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ABSTRACT

This training guide, developed during a project to retrain defense industry workers at risk of job loss or dislocation because of conversion of the defense industry, is designed for a course in blueprint reading for sheet metal workers. The following are among the topics covered in the course: orthographic projection; isometric and oblique projection; auxiliary views; surface identification; basic lines; drawing notes; title blocks; dimensions; flat pattern layout; tabulation tables; assembling drawings; and orthographic drawing interpretation. Included in the guide are the following: course outline; transparency masters; student handouts; quiz; student exercises; and reference tables. (MN)

Blueprint Reading for Sheet Metal Workers

Training Guide

Blueprint Reading Outline

September 13, 20 and 27, 1995

Blueprint Reading Outline

X. Flat Pattern Layout

A. Visualize orthographic views as isometric projection

B. Visualize orthographic views as flat pattern

C. Introduce air formed chart for 90 degree bends to calculate flat pattern
   1. exercise: calculate flat from example on chart
   2. calculate using outside dimensions
   3. calculate suing inside dimensions

D. Introduce square bend chart for 90 degree bends to calculate flat pattern
   1. exercise: calculate flat from example on chart
   2. calculate using outside dimensions
   3. calculate using inside dimensions

E. Discuss drawing number 403-1304
   1. visualize 3D part
   2. calculate flat pattern layout
   3. determine proper side for fasteners
   4. determine which way flanges bend for press break operation

F. Discuss drawing number 0318-2670
   1. visualize 3D part
   2. calculate flat pattern layout
      Note: material call out
      bend radii call out
      tolerance call out
   3. determine proper side for fasteners
   4. determine which way flanges bend for press break operation
      Note: bend reliefs front flange

Blueprint Reading Outline

X. Flat Pattern Layout, continued

G. Discuss drawing number 0405-4913
1. visualize 3D part
2. metric to English conversion
3. calculate flat pattern layout
   Note: material call out
   bend radii call out
   tolerance call out
4. determine proper side for fasteners
5. determine which way flanges bend for break operation
6. determine Weldnut location and position

H. Discuss drawing number 232-2819
1. visualize 3D part
2. calculate flab pattern layout
3. metric to english conversion
   Note: material call out
   bend radii call out
   tolerance call out
4. determine proper side for fasteners
5. determine which way flanges bend for press break operation
   Note: tabulation table

XI. Tabulation Tables

Blueprint Reading Outline

XII. Assembly Drawings

A. Discussion
B. Interpretation
C. Visualization

XIII. Orthographic Drawing Interpretation ***practice***

Dwg. No. 0319-2780
- position of fasteners (weldnuts)
- bend directions
- tabulation tables

Dwg. No. 403-1304
- direction of bends (parts have been bent backwards)
- holes and direction of part

Dwg. No. 0319-2670
- bend radius (see dwg. note)
- bend direction
- tolerances
- decimal places

Dwg. No. 130-3244
- flat pattern layout
- proper side for fasteners

Blueprint Reading Outline

XIII. Orthographic Drawing Interpretation ***practice continued***

Dwg. No. 403-3629
- flat pattern layout
- proper side for fasteners

Dwg. No. 0405-4913
- views (how to interpret)
- inside/outside
- views: front, top, right, left, bottom

Dwg. No. 232-3819
- tabulation tables
- flat pattern
- formed view
- inside/outside of a part

Table of Contents

Information on a Blueprint

Information found on a blueprint:

- Parts to be manufactured
- Dimensions
- Notes
- Material
- Title of the drawing and part
- Drawing number
- Manufactures name
- Tolerances
- Scale of the drawing
- Names of the drafter, engineer, and checkers
- Drawing and approval dates
- Revision information
- Tabulation tables

Team Quiz:

Look at the provided prints in your folder. Locate the requested information below. With your partner, number the various parts of a print.

1. Locate the parts, as shown in line drawings.
2. Point out the dimensions.
3. Point out the notes.
4. Where is the material listed?
5. What's the title of the drawing and the drawing number?
6. Where is the Onan/Cummins name located on the print?
7. Point out the tolerances.
8. What is the scale of this drawing?
9. Who drafted this print?
10. Who approved the print?
11. When was the print drafted?
12. Point out the revision information.

Orthographic Projection

Orthographic projection is a method of representing the true shape of an object on a single plane.

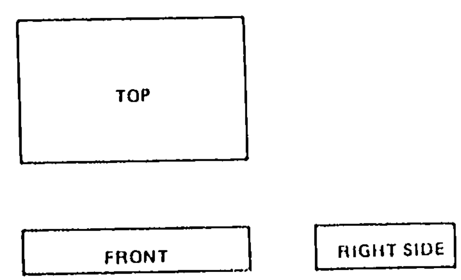
- Every line of an object is on a single plane.
- Every line of the object must appear as a line or point on the plane of projection.
- Lines that can be seen are shown as solid lines.
- Lines that are not visible, because they are hidden by some part of the object, are represented by dashed lines.

Orthographic projection is divided into 6 views:

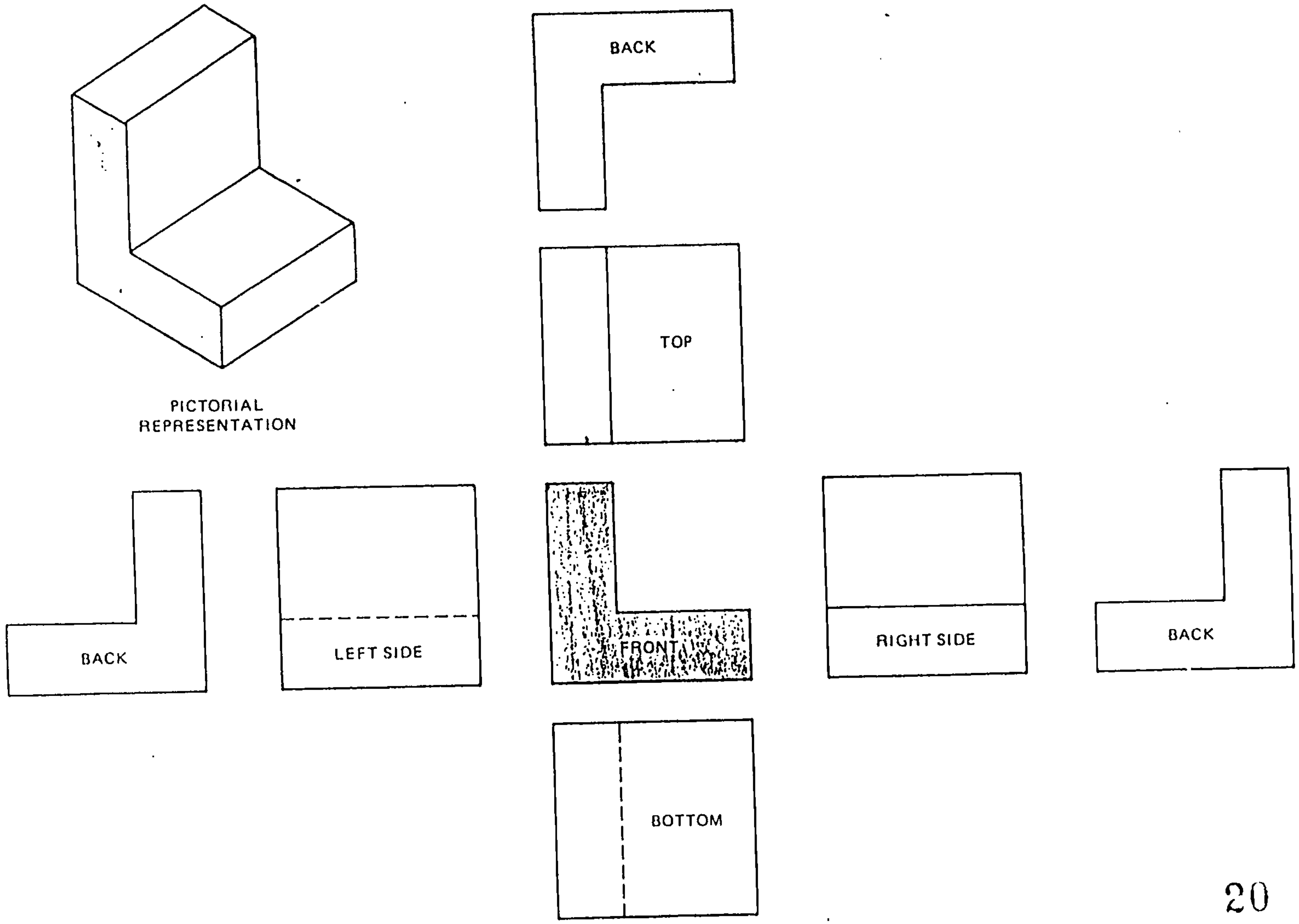
Front View:	main view of the part that shows most detail.
Top View:	projection upward from front view.
Right side:	view to the right of the front.
Left side:	view to the left of the front.
Bottom view:	opposite the top view.
Back view:	opposite the front view.

