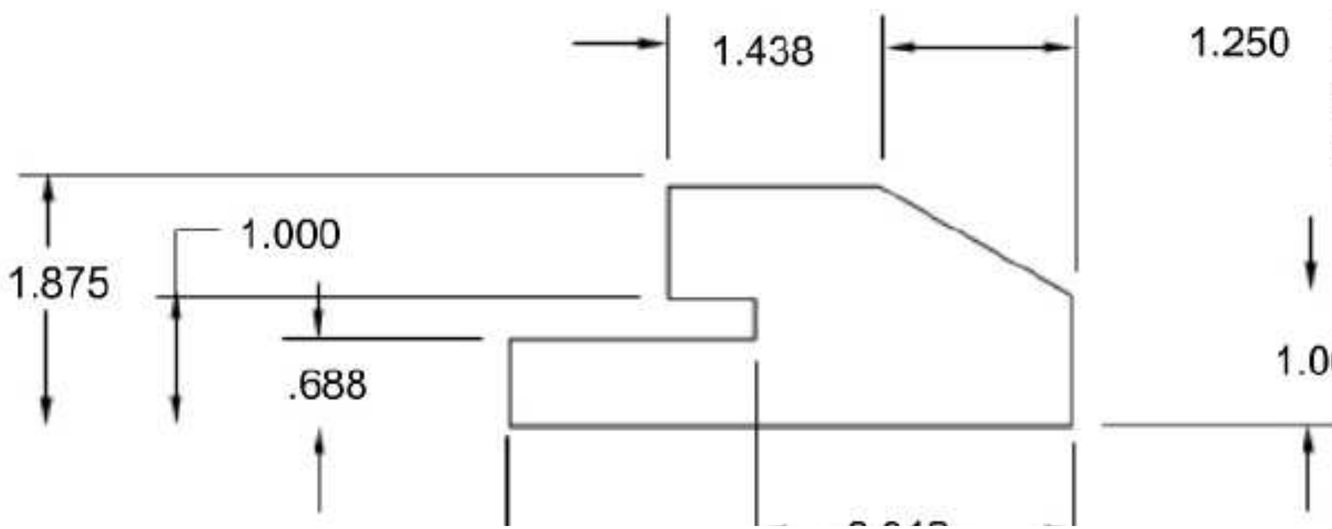


- **Reference dimensions are used on drawings to provide support information only.**
- **They are values that have been derived from other dimensions and therefore should not be used for calculation, production or inspection of parts.**
- **The use of reference dimensions on drawings should be minimized.**

Basic Dimensioning – Good Practice

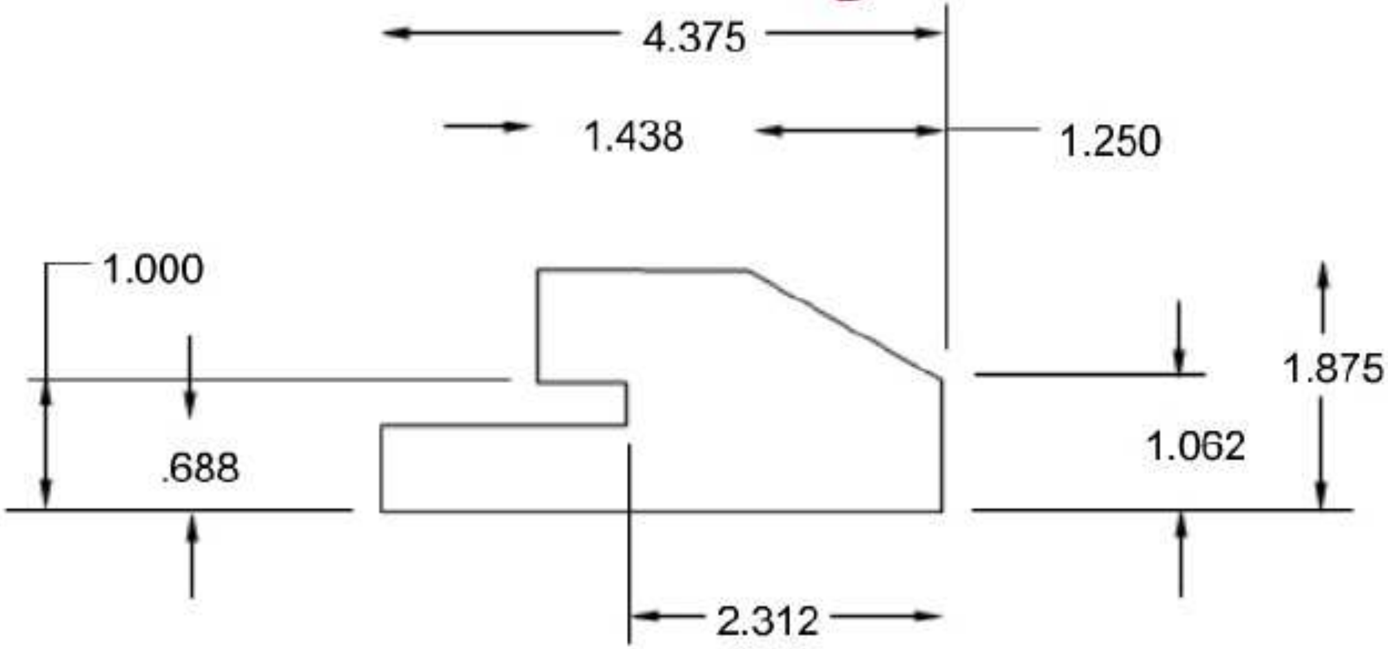


Extension lines should not cross dimension lines if avoidable

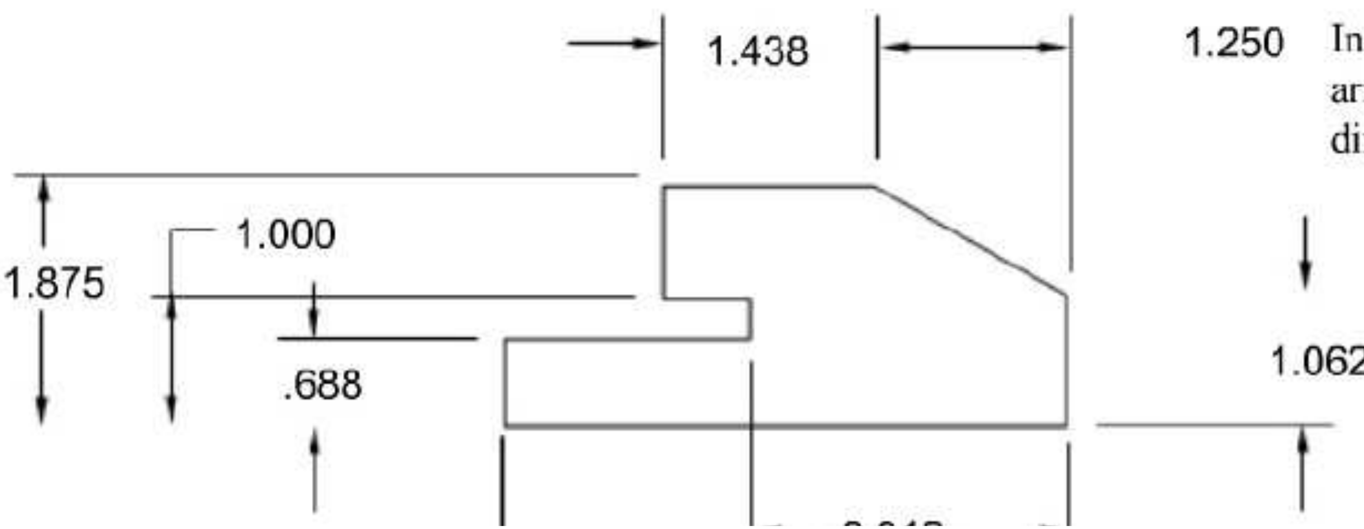


In-line dimensions can share arrowheads with contiguous dimensions

Basic Dimensioning – Good Practice



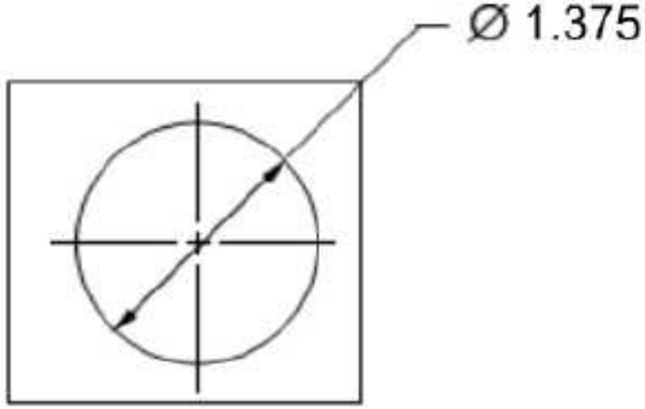
Extension lines should not cross dimension lines if avoidable

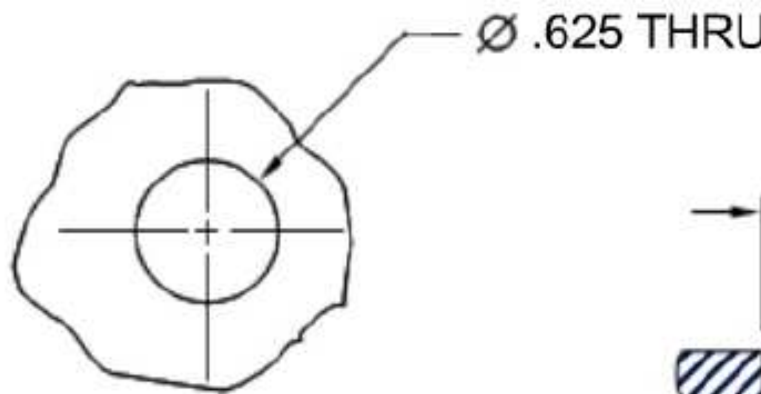


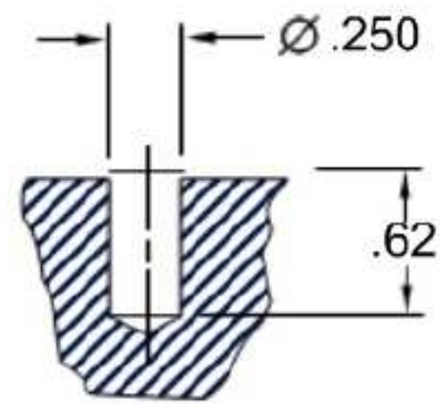
In-line dimensions can share arrowheads with contiguous dimensions

