

Blueprint Reading



A Member of the Alabama Community College System

AIDT STUDENT TRAINING MANUAL TABLE OF CONTENTS

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I. BLUEPRINT READING

A. ALPHABET OF LINES

In industrial manufacturing, production personnel, product designers and manufacturing engineers must all speak the same language if the finished product is to look like the one needed. The product dimensions tolerances, material callouts, assembly directions and other information must be clearly understood.

The language that is used in manufacturing is not a spoken language, but a language of lines, numbers, symbols and illustrations. It is a graphic language that is drawn and read rather than spoken and heard. It is the language of blueprints where pictorial representations replace written instructions, and descriptions are expressed in graphic form.











A blueprint can take many different forms according to its purpose and the people who use it. Examples of these different forms include:

- Drawings for fabrication with standardized symbols for mechanical, welding, construction, electrical wiring and assembly.
- Sketches that illustrate an idea, technical principle or function.

The ability to read and interpret drawings and blueprints depends on the ability to recognize the different types of lines used in making the drawings, and to understand how these lines describe the object or parts represented. Lines used to represent an object and to aid in reading the drawing are made in definite standard forms. The relative thickness of a line, (thick or thin) and the line's composition—solid, broken, dashed—have specific meanings.

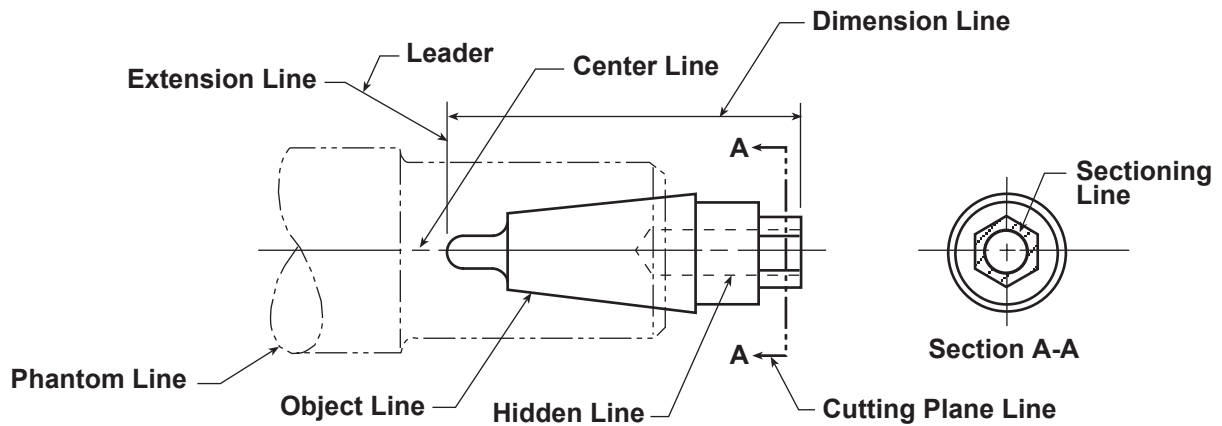
The combinations of line thickness and compositions are standardized in the Alphabet of Lines. (Figure 1-1)

FIGURE 1-1
Alphabet of Lines

BASIC LINES	LINE CHARACTERISTICS
① Visible (Object) Line	(THICK) 
② Hidden Line	(THIN) 
③ Center Line	(THIN) 
④ Extension and Dimension Line	(THIN) 
⑤ Cutting Plane Lines (Shows Direction of Viewing Plane)	(THICK)  (THICK) 
⑥ Section Line	(THIN) 
⑦ Break Lines	(THICK) (FOR SHORT BREAKS)  (THIN) 
⑧ Phantom Line	(THIN) 

As with each letter in the alphabet, each line in the Alphabet of Lines has a designated purpose in the language of blueprints. The most obvious reason for a line appearing in a drawing is to define the shape of an object. Lines are used for many other purposes, however, and the ability to recognize the type and purpose of a line in a drawing is the first step in becoming a good blueprint reader. Figure 1-2 provides examples of each type of line in the Alphabet of Lines. Definitions for each type of line follow the drawing.

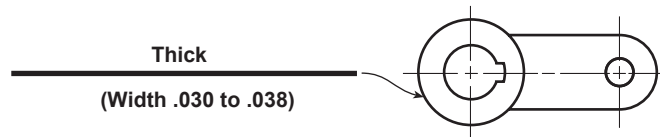
FIGURE 1-2
Examples of Line Types



1. Object Lines

Object or visible lines (see Figure 1-3) are thick solid lines that outline all surfaces visible to the eye. These are the most important lines because they are thick and solid and thus become the basis for comparing the weights and composition of all other lines used in a drawing.

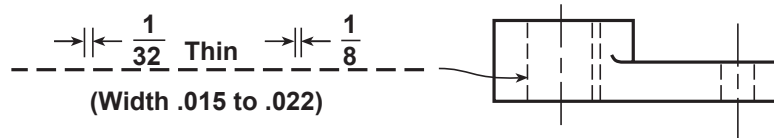
FIGURE 1-3
Object Line



2. Hidden Lines

Hidden or invisible lines, consisting of short, evenly-spaced dashes, outline invisible or hidden surfaces. They are thin lines, about half as heavy as visible lines. They always begin with a dash in contact with the line from which they start, except when a dash would form a continuation of a solid line. A hidden line is shown in Figure 1-4.

FIGURE 1-4
Hidden Lines



3. Center Lines

Center lines (see Figure 1-5) consist of alternating long and short dashes, with a long dash at each end and short dashes at points of intersection. The lines are the same weight as invisible lines. Center lines indicate the central axis of an object or part, particularly circular objects or objects made up of circular or curved parts. They are also used to indicate the travel of a center. Whenever a complete circle or hole is shown on a drawing, both horizontal and vertical center lines are used to indicate the center point of the circle or hole.

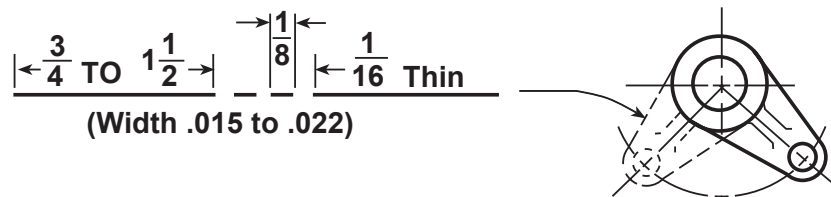
FIGURE 1-5
Center Line



4. Phantom Lines

Phantom lines (see Figure 1-6) are thin lines used to indicate alternate positions of the parts of an object, repeated detail or the locations of absent parts. They are made by alternating one long and two evenly-spaced, short dashes, with a long dash at each end.

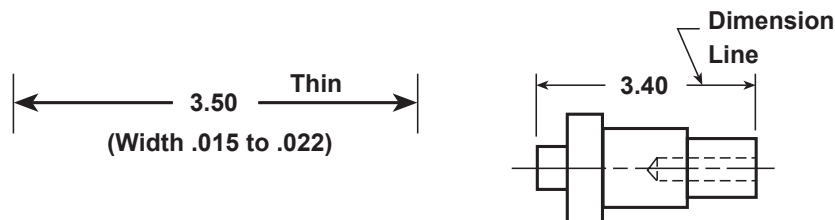
**FIGURE 1-6
Phantom Lines**



5. Dimension Lines

Dimension lines (see Figure 1-7) are short, solid lines that indicate the distance between two points on a drawing. They terminate or end in arrowheads at each end, and are broken to insert the dimension.

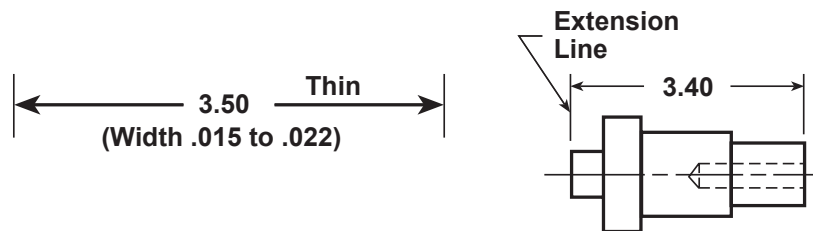
**FIGURE 1-7
Dimension Lines**



6. Extension Lines

Extension lines (see Figure 1-8) are short, solid lines used to show the limits of dimensions. They may be placed inside or outside the outline of an object. They extend from an outline or surface, but do not touch it. Extension lines are the same weight as invisible lines.

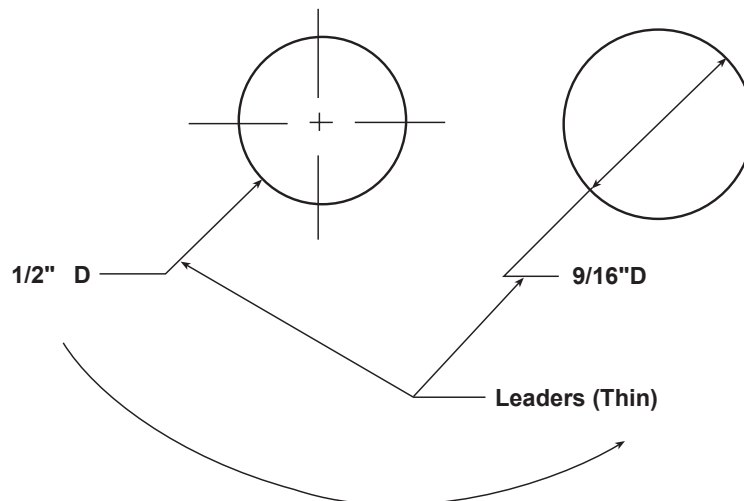
FIGURE 1-8
Extension Lines



7. Leaders

Leaders or leader lines (see Figure 1-9) indicate the part or area of a drawing to which a number, note or other reference applies. They are solid lines and usually terminate in a single arrowhead.

FIGURE 1-9
Leaders



8. Break Lines

There are long and short break lines (see Figure 1-10). These indicate that a part is broken out or removed to show more clearly the part or the parts that lie directly below the broken out part. They also are used to reduce the size of the drawing of a long part having a uniform cross section so that it can be shown on a smaller sheet of paper. Short breaks are indicated by solid, thick, freehand lines. Long breaks are indicated by solid, thin, ruled lines broken by freehand zigzags. Breaks on shafts, rods, tubes, and pipes are curved (see Figure 1-11).

FIGURE 1-10
Long-break Line

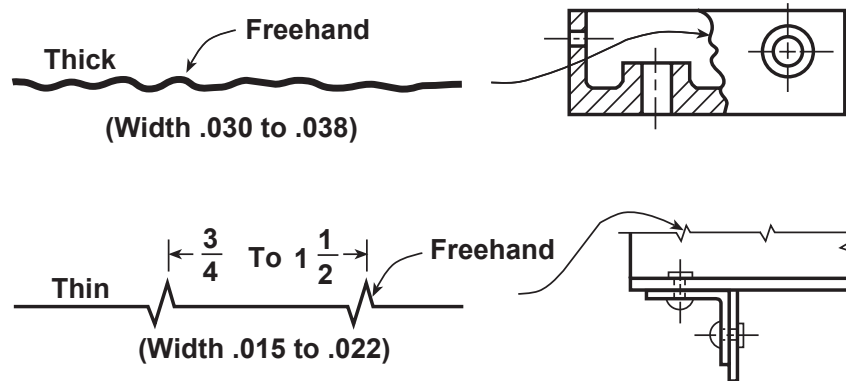
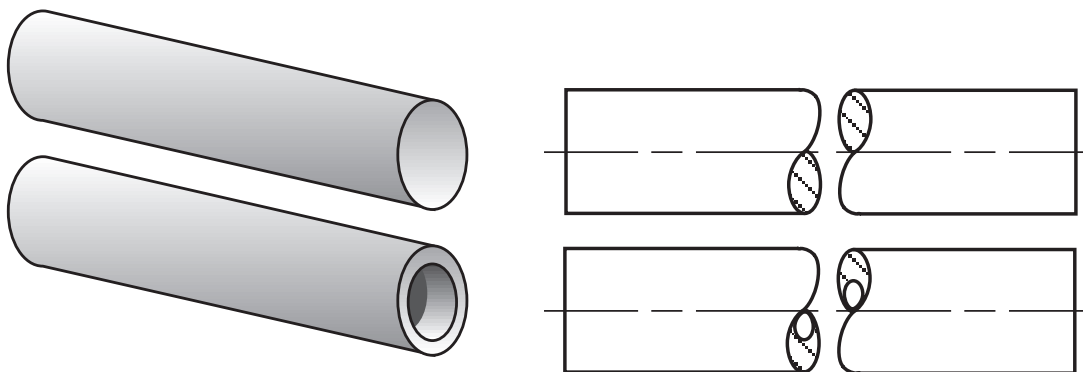
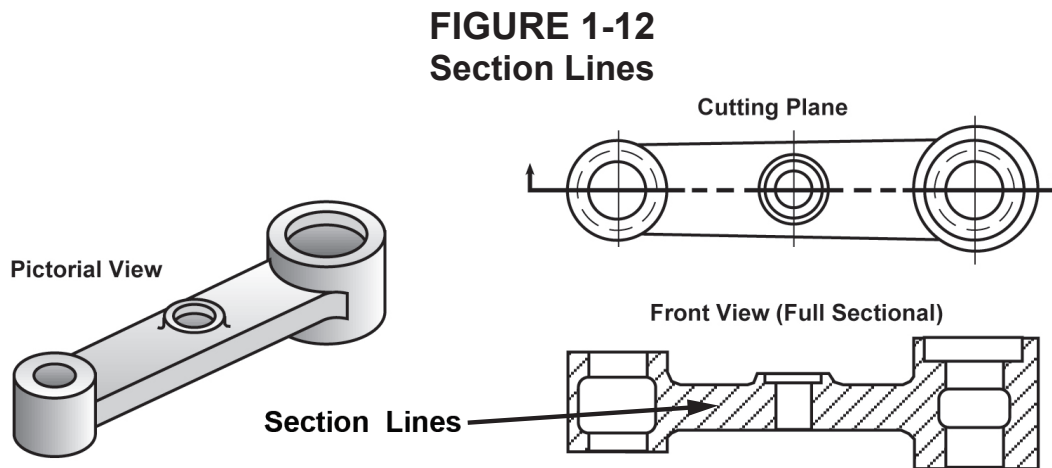


