Necessity of Interchangeability in engineering field

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of mass production**
- **outline the meaning of the term,'interchangeability'**
- **state the necessity for the limit system**
- **name the different standards of system of limits and fits.**

Mass production

Mass production means production of a unit, component or part in large numbers.

Advantages of mass production

Time for the manufacture of components is reduced.

The cost of a piece is reduced.

Spare parts can be quickly made available.

Disadvantages of mass production

Special purpose machines are necessary.

Jigs and fixtures are needed.

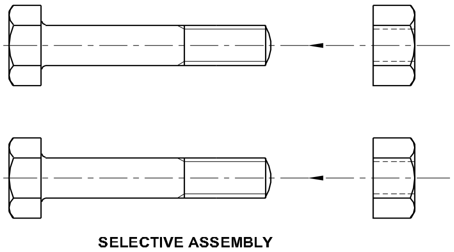
Gauges are to be used instead of conventional precision instruments.

Initial expenditure will be very high.

Selective assembly

The figures illustrate the difference between a selective assembly and a non-selective assembly. It will be seen in (Fig 1) that each nut fits only one bolt. Such an assembly is slow and costly, and maintenance is difficult because spares must be individually manufactured.

Fig 1

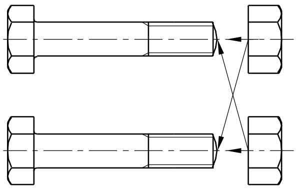


Non-selective assembly

Any nut fits any bolt of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 2)

> **Non-selective assembly provides interchangeability between the components.**

Fig 2



In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some special circumstances, selective assembly is still justified.

Interchangeability

When components are mass-produced, unless they are interchangeable, the purpose of mass production is not fulfilled. By interchangeability, we mean that identical components, manufactured by different personnel under different environments, can be assembled and replaced without any further rectification during the assembly stage, without affecting the functioning of the component when assembled.

Necessity of the limit system

If components are to be interchangeable, they need to be manufactured to the same size which is not possible, when they are mass-produced. Hence, it becomes necessary to permit the operator to deviate by a small margin from the exact size which he is not able to maintain for all the components. At the same time, the deviated size should not affect the quality of the assembly. This sort of dimensioning is known as limit dimensioning.

A system of limits is to be followed as a standard for the limit dimensioning of components.

Various standard systems of limits and fits are followed by different countries based on the ISO (International Standards Organisation) specifications.

> **The system of limits and fits followed in our country is stipulated by the BIS. (Bureau of Indian Standards)**

Other systems of limits and fits

International Standards Organisation (ISO)

British Standard System (BSS)

German Standard (DIN)

The indian standard system of limits & fits - terminology

Objectives: At the end of this lesson you shall be able to
- **state the terms under the BIS system of limits and fits**
- **define each term under the BIS system of limits and fits**.

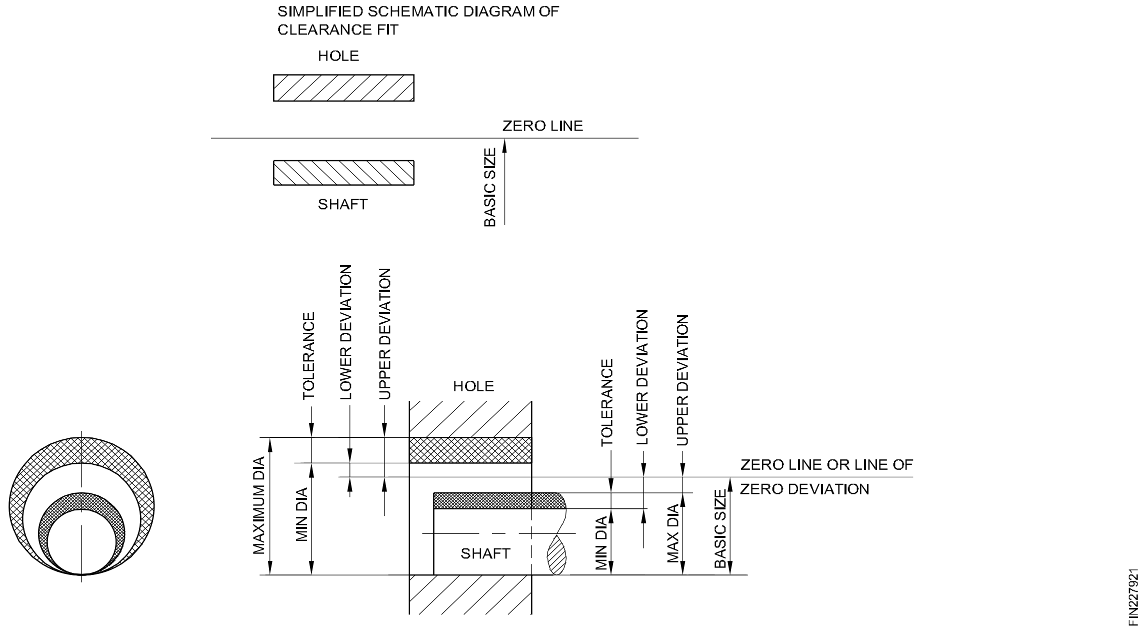
Size

It is a number expressed in a particular unit in the measurement of length.