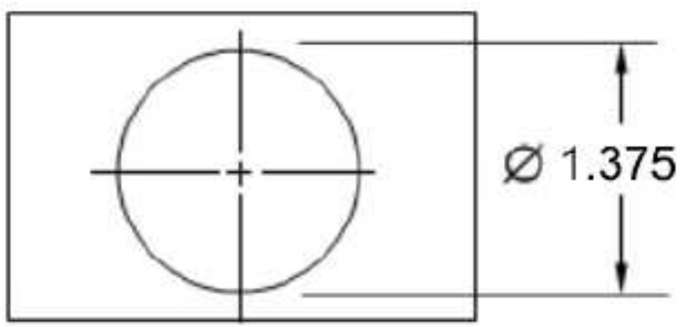
Diameter Dimensions

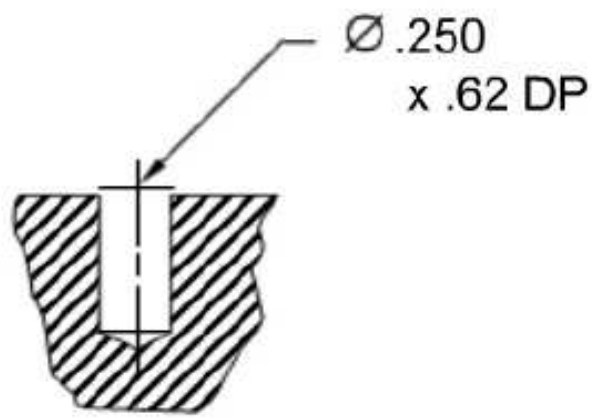
Holes and cutouts







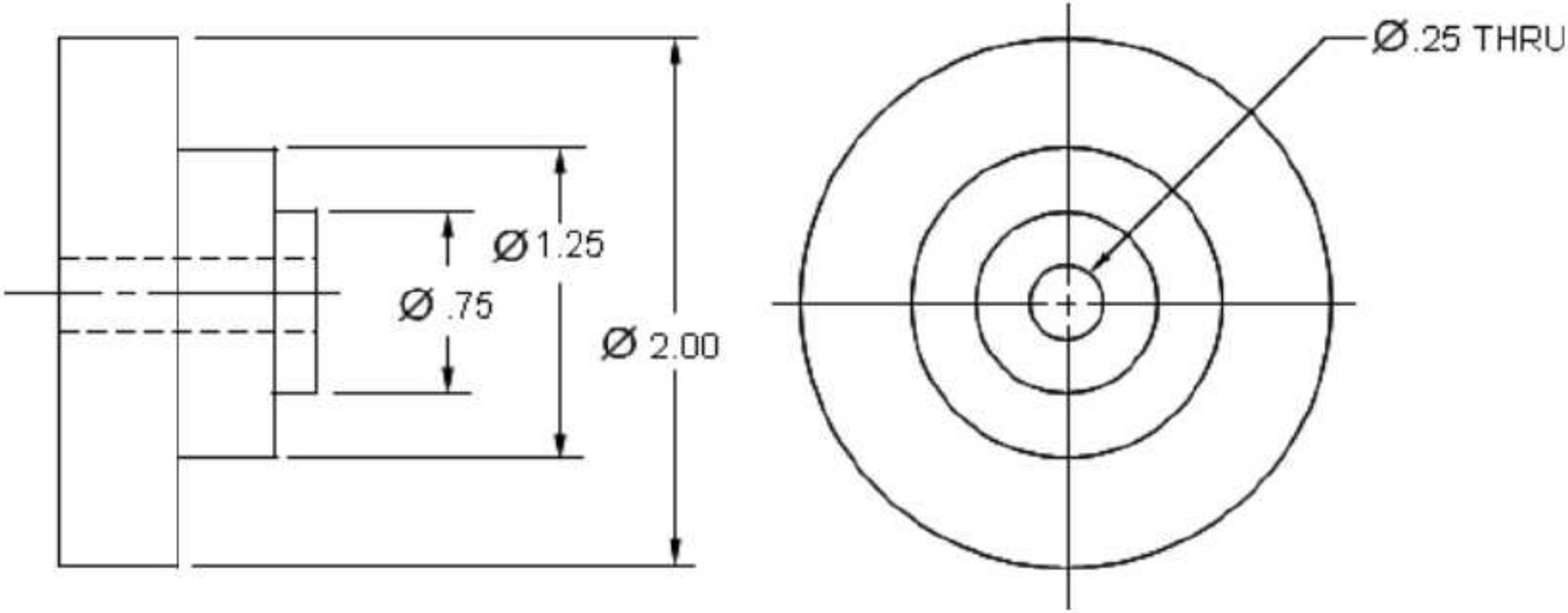




Diameter Dimensions

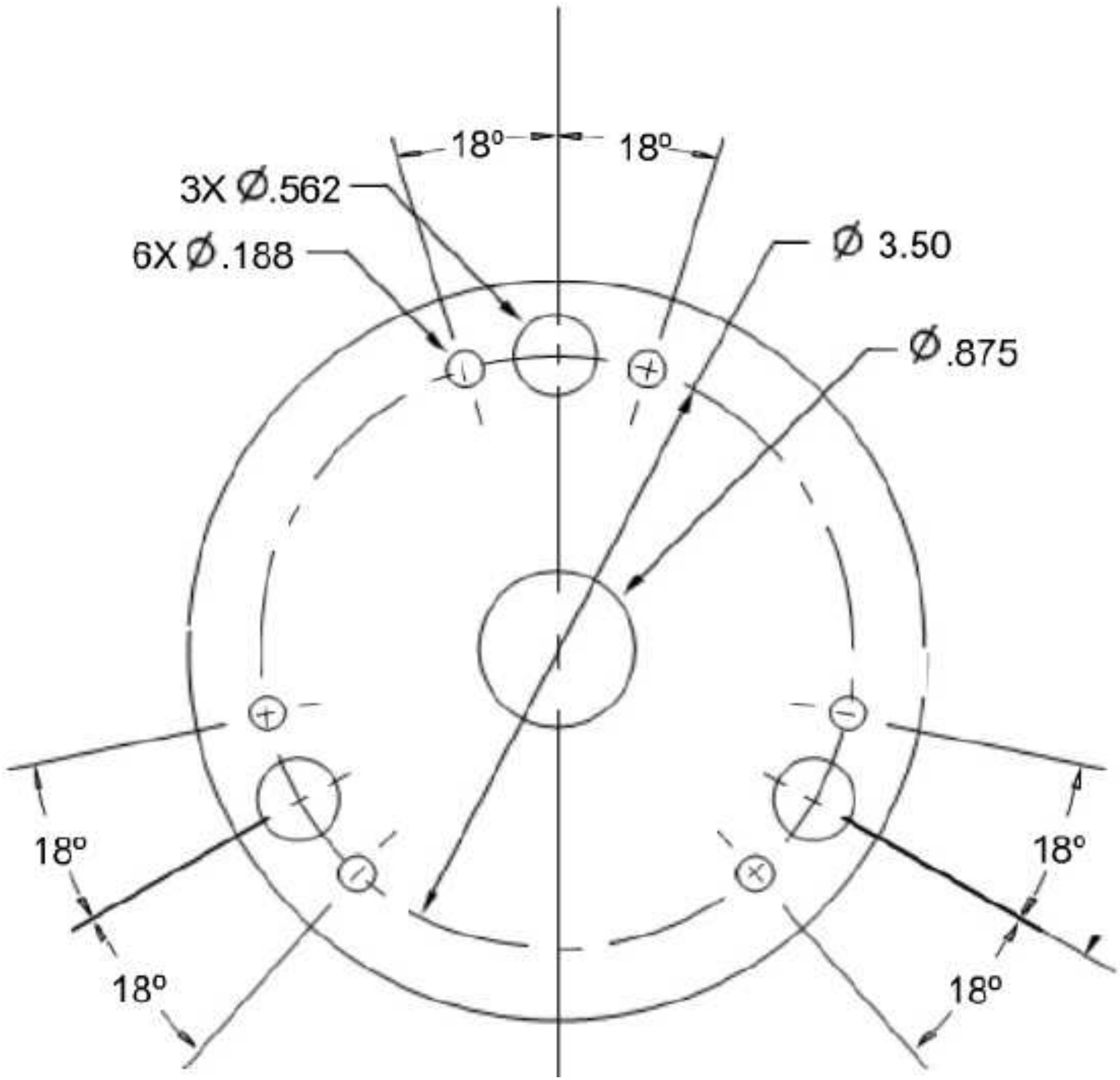
Shafts and Holes

- **Whenever it is practical to do so, external diameters are dimensioned in rectangular (or longitudinal) views. Cylindrical holes, slotted *holes*, and cutouts that are irregular in shape would normally be dimensioned in views where their true geometric shape is shown.**



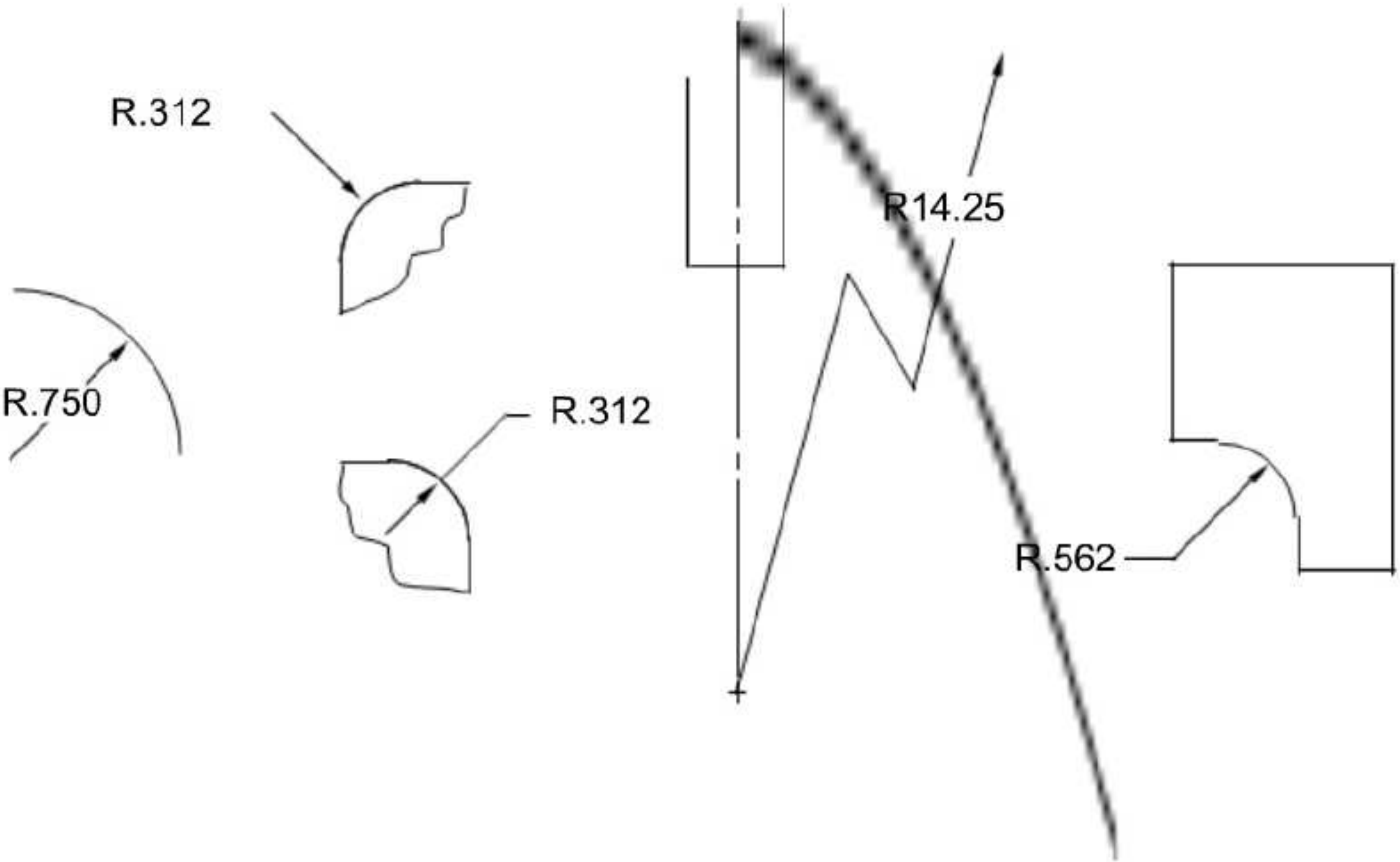
Placement with Polar Coordinates

To dimension features on a round or axisymmetric component



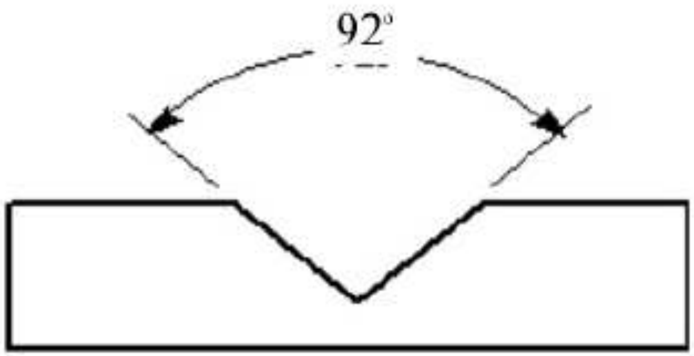
Radial Dimensions

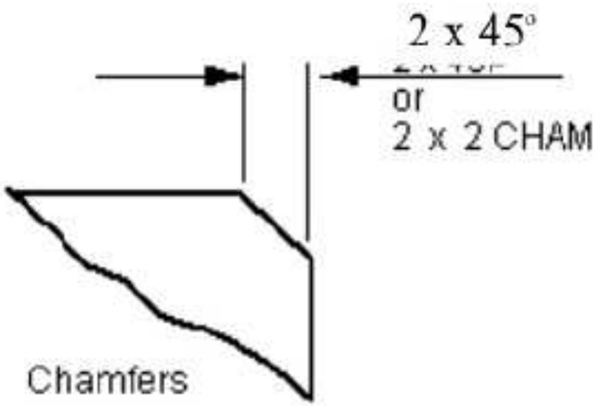
To indicate the size of fillets, rounds, and radii

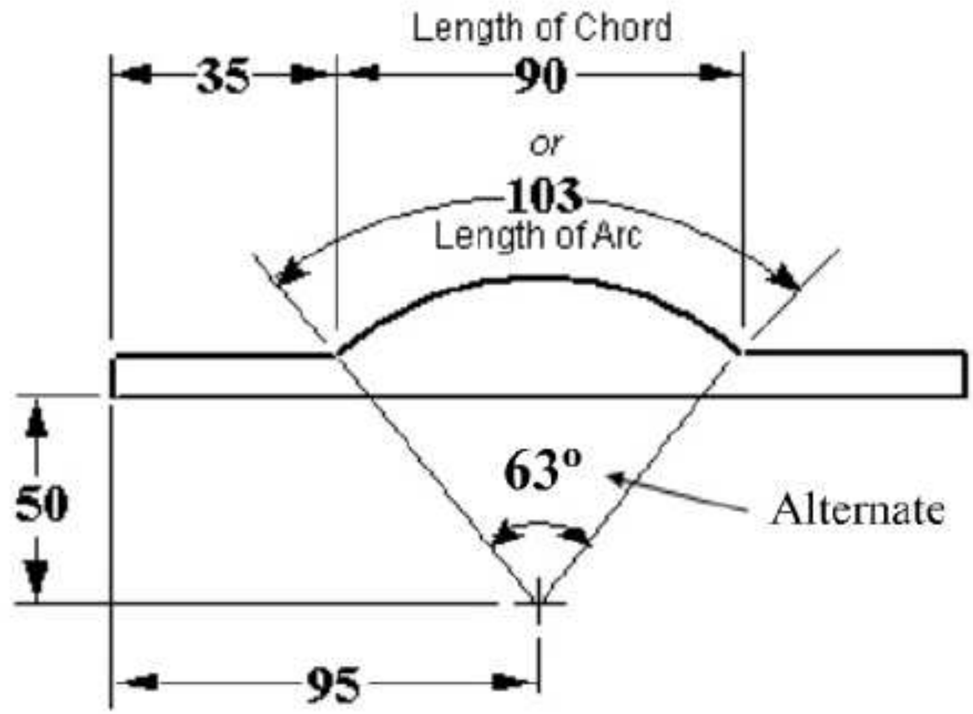


Angular Dimensions:

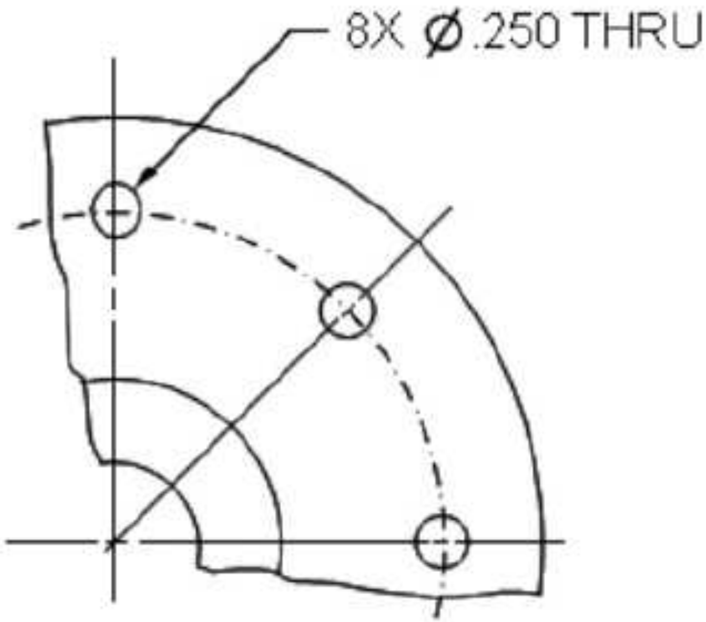
To indicate the size of angular details appearing as either angular or linear dimensions.

