Limits & Fits

- & Expla
- & Identi
- & Identi
- & Select
- & Trans
  BS45

1. Why study Limits & Fits ?

- **Exact size is impossible to achieve.**

- **Establish boundaries within which deviation from perfect form is allowed YET still fulfil its design intent.**

- **Enable interchangeability of engineering components during assembly.**

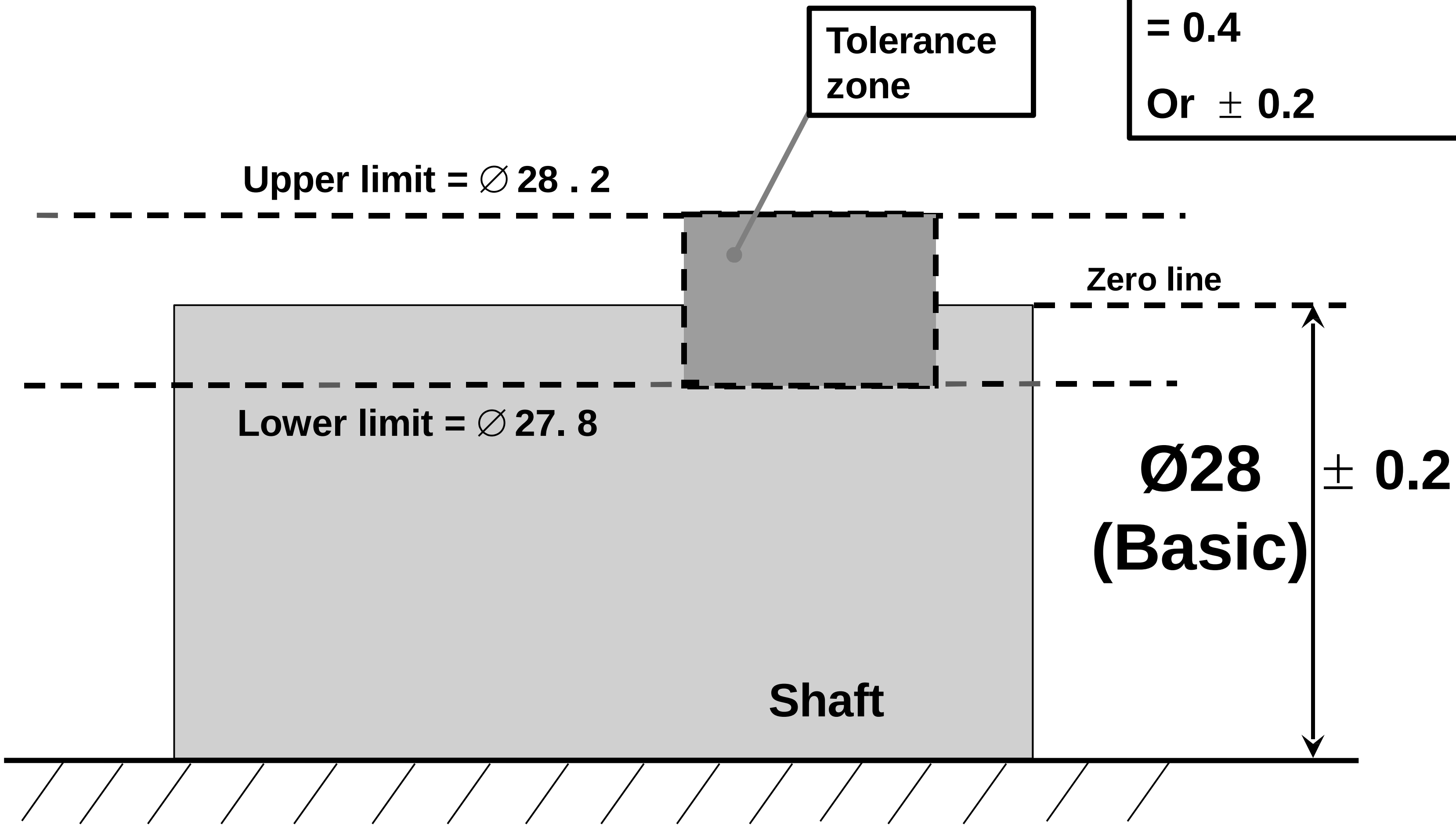
2. Limits (extreme sizes of a part)

Tolerance = UL – LL

= 28.2 – 27.8

= 0.4

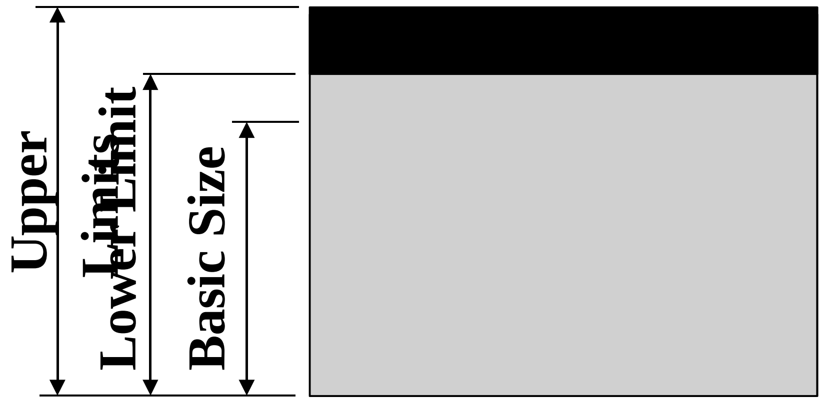
Or ± 0.2



Limits of Size

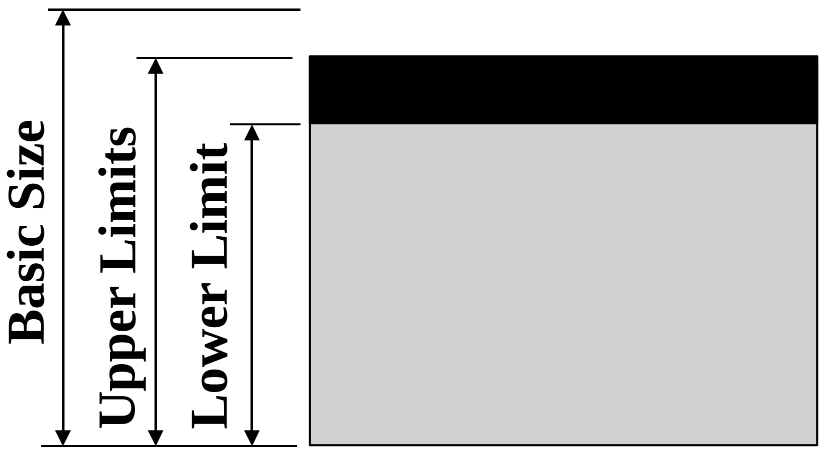
Unilateral Limits occurs when both maximum limit and minimum limit are either above or below the basic size.