FIGURE 1-11
Round, Solid, Hollow Cross-Sections



9. Section Lines

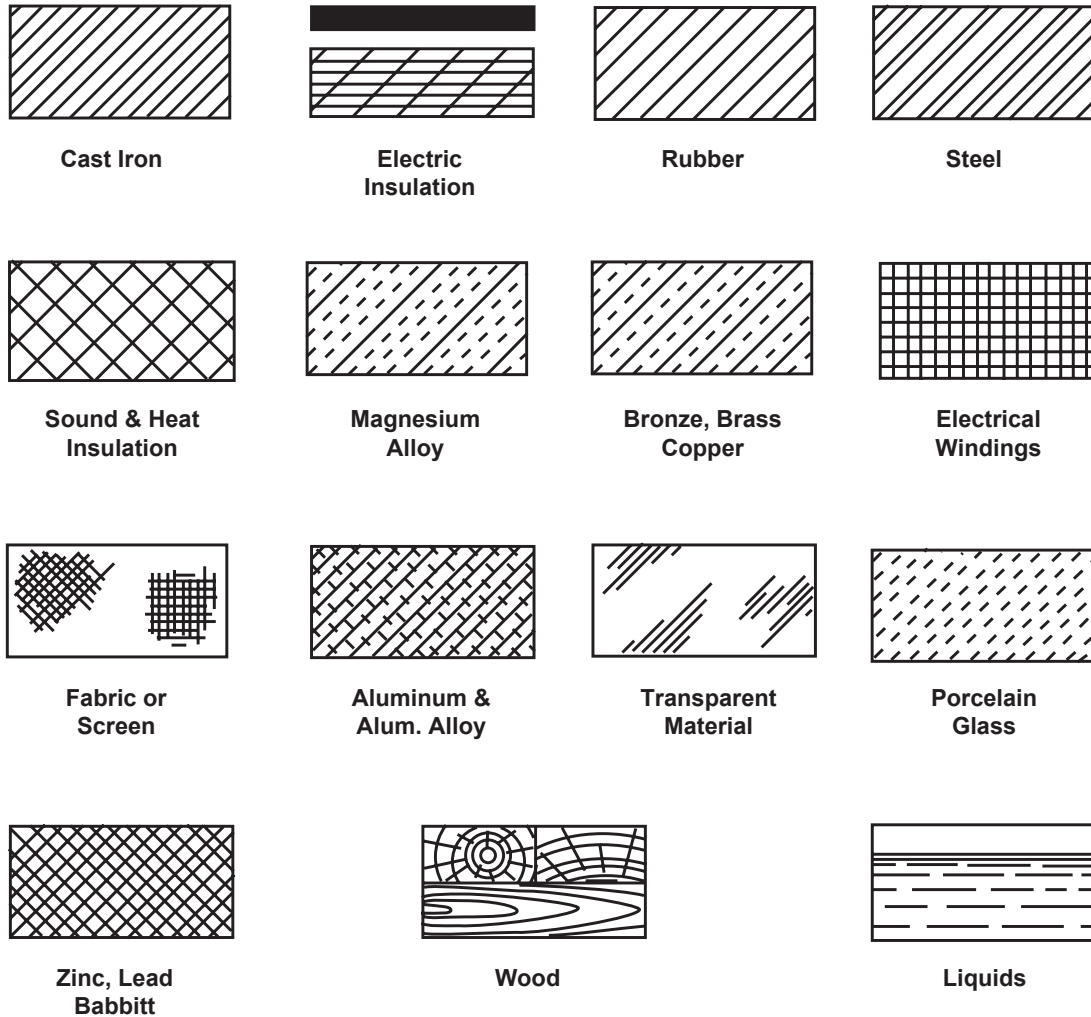
Section lines (see Figure 1-12) or crosshatch lines distinguish between two separate parts that meet at a given point. Each part is lined or hatched in opposite directions with thin parallel lines placed approximately $\frac{1}{16}$ inch apart at 30 degrees, 45 degrees, or 60 degrees across the exposed cut surface. Most section lines follow this pattern.



Section lines are also used to depict specific types of materials used in the part or subject of the drawing. The lines in the previous drawing represent cast iron but are used generally to show any cut or sectioned surface. If there is a need to represent a variety of materials or if a specific material must be used, individual parts within the drawing may be lined or crosshatched using different patterns for the various materials.

Patterns used to represent some of the more common materials used in manufacturing are shown in Figure 1-13.

FIGURE 1-13
Common Manufacturing Materials

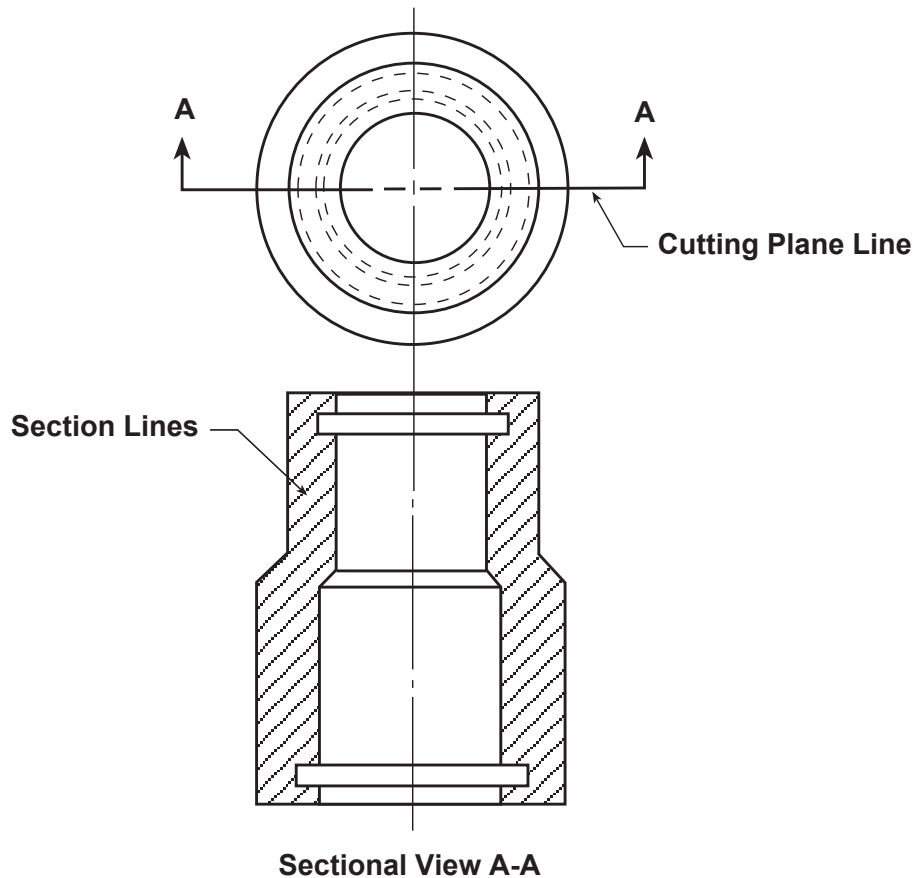


10. Cutting Plane Lines

A cutting plane line (see Figure 1-14) consists of a heavy dash followed by two shorter dashes. At each end, it has a short line at right angles to the cutting plane line terminating with arrowheads pointing in the direction from which the cut surface is viewed.

Cutting plane lines are usually labeled with a letter at either end to identify the drawing of the cut surface indicated by the same letters on the same sheet of paper. The cut surface drawing is called a section.

FIGURE 1-14
Cutting Plane Lines



Remember, the two factors which determine the appearance of a line are its relative thickness and its composition. Lines are drawn in two thicknesses—thick and thin. The composition of a given type line refers to the factors such as whether it is solid or broken, whether it contains dashes, whether the dashes are short or long or alternating, and similar variations in the way the line is drawn.

Application of lines is vital to ensure that the placement of the line does not interfere with the accurate representation of the part or subject of the drawing. For example, a hidden line begins with a dash in contact with the line from which it starts except when a dash would form a continuation of a solid line.

ALPHABET OF LINES EXERCISE

Perform practice exercises in student workbook.

B. SYMBOLS AND TERMINOLOGY

In addition to lines, information on blueprints is often provided by a variety of standard symbols and terminology. These terms and symbols eliminate the need for drawing each item in painstaking detail.

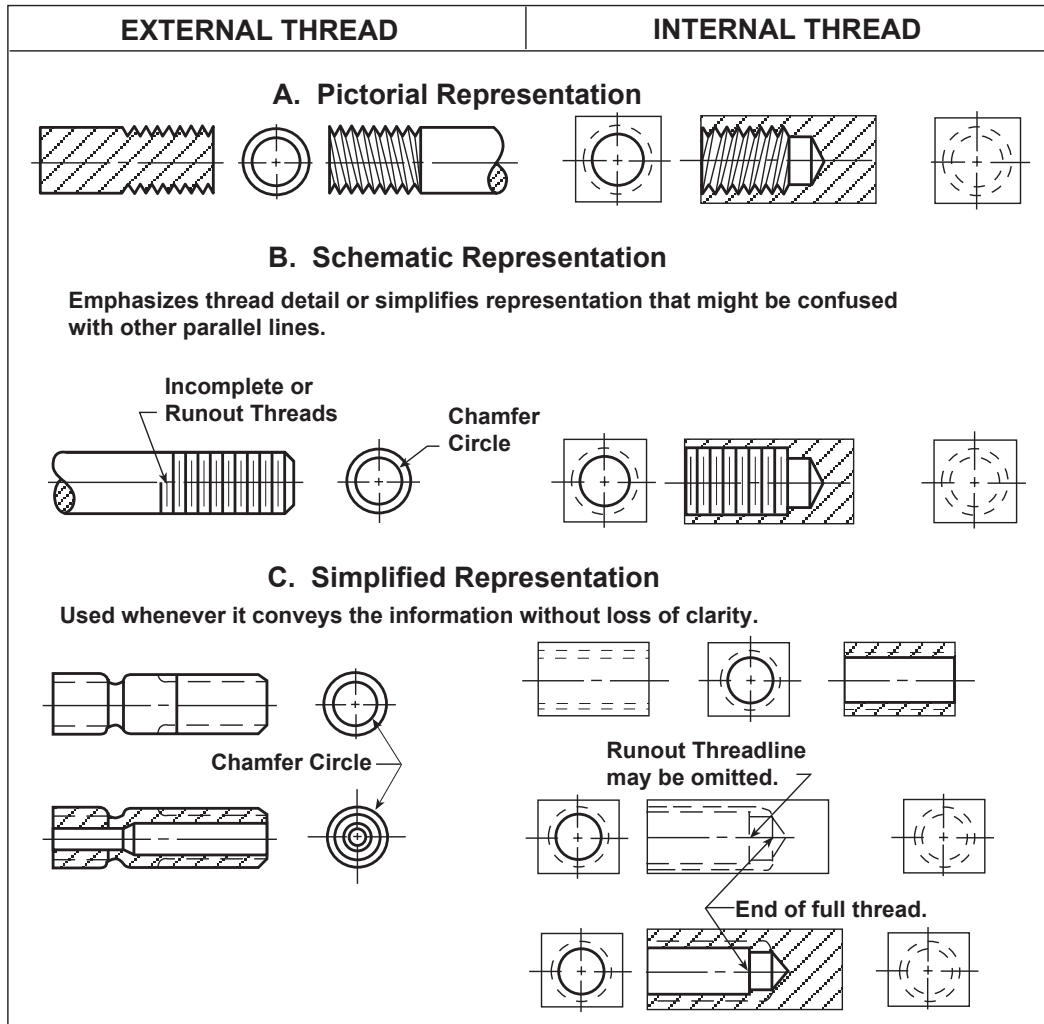
1. Thread Representation

True representation of a screw thread is seldom provided on working drawings because of the time required to draw such detail. Three types of conventions, or accepted drafting practices, are in general use for screw thread representation: pictorial, schematic and simplified presentation.

Simplified presentation is used to clearly portray the requirements.

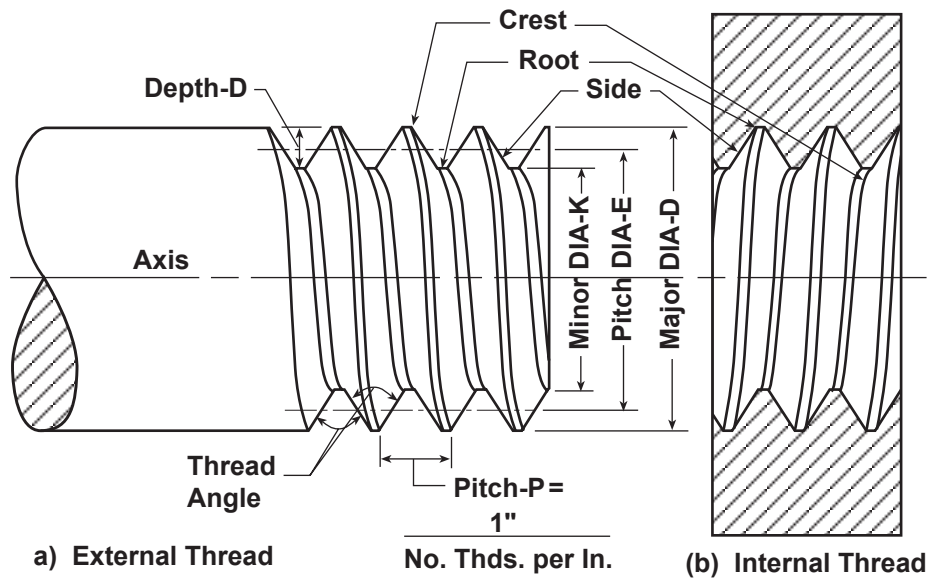
Schematic and pictorial representations require more drafting time but they are sometimes used to avoid confusion with other parallel lines, or to more clearly portray particular aspects of threads. The three types of thread representations for internal and external threads are shown in Figure 1-15 on the next page.

FIGURE 1-15
Three Types of Thread Representations



Threaded fasteners are used throughout industry, so it is important that you are familiar with the descriptive terms used to identify specific thread arrangements. Figure 1-16 shows the terms used in describing a threaded part.

FIGURE 1-16
Threaded Part



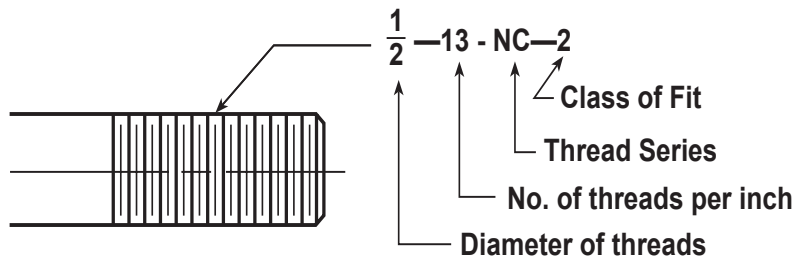
For convenience, several series of diameter-pitch combinations have been standardized. These series are Coarse, Fine, Extra Fine, and the Unified pitch series; that is, 8 thread, 12 thread, and 16 thread. The fit of a screw thread is the amount of clearance between the screw and the nut when they are assembled together. To provide for various grades of fit, three classes of external threads (Classes 1A, 2A, and 3A) and three classes of internal threads (Classes 10, 2B, and 30) are provided in the unified thread standard. These classes differ from each other in the amount of allowances and tolerances.

A number of different specifications are given in representing screw threads on a drawing:

- Diameter of the thread
- Number of threads per inch
- Thread series either National Coarse, National Fine, National Extra Fine, Square, Acme or Pipe
- Class of fit, ranging from a loose fit No. 1 to the theoretically most perfect fit attainable

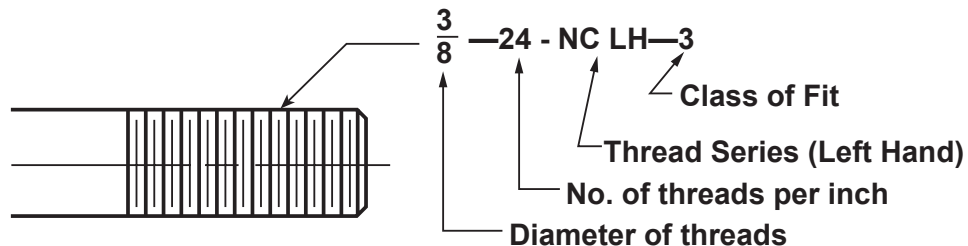
These specifications are usually presented in notation like those in Figure 1-17.

**FIGURE 1-17
Thread Specifications**



Unless designated otherwise, threads are assumed to be right handed. A cap screw being threaded into a tapped hole would be turned in a right-hand clockwise direction. For some special applications, such as turnbuckles, left-hand threads are required. When such a thread is necessary, the letters LH are added after the thread designation (see Figure 1-18).

