## SYSTEM OF FITS AND TOLERANCES

$>$ The standard reference temperature is 20 C for industrial measurements and, consequently, for dimensions defined by the system.
>Due to the inevitable inaccuracy of manufacturing methods, a part cannot be made precisely to a given dimension, the difference between maximum and minimum limits of size is the tolerance.
-When two parts are to be assembled, the relation resulting from the difference between their sizes before assembly is called a fit.


## Tolerance

- How to decide tolerance?
- Functional requirements of mating parts
- Cost of production
- Available manufacturing process
- Choose as coarse tolerance as possible without compromising functional requirements
- Proper balance between cost and quality of parts


## HOLE

## SHAFT

Max Hole size - Basic Size = Upper Deviathax shaft size - Basic Size = Upper Deviation Min Hole size - Basic Size = Lower Deviakitin shaft size - Basic Size = Lower Deviation


## CLEARANCE FIT



SHAFT


Maximum shaft dimension < Minimum hole dimension

FIT - condition of looseness or tightness between two mating parts being assembled together

## INTERFERANCE FIT

SHAFT


Maximum Hole size < Minimum Shaft size

## TRANSITION FIT



Obtained by overlapping of tolerance zones of shaft and hole ......Does not guarantee neither clearance nor interference fit

## To obtain different types of fits, it is general practice to vary tolerance zone of one of the mating parts



HOLE BASED SYSTEM-
Size of hole is kept constant, shaft size is varied to get different fits.


SHAFT BASED SYSTEMSize of shaft is kept constant, hole size is varied to get different fits.


A fit is indicated by the basic size common to both components, followed by symbol corresponding to each component, the hole being quoted first.

$$
\text { E.g. } \quad 45 \mathrm{H} 8 / \mathrm{g} 7
$$



The selection of letter freezes Representation of
one limit of hole / shaft Tolerance

1) Letter Symbol

Basic Size $\longrightarrow 45$ E8/e7

One can have different possible combinations; eg.
45H6g7, 45H8r6, 45E5p7
E.S. - upper deviation
E.I. - lower deviation

H: lower deviation of hole is zero
h: upper deviation of shaft is zero

# Representation of Tolerance 2) Number or Grade IT01, IT0, IT1,....IT16 

Tolerance Grade defines range of dimensions (dimensional variation)

There are manufacturing constraints on tolerance grade chosen

| Tolerance grade | Manufacturing process and applications | Machine reguired |
| :---: | :---: | :---: |
| $\begin{aligned} & \text { IT01, IT0 } \\ & \text { IT1 to IT5 } \end{aligned}$ | Super finishing process, such as lapping, diamond boring etc. Use: Gauges | Super finishing machines |
| IT6 | Grinding | Grinding machines |
| IT7 | Precision turning, broaching, honing | Boring machine, honing machine |
| IT8 | Turning, boring and reaming | Lathes, capstan and automats |
| IT9 | Boring | Boring machines |
| IT10 | Milling, slotting, planing, rolling and extrusion | Milling machine, slotting machine, planing machine and extruders |
| IT11 | Drilling, rough turning | Drilling machine, lathes |
| IT12, IT13, IT14 | Metal forming processes | Presses |
| IT15 | Die casting, stamping | Die casting machine, hammer machine |
| IT16 | Sand casting | - |

FUNDAMENTAL TOLERANCES OF GRADES 01, O AND 1 TO 16

| Diameter <br> steps in mm | Values of tolerance in microns |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Tolerance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 01 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14* | 15* | 16* |
| To and inc 3 | 0.3 | 0.5 | 0.8 | 1.2 | 2 | 3 | 4 | 6 | 10 | 14 | 25 | 40 | 60 | 100 | 140 | 250 | 400 | 600 |
| Over 3 <br> To and inc 6 | 0.4 | 0.6 | 1 | 1.5 | 2.5 | 4 | 5 | 8 | 12 | 18 | 30 | 48 | 75 | 120 | 180 | 300 | 480 | 750 |
| Over 6 <br> To and inc 10 | 0.4 | 0.6 | 1 | 1.5 | 2.5 | 4 | 6 | 9 | 15 | 22 | 36 | 58 | 90 | 150 | 220 | 360 | 580 | 900 |
| Over 10 <br> To and inc 18 | 0.5 | 0.8 | 1.2 | 2 | 3 | 5 | 8 | 11 | 18 | 27 | 43 | 70 | 110 | 180 | 270 | 430 | 700 | 1100 |
| Over 18 <br> To and inc 30 | 0.6 | 1 | 1.5 | 2.5 | 4 | 6 | 9 | 13 | 21 | 33 | 52 | 84 | 130 | 210 | 330 | 520 | 840 | 1300 |
| Over 30 <br> To and inc 50 | 0.6 | 1 | 1.5 | 2.5 | 4 | 7 | 11 | 16 | 25 | 39 | 60 | 110 | 160 | $250$ | 390 | 620 | 1000 | 1600 |
| Over 50 <br> To and inc 80 | 0.8 | 1.2 | 2 | 3 | 5 | 8 | 13 | 19 | 30 | 46 | 74 | 120 | 190 | 300 | 460 | 740 | 1200 | 1900 |
| Over 80 <br> To and inc 120 | 1 | 1.5 | 2.5 | 4 | 6 | 10 | 15 | 22 | 35 | 54 | 87 | 140 | 220 | 350 | 540 | 870 | 1400 | 2200 |
| Over 120 <br> To and inc 180 | 1.2 | 2 | 3.5 | 5 | 8 | 12 | 18 | 25 | 40 | 63 | 100 | 160 | 250 | 400 | 630 | 1000 | 1600 | 2500 |
| Over 180 <br> To and inc 250 | 2 | 3 | 4.5 | 7 | 10 | 14 | 20 | 29 | 46 | 72 | 115 | 185 | 290 | 460 | 720 | 1150 | 1850 | 2900 |
| Over 250 <br> To and inc 315 | 2.5 | 4 | 6 | 8 | 12 | 16 | 23 | 32 | 52 | 81 | 130 | 210 | 320 | 520 | 810 | 1300 | 2100 | 3200 |
| Over 315 <br> To and inc 400 | 3 | 5 | 7 | 9 | 13 | 18 | 25 | 36 | 57 | 89 | 140 | 230 | 360 | 570 | 890 | 1400 | 2300 | 3600 |
| Over 400 <br> To and inc 500 | 4 | 6 | 8 | 10 | 15 | 20 | 27 | 40 | 63 | 97 | 155 | 250 | 400 | 630 | 970 | 1150 | 2500 | 4000 |