Principle Projections:

The principle projections are called front, top and side views. The process of projecting the essential views into a single plane is known as orthographic projection.

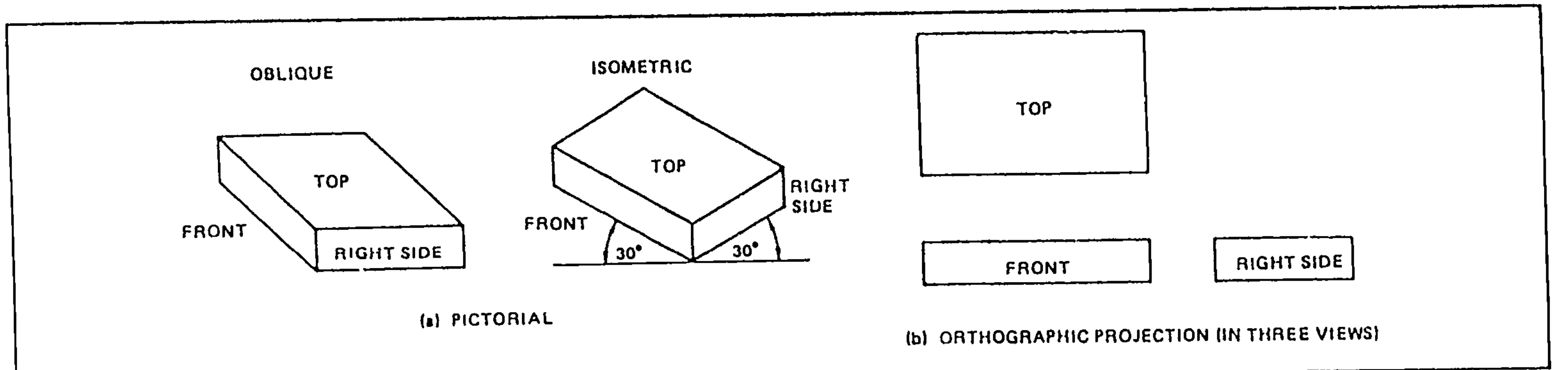


Views in Orthographic Drawings



19 20

Representing an Object



Oblique: To develop an oblique drawing, an orthographic view of the object is first drawn which best describes the shape and shows the most detail of the object.

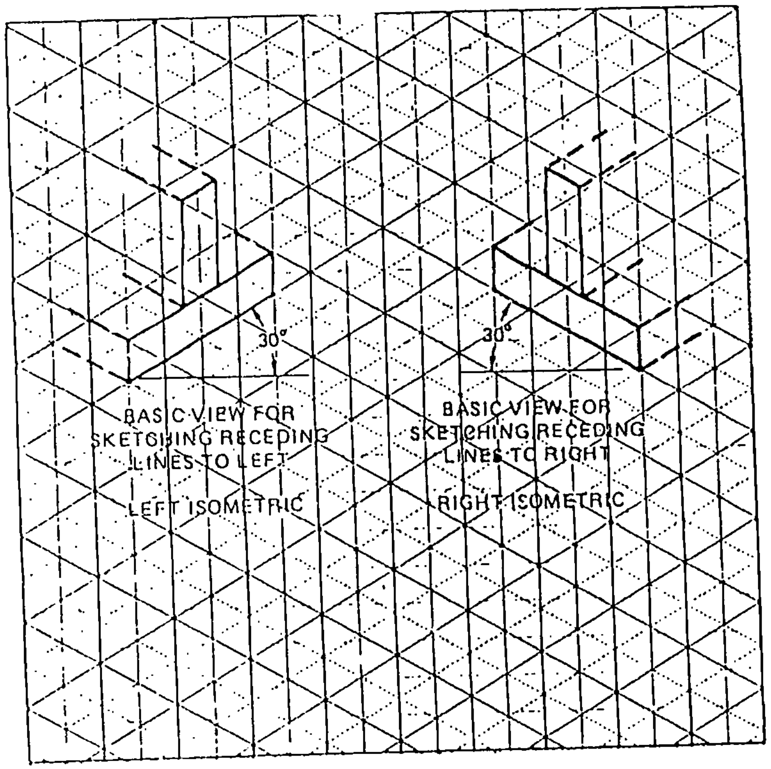
After the orthographic view is completed, one should draw parallel receding lines about 45 degree angles from the corners of the view (either to the right or to the left) to develop the three-dimensional effect. The extent of the receding lines is about one-half the length that would be shown for an orthographic drawing.

Isometric: To develop an isometric sketch, isometric graph paper is preferable. An isometric sketch has all of its surfaces shown at 30 degree angles. In the initial preparation of the sketch, a view of the object that best shows its shape and detail is selected and sketched at 30 degrees.

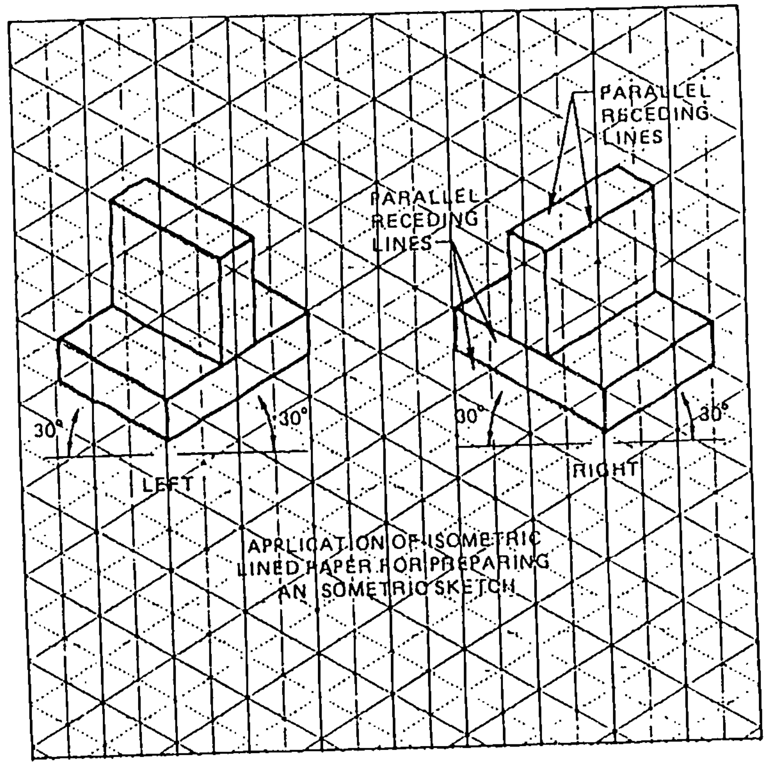
After completion of the basic view, parallel receding lines are sketched at 30 degree angles from each of the corners. Only those lines that represent the visible part of the object are shown. The sketch is completed by drawing the back edges.

Sketching an Isometric Drawing

Preliminary view for sketching isometric drawing of a fabricated T-support.