**FIGURE 1-18
Left-Hand Thread Notations**



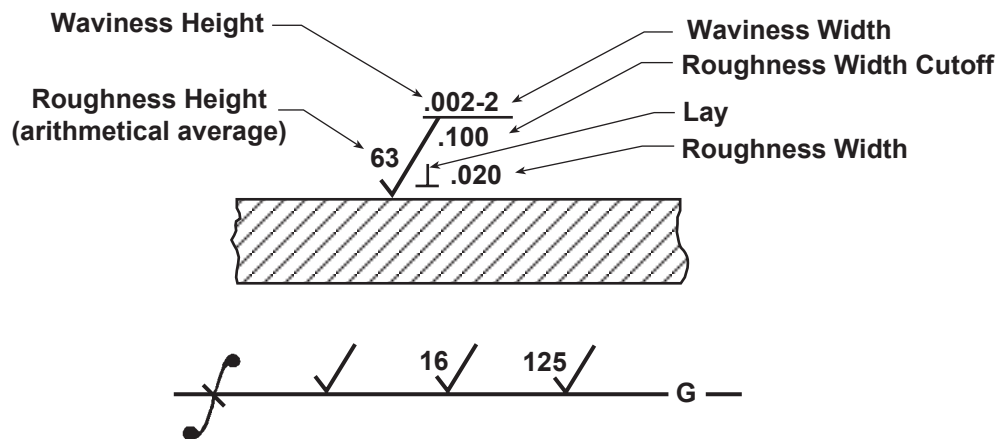
2. Finish Symbols

The term finished surface means any surface that requires material to be removed from it in order to improve its size, geometry or smoothness. This can be done by such processes as planing, milling, turning, broaching or grinding. The method used depends on the contour, the type of finish required and the kind of material. A surface finish symbol

is used to indicate that a specific surface finish is required. Numbers are added to the left of this basic symbol to designate surface roughness in micro-inches or millionths of an inch (arithmetical average deviations from the center line of the surface as measured by a profilometer or surface analyzer).

Numbers may also be written above the horizontal extension of the symbol to designate maximum waviness height, in decimal inches, and maximum waviness width, in inches, placing the width notation to the right of the maximum height notation. The symbols used to indicate surface finish are shown in Figure 1-19 along with standardized finishes in micro-inches.

**FIGURE 1-19
Finish Symbols**

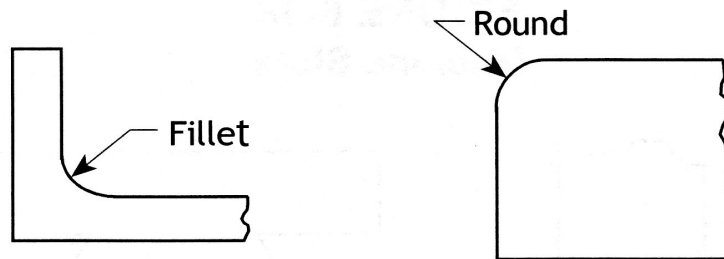


Micro inches	Type of Surface	Purpose
1000	Extremely Rough	Clearance surfaces where appearance is not important
500	Rough	Used where stress requirements and close tolerances are not required.
250	Medium	Most popular where stress and tolerances requirements are essential.
125	Average Smooth	Suitable for mating surfaces and parts held by bolts and rivets with no motion between them.
63	Better than Average Finish	For close fits or stress parts, except rotating shaft, axles and parts subject to extreme vibration.
32	Fine Finish	Used where stress concentration is high, and for applications such as bearings.
16	Very Fine Finish	Used where smoothness is of primary importance, i.e. high-speed shaft bearings, heavily- loaded bearings and extreme tension members.
8	Extremely Fine Finish (by grinding, honing, lapping and buffing)	Used for cylindrical surfaces.

3. Fillets and Rounds

Fillets and rounds (see Figure 1-20) are designed into parts for purposes that include strengthening a shoulder on a shaft, enhancing the appearance of a corner, or removing the sharp edge on a part.

FIGURE 1-20
Fillets and Rounds



A fillet is made by allowing for additional metal in the inner intersection of two surfaces. The rounding out of the internal corner increases the strength of the object.

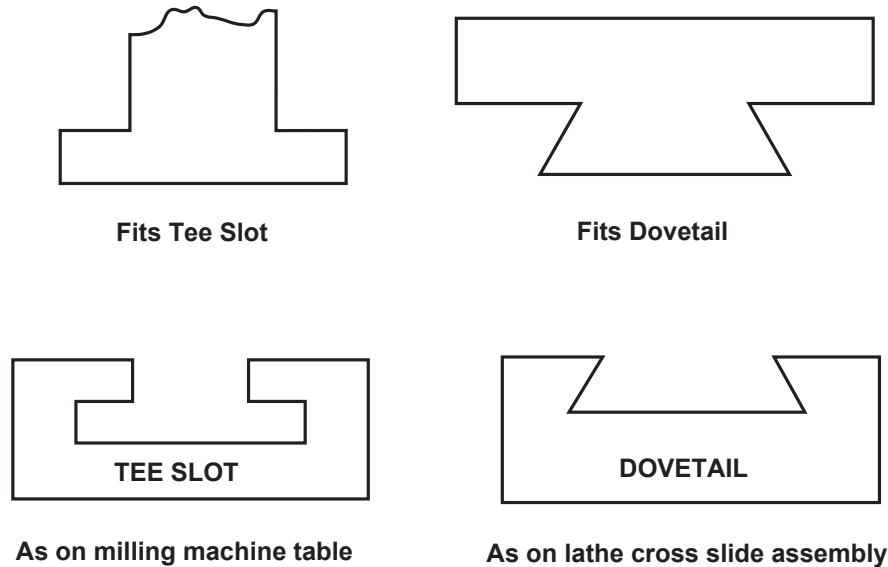
A round or radius is made by rounding off the external edge of a sharp corner on an object. This rounding off improves appearance and allows for avoiding the forming of a sharp edge that could cause interference or chip off under a sharp blow.

4. Machine Slots

Parts made on lathes, mills and other machine tools must be held in place while being machined. Slots are used as a means to secure parts or hold parts together.

Two of the main types of slots are tee slots and dovetails (see Figure 1-21).

**FIGURE 1-21
Machine Slots**



The use of blueprints is most commonly associated with machine shop operations. However, blueprints in the form of schematics, sketches, diagrams and pictorial representations also are used in manufacturing, maintenance and construction. Figures 1-22 through 6-26 show an assortment of terms used with blueprints. The glossary further defines these and other relevant terms.

FIGURE 1-22
Terms

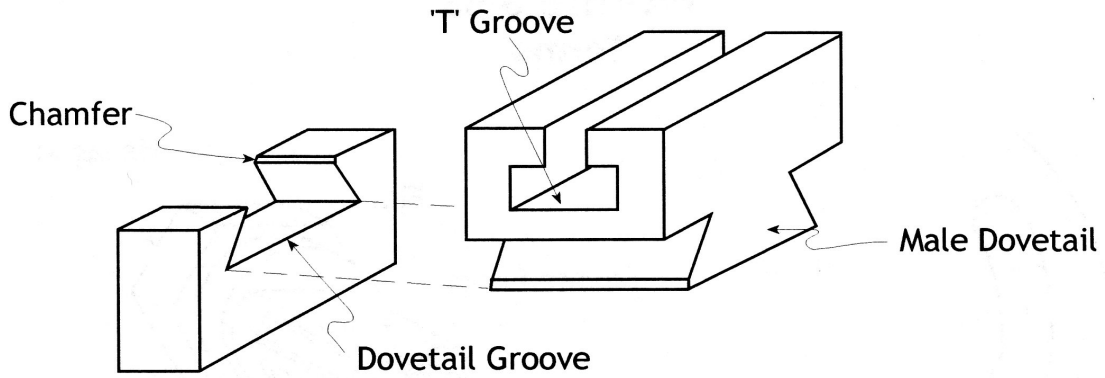


FIGURE 1-23
Terms

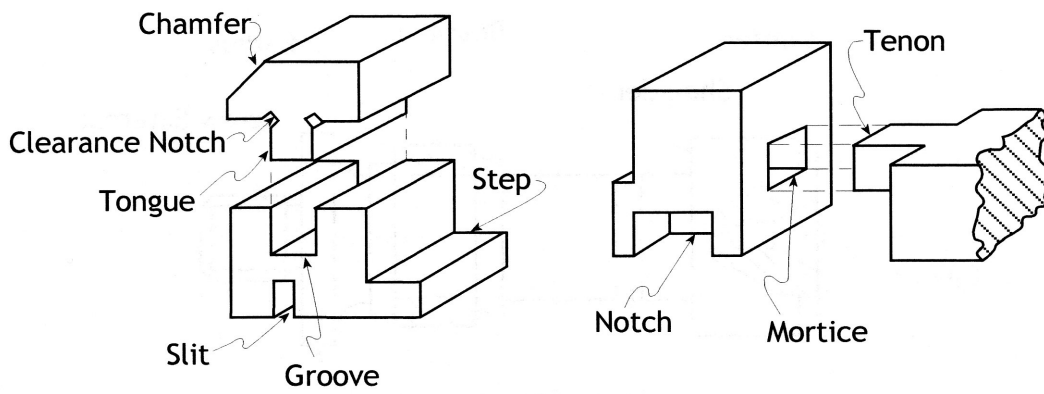


FIGURE 1-24
Terms

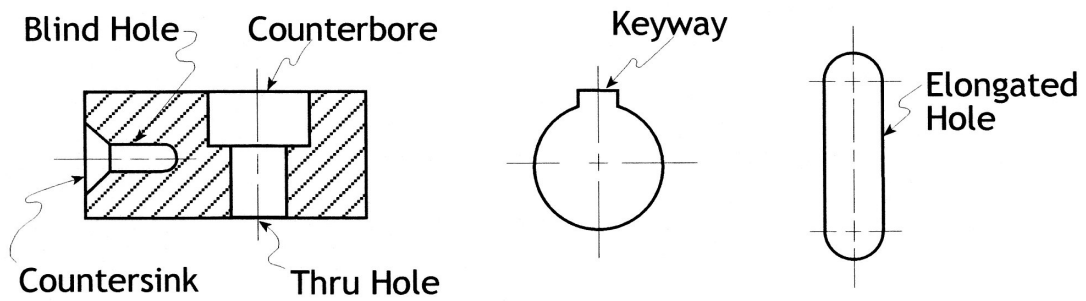


FIGURE 1-25
Terms

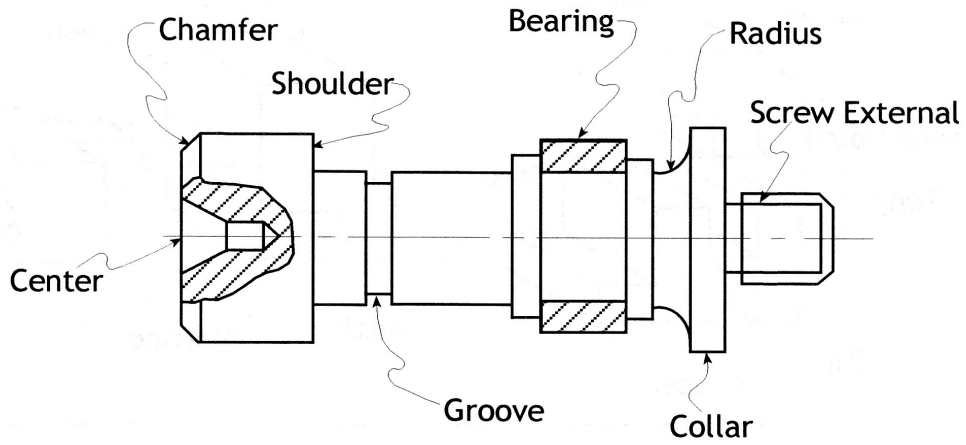
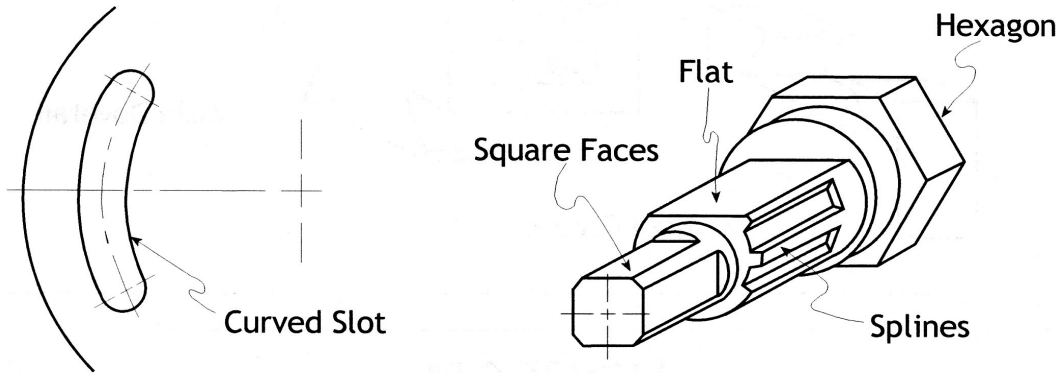


FIGURE 1-26
Terms



5. Title Blocks

The title block, usually located in the lower right-hand corner of a drawing, contains information that is not always directly related to the construction of an object, but is needed for its manufacture. The title block's location, content, layout, and appearance will vary from company to company, but will usually be standardized within a given company.

Remember that the purpose of a print is to relay information in a simple, accurate graphic language. The title block allows the draftsman or engineer to include important information without cluttering up the drawing.

Specific types of information can be included on the print in the title block so that it can be located easily and interpreted correctly. In addition to the title block, notes and revisions can also be included on a print to further clarify the information contained in the drawing.

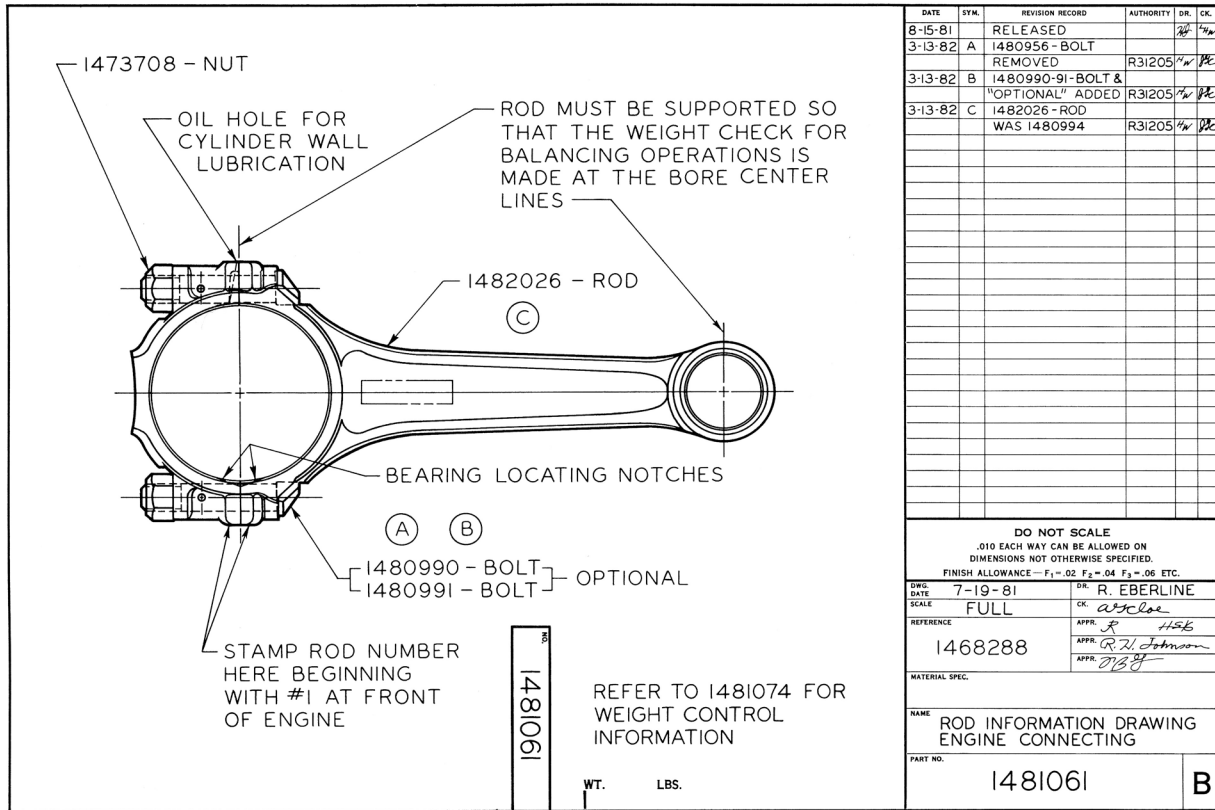
The title block is divided into sections which may provide the following information:

- **Company** name and location.
- **Part** name.
- **Part number**, die number, forging number, etc.
- **Drawing number** assigned to the part number.
- **Number of parts** required for each assembly.
- **Scale** indicates the size of the drawing compared with the actual size of the part. Detail drawings are usually made full size. Large parts and assemblies may be drawn to a reduced scale to fit on the paper. Very small parts may be drawn two or three times their actual size to show details clearly. The most common scales are full (actual) size, and 2, 4, $\frac{1}{2}$, and $\frac{1}{4}$ times the actual size.