* Upto 1 mm , Grades 14 to 16 are not provided.


## RANGE IN A GIVEN TOLERANCE GRADE

TABLE 18-14(i)
(Values in microns)

|  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal sizes | H7 | H8 | H9 | H10 | H11 | d 9 | e 8 | f 7 | g 6 | h6 |
| $\begin{array}{ll} \text { From } & 1 \\ \text { Upto } & 3 \end{array}$ | $\begin{gathered} +10 \\ 0 \end{gathered}$ | $\begin{gathered} +14 \\ 0 \\ \hline \end{gathered}$ | + + 0 | +40 0 | +60 0 | -20 <br> -45 | $\begin{array}{r}-14 \\ -28 \\ \hline\end{array}$ | $-\quad 6$ -16 | -2 $-\quad 8$ | 0 $-\quad 6$ |
| $\begin{array}{ll} \text { Over } & 3 \\ \text { Upto } & 6 \end{array}$ | $\begin{gathered} +12 \\ 0 \end{gathered}$ | $\begin{gathered} +18 \\ 0 \end{gathered}$ | $\begin{aligned} &+ 30 \\ & 0\end{aligned}$ | +45 0 | +75 0 | $\begin{array}{r}-30 \\ -60 \\ \hline\end{array}$ | -20 -38 | $\begin{array}{r}-10 \\ -22 \\ \hline\end{array}$ | -4 <br> -12 | $\begin{gathered} 0 \\ -\quad 8 \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 6 \\ \text { Upto } & 10 \\ \hline \end{array}$ | $\begin{gathered} +15 \\ 0 \end{gathered}$ | $\begin{gathered} +22 \\ 0 \end{gathered}$ | $+{ }_{0} 36$ | $\begin{gathered} +58 \\ 0 \end{gathered}$ | $\begin{gathered} +90 \\ 0 \end{gathered}$ | $\begin{aligned} & -40 \\ & -75 \\ & \hline \end{aligned}$ | $\begin{aligned} & -25 \\ & -\quad 47 \\ & \hline \end{aligned}$ | $\begin{array}{r}-13 \\ -28 \\ \hline\end{array}$ | $\begin{aligned} & -5 \\ & -14 \end{aligned}$ | $\begin{array}{r} 0 \\ -\quad 9 \\ \hline \end{array}$ |
| $\begin{array}{ll} \text { Over } & 10 \\ \text { Upto } & 18 \end{array}$ | $\begin{gathered} +18 \\ 0 \end{gathered}$ | $\begin{gathered} +27 \\ 0 \end{gathered}$ | $+{ }_{0}^{43}$ | $+70$ | $\begin{gathered} +110 \\ 0 \end{gathered}$ | $\begin{array}{r} -50 \\ -93 \\ \hline \end{array}$ | $\begin{aligned} & -32 \\ & -59 \end{aligned}$ | $\begin{aligned} & -16 \\ & -34 \end{aligned}$ | $\begin{aligned} & -6 \\ & -17 \end{aligned}$ | $\begin{gathered} 0 \\ -11 \end{gathered}$ |
| $\begin{array}{ll}\text { Over } & 18 \\ \text { Upto } & 30\end{array}$ | $\begin{gathered} +21 \\ 0 \end{gathered}$ | $\begin{gathered} +33 \\ 0 \end{gathered}$ | $+52$ | $+{ }_{0} 84$ | $\begin{gathered} +130 \\ 0 \end{gathered}$ | $\begin{aligned} & -65 \\ & -117 \end{aligned}$ | $\begin{array}{r} -40 \\ -\quad 73 \\ \hline \end{array}$ | $\begin{aligned} & -20 \\ & -41 \\ & \hline \end{aligned}$ | $\begin{aligned} & -7 \\ & -20 \\ & \hline \end{aligned}$ | $\begin{gathered} 0 \\ -13 \\ \hline \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 30 \\ \text { Upto } & 50 \\ \hline \end{array}$ | $\begin{gathered} +25 \\ 0 \end{gathered}$ | $\begin{gathered} +39 \\ 0 \end{gathered}$ | $+{ }_{0}^{62}$ | $\begin{gathered} +100 \\ 0 \end{gathered}$ | $\begin{gathered} +160 \\ 0 \end{gathered}$ | $\begin{array}{r} -80 \\ -142 \\ \hline \end{array}$ | $\begin{array}{r} -50 \\ -89 \end{array}$ | $\begin{aligned} & -25 \\ & -50 \end{aligned}$ | $\begin{aligned} & -9 \\ & -25 \end{aligned}$ | $\begin{gathered} 0 \\ -16 \end{gathered}$ |
| $\begin{array}{ll} \hline \text { Over } & 50 \\ \text { Upto } & 80 \\ \hline \end{array}$ | $\begin{gathered} +30 \\ 0 \end{gathered}$ | $\begin{gathered} +46 \\ 0 \end{gathered}$ | $+{ }_{0}^{76}$ | $\begin{gathered} +120 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +190 \\ 0 \\ \hline \end{gathered}$ | $\begin{aligned} & -100 \\ & -174 \end{aligned}$ | $\begin{aligned} & -60 \\ & -105 \end{aligned}$ | $\begin{array}{r} -30 \\ -60 \\ \hline \end{array}$ | $\begin{aligned} & -10 \\ & -29 \\ & \hline \end{aligned}$ | $\begin{gathered} 0 \\ -19 \\ \hline \end{gathered}$ |