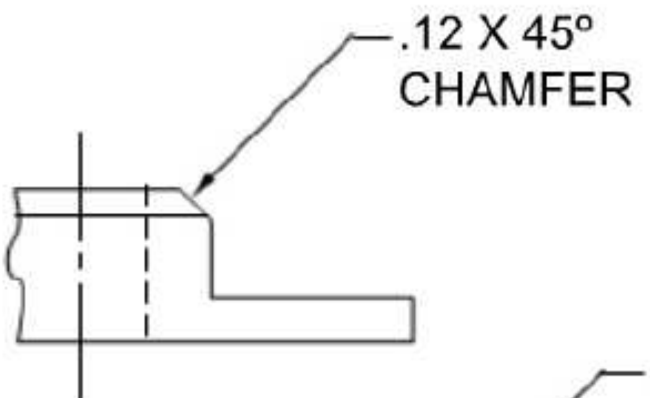


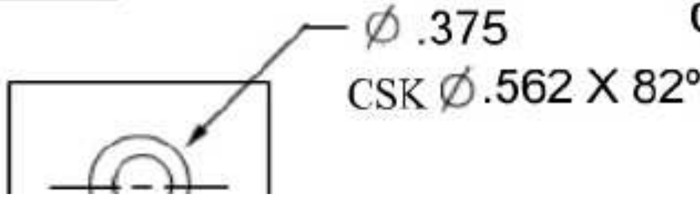




"Times" and "By" Symbol: X



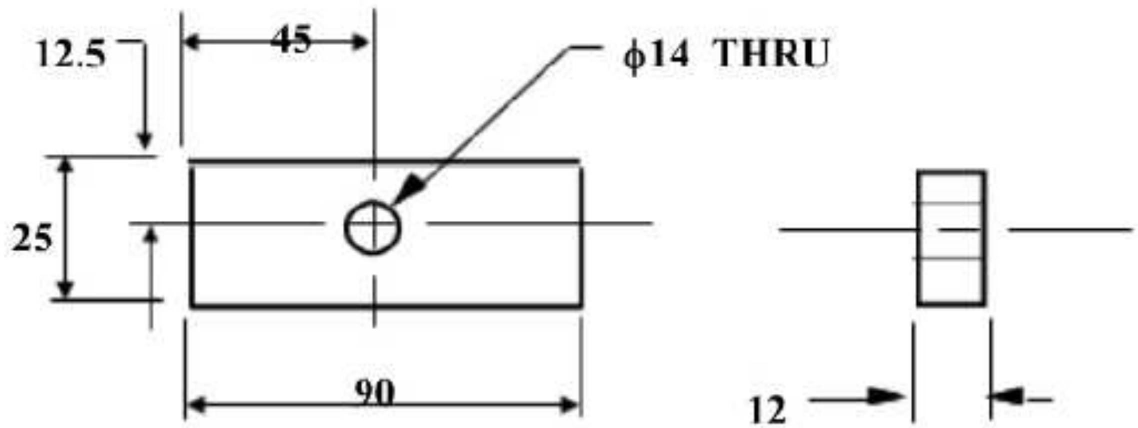




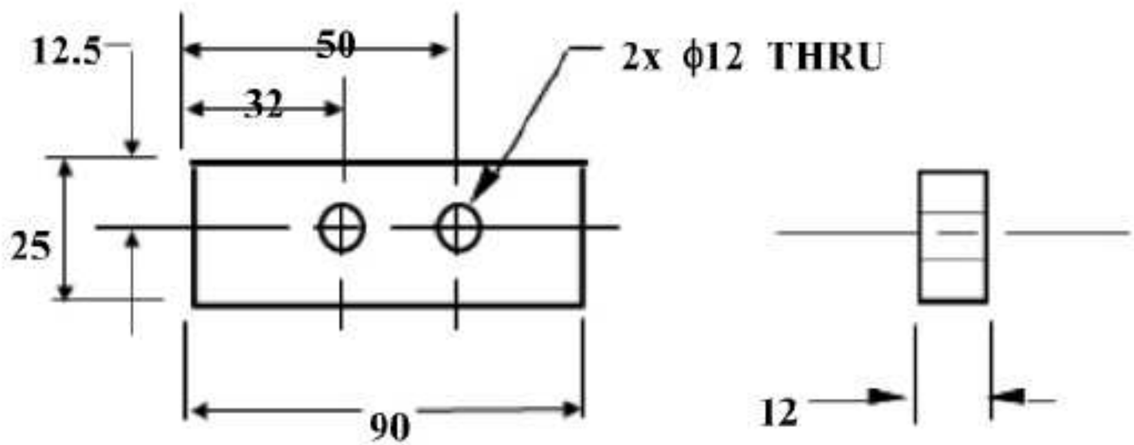
- The X symbol can also be used to indicate the word "by". For instance, when a slot that has a given width *by* a specified length, or a chamfer that has equal sides (.12 X .12).
- When used to imply the word '*by', a space must precede and follow the X symbol*.
- If the same feature is repeated on the drawing (such as 8 holes of the same diameter and in a specified pattern), the number of times the instruction applies is called out using the symbol X.

Drilled Holes

Normally specified by diameter and depth (or THRU note used).



Specify reaming if accuracy/finish is important.

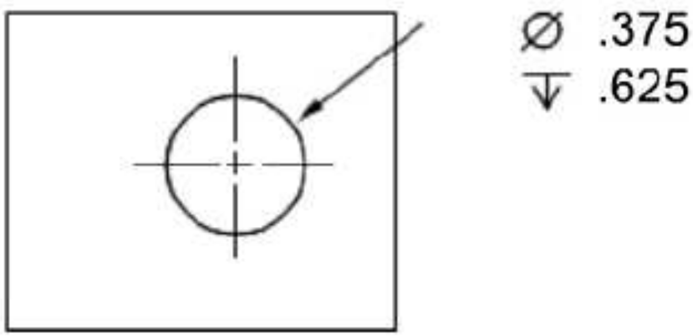


ASME/ANSI Hole Depth Symbol

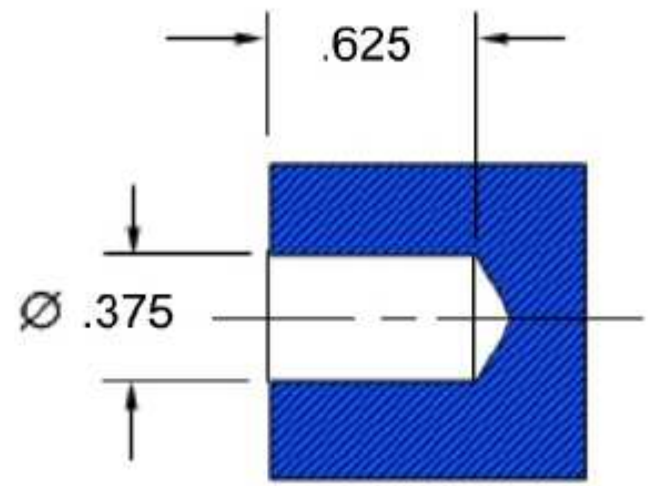
Depth or Deep Symbol* $\overline{\vee}$

- **Features such as blind holes and counterbores, *must* have a depth called out to fully describe their geometry.**

EXAMPLE



OR



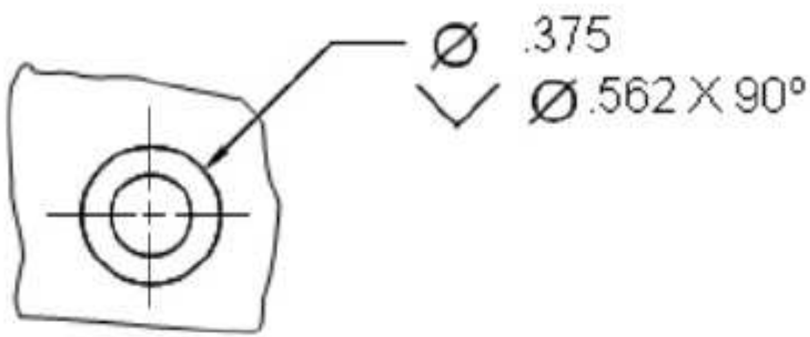
* This symbol is currently not used in the ISO standard. It has been proposed

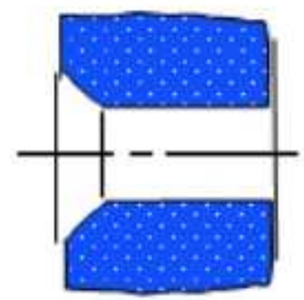
ASME/ANSI Countersink Symbol

Countersink Symbol* 

EXAMPLE

- **The symbol denotes a requirement for countersunk holes used to recess flathead screws. The height of the symbol is equal to the letter height on the drawing, and the included angle is *drawn* at 90º. Note that this symbol is not used in the ISO (international) standard.**



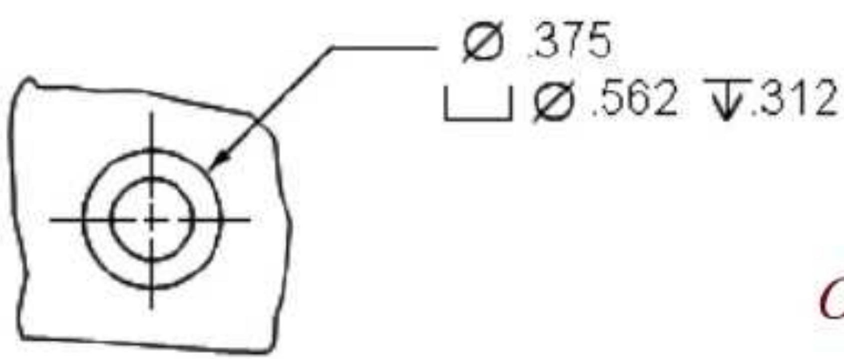


ASME/ANSI Counterbore Symbol

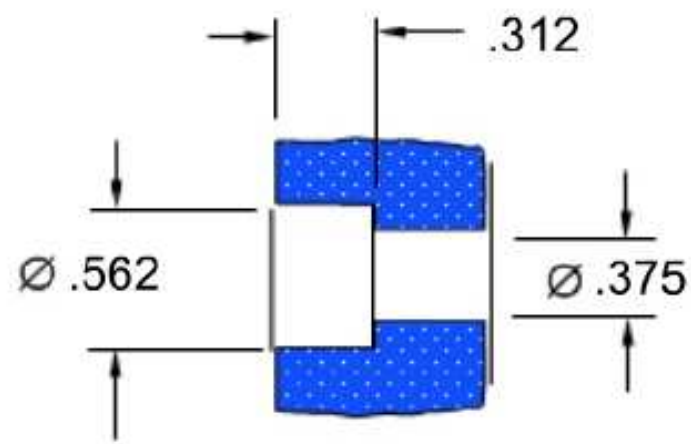
Counterbore Symbol* ⌴

- **This symbol denotes *counterbored* holes used to recess machine screw heads.**