- **Assembly drawing number** (on a detail drawing) to identify the part in the assembly.
- **Drafting room record** includes names or initials (with date signed) of persons responsible for the accuracy of the drawing, draftsman, checker, engineer, examiner and production approval authority.
- **Material callouts** or materials to be used in making the part, with optional materials. Reference is usually made to notes due to limited space in the block.
- **Stock form** and/or size.
- **Tolerances** (general) that apply to all dimensions that do not have individual tolerances included with the basic dimensions.
- **Shop notes** (general and specific) provide information and instruction that cannot be given conveniently by any other means. General notes apply to the drawing as a whole. Specific notes apply to particular parts of the drawing and are located near the area of the drawing to which they pertain.
- **Drawing revisions** or changes call attention to variations in original design caused by unsatisfactory performance or difficulty in manufacturing. Changes are usually located in upper, right-hand corner of a drawing in a separate box called the Revision Box. All changes to the drawing are entered, dated and identified by a number or letter, and a letter indicating that it is a revised drawing is added to original drawing number.

Figure 1-27 is an assembly drawing of a connecting rod. The title block includes the part name and number; information about the scale, tolerances, and finish allowances; the date of the drawer, checker and approvers; the print's reference number; and a space for the material specification. In addition, there is a revision record and notes on the drawing concerning parts and assembly techniques.

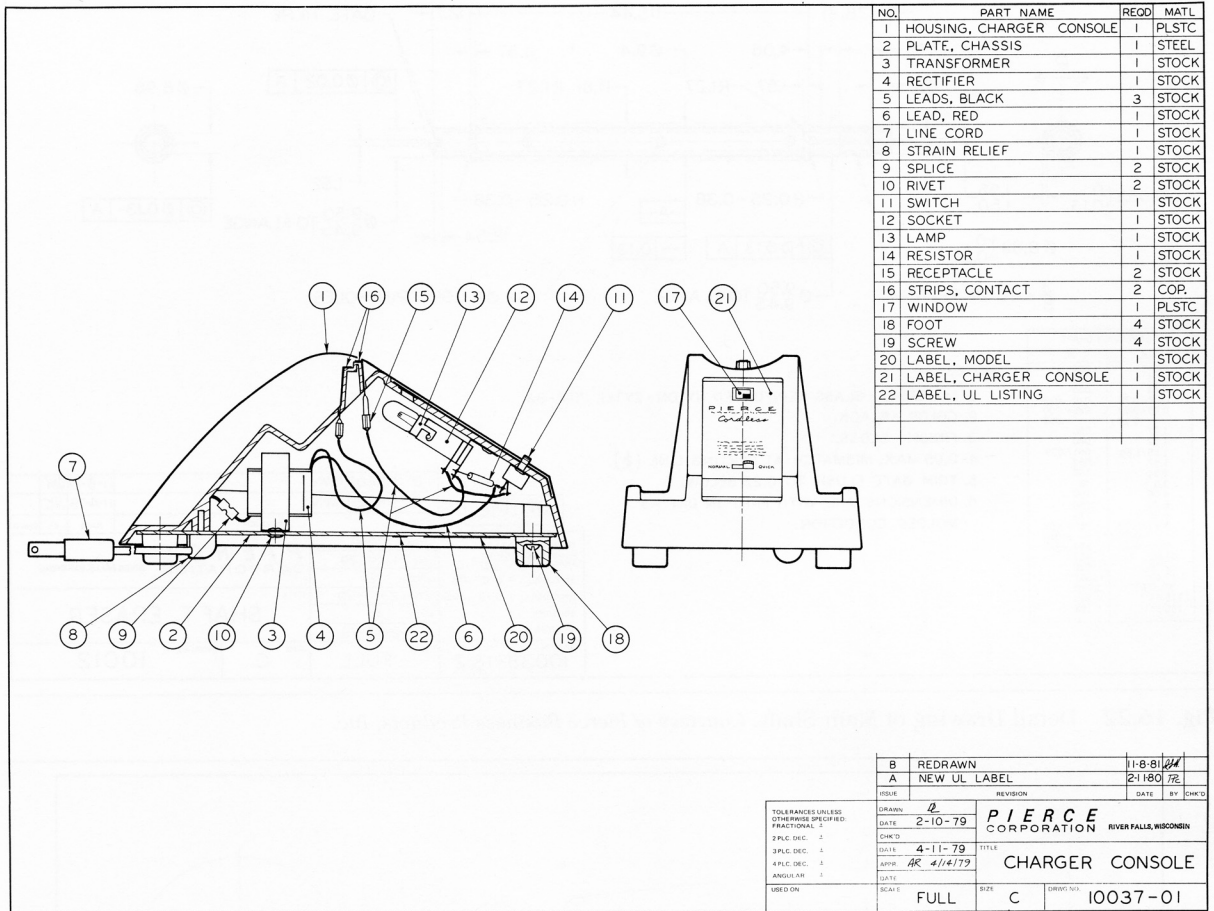
FIGURE 1-27
Assembly Drawing



6. Bill of Materials

The drawing in Figure 1-28 has a title block that includes notes (notice that the drawing has been redrawn and also that the UL label is new). This drawing also includes a bill of materials which identifies the parts by name, the required number of each part, and the material callout for each part. A bill of material may also include part numbers, dimensions and other relevant information.

FIGURE 1-28
Bill of Materials

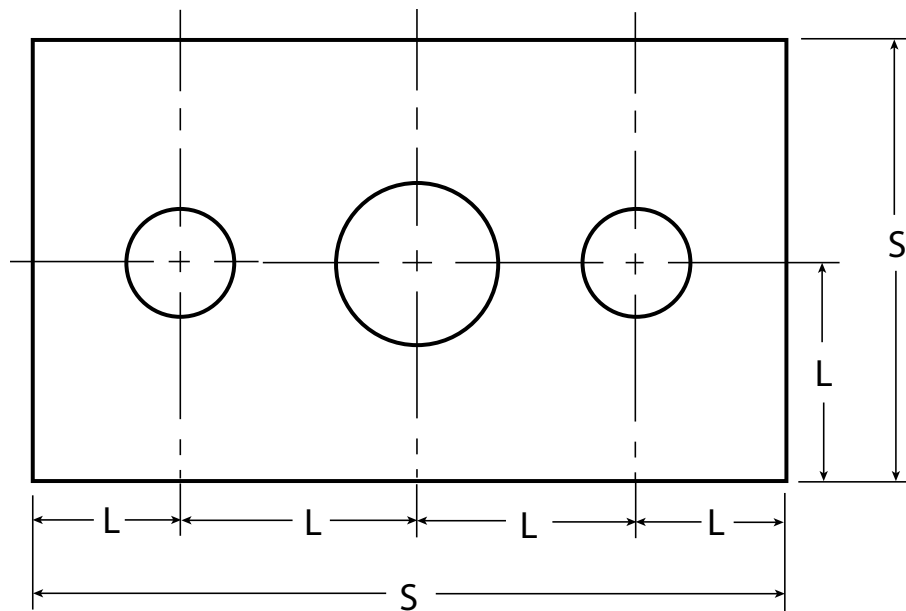


7. Dimension Types

Dimensions enable the designer of a product to express exact linear and angular distances. There are two types of dimensions used in blueprints: size and location. The first type is used to indicate the exact size of the product. The second gives exact locations of the holes, indentations, etc. on an object.

Examples of both types of dimensions are shown in Figure 1-29.

FIGURE 1-29
Dimension Types



S = Size Dimensions

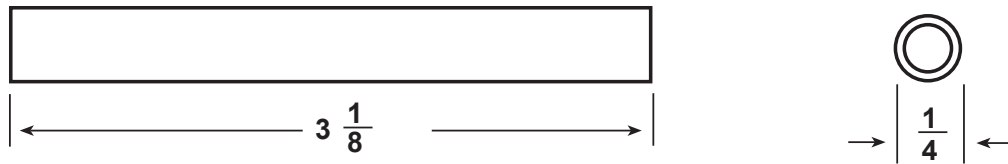
L = Location Dimensions

The diameter of a circle would also be considered a size dimension.

Dimensions are used to measure straight and angular distances. Straight distances are expressed in fractional or decimal form. Angular measures are expressed in degrees, minutes and seconds.

Fractional dimensions are used on parts which do not require a high degree of accuracy. In most blueprint systems, when an object is fractionally dimensioned it is implied that the overall dimension is to be maintained plus or minus $\frac{1}{64}$ ". The print in Figure 1-30 calls for a piece of tubing $3\frac{1}{8}" \times \frac{1}{4}"$. It is implied that the part can be $3\frac{1}{8}" \pm \frac{1}{64}"$ or between $3\frac{7}{64}"$ and $3\frac{9}{64}"$ in length and be $\frac{1}{4}" \pm \frac{1}{64}"$ or between $\frac{15}{64}"$ and $\frac{17}{64}"$ in diameter.

FIGURE 1-30
Fractional Dimensions



Decimal dimensions, on the other hand, are used on parts requiring a high degree of accuracy. Many blueprints use decimal dimensioning entirely, even though the criticality of the dimensions may vary. There is usually a note on the print stating the tolerance for the less critical dimensions.

Decimal tolerances commonly range from tenths (.10) to ten-thousandths (.0001) of an inch. When the degree of accuracy is critical in a dimension, the tolerance becomes tighter (thousandths and ten-thousandths range).

The number of decimal places that a dimension is carried will determine the decimal places a tolerance is carried. For example, a dimension carried two decimal places ($5.10"$) would have a tolerance carried two places ($\pm .02$). If the dimension had been carried three places ($5.100"$), then the tolerance would be carried three places ($\pm .002"$).

Some objects do not have all of their straight lines drawn horizontally and vertically. The design of the part may require some lines to be drawn at an angle, either to each other, or to the horizontal or vertical. In this case, angular dimensions would be used.

Angular dimensions are measurements of angles contained in parts. Angles on blueprints are expressed in degrees ($^{\circ}$), minutes ($'$), and seconds ($''$). Angular tolerances can also be expressed in tenths (.10) or hundredths (.01) of degrees.

8. Tolerance Blocks

Tolerance blocks are also used to indicate fractional, decimal and angular tolerances. Figure 1-31 shows an example of a tolerance block.

**FIGURE 1-31
Tolerance Blocks**

Tolerances Unless Otherwise Specified			
Fractions	Decimals		Angles
$\pm 1/64''$	$.00 \pm .02''$	$.000 \pm .003''$	$.0 \pm .02^{\circ}$

Remember, dimensions add exactness to drawings by expressing lengths, widths, heights and angles in numerical form.

C. VISUALIZATION

Engineering or technical drawings furnish a description of the shape and size of an object and provide other information necessary for its construction or assembly. A picture or photograph of an object shows the object as it appears to the observer from a single angle or perspective; but it does not show the exact size and shape of the object, the location of its various parts or the sides not visible from the angle the picture is taken.

1. Orthographic Projection

Rather than relying on a single photograph, imagine taking three or more pictures of the object, each from a different, distinct 90° angle. The result would be multiple views or perspectives of the same object. One picture could be taken looking at the front of the object, another at

the top and a third which viewed the object from the side. Looking at each picture, front, top, and side, one could then visualize the object.

The systematic selection and arrangement of the views of an object is called Orthographic Projection or Multi-View Drawing.

2. View Arrangement

There are six possible views of any object. There is a view for each side or surface of the object: front, back, top, bottom, left side and right side. The development of a multi-view drawing requires the selection and arrangement of some or all of these views. How many and which of these views are selected depends on the nature, shape and complexity of the object being drawn.

The only difference between what is called a third-angle and first-angle projection is in the arrangement of the views. International projection symbols, shown in Figure 1-32, have been developed to distinguish between first-angle and third-angle projections on drawings. In the United States and Canada, third-angle projection is standard, while in most of the rest of the world, first-angle projection is used.

FIGURE 1-32
First-Angle Projection

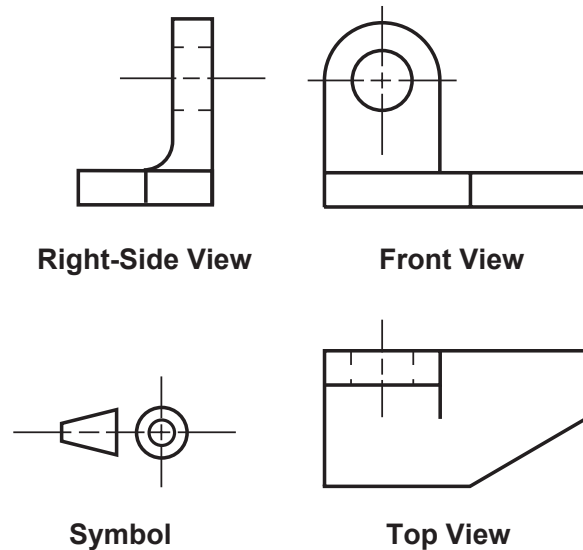


FIGURE 1-33
Third-Angle Projection

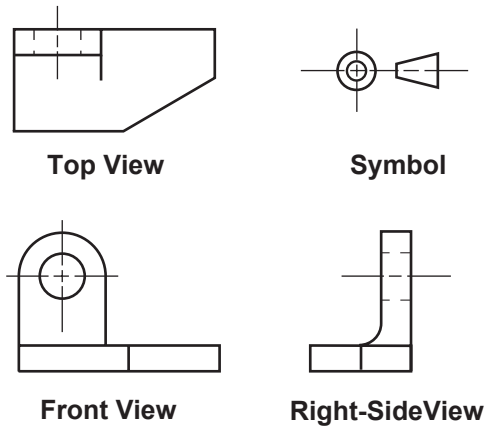
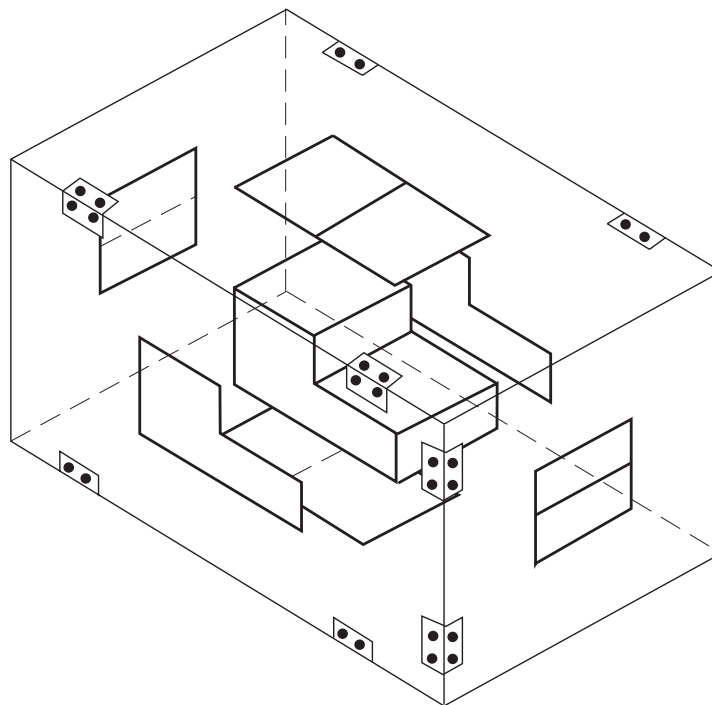


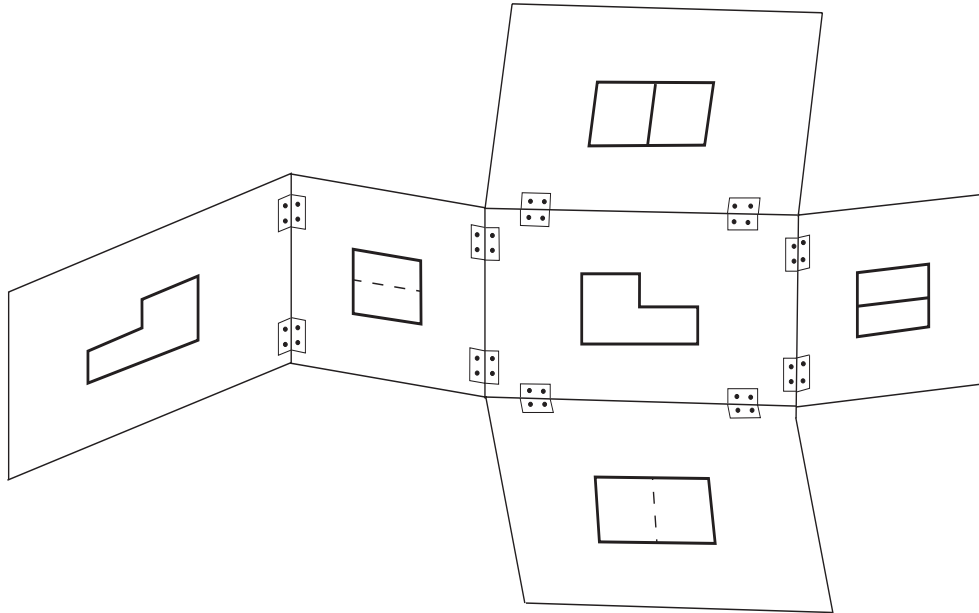
Figure 1-34 is an example of a third-angle projection of a part in a glass box. Each of the six sides of the object is projected onto the sides of the glass box.