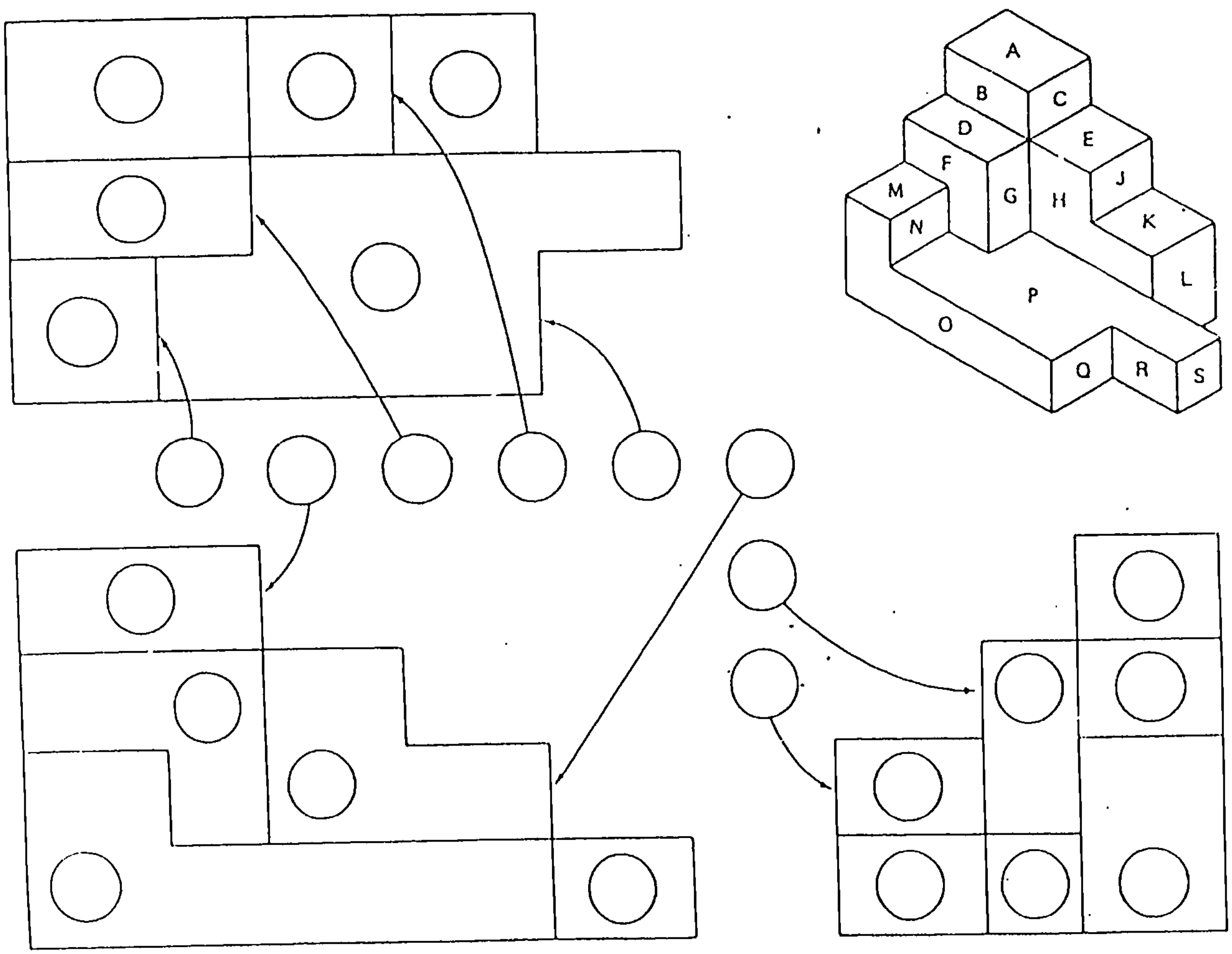


Left and right isometric sketches of a fabricated T-support.

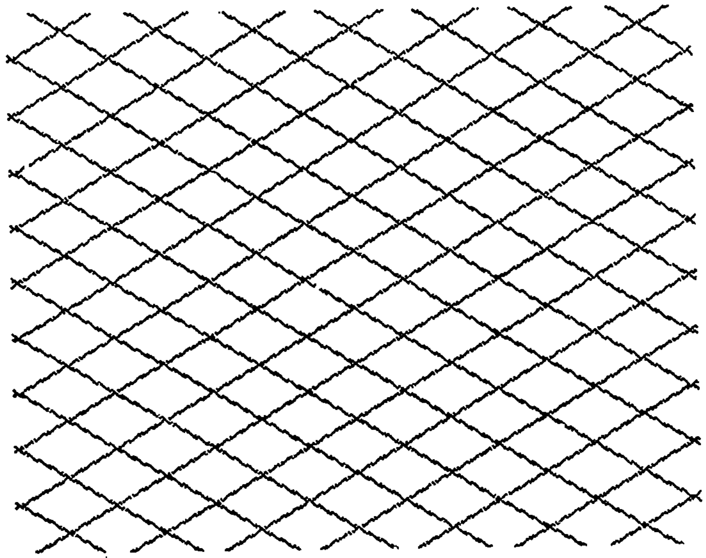


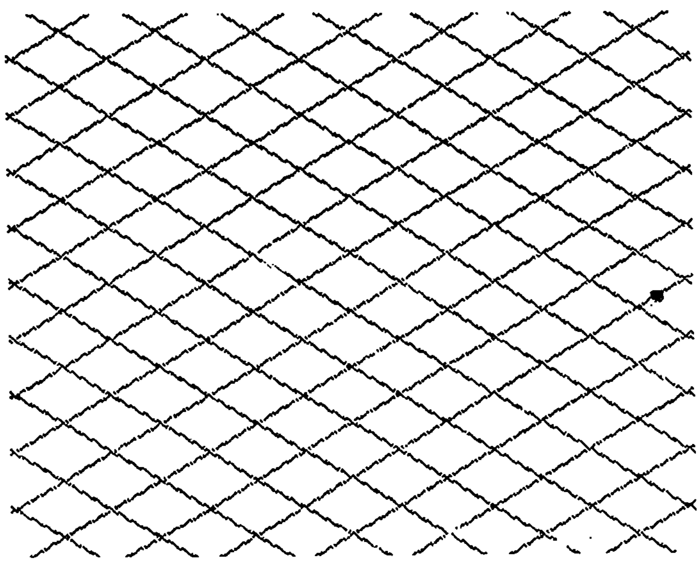
Surface Identification

Enter the letters from the pictorial view into the corresponding balloons on the orthographic views.



Your Sketches





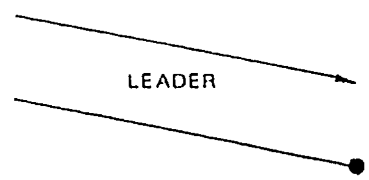
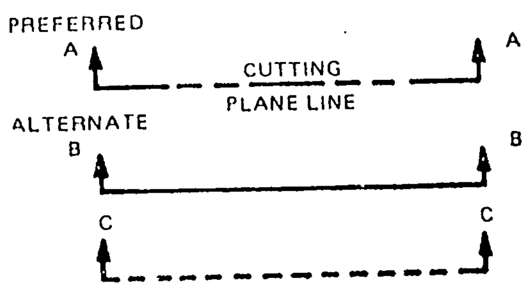
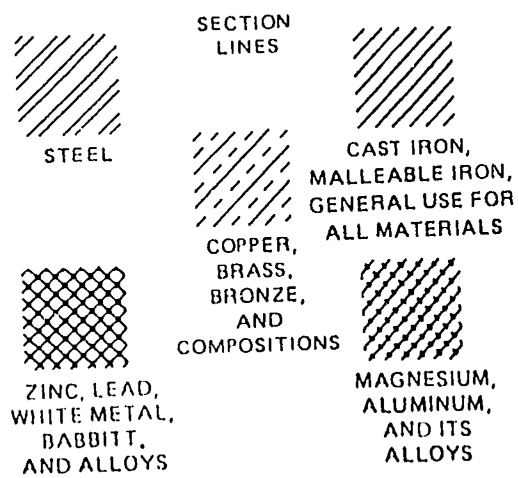
Basic Lines

There are several different types of lines used on a print.
Each line has a different meaning.

