1. Machine Drawing – Introduction

A technical person can use the graphic language as powerful means of communication with others for conveying ideas on technical matters. However, for effective exchange of ideas with others, the engineer must have proficiency in (*i*) language, both written and oral, (*ii*) symbols associated with basic sciences and (*iii*) the graphic language. Engineering drawing is a suitable graphic language from which any trained person can visualize the required object. As an Engineering drawing displays the exact picture of an object; it obviously conveys the same ideas to every trained eye.

Machine Drawing is pertaining to machine parts or components. It is presented through a number of orthographic views, so that the size and shape of the component is fully understood. Part drawings and assembly drawings belong to this classification.

Component or part drawing is a detailed drawing of a component to facilitate its manufacture. All the principles of orthographic projection and the technique of graphic representation must be followed to communicate the details in a part drawing.

A drawing that shows the various parts of a machine in their correct working locations is an **Assembly drawing**.

2. Conventional Representations

Certain draughting conventions are used to represent materials in section and machine elements in machine drawings.

As a variety of materials are used for machine components in engineering applications, it is preferable to have different conventions of section lining to differentiate between various materials. The recommended conventions in use are shown in Fig.2.1.

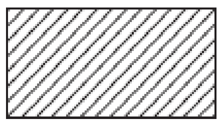
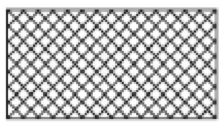
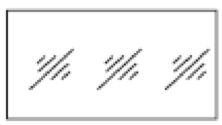
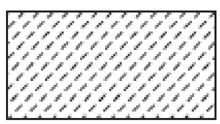
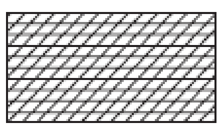
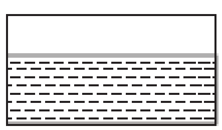
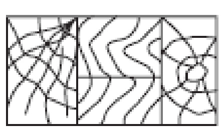
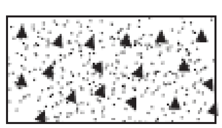
Type	Convention	Material
Metals		Steel, Cast Iron, Copper and its Alloys, Aluminium and its Alloys, etc.
		Lead, Zinc, Tin, White-metal, etc.
Glass		Glass
Packing and Insulating material		Porcelain, Stoneware, Marble, Slate, etc.
		Asbestos, Fibre, Felt, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, Insulating and Filling materials, etc.
Liquids		Water, Oil, Petrol, Kerosene, etc.
Wood		Wood, Plywood, etc.
Concrete		A mixture of Cement, Sand and Gravel

Fig.2.1. Conventional Representations of Materials

When the drawing of a component in its true projection involves a lot of time, its convention may be used to represent the actual component. Fig.2.2 shows typical examples of conventional representation of various machine components used in engineering drawing.

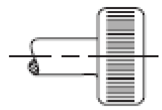
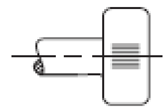
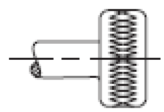
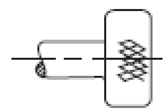
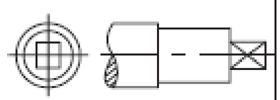
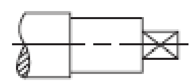
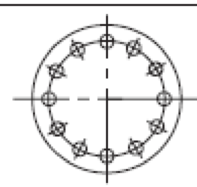
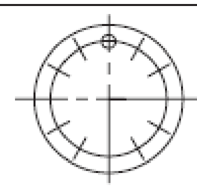
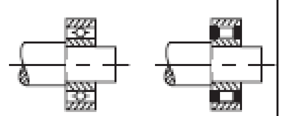
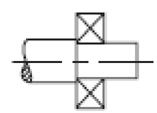
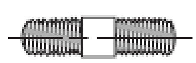
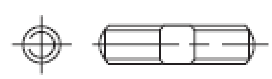
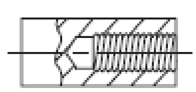
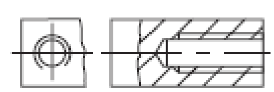
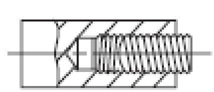
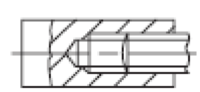
Title	Subject	Convention
Straight knurling		
Diamond knurling		
Square on shaft		
Holes on circular pitch		
Bearings		
External screw threads (Detail)		
Internal screw threads (Detail)		
Screw threads (Assembly)		

Fig.2.2 Conventional Representations of machine components

3. Drawing Standards – Welding Joints and Symbols

Welding is an effective method of making permanent joints between two or more metal parts. Cast iron, steel and its alloys, brass and copper are the metals that may be welded easily.