FIGURE 1-34
Third-Angle Projection of Part in Glass Box



The glass box is outfitted with hinges so that the sides can be rotated out allowing the box to be viewed as a flat object in a single plane as if the six sides were drawn on a sheet of drawing paper (Figure 1-35).

FIGURE 1-35
Box Flattened Into a Single Plane



The sides are arranged as follows:

- The top view aligns directly over the front view.
- The right side view appears directly to the right of and in line with the front view.
- The left side view appears directly to the left of and in line with the front view.
- The bottom view aligns vertically below the front and top views.
- The back view appears to the left of and in line with the right side, front, and left side views.

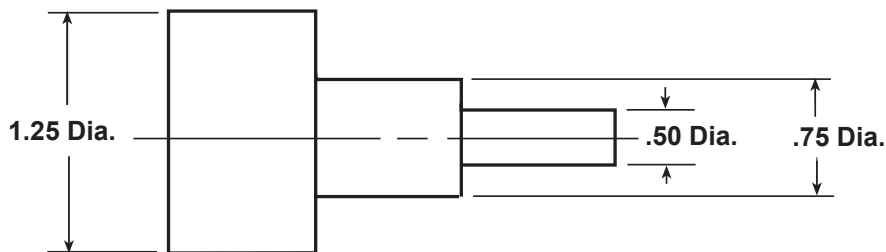
It is rare that all six views are required, however, no view should appear in any other position on a drawing. The side views are always placed laterally (to the sides) of the front view in logical sequence. Top views are always above the front, and bottom views are always below the front.

It would be possible for the arrangement of views to be different than in Figure 1-35. This would be the result of selecting a different side of the object as the front view. The front view is also referred to as the primary view because the arrangement of all other views is determined by the position of the front view. The side which offers the most detail or clearest view of the object and which results in the least amount of hidden lines is usually selected for the front view.

Multi-view drawings are also referred to as detail drawings. The detail drawing in Figure 1-36 was developed from the isometric or pictorial drawing of the object (shown in the top, right-hand corner). The side selected for the front view provides the clearest representation of the object. The top view and right side view have been drawn in positions based on the selection of the primary view.

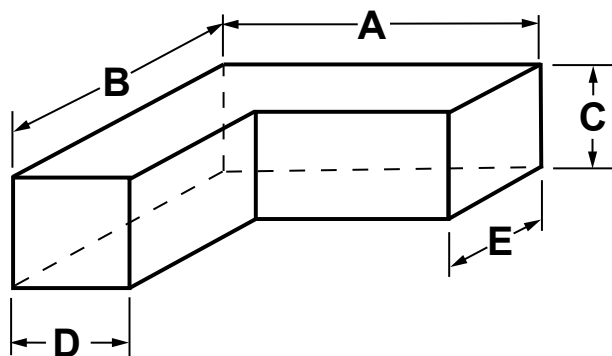
Cylindrical objects require a center-line running through the middle of the piece and the letter D for diameter, in the dimensions. Although there are three different diameter shafts in Figure 1-38, the addition of the three dimensions to the front view eliminates the need for the side view. Any extra machining operations to be done on the part such as drilled holes, threads, keyways, counter-bores and countersinks would require a second or even a third view to accurately describe their size and location.

FIGURE 1-38
Cylindrical Object



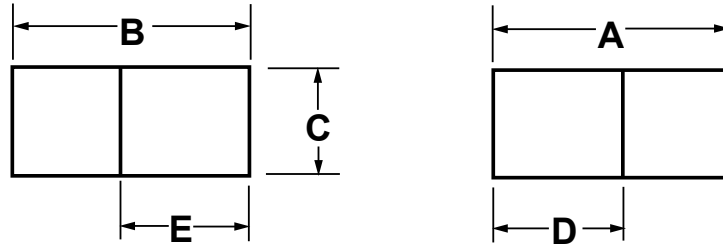
In most cases, at least two views are necessary to represent a single part. Choose the view with the least hidden lines as the primary or front view. For example, several different views could be selected for the part shown in Figure 1-39.

FIGURE 1-39
Different Views



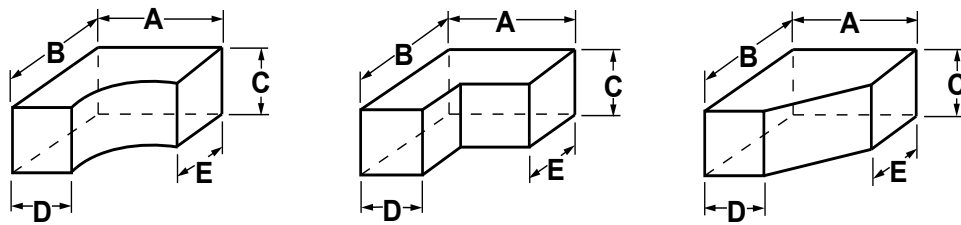
If the primary or front view is used and front and side views are selected as the two views for the multi-view drawing, the object is not truly defined (see Figure 1-40).

FIGURE 1-40
Different Views



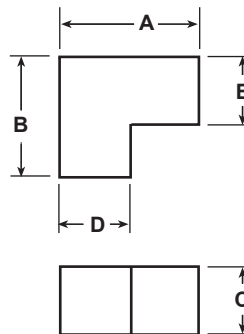
Using these two views, the slot can be several different shapes, but still correspond to the front and side views selected in the initial multi-view (see Figure 1-41).

FIGURE 1-41
Different Views



If the side view is replaced by the top view, only one of these three possibilities is accurate. Therefore, the correct two-view drawing of the object must include the front and top views (Figure 1-42). The side view could replace the front view although this is not a common drafting practice.

FIGURE 1-42
Top View



D. SECTIONAL AND AUXILIARY VIEWS

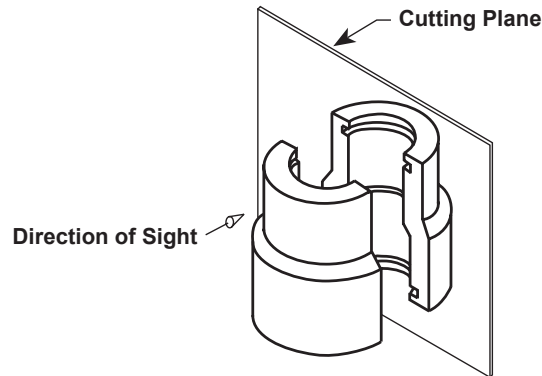
Objects that are complex in shape, or that have many interior features, can be difficult and confusing to depict in multi-view projections. Two special techniques used to provide a clearer representation of how such an object should be constructed are sectional views and auxiliary views.

1. Sectional Views

Sectional views, or just sections, are used to show interior detail that is too complicated to be shown clearly by outside views and by the use of hidden lines. In assembly drawings, they also serve to indicate a difference in materials.

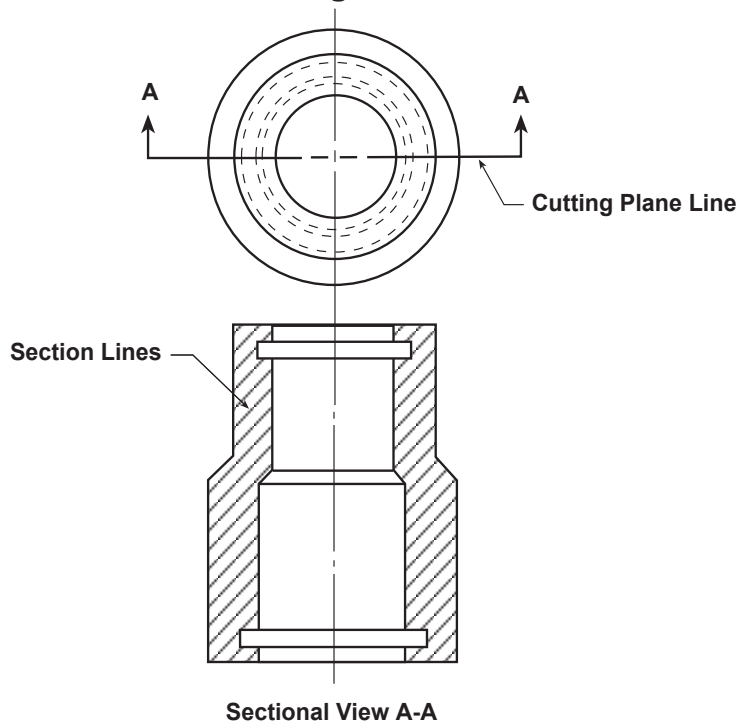
A sectional view is obtained by imagining that a portion of the object has been cut away to expose internal lines and surfaces (Figure 1-43). The exposed or cut surfaces are identified by section lining or crosshatching. A sectional view frequently replaces one of the regular views.

FIGURE 1-43
Sectional View



A cutting plane line is used to indicate where the imaginary cutting takes place. The position of the cutting plane is indicated, when necessary, on a view of the object or assembly by a cutting plane line. The ends of the cutting plane line are bent at 90° and terminated by arrowheads to indicate the direction of site for viewing the section (Figure 1-44).

FIGURE 1-44
Cutting Plane Lines



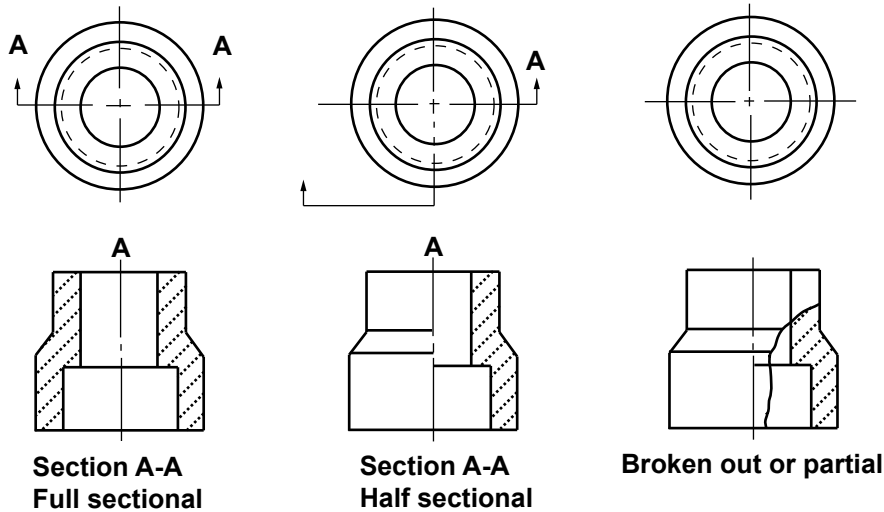
Full sectional views are obtained by passing the cutting plane across the entire object, exposing the whole inner surface.

Half-sectional views are obtained by placing two cutting planes at right angles to each other along the center-lines or symmetrical axes of the object, exposing one-half of the inner surface. The cut is made along the horizontal and vertical center-lines so that either one-fourth or three-fourths of the interior of the object is exposed.

A broken-out or partial section is sometimes necessary to show a single detail, or a closely related group of details, that exist within the interior of an object. If these details are all that are needed, then the broken-out partial section view can provide the necessary detail.

Examples of full, half and partial sectional views are shown in Figure 1-45.

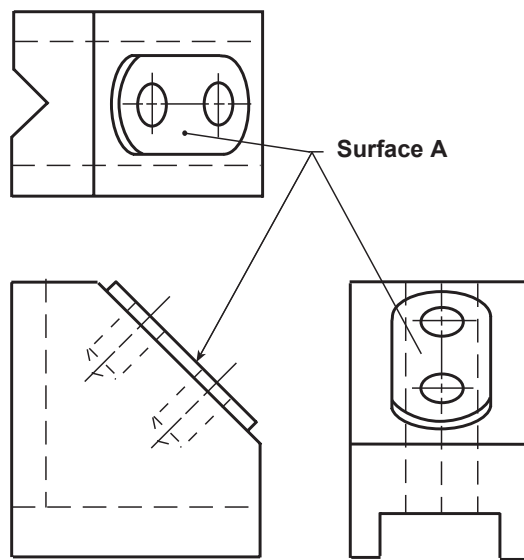
**FIGURE 1-45
Multiple Views**



2. Auxiliary Views

Many machine parts have surfaces that are not perpendicular or at right angles to the plane of projection. These surfaces are referred to as sloping or inclining surfaces. In the regular multi-view projection (see Figure 6-46) such surfaces appear to be foreshortened and their true shape is not shown.

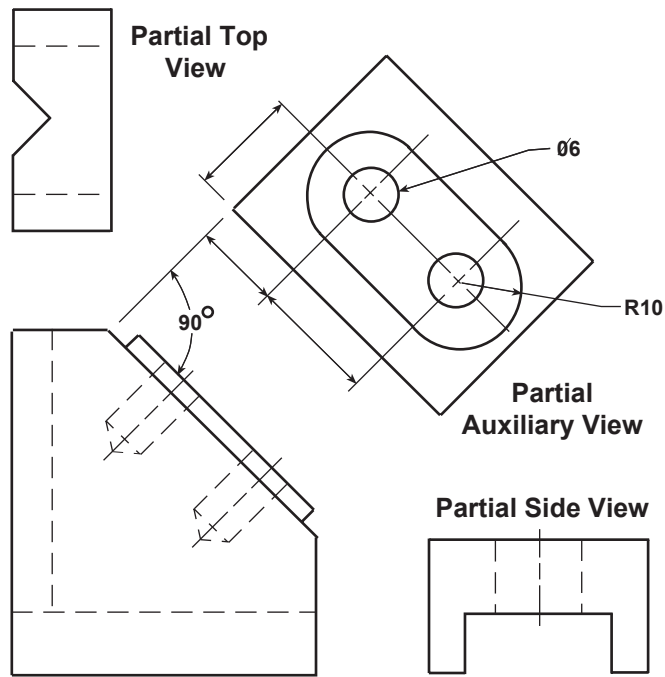
FIGURE 1-46
Regular Views Do Not Show True Features of Surface A



When an inclined surface has important characteristics that should be shown very clearly and without distortion, an auxiliary view is used so the drawing explains the shape of the object completely and clearly.

