# CHAPTER- 1

## NEED OF LIMIT, FITS AND TOLERANCE, MAXIMUM LIMIT OF SIZE, MINIMUM LIMIT OF SIZE, DEVIATION, UPPER DEVIATION, LOWER DEVIATION, TOLERANCE, ALLOWANCE,

### Need of Limits, Fit and Tolerance

The need of limits, fit and tolerance is due to following reasons:

1. Mass production and specialization
2. Standardization
3. Interchangeability

- **Mass production and specialization:** Due to various advantages of mass production, it is not possible for an industry to produce all the components of a machine. This concept leads to the need of maximum and minimum limit of sizes of machine components.
- **Standardization:** The growing technology has introduce elements of standardization specifying the size of machine components nationally and internationally in order to enjoy the benefits of large scale production. It helps in reducing the time and efforts to make the new machine. It minimizes the production cost. It helps in improving the quality of finishing goods.
- **Interchangeability:** It ensures the possibility of assembling a unit or machine without indulging in extra machining. If various machines are provided with interchangeability for spare parts, they can be repairable for replacement of worn out parts in service condition.

### Important Terms used in Limit System

- **Basic Dimension:** It is also known as Nominal dimension. It is dimension of machine element derived from design calculation.
- **Limit if Sizes:** These are extreme permissible sizes for dimension. The largest permissible size is called Maximum limit of size or upper limit while the smallest permissible size is called minimum limit of size or lower limit.
- **Deviation:** It is the algebraic difference between actual measured size and corresponding basic size.
- **Upper Deviation:** It is the algebraic difference between maximum limit of size and corresponding basic size.
- **Lowe Deviation:** It is the algebraic difference between minimum limit of size and corresponding basic size.
- **Tolerance:** It is the difference between upper limit and lower limit of the sizes of a component. It is of two types:
  (i) Unilateral Tolerance
  (ii) Bilateral Tolerance
- **Allowance:** It is the intentional difference between maximum material condition of mating parts.

## FUNDAMENTAL DEVIATION, CLEARANCE, MAXIMUM CLEARANCE, MINIMUM CLEARANCE. FITS – CLEARANCE FIT, INTERFERENCE FIT AND TRANSITION FIT. HOLE BASIS SYSTEM, SHAFT BASIS SYSTEM

### Important Terms used in Limit System

- **Basic Dimension:** It is also known as Nominal dimension. It is dimension of machine element derived from design calculation.

- **Fundamental deviation:** It is one of the two deviation which is easily chosen in order to define the position of tolerance zone with respect to zero line.
- **Clearance:** It may be defined as the difference between the dimension of the hole and the shaft given intentionally to get particular type of fit. Clearance may be positive or negative.
- **Maximum Clearance:** It is the difference between the maximum size of hole and minimum size of shaft.
- **Minimum Clearance:** It is the difference between the minimum size of hole and maximum size of shaft.

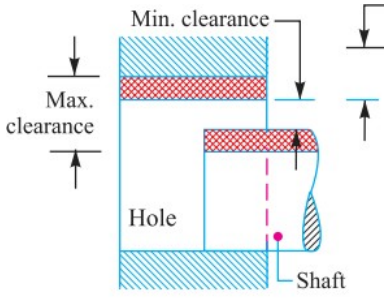
## Fit

The assembly of two mating parts is called fit. The fits are given as under in ordinary machine condition:

1. Force fit e.g. Railway fit, Tram card.
2. Running fit e.g. shaft is rotating in bearing.
3. Push fit e.g. Shaft rotate in locating plugs.
4. Driving fit. e.g. pulley fitted on a shaft with key.

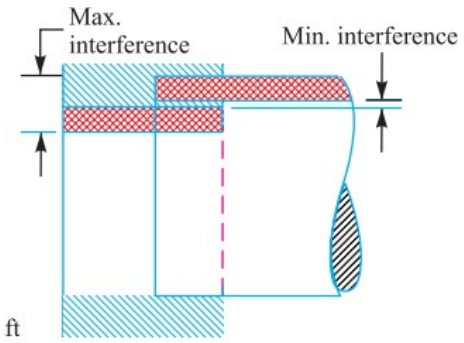
## Types of Fit

1. **Clearance Fit:** In this fit, minimum hole diameter is larger than maximum shaft diameter. Here both maximum and minimum clearances are always positive.



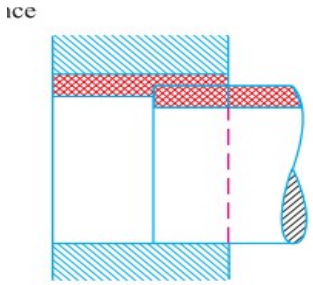

(*a*) Clearance fit.

2. **Transition Fit:** In this fit, tolerance zone of both shaft and hole overlap. Here maximum clearance is positive while minimum clearance is negative.




(*b*) Interference fit.