The purpose of each line deals with:

1. Shape of an object
2. Dimensioning of an object

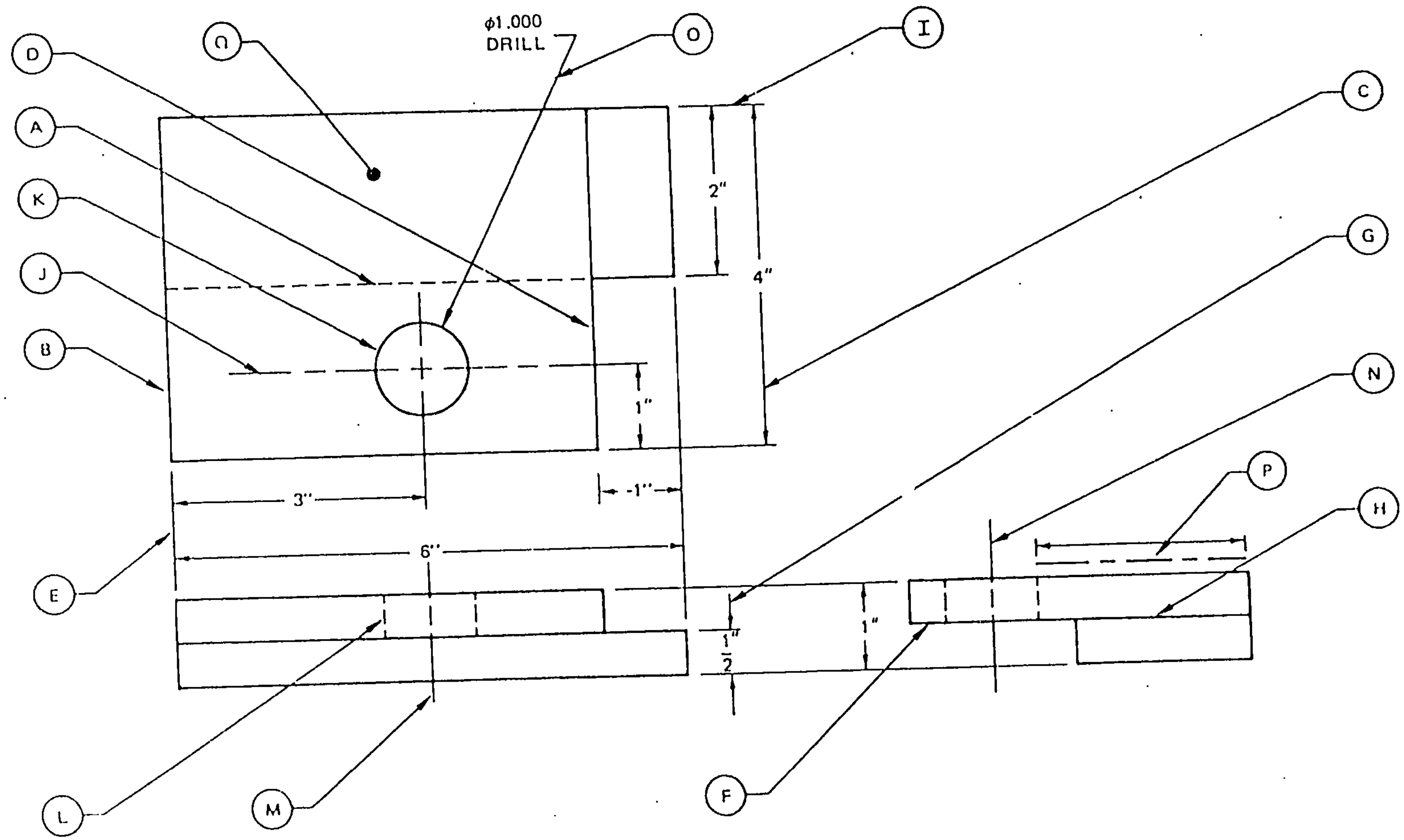
Type of Line	Description	Purpose
OBJECT LINE	Thick solid line.	To show the visible shape of a part.
HIDDEN LINE	Broken line of medium thickness.	To show edges and outlines **NOT** visible to the eye.
CENTER LINE	Fine, broken line made up of a series of short and long dashes alternately spaced.	To show the center of circles, arcs and symmetrical objects and to aid in dimensioning these parts.
EXTENSION LINE EXTENSION LINE DIMENSION LINE	Extension lines: fine lines that extent from the object with a light break between. Dimension lines: fine lines with arrowheads, unbroken except where the dimension is	Extension lines: show dimensioning points. Dimension lines: touch the extension lines and show distance given by the dimensions.

Type of Line	Description	Purpose
	Fine, straight line with an arrowhead or round solid dot at one end. It is usually drawn at an angle.	Points directly to surface for the purpose of dimensioning or adding a note. A dot may be used at the end of the straight line where reference is made a surface area.
	A heavy, broken line made up of a series of short dashes alternately spaced (or solid heavy lines or long dashes). Arrowheads are placed at right angles to the cutting plane lines.	Indicate where an imaginary cut is made through the object. The arrow points in the direction in which the section should be viewed. Letters next to the arrowheads identify the section in cases where more than one section is shown on the drawing.
	Series of fine lines - solid or solid and broken - arranged in specific patterns. They may be shown either straight or curved. When shown straight, they are usually drawn at 45 degree angle.	Indicate the imaginary cut surface referred to by the cutting plan line. To represent various kinds of materials.

Type of Line	Description	Purpose
CHAIN LINE	Heavy, broken line made up of a series of long and short dashes alternately spaced.	Indicates the location and extent of a surface area.
SHORT BREAK LINE	Heavy, irregular line drawn freehand.	To show a short break. To conserve space on a drawing. To show a partial section.
LONG BREAK LINE	Ruled, light line with freehand zigzags.	To show a long break. To conserve space on a drawing.
PHANTOM LINE	Light, broken line made up of a series of one long and two shot dashes.	To show alternate positions of a part. To show relationship of existing part to new part. To show machined surfaces.

Your Notes

Identifying Basic Lines



Identifying Basic Lines

Refer to the drawing above to identify the types and lines and their functions.

Identify to following types of lines:

A ______________________

B ______________________

C ______________________

D ______________________

E ______________________

F ______________________

G ______________________

H ______________________

I ______________________

J ______________________

K ______________________

L ______________________

M ______________________

N ______________________

O ______________________

P ______________________

Given the function or functions of the following lines:

A ______________________

B ______________________

C ______________________

E ______________________

J ______________________

Bonus Question:

What does Q have reference to?

____

Local & General Notes

A note is lettered information concerning the details of construction. The note explains, specifies, or refers to the material and/or processes needed to make the part. Notes help to conserve space on the print, and to save time in preparing the drawing. It is often shown as an abbreviation or symbol.

Local Notes: When a note applies to a particular part on an object, it is called a local note. Such a note is placed near one of the views representing the part.

General Notes: A general note applies to the drawing as a whole. It is placed in an open space away from the views so that it can be seen easily.