In Figure 1-47, the circular features on the sloped surface on the front view cannot be seen in their true shape on either the top or side views. The auxiliary view is the only view which shows the true shape of these features. Note that only the sloped surface details are shown. Dimensions for the detail on the inclined face are placed on the auxiliary view, where such a detail is seen in its true shape.

FIGURE 1-47
Auxiliary View Added to Show True Features of Surface A



3. Multi-View Review

In blueprint reading, the term projection refers to a view of an object. Multi-view or three-view projections are drawings that illustrate a combination of views of an object.

The primary view or front view determines the arrangement of all other views on the drawing. There is a possibility of at least six views of an object plus the additional potential for auxiliary and section views.

The top, bottom, left and right sides, and back views are developed by projecting lines at a 90° angle, horizontally and vertically, from the front view.

In arranging views, the side views are always placed laterally (to the sides) of the front view in logical sequence, the top view is always above the front, and the bottom view is always below the front.

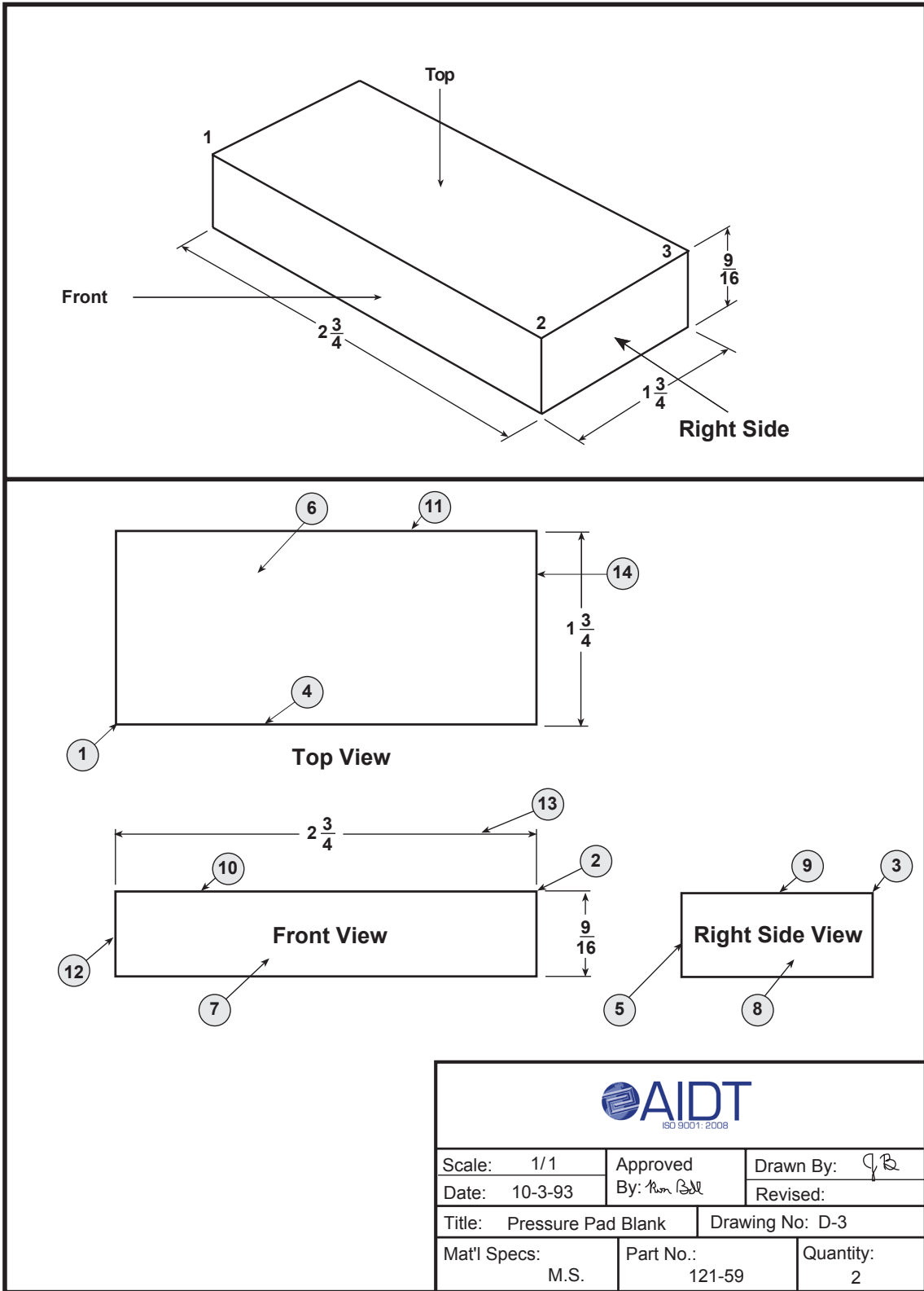
Sectional views reveal an object's inner detail by graphically removing portions of the surface. This is done in a standardized way by using a cutting plane line or break lines. Either way, the purpose of sectional views is to simplify the drawing by eliminating hidden lines.

Auxiliary views show an inclined surface or line in its true size and shape. This makes it easier to visualize the object and provides a true surface to be dimensioned according to standard drawing practices.

Exercise 1

Views and Title Block

1. What is the name and part number of the part?
2. How many are required?
3. How many views of the part are shown?
4. What is the overall length, height thickness and width?
5. In what two views is length, height and width shown?
6. If number 6 represents the top surface, what line represents this surface in the front view?
7. If number 8 represents the surface in the right side view, what line represents this surface in the top view?
8. What line in the top view represents the surface 7 of the front view?
9. What line in the right side view represents the front surface of front view?
10. What surface shown does line 10 represent?
11. What line of the front view does point 1 represent?
12. What line of the top view does point 2 represent?
13. What line of the top view does point 3 represent?
14. What kind, or type of line, is line 12?
15. What kind, or type of line, is line 14?

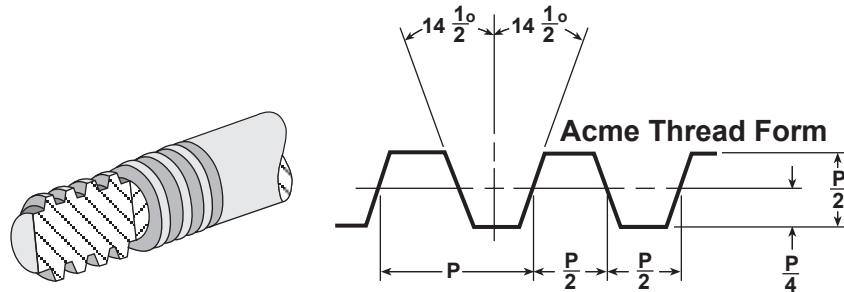


Scale: 1/1	Approved	Drawn By: <i>JB</i>
Date: 10-3-93	By: <i>Tom Bell</i>	Revised:
Title: Pressure Pad Blank		Drawing No: D-3
Mat'l Specs: M.S.	Part No.: 121-59	Quantity: 2

E. GLOSSARY

Acme – A screw thread form. (see Figure 1-48)

FIGURE 1-48
Acme Screw Thread

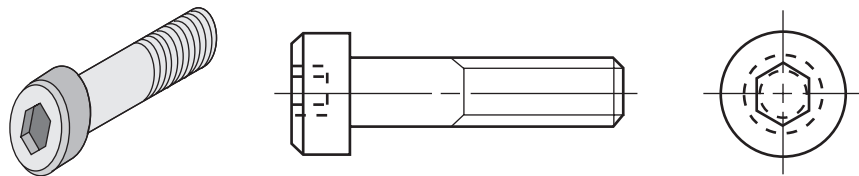


Addendum (Add.) – The height of a gear tooth from the pitch circle to the outside diameter of the gear.

Adjacent (Adj.) – Next to; angle that shares a common side of another angle.

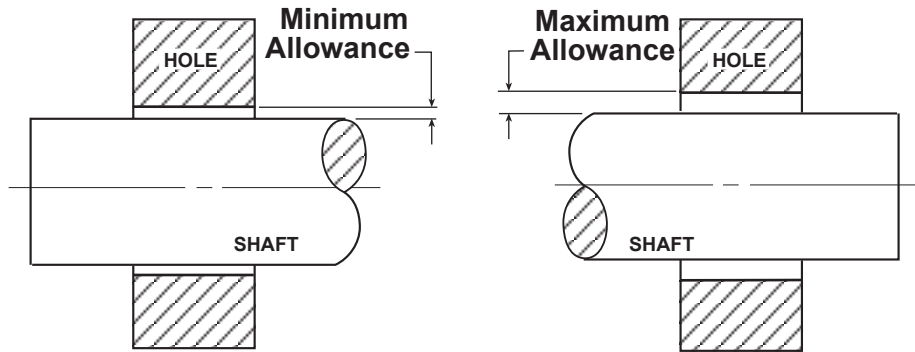
Allen Screw – A screw with a hexagonal socket in the head. (see Figure 1-49)

FIGURE 1-49
Allen Screw



Allowance – The minimum clearance between mating parts. (Figure 1-50)

FIGURE 1-50
Allowances



Alloy – Two or more metals in combination.

Aluminum (Alum.) – A lightweight, white, soft, nonferrous metal produced from bauxite ore.

American Iron and Steel Institute (AISI) – A professional organization of engineers responsible for research and standards in the steel and iron industry.

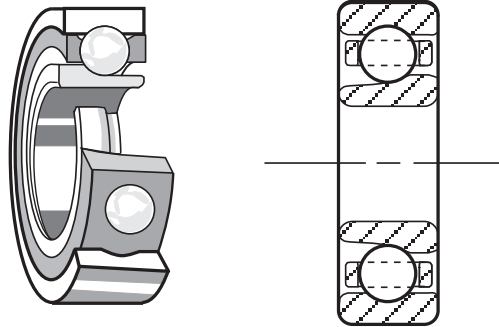
American National Standard Pipe Threads (ANPT) – A 60-thread form cut straight or, more commonly, tapered at $\frac{3}{4}$ in. 1 ft.. Pipe is used to conduct fluid or gas.

Angle (Ang.) – A geometric figure formed by two lines intersecting, or meeting at a point.

Anneal – To heat and then cool gradually to reduce brittleness and increase ductility.

Antifriction Bearing – An assembly of rollers, or balls and races, used to support linear and/or rotary motion. (see Figure 1-51.)

FIGURE 1-51
Anti-friction Bearing
Angular Contact Bearing



Approximate (Approx.) – An estimated or general statement about an object; for example, nominal length, width or other dimensions.

Assembly (Assy.) – A mechanism consisting of two or more parts placed in proper locations.

Auxiliary (Aux.) – An orthographic view not contained in any of the six regular planes of projection, but constructed from one or more of them.

Plain Journal Bearing (Brg.) – Plain journal bearings are made from soft metals such as brass, bronze, babbitt, etc., and have no rolling elements.

Bevel – An inclined edge, not at a right angle, to an adjoining surface.

Blueprint (B/P or BP) – A photographic copy of an engineering drawing; a graphic communication from a designer or engineer that tells a mechanic how an object looks.

Body – The largest diameter found on a screw. The main portion of any object.

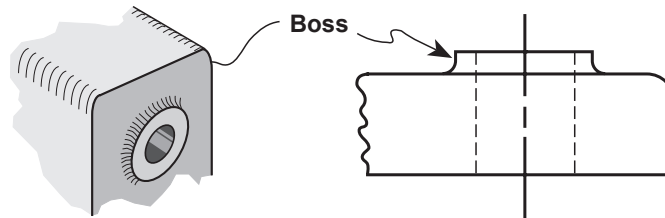
Bolt Circle (BC) – The circular centerline for any group of part features, usually bolt holes.

Bore – The inside diameter of a cylinder. Bore size is usually designated by the length of the diameter.

Boss – A raised, machined surface that adds strength, facilitates assembly, provides for fastening, etc. (see Figure 1-52)

FIGURE 1-52

Boss



Brass (Br.) – A non-ferrous metal that is an alloy of copper and zinc. Color ranges from yellow to red.

Brinell – To upset a metallic surface with repeated blows, causing stress and hardness by compressing the microstructure of the metal.

Brinell Hardness Tester – A materials-testing device that determines a metal's resistance to indentation or cutting. A small, steel base is pressed with standard force into the surface of the metal being tested. The spherical surface area of the resulting indentation is measured and divided into the load. The results are expressed as a Brinell Number.

Brinell Number – See Brinell Hardness Tester.

Broach – A multiple-tooth, bar-like cutting tool. Also, a machining operation that uses progressively-sized and -shaped cutters mounted consecutively to produce a desired surface or contour.

Broken-Out-Section – The region of an object graphically removed to show inner detail. Bound by an irregular break line.

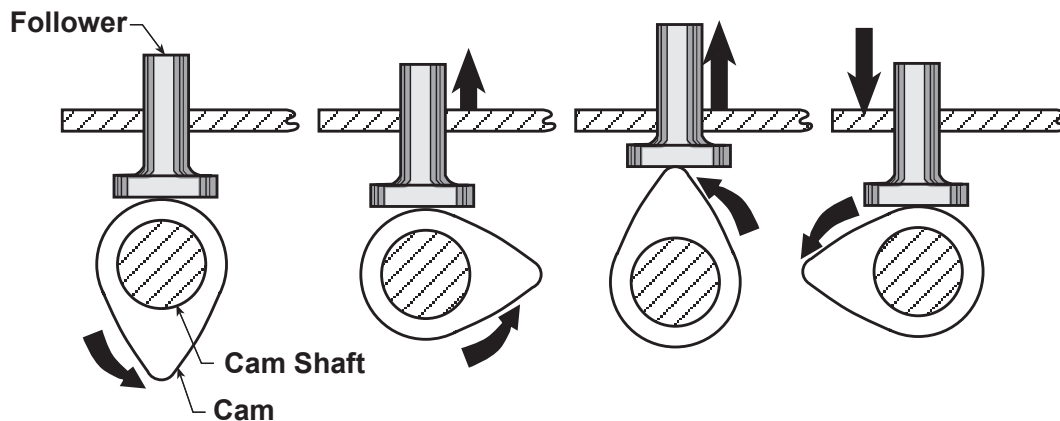
Bronze (Brnz.) – A non-ferrous, yellow metal alloy composed mainly of copper and tin.

Burr – A jagged edge on metal resulting from cutting or punching.

Cadmium (Cas.) – A blue-white metallic element used as protective plating in bearing metal.

Cam – A rotating member for changing circular motion to reciprocating motion. (see Figure 1-53)

FIGURE 1-53
Cam



Capacity (Capy.) – Indicates size by volume, weight, or both. Capacity may be given in gallons, cubic feet, pounds, etc., whichever is most descriptive according to the use of the container.

Case Hardness or (Case Hardened) (CH) – The hardness of the outer layer (case) of a part. To harden only the outer surface of a part by such methods as flame hardening, carburizing, nitriding, etc.

Casting (Cstg.) – A part produced when molten metal is poured into a preformed cavity, and allowed to solidify before removing.

Cast Iron (CI) – A brittle, ferrous metal alloy containing large quantities of carbon that is cast into a shape.

