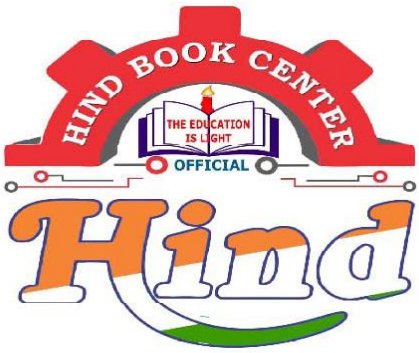


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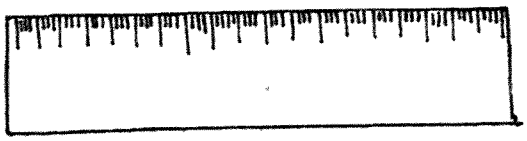
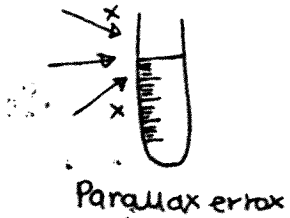
# Metrology :→ [Science of Measurement]

↓

Standard is required



Line Standard



Parallax error

Standard ⇒ It is an authority which is set-up or established to measure Length, Weight, quantity, quality, angle etc.

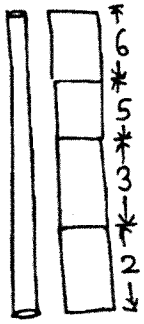
eg: IOML → International organisation for measurement of Length.

## LENGTH STANDARD

IS - 919 - 1996

- Line Standard
  - eg: metre Scale
  - → Less time consuming
  - → Less Accuracy
- End Standard
  - eg: Slip Gauge
  - → Time consuming
  - → High Accuracy
  - → Skilled Labour required

| Range | Step size | Number |
|---|---|---|
| 1·001 - 1·009 | 0·001 | 9 |
| 1·01 - 1·49 | 0·01 | 49 |
| 0·5 - 9·5 | 0·5 | 19 |
| 10 - 100 | 10 | 10 |




eg: 96.999

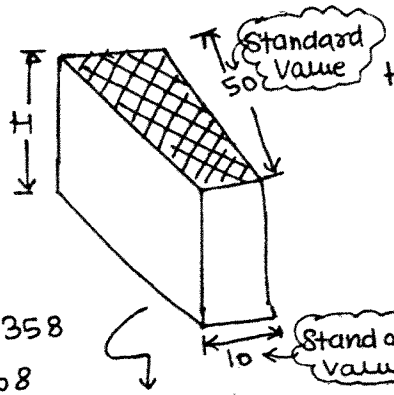
1·009
1·49
4·5
90

96.999

eg 72.358

1·008
1·35
6·5
50

58.975




Hardened Steel & Heat treated

Slip Gauge

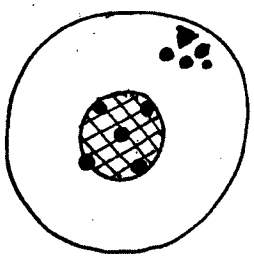
→ Ground to High Accuracy and Surface finish

eg: 58.975

1·005
1·47
6·5
50

58.975

- **Accuracy:→**
  It is the degree of closeness of a value with respect to true value.



- **Precision:→** Degree of Repeatability
  It is the degree of closeness of a value w.r.t. other measured values