Basic terms of a welded joint are shown in Fig.3.1

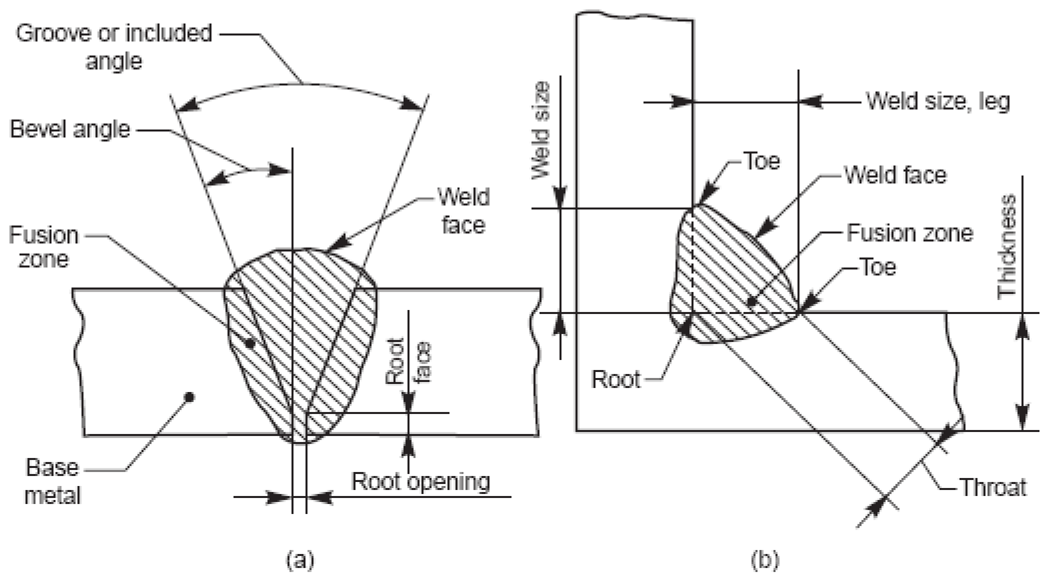


Fig.3.1 (a) Butt Weld (b) Fillet Weld

The complete method of representation of the welds on the drawing is shown in Fig 3.2.

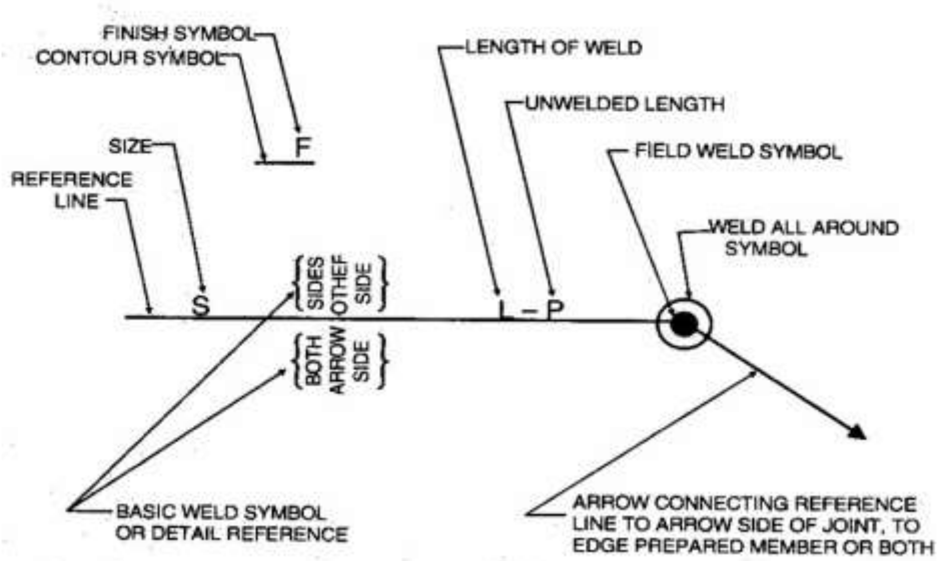


Fig.3.2 Weld symbol representation

Elementary weld symbols for various types of welds are shown in fig 3.3.