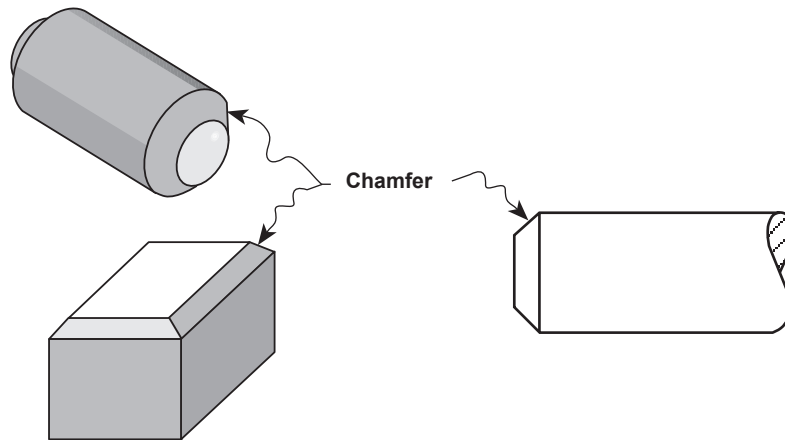
Celsius Temperature Scale (°C) – The metric temperature measurement scale, in which 0 degrees is the freezing point of water, and 100 degrees C is the boiling point of water. Formerly called Centigrade.

Centerline or Center Line (CL) – The imaginary horizontal or vertical line passing through the center of a part feature, extending infinitely in both directions.

Center-to-Center (C to C) – Any reference to the imaginary line running between and intersecting the centers of two sharp edges.

Chamfer (Cham) – A bevel or angle cut across the edge of a part to give a finished look or to remove sharp edges. (see Figure 1-54)

FIGURE 1-54
Chamfer



Chuck – A mechanism for holding a rotating tool or work piece.

Circumference (Circum.) – The perimeter of a circle. Also, the distance around a circular part. The length of the periphery of a circle or circular part.

Clockwise – Rotation in the same direction as the hands of a clock.

Cold-Rolled Steel (CRS) – Barstock which has been rolled and shaped at room temperature. Usually has a smoother surface finish and more accurate rough dimensional size ($\pm.002$) than hot-rolled steel.

Collar – A round flange or ring fitted on a shaft to prevent sliding.

Concentricity – When the positions of consecutive diameters lie along the same axis of a shaft.

Core – The part of a casting mold that forms internal holes in a casting. When the casting is cool, the core is broken out, leaving a cavity in the casting.

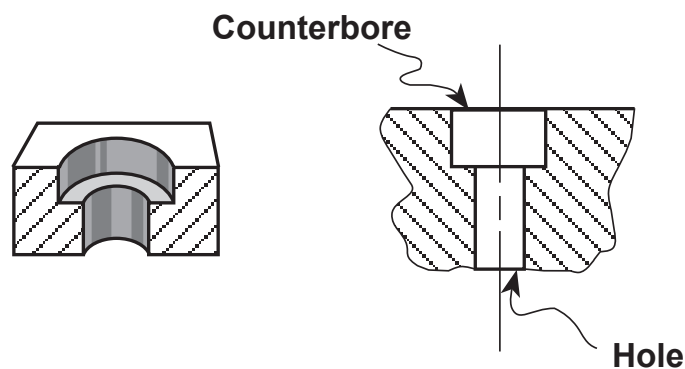
Core Hardness – The degree of hardness of the core of a steel part that is refined after carburizing.

Cosine (Cos) – A Trigonometric function that solves for an unknown side of a triangle when adjacent side and the hypotenuse are known. $\text{Cos} = \text{Adj./Hyp.}$

Cotangent (Cot) – Trigonometric equation which states that the value of an angle in a triangle is equal to the adjacent side divided by the opposite side. $\text{Cot} = \text{Adj./Opp.}$

Counterbore (C'Bore) – A flat-bottomed enlargement of the mouth of a cylindrical bore used to set the head of fastener below the surface of the work. Also, to enlarge a bore hole by means of a counterbore. (see Figure 1-55)

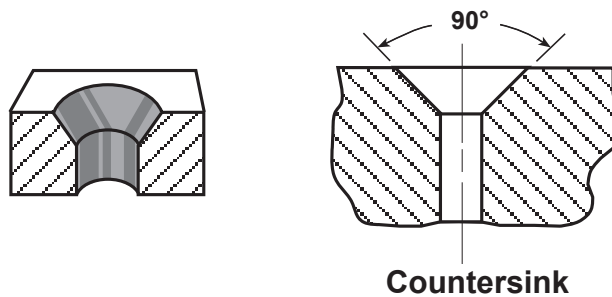
FIGURE 1-55
Counterbore



Counter-Clockwise (CCW) – Rotary motion in the direction opposite that of the hands of a clock.

Countersink (C'Sink) – A bevel or flared depression around edge of a hole used to set the head of a flathead screw below surface of work. (Figure 1-56)

FIGURE 1-56
Countersink



Crankcase (C-Case) – Crankshaft housing, i.e., engine block.

Cylinder (Cyl.) – A geometric figure having a circular cross section.

Dedendum – The distance from the pitch circle to the base of a gear tooth.

Degree (°or Deg) – Unit of temperature measurement (degrees Fahrenheit or degrees Celsius). Also, unit of angle measurement = $\frac{1}{360}$ part of a circle.

Detail – Special drawing of an object, or a portion of an object, that requires more information than is normally on a working drawing. The detail may be isolated or enlarged to attract attention to some important aspect or feature.

Diagonal (Dial.) – In a regular square or rectangle, the line drawn between opposite corners: slanting, oblique.

Diameter (Dia or D) – A line segment passing through the center of a circle, and whose end points lie on the circle.

Diametral Pitch (DP) – Ratio of the number of teeth on a gear to the pitch diameter: equals the number of gear teeth per inch of pitch diameter.

Die – One of a pair of hardened metal blocks for forming, impressing, or cutting out a desired shape. Also, a tool sometimes used to cut external screw threads (thread-cutting die).

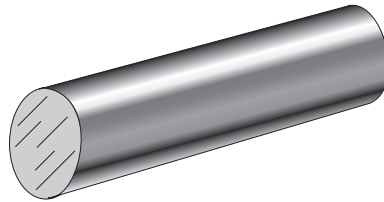
Die Casting – A very accurate and smooth casting made by pouring a molten alloy (usually under pressure) into a metal mold or die. Distinguished from a casting made in sand.

Dimension (Dim.) – Numerical value expressed in appropriate units of measure (inches, fractional inches, decimal inches, millimeters, degrees, etc.).

Direction (Dir.) – Movement toward a special location.

Dowel – Cylindrical pin, used to prevent sliding between two flat surfaces. (see Figure 1-57)

FIGURE 1-57
Dowel



Drawing (Dwg.) – A graphic representation (sketch, blueprint, etc.) of an object. A collection of straight lines, curves and dimensions that shows the shape and size of an object.

Drilled Hole – A hole created or enlarged by a drill bit. Distinguished from a bored or reamed hole.

Drill Rod (DR) – Carbon tool steel purchased in round or square cross section in lengths of 3 ft. and $\frac{1}{8}$ to 1 inch in diameter. Used to make cutters and pins of various types

External (Ext.) – The area or surface on the outside of an object.

Face – To machine a flat surface. Cut taken on a lathe to square end of stock with its axis of rotation. Also, working surface of a gear tooth above pitch circle.

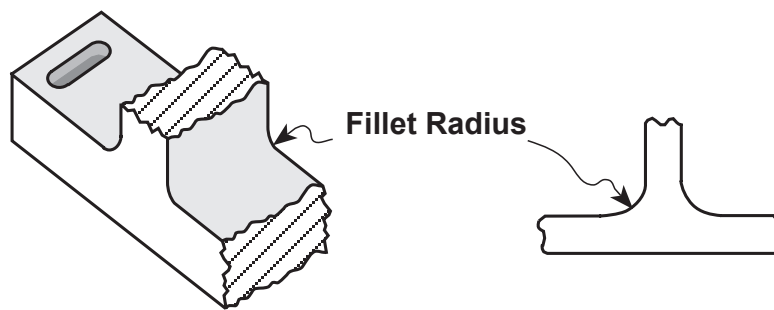
Fahrenheit Temperature (°F) Scale – The temperature measurement scale in which 32°F is water’s freezing point, and 212°F is water’s boiling point.

Feather Key – A flat key, which is partly sunk in a shaft and partly in a hub, permitting the hub to slide lengthwise on the shaft.

Figure (Fig.) – An illustration, a numeral, or a geometric shape.

Fillet (Fill.) – A curved or rounded surface between two intersecting surfaces. Radius cast in the joint between intersecting surfaces of casting. (see Figure 1-58)

FIGURE 1-58
Fillet Radius



Fillister Head (Fill. Hd.) – A type of screw head having long, straight sides (much like a socket-head screw) and a dome-shaped top with a single slot.

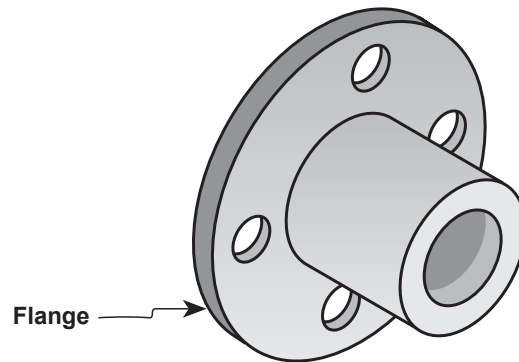
Fin – A thin metal projection rib found especially on cylinder heads, and used to dissipate heat.

Finish (Fin.) – Any final surface preparation on a part that protects it, makes it function more efficiently, and improves its appearance. Also, used to designate surface quality and surface texture.

Fit – Degree of tightness or slackness between two mating parts.

Flange – A projecting rim or rib used for strength, guidance, or as a means of attaching to another object. (see Figure 1-59)

FIGURE 1-59
Flange



Flat Head (Fl. Hd.) – A 82° tapered head fastener designed to set below the surface of the work.

Forging – The process by which metal is shaped by compressive force (hammer, press, rolls, etc.). May be accomplished while metal is hot or cold, depending upon manufacturing process.

Gauge (GA) – A standard of reference for size or shape, for example, gauge block, thread gauge, etc.

Galvanize – To treat the surface of an item with an alloy composed mainly of zinc, in order to prevent rusting.

Gasket – A thin piece of rubber, metal, or suitable material placed between surfaces to make a sealed joint.

Gear – A wheel or disk, having teeth around its periphery, used to interlock with other gears to transmit motion.

Grind (G) – To remove material from, or reduce the size of a work piece by contact with an abrasive wheel. To finish or polish a flat or curved surface with an abrasive wheel. To sharpen with an abrasive wheel.

Harden (Hdn.) – The most important of the heat treating processes, hardening increases the tensile properties of metals. To harden metals by heating and cooling at pre-determined rates.

Heat Treat – To change the properties of a material by heating, then cooling.

Height (Ht.) – A vertical dimension.

Hexagon (Hex.) – A six-sided polygon.

Horizontal (Hor.) – Parallel to the plane of the horizon.

Hypotenuse (Hyp.) – In a right triangle, the longest side and the side opposite the 90 degree angle.

Inch (In. Or") – $\frac{1}{12}$ of 1 foot, equal to 2.54 cm.

Included (Incl.) – Found within or between; such as an included angle or side.

Inside Diameter (ID) – The length of a line drawn through the center of a cylinder or sphere, terminating at the inside circumference on each end.

Inspection (Insp.) – Careful examination of an object by a qualified person to determine whether or not the object conforms to applicable specifications or quality standards, such as the dimensional accuracy of a part. May be an interim or final check.

Interchangeable – Refers to a part made to limited dimensions so that it will fit any mating part similarly manufactured.

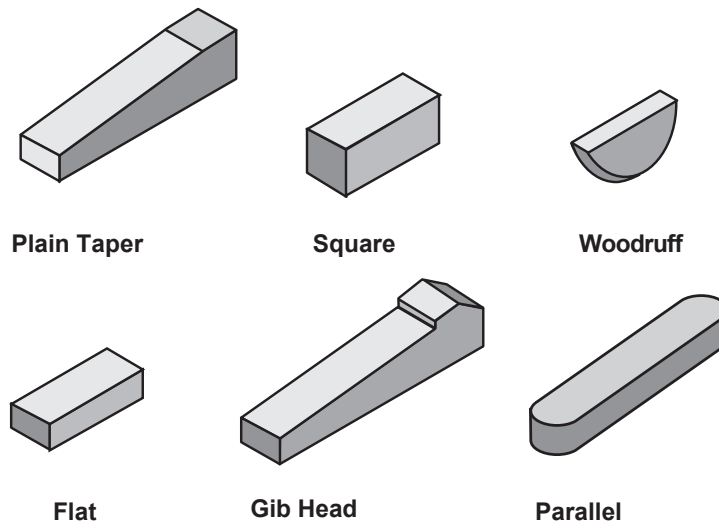
Internal (Int.) – The surface or area inside an object.

Jig – A device for guiding a tool in cutting a piece. Usually, it holds the work in position. Also called a fixture.

Junction (Jct.) – The point of intersection of two or more lines, planes, axes or features.

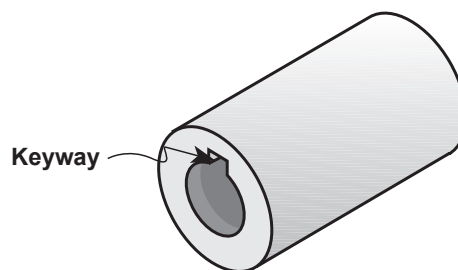
Key – A small piece of metal sunk into both shaft and hub to prevent rotation. (see Figure 1-60)

FIGURE 1-60
Keys



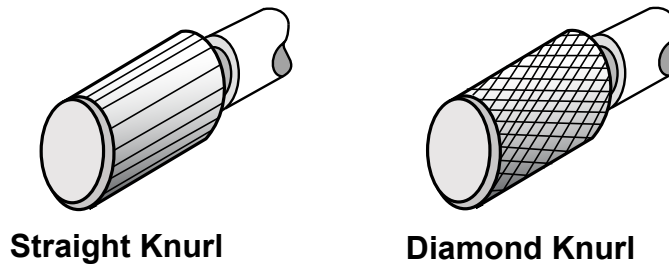
Keyway – In a mechanical power transmission system, the pocket in the driven element that is a driving surface for key. A groove or channel in a shaft or the hole of a gear or pulley that fits a key to prevent joint slippage. (see Figure 1-61)

FIGURE 1-61
Keyway



Knurl – To impress a pattern of dents in a turned surface with a special lathe tool to produce a better hand grip. (see Figure 1-62)

FIGURE 1-62
Knurl



Left-hand (LH) – Oriented to the viewer’s left hand. A left-hand screw thread advances into a material when turned counter-clockwise.

Linear (Lin.) – Of or relating to a line. Also, in a straight line; for example, linear motion. Having a single dimension.

Line Ream – To ream holes in line, or parallel to each other.

Lug – A projection or head on a metal part that serves as a cap, handle, support, or fitting connection. A projection from a casting of irregular shape. (see Figure 1-63)

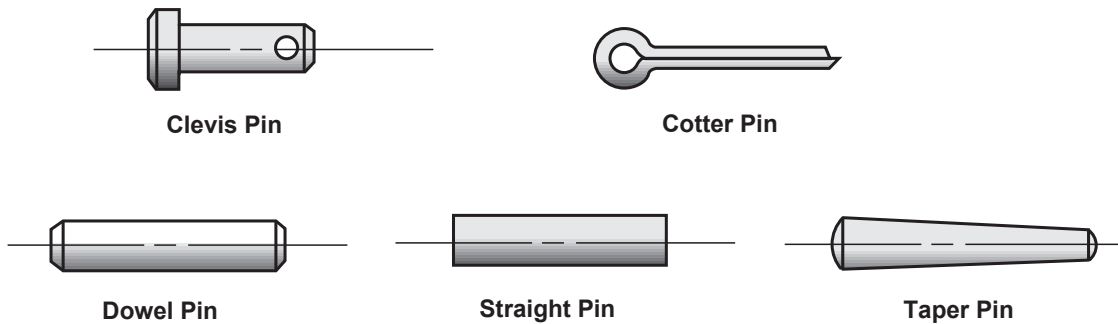
FIGURE 1-63
Lug



Machine (Mach.) – To perform various cutting or grinding operations on a work piece.