| Over 80 <br> Upto 120 | $\begin{gathered} +35 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +54 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +87 \\ 0 \end{gathered}$ | $\begin{gathered} +140 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +220 \\ 0 \\ \hline \end{gathered}$ | $\begin{aligned} & -120 \\ & -207 \\ & \hline \end{aligned}$ | $\begin{aligned} & -72 \\ & -126 \end{aligned}$ | $\begin{aligned} & -36 \\ & -71 \end{aligned}$ | $\begin{aligned} & -12 \\ & -34 \end{aligned}$ | $\begin{gathered} 0 \\ -22 \end{gathered}$ |
| $\begin{array}{ll}\text { Over } 120 \\ \text { Upto } & 180\end{array}$ | $\begin{gathered} +40 \\ 0 \end{gathered}$ | $\begin{gathered} +63 \\ 0 \end{gathered}$ | $\begin{aligned} & +100 \\ & 0 \\ & \hline \end{aligned}$ | $\begin{gathered} +160 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +250 \\ 0 \\ \hline \end{gathered}$ | $\begin{aligned} & -145 \\ & -245 \end{aligned}$ | $\begin{array}{r} -85 \\ -148 \\ \hline \end{array}$ | $\begin{array}{r} -43 \\ -83 \\ \hline \end{array}$ | $\begin{array}{r} -14 \\ -39 \\ \hline \end{array}$ | $\begin{gathered} 0 \\ -25 \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 180 \\ \text { Upto } & 250 \\ \hline \end{array}$ | $\begin{gathered} +45 \\ 0 \end{gathered}$ | $\begin{gathered} +72 \\ 0 \end{gathered}$ | $\begin{gathered} +115 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +185 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +290 \\ 0 \\ \hline \end{gathered}$ | $\begin{aligned} & -170 \\ & -285 \end{aligned}$ | $\begin{aligned} & -100 \\ & -172 \\ & \hline \end{aligned}$ | $\begin{array}{r} -50 \\ -96 \\ \hline \end{array}$ | $\begin{aligned} & -15 \\ & -44 \\ & \hline \end{aligned}$ | $\begin{gathered} 0 \\ -29 \\ \hline \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 250 \\ \text { Upto } & 315 \end{array}$ | $\begin{gathered} +52 \\ 0 \end{gathered}$ | $\begin{gathered} +81 \\ 0 \end{gathered}$ | $\begin{gathered} +130 \\ 0 \end{gathered}$ | $\begin{gathered} +210 \\ 0 \end{gathered}$ | $\begin{gathered} +320 \\ 0 \end{gathered}$ | $\begin{aligned} & -190 \\ & -320 \end{aligned}$ | $\begin{aligned} & -110 \\ & -191 \end{aligned}$ | $\begin{aligned} & -56 \\ & -108 \end{aligned}$ | $\begin{aligned} & -17 \\ & -49 \end{aligned}$ | $\begin{gathered} 0 \\ -32 \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 315 \\ \text { Upto } & 400 \\ \hline \end{array}$ | $\begin{gathered} +57 \\ 0 \end{gathered}$ | $\begin{gathered} +89 \\ 0 \end{gathered}$ | $\begin{gathered} +140 \\ 0 \end{gathered}$ | $\begin{gathered} +230 \\ 0 \\ \hline \end{gathered}$ | $\begin{gathered} +360 \\ 0 \end{gathered}$ | $\begin{aligned} & -210 \\ & -350 \\ & \hline \end{aligned}$ | $\begin{aligned} & -125 \\ & -214 \end{aligned}$ | $\begin{aligned} & -62 \\ & -119 \\ & \hline \end{aligned}$ | $\begin{array}{r} -18 \\ -54 \\ \hline \end{array}$ | $\begin{gathered} 0 \\ -35 \\ \hline \end{gathered}$ |
| $\begin{array}{ll} \text { Over } & 400 \\ \text { Upto } & 500 \end{array}$ | $\begin{gathered} +63 \\ 0 \end{gathered}$ | $\begin{gathered} +97 \\ 0 \end{gathered}$ | $\begin{gathered} +155 \\ 0 \end{gathered}$ | $\begin{gathered} +250 \\ 0 \end{gathered}$ | $\begin{gathered} +400 \\ 0 \end{gathered}$ | $\begin{aligned} & -230 \\ & -385 \end{aligned}$ | $\begin{aligned} & -135 \\ & -232 \end{aligned}$ | $\begin{aligned} & -68 \\ & -131 \end{aligned}$ | $\begin{aligned} & -20 \\ & -60 \end{aligned}$ | $\begin{gathered} 0 \\ -40 \end{gathered}$ |