e.g. $\varnothing 25^{+0.18}_{+0.10}$



Basic Size = 25.00 mm
Upper Limit = 25.18 mm
Lower Limit = 25.10 mm
Tolerance = **0.08 mm**

e.g. $\varnothing 25^{-0.10}_{-0.20}$



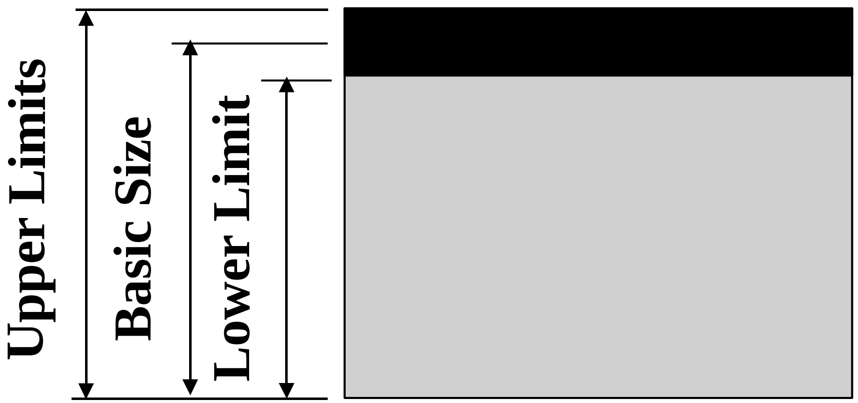
Basic Size = 25.00 mm
Upper Limit = 24.90 mm
Lower Limit = 24.80 mm
Tolerance = **0.10 mm**

Limits of Size

For Unilateral Limits, a case may occur when one of the limits ***coincides*** with the basic size,

e.g. $Ø25^{+0.20}_{0}$, $Ø25^{0}_{-0.10}$

Bilateral Limits occur when the maximum limit is above and the minimum limit is below the basic size.



e.g. $Ø25^{\pm 0.04}$

Basic Size = 25.00 mm

Upper Limit = 25.04 mm

Lower Limit = 24.96 mm

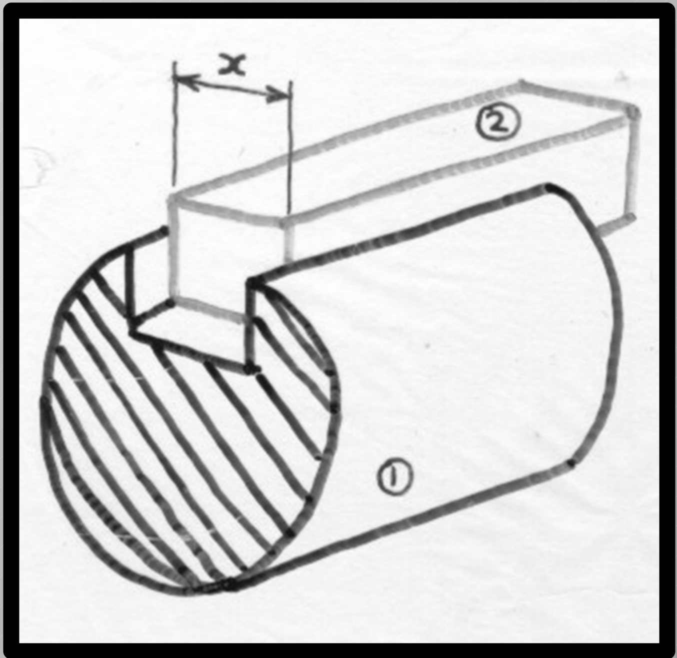
Tolerance = 0.08 mm

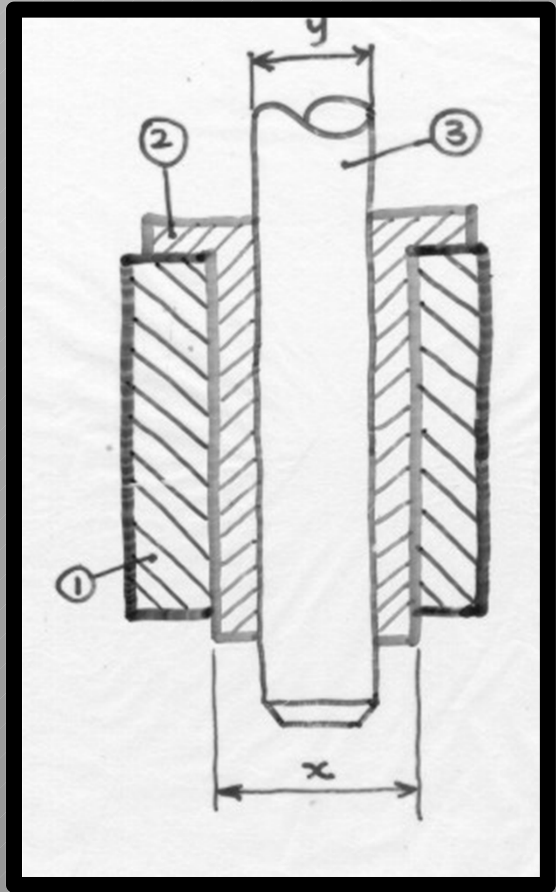
3. Fits

(assembly condition between "Hole" & "Shaft")

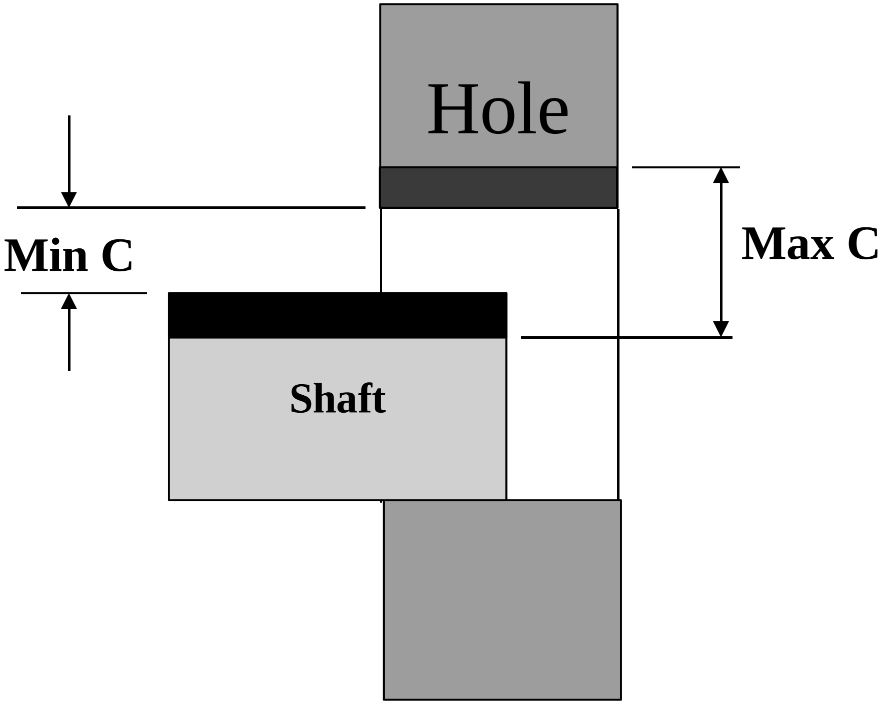
Hole – **A feature engulfing a component**