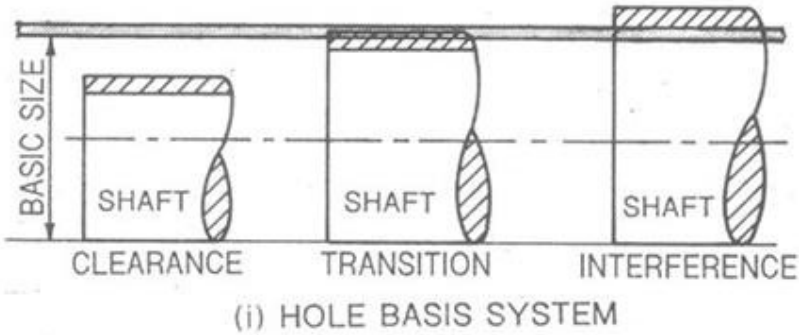
3. **Interference Fit:** In this fit, maximum hole diameter is always smaller than minimum shaft diameter. Here both maximum and minimum clearances are always negative.




(*c*) Transition fit.

## Hole Basis System:

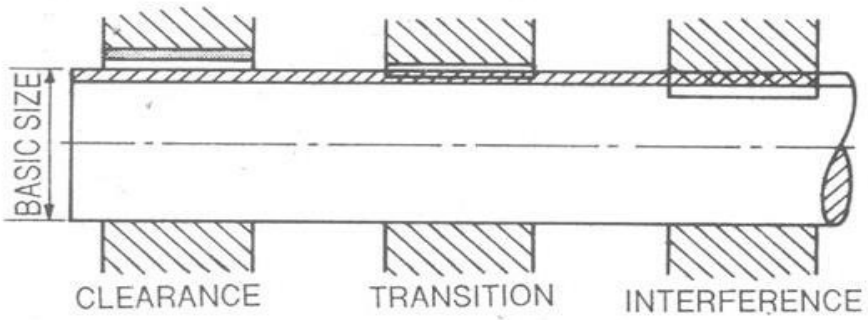
In this system, tolerance zone of hole is kept constant while tolerance zone of shaft is varied above and below the zero line. The hole basis system is used for engine building, locomotive construction etc. In this system lower deviation for hole is zero.




(i) HOLE BASIS SYSTEM

## Shaft Basis System:

In this system, tolerance zone of shaft is kept constant while tolerance zone of hole is varied above and below the zero line. In this system upper deviation for shaft is zero.




(ii) SHAFT BASIS SYSTEM

# TOLERANCE GRADES, CALCULATING VALUES OF CLEARANCE, INTERFERENCE, HOLE TOLERANCE, SHAFT TOLERANCE WITH GIVEN BASIC SIZE FOR COMMON ASSEMBLIES LIKE H7/G6, H7/M6, H8/P6.

**Table 1.2 : Fundamental Tolerance of Grades**

| Basic size (mm) | | Fundamental Tolerance of Grades (microns) or International Tolerance Grades (microns) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Over | Upto | *01* | *0* | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* | *14* | *15* | *16* |
| 0 | 3 | 0.3 | 0.5 | 0.8 | 1.2 | 2.0 | 3 | 4 | 6 | 10 | 14 | 25 | 40 | 60 | 100 | 140 | 250 | 400 | 600 |
| 3 | 6 | 0.4 | 0.6 | 1.0 | 1.5 | 2.5 | 4 | 5 | 8 | 12 | 18 | 30 | 48 | 75 | 120 | 180 | 300 | 480 | 750 |
| 6 | 10 | 0.4 | 0.6 | 1.0 | 1.5 | 2.5 | 4 | 6 | 9 | 15 | 22 | 36 | 58 | 90 | 150 | 220 | 360 | 580 | 900 |
| 10 | 18 | 0.5 | 0.8 | 1.2 | 2.0 | 3 | 5 | 8 | 11 | 18 | 27 | 43 | 70 | 110 | 180 | 270 | 430 | 700 | 1100 |
| 18 | 30 | 0.6 | 1.0 | 1.5 | 2.5 | 4 | 6 | 9 | 13 | 21 | 33 | 52 | 54 | 130 | 210 | 330 | 520 | 840 | 1300 |
| 30 | 50 | 0.6 | 1.0 | 1.5 | 2.5 | 4 | 7 | 11 | 16 | 25 | 39 | 62 | 100 | 160 | 250 | 390 | 620 | 1000 | 1600 |
| 50 | 80 | 0.8 | 1.2 | 2.0 | 3 | 5 | 8 | 13 | 19 | 30 | 46 | 74 | 120 | 190 | 300 | 460 | 740 | 1200 | 1900 |
| 80 | 120 | 1.0 | 1.5 | 2.5 | 4 | 6 | 10 | 15 | 22 | 35 | 54 | 87 | 140 | 220 | 350 | 540 | 870 | 1400 | 2200 |
| 120 | 180 | 1.2 | 2 | 3.5 | 5 | 8 | 12 | 18 | 25 | 40 | 63 | 100 | 160 | 250 | 400 | 630 | 1000 | 1600 | 2500 |
| 180 | 250 | 2.0 | 3 | 4.5 | 7 | 10 | 14 | 20 | 29 | 46 | 72 | 115 | 185 | 290 | 460 | 720 | 1150 | 1850 | 2900 |
| 250 | 315 | 2.5 | 4 | 6 | 8 | 12 | 16 | 23 | 32 | 52 | 81 | 130 | 210 | 320 | 520 | 810 | 1300 | 2100 | 3200 |
| 315 | 400 | 3.0 | 5 | 7 | 9 | 13 | 18 | 25 | 36 | 57 | 89 | 140 | 230 | 360 | 570 | 890 | 1400 | 2300 | 3600 |
| 400 | 500 | 4.0 | 6 | 8 | 10 | 15 | 20 | 27 | 40 | 63 | 97 | 155 | 250 | 400 | 630 | 970 | 1500 | 2500 | 4000 |