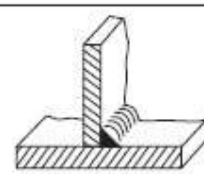
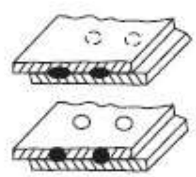
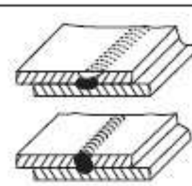
No.	*Designation*	*Illustration*	*Symbol*
1.	Butt weld between plates with raised edges (the raised edges being melted down completely)		
2.	Square butt weld		
3.	Single-V butt weld		
4.	Single-bevel butt weld		
5.	Single-V butt weld with broad root face		
6.	Single-bevel butt weld with broad root face		
7.	Single-U butt weld (parallel or sloping sides)		
8.	Single-U butt weld		
9.	Backing run; back or backing weld		
10.	Fillet weld		
11.	Plug weld; plug or slot weld		
12.	Spot weld		
13.	Seam weld		

Fig.3.3 Elementary Weld symbols

4. Drawing Standards - Riveted joints, Keys, Fasteners

Mechanical Joints

Often small machine components are joined together to form a larger machine part. Design of joints is as important as that of machine components because a weak joint may spoil the utility of a carefully designed machine part.

Mechanical joints are broadly classified into two classes viz., non-permanent joints and permanent joints.

Non-permanent joints can be assembled and dissembled without damaging the components. Examples of such joints are threaded fasteners (like screw-joints), keys and couplings etc.

Permanent joints cannot be dissembled without damaging the components. These joints can be of two kinds depending upon the nature of force that holds the two parts. The force can be of mechanical origin, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by applying mechanical force.

Riveted joints

A Rivet is a short cylindrical rod having a head and a tapered tail. The main body of the rivet is called shank (shown in fig 4.1). According to Indian standard specifications rivet heads are of various types. Rivets heads for general purposes are specified by Indian standards IS: 2155-1982 (below 12 mm diameter) and IS: 1929-1982 (from 12 mm to 48 mm diameter). Rivet heads used for boiler works are specified by IS: 1928-1978. To get dimensions of the heads see any machine design handbook.

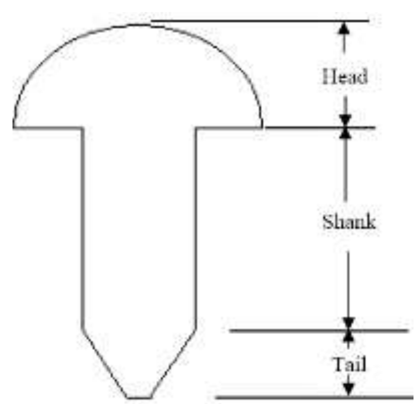


Fig.4.1 Rivet and its parts

Riveting is an operation whereby two plates are joined with the help of a rivet. Adequate mechanical force is applied to make the joint strong and leak proof. Smooth holes are drilled (or punched and reamed) in two plates to be joined and the rivet is inserted. Holding, then, the head by means of a backing up bar as shown in figure 4.2, necessary force is applied at the tail end with a die until the tail deforms plastically to the required shape.

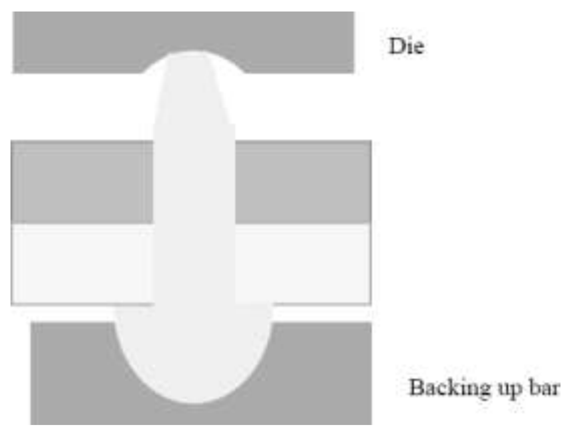


Fig.4.2 Riveting operation

Types of riveted joints

Riveted joints are mainly classified into two types

1. Lap joints
2. Butt joints

1. Lab Joint

The plates that are to be joined are brought face to face such that an overlap exists, as shown in fig.4.3. Rivets are inserted on the overlapping portion. Single or multiple rows of rivets are used to give strength to the joint.

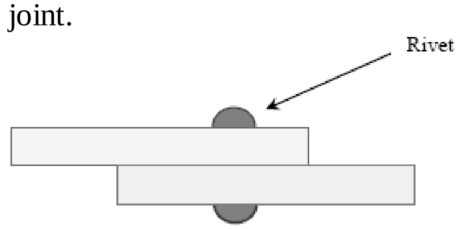


Fig.4.3 Lab joint

2. Butt Joint

In this type of joint, the plates are brought to each other without forming any overlap. Riveted joints are formed between each of the plates and one or two cover plates. Depending upon the number of cover plates the butt joints may be single strap or double strap butt joints. A single strap butt joint is shown in fig. 4.4.

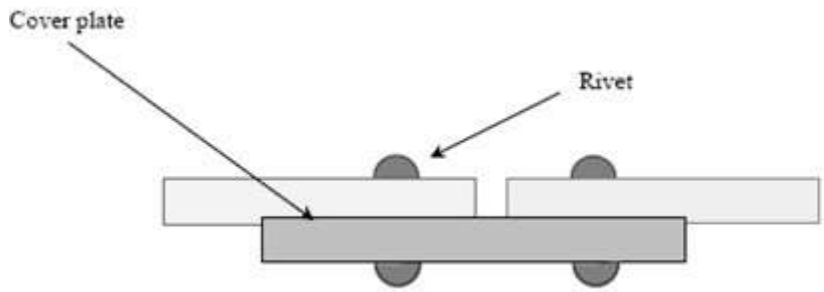


Fig.4.4 Butt joint

Keys

Keys are machine elements used to prevent relative rotational movement between a shaft and the parts mounted on it, such as pulleys, gears, wheels, couplings, etc. Fig.4.5 and Fig.4.6. shows the parts of a key joint and its assembly.

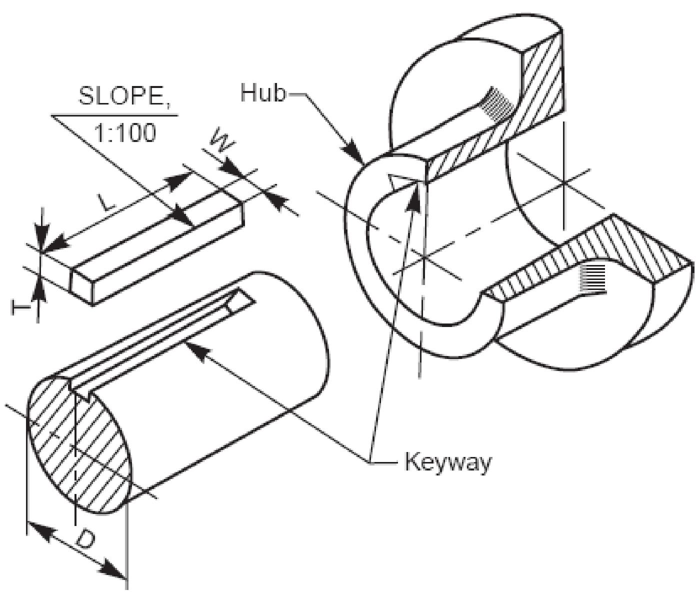


Fig.4.5 Parts of Key Joints

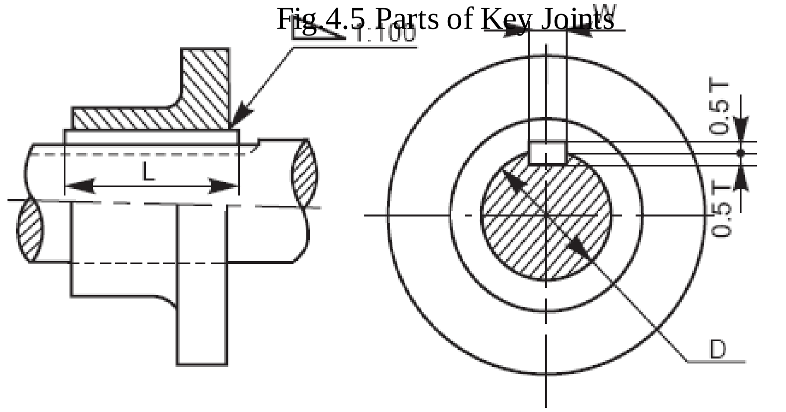


Fig.4.6 Assembly of Key Joints

Fasteners

A machine element used for holding or joining two or more parts of a machine or structure is known as a fastener. The process of joining the parts is called fastening. The fasteners are of two types: permanent and removable (temporary). Riveting and welding processes are used for fastening permanently. Screwed fasteners such as bolts, studs and nuts in combination, machine screws, set screws, etc., and keys, cotters, couplings, etc., are used for fastening components that require frequent assembly and dissembly.

Screwed fasteners occupy the most prominent place among the removable fasteners. A screw thread is obtained by cutting a continuous helical groove on a cylindrical surface (external thread). The threaded portion engages with a corresponding threaded hole (internal thread); forming a screwed fastener. Following are the terms that are associated with screw threads shown in fig, 4.7.

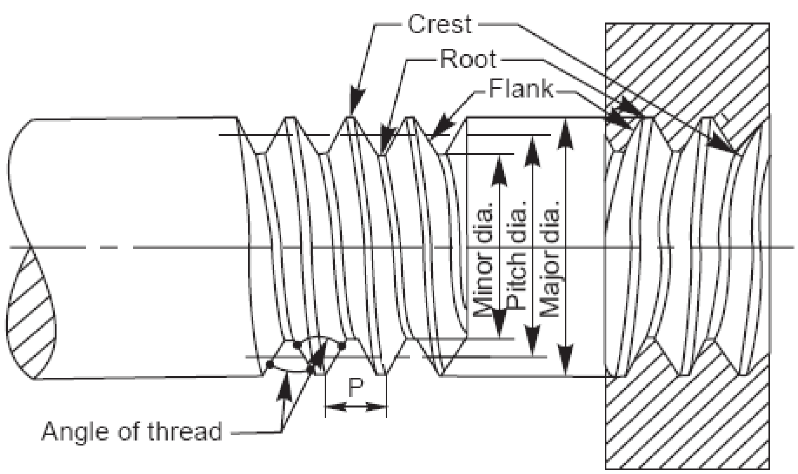


Fig.4.7. Screw Thread

5. Limits, Fits and Tolerances

The manufacture of interchangeable parts require precision. Precision is the degree of accuracy to ensure the functioning of a part as intended. However, experience shows that it is impossible to make parts economically to the exact dimensions.

The workman, therefore, has to be given some allowable margin so that he can produce a part, the dimensions of which will lie between two acceptable limits, a maximum and a minimum.

The system in which a variation is accepted is called the **limit system** and the allowable deviations are called **tolerances**.

The relationships between the mating parts are called **fits.**

The study of limits, tolerances and fits is a must for technologists involved in production. The same must be reflected on production drawing, for guiding the craftsman on the shop floor.

Limits

The two extreme permissible sizes between which the actual size is contained are called limits. The maximum size is called the upper limit and the minimum size is called the lower limit.

Allowance

It is the dimensional difference between the maximum material limits of the mating parts, intentionally provided to obtain the desired class of fit. If the allowance is positive, it will result in minimum clearance between the mating parts and if the allowance is negative, it will result in maximum interference.

Basic Size

It is determined solely from design calculations. If the strength and stiffness requirements need a 50mm diameter shaft, then 50mm is the basic shaft size. If it has to fit into a hole, then 50mm is the basic size of the hole.

Figure 5.1 illustrates the basic size, deviations and tolerances.

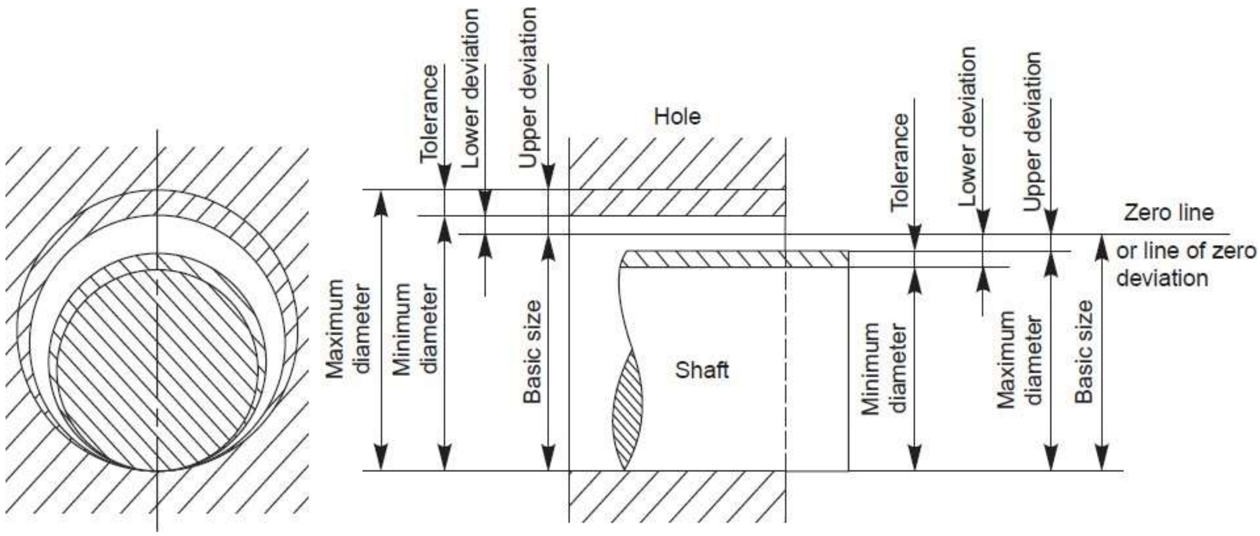


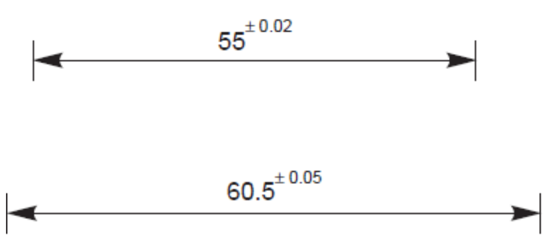
Fig.5.1. Basic size, Deviations and Tolerances

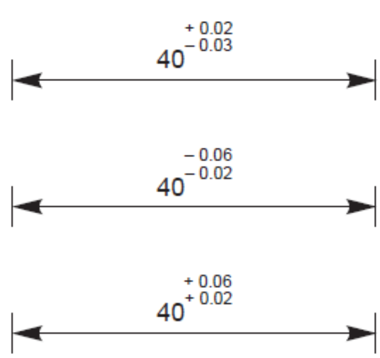
Tolerances

Tolerance is the total amount that a specific dimension is permitted to vary; It is th difference between the maximum and the minimum limits for the dimension.For Example a dimension given as 1.625 ± .002 means that the manufactured part may be 1.627" or 1.623", or anywhere between these limit dimensions.

Specifications of Tolerances

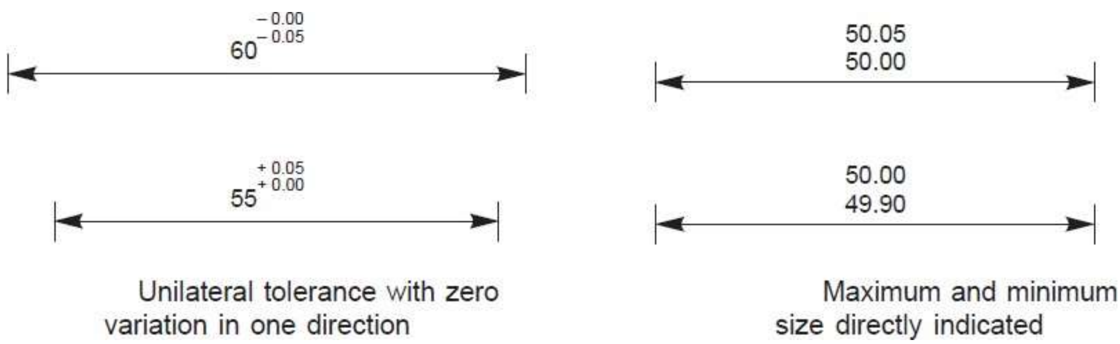
The basic size and the tolerance values are indicated above the dimension line; the tolerance values being in a size smaller than that of the basic size and the lower deviation value being indicated in line with the basic size. The following is one of the method for indicating tolerance limit.





Bilateral tolerance of equal variation

Bilateral tolerance of unequal variation



Fits

The relation between two mating parts is known as a fit. Depending upon the actual limits of the hole or shaft sizes, fits may be classified as clearance fit, transition fit and interference fit.

Clearance Fit

An internal member fits in an external member (as a shaft in a hole) and always leaves a space or clearance between the parts.

Fig.5.2 shows the schematic representation of clearnce fit.

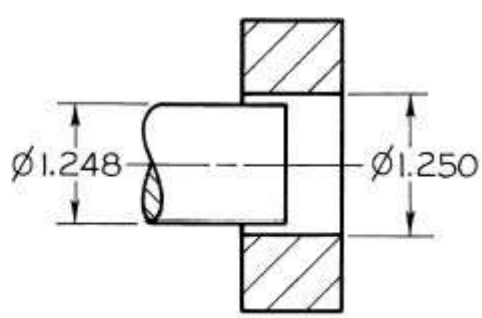


Fig.5.2. Clearance Fit

Interference Fit

The internal member is larger than the external member such that there is always an actual interference of material. For an example(shown in fig 5.3), the smallest shaft is 1.2513” and the largest hole is 1.2506”, so that there is an actual interference of metal amounting to at least 0.0007”. Under maximum material conditions the interference would be 0.0019”.

Fig.5.3 shows the schematic representation of Interference fit.

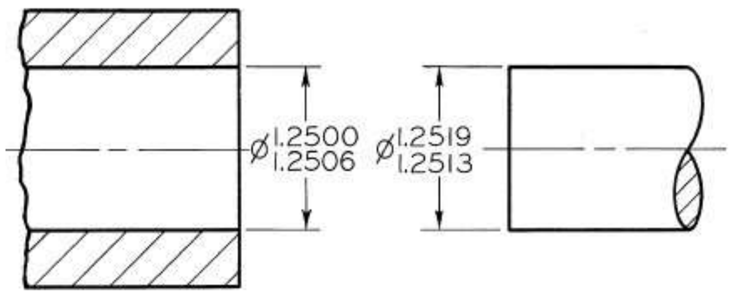


Fig.5.3. Interference Fit

Transition Fit

It may result in either a clearance or interference condition. In the fig 5.4, the smallest shaft 1.2503” will fit in the largest hole 1.2506”, with 0.003” to spare. But the largest shaft, 1.2509” will have to be forced into the smallest hole, 1.2500” with an interference of metal of 0.009”.

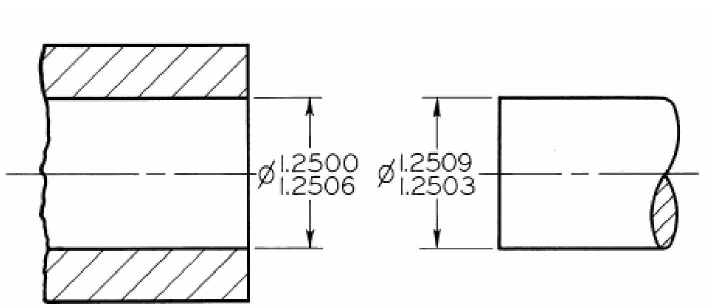


Fig.5.3. Transition Fit