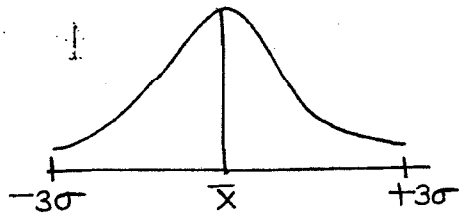
**No Dimension is Exact** ★
↳ Tolerance

- **Limits And Tolerance:→**

Limit → Permissible range within which value must lie

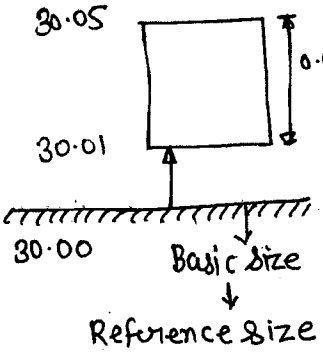
Ecart Superieur

Ecart Inferieur

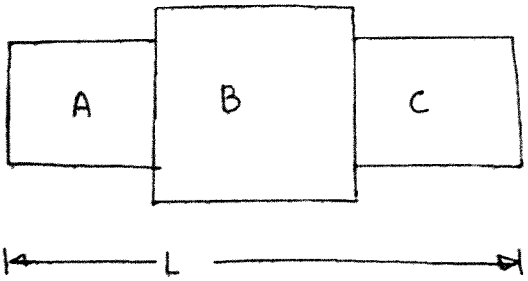



Value= $\bar{X} \pm 3\sigma$

Tolerance = ES − EI
↓
Difference b/w Upper Limit & Lower Limit




Tolerance
- Unilateral
  - $30^{+0.05}_{+0.01}$
  - $30^{-0.03}_{-0.06}$
- Bilateral
  - $30^{+0.03}_{-0.01}$ → Unequally Bilateral
  - $30.01 \pm 0.02$ → Equally bilateral




$B = L - (A + C)$

$= 30.01 \pm 0.06$

$A = 30^{+0.02}_{-0.04} = 29.99 \pm 0.03$

$B = ?$

$C = 40 \pm 0.02$

$L = 100 \pm 0.01$

$B = 30^{+0.07}_{-0.05}$

$B = 30.01 \pm 0.06$

$B_{max} = L_{max} - A_{min} - C_{min}$

$= 100.01 - 29.96 - 39.98$

$= 30.07$

$B_{min} = L_{min} - A_{max} - C_{max}$

$= 99.99 - 30.02 - 40.02$

$= 29.95$

Steps:

(i) Convert all tolerance as equal bilateral.

(ii) Use B.S only in arithmatic operation.

(iii) Add all tolerances.

Que → 17/ωB|cn-13

$R = 13.01 \pm 0.03$

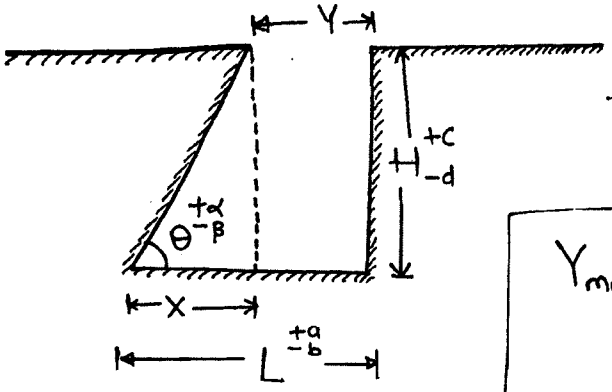
$W = 35 - 12 - 13.01 = 9.99$

$W = 9.99 \pm 0.13$

$0.08$
$0.02$
$0.03$
$0.13$

→

- **Compound Tolerance :→**




$$Y = L - X$$

$$Y_{max} = L_{max} - X_{min}$$

$$= L^{+a} - \frac{H^{-d}}{\tan\theta^{+\alpha}}$$

$$Y_{min} = L_{min} - X_{max}$$

$$= L^{-b} - \frac{H^{+c}}{\tan\theta^{-\beta}}$$

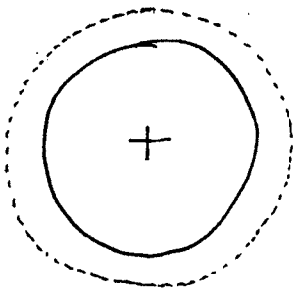
$$\tan\theta = \frac{H}{X}$$

$$X = \frac{H}{\tan\theta}$$

$$X_{max} = \frac{H_{max}}{(\tan\theta)_{min}} = \frac{H^{+c}}{\tan\theta^{-\beta}}$$

$$X_{min} = \frac{H_{min}}{(\tan\theta)_{max}} = \frac{H^{-d}}{\tan\theta^{+\alpha}}$$

- **Shaft Plating**



t = Plating thickness
Di = diameter before Plating
Df = diameter after Plating

$$D_f = D_i + 2t$$

$$t = 30 \pm 2\ \mu m$$

dia after Plating $= 20^{+0.05}_{-0.03}$ mm

find the diameter of shaft before Plating.