Local Note

NOTE:
1. ALL CORNERS WHICH PRODUCE FLANGES WHICH CLOSE UPON EACH OTHER MUST HAVE A R.12 MAX RELIEF AT THE INTERSECTION.
2. WELDNUTS IN THIS AREA MUST BE ATTACHED AS SHOWN.
3. OPTIONAL MATERIAL: MS02095

General Note

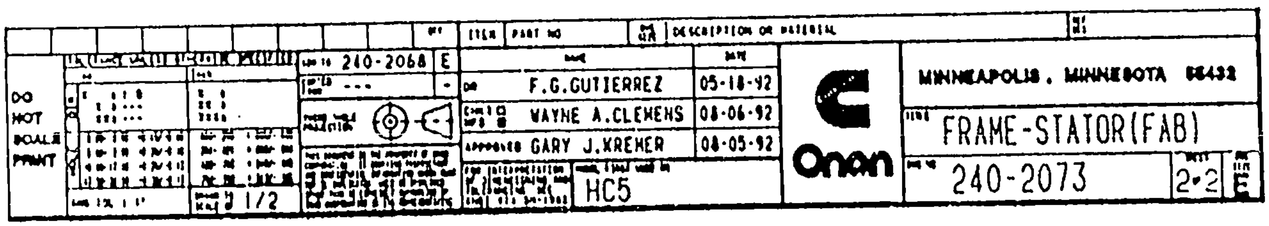
NOTES:
1. MATERIAL:
   1.1. NI MATERIAL:
   BMS SHEET
   011-11402 1.6MM THK
2. NI PART NO. (REF): SEE TAB

Title Blocks

Title blocks consist of:

A. Name of part or project
B. Quantity required
C. Material description
D. Scale size used
E. Drawn by
F. Checked by
G. Drawing Number
H. Dates
I. Tolerances
J. Onan/Cummins name
K. Drawing Projection
3rd Angle vs. 1st Angle

Place the corresponding letters in the Onan/Cummins title block below:

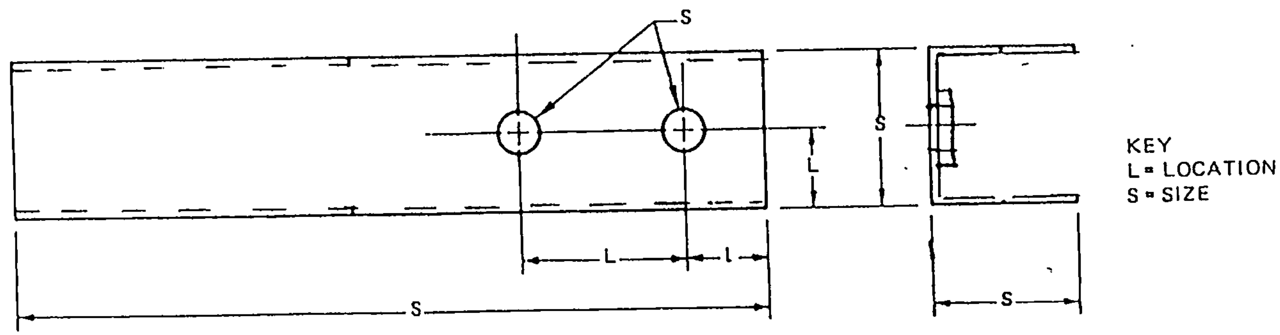


Dimensions

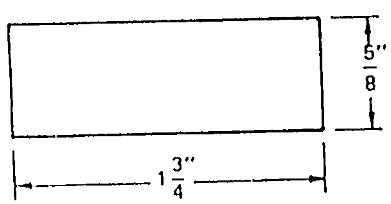
Dimensions serve two important functions on a print:

1. They give the sizes needed to fabricate a part.
2. They indicate the location where components of the part should be placed, assembled, machined or welded.

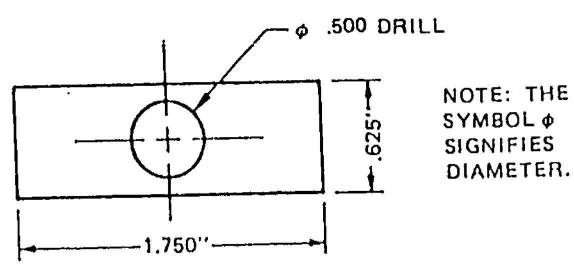
Size and location of dimensions:



Fractional Inch



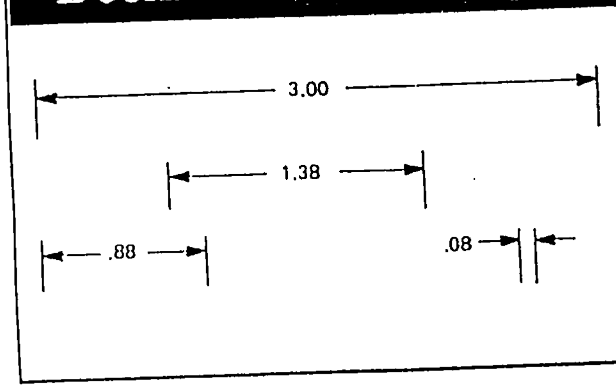
Decimal Inch



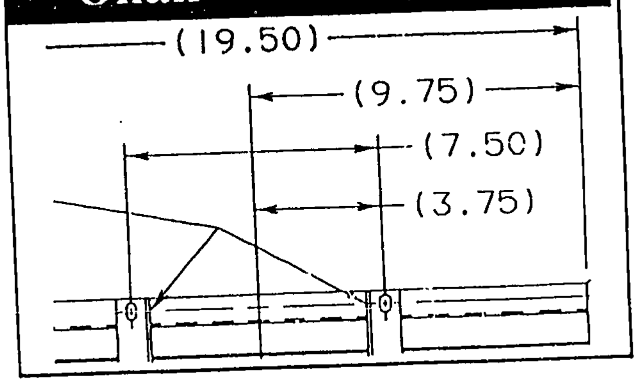
Dimensioning Units

In the decimal inch system (U.S. Customary), parts are designed in basic decimal increments, preferable .02 inch and are expressed as two-place decimal numbers. Using the .02 module, the second decimal place (hundreths) is an even number or zero. Sizes other than these, such as .25 are used when they are essential to meet design requirements.

Decimal Inch Example



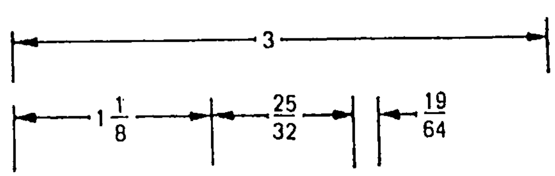
Onan - Decimal Inch



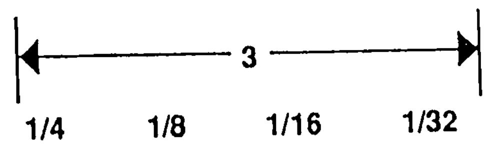
Dimensioning Units

Some dimensions are shown in fraction inches. In the Fractional Inch System, sizes are expressed in common fractions, the smallest division being 64ths.

Fractional Inch Example



Onan - Fractional Inch



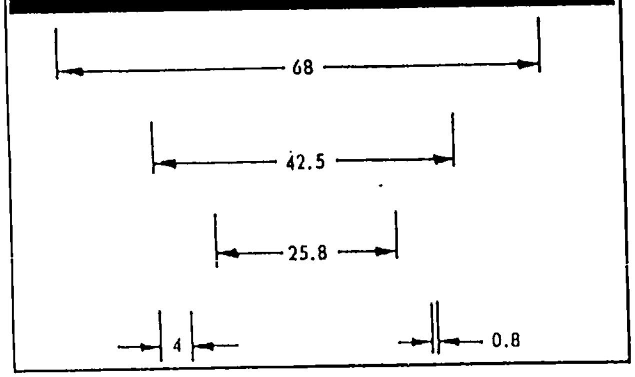
Dimensioning Units

Some projects are dimensioned in metric or millimeters. The SI Metric Unites of Measurement shows engineering drawings in: millimeters for the linear measure and micro meters for surface roughness. A millimeter value of less than one is shown with a zero to the left of the decimal point.