Note: Upto means including. Over means excluding.

TABLE 18-14(ii)
(Values in microns)

| Tolerances of holes |  |  |  |  |  |  | Tolerances of shafts |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal sizes | D10 | E 9 | F 8 | G 7 | JS7 | K 7 | j 6 | k 6 | n 6 | p6 |
| $\begin{array}{ll} \hline \text { From } & 1 \\ \text { Upto } & 3 \end{array}$ | $\begin{aligned} & +60 \\ & +\quad 20 \end{aligned}$ | $\begin{array}{r} +39 \\ +\quad 14 \end{array}$ | $\begin{array}{r} +20 \\ +\quad 6 \end{array}$ | $\begin{aligned} & +12 \\ & +\quad 2 \end{aligned}$ | $\begin{aligned} & +5 \\ & -5 \end{aligned}$ | $\begin{gathered} 0 \\ -10 \end{gathered}$ | $\begin{aligned} & +3 \\ & -3 \end{aligned}$ | $\begin{gathered} 6 \\ 0 \end{gathered}$ | $\begin{aligned} & +10 \\ & +\quad 4 \end{aligned}$ | $\begin{aligned} & +\quad 12 \\ & +\quad 6 \end{aligned}$ |
| $\begin{array}{ll} \hline \text { Over } & 3 \\ \text { Upto } & 6 \end{array}$ | $\begin{array}{r} +78 \\ +\quad 30 \end{array}$ | $\begin{array}{r} +50 \\ +\quad 20 \end{array}$ | $\begin{aligned} & +28 \\ & +10 \end{aligned}$ | $\begin{aligned} & +16 \\ & +\quad 4 \end{aligned}$ | $\begin{aligned} & +6 \\ & -6 \end{aligned}$ | $\begin{array}{r} +3 \\ -9 \end{array}$ | $\begin{aligned} & +4 \\ & -4 \end{aligned}$ | $\begin{aligned} & +9 \\ & +\quad 1 \end{aligned}$ | $\begin{aligned} & +16 \\ & +\quad 8 \end{aligned}$ | $\begin{aligned} & +20 \\ & +\quad 12 \end{aligned}$ |
| $\begin{array}{ll} \text { Over } 6 \\ \text { Upto } & 10 \\ \hline \end{array}$ | $\begin{aligned} & +98 \\ & +\quad 40 \end{aligned}$ | $\begin{array}{r} +61 \\ +25 \end{array}$ | $\begin{aligned} & +35 \\ & +\quad 13 \end{aligned}$ | $\begin{array}{r} +20 \\ +\quad 5 \\ \hline \end{array}$ | $\begin{aligned} & +7.5 \\ & -7.5 \end{aligned}$ | $\begin{aligned} & +5 \\ & -10 \end{aligned}$ | $\begin{aligned} & +4.5 \\ & -4.5 \end{aligned}$ | $\begin{aligned} & +10 \\ & +\quad 1 \end{aligned}$ | $\begin{aligned} & +19 \\ & +10 \end{aligned}$ | $\begin{array}{r} +24 \\ +\quad 15 \end{array}$ |
| $\begin{array}{ll} \hline \text { Over } & 10 \\ \text { Upto } & 18 \end{array}$ | $\begin{aligned} & +120 \\ & +\quad 50 \end{aligned}$ | $\begin{aligned} & +75 \\ & +32 \end{aligned}$ | $\begin{aligned} & +43 \\ & +\quad 16 \end{aligned}$ | $\begin{aligned} & +24 \\ & +\quad 6 \end{aligned}$ | $\begin{aligned} & +9 \\ & -9 \end{aligned}$ | +6 -12 | +5.5 -5.5 | $\begin{aligned} & +12 \\ & +\quad 1 \end{aligned}$ | $\begin{aligned} & +23 \\ & +12 \end{aligned}$ | $\begin{array}{r} +29 \\ +\quad 18 \end{array}$ |
| $\begin{array}{ll} \hline \text { Over } & 18 \\ \text { Upto } & 30 \\ \hline \end{array}$ | $\begin{array}{r} +149 \\ +\quad 65 \end{array}$ | $\begin{aligned} & +92 \\ & +\quad 40 \end{aligned}$ | $\begin{array}{r} +53 \\ +\quad 20 \end{array}$ | $\begin{aligned} & +28 \\ & +\quad 7 \end{aligned}$ | $\begin{aligned} & +10.5 \\ & -10.5 \end{aligned}$ | $\begin{array}{r} +6 \\ -15 \end{array}$ | +6.5 -6.5 | $\begin{array}{r} +15 \\ +\quad 2 \end{array}$ | $\begin{aligned} & +28 \\ & +15 \end{aligned}$ | $\begin{aligned} & +35 \\ & +\quad 22 \end{aligned}$ |