Shaft – **A feature being engulfed by a component**





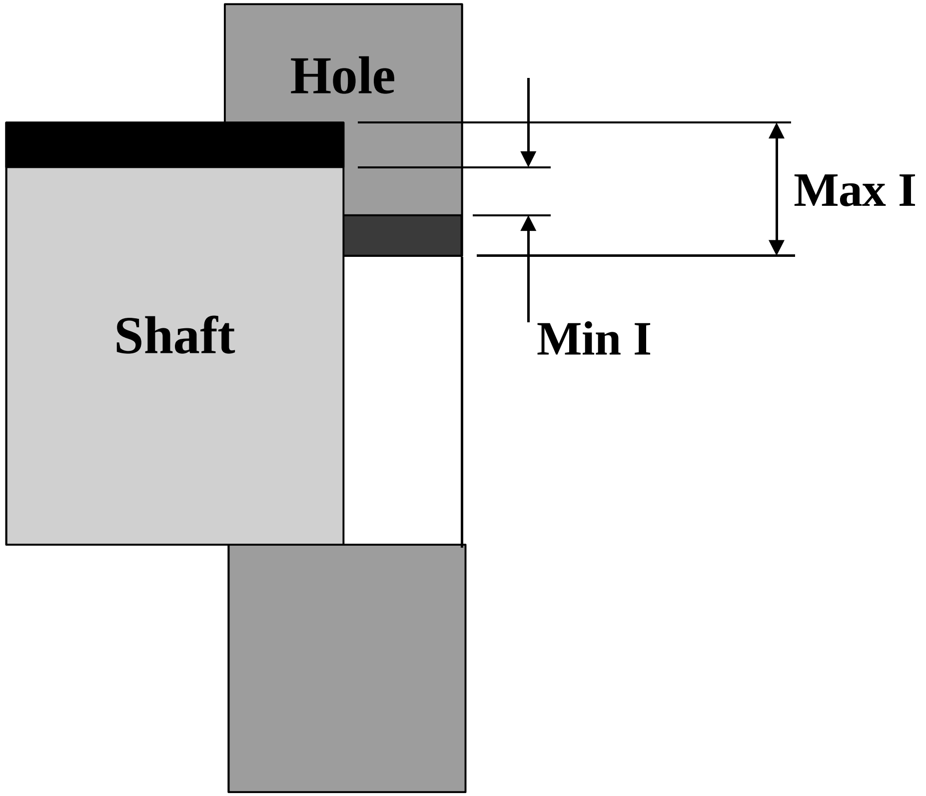
Clearance Fits



Tolerance zones never meet

Max. C = UL of hole - LL of shaft
Min. C = LL of hole - UL of shaft

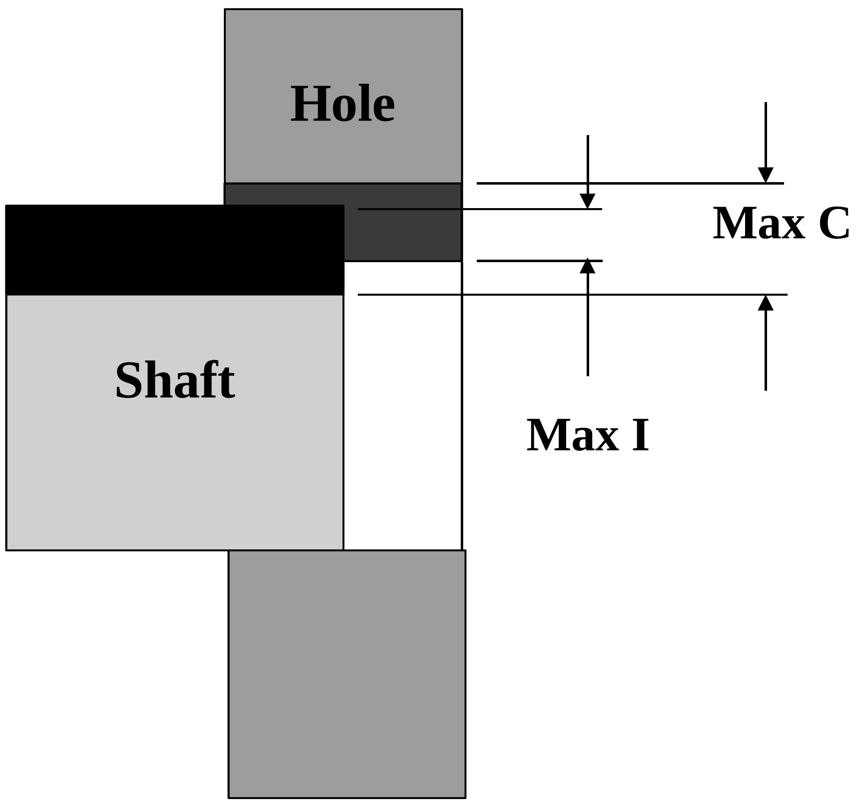
Interference Fits