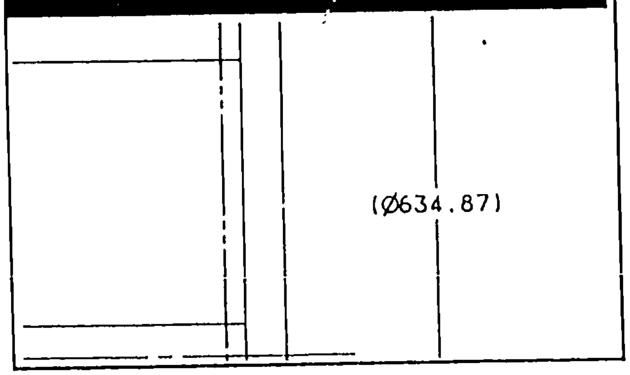
For example:

0.2	not	.2 or .20
0.26	not	.26

SI Metric Units Example



Onan - SI Metric Units

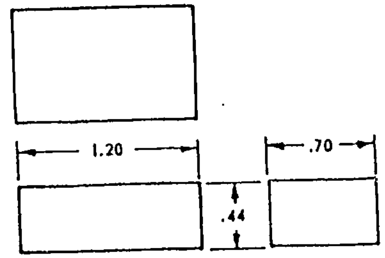


Basic Rules for Dimensioning

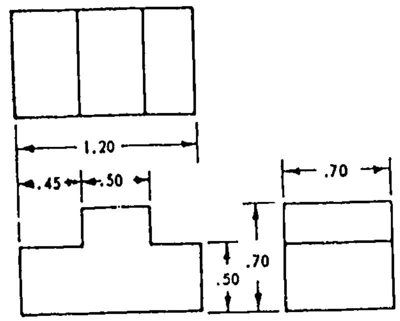
1. Place dimensions between views when possible (See A).

2. Place the dimension line for the shortest width, height, and depth, nearest the outline of the object (See B).
   Parallel dimension lines are placed in order of their size, making the longest dimension line the outermost line.

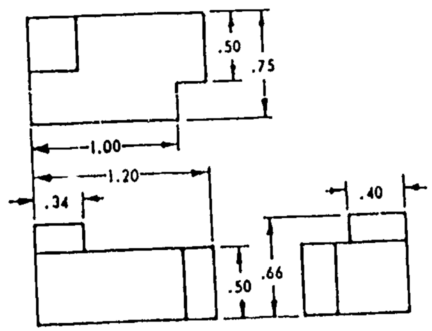
3. Place dimensions near the view that best shows the shape of the object (See C).



(A) PLACE DIMENSIONS BETWEEN VIEWS



(B) PLACE SMALLEST DIMENSION NEAREST THE VIEW BEING DIMENSIONED



(C) DIMENSION THE VIEW THAT BEST SHOWS THE SHAPE

QUESTIONS

1. What is the name of the object?
2. What is the drawing number?
3. How many pieces are to be made?
4. Of what material is the part made?
5. What is the overall width?
6. What is the overall depth?
7. What is the overall height?
8. Which line or surface in the side view represents surface (F) in the top view?
9. Which line or surface in the side view represents surface (E) in the top view?
10. Which line or surface in the side view represents surface (G) in the top view?
11. Which line or surface in the side view represents surface (L) of the front view?
12. What is the vertical height in the side view from the surface represented by line (P) to that represented by line (Q)?
13. What is the height of the step in the side view from the bottom of the part to the surface represented by surface (E)?
14. Which two dimensions (letters) in the top view represent distance V in the side view?
15. Which two dimensions (letters) in the top view represent distance W in the side view?
16. Which line or surface in the side view represents surface (M) in the front view?
17. What is the height of line (N)?
18. Which line or surface in the front view represents the surface (R) in the side view?
19. Which line or surface in the top view represents surface (L)?
20. Which line or surface in the front view represents surface (F)?
21. Which line or surface in the front view represents surface (E)?
22. Which line or surface in the top view represents surface (M)?
23. What type of line is (T)?
24. What type of line is (Y)?
25. What units of measurement are used on this drawing?
26. Calculate dimensions B, C, D, and W.

ANSWERS

1 ______
2 ______
3 ______
4 ______
5 ______
6 ______
7 ______
8 ______
9 ______
10 ______
11 ______
12 ______
13 ______
14 ______
15 ______
16 ______
17 ______
18 ______
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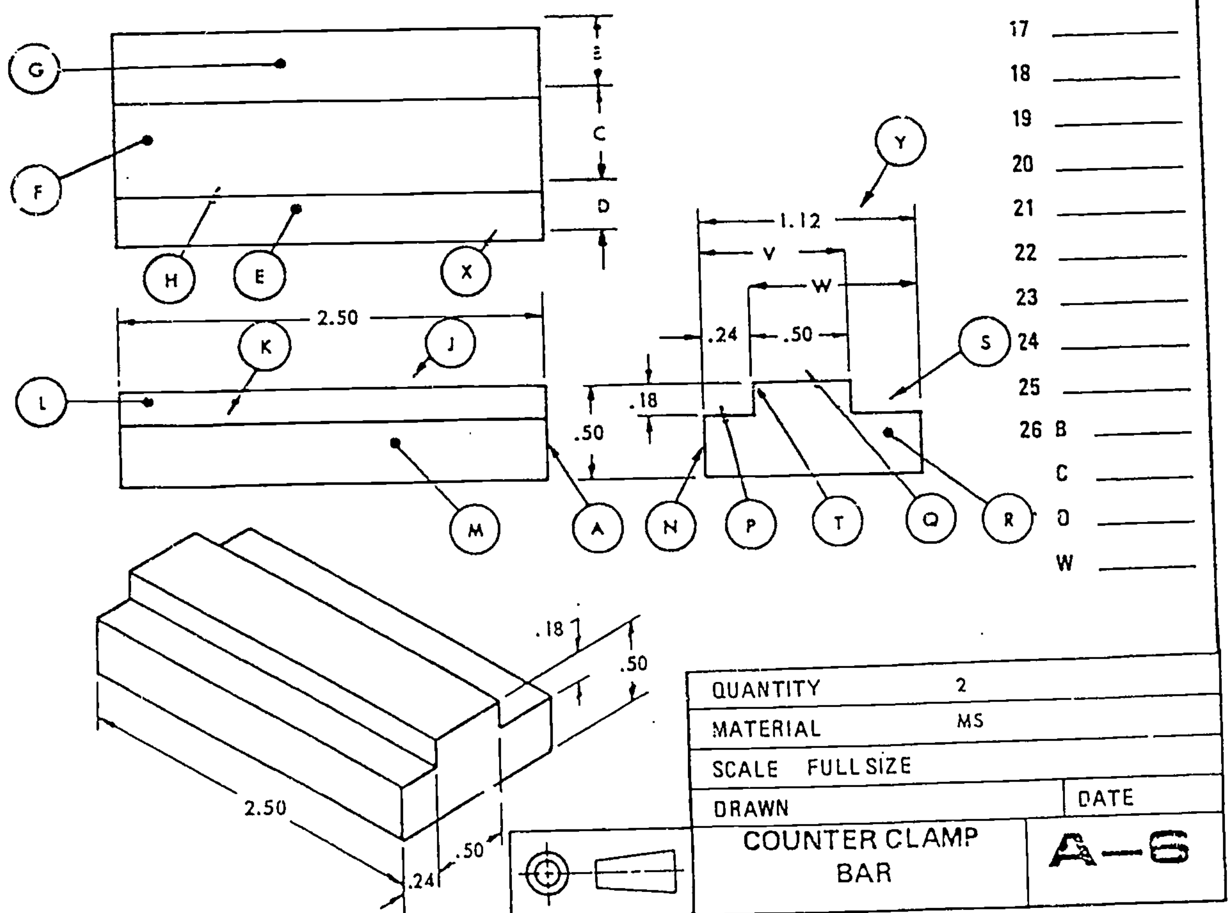
20 ______
21 ______
22 ______
23 ______
24 ______
25 ______
26 B ______
C ______
D ______
W ______



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Tolerance Dimensions

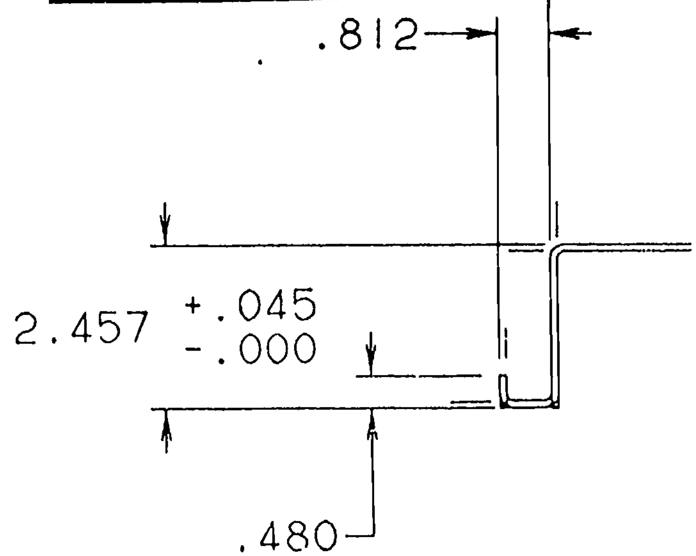
Tolerance is another important element of dimensioning. It is a figure given a plus (+) or minus (-) quality.