| $\begin{array}{ll} \hline \text { Over } & 30 \\ \text { Upto } & 50 \\ \hline \end{array}$ | $\begin{aligned} & +180 \\ & +\quad 80 \end{aligned}$ | $\begin{array}{r} +112 \\ +\quad 50 \end{array}$ | $\begin{array}{r} +64 \\ +\quad 25 \\ \hline \end{array}$ | $\begin{array}{r} +34 \\ +\quad 9 \end{array}$ | $\begin{aligned} & +12.5 \\ & -12.5 \end{aligned}$ | $\begin{aligned} & +7 \\ & -18 \end{aligned}$ | $\begin{aligned} & +8 \\ & -8 \end{aligned}$ | $\begin{aligned} & +18 \\ & +\quad 2 \end{aligned}$ | $\begin{aligned} & +33 \\ & +17 \end{aligned}$ | $\begin{aligned} & +42 \\ & +26 \end{aligned}$ |
| Over 50 Upto 80 | +220 +100 | $\begin{array}{r} +134 \\ +\quad 60 \end{array}$ | $\begin{aligned} & +76 \\ & +30 \end{aligned}$ | +40 +10 | $\begin{aligned} & +15 \\ & -15 \end{aligned}$ | +9 -21 | +9.5 <br> -9.5 | $\begin{aligned} & +21 \\ & +\quad 2 \end{aligned}$ | +39 +20 | $\begin{aligned} & +51 \\ & +\quad 32 \end{aligned}$ |
| Over 80 <br> Upto 120 | $\begin{aligned} & +260 \\ & +120 \end{aligned}$ | $\begin{array}{r} +159 \\ +\quad 72 \end{array}$ | $\begin{aligned} & +90 \\ & +\quad 36 \end{aligned}$ | $\begin{aligned} & +47 \\ & +12 \end{aligned}$ | $\begin{aligned} & +17.5 \\ & -17.5 \end{aligned}$ | $\begin{array}{r} +10 \\ -25 \end{array}$ | $\begin{aligned} & +11 \\ & -11 \end{aligned}$ | $\begin{aligned} & +25 \\ & +\quad 3 \end{aligned}$ | $\begin{aligned} & +45 \\ & +23 \end{aligned}$ | $\begin{aligned} & +\quad 59 \\ & +\quad 37 \end{aligned}$ |
| Over 120 <br> Upto 180 | +305 <br> +145 | $\begin{array}{r} +185 \\ +\quad 85 \end{array}$ | $\begin{aligned} & +106 \\ & +\quad 43 \end{aligned}$ | $\begin{aligned} & +54 \\ & +14 \end{aligned}$ | $\begin{aligned} & +20 \\ & -20 \end{aligned}$ | $\begin{aligned} & +12 \\ & -28 \end{aligned}$ | $\begin{aligned} & +12.5 \\ & -12.5 \end{aligned}$ | $\begin{aligned} & +28 \\ & +\quad 3 \end{aligned}$ | $\begin{aligned} & +52 \\ & +27 \end{aligned}$ | $\begin{aligned} & +68 \\ & +43 \end{aligned}$ |
| Over 180 Upto 250 | $\begin{aligned} & +355 \\ & +170 \end{aligned}$ | $\begin{aligned} & +215 \\ & +100 \end{aligned}$ | $\begin{aligned} & +122 \\ & +\quad 50 \end{aligned}$ | +61 +15 | $\begin{aligned} & +23 \\ & -23 \end{aligned}$ | +13 +33 | +14.5 -14.5 | $\begin{aligned} & +33 \\ & +\quad 4 \end{aligned}$ | +60 +31 | $+\quad 79$ <br> +50 |
| $\begin{array}{ll} \hline \text { Over } & 250 \\ \text { Upto } & 315 \\ \hline \end{array}$ | +400 +190 | +240 +110 | $\begin{array}{r} +135 \\ +\quad 55 \\ \hline \end{array}$ | $\begin{aligned} & +69 \\ & +17 \end{aligned}$ | $\begin{aligned} & +26 \\ & -26 \end{aligned}$ | $\begin{aligned} & +16 \\ & -36 \end{aligned}$ | $\begin{aligned} & +16 \\ & -16 \end{aligned}$ | $\begin{aligned} & +36 \\ & +\quad 4 \end{aligned}$ | $\begin{aligned} & +66 \\ & +34 \end{aligned}$ | $\begin{aligned} & +88 \\ & +\quad 56 \end{aligned}$ |
| Over 315 <br> Upto 400 | +440 +210 | $\begin{aligned} & +265 \\ & +125 \end{aligned}$ | $\begin{aligned} & +151 \\ & +\quad 69 \end{aligned}$ | $\begin{aligned} & +75 \\ & +18 \end{aligned}$ | $\begin{aligned} & +28.5 \\ & -28.5 \end{aligned}$ | +17 -40 | $\begin{aligned} & +18 \\ & -18 \end{aligned}$ | $\begin{aligned} & +40 \\ & +\quad 4 \end{aligned}$ | $\begin{aligned} & +73 \\ & +37 \end{aligned}$ | $\begin{aligned} & +98 \\ & +\quad 62 \end{aligned}$ |
| Over 400 Upto 500 | +480 +230 | +290 +135 | $\begin{aligned} & +165 \\ & +\quad 68 \end{aligned}$ | +83 +20 | $\begin{aligned} & +31.5 \\ & -31.5 \end{aligned}$ | +18 -45 | +20 -20 | $\begin{aligned} & +45 \\ & +\quad 5 \end{aligned}$ | +80 +40 | $\begin{aligned} & +108 \\ & +\quad 68 \end{aligned}$ |