Tolerance zones never meet but crosses each other

Max. I = LL of hole - UL of shaft
Min. I = UL of hole - LL of shaft

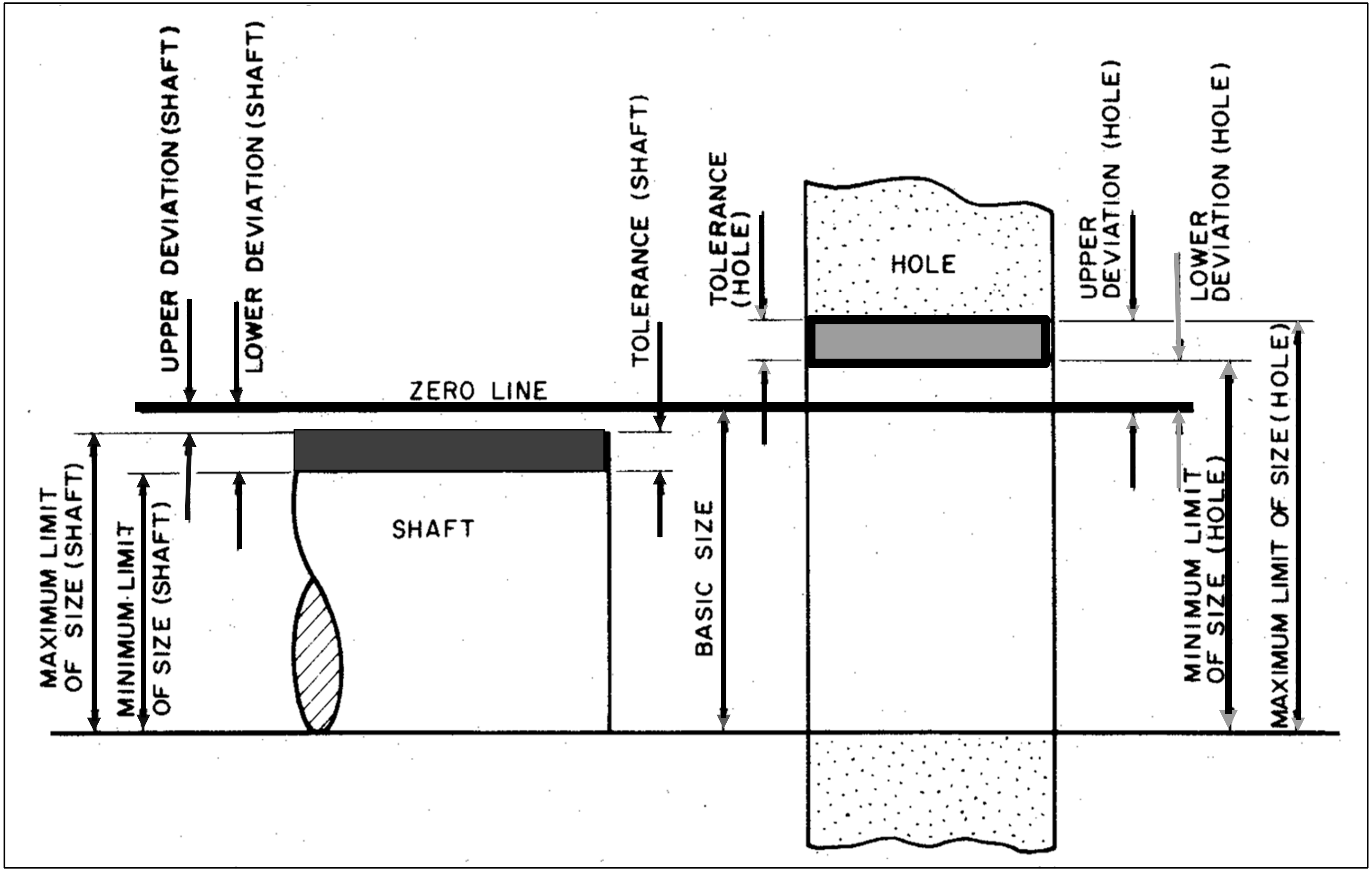
Transition Fits



Tolerance zones always overlap

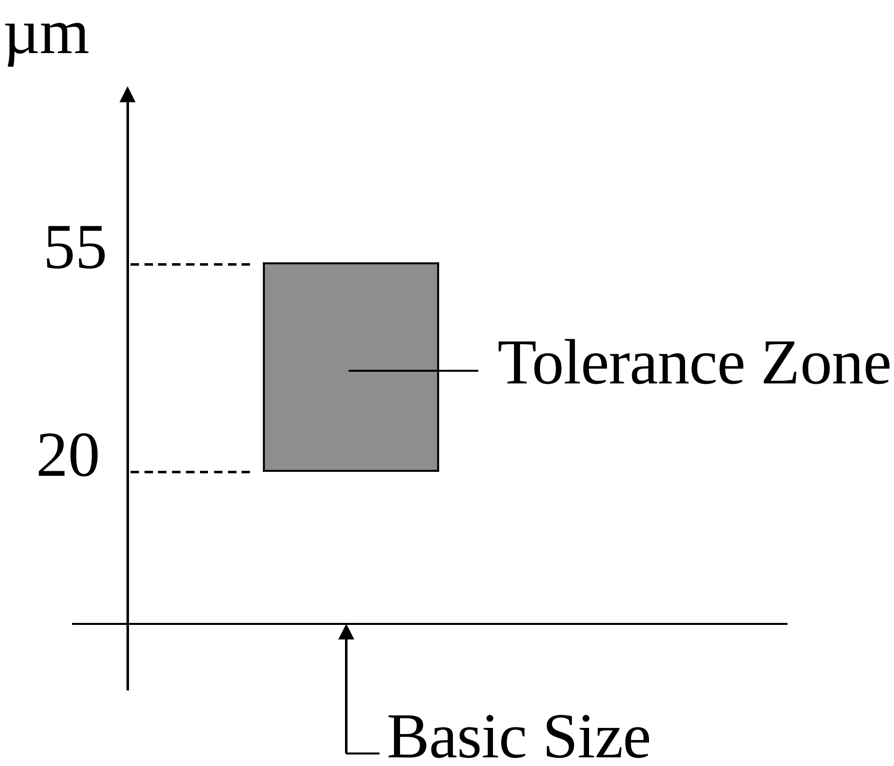
Max. C = UL of hole - LL of shaft
Max. I = LL of hole - UL of shaft