$D_f = D_i + 2t$

$D_i = D_f - 2t$

$(D_i)_{max} = (D_f)_{max} - 2t_{min}$

$= 20.05 - 0.056$

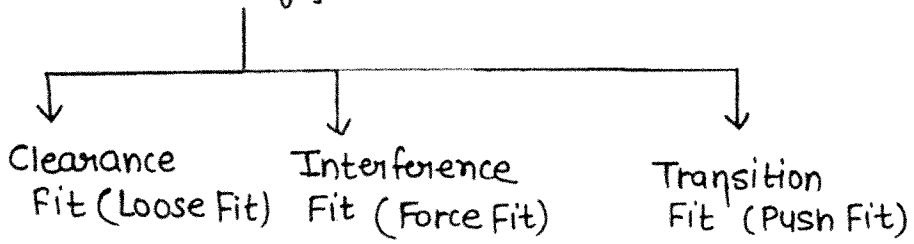
$= 19.994$

$(D_i)_{min} = (D_f)_{min} - 2t_{max}$

$= 19.970 - 0.064$

$= 19.906$

- Fits : [Assembly]



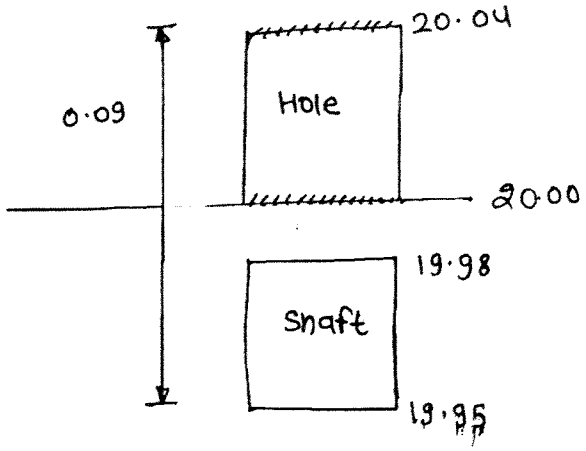

1. Clearance Fit → Min Hole Size > Max. Shaft Size

eg: Hole → [20.00, 20.04]
Shaft → [19.95, 19.98]

min Hole Size > max. Shaft Size
20.00 > 19.98

max. clearance = max. Hole − min shaft
= 20.04 − 19.95 = 0.09

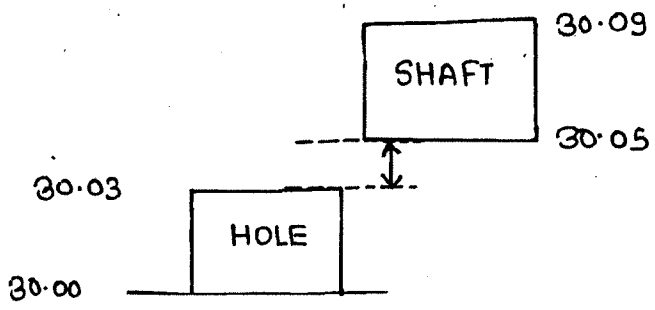
min. clearance = min Hole − max. Shaft
= 20.00 − 19.98 = 0.02



2. Interference Fit →

~~Min Hole~~

Min Shaft size > max. Hole size ...




min Interference = 30.05 − 30.03 = 0.02

max. Interference = 30.09 − 30.00 = 0.09

WORST ASSEMBLY ⇒ Max. clearance

max. material limit of Hole = min size of the Hole

Allowance = min clearance

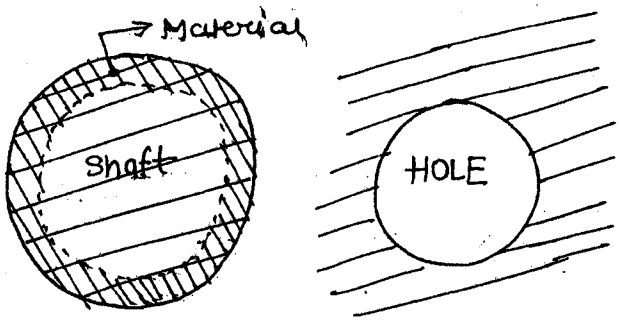
(or)

max. Interference

max. Material limit = max. shaft and min. Hole

(Material: To be machined)

R→ Allowance is the difference of max. material limit.