TABLE 18-14(iii)
(Values in microns)

| Tolerances of holes |  |  |  |  |  | Tolerances of shafts |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Nominal } \\ & \text { sizes } \end{aligned}$ | C11 | N7 | P7 | R7 | S 7 | r 6 | s 6 | t 6 | u 6 | u 6 |
| From 1 | $+120$ | - 4 | - 6 | - 10 | - | + 16 | + 20 | - | + 24 | + 28 |
| Upto 3 | + 60 | -14 | -16 | - 20 | - 24 | + 10 | + 14 |  | + 10 | +18 $+\quad 18$ |
| Over 3 | +145 | - 4 | - 8 | - 11 | - 15 | + 23 | + 27 | - | 31 | +35 |
| Upto 6 | + 70 | -16 | -20 | - 23 | - 27 | + 15 | + 19 |  | + 23 | + 23 |
| Over 6 | +170 | - 4 | - 9 | $-13$ | $-17$ | + 28 | + 32 | - | + 37 | + 43 |
| Upto 10 | + 80 | -19 | -24 | - 28 | - 32 | + 19 | + 28 |  | + 28 | + 28 |
| Over 10 | $+205$ | - 5 | -11 | - 16 | - 21 | + 34 | + 39 | - | + 44 | + 51 |
| Upto 18 | + 95 | -23 | -29 | - 34 | - 39 | + 23 | + 28 |  | + 33 | + 33 |
| Over 18 | $+240$ | - 7 | -14 | - 20 | - 27 | + 41 | + 48 | + 54 | + 61 | + 62 |
| Upto 30 | + 110 | -28 | -35 | - 41 | -48 | + 28 | $\begin{array}{r}+35 \\ \hline\end{array}$ | + 41 | + 41 | + 41 |
| Over 30 | $+280$ | $-8$ | -17 | - 25 | $-34$ | + 50 | + 59 | + 64 | + 76 | + 85 |
| Upto 40 | + 120 |  |  |  |  |  |  | + 48 | $+60$ | + 60 |
| Over 40 | $+290$ | -33 | -42 | $-50$ | - 59 | + 34 | $+43$ | +70 $+\quad 54$ | +86 $+\quad 70$ | +95 $+\quad 70$ |
| Upto 50 | +130 |  |  |  |  |  |  | + 54 | + 70 | + 70 |
| Over 50 | $+330$ | - 9 | -21 | $-30$ | - 42 | + 60 | + 72 | + 85 | +106 | +117 |
| Upto 65 | +140 |  |  | -60 | - 72 | + 41 | + 53 | + 66 | + 87 | + 87 |
| Over 65 | $+340$ | -39 | -51 | - 32 | - 48 | + 62 | + 78 | + 94 | +121 | +132 |
| Upto 80 | +150 |  |  | - 62 | - 78 | + 43 | + 59 | + 75 | $+102$ | +102 |
| Over 80 | $+390$ | -10 | -24 | - 38 | - 58 | + 73 | + 93 | +113 | + 146 | +159 |
| Upto 100 | $+170$ |  |  | - 73 | -93 | + 51 | + 71 | + 91 | $+124$ | $+124$ |
| Over 100 | $+400$ | -45 | -59 | - 41 | - 66 | + 76 | +101 | +126 | +166 | $+175$ |
| Upto 120 | +180 |  |  | - 76 | -101 | + 54 | + 79 | +104 | $+144$ | +144 |
| Over 120 | $+450$ | -12 | -28 | - 48 | - 77 | + 88 | + 117 | +147 | +195 | $+230$ |
| Upto 140 | $+200$ |  |  | - 88 | -117 | + 63 | + 92 | +122 | +170 | +170 |
| Over 140 | $+480$ | -52 | -68 | - 50 | -85 | + 93 | +133 | +171 | $+235$ | $+250$ |
| Upto 180 | $+210$ |  |  | - 93 | -133 | + 65 | $+100$ | +134 | +190 | +190 |
| Over 180 | $+570$ | -14 | -33 | - 60 | -105 | +113 | +169 | +225 | +330 | $+330$ |
| Upto 250 | $+240$ | -60 | -79 | -113 | -169 | + 77 | +122 | +166 | $+236$ | +236 |
| Over 250 | $+650$ | -14 | -36 | - 74 | -138 | +130 | $+202$ | $+272$ | $+382$ | $+402$ |
| Upto 315 | $+300$ | -66 | -88 | -130 | -202 | + 94 | $+158$ | $+218$ | $+350$ | $+315$ |
| Over 315 | $+760$ | -16 | -41 | $-87$ | -169 | +150 | $+244$ | +330 | +471 | +492 |
| Upto 400 | $+360$ | -73 | -98 | -150 | -224 | +108 | +190 | $+268$ | $+390$ | $+390$ |
| Over 400 | $+880$ | -17 | -45 | -103 | -209 | +172 | $+292$ | $+400$ | $+580$ | $+603$ |
| Upto 500 | $+440$ | -80 | -108 | -172 | -292 | +126 | $+232$ | $+330$ | $+490$ | $+490$ |