Tolerance Grades

## 1.16 CLEARANCE

It may be defined as *the difference between the dimensions of the hole and the shaft assigned intentionally to obtain a particular type of fit.* It may be positive or negative. When the shaft size is smaller than the hole size, it will be positive and when the shaft size is bigger than the hole size, it will be negative.

### 1.16.1 Maximum Clearance

*In a clearance fit, the maximum clearance is the difference between the maximum size of hole and minimum size of shaft.*

### 1.16.2 Minimum Clearance

*In a clearance fit, the minimum clearance is the difference between the minimum size of hole and the maximum size of shaft.*

**Problem 1.1. Determine the tolerance for the basic dimension in the steps of 50 mm to 80 mm.**

**Solution.** Geometric mean of two diameters,

$$D = \sqrt{50 \times 80} = 63.25 \text{ mm}$$

Standard tolerance unit, $i = 0.45 \times D^{1/3} + 0.001D$

$$= 0.45 \times (63.25)^{1/3} + 0.001 \times 63.25 = 1.856$$

Now tolerance for any grade can be calculated.

Let us take IT11 grade.

$\therefore$ Tolerance $= 100\, i = 100 \times 1.856$

$= 185.6$ microns **Ans.**

which is approximately the same as given is table 1.2.

**Problem 1.7. Explain the meaning of $\phi$30 H7/g6.**

**Solution.** $\phi$30 indicates the basic size of hole.

Hole : H7 + 21 microns

00 microns

Hole size = $\phi^{30.021\text{ mm}}_{30.000\text{mm}}$ **Ans.**

Shaft : g6 – 7 microns

– 20 microns

Shaft size = $\phi^{29.993\text{mm}}_{29.980\text{ mm}}$ **Ans.**

As the shaft size is smaller than hole size, therefore, the mating pair provides clearance fit. **Ans.**

**Problem 1.8. Explain the meaning of $\phi$50 H7/p6.**

**Solution.** $\phi$50 indicates the basic size of hole.

Hole : H7 + 25 microns

0 microns

Hole size = $\phi^{50.025\text{mm}}_{50.000\text{mm}}$ **Ans.**

Shaft : $p6$ + 42 microns
+ 26 microns

Shaft size = $\phi^{50.042\text{ mm}}_{50.026\text{ mm}}$ **Ans.**

Allowance = Lower limit of hole – Upper limit of shaft
= 50.000 –50.042
= –0.042 mm

Negative sign indicates interference fit. **Ans.**

## Symbols of Fit

**Table 1.9 : Fits for Various Engineering Applications**

| Type of Fit | Symbol | Applications |
|---|---|---|
| **Clearance Fit :** | | |
| Slack running fit | H8/*c*11 | Oil seals |
| Loose running fit | H8/*d*9 | Low speed sleeve bearings, plastic bearings. |
| Easy running fit | H8/*e*8 | Medium speed sleeve bearings, grease lubricated bearings, sliding blocks, gear sliding on shafts. |
| Close running fit | H7/*f* 7 | Sleeve bearings with high revolutions, crank and connecting rod bearings. |
| Sliding fit | H7/*g*6 | Clutches, spline shafts |
| Locational fit | H7/*h*6 | Milling cutters on milling mandrels, sealing rings. |
| **Transition Fit :** | | |
| Easy push fit | H7/*i*6 | Pulleys, bushes, bearing shells, pistons on piston rods. |
| Push fit | H7/*k*6 | Gears, pulleys, inner race of ball bearings, couplings. |
| Force fit | H7/*m*6 | Gears, pulleys, inner race of ball bearings, couplings. |
| Light press fit | H7/*n*6 | Worm wheels, press tools, rotors on motor shaft. |
| **Interference Fit :** | | |
| Press fit | H7/*r*6 | Valve seats, couplings on shaft ends. |
| Medium press fit | H7/*p*6 | Gear wheels. |
| Heavy press fit | H7/*s*6 | Couplings. |
| Shrunk fit | H8/*u*8 | Wheel steel tyres. |