- It specifies the amount of error allowed when making a part.
- Tolerances are used to ensure the accuracy and proper fit of parts. This allows assembly and construction with the minimum of rework or adjustment.
- For many parts, tolerances are standardized and are found in prepared tolerance tables.

Tolerance Table

TOLERANCE UNLESS OTHERWISE SPECIFIED				
	mm		Inch	
DIM	X ± .X ± .XX ±		.X ± .XX ± .03 .XXX ± .015	
HOLE	0.09- 4.99 5.00- 9.99 10.00-17.49 17.50-24.99	+0.15/-0.08 +0.20/-0.10 +0.25/-0.13 +0.30/-0.13	.004-.200 .201-.421 .422-.703 .704-.999	+.006/-.003 +.008/-.004 +.010/-.005 +.012/-.005

Tolerance Notes



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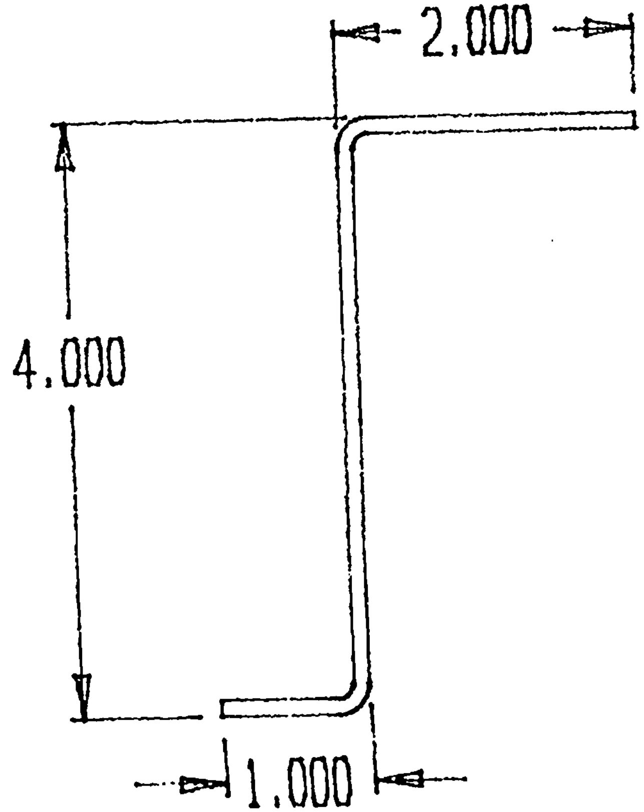
Your Notes

Air Bending Bend Allowances Table

Material Gauge Thickness	Die Set	Bend Allowance Per 90% Bend
20 GA. CRS (.036")	100, 105, 123	ID + .012" or OD - .060"
18 GA. CRS (.048")	101, 106, 119, 124, 129	ID + .006" or OD - .090"
16 GA. CRS (.060")	101, 106, 119, 124, 129	ID + .020" or OD - .100"
14 GA. CRS (.075")	102, 107, 118, 125, 130	ID + .025" or OD - .125"
12 GA. CRS (.105")	127, 128, 131	ID + .023" or OD - .187"
11 GA. CRS (.120")	103, 108, 113, 116, 126, 132	ID + .022" or OD - .218"
10 GA. HRS (.135")	103, 108, 113, 116, 126, 132	ID + .045" or OD - .225"
6 GA. HRS (.187")	109	ID + .029" or OD - .345"
1/4 GA. HRS (.250")	110	ID + .050" or OD - .450"

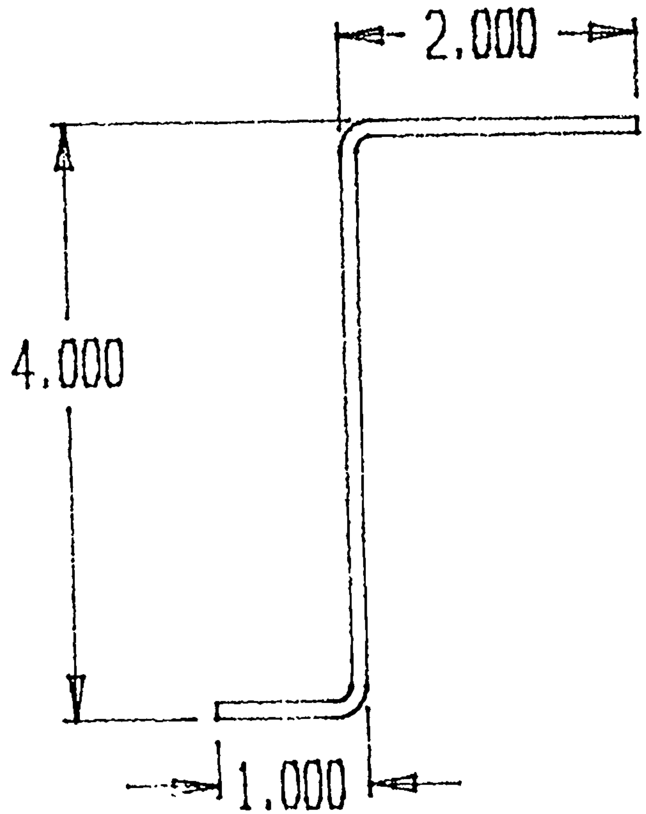
Bend Allowance Calculations

Example from Table



Bend Allowance Calculations

Example from Table



Mat. 12ga. CRS

Cut size calculation
using outside (OS) dimensions
$2.0 + 4.0 + 1.0 - (2 \times .187) =$

Cut size calculation
using inside (IS) dimensions
$1.895 + 3.790 + 0.895 + (2 \times .023) =$

Square Bends Bend Allowances

MT	INSIDE +	OUTSIDE	
26 ga (.0179)	.006	-.030 =	(.006 - .036)
22 ga (.0299)	.010	-.050 =	(.010 - .060)
20 ga (.0359)	.012	-.060 =	(.012 - .072)
18 ga (.0478)	.016	-.082 =	(.016 - .098)
16 ga (.059)	.020	-.100 =	(.020 - .120)
14 ga (.0747)	.025	-.125 =	(.025 - .150)
12 ga (.1046)	.052	-.157 =	(.052 - .209)
1/8 (.125)	.062	-.188 =	(.062 - .250)
11 ga (.1192)	.060	-.178 =	(.060 - .238)
10 ga (.1345)	.067	-.202 =	(.067 - .269)
8 ga (.1644)	.082	-.246 =	(.082 - .329)
3/16 (.1875)	.094	-.281 =	(.094 - .375)
1/4 (.2500)	.125	-.375 =	(.125 - .500)

Radius bend
R + 1/3 MT x 1.570

Outside R Bend
1 BA - 2R - 2MT =

Inside R Bend
1 BA - 2R =

R = Radius
BA - Bend Allowance
MT - Material Thickness

Material	Prod. Set	Air Bending Difference	(For Back Gauge Setting) LVD Actual Bend Allowance
20 GA. CRS	100 or 105	+ .015"/Bend	Flange OD - .035"
16 GA CRS	101 or 106	None	Flange OD - .050"
14 GA. CRS	102 or 107	+ .007"/Bend	Flange OD - .060"
12 GA. CRS	103 or 108	+ .030"/Bend	Flange OD - .095"
12 GA. CRS	104	None	Flange OD - .080"
10 GA. CRS	103 or 108	+ .020"/Bend	Flange OD - .115"

EXAMPLE: A 10 GA. part which has two bends to form a channel will be 2 times .020" = .040" deviation with air bending. This deviation can be either divided equally among each side or distributed differently to hold a close tolerance dimension.