## Representation of Tolerance

|  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Nominal sizes | H7 | H8 | H9 | H10 | H11 | d9 | e8 | $\mathfrak{¢ 7}$ | g6 | h6 |
| $\begin{aligned} & \text { From } 1 \\ & \text { Upto } 3 \end{aligned}$ | $\begin{gathered} +10 \\ 0 \end{gathered}$ | $\begin{gathered} +14 \\ 0 \end{gathered}$ | $\begin{gathered} +25 \\ 0 \end{gathered}$ | $\begin{gathered} +40 \\ 0 \end{gathered}$ | $\begin{gathered} +60 \\ 0 \end{gathered}$ | $\begin{aligned} & -20 \\ & -45 \end{aligned}$ | $\begin{array}{\|l\|l\|} -14 \\ -28 \end{array}$ | $\begin{array}{\|c} -6 \\ -16 \end{array}$ | $\begin{aligned} & -2 \\ & -8 \end{aligned}$ | 0 -6 |
| Over 3 <br> Upto 6 | $\begin{gathered} +12 \\ 0 \end{gathered}$ | $\begin{gathered} +18 \\ 0 \end{gathered}$ | $+\begin{gathered} 30 \\ 0 \end{gathered}$ | $\begin{gathered} +45 \\ 0 \end{gathered}$ | $\begin{gathered} +75 \\ 0 \end{gathered}$ | $\begin{aligned} & -30 \\ & -60 \end{aligned}$ | $\begin{aligned} & -20 \\ & -38 \\ & \hline \end{aligned}$ | $\begin{aligned} & -10 \\ & -22 \\ & \hline \end{aligned}$ | $\begin{aligned} & -4 \\ & -12 \\ & \hline \end{aligned}$ | 0 -8 |
| Over 6 Upto 10 | $\begin{gathered} +15 \\ 0 \end{gathered}$ | $\begin{gathered} +22 \\ 0 \end{gathered}$ | $\begin{gathered} +36 \\ 0 \end{gathered}$ | $\begin{gathered} +58 \\ 0 \end{gathered}$ | $\begin{gathered} +90 \\ 0 \end{gathered}$ | $\begin{aligned} & -40 \\ & -75 \end{aligned}$ | $\begin{aligned} & -25 \\ & -47 \end{aligned}$ | $\begin{aligned} & -13 \\ & -28 \\ & \hline \end{aligned}$ | $\begin{aligned} & -5 \\ & -14 \end{aligned}$ | 0 <br> -9 |
| Over 10 Upto 18 | $\begin{gathered} +18 \\ 0 \end{gathered}$ | $\begin{gathered} +27 \\ 0 \end{gathered}$ | $\begin{gathered} +43 \\ 0 \end{gathered}$ | $\begin{gathered} +70 \\ 0 \end{gathered}$ | $\begin{gathered} +110 \\ 0 \end{gathered}$ | -50 <br> -93 | $\begin{aligned} & -32 \\ & -59 \end{aligned}$ | $\begin{aligned} & -16 \\ & -34 \\ & \hline \end{aligned}$ | $\begin{gathered} -6 \\ -17 \end{gathered}$ | 0 |
| Over 18 Upto 30 | $\begin{gathered} +21 \\ 0 \end{gathered}$ | $\begin{gathered} +33 \\ 0 \end{gathered}$ | $+52$ | $\begin{gathered} +84 \\ 0 \end{gathered}$ | $\begin{gathered} +130 \\ 0 \\ \hline \end{gathered}$ | -65 -117 | $\begin{array}{\|l} \hline-40 \\ -73 \\ \hline \end{array}$ | $\begin{array}{\|l} -20 \\ -41 \end{array}$ | $\begin{aligned} & -7 \\ & -20 \\ & \hline \end{aligned}$ | 0 -13 |
| Over 30 Upto 50 | $\begin{gathered} +25 \\ 0 \end{gathered}$ | $\begin{gathered} +39 \\ 0 \end{gathered}$ | $+62$ | $\begin{gathered} +100 \\ 0 \end{gathered}$ | $\begin{gathered} +160 \\ 0 \end{gathered}$ | -80 -142 | $\begin{array}{\|l\|} \hline-50 \\ -89 \\ \hline \end{array}$ | $\begin{array}{\|l} \hline-25 \\ -50 \\ \hline \end{array}$ | $\begin{aligned} & -9 \\ & -25 \end{aligned}$ | 0 -16 |
| Over 50 Upto 80 | +30 | +46 | + 76 | $\begin{gathered} +120 \\ 0 \end{gathered}$ | +190 0 | -100 | -60 | -30 -60 | -10 -29 | 0 -19 |
| $\cdots$ |  |  |  |  |  |  |  |  |  |  |