- System of design

1. Hole Base System  2. Shaft Based System

1. Hole Based System :→

In this system of manufacturing firstly Hole is manufactured and then shaft is designed and produced according to the dimension of Hole.

Hole Base System is the industrial Preference because internal machining is more complex then external machining and hence it is easilier to modify the dimension of shaft

2. Shaft Based System :→

Shaft is manufacured first and then Hole is design and Produced According to the dimension of Shaft.

NOTE→

Hole Based System

min. Hole Size = Basic Size

Shaft Based System

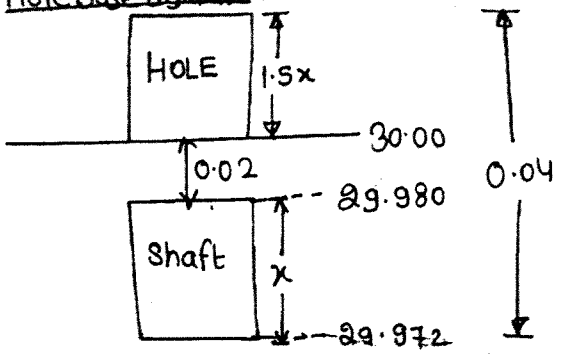
max. Shaft Size = Basic Size

Que→ In an Assembly of hole and shaft, Basic Size = 30mm and Allowance = 0.02mm and if it is said to have a clearance fit With max. clearance of 0.04mm. If tolerance of hole is 1.5 times the tolerance of Shaft then find hole and Shaft Size According to

(1) Hole Base System

(2) Shaft Base System

Sol→ (1) Hole Base System→



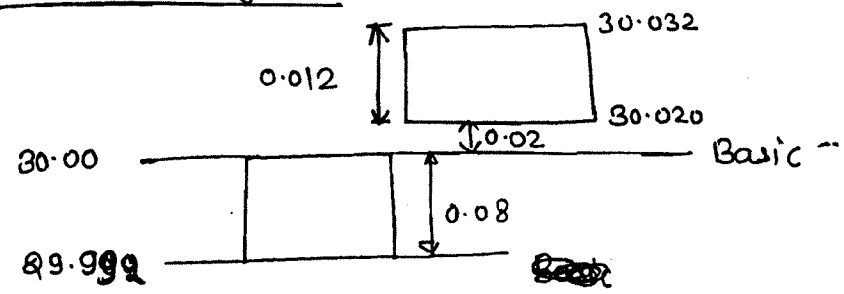

$x + 0.02 + 1.5x = 0.04$

$2.5x = 0.02$

$x = 0.008$

$1.5x = 0.012$

## Shaft Base System

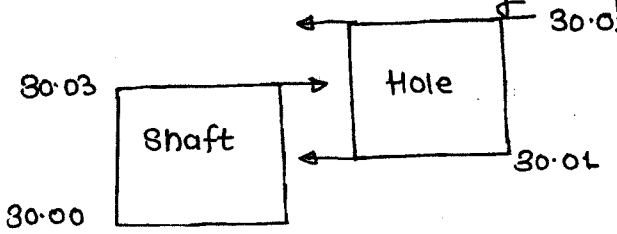



- **Transition fit**

Min Hole Size $\not>$ Max. Shaft Size

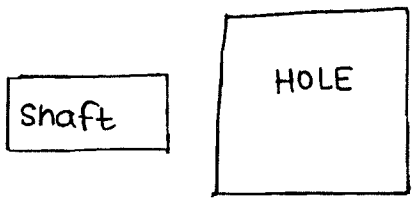
Min Shaft size $\not>$ Max. Hole Size

The upper limit of one component lies between upper & lower limit of other mating Component




max. clearance = 0·05

max. Interference = 0·02




Transition Fit