Basic size

It is the size based on which the dimensional deviations are given. (Fig 1)

Fig 1



Actual size

It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size if the component is to be accepted.

Limits of size

These are the extreme permissible sizes within which the operator is expected to make the component. (Fig 2) (Maximum and minimum limits)

Maximum limit of size

It is the greater of the two limit sizes.(Fig 2) (Table 1)

Minimum limit of size

It is the smaller of the two limits of size. (Fig 2) (Table 1)

Hole

In the BIS system of limits & fits, all internal features of a component including those which are not cylindrical are designated as ` hole'. (Fig 3)

Shaft

In the BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as shaft. (Fig 3)

Fig 2

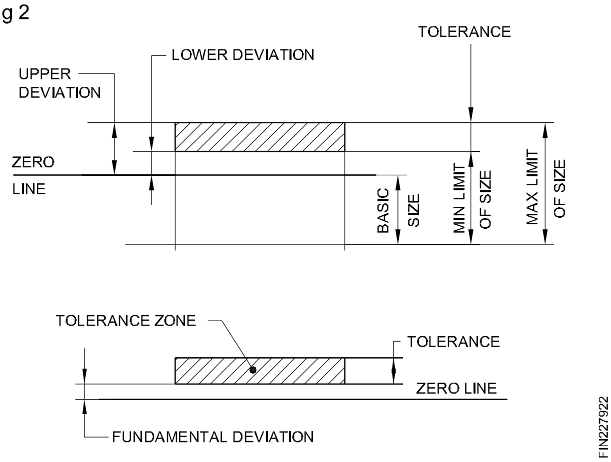


Fig 3

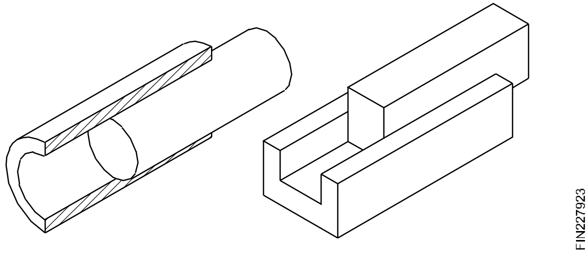


TABLE 1 (Examples)

SL. NO.	SIZE OF COMPONENT	UPPER DEVIATION	LOWER DEVIATION	MAX-LIMIT OF SIZE	MIN-LIMIT OF SIZE
1	$20^{+.008}_{-.005}$	+ 0.008	- 0.005	20.008	19.995
2	$20^{+.028}_{+.007}$	+ 0.028	+ 0.007	20.028	20.007
3	$20^{-.012}_{-.021}$	- 0.012	- 0.021	19.988	19.979

Deviation

It is the algebraic difference between a size, to its corresponding basic size. It may be positive, negative or zero. (Fig 2)

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. (Fig 2) (Table 1)

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size.(Fig 2) (Table 1)

Upper deviation is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size. (Fig 2)

Tolerance

It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign. (Fig 2)

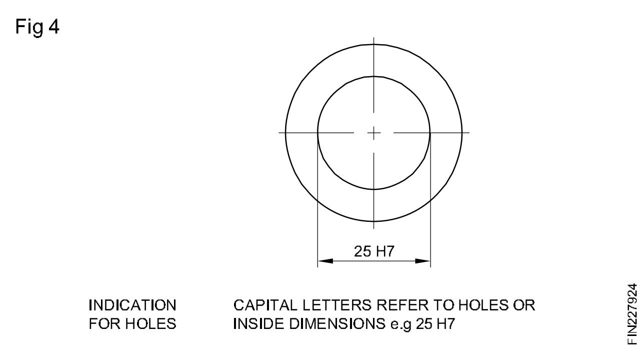
Zero line

In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation. (Figs 1 and 2)

Fundamental deviation

There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e for holes - ABCD....Z excluding I,L,O,Q & W. (Fig 4)

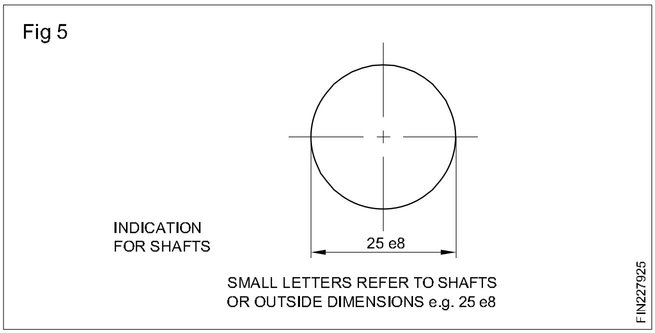
Fig 4



In addition to the above, four sets of letters JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added. (Ref.IS:919 Part II - 1979)

For shafts, the same 25 letter symbols but in small letters are used. (Fig 5)

Fig 5



The position of tolerance zone with respect to the zero line is shown in Figs 6 and 7.

Fig 6

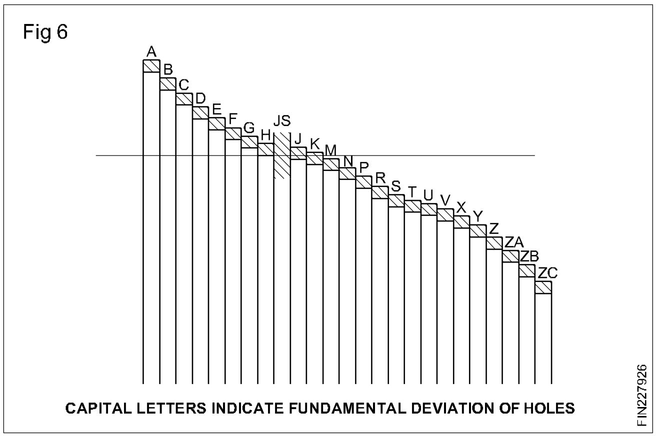
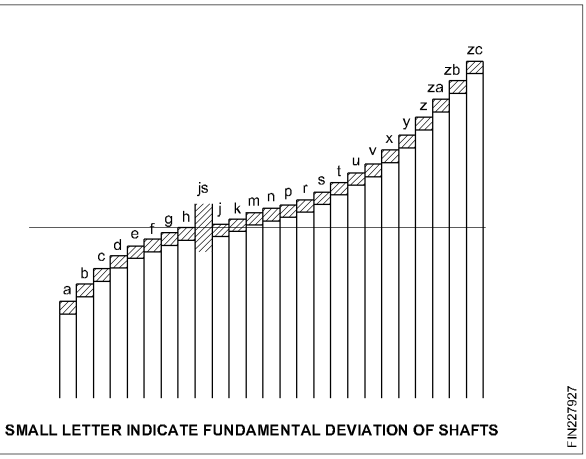


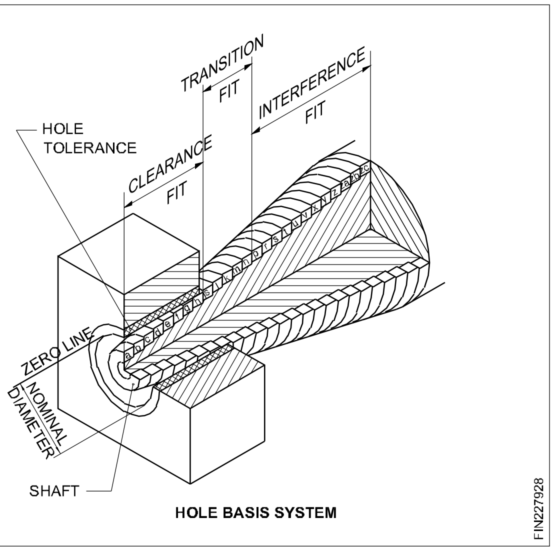
Fig 7



SMALL LETTER INDICATE FUNDAMENTAL DEVIATION OF SHAFTS

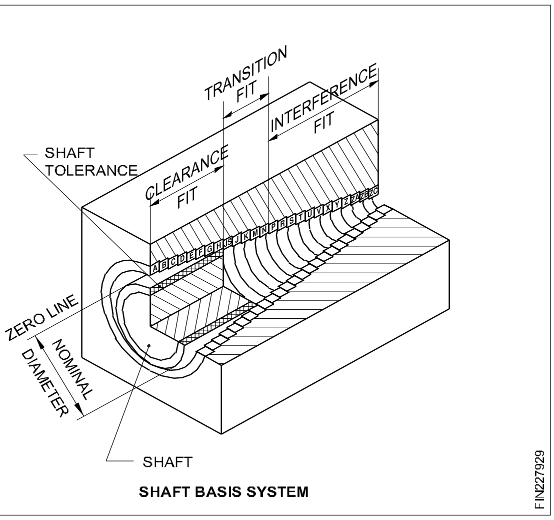
The fundamental deviations are for achieving the different classes of fits. (Figs 8 and 9)

Fig 8



HOLE BASIS SYSTEM

Fig 9

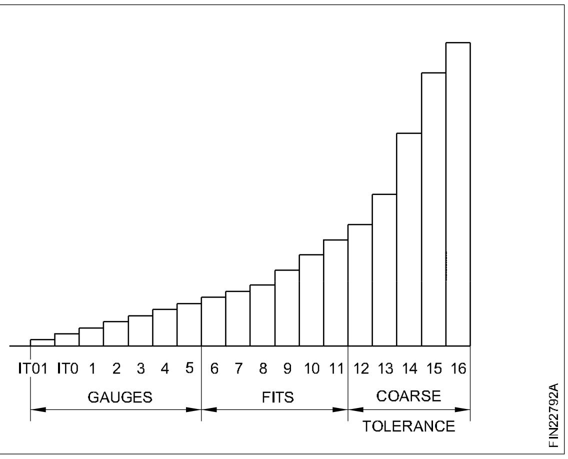


SHAFT BASIS SYSTEM

Fundamental tolerance

This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1....to IT16. (Fig 10) A high number gives a large tolerance zone.

Fig 10



The grade of tolerance refers to the accuracy of manufacture.

In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging up to 500 mm. (Refer to IS 919)

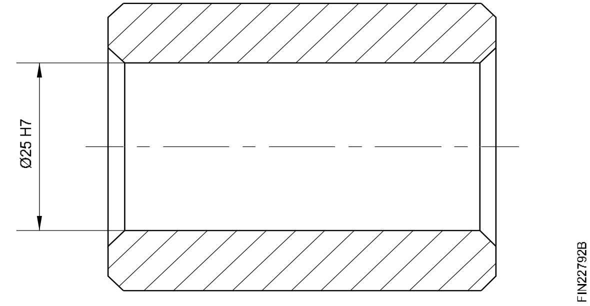
Toleranced size

This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

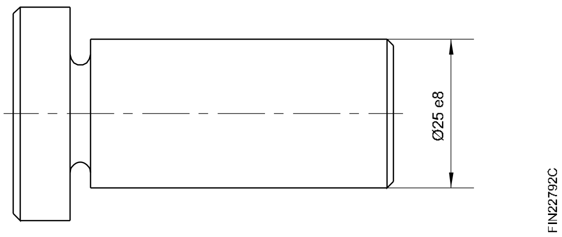
25 H7 - toleranced size of a hole whose basic size is 25. The fundamental deviation is represented by the letter symbol H and the grade of tolerance is represented by the number symbol 7. (Fig 11)

Fig 11



25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol e and the grade of tolerance is represented by the number 8. (Fig 12)

Fig 12



A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Example

In figure 13, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

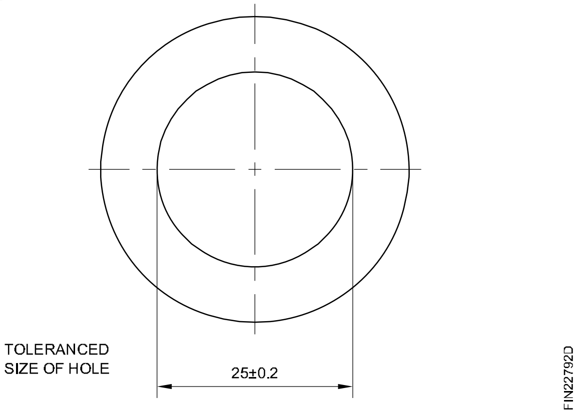
The deviation is mostly given on the drawing with the dimensions.

In the example 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm diameter. (Fig 13) This means that the hole is of acceptable size if its dimension is between

25 + 0.2 = 25.2 mm

or 25 - 0.2 = 24.8 mm.

Fig 13



25.2 mm is known as the maximum limit. (Fig 14)

24.8 mm is known as the minimum limit. (Fig 15)

Fig 14

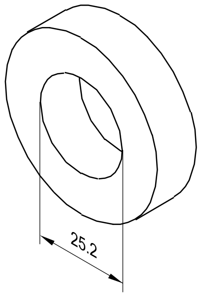
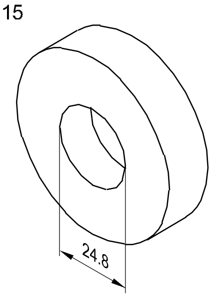
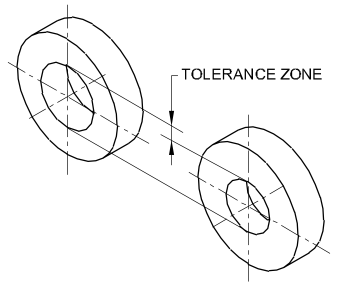


Fig 15



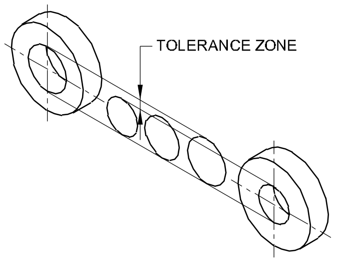
The difference between the maximum and minimum limits is the TOLERANCE. Tolerance here is 0.4 mm. (Fig 16)

Fig 16



All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 17.

Fig 17



As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Fits and their classification as per the Indian Standard

Objectives: At the end of this lesson you shall be able to

- **define 'Fit' as per the Indian Standard**
- **list out the terms used in limits and fits as per the Indian Standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit

A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft,) followed by the symbol for the hole, and by the symbol for the shaft.

Example

30 H7/g6 or 30 H7 - g6 or $30 \frac{H7}{g6}$

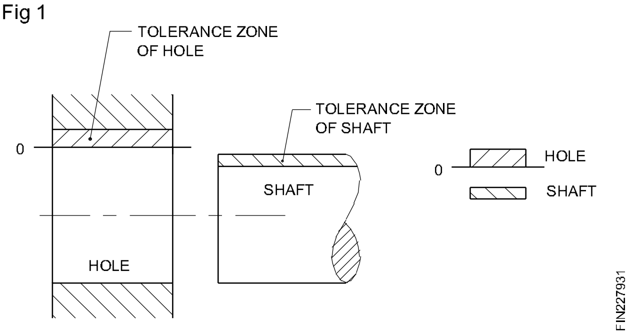
Clearance

In a fit the clearance is the difference between the size of the hole and the size of the shaft which is always positive.

Clearance fit

It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Fig 1



Example 20 H7/g6

With the fit given, we can find the deviations from the chart.

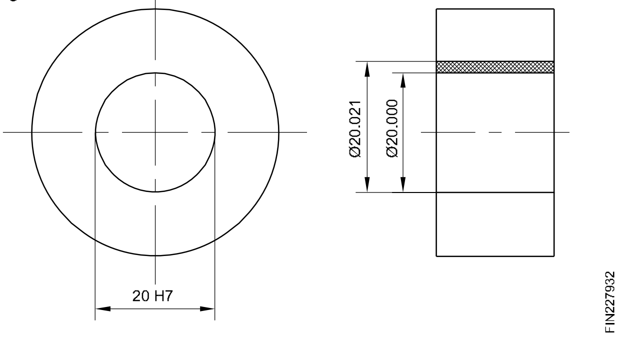
For a hole 20 H7 we find in the table + 21.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

The limits of the hole are 20 + 0.021 = 20.021 mm and 20 + 0 = 20.000mm. (Fig.2)

Fig 2



For a shaft 20 g6 we find in the table – 7

– 20.

So the limits of the shaft are

20 – 0.007 =19.993 mm

and 20 – 0.020 =19.980mm.(Fig .3)

Maximum clearance

In a clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft. (Fig 4)

Fig 3

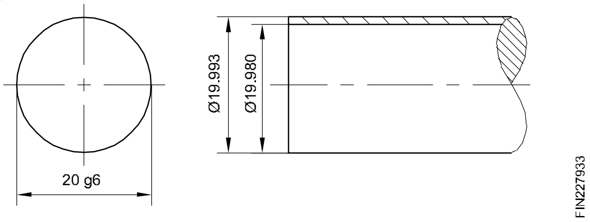
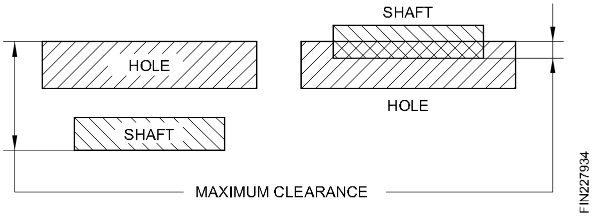


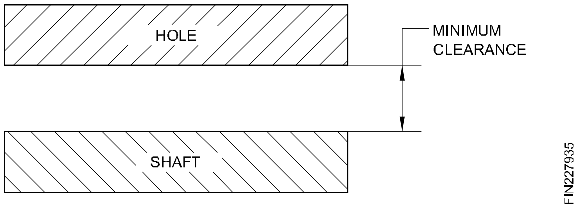
Fig 4



Minimum Clearance

In a clearance fit, it is the difference between the minimum hole and the maximum shaft. (Fig 5)

Fig 5



The minimum clearance is 20.000 - 19.993 = 0.007mm. (Fig 6)

Fig 6

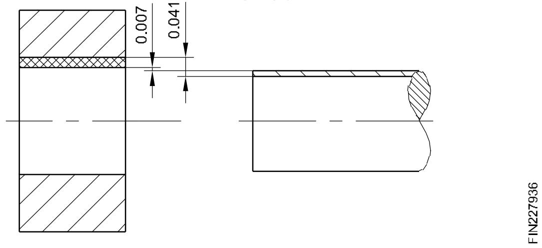
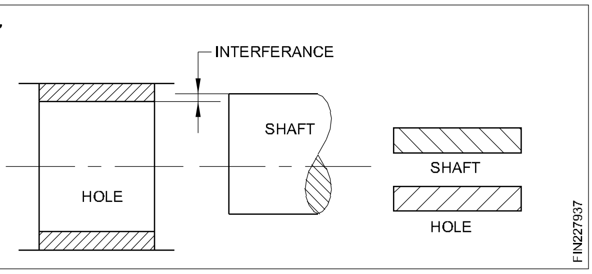


Fig 6(a)

The maximum clearance is 20.021 - 19.980 = 0.041 mm. (Fig 7)

Fig 7



There is always a clearance between the hole and the shaft. This is the clearance fit.

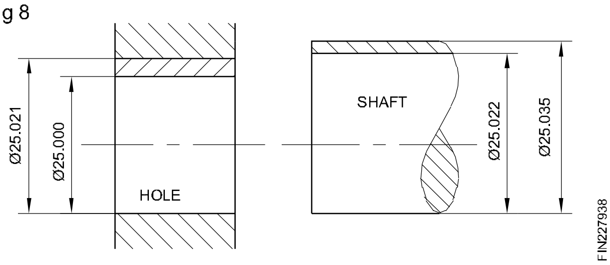
Interference

It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

Interference Fit

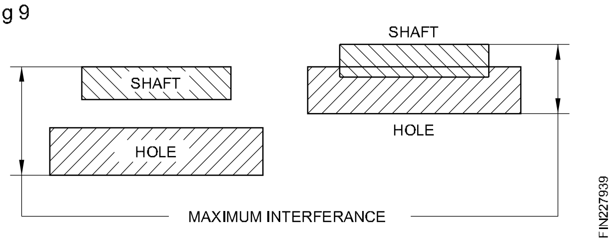
It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 8)

Fig 8



Example: Fit 25 H7/p6 (Fig 9)

Fig 9

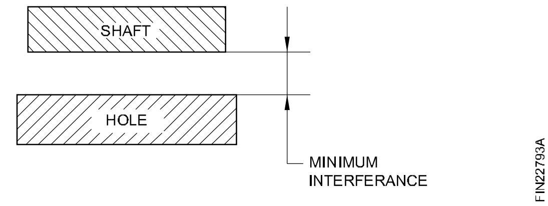


The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.

Maximum interference

In an interference fit or transition fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 10)

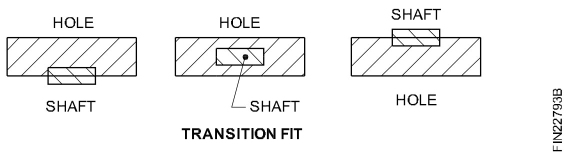
Fig 10



Minimum interference

In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 11)

Fig 11



In the example shown in figure 9

The maximum interference is = 25.035 – 25.000

= **0.035**

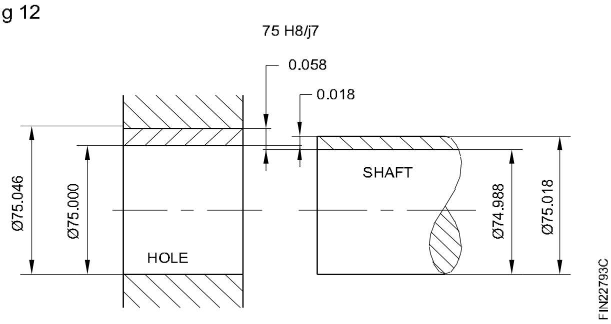
The minimum interference is = 25.022 – 25.021

= 0.001

Transition fit

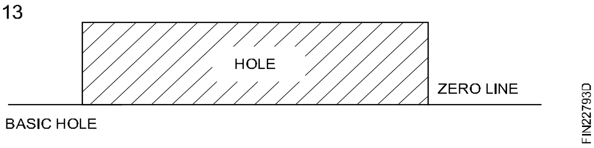
It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 12)

Fig 12



Example Fit 75 H8/j7 (Fig 13)

Fig 13



The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

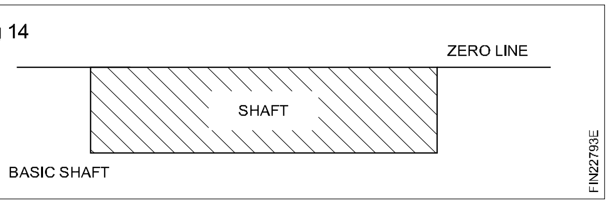
If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference. This is a transition fit because it can result in a clearance fit or an interference fit.

Hole basis system

In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then it is known as the hole basis system.

The fundamental deviation symbol `H' is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole `H' is zero. It is known as `basic hole'. (Fig 14)

Fig 14



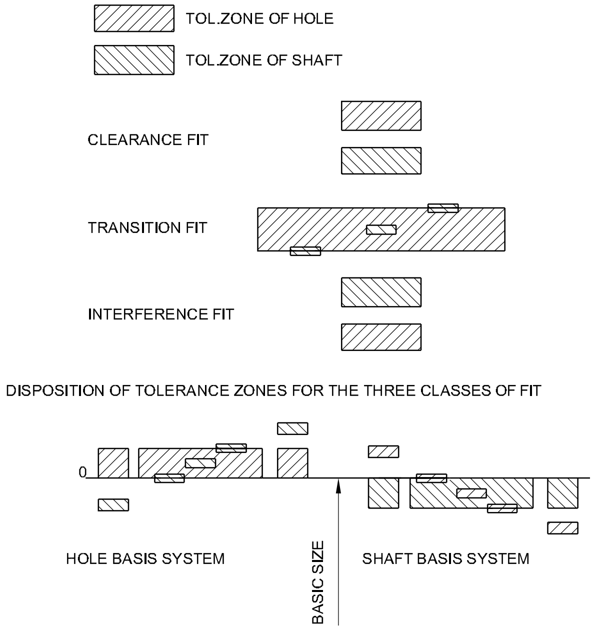
Shaft basis system

In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol `h' is chosen for the shaft when the shaft basis is followed. This is because the upper deviation of the shaft `h' is zero. It is known as `basic shaft'. (Fig 15)

The hole basis system is followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft because it is external, but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard toolings.

The three classes of fits, both under hole basis and shaft basis, are illustrated in (Fig 15).

Fig 15



EXAMPLES ILLUSTRATING THE HOLE BASIS AND SHAFT BASIS SYSTEM

The BIS system of limits and fits- reading the standard chart

Objective: At the end of this lesson you shall be able to
- **refer to the standard limit system chart and determine the limits of sizes.**

The standard chart covers sizes upto 500 mm (I.S. 919 of 1963) for both holes and shafts. It specifies the upper and lower deviations for a certain range of sizes for all combinations of the 25 fundamental deviations, and 18 fundamental tolerances.

The upper deviation of the hole is denoted as ES and the lower deviation of the hole is denoted as E I. The upper deviation of the shaft is denoted as **es** and the lower deviation of the shaft is denoted as **ei.**

"ES is expanded as ECART SUPERIEUR and "EI" as ECART INFERIEUR.

Determining the limits from the chart

Note whether it is an internal measurement or an external measurement.

Note the basic size.

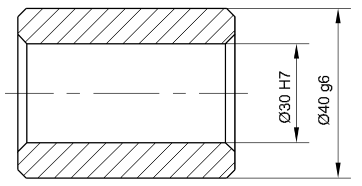
Note the combination of the fundamental deviation and the grade of tolerance.

Then refer to the chart and note the upper and lower deviations which are given in microns, with the sign. Accordingly add or subtract from the basic size and determine the limits of size of the components.

Example

30 H7 (Fig 1)

Fig 1



It is an internal measurement. So we must refer to the chart for 'holes'.

The basic size is 30 mm. So see the range 30 to 40.

Look for ES, and EI values in microns for H7 combination for 30 mm basic size.

It is given as

Therefore, the maximum limit of the hole is 30 + 0.025 = 30.025mm.

The minimum limit of the hole is 30 + 0.000 = 30.000mm.

Refer to the chart and note the values of 40 g6.

The table for tolerance zones and limits as per IS 2709 is attached.

British standard limits and fits BS 4500: 1969

International Tolerance Grades (IT)

The specific tolerance for a particular IT grade is calculated via the following formula:

$$T = 10^{0.2 \times (ITG - 1)} . (0.45 \times \sqrt[3]{D} + 0.001 \times D)$$

T is the tolerance in micrometres [μ m]

D is the geometric mean dimension in millimeters [mm]

ITG is the IT Grade, a positive integer.