Terminology Related to Limits and Fits



Main Menu

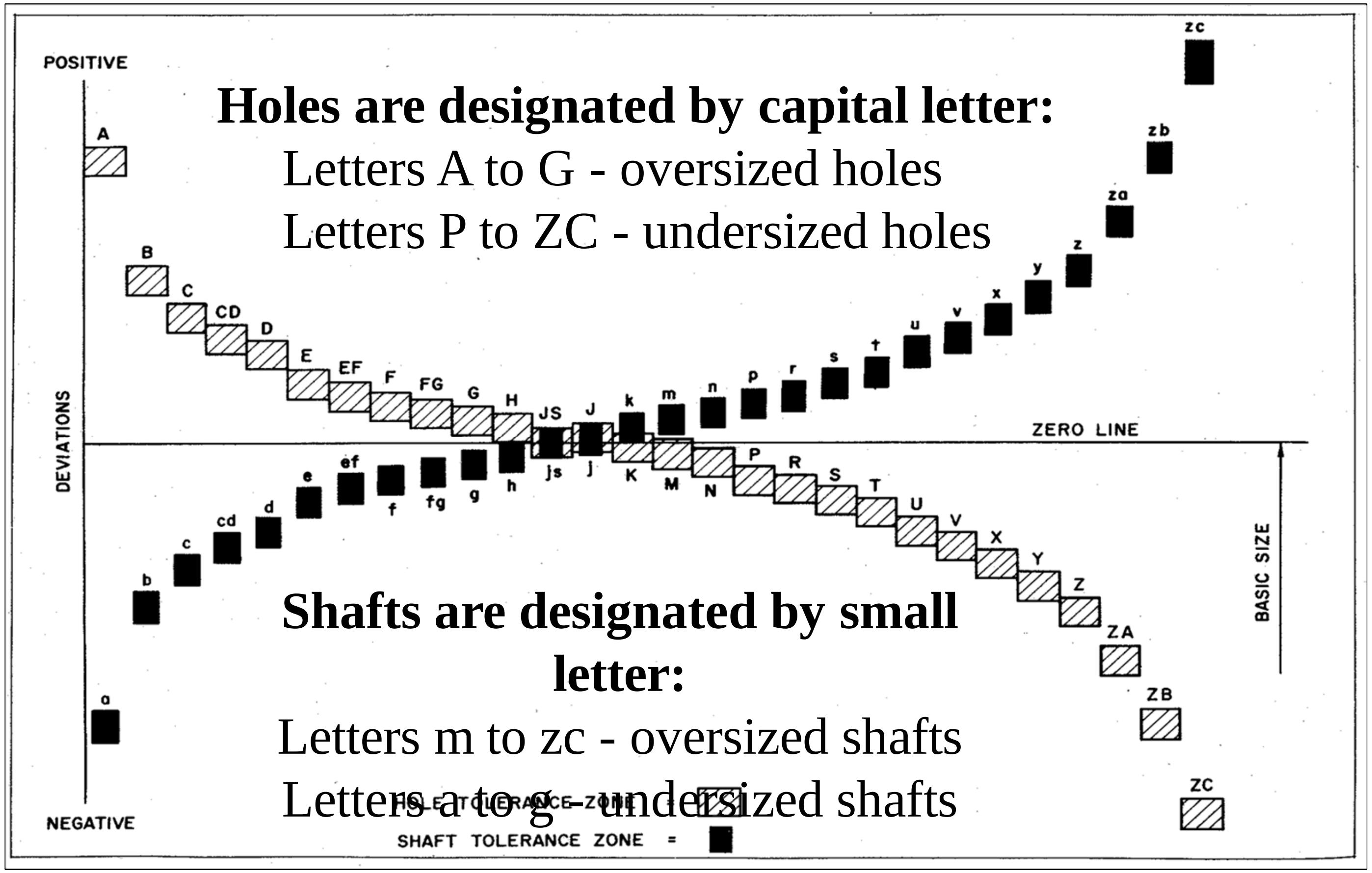
4. Tolerance Zone



- It is defined graphically by the magnitude of the tolerance and by its position in relation to the zero line.

4a. Fundamental Deviation

is chosen to locate the tolerance zone w.r.t. the zero line



Holes are designated by capital letter:

Letters A to G - oversized holes

Letters P to ZC - undersized holes

Shafts are designated by small letter:

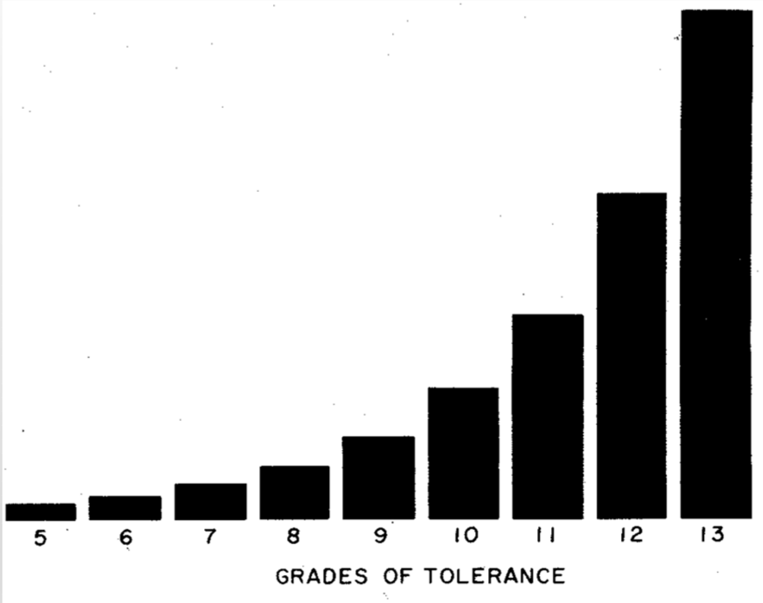
Letters m to zc - oversized shafts

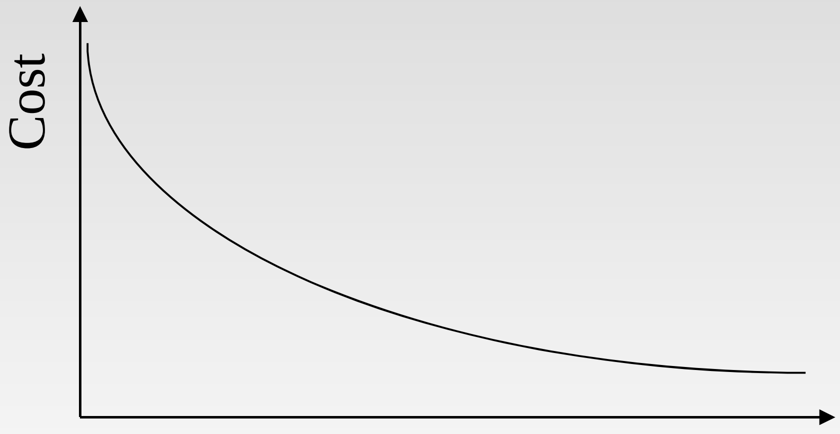
Letters a to g - undersized shafts

H is used for holes and h is used for shafts whose fundamental deviation is zero

4b. Grades of Tolerances

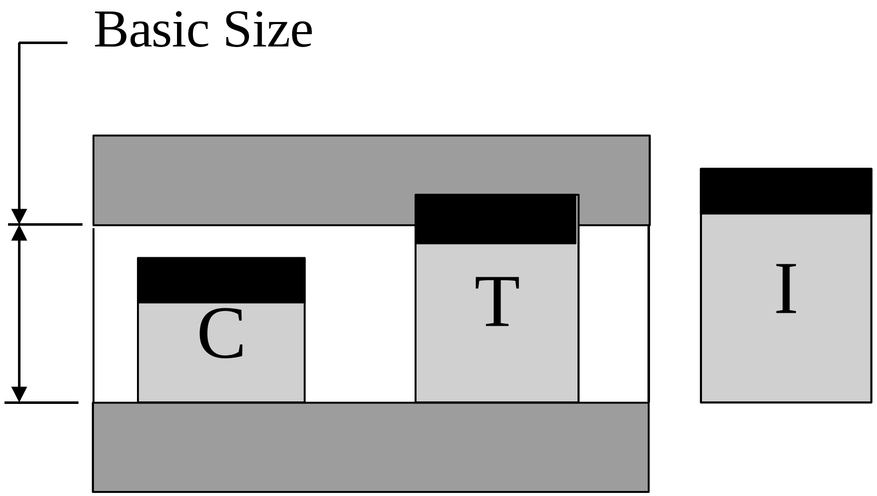
- Grade is a measure of the magnitude of the tolerance.
- The lower the grade the finer the tolerance.
- There are total of **18 grades** which are allocated the numbers IT01, IT0, IT1, IT2 ..... IT16.
- Fine grades are referred to by the first few numbers.
- As the numbers get larger, so the tolerance zone becomes progressively wider.
- Selection of grade should depends on the circumstances.
- As the grades get finer, the cost of production increases at a sharper rate.





Grades of Tolerances

5. Basis of Fits - Hole Basis



Hole Basis Fits

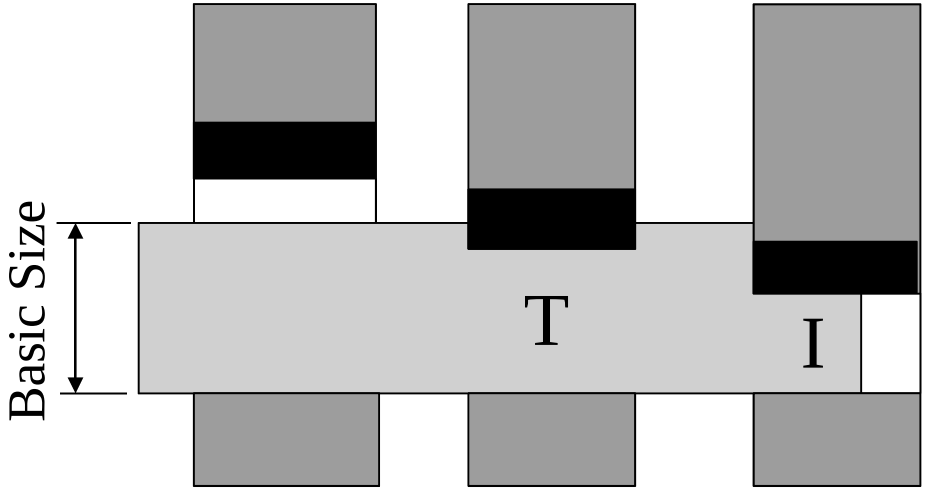
Legends:

Hole
Shaft
Tolerance

C - Clearance
T - Transition I
- Interference

- In this system, the basic diameter of the hole is constant while the shaft size varies according to the type of fit.

Basis of Fits - Shaft Basis



Shaft Basis Fits

Legends:

Hole
Shaft
Tolerance

C - Clearance
T - Transition I
- Interference

- Here the hole size is varied to produce the required class of fit with a basic-size shaft.
- A series of drills and reamers is required for this system, therefore it tends to be costly.
- It may, however, be necessary to use it where different fits are required along a long shaft. For example, in the case of driving shafts where a single shaft may have to accommodate to a variety of accessories such as couplings, bearings, collars, etc., it is preferable to maintain a constant diameter for the permanent member, which is the shaft, and vary the bore of the accessories.

Selected ISO Fits- Hole Basis {Table 1.24(a) on Pg 56/57}

- The ISO system provides many holes and shaft tolerances so as to cater for a wide range of conditions.

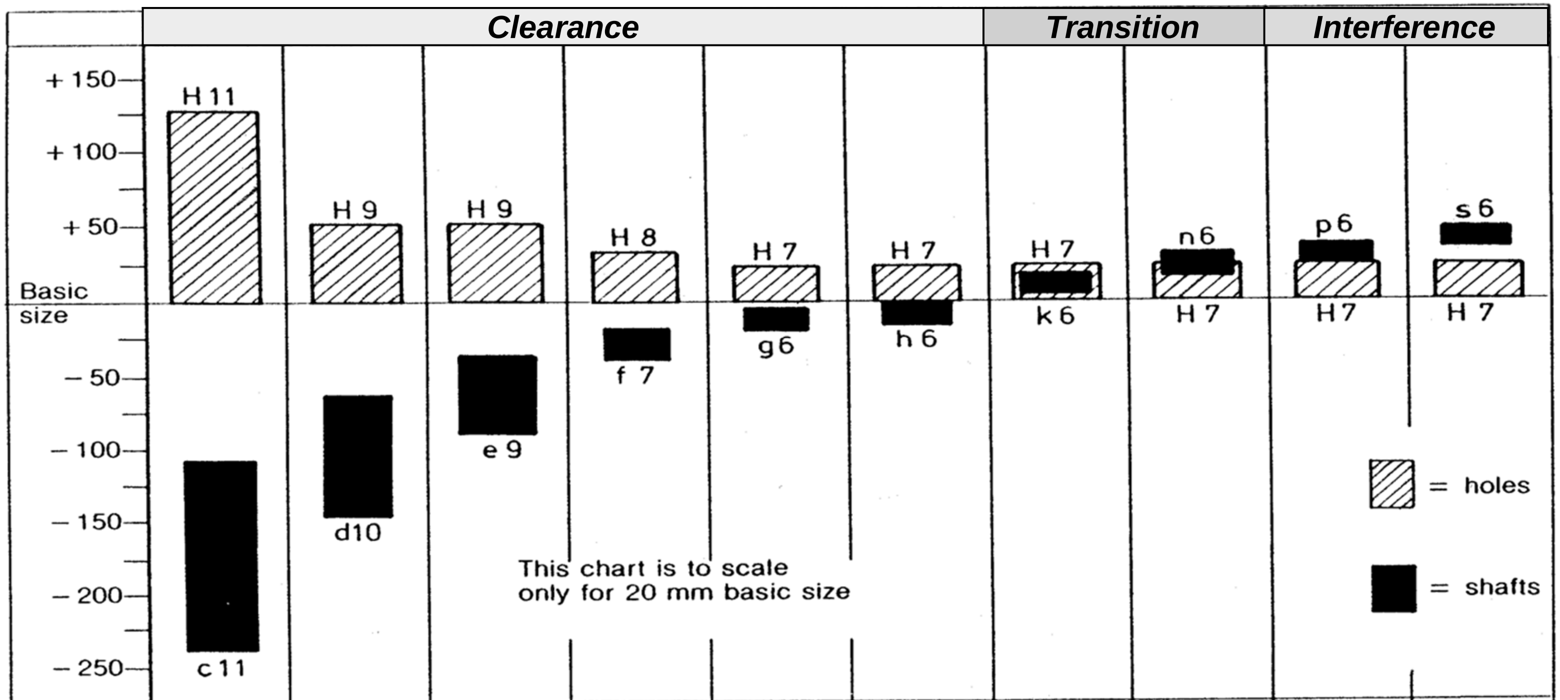
- The following selected hole and shaft tolerances have been found to be commonly applied:

Selected hole tolerances: H7, H8, H9, H11
Selected shaft tolerances: c11, d10, e9, f7, g6, h6, k6, n6, p6, s6

- Data sheet 4500A shows a range of fits derived from these selected hole and shaft tolerances.
- It covers fits from loose clearance to heavy interference and are suitable for most general engineering applications.
- This data sheet covers all basic sizes up to 500 mm.