EXAMPLE



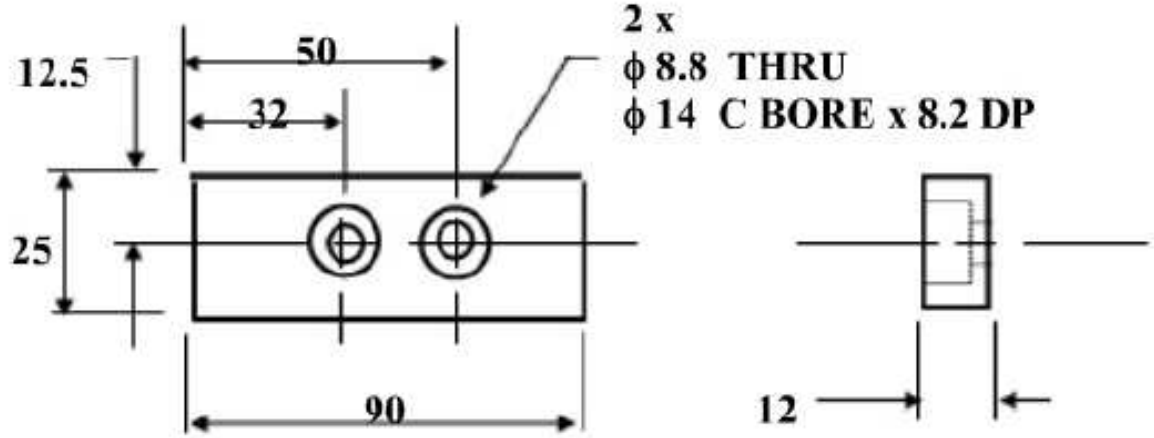
OR



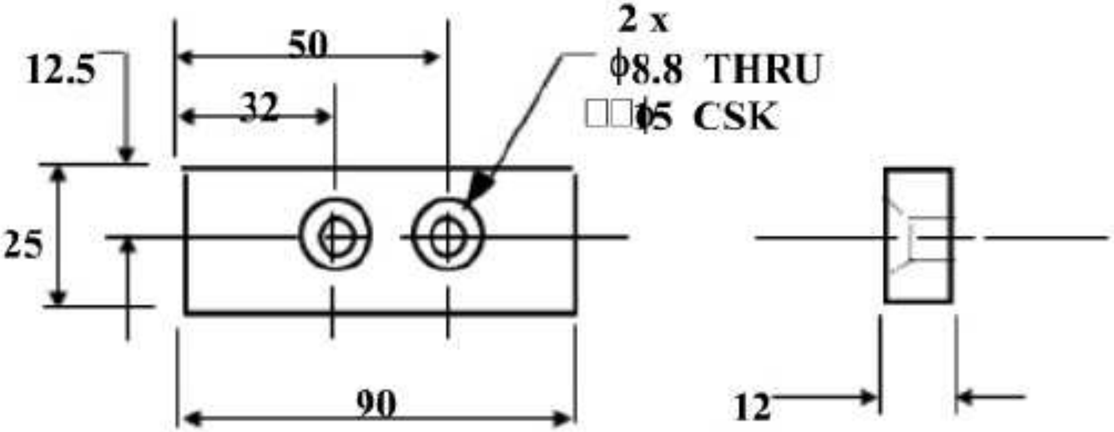
* This symbol is currently not used in the ISO standard. It has been proposed

Counterbores and Countersinks – ISO Standard

Socket Cap Head or Machine screws



Flat Head



Screw Threads

ISO specify metric only: M 16 x 2

M 16 x 2 - 4h - 5H

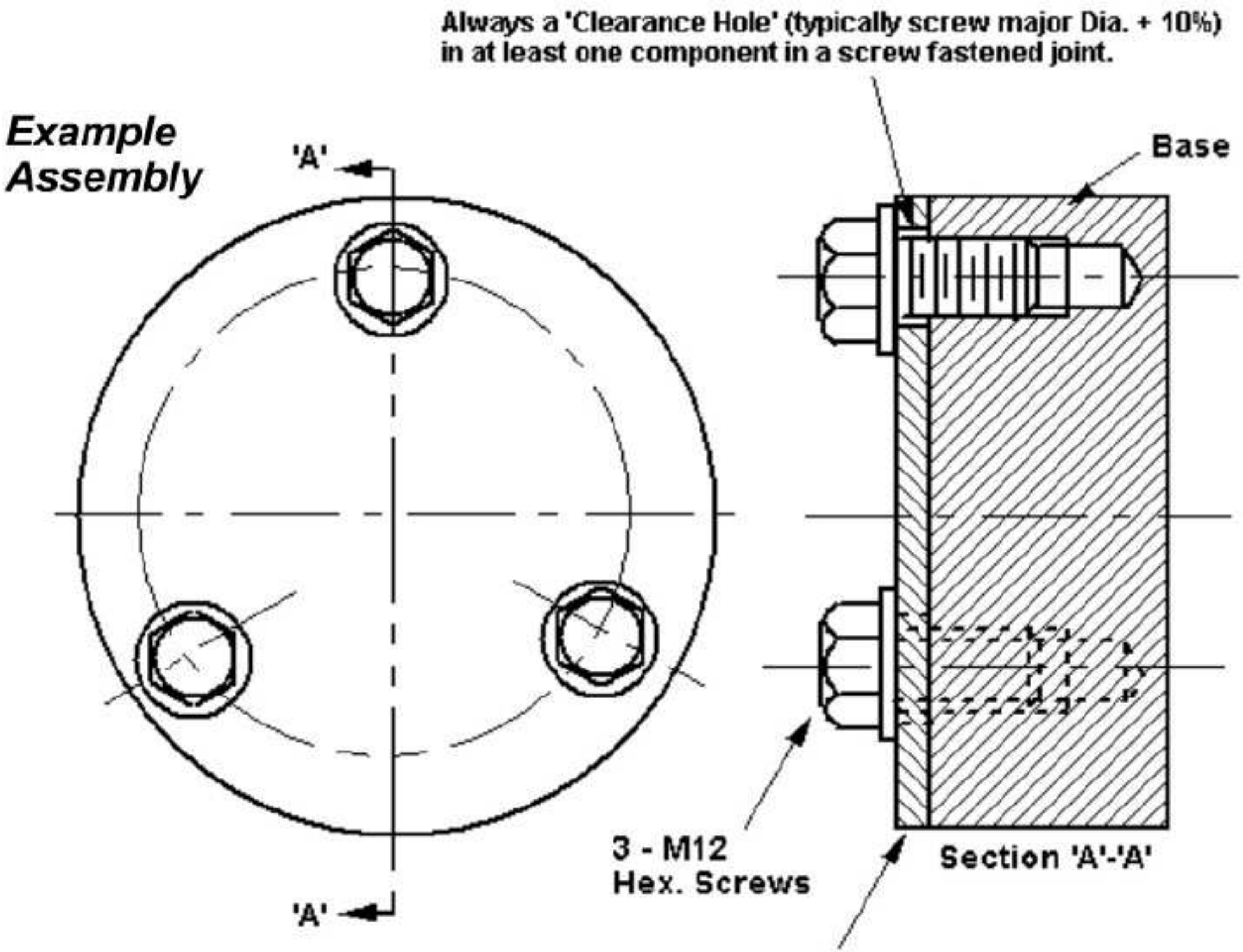
- **ISO metric designation**
- **Nominal Diameter (mm)**
- **Thread Pitch(mm)**
- **Class of fit of this thread (optional)**
- **Class of fit of mating thread (optional)**

American Unified Threads: 3/4 - 10 - UNC

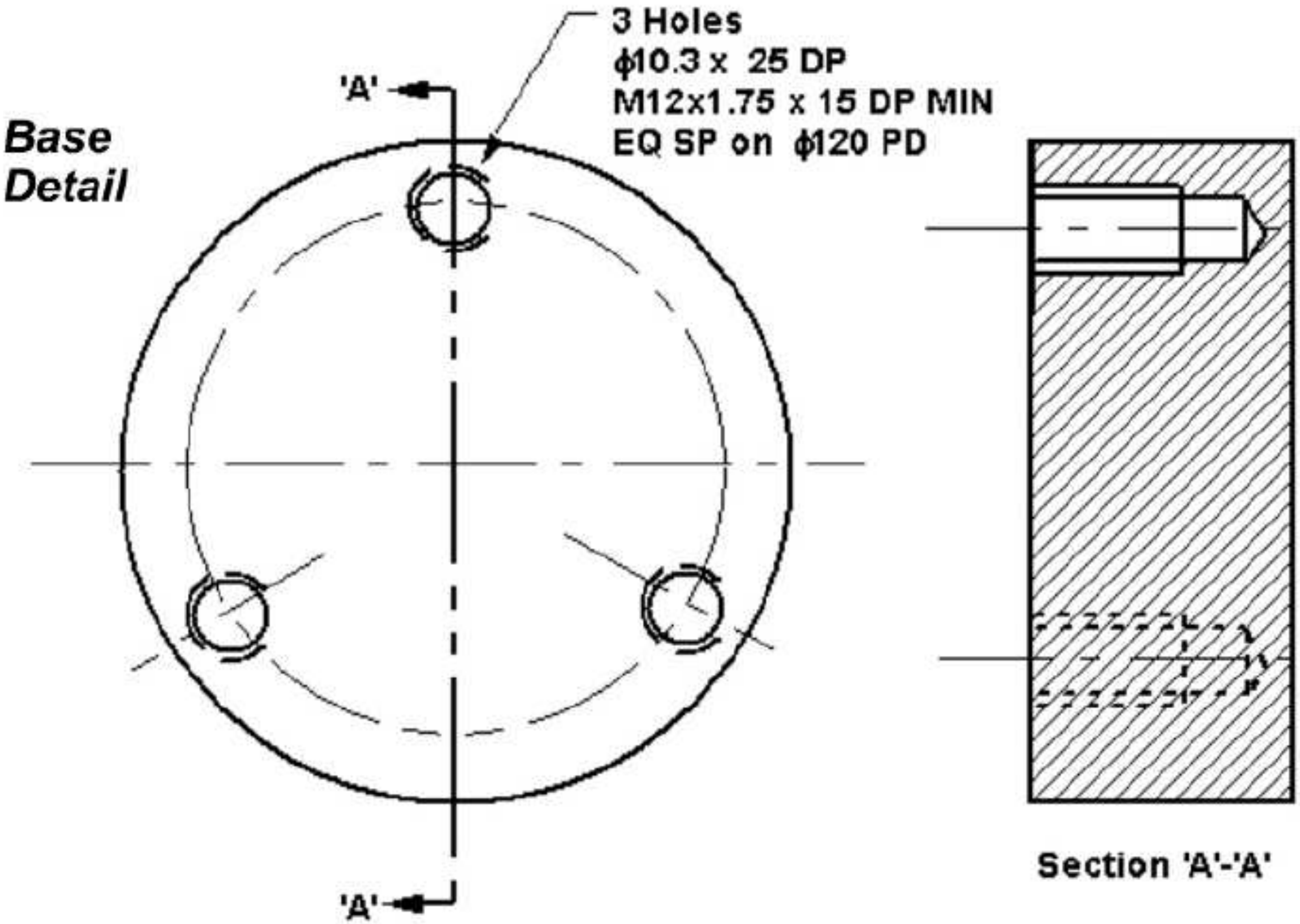
3/4 - 10 - UNC - 2A

- **Nominal Diameter (inches)**
- **Threads per inch**
- **Thread Series**
  UNC = Unified Coarse
  UNF = Unified Fine
- **Class of fit (optional)**
- **Thread Type (optional)**
  A=External
  B=Internal

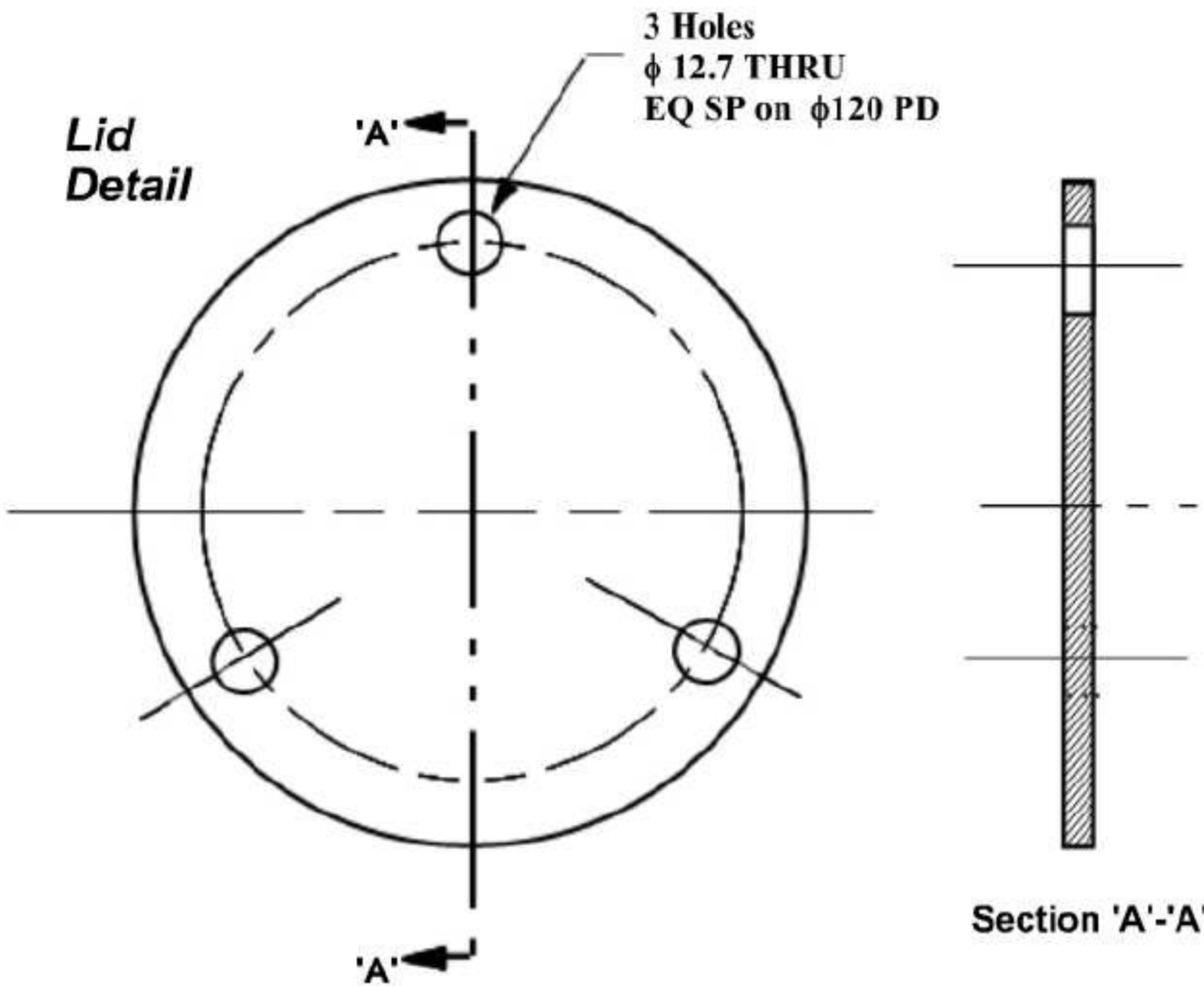
Threads and Screw Fastening



Threads and Screw Fastening (cont.)