Machine Pins – Semi-permanent fasteners for parts which are to be assembled and disassembled. (see Figure 1-64)

**FIGURE 1-64
Machine Pins**



Machine Steel (MS) – Free-machining, general-purpose, plain carbon steel with a 0.2 to 0.3% carbon content.

Magnaflux (M) – Trade name for non-destructive magnetic particle materials testing method, which is used only on magnetic steels to identify cracks.

Magnesium (Mag. or Mg) – A silver-white, lightweight, malleable, ductile metal.

Manufacturing (Mfg.) – That portion of the industrial world involved in producing the goods that our society uses day-to-day.

Material (Mat'l) – The substance from which an object is made.

Maximum (Max.) – The greatest quantity or degree; highest possible value.

Mechanical (Mech.) – Pertaining to or concerned with machinery or tools.

Milling – To machine metal surfaces by forcing a part past a rotating cutter.

Journal – Portion of a rotating shaft supported by a bearing.

Minimum (Min.) – The least quantity, amount or degree; the least value.

Minute (Min.) – A unit of time equal to $\frac{1}{60}$ of an hour or 60 seconds. Also, a unit of angle measurement equal to $\frac{1}{60}$ of 1° .

National Coarse (NC) – A screw thread designation for a coarse thread.

National Extra-Fine (NEF) – A screw thread name for an extra-fine thread.

National Fine (NF) – A screw thread designation for a fine thread.

National Pipe Threads (NPT) – American National Standard Taper Pipe Threads. A 60° -thread form for pipe.

Normalize – To heat treat a component to restore it to its original shape.

Number (No. or #) – A symbol or word expressing a quantity.

Numeral – A symbol that expresses or names a number: 1, 2, 3, etc.

Opposite (Opp.) – A part feature in line with another feature but separated by space.

Out-of-Round – Not round. Egg-shaped or elliptical. Not turning on a geometrical axis.

Outside Diameter (OD) – The length of a line drawn through the center of a cylinder or sphere, terminating at the outside circumference on each end.

Overall (OA) – A general statement pertaining to an entire object.

Pad – A projection of excess metal on a casting, forging or welded part. Usually irregular in shape.

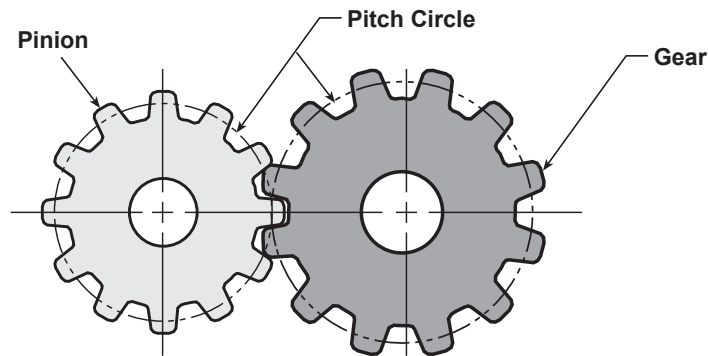
P & I – Primer coat plus one coat of paint.

Parallel – A situation wherein two or more lines or planes are at a fixed distance from one another, never converging or diverging.

Pattern (Patt.) – The exact replica of a finished casting, except that it is slightly larger to allow for shrinkage. Made from wood or metal, the pattern is set in sand or similar material to form the cavity of the mold.

Pinion – The smaller of two mating gears. (see Figure 1-65)

FIGURE 1-65
Pinion



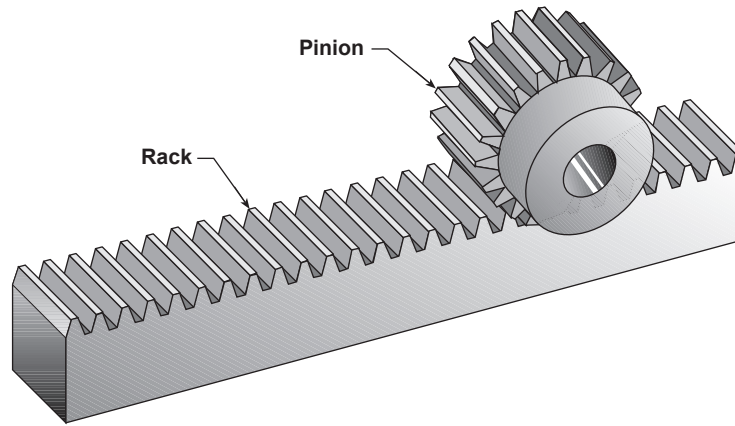
Pitch (P) – In a screw thread, the distance from a point on a thread to the same point on an adjacent thread.

Pitch Circle – An imaginary circle corresponding to the circumference of the friction gear from which the spur gear was derived.

Pitch Diameter (PD) – The diameter of an imaginary circle on a gear that separates the addendum and dedendum of the tooth. RPM calculations for gears are based on this circle, because (theoretically) the pitch circles of mating gears are tangent.

Rack – Flat bar with gear teeth in a straight line to engage with teeth in gear. Also, a gear with an infinite radius. (see Figure 1-66)

FIGURE 1-66
Rack



Radius (R or Rad.) – Equal to $\frac{1}{2}$ the diameter of a circle. The distance from the center of a circle or sphere to any point on the periphery.

Reamed Hole – Any previously-drilled or -bored hole that has been sized, enlarged or smoothed by a cutting tool called a reamer.

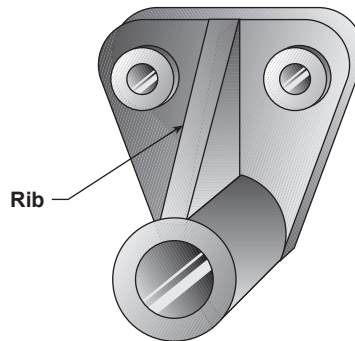
Reference Dimension (REF.) – A dimension without a tolerance used for informational purposes only, and does not govern machining operations in any way. A distance from a point or plane used to locate a part feature.

Revised or Revision (Rev.) – Any formal changes made to a blueprint.

Revolutions Per Minute (rpm) – The number of times in one minute that a body spins 360° in its axis.

Rib – A relatively thin, flat member acting as a support. Also see web and gusset. (see Figure 1-67)

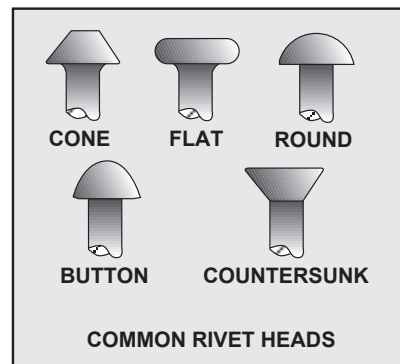
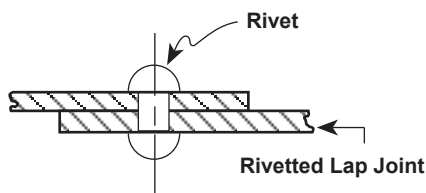
FIGURE 1-67
Rib



Right Hand (RH) – Oriented to the viewer’s right hand. A right-hand screw thread advances into a material when turned clockwise.

Rivet – To fasten by rivets, or to clench over the end of a pin spreading the end. (see Figure 1-68).

FIGURE 1-68
Rivets



Root Diameter (RD) – The diameter of a screw taken at the bottom of the grooves. Also, the diameter of a gear taken at the root circle, or base, of teeth.

Round Head (Rnd. Hd.) – Shape of a common screw fastener’s head representing one-half of a sphere.

Sandblast – To blow sand at high velocity with compressed air against a component to clean them.

Screw – A cylinder with a helical groove cut into its surface.

Section or Sectional View (Sec.) – The graphic removal of a portion of an object to reveal internal lines and surfaces.

Shim – A thin piece of metal or material used as a spacer in adjusting two parts.

Sine (Sin) – A trigonometric function showing the relationship between the value of an acute angle in a right triangle, and the side opposite that angle and the hypotenuse. $\text{Sine} = \text{Opp./Hyp.}$

Society of Automotive Engineers (SAE) – Organization that promotes all aspects of the design, construction and use of self-propelled mechanisms, prime movers, their components and related equipment.

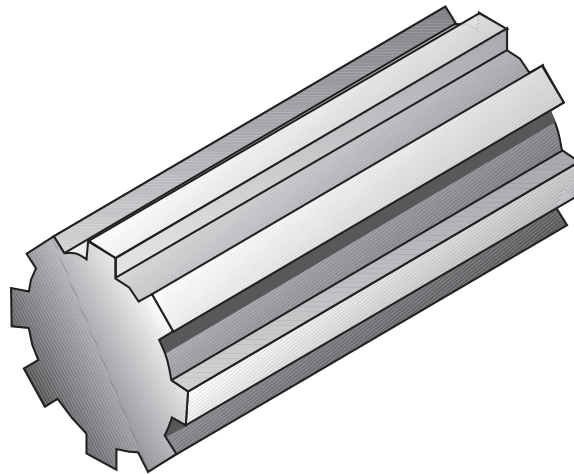
Socket Head (Skt. Hd.) – The head of a screw fastener in which a hexagonal-shaped pocket is recessed. Tightened with an Allen wrench or hexagonal key. Standard for capscrews.

Solder – To join two parts with an alloy composed of lead and tin.

Specifications (Spec(s).) – An organized list of basic requirements for materials, product composition and dimensions. The information on a blueprint relating to an object’s size, surface quality, hardness, etc.

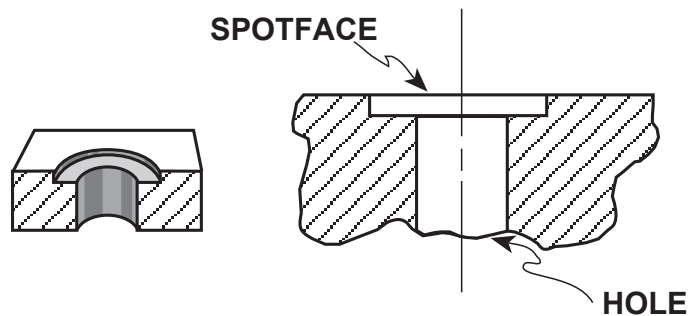
Spline – A gear-like coupling mechanism for connecting shafts, transmitting mechanical power and attaching parts. (see Figure 1-69)

FIGURE 1-69
Spline



Spot Face (Spt. Fc.) – The machining of a circular area around a hole in a weldment or casting to provide a flat, smooth surface to accept the head of a fastener. (see Figure 1-70)

FIGURE 1-70
Spot Face



Square (Sq.) – The plane geometric figure having four equal sides and four interior 90° angles.

Standard (Std.) – Data established by authority, custom or general consent as a rule for measuring quantity, weight, extent, value, quality, etc. Usually written and published by technical societies, professional organizations or trade associations.

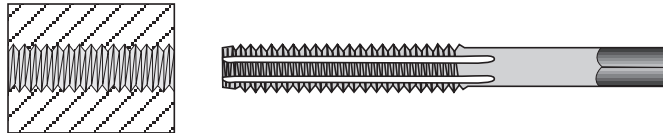
Stock – The products of metal manufacturers and processors stored in a machine shop for use in making an object or part.

Surface (Surf.) – An exterior or interior area of object; may be flat or curved.

Tangent (Tan) – A trigonometric function showing the relationship between the value of an acute angle in a right triangle and the side opposite that angle and the side adjacent. $Tan = Opp/Adj$.

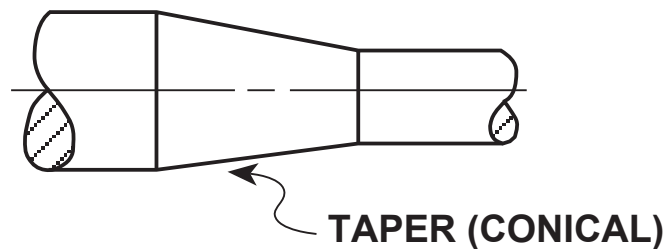
Tap – A cutting tool used to form internal screw threads. (see Figure 1-71)

FIGURE 1-71
Tap



Taper – Gradually changing shape given to a shaft, hole or part. (see Figure 1-72)

FIGURE 1-72
Taper



Temperature (Temp – F° or C°) – The degree of hotness or coldness of a substance or object measured in degrees Fahrenheit or Celsius.

Template – A guide or pattern used to mark out work, guide the tool in cutting it or to check the finished product.

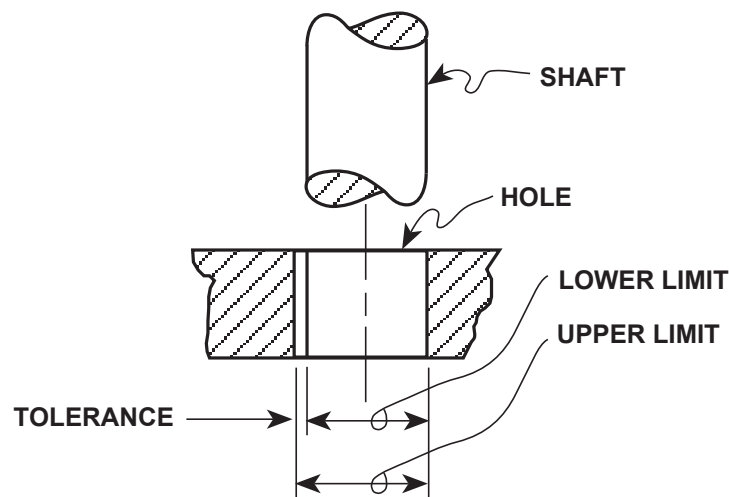
Tensile Strength (Ten. Str.) – The maximum stress that a material subjected to a stretching load can withstand without tearing. Also called hot strength.

Thread, Threading (Thd.) – The interior or exterior continuous helical rib on a screw or pipe used to join and hold parts together. To cut screw threads in a material.

Thru Hole (Thru) – The depth of a hole in a part that goes “all the way through.”

Tolerance – Allowable deviation from a standard. (see Figure 1-73)

FIGURE 1-73
Tolerance



Total Indicator Reading (TIR) – A maximum/minimum reading obtained from a full sweep of a part with a dial indicator. Dial indicators are used to check linear alignment, circular positioning and measure of travel, etc.

Turn – The cutting operation performed on the lathe.

Undercutting – An undesirable recess, either cut or molded into an object, that leaves a topside lip or protuberance. To turn a section of a shaft undersize to provide clearance; to bore out a shoulder for clearance.

Unified National Coarse (UNC) – The unified U.S., United Kingdom and Canadian screw thread form having a National Coarse designation.

Unified National Fine (UNF) – The unified United States, United Kingdom and Canadian screw thread form having a National Fine designation.

Unified National Special (UNS) – The unified United States, United Kingdom and Canadian screw thread form having a special designation.

Unified Thread Form (U) – The United States, United Kingdom and Canadian screw thread form having a radius at the root instead of a flat as in the National system. The National and Unified forms are interchangeable.

Vertical (Vert.) – Perpendicular to the plane of the horizon; upright.

Volume (Vol.) – The measure of the size of an object or defined region in three-dimensional space. The product of height x width x depth, measured in cubic units: cubic feet, cubic inches, cubic centimeters, etc.

Web – A thin, metal section between the ribs, bosses or flanges of a casting to add strength. In a forging, the thin metal section remaining at the bottom of a depression or at the location of the punches.

Weight (Wt.) – The gravitational force with which the Earth attracts a body or object measured in pounds, ounces, kilograms or grams.

Yard (Yd.) – A unit of length used in the United States and United Kingdom equal to 3 ft., 36 in., or 0.9144 meters.



NOTES: