

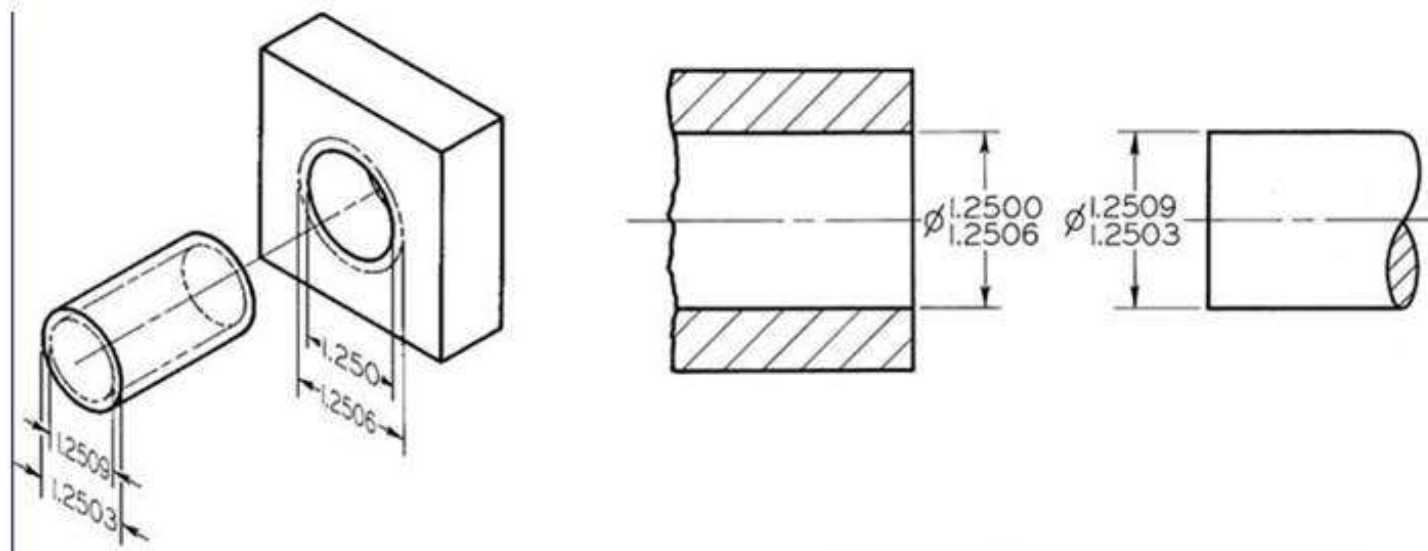
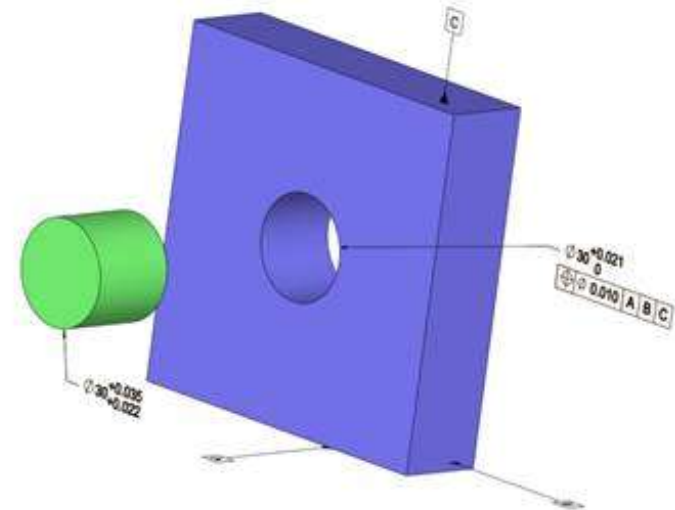
Mechanical Drawing II

Code: MAE227

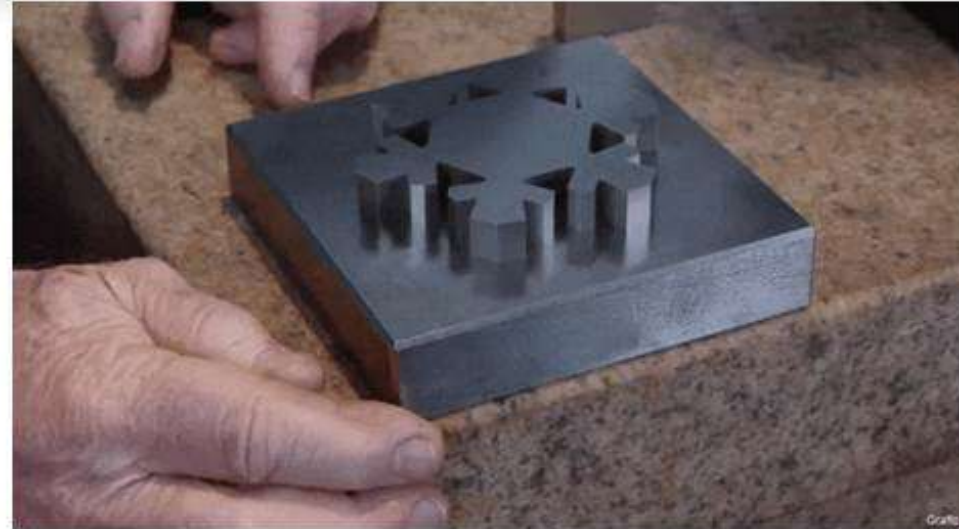
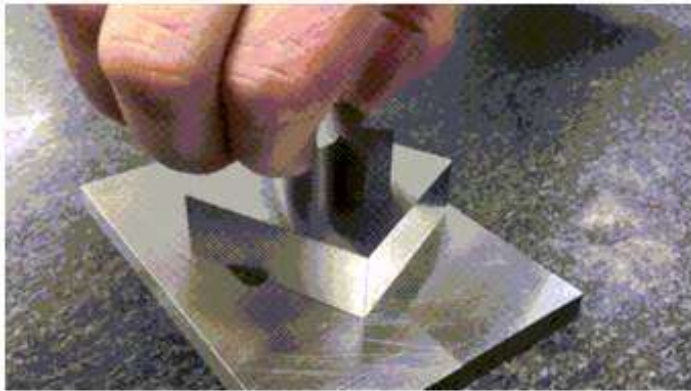
Fits and Tolerances

Introduction:

This section, based on the International Standards Organisation (ISO) system introduces the engineering concept of sizing parts before fitting them together to achieve a desirable relative motion between them.

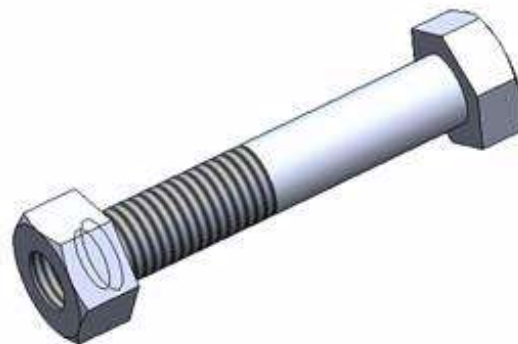


Introduction:



Introduction:

In manufacture it is impossible to produce components to an exact size, even though they may be classified as identical.



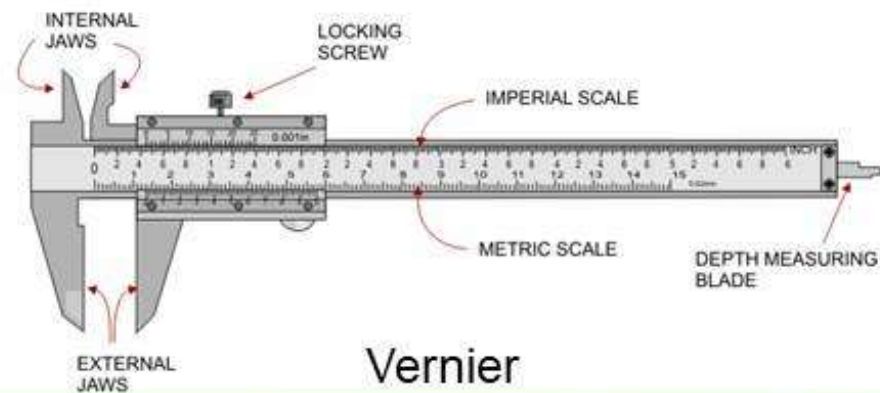
Introduction:

In the most precise methods of production it would be extremely difficult and costly to reproduce a diameter time after time so that it was always within 0.01 mm of a given basic size.

Industry however does demand that parts produced shall be between a given maximum and minimum size.



Micrometre Gauge



Vernier

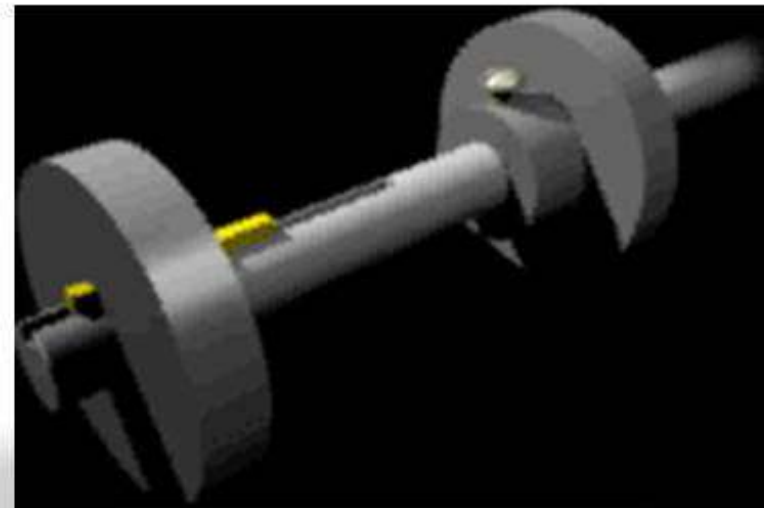
Introduction:

Shaft:

A shaft is defined as a member which fits into another member. It may be stationary or rotating.

Hole:

A hole is defined as a member which houses or fits the shafts. It may be stationary or rotating.



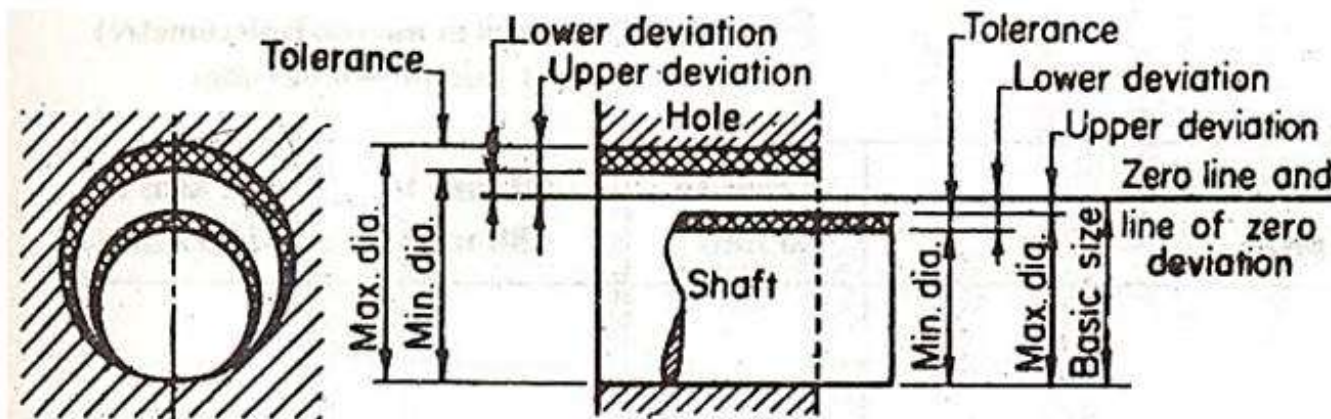
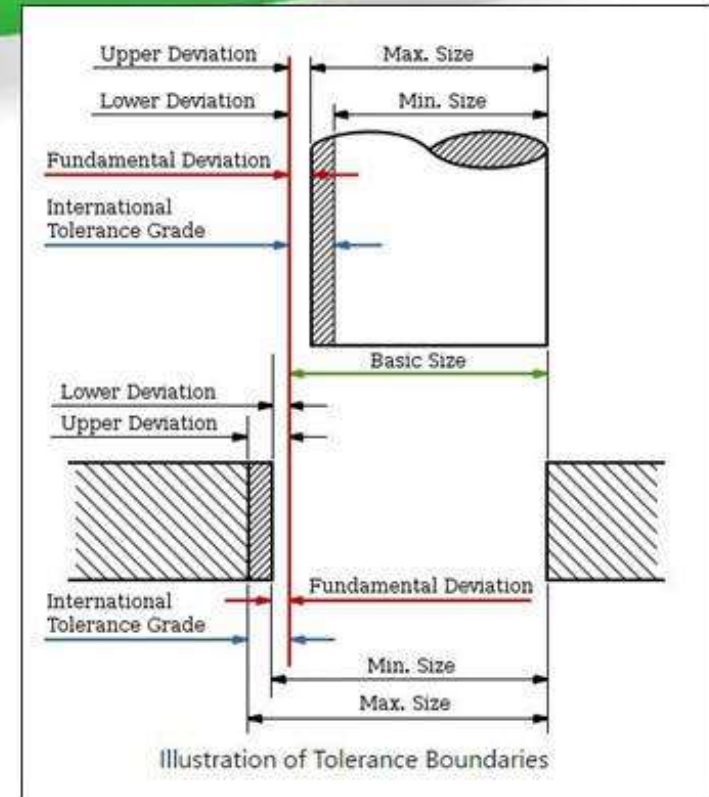
Introduction:

Basic Size

This is the size about which the limits of a particular fit are fixed. It is the same for both 'shaft' and 'hole'. It is also called the "nominal size" or "basic size".

Limits of Size

These are the extremes of size which are allowed for a dimension. Two limits are possible: one the maximum allowable size and the other the minimum allowable size.



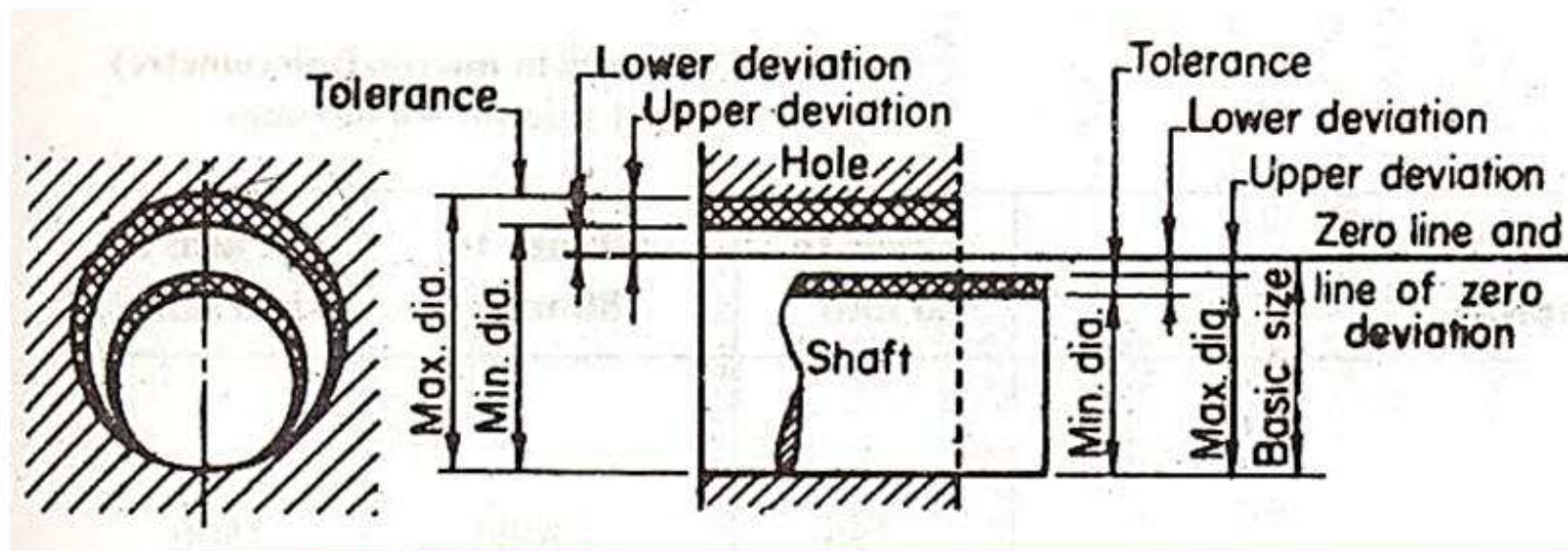
Introduction:

Deviation

This is the algebraic difference between the basic size and the actual size. The extremes of deviation are referred to as the upper and lower deviations.

Upper deviation = algebraic difference between the basic size and the maximum allowable size

Lower deviations = algebraic difference between the basic size and the minimum allowable size



Introduction:

Tolerance

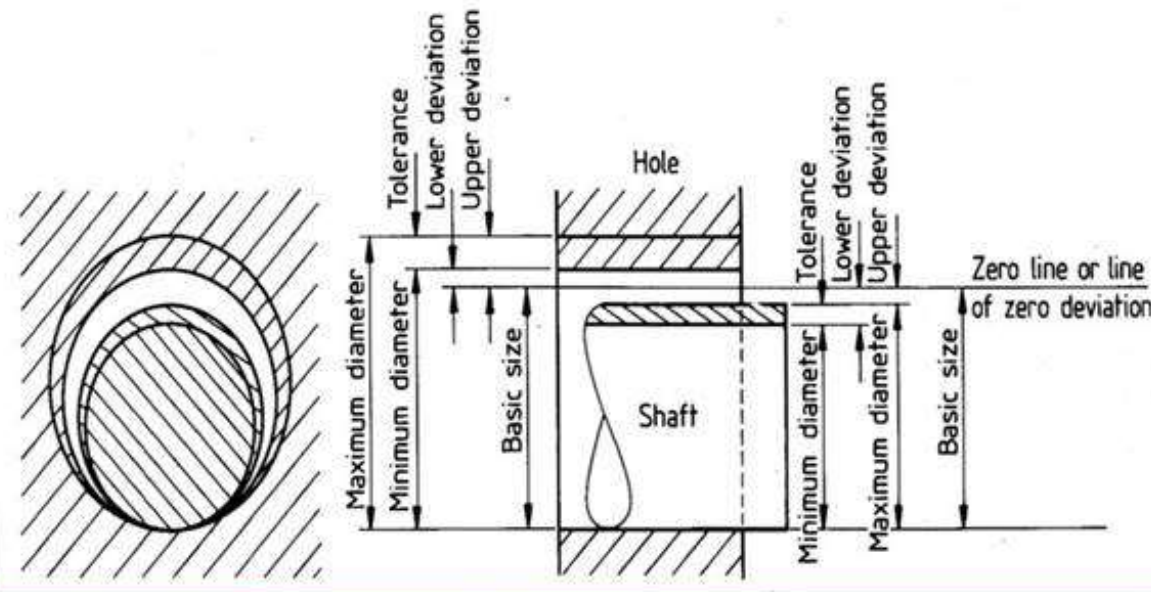
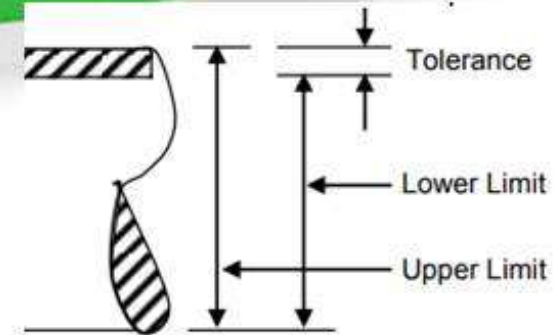
Tolerance is defined as the difference between the maximum and minimum limits of size for a hole or shaft.

It is also the difference between the upper and lower deviations.

Tolerance = the maximum limit – the minimum limit.

Or

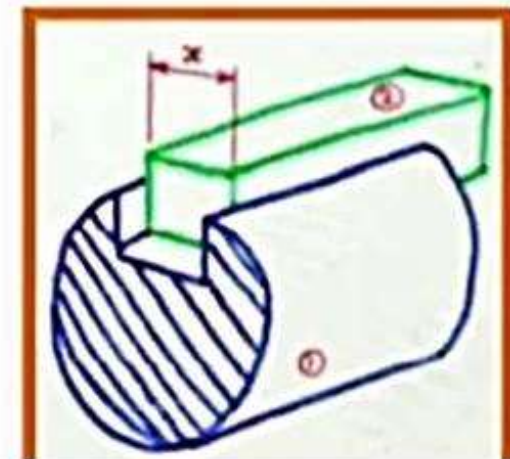
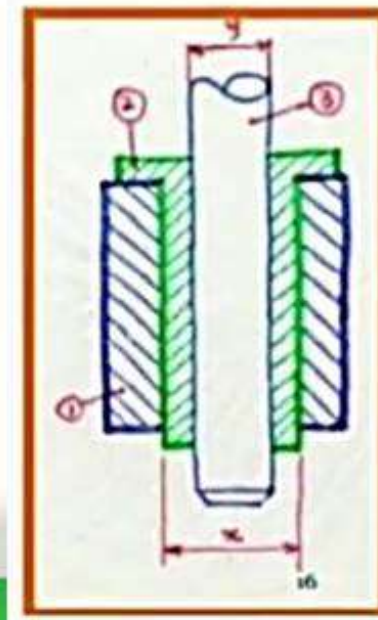
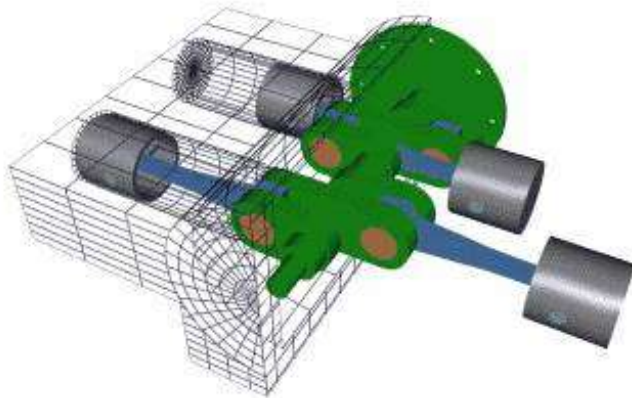
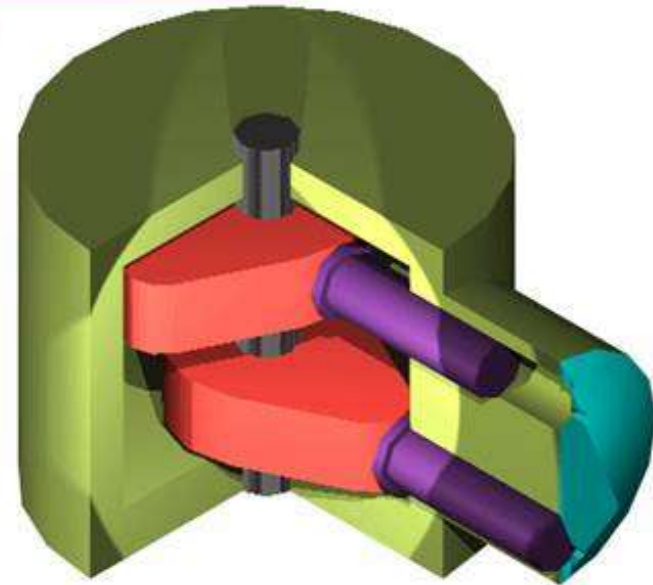
Tolerance = the upper deviation – the lower deviation.



Introduction:

Fit

A fit may be defined as the relative motion which can exist between a shaft and hole resulting from the final sizes which are achieved in their manufacture.



Introduction:

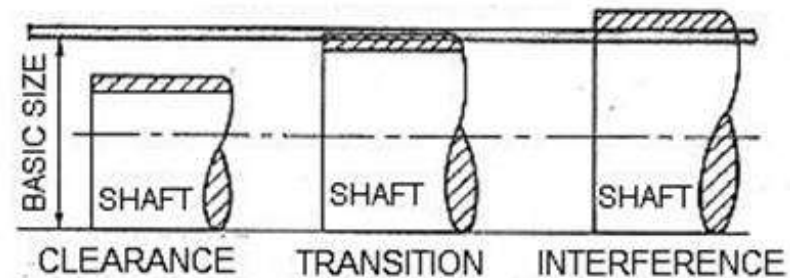
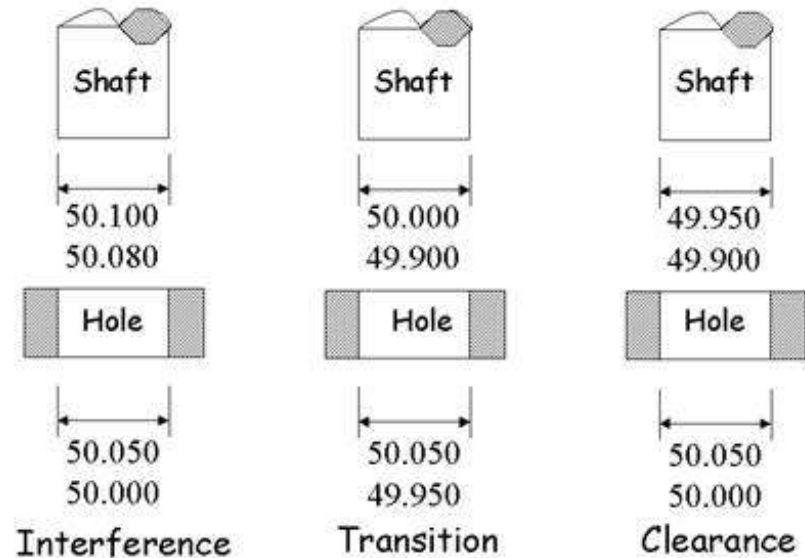
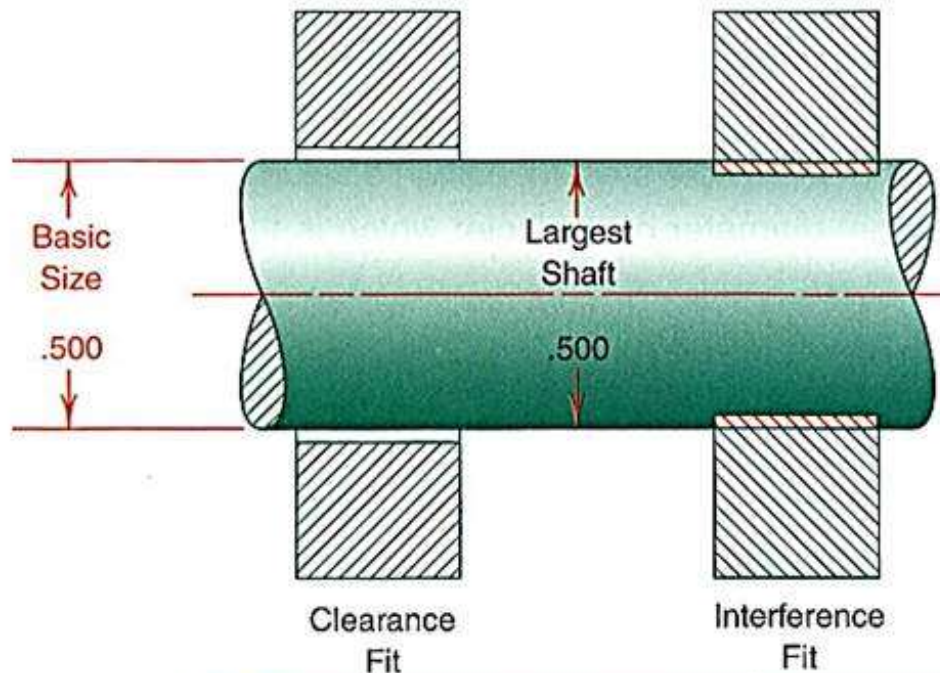
Fit

There are three classes of fit in common use:

Clearance.

Transition.

Interference.



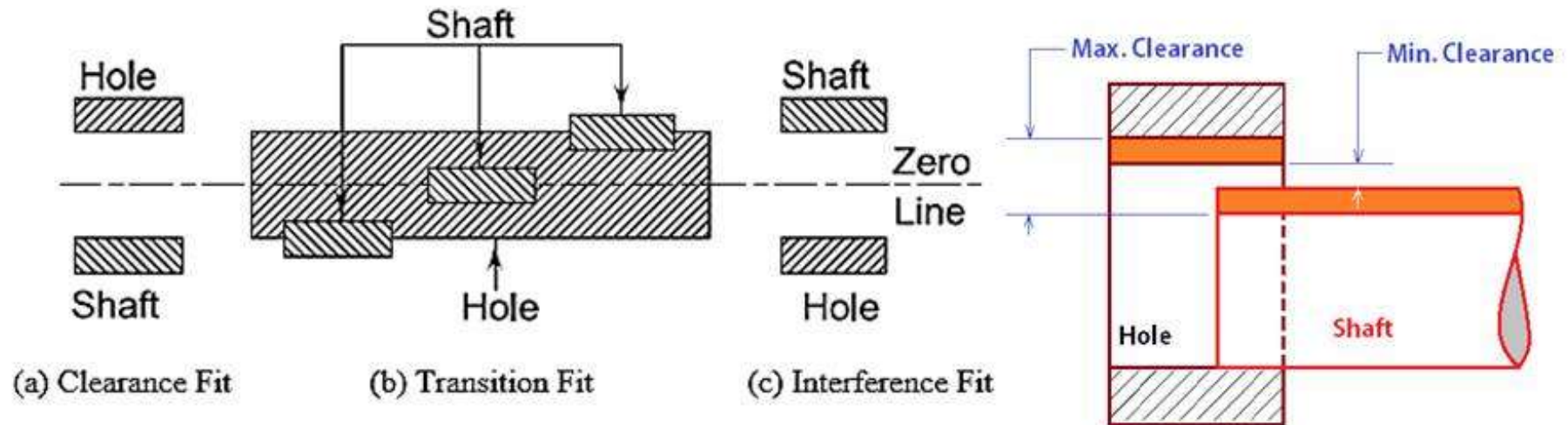
Fit Types:

Clearance Fit

This fit results when the shaft size is always less than the hole size for all possible combinations within their tolerance ranges. Relative motion between shaft and hole is always possible.

The maximum clearance = the maximum hole size - the minimum shaft size.

The minimum clearance = the minimum hole size - the maximum shaft size.



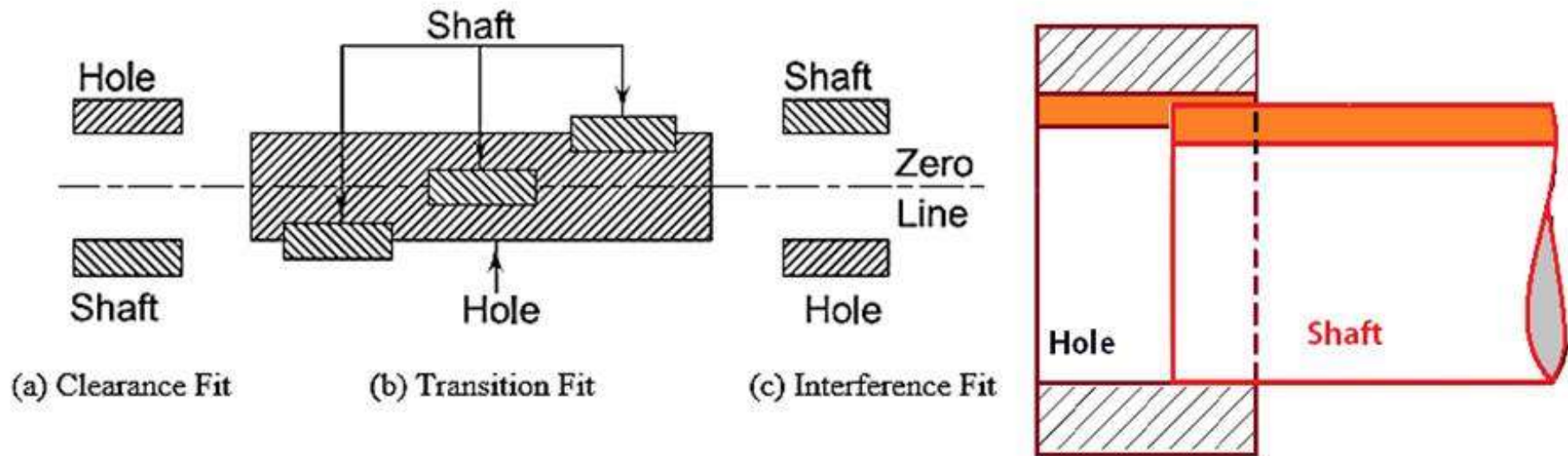
Fit Types:

Transition Fit

A pure transition fit occurs when the shaft and hole are exactly the same size.

The maximum interference = the minimum hole size - the maximum shaft size.

The maximum clearance = the maximum hole size - the minimum shaft size.

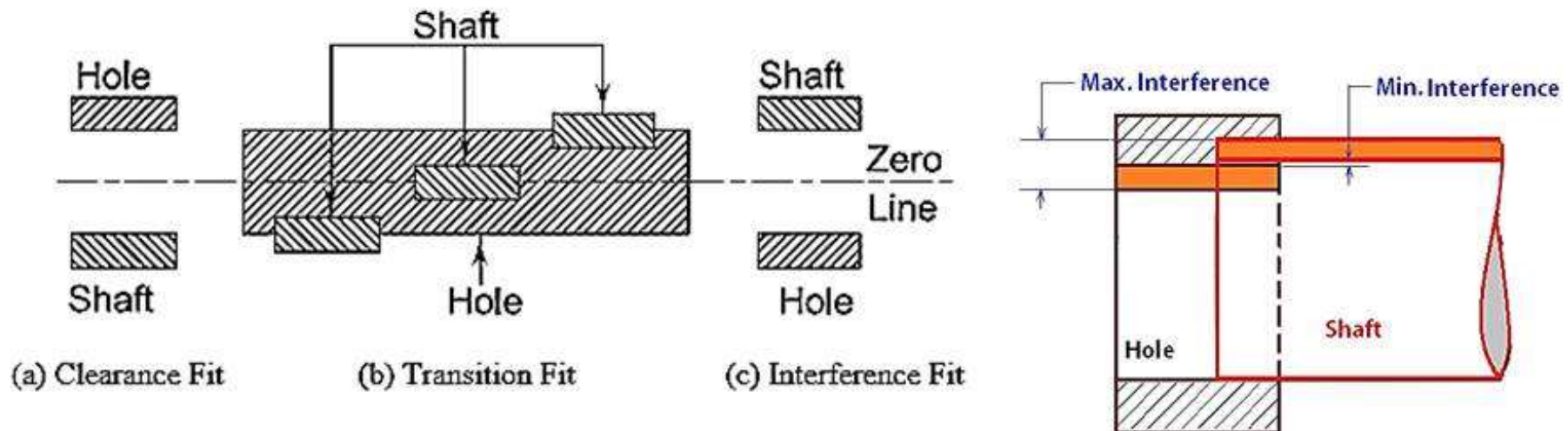


Fit Types:

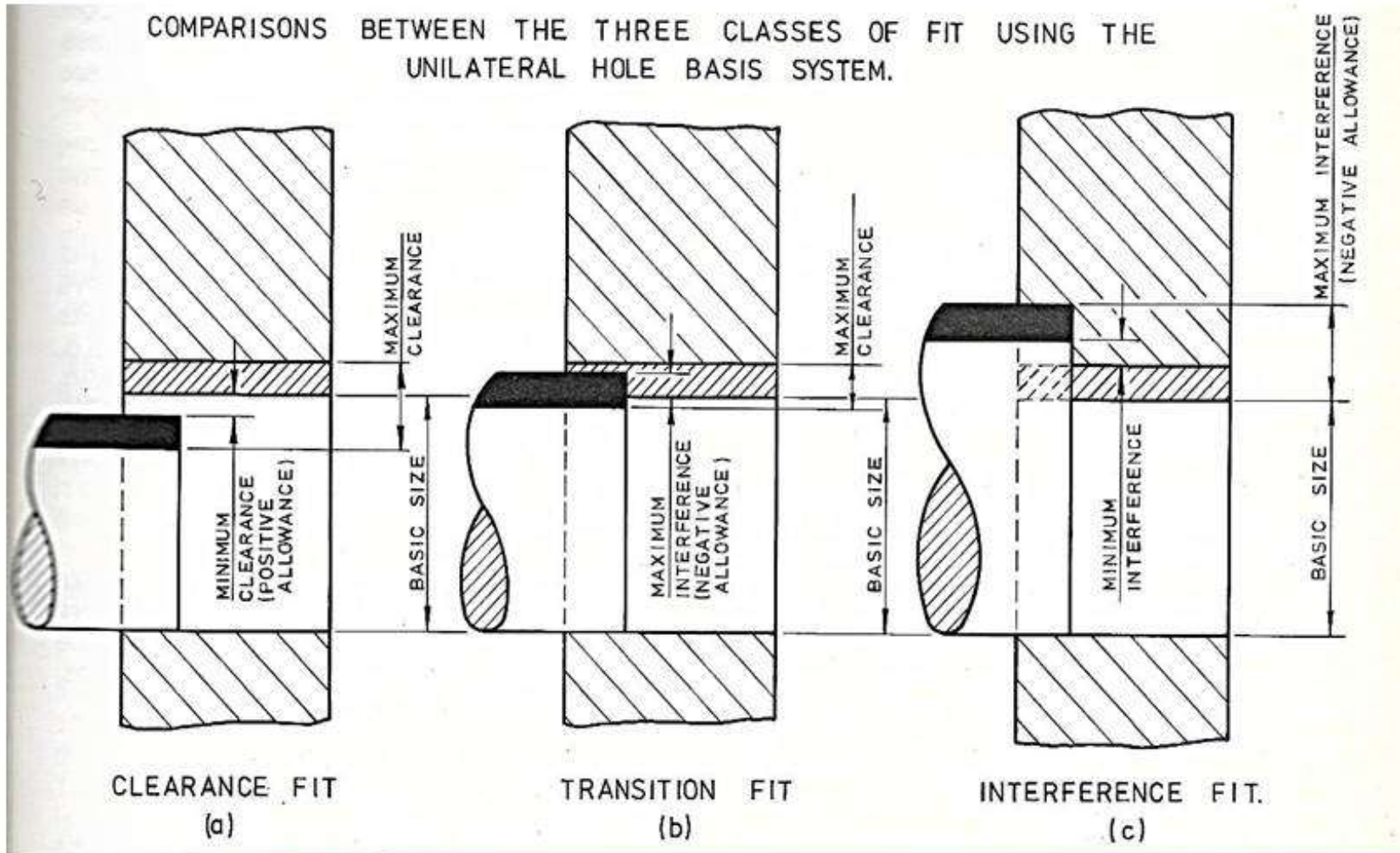
Interference Fit

This is a fit which always results in the minimum shaft size being larger than the maximum hole size for all possible combinations within their tolerance ranges. Relative motion between the shaft and hole is impossible.

The maximum interference = the minimum hole size - the maximum shaft size.
The minimum interference = the minimum shaft size - the maximum hole size.



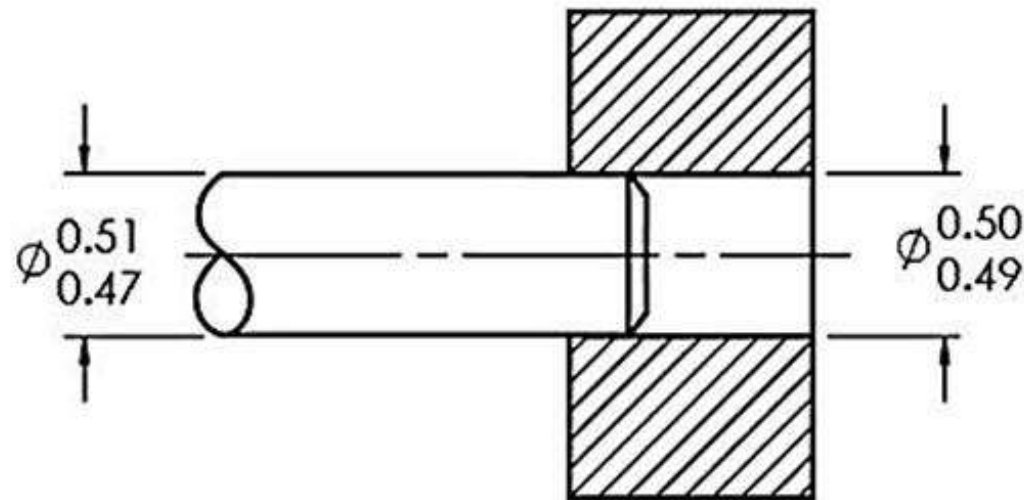
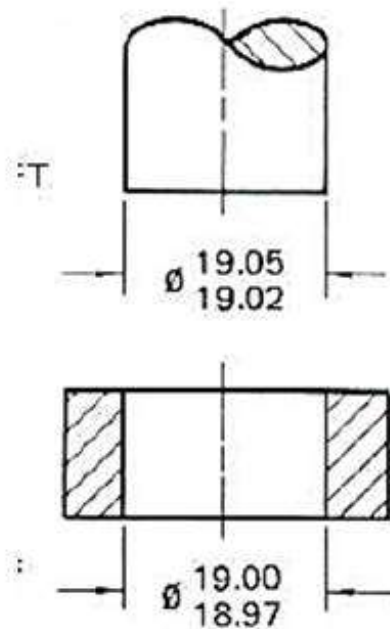
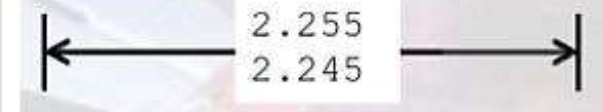
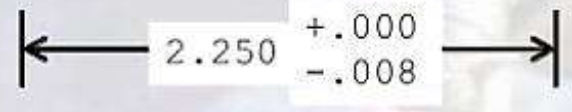
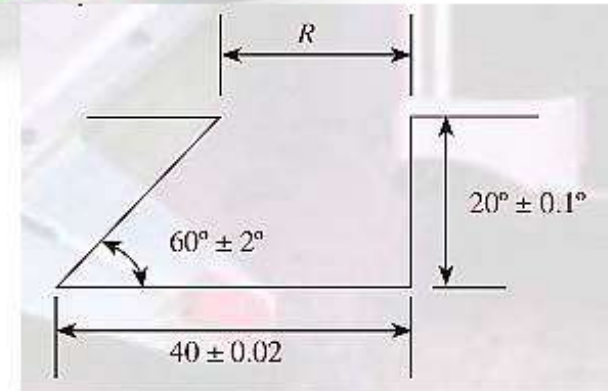
Fit Types:



Specifying Tolerance and Fit:

Classification of Tolerance

$$40^{+0.02}_{+0.01}, 40^{+0.02}_{-0.00}, 40^{-0.01}_{-0.02}, 40^{+0.00}_{-0.02}$$



Specifying Tolerance and Fit:

Example 1:

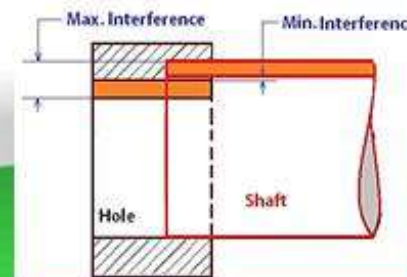
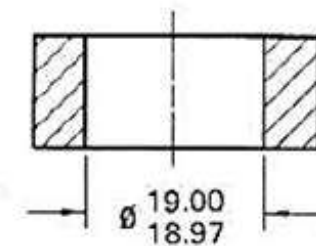
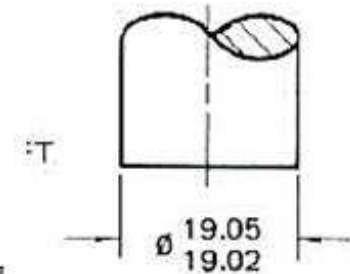
$$40 \begin{matrix} +0.02 \\ +0.01 \end{matrix}$$

Basic size	type	Upper deviation	Lower deviation	Max. Dia.	Min. Dia.	Tolerance
40	?	+0.02	+0.01	40.02	40.01	0.01

Example 2:

Basic size	type	Upper deviation	Lower deviation	Max. Dia.	Min. Dia.	Tolerance
19	hole	0	-0.03	19	18.97	0.03
19	Shaft	+0.05	+0.02	19.05	19.02	0.03

Fit type	Max. Clearance	Min. Clearance	Max. interference	Min. interference
Interference fit	-	-	0.08	0.02



Specifying Tolerance and Fit:

Tolerance symbols:

These are used to specify the tolerance and fits for mating components.

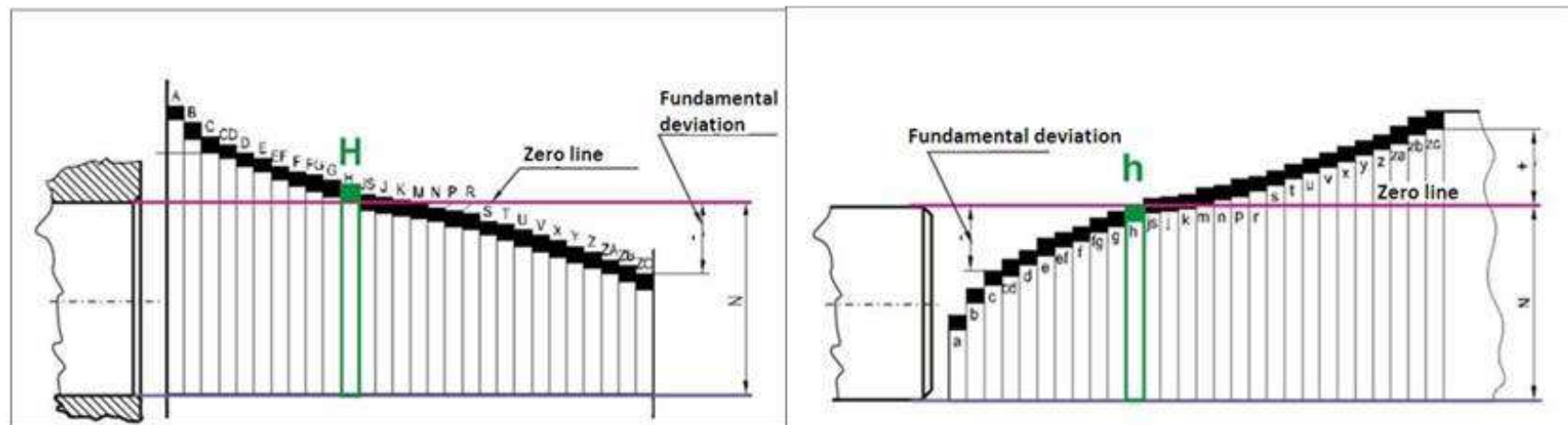
For example, 40 H8f7:

The number 40 indicates the basic size in millimetres.

Capital letter H indicates the fundamental deviation for the hole.

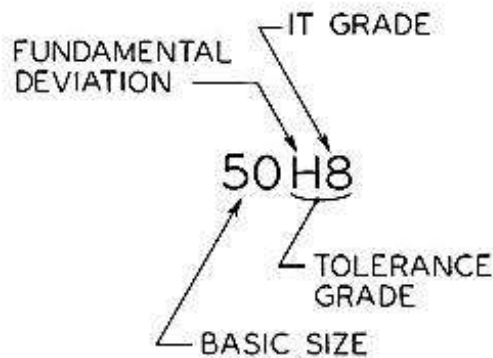
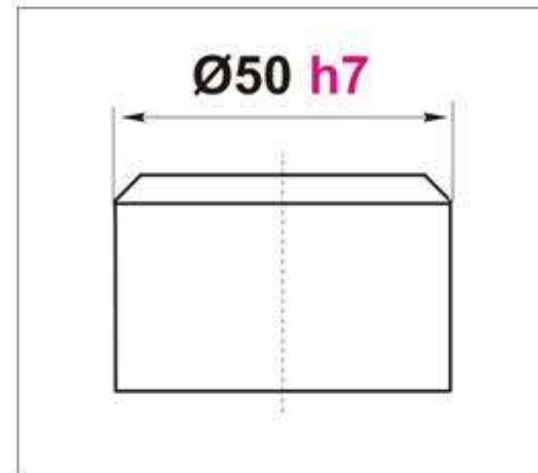
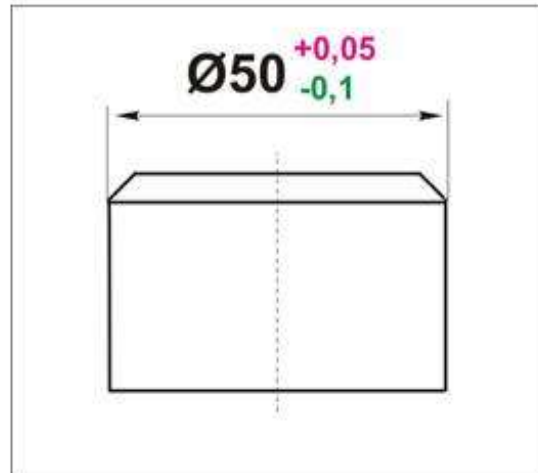
Lower-case letter f indicates the shaft.

The numbers following the letters indicate corresponding IT grades.

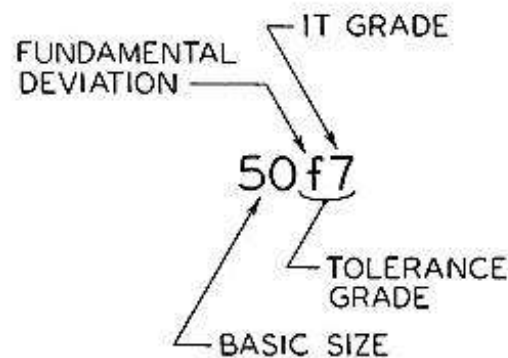


Specifying Tolerance and Fit:

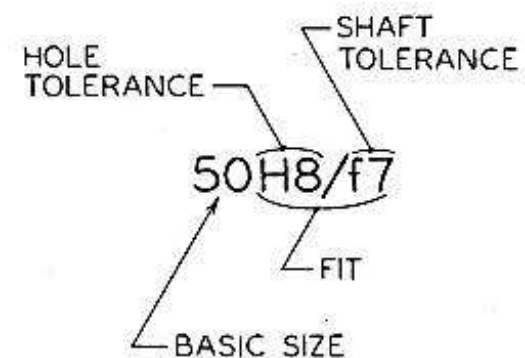
Two ways of indicating tolerances on technical drawings



(a) HOLE



(b) SHAFT



(c) FIT

Introduction:

Tolerance Grade Chart

جدول 9 . 1 منطقة التفاوت للتقريب .

FOR DIAMETER STEP IN MILLIMETRE	ISO - TOLERANCE ZONE FOR HOLE																VALUES OF DEVIATIONS IN MICRONS ($1\mu = 0.001\text{ mm}$)			
	A ₁₁	B ₁₁	C ₁₁	D ₁₀	E ₉	F ₈	G ₇	H ₁₁	H ₉	H ₈	H ₇	J _{s7}	K ₇	N ₇	P ₇	R ₇	S ₇			
— 3	+330 +270	+200 +140	+120 +60	+60 +20	+39 +14	+20 +6	+12 +2	+60 0	+25 0	+14 0	+10 0	+5 -5	0 -10	-4 -14	-6 -16	-10 -20	-14 -24			
> 3 — 6	+345 +270	+215 +140	+145 +70	+78 +30	+50 +20	+28 +10	+16 +4	+75 0	+30 0	+18 0	+12 0	+6 -6	+3 -9	-4 -16	-8 -20	-11 -23	-15 -27			
> 6 — 10	+370 +280	+240 +150	+170 +80	+98 +40	+61 +25	+35 +13	+20 +5	+90 0	+36 0	+22 0	+15 0	+75 -75	+5 -10	-4 -19	-9 -24	-13 -28	-17 -32			
> 10 — 18	+400 +290	+260 +150	+205 +95	+120 +50	+75 +32	+43 +16	+24 +6	+110 0	+43 0	+27 0	+18 0	+9 -9	+6 -12	-5 -23	-11 -29	-16 -34	-21 -39			
> 18 — 30	+430 +300	+290 +160	+240 +110	+149 +65	+92 +40	+53 +20	+28 +7	+130 0	+52 0	+33 0	+21 0	+10.5 -10.5	+6 -15	-7 -28	-14 -35	-20 -41	-27 -48			
> 30 — 40	+470 +310	+330 +170	+280 +120	+180	+112	+64	+34	+160	+62	+39	+25	+12.5	+7	-8	-17	-25	-34			
> 40 — 50	+480 +320	+340 +180	+290 +130	+80	+50	+25	+9	0	0	0	0	-12.5	-18	-33	-42	-50	-59			
> 50 — 65	+530 +340	+380 +190	+330 +140	+220	+134	+76	+40	+190	+74	+46	+30	+15	+9	-9	-21	-30	-42			
> 65 — 80	+550 +360	+390 +200	+340 +150	+100	+60	+30	+10	0	0	0	0	-15	-21	-39	-51	-60	-72			
> 80 — 100	+600 +380	+440 +220	+390 +170	+260	+159	+90	+47	+220	+87	+54	+35	+17.5	+10	-10	-24	-38	-58			
> 100 — 120	+630 +410	+460 +240	+400 +180	+120	+72	+36	+12	0	0	0	0	-17.5	-25	-45	-59	-73	-93			
> 120 — 140	+710 +460	+510 +260	+450 +200	+305	+185	+106	+54	+250	+100	+63	+40	+20	+12	-12	-28	-48	-77			
> 140 — 160	+770 +520	+530 +280	+460 +210	+145	+85	+43	+14	0	0	0	0	-20	-28	-52	-63	-88	-117			
> 160 — 180	+830 +580	+560 +310	+480 +230	+355	+215	+122	+61	+290	+115	+72	+46	+23	+13	-14	-33	-50	-85			
> 180 — 200	+950 +660	+630 +340	+530 +240	+170	+100	+50	+15	0	0	0	0	-23	-33	-60	-79	-90	-125			
> 200 — 225	+1030 +740	+670 +380	+550 +260	+400	+240	+137	+69	+320	+130	+81	+52	+26	+16	-14	-35	-53	-93			
> 225 — 250	+1110 +820	+710 +420	+570 +280	+355	+215	+122	+61	+290	+115	+72	+46	+23	+13	-14	-33	-60	-105			
> 250 — 280	+1240 +920	+800 +480	+620 +300	+170	+100	+50	+15	0	0	0	0	-23	-33	-60	-79	-106	-151			
> 280 — 315	+1370 +1050	+860 +540	+650 +330	+400	+240	+137	+69	+320	+130	+81	+52	+26	+16	-14	-35	-63	-113			
> 315 — 355	+1560 +1200	+960 +600	+720 +360	+170	+100	+50	+15	0	0	0	0	-23	-33	-60	-79	-109	-159			
> 355 — 400	+1710 +1350	+1040 +680	+760 +400	+400	+240	+137	+69	+320	+130	+81	+52	+26	+16	-14	-35	-67	-123			
> 400 — 450	+1900 +1500	+1160 +760	+840 +440	+190	+110	+56	+17	0	0	0	0	-26	-36	-66	-88	-113	-169			
> 450 — 500	+2050 +1650	+1240 +840	+880 +480	+400	+240	+137	+69	+320	+130	+81	+52	+26	+16	-14	-35	-74	-138			
																-126	-190			
																-130	-202			
																-87	-169			
																-144	-226			
																-93	-187			
																-150	-244			
																-103	-209			
																-166	-272			
																-109	-229			
																-172	-282			

Introduction:

Tolerance Grade Chart

جدول 9.2 منطقة التفاوت للأصعدة .

FOR DIAMETER STEPS IN MILLIMETER	ISO -TOLERANCE ZONE FOR SHAFT															VALUES OF DEVIATION IN MICRONS ($1\mu = 0.001 \text{ mm}$)		
	σ_{11}	b_{11}	c_{11}	d_9	e_8	f_7	g_6	h_{11}	h_9	h_7	h_6	js_6	k_6	n_6	p_6	r_6	s_6	
- 3	- 270 - 330	- 140 - 200	- 60 - 120	- 20 - 45	- 14 - 28	- 6 - 16	- 2 - 8	0 - 60	0 - 25	0 - 10	0 - 6	+ 3 - 3	+ 6 0	+ 10 + 4	+ 12 + 6	+ 16 + 10	+ 20 + 14	
> 3 - 6	- 270 - 345	- 140 - 215	- 70 - 145	- 30 - 60	- 20 - 38	- 10 - 22	- 4 - 12	0 - 75	0 - 30	0 - 12	0 - 8	+ 4 - 4	+ 9 + 1	+ 16 + 8	+ 20 + 12	+ 23 + 15	+ 27 + 19	
> 6 - 10	- 280 - 370	- 150 - 240	- 80 - 170	- 40 - 76	- 25 - 47	- 13 - 28	- 5 - 14	0 - 90	0 - 36	0 - 15	0 - 9	+ 4.5 - 4.5	+ 10 + 1	+ 19 + 10	+ 24 + 15	+ 28 + 19	+ 32 + 23	
> 10 - 18	- 290 - 400	- 150 - 260	- 95 - 205	- 50 - 93	- 32 - 59	- 16 - 34	- 6 - 17	0 - 110	0 - 43	0 - 18	0 - 11	+ 5.5 - 5.5	+ 12 + 1	+ 23 + 12	+ 29 + 18	+ 34 + 23	+ 39 + 28	
> 18 - 30	- 300 - 430	- 160 - 290	- 110 - 240	- 65 - 117	- 40 - 73	- 20 - 41	- 7 - 20	0 - 130	0 - 52	0 - 21	0 - 13	+ 6.5 - 6.5	+ 15 + 2	+ 28 + 15	+ 35 + 22	+ 41 + 28	+ 48 + 35	
> 30 - 40	- 310 - 470	- 170 - 330	- 120 - 280	- 80	- 50	- 23	- 9	0	0	0	0	+ 8	+ 18	+ 33	+ 42	+ 50	+ 59	
> 40 - 50	- 320 - 480	- 180 - 340	- 130 - 290	- 142	- 89	- 50	- 25	- 160	- 62	- 25	- 16	- 8	+ 2	+ 17	+ 25	+ 34	+ 42	
> 50 - 65	- 340 - 530	- 190 - 380	- 140 - 330	- 100	- 60	- 30	- 10	0	0	0	0	+ 9.5	+ 21	+ 39	+ 51	+ 60 + 41	+ 72 + 53	
> 65 - 80	- 360 - 550	- 200 - 390	- 150 - 340	- 174	- 106	- 60	- 29	- 190	- 74	- 30	- 19	- 9.5	+ 2	+ 20	+ 32	+ 62 + 43	+ 78 + 59	
> 80 - 100	- 380 - 600	- 220 - 440	- 170 - 390	- 120	- 72	- 36	- 12	0	0	0	0	+ 11	+ 25	+ 45	+ 59	+ 73 + 51	+ 93 + 71	
> 100 - 120	- 410 - 630	- 240 - 460	- 180 - 400	- 207	- 126	- 71	- 34	- 220	- 87	- 35	- 22	- 11	+ 3	+ 23	+ 37	+ 76 + 54	+ 101 + 79	
> 120 - 140	- 460 - 710	- 260 - 510	- 200 - 450	- 145	- 85	- 43	- 14	0	0	0	0	+ 12.5	+ 28	+ 52	+ 66	+ 88 + 63	+ 117 + 92	
> 140 - 160	- 520 - 770	- 280 - 530	- 210 - 460													+ 90 + 65	+ 225 + 100	
> 160 - 180	- 580 - 830	- 310 - 560	- 230 - 480	- 245	- 148	- 83	- 39	- 250	- 100	- 40	- 25	- 12.5	+ 3	+ 27	+ 43	+ 93 + 68	+ 133 + 108	
> 180 - 200	- 660 - 950	- 340 - 630	- 240 - 530	- 170	- 100	- 50	- 15	0	0	0	0	+ 14.5	+ 33	+ 60	+ 76	+ 106 + 77	+ 151 + 122	
> 200 - 225	- 740 - 1030	- 380 - 670	- 260 - 550													+ 109 + 80	+ 159 + 130	
> 225 - 250	- 820 - 1110	- 420 - 710	- 280 - 570	- 285	- 172	- 96	- 44	- 290	- 115	- 46	- 29	- 14.5	+ 4	+ 31	+ 50	+ 113 + 84	+ 169 + 140	
> 250 - 280	- 920 - 1340	- 480 - 800	- 300 - 620	- 190	- 110	- 68	- 17	0	0	0	0	+ 16	+ 36	+ 66	+ 86	+ 126 + 94	+ 190 + 158	
> 280 - 315	- 1050 - 1470	- 520 - 860	- 330 - 650	- 320	- 191	- 108	- 49	- 320	- 130	- 52	- 32	- 16	+ 4	+ 34	+ 56	+ 130 + 98	+ 202 + 170	
> 315 - 355	- 1200 - 1560	- 600 - 960	- 360 - 720	- 210	- 125	- 62	- 18	0	0	0	0	+ 18	+ 40	+ 73	+ 98	+ 144 + 108	+ 226 + 190	
> 355 - 400	- 1350 - 1710	- 680 - 1040	- 400 - 760	- 350	- 214	- 119	- 54	- 360	- 140	- 53	- 36	- 18	+ 4	+ 37	+ 62	+ 150 + 114	+ 244 + 208	
> 400 - 450	- 1500 - 1900	- 710 - 1160	- 440 - 840	- 230	- 135	- 68	- 20	0	0	0	0	+ 20	+ 45	+ 80	+ 108	+ 166 + 126	+ 272 + 232	
> 450 - 500	- 1650 - 2050	- 840 - 1240	- 480 - 880	- 385	- 232	- 131	- 60	- 400	- 155	- 63	- 40	- 20	+ 5	+ 40	+ 68	+ 172 + 132	+ 292 + 252	

101

Specifying Tolerance and Fit:

Example 3:

Find the fit type, max. and min. clearance or transition fit for the following:

30 K7-r6

Basic size	type	Upper deviation	Lower deviation	Max. Dia.	Min. Dia.	Tolerance
30	Hole K7	0.006	-0.015	30.006	29.985	0.021
30	Shaft r6	0.041	0.028	30.041	30.028	0.013

Fit type	Max. Clearance	Min. Clearance	Max. interference	Min. interference
Interference fit	-	-	0.056	0.022

50 JS7-h6
10 N7-p6