## H: lower deviation of hole is zero

Representation of Fit


Together (Letter \& Grade) on both mating components decide quality of fit


INTERFERENCE ${ }_{\text {shaft }}$


Ф30.035
Ф30.022
Ф30.021
Ф30.000


H7 : Tol Grade 7 mean $21 \mu$ variation (H means upper deviation zero)
p6 : Tol Grade 6 means $13 \mu$ variation ( p means upper deviation is $22 \mu$ )

## Tolerance on Components

| METHOD | ILLUSTRATIONS |
| :---: | :---: |
| I |  |
| II | UNILATERAL SYSTEM <br> BILATERAL SYSTEM |
| III |  |



## Estimate kind of fit



## FITS APPLICATIONS

Interference fit

| Shring fit | H8/u8 | Wheel steel tyres, bronze crowns on worm wheel <br> hubs, couplings etc |
| :--- | :--- | :--- |
| Heavy drive fit | H7/s6 |  |
| Press fit | H7/r6 | Coupling of shaft ends, bearing bushing in hubs, <br> valve seats, gear wheels |
| Medium press fit | H7/p6 |  |

Transition fit

| Light press fit | H7/n6 | gears and bearing bushes, shaft and wheel <br> assembly fixed by feather key. |
| :--- | :--- | :--- |
| Force fit | H7/m6 | parts of machine tools that must be dismantled <br> without damage e.g. gears belt pulleys, couplings, <br> fit bolts, inner rring of ball bearings |
| Push fit | H7/k6 | belt pulleys, brake pulleys, gears and couplings as <br> well as inner rings of ball bearngs on shafts for <br> average loading conditions |
| Easy push fit | H7/j6 | parts which are frequently dismantled, but are <br> secured by keys, e.g. pulleys, hand wheels, <br> bushes, bearing shells, piston on piston rods, <br> change gear trains |

## Clearance fit

| Precision sliding fit | H7/h6 | sealing rings, bearing covers, milling cutters on <br> milling mandrels |
| :--- | :--- | :--- |
| Close running fit | H7/g6 | sleeve shafts, clutches, movable gears in change <br> gear trains |
| Normal running fit | H7/77 | Sleeve bearings with high revolution, bearings on <br> machine tool spindles |
| Easy running fit | H8/e8 | Sleeve bearings with mediuam revolution, greease <br> lubricated bearings of wheel boxes, gear sliding on <br> shafts and sliding blocks |
| Loose running fit | H8/d9 | Sleeve bearings with low revolution |
| Slack running fit | H8/c11 | Oil seals with metal housings, multi-spline shafts |
|  | H11/a11 | Large clearance and widely used |

## FITS AND TOLERANCES

The components of the toleranced dimension shall be indicated in the following order:
a) the basic size, and
b) the tolerance symbol.

If, in addition to the symbols it is necessary to express the values of the deviations or the limits of size, the additional information shall be shown in brackets.


## Permissible deviation


-If a dimension needs to be limited in one direction only, this should be indicated by adding "min" or "max" to the dimension.

-The upper deviation or the upper limit of size shall be written in the upper position and the lower deviation or the lower limit of size in the lower position, irrespective of whether a hole or a shaft is toleranced.
-The tolerance symbol for the hole shall be placed before that for the shaft or above it, the symbols being preceded by the basic size indicated once only.

shaft $30-0.2$


## Indication of Tolerances on Angular Dimensions






Fig. 8.1 Tappet in guide


Fig. 8.2 Flange on shaft


Tolerances

$$
\begin{aligned}
& \Phi 32 \mathrm{H7}-32+\begin{array}{c}
+0.025 \\
+0.000 \\
\Phi 25 \mathrm{H7}-25+0.021 \\
\pm 0.000 \\
\Phi 32 \mathrm{nc}-32+0.033 \\
+0.017
\end{array} \\
& \hline
\end{aligned}
$$

Fig. 8.7 Bush bearing


## STUFFING BOX



FIG. 17-8



Fig. 9.13 Details of stuffing box


Fig. 8.6 Cylinder liner in block