(NOTE THE RESULTS APPLY TO 90° BENDS)

Square Bends Bend Allowance Table

MT	Inside +	Outside -	
26 ga (.0179)	.006	-.030 =	(.006 - .036)
22 ga (.0299)	.010	-.050 =	(.010 - .060)
20 ga (.0359)	.012	-.060 =	(.012 - .072)
18 ga (.0478)	.016	-.082 =	(.016 - .098)
16 ga (.059)	.020	-.100 =	(.020 - .120)
14 ga (.0747)	.025	-.125 =	(.025 - .150)
12 ga (.1046)	.052	-.157 =	(.052 - .209)
1/8 (.125)	.062	-.188 =	(.062 - .250)
11 ga (.1192)	.060	-.178 =	(.060 - .238)
10 ga (.1345)	.067	-.202 =	(.067 - .269)
8 ga (.1644)	.082	-.246 =	(.082 - .329)
3/16 (.1875)	.094	-.281 =	(.094 - .375)
1/4 (.2500)	.125	-.375 =	(.125 - .500)

Square Bends Bend Allowance Table

Material	Prod. Set	Air Bending Difference	(For back gauge setting) LVD Actual Bend Allowance
20 GA. CRS	100 or 105	+.015"/Bend	Flange OD - .035"
16 GA. CRS	101 or 106	None	Flange OD - .050"
14 GA. CRS	102 or 107	+.007"/Bend	Flange OD - .060"
12 GA. CRS	103 or 108	+.030"/Bend	Flange OD - .095"
12 GA. CRS	104	None	Flange OD - .080"
10 GA. CRS	103 or 108	+.020"/Bend	Flange OD - .115"

Example: A 10 GA part which has two bends to form a channel will be 2 times .020" = .040" deviation with air bending. This deviation can be either divided equally among each side or distributed differently to hold a close tolerance dimension.

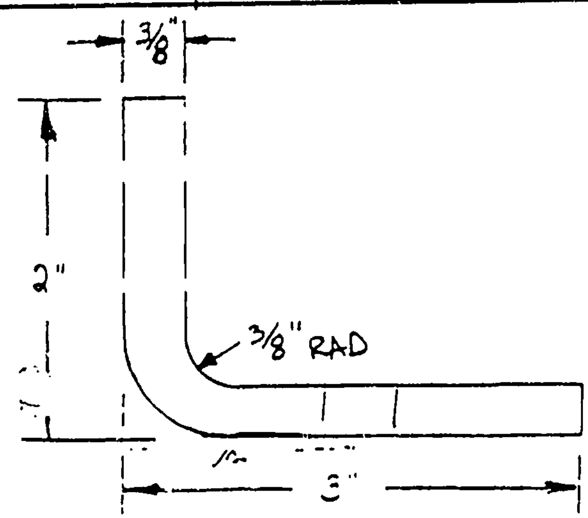
(Note the results apply to 90 degree bends)

Copper Bus Bar Bend Allowance

The Sheet Metal Department has new tooling for forming copper bus bar. There are separate upper and lower dies for 1/4", 3/8" and 1/2" radius and thickness. Samples of each material were formed to determine actual bend allowances. Listed below are the bend allowances, and they should be used on all formed copper components.

Material	Bend Allowance (Per Bend)
1/4" Copper	OD + OD -.460"
3/8" Copper	OD + OD -.650"
1/2" Copper	OD +OD -.875"

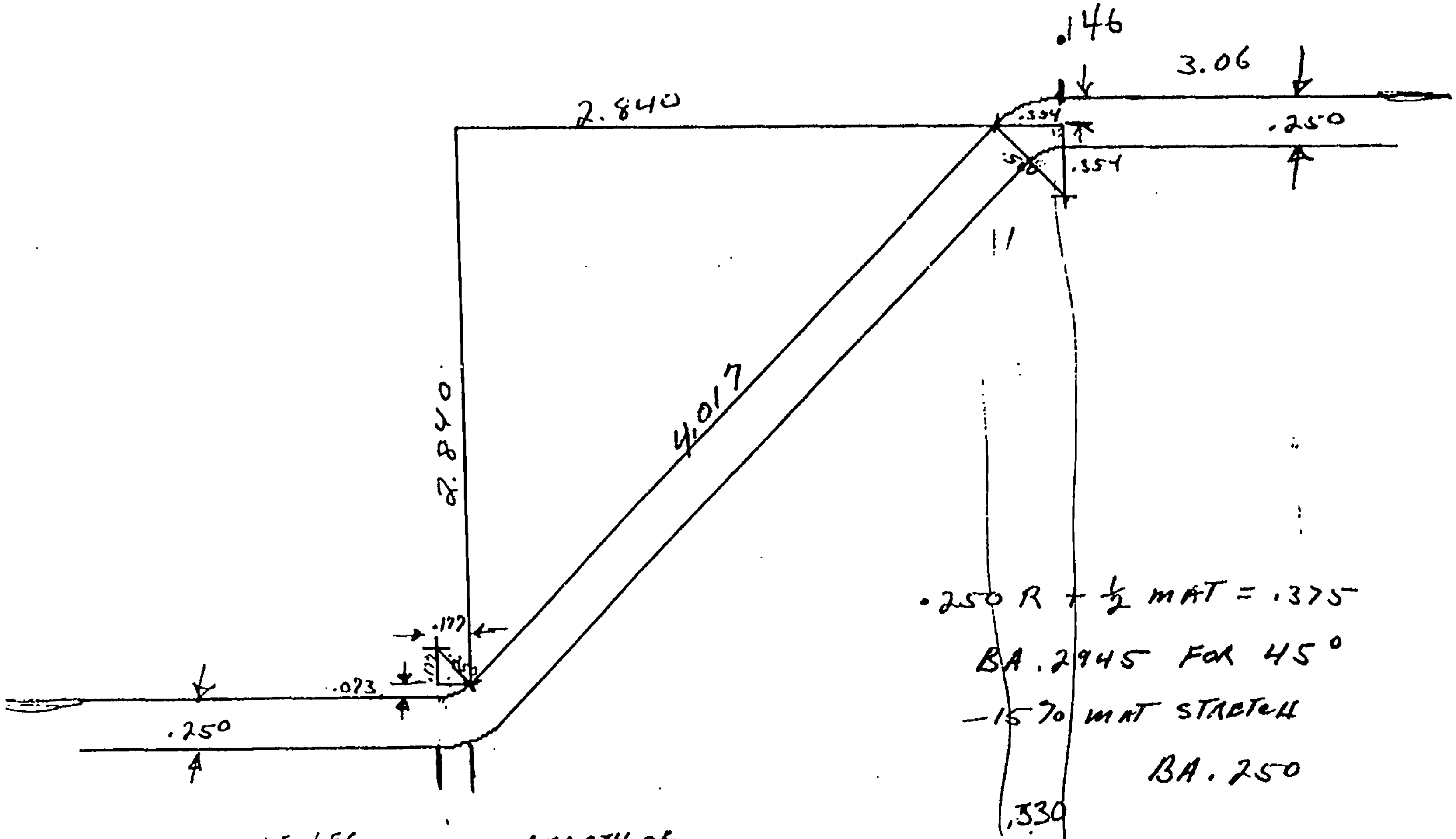
Example:
Cut size calculation
is 2" + 3" -.650
= .435 cut length



45 Degree Copper Bend Formula

1/8	-.110	+.265	+.125 each bend
1/4	-.220	+.530	+.25 each bend
3/8	-.330	+.795	+.375 each bend
1/2	-.440	+1.060	+.500 each bend

45 Degree Bend Example



ID-OD — .220 = ONE LEG OF TRI ÷ .707 = LENGTH OF 45° LINE