Selected ISO Fits- Hole Basis (Extracted from BS 4500)

Table 1.24 (a) Selection of fits—hole-basis system



Tolerance unit = 0.001mm		Coarse tolerance	Loose (running fit)	Easy (running fit)	Normal running	Precision running, location	Average location	Light (push fit)	Heavy (push fit)	Press fit (ferrous)	Heavy press fit (non-ferrous)
Basic sizes (mm) over	to	*H11 - c11*	*H9–d10*	*H9–e9*	*H8–f7*	*H7–g6*	*H7–h6*	*H7 - k6*	*H7–n6*	*H7 - p6*	*H7–s6*
0	3	+ 60 − 60 0 − 120	+ 25 − 20 0 − 60	+ 25 − 14 0 − 39	+ 14 − 6 0 − 16	+ 10 − 2 0 − 8	+ 10 0 0 − 6	+ 10 + 6 0 0	+ 10 + 10 0 + 4	+ 10 + 12 0 + 6	+ 10 + 20 0 + 14
3	6	+ 75 − 70 0 − 145	+ 30 − 30 0 − 78	+ 30 − 20 0 − 50	+ 18 − 10 0 − 28	+ 12 − 4 0 − 12	+ 12 0 0 − 8	+ 12 + 9 0 + 1	+ 12 + 16 0 + 8	+ 12 + 20 0 + 12	+ 12 + 27 0 + 19
6	10	+ 90 − 80 0 − 170	+ 36 − 40 0 − 98	+ 36 − 25 0 − 61	+ 22 − 13 0 − 28	+ 15 − 5 0 − 14	+ 15 0 0 − 9	+ 15 + 10 0 + 1	+ 15 + 19 0 + 10	+ 15 + 24 0 + 15	+ 15 + 32 0 + 23
10	18	+ 110 − 95 0 − 205	+ 43 − 50 0 − 120	+ 43 − 32 0 − 75	+ 27 − 16 0 − 34	+ 18 − 6 0 − 17	+ 18 0 0 − 11	+ 18 + 12 0 + 1	+ 18 + 23 0 + 12	+ 18 + 29 0 + 18	+ 18 + 39 0 + 28
18	30	**+ 130 - 110** **0 - 240**	+ 52 − 65 0 − 149	+ 52 − 40 0 − 92	+ 33 − 20 0 − 41	+ 21 − 7 0 − 20	+ 21 0 0 − 13	+ 21 + 15 0 + 2	+ 21 + 28 0 + 15	+ 21 + 35 0 + 22	+ 21 + 48 0 + 35
30	40	+ 160 − 120 − 280 0 − 130	+ 62 − 80 0 − 180	+ 62 − 50 0 − 112	+ 39 − 25 0 − 50	+ 25 − 9 0 − 25	+ 25 0 0 − 16	+ 25 + 18 0 + 2	+ 25 + 33 0 + 17	+ 25 + 42 0 + 26	+ 25 + 59 0 + 43

∴ You must know….

- **Identify fitting conditions from Fundamental deviation. (e.g 30 H7/ g6)**
- **Convert from F.D to limits of tolerance for hole and shaft. (e.g 100 $\pm$ 0.5)**
- **Calculate max. & min. limit of size of hole and shaft.**
- **Max./ Min. Clearance or Interference**

(for Transition, we have max. clearance and max interference)

6. Application of Tolerances to Dimensions

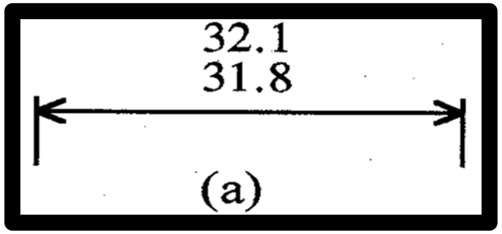
- Tolerances should be specified in the case where a dimension is critical to the proper functioning or interchangeability of a component.
- A tolerance can also be supplied to a dimension which can have an unusually large variation in size.
- General tolerances are generally specified as a note at the bottom of the drawing.

NOTE: TOLERANCE EXCEPT WHERE OTHERWISE STATED ON
DIMENSIONS ±0.5
ANGLES ±1°

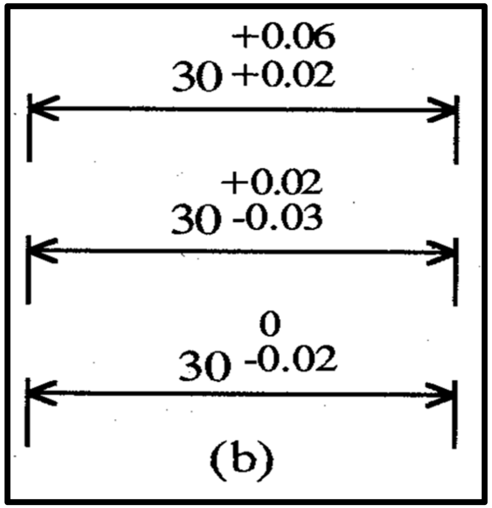
Unless Otherwise Specified General Tolerance as per BS4500, Part3, 1973 (Medium Series)							
Nominal Dimension	Over	0.5	3	6	30	120	315
	Up to	3	6	30	120	315	1000
Permissable Variation		±0.1	±0.1	±0.2	±0.3	±0.5	±0.8

Specifications of Tolerances on Drawings
(Detailed Parts for Critical Linear Dimensions)

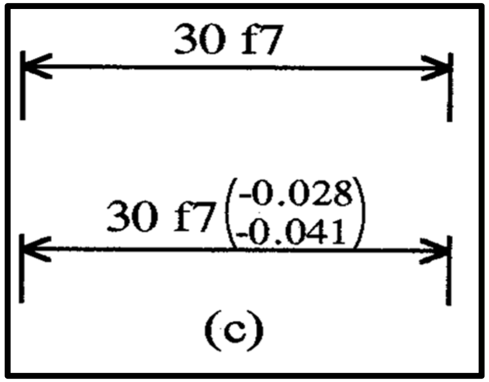
(a) Maximum and Minimum Limits
By specifying directly both limits of size, the maximum limit being quoted first and the same number decimal places used in both figures. This method eliminates calculations on the shop floor.