Threads and Screw Fastening (cont.)



Tolerances

important to interchangeability and provision for replacement parts

It is impossible to make parts to an exact size. The tolerance, or accuracy required, will depend on the function of the part and the particular feature being dimensioned. Therefore, the range of permissible size, or tolerance, must be specified for all dimensions on a drawing, by the designer/draftsperson.

Nominal Size: is the size used for general identification, not the exact size.

Actual Size: is the measured dimension. A shaft of nominal diameter 10 mm may be measured to be an actual size of 9.975 mm.

General Tolerances:
***In ISO metric*, general tolerances are specified in a note, usually in the title block, typically of the form: "General tolerances ±.25 unless otherwise stated".**

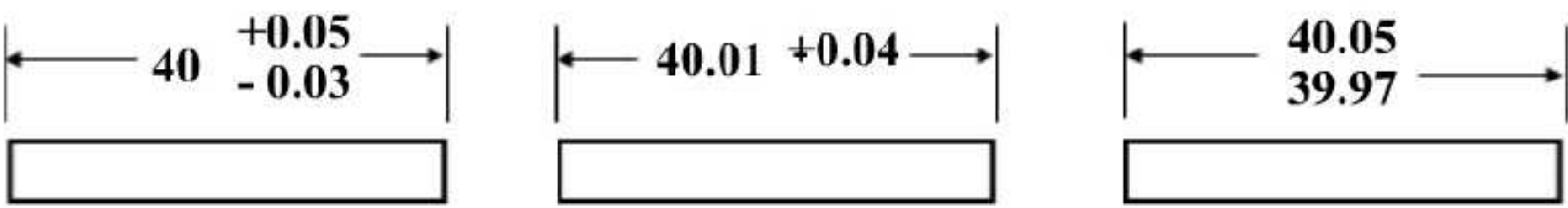
***In English Units* , the decimal place indicates the general tolerance given in the title block notes, typically:**
Fractions = ±1/16, .X = ±.03, .XX = ±.01, .XXX = ±.005, .XXXX = ±0.0005,

Note: Fractions and this type of general tolerancing is not permissible in ISO metric standards.

Specific Tolerances

Specific Tolerances indicate a special situation that cannot be covered by the general tolerance.

Specific tolerances are placed on the drawing with the dimension and have traditionally been expressed in a number of ways:



Bilateral Tolerance ***Unilateral Tolerance*** ***Limit Dimensions***

Limits are the maximum and minimum sizes permitted by the the tolerance. All of the above methods show that the dimension has:

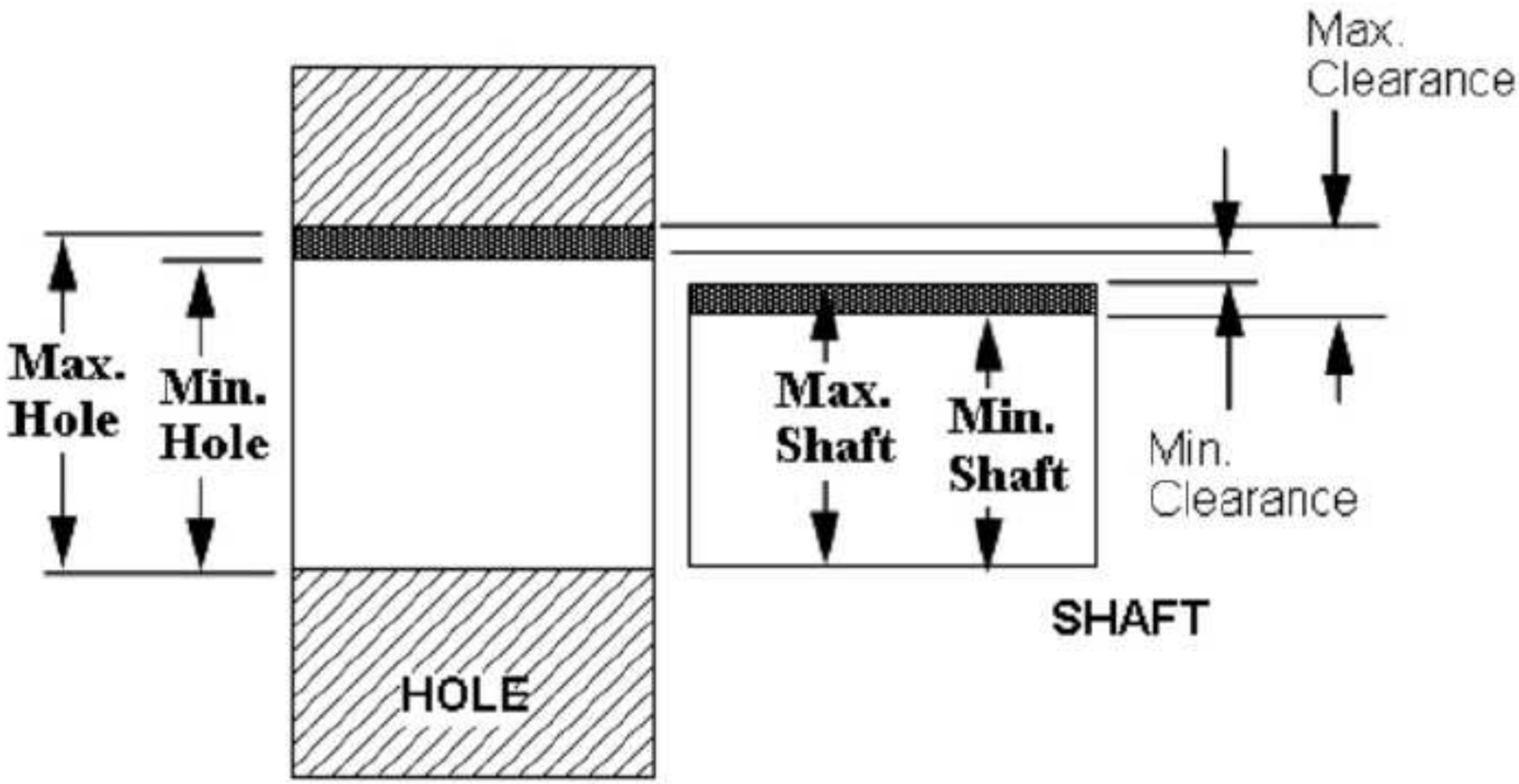
a Lower Limit = 39.97 mm
an Upper Limit = 40.05 mm
a Tolerance = 0.08 mm

Manufacturing must ensure that the dimensions are kept within the limits specified. Design must not over specify as tolerances have an exponential affect on cost.

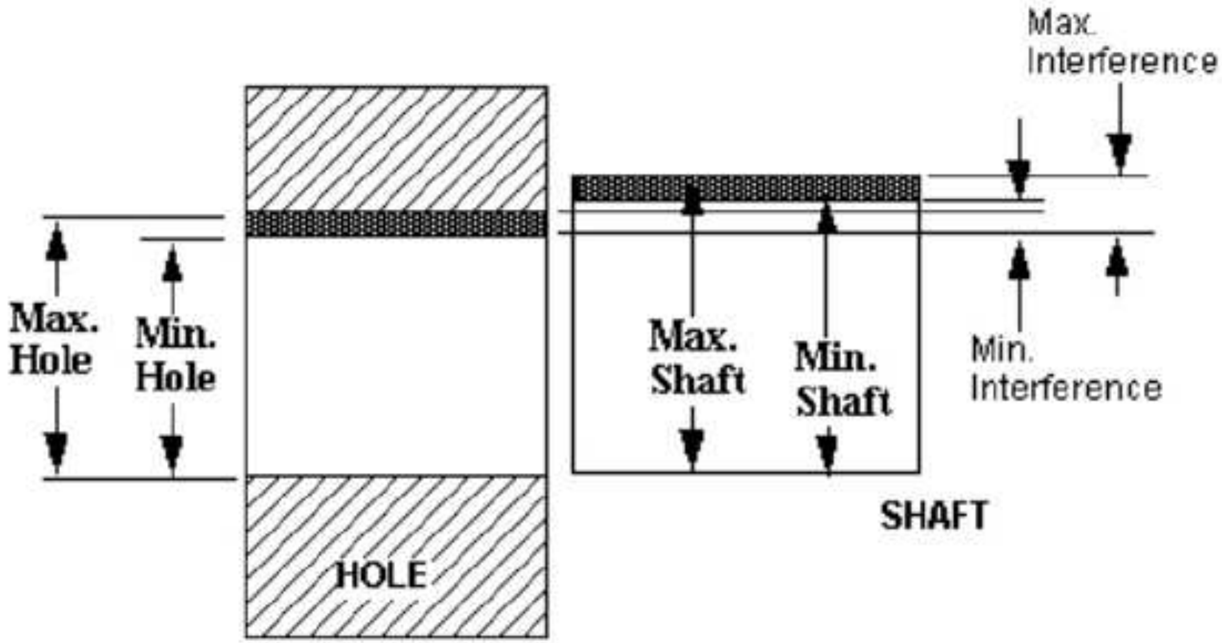
Limits and Fits

1. Clearance Fits

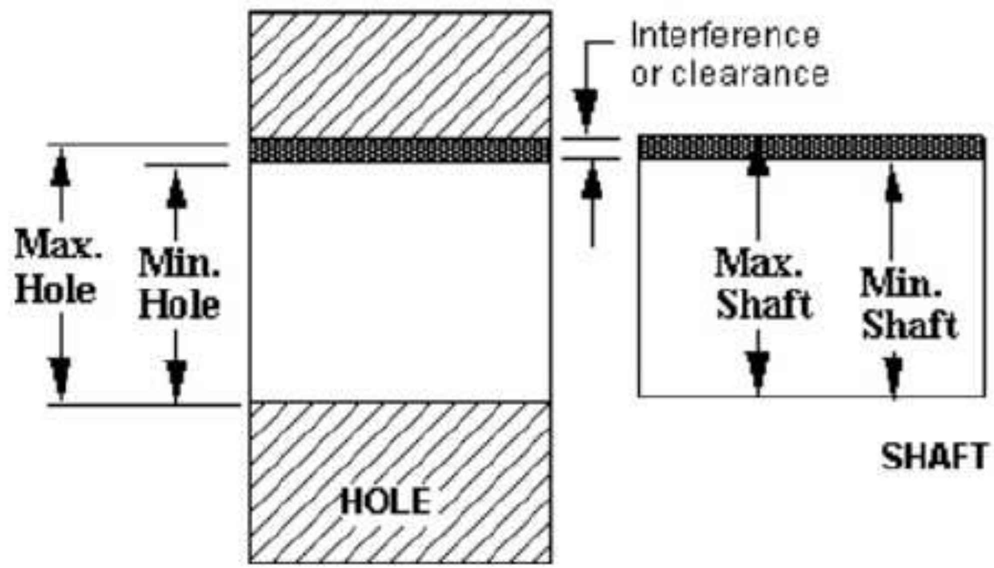
The largest permitted shaft diameter is smaller than the diameter of the smallest hole



2. Interference Fits
The minimum permitted diameter of the shaft is larger than the maximum diameter of the hole



3. Transition Fits
The diameter of the largest allowable hole is greater than that of the smallest shaft, but the smallest hole is smaller than the largest shaft



Standard Limits and Fits -- ANSI

Extract from Table of Clearance Fits

RC 1 Close sliding fits are intended for the accurate location of parts which must assemble without perceptible play.

RC 2 Sliding fits are intended for accurate location, but with greater maximum clearance than class RC 1. Parts made to this fit move and turn easily but are not intended to run freely, and in the larger sizes may seize with small temperature changes.

RC 3 Precision running fits are about the closest fits which can be expected to run freely, and are intended for precision work at slow speeds and light journal pressures, but are not suitable where appreciable temperature differences are likely to be encountered.

RC 4 Close running fits are intended chiefly for running fits on accurate machinery with moderate surface speeds and journal pressures, where accurate location and minimum play are desired.

RC 5, RC 6 Medium running fits are intended for higher running speeds, or heavy journal pressures, or both.

Basic hole system. Limits are in thousandths of an inch.

Nominal Size Range in Inches	Class RC 1			Class RC 2			Class RC 3			Class RC 4			Class RC 5			Class RC 6		
	Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits		Limits of Clearance	Standard Limits	
		Hole H5	Shaft g4		Hole H6	Shaft g5		Hole H7	Shaft f6		Hole H8	Shaft f7		Hole H8	Shaft e7		Hole H9	Shaft e8
0 - 0.12	0.1	+ 0.2	- 0.1	0.1	+ 0.25	- 0.1	0.3	+ 0.4	- 0.3	0.3	+ 0.6	- 0.3	0.6	+ 0.6	- 0.6	0.6	+ 1.0	- 0.6
	0.45	- 0	- 0.25	0.55	- 0	- 0.3	0.95	- 0	- 0.55	1.3	- 0	- 0.7	1.6	- 0	- 1.0	2.2	- 0	- 1.2
0.12 - 0.24	0.15	+ 0.2	- 0.15	0.15	+ 0.3	- 0.15	0.4	+ 0.5	- 0.4	0.4	+ 0.7	- 0.4	0.8	+ 0.7	- 0.8	0.8	+ 1.2	- 0.8
	0.5	- 0	- 0.3	0.65	- 0	- 0.35	1.12	- 0	- 0.7	1.6	- 0	- 0.9	2.0	- 0	- 1.3	2.7	- 0	- 1.5
0.24 - 0.40	0.2	+ 0.25	- 0.2	0.2	+ 0.4	- 0.2	0.5	+ 0.6	- 0.5	0.5	+ 0.9	- 0.5	1.0	+ 0.9	- 1.0	1.0	+ 1.4	- 1.0
	0.6	- 0	- 0.35	0.85	- 0	- 0.45	1.5	- 0	- 0.9	2.0	- 0	- 1.1	2.5	- 0	- 1.6	3.3	- 0	- 1.9
0.40 - 0.71	0.25	+ 0.3	- 0.25	0.25	+ 0.4	- 0.25	0.6	+ 0.7	- 0.6	0.6	+ 1.0	- 0.6	1.2	+ 1.0	- 1.2	1.2	+ 1.6	- 1.2
	0.75	- 0	- 0.45	0.95	- 0	- 0.55	1.7	- 0	- 1.0	2.3	- 0	- 1.3	2.9	- 0	- 1.9	3.8	- 0	- 2.2
0.71 - 1.19	0.3	+ 0.4	- 0.3	0.3	+ 0.5	- 0.3	0.8	+ 0.8	- 0.8	0.8	+ 1.2	- 0.8	1.6	+ 1.2	- 1.6	1.6	+ 2.0	- 1.6
	0.95	- 0	- 0.55	1.2	- 0	- 0.7	2.1	- 0	- 1.3	2.8	- 0	- 1.6	3.6	- 0	- 2.4	4.8	- 0	- 2.8
1.19 - 1.97																		

ISO Tolerance Designation

The ISO system provides for:

- **21 types of holes (standard tolerances) designated by uppercase letters A, B, C, D, E....etc. and**
- **21 types of shafts designated by the lower case letters a, b, c, d, e...etc.**

These letters define the position of the tolerance zone relative to the nominal size. To each of these types of hole or shaft are applied 16 grades of tolerance, designated by numbers IT1 to IT16 - the "Fundamental Tolerances":

$$ITn = (0.45 \times \sqrt[3]{D} + 0.001\,D)\,Pn$$

where D is the mean of the range of diameters and Pn is the progression:1, 1.6, 2.5, 4.0, 6.0, 10, 16, 25......etc. which makes each tolerance grade approximately 60% of its predecessor.

For Example:

Experience has shown that the dimensional accuracy of manufactured parts is approximately proportional to the cube root of the size of the part.

Example:
A hole is specified as: $\phi 30$ **H7**

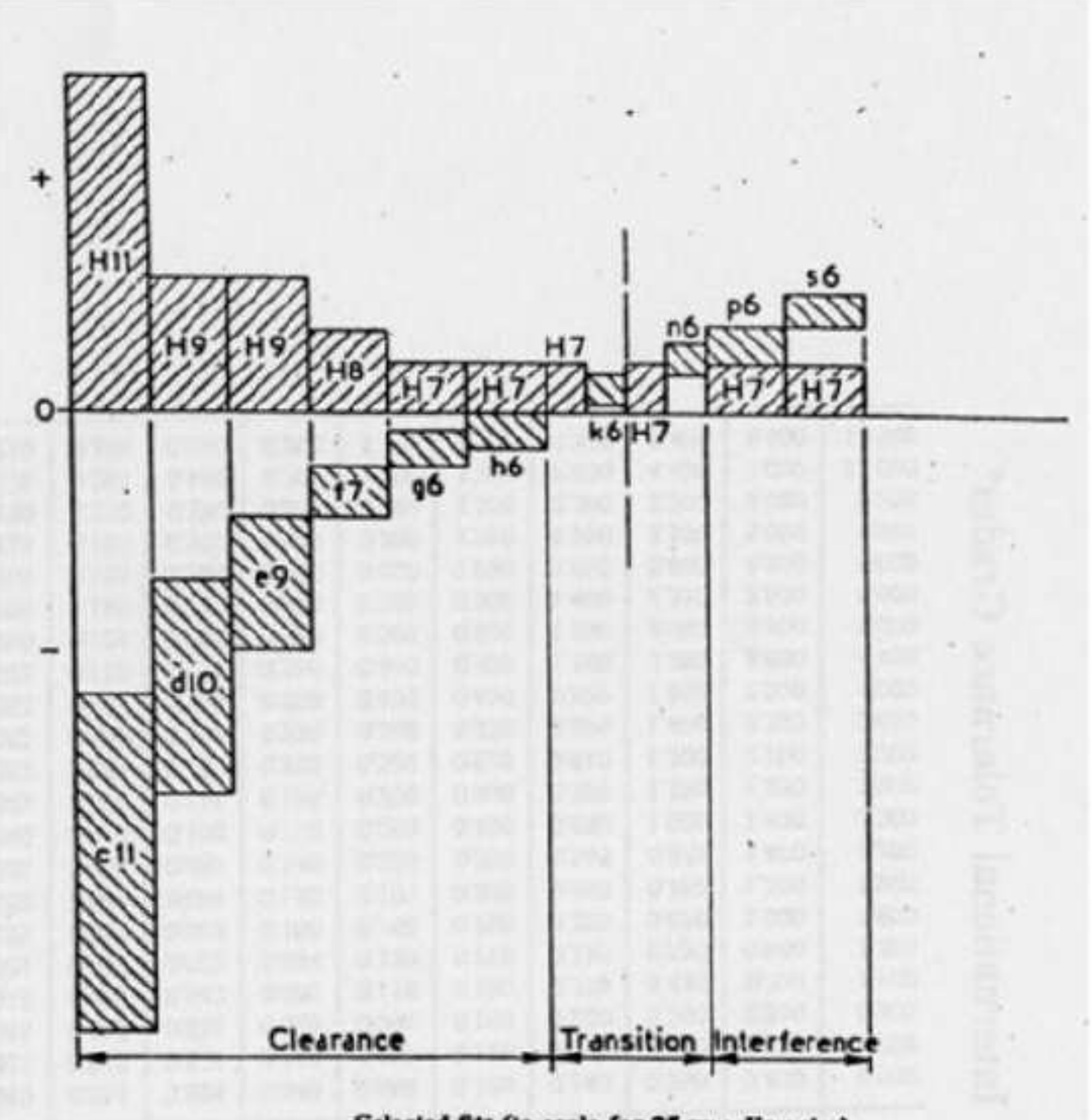
The H class of holes has limits of $^{+x}_{+0}$ **. i.e. all tolerances start at the nominal size and go positive by the amount designated by the IT number.**

IT7 for diameters ranging 30- 50 mm:

Tolerance for IT7 = (0.45 x $\sqrt[3]{40}$ **+0.001x 40) 16 = 0.025 mm**

Written on a drawing as $\phi 30$ **H7** $\left(\begin{matrix} +0.025 \\ +0 \end{matrix}\right)$

Graphical illustration of ISO standard fits



Selected fits (to scale for 25 mm diameter)

Selection of Fits and the ISO Hole Basis system

From the above it will be realized that there are a very large number of combinations of hole deviation and tolerance with shaft deviation and tolerance. However, a given manufacturing organization will require a number of different types of fit ranging from tight drive fits to light running fits for bearings etc. Such a series of fits may be obtained using one of two standard systems:

The Shaft Basis System:

For a given nominal size a series of fits is arranged for a given nominal size using a standard shaft and varying the limits on the hole.

The Hole Basis System:

For a given nominal size, the limits on the hole are kept constant, and a series of fits are obtained by only varying the limits on the shaft.

The HOLE SYSTEM is commonly used because holes are more difficult to produce to a given size and are more difficult to inspect. The H series (lower limit at nominal, 0.00) is typically used and standard tooling (e.g. H7 reamers) and gauges are common for this standard.

ISO Standard "Hole Basis"

Clearance Fits

Type of Fit	Hole	Shaft
Loose Running Fits. Suitable for loose pulleys and the looser fastener fits where freedom of assembly is of prime importance	H11	c11
Free Running Fit. Where accuracy is not essential, but good for large temperature variation, high running speeds, heavy journal pressures	H9	d10
Close Running Fit. Suitable for lubricated bearing, greater accuracy, accurate location, where no substantial temperature difference is encountered.	H8	f7
Sliding Fits. Suitable for precision location fits. Shafts are expensive to manufacture since the clearances are small and they are not recommended for running fits except in precision equipment where the shaft loadings are very light.	H7	g6
Locational Clearance Fits. Provides snug fit for locating stationary parts; but can be freely assembled and disassembled	H7	h6

ISO Standard "Hole Basis"
Transition Fits

Type of Fit	Hole	Shaft
Locational Transition Fits. for accurate location, a compromise between clearance and interference	H7	k6
Push Fits. Transition fits averaging little or no clearance and are recommended for location fits where a slight interferance can be tolerated for the purpose, for example, of eliminating vibration.	H7	n6

ISO Standard "Hole Basis"
Interference Fits

Type of Fit	Hole	Shaft
Press Fit. Suitable as the standard press fit into ferrous, i.e. steel, cast iron etc., assemblies.	H7	p6
Drive Fit Suitable as press fits in material of low modulus of elasticity such as light alloys.	H7	s6

ISO Clearance Fits

Nominal Sizes		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance	
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm
—	3	+60 0	-60 -120	+25 0	-20 0	+25 0	-14 -39	+14 0	-6 -16	+10 -	-2 -8	+10 0	-6 0
3	6	+75 0	-70 -145	+30 0	-30 -78	+30 0	-20 -50	+18 0	-10 -22	+12 0	-4 -12	+12 0	-8 0
6	10	+90 0	-80 -170	+36 0	-40 -98	+36 0	-25 -61	+22 0	-13 -28	+15 0	-5 -14	+15 0	-9 0
10	18	+110 0	-95 -205	+43 0	-50 -120	+43 0	-32 -75	+27 0	-16 -34	+18 0	-6 -17	+18 0	-11 0
18	30	+130 0	-110 -240	+52 0	-65 -149	+52 0	-40 -92	+33 0	-20 -41	+21 0	-7 -20	+21 0	-13 0
30	40	+160 0	-120 -280	+62 0	-80 -180	+62 0	-50 -112	+39 0	-25 -50	+25 0	-9 -25	+25 0	-16 0
40	50	+160 0	-130 -290										
50	65	+190 0	-130 -330	+74 0	-100 -220	+76 0	-60 -134	+46 0	-30 -60	+30 0	-12 -34	+30 0	-19 0
65	80	+190 0	-150 -340										
80	100	+220 0	-170 -390	+87 0	-120 -260	+87 0	-72 -159	+54 0	-36 -71	+35 0	-12 -34	+35 0	-22 0
100	120	+220 0	-180 -400										
120	140	+250 0	-200 -450	+100 0	-145 -305	+100 0	-84 -185	+63 0	-43 -83	+40 0	-14 -39	+40 0	-25 0
140	160	+250 0	-210 -460										
160	180	+250 0	-230 -480										
180	200	+290 0	-240 -530	+115 0	-170 -355	+115 0	-100 -215	-72 0	-50 -96	+46 0	-15 -44	+46 0	-29 0
200	225	+290 0	-260 -550										
225	250	+290 0	-280 -570										
250	280	+320 0	-300 -620	+130 0	-190 -400	+130 0	-190 -400	+130 0	-110 -240	+81 0	-96 -108	+52 0	-17 -49
280	315	+320 0	-330 -650										
315	355	+360 0	-360 -720	+140 0	-210 -440	+140 0	-135 -265	+89 0	-62 -119	+57 0	-18 -54	+57 0	-36 0
355	400	+360 0	-400 -760										
400	450	+400 [illegible]	-440 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

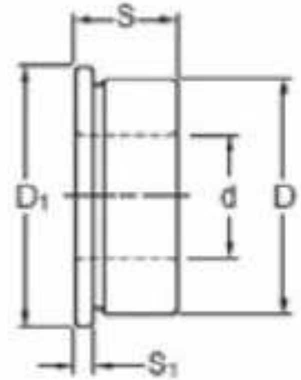
ISO Transition Fits

Nominal Sizes				Tolerance	
Over mm	To mm	H7 0.001 mm	k6 0.001 mm	H7 0.001 mm	n6 0.001 mm
—	3	+10 0	+6 +0	+10 0	+10 +4
3	6	+12 0	+9 +1	+12 0	+16 +8
6	10	+15 0	+10 +1	+15 0	+19 +10
10	18	+18 0	+12 +1	+18 0	+23 +12
18	30	+21 0	+15 +2	+21 0	+23 +15
30 40	40 50	+25 0	+18 +2	25 0	+33 +17
50 65	65 80	+30 0	+21 +2	+30 0	+39 +20
80 100	100 120	+35 0	+25 +3	+35 0	+45 +23
120 140 160	140 160 180	+40 0	+28 +3	+40 0	+52 +27
180 200 225	200 225 250	+46 0	+33 +4	+46 0	+60 +34
250 280	280 315	+52 0	-32 -	+52 0	+36 +4
315 355	355 400	+57 0	+40 +4	+57 0	+73 +37
400	450	+63	+45	+63	+80

ISO Interference Fits

Nominal Sizes		Tolerance		Tolerance	
Over	To	H7	p6	H7	s6
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm
—	3	+10 0	+12 +6	+10 0	+20 +14
3	6	+12 0	+20 +12	+12 0	+27 +19
6	10	+15 0	+24 +15	+15 0	+32 +23
10	18	+18 0	+29 +18	+18 0	+39 +28
18	30	+21 0	+35 +22	+21 0	+48 +35
30	40	+25 0	+42 +26	+25 0	+59 +43
40	50				
50	65	+30 0	+51 +32	+30 0	+72 +53
65	80			+30 0	+78 +59
80	100	+35 0	+59 +37	+35 0	+93 +78
100	120			+35 0	+101 +79
120	140	+40 0	+68 +43	+40 0	+117 +92
140	160			+40 0	+125 +100
160	180			+40 0	+133 +108
180	200	+46 0	+79 +50	+46 0	+151 +122
200	225			+46 0	+159 +130
225	250			+46 0	+169 +140
250	280	+52 0	+88 +56	+52 0	+190 +158
280	315			+52 0	+202 +170
315	355	+57 0	+98 +62	+57 0	+226 +190
355	400			+57 0	+244 +208
400	450	+63	+108	+63 0	+272 +232

Flanged Sintered Bronze Plain Bearing



Precision Component

FEATURES:
- Economical replacement for ball bearings.
- Dimensioned to be readily interchangeable with comparable ball bearings.

MATERIAL: Porous Sintered Bronze

LUBRICATION: Vacuum impregnated with oil

SPECIFICATIONS:

O.D. concentric to bore within 0.005 mm.
Faces square to bore within 0.008 mm.

$$\text{Load} = \frac{\text{Load Speed Rating}}{\text{rpm}} = \text{Newtons}$$

Catalog Number	Shaft Size h6	d Bore H7	D h6	S - 0.17 Width	D_1 Flange Dia. h14	S_1 - 0.05 Flange Width	Load Speed Rating N • rpm
S99BP4MFB030625			6	2.5	8	0.5	84000
S99BP4MFB030830	3	3	8	3	10	0.5	100000
S99BP4MFB031040			10	4	12	1	134000
S99BP4MFB040840	4	4	8	4	10	1	134000
S99BP4MFB051050			10	5	12		167000
S99BP4MFB051240	5	5	12	4	14	1	134000
S99BP4MFB051350			13	5	14		167000
S99BP4MFB061050	6	6	10	5	12	1	167000
S99BP4MFB061650			16		18		
S99BP4MFB081660	8	8	16	6	18	1	200000
S99BP4MFB101970	10	10	19	7	21	1.5	220000

SDP/SI

Ultraprecision Ball Bearings

Stock Drive Products/Sterling Instrument ■ Phone: 516-328-3300 ■ Fax: 516-328-8827

■ ABEC 7 ■ PLAIN AND FLANGED, NO SHIELD ■ .0002 / .0005 RADIAL PLAY

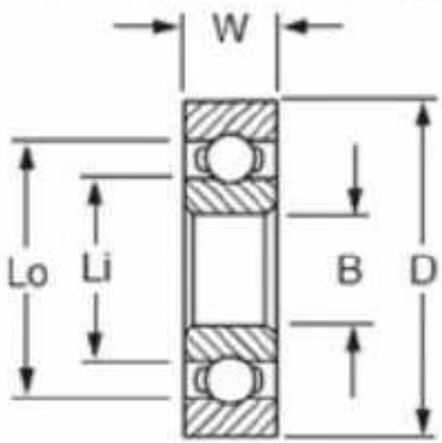


Fig. 1
PLAIN

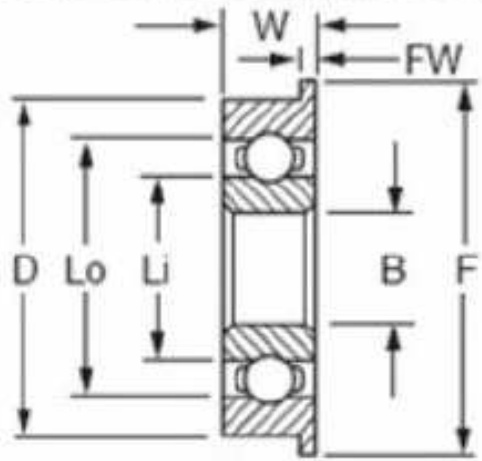


Fig. 2
FLANGED

Precision Component

MATERIAL: 440C or DD Stainless Steel
LUBRICATION: Synthetic Oil, MIL-L-6085A

Catalog Number	Fig. No.	B Bore +.0001 -.0000	D Outer Ring Dia. +.0000 -.0002	W Width +.000 -.001	FW Flange Width +.000 -.002	F Flange Dia. +.000 -.001	Land Dia. (Ref.)		Load Rating lb.	
							Li Inner	Lo Outer	Dynamic	Static
S9912Y-UBM-1	1	.1248	.2500	.0937	—	—	.166	.220	35	11
S9912Y-UBM-1F	2				.023	.296				
S9912Y-UB-2	1	.1873	.5000	.1562	—	—	.272	.415	139	50
S9912Y-UB-2F	2				.042	.565				
S9912Y-UB-3	1	.2498	.6250	.196	—	—	.366	.509	161	63
S9912Y-UB-3F	2				[illegible]	[illegible]				

Open

Double Shielded

Double Sealed

	Tolerance for Shaft Dia.	
For Shaft Dia.	Open—6383K	Double Shielded & Double Sealed—6384K
3/16"	+0.005" to −0"	+0.005" to −0"
1/4"	+0.005" to −0"	+0.005" to −0"
5/16"	+0.005" to −0"	+0.005" to −0"
3/8"	+0.005" to −0"	+0.005" to −0"
7/16"	+0.005" to −0"	+0.005" to −0"
1/2"	+0.005" to −0"	+0.005" to −0"
9/16"	—	+0.005" to −0"
5/8"	+0.005" to −0"	+0.005" to −0"
3/4"	+0.005" to −0"	+0.005" to −0"
7/8"	+0.005" to −0"	+0.005" to −0"
1"	+0.005" to −0"	+0.005" to −0"

	OD Tolerance					
OD	Open—6383K		Double Shielded—6384K		Double Sealed—6384K	
11/16"	6383K11	+0" to −0.005"	6384K51	+0" to −0.0005"	6384K38	+0" to −0.0005"
11/16"	6383K12	+0" to −0.0005"	6384K52	+0" to −0.0005"	6384K39	+0" to −0.0005"
7/8"						
7/8"						
7/8"						
7/8"						
29/32"						
29/32"						
29/32"						
15/16"						

Open

Double Shielded

Double Sealed

	Width Tolerance					
Width	Open—6383K		Double Shielded—6384K		Double Sealed—6384K	
1/4"	6383K11	±0.010"	6384K51	±0.005"	—	—
1/4"	6383K12	+0" to −0.005"	6384K52	+0" to −0.005"	—	—
1/4"	6383K14	±0.010"	—	—	—	—
1/4"	6383K25	±0.010"	—	—	—	—
1/4"	6383K15	±0.010"	—	—	—	—
1/4"	6383K16	±0.010"	—	—	—	—
1/4"	6383K17	±0.010"	—	—	—	—
5/16"	6383K22	±0.010"	6384K55	+0" to −0.005"	6384K42	±0.005"
5/16"	6383K18	±0.010"	6384K56	+0" to −0.005"	6384K44	+0" to −0.005"
5/16"	6383K38	±0.010"	6384K57	+0" to −0.005"	6384K46	+0" to −0.005"
5/16"	6383K19	±0.010"	—	—	6384K38	±0.005"
5/16"	6383K23	±0.010"	—	—	6384K39	+0" to −0.005"
5/16"	6383K39	±0.010"	—	—	—	—
3/8"	6383K26	±0.010"	6384K58	+0" to −0.005"	6384K45	+0" to −0.005"
3/8"	6383K27	±0.010"	6384K59	+0" to −0.005"	6384K47	+0" to −0.005"
3/8"	6383K32	+0" to −0.005"	6384K61	+0" to −0.005"	6384K49	+0" to −0.005"
3/8"	6383K24	±0.010"	—	—	—	—
3/8"	6383K33	+0" to −0.005"	—	—	—	—
3/8"	6383K34	+0" to −0.005"	—	—	—	—
3/8"	6383K49	±0.010"	—	—	—	—
7/16"	6383K41	+0" to −0.005"	6384K62	+0" to −0.005"	6384K48	+0" to −0.005"
7/16"	6383K45	±0.010"	6384K63	+0" to −0.005"	6384K74	+0" to −0.005"

SKF.com / Products / Interactive Engineering Catalogue /

On-line Interactive Catalogs

Rolling bearings

- Principles of bearing selection and application
- Deep groove ball bearings
- Angular contact ball bearings
- Cylindrical roller bearings
- Combined needle roller bearings
- Taper roller bearings
- CARB® toroidal roller bearings
- Angular contact thrust ball bearings
- Needle roller thrust bearings
- Spherical roller thrust bearings
- Backing bearings for cluster mills
- Engineering products
- Bearing accessories
- Y-bearings
- Self-aligning ball bearings
- Needle roller bearings
- Combined cylindrical roller/taper roller bearings
- Spherical roller bearings
- Thrust ball bearings
- Cylindrical roller thrust bearings
- Taper roller thrust bearings
- Track runner bearings
- Indexing roller units
- Mechatronics
- Other SKF rolling bearings

Tolerance Calculation - 'Worst Case Method'

for correct fit in all cases, if manufactured to specification

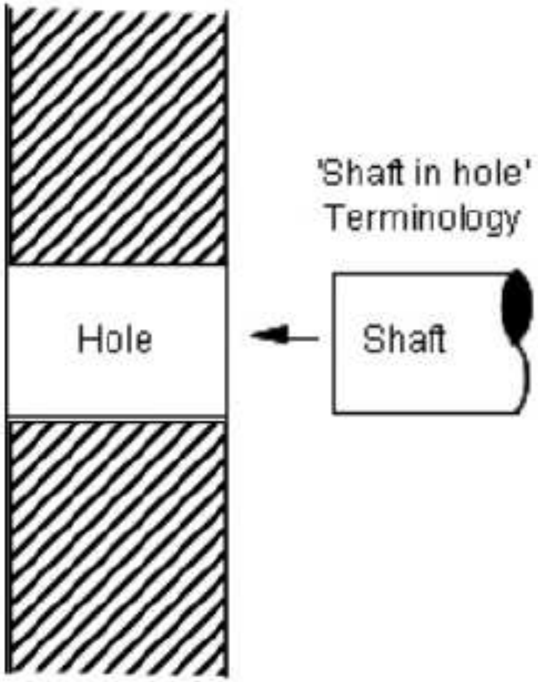
Allowance
The minimum allowable difference between mating parts:

Allowance = Smallest Hole Size - Largest Shaft Size

Clearance
The maximum allowable difference between mating parts:

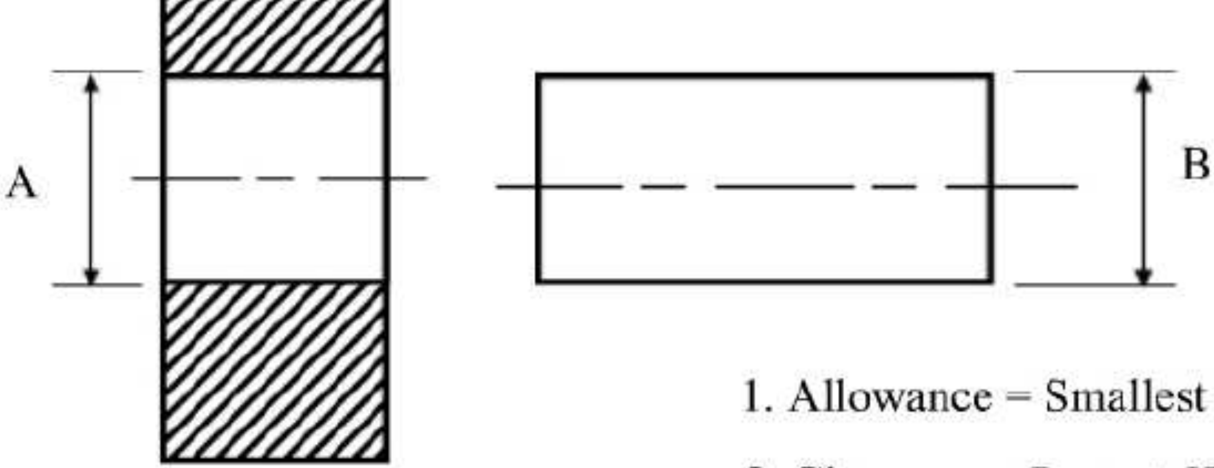
Clearance = Largest Hole Size - Smallest Shaft Size

The 'Tolerance Build-up Problem'
Where the combined dimension of several mating parts results in an unacceptable condition: generally non-functional (e.g. rotating or sliding action impaired), or parts will not assemble, or aesthetically unacceptable (e.g. inconsistent gaps around car doors)



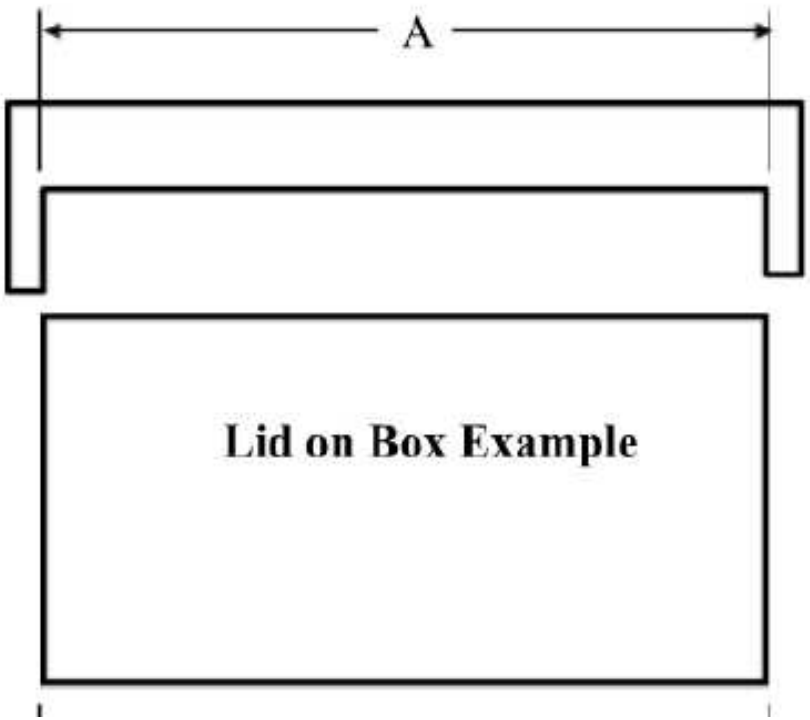
Worst Case Tolerancing

Shaft in Hole Example



1. Allowance = Smallest Hole Size (A) – Largest Shaft Size (

2. Clearance = Largest Hole Size (A) – Smallest Shaft Size (



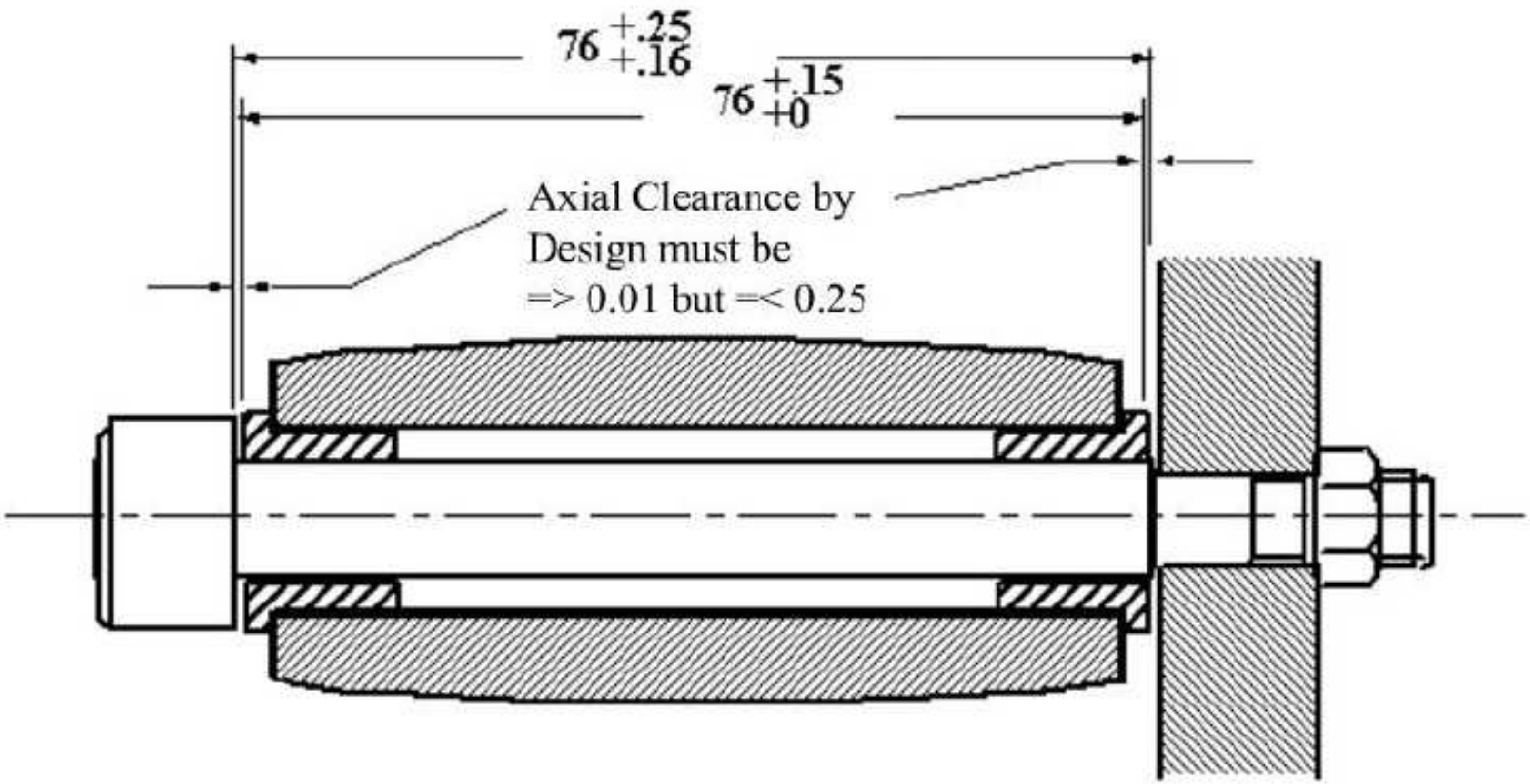
Lid on Box Example

If dimension with tolerance is $10^{+0.125}_{-0.125}$

Largest feature size = 10.125

Smallest feature size = 9.875

Tolerance Calculation - Tensioner Assy. Example



Worst Case Tolerancing:

1. Allowance = Smallest Hole Size (76.16) – Largest Shaft Size (76.15) = 0.01
2. Clearance = Largest Hole Size (76.25) – Smallest Shaft Size (76.00) = 0.25

Surface Properties - Texture and Hardness

Surface Finish

Basic Surface Texture Symbol

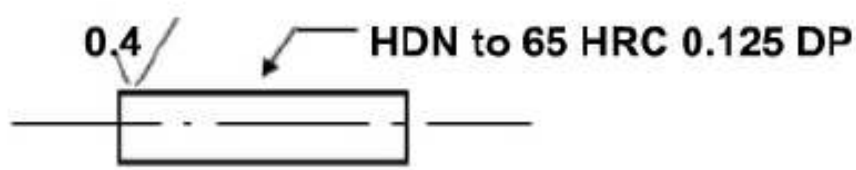
With Roughness Value (Typically R_a µm or µ")

Material Removal by Machining

With Machining Allowance

Hardness

Harden = HDN - may see symbol 
Heat Treat = H/T
Rockwell = HRC, HRA etc or R_a or R_c
Brinell = BNL



Comparative Roughness Values

Roughness Ra	Typical Processes
25 µm (1000 µ”)	*Flame Cutting*
12.5 µm (500µ”)	*Sawing*, sand casting,
6.3 µm (250µ”)	*forging,* shaping, planing
3.2 µm (125µ”)	*Rough machining*, milling, rough turning, drilling, and die casting
1.6 µm (63µ”)	*Machining*, turning, milling, die and investment casting, injection molding, and stamping
0.8 µm (32µ”)	*Grinding*, fine turning & milling, reaming, honing, injection molding, stamping, investment casting
0.4 µm (16µ”)	*Diamond Turning*, Grinding, lapping, honing
0.2 µm (8µ”)	*Lapping*, honing, polishing
0.1 µm (4µ”)	*Superfinishing*, polishing, lapping

Some Common Steel, Hardness and Surface Finish Specs.

Common Types

Common Steel Specs: **(10xx series: xx = % carbon)**

Mild steel (low carbon = up to 30 %): Low cost general purpose applications, typ. hardening not required — **1020**

Medium Carbon (up to 60%): requiring higher strength; e.g. gears, axles, con-rods etc. — **1040, 1060**

High Carbon (> 60%): High wear, high strength; e.g. cutting tools, springs etc. — **1080**

Ground Bearing Shaft Examples:

General Purpose

1060: Surface HDN to 55 HRC 0.125 mm deep min.; 0.4 µm (16 µ")

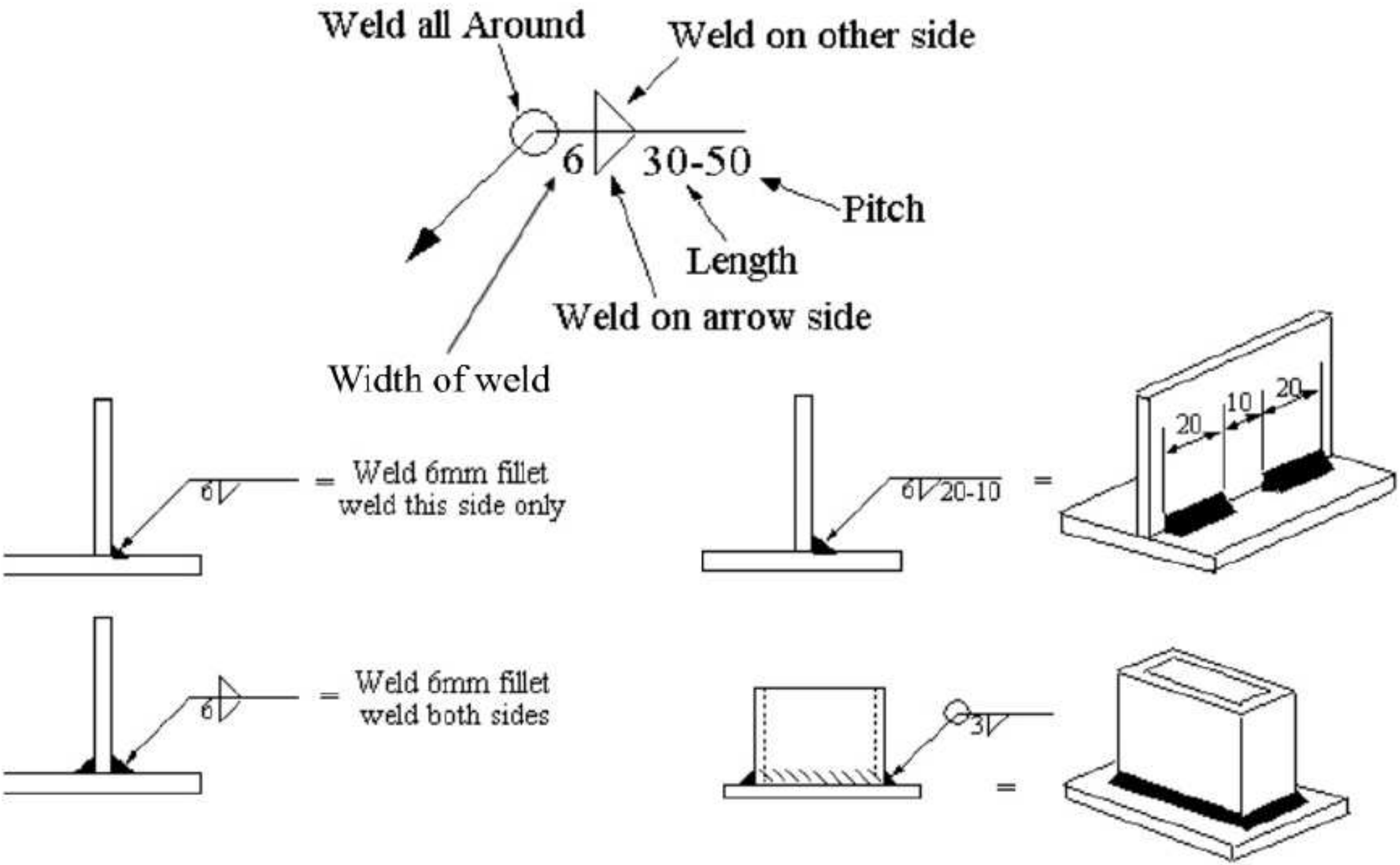
303 Stainless: (natural surface hardness 5 HRC); 0.4µm (16 µ")

Better Finish, Longer Life

1020: Case HDN to 65 HRC 0.25 mm deep min.; 0.2µm (8 µ")

440 Stainless: (natural circa 15 HRC); 0.2µm (8 µ")

Specifying Welds on Drawings



THANK YOU