(b) Limits of Tolerance
By specifying a size with limits of tolerance in both direction stated. In this case, again, the same number of decimal places must be used in both limits. The larger limit is usually quoted first. If one of the two deviations in nil, this should be expressed by the figure 0 (zero).

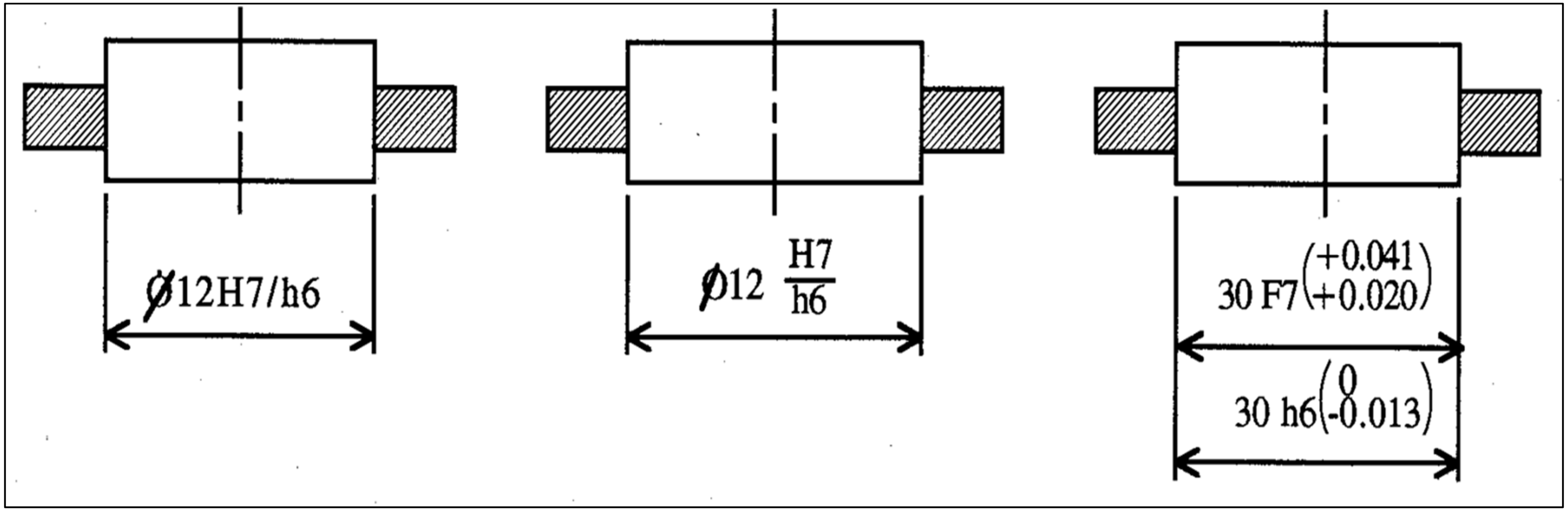


(c) Deviation and Grade
By using the appropriate deviation and grade symbols H8, g6 and so on, may be quoted with or without the limits specified.



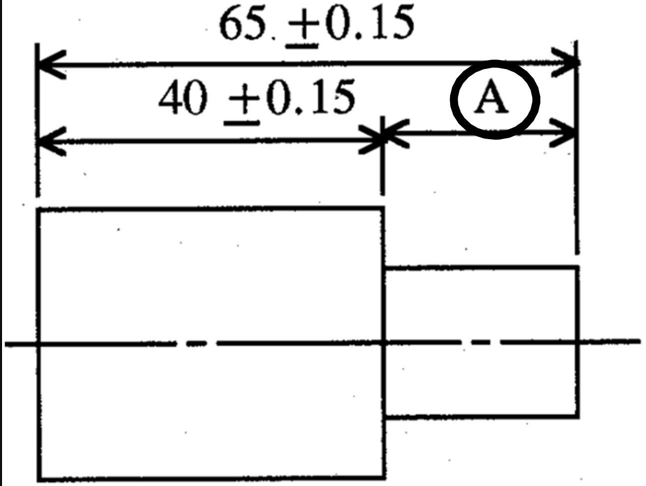
Specifications of Tolerances on Drawings on Assembled Parts for Critical Linear Dimensions

(a) By specifying the basic size followed by the deviation and grade symbols. The symbols for the hole must be placed before that of the shaft or above it. If it is necessary to specify also the numerical value of the deviations, they should be written in brackets.

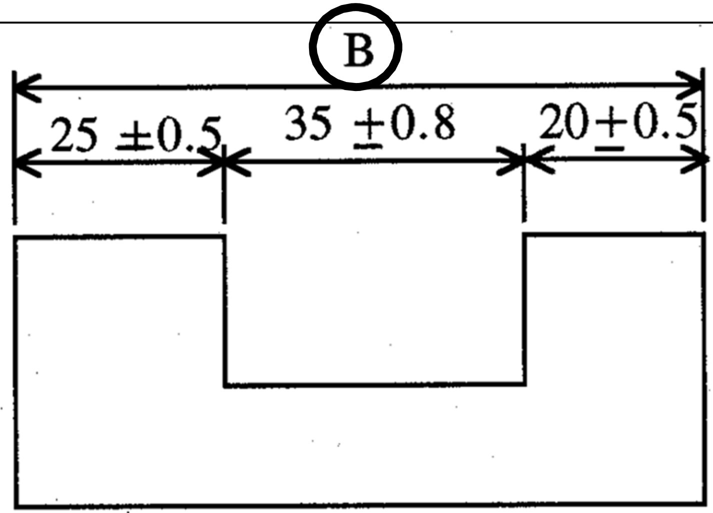


Tolerance Accumulation Analysis

The way a designer dimensions a component and the way each dimension is toleranced can result in certain amount of tolerances accumulated. Two examples of tolerance accumulation check on component dimensions are shown below:



$A = 65 \pm 0.15 - 40 \pm 0.15$
$\quad = 25 \pm 0.3$
A max. = 25.3 mm
A min = 24.7 mm



$B = 25 \pm 0.5 + 35 \pm 0.8 + 20 \pm 0.5$
$\quad = 80 \pm 1.8$
B max. = 81.8 mm
B min = 78.2 mm