NOMINAL (BASIC) SIZES (INCHES)		INTERNATIONAL TOLERANCE GRADES OVER UP TO INCL.									
OVER	UP TO INCL	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13
0	0.12	0.12	0.15	0.25	0.4	0.6	1.0	1.6	2.5	4	6
0.12	0.24	0.15	0.20	0.3	0.5	0.7	1.2	1.8	3.0	5	7
0.24	0.40	0.15	0.25	0.4	0.6	0.9	1.4	2.2	3.5	6	9
0.40	0.71	0.2	0.3	0.4	0.7	1.0	1.6	2.8	4.0	7	10
0.71	1.19	0.25	0.4	0.5	0.8	1.2	2.0	3.5	5.0	8	12
1.19	1.97	0.3	0.4	0.6	1.0	1.6	2.5	4.0	6	10	16
1.97	3.15	0.3	0.5	0.7	1.2	1.8	3.0	4.5	7	12	18
3.15	4.73	0.4	0.6	0.9	1.4	2.2	3.5	5	9	14	22
4.73	7.09	0.5	0.7	1.0	1.6	2.5	4.0	6	10	16	25
7.09	9.85	0.6	0.8	1.2	1.8	2.8	4.5	7	12	18	28
9.85	12.41	0.6	0.9	1.2	2.0	3.0	5.0	8	12	20	30
12.41	15.75	0.7	1.0	1.4	2.2	3.5	6	9	14	22	35
15.75	19.69	0.8	1.0	1.63	2.5	4	6	10	16	25	40
19.69	30.09	0.9	1.2	2.0	3	5	8	12	20	30	50
30.09	41.49	1.0	1.6	2.5	4	6	10	16	25	40	60
41.49	56.19	1.2	2.0	3	5	8	12	20	30	50	80
56.19	76.39	1.6	2.5	4	6	10	16	25	40	60	100
76.39	100.9	2.0	3	5	8	12	20	30	50	80	125
100.9	131.9	2.5	4	6	10	16	25	40	60	100	160
131.9	171.9	3	5	8	12	20	30	50	80	125	200
171.9	200	4	6	10	16	25	40	60	100	160	250

Tolerances in Thousandths of an Inch (0.001)

Table 1 for Tolerance Zones & Limits (Dimensions in µm)

NOMINAL SIZE RANGE mm	s6	r6	p6	n6	k6	js6	h6	h7	h9	h11	g6	f7	e8	d9	c11	b11	a11	S7	R7	P7	N7	K7	JS7	H7	H8	H9	H11	G7	F8	E9	D10	C11	B11	A11
From 1 up to 3	+20 +14	+16 +10	+12 +6	+10 +4	+6 0	+3 -3	0 -6	0 -10	0 -25	0 -60	-2 -8	-6 -16	-14 -28	-20 -45	-60 -120	-140 -200	-270 -330	-14 -24	-10 -20	-6 -16	-4 -14	0 -10	+5 -5	+10 0	+14 0	+25 0	+60 0	+12 +2	+20 +6	+39 +14	+60 +20	+120 +60	+200 +140	+330 +270
Over 3 up to 6	+27 +19	+23 +15	+20 +12	+16 +8	+9 +1	+4 -4	0 -8	0 -12	0 -30	0 -75	-4 -12	-10 -22	-20 -38	-30 -60	-70 -145	-140 -215	-270 -345	-15 -27	-11 -23	-8 -20	-4 -16	+3 -9	+6 -6	+12 0	+18 0	+30 0	+75 0	+16 +4	+28 +10	+50 +20	+78 +30	+145 +70	+215 +140	+345 +270
Over 6 up to 10	+32 +23	+28 +19	+24 +15	+19 +10	+10 +1	+4.5 -4.5	0 -9	0 -15	0 -36	0 -90	-5 -14	-13 -28	-25 -47	-40 -76	-80 -170	-150 -240	-280 -370	-17 -32	-13 -28	-9 -24	-4 -19	+5 -10	+7.5 -7.5	+15 0	+22 0	+36 0	+90 0	+20 +5	+35 +13	+61 +25	+98 +40	+170 +80	+240 +150	+370 +280
Over 10 up to 14	+39 +28	+34 +23	+29 +18	+23 +12	+12 +1	+5.5 -5.5	0 -11	0 -18	0 -43	0 -110	-6 -17	-16 -34	-32 -59	-50 -93	-95 -205	-150 -260	-290 -400	-21 -39	-16 -34	-11 -29	-5 -23	+6 -12	+9 -9	+18 0	+27 0	+43 0	+110 0	+24 +6	+43 +16	+75 +32	+120 +50	+205 +95	+260 +150	+400 +290
Over 14 up to 18																																		
Over 18 up to 24	+48 +35	+41 +28	+35 +22	+28 +15	+15 +2	+6.5 -6.5	0 -13	0 -21	0 -52	0 -130	-7 -20	-20 -41	-40 -73	-65 -117	-110 -240	-160 -290	-300 -430	-27 -48	-20 -41	-14 -35	-7 -28	+6 -15	+10.5 -10.5	+21 0	+33 0	+52 0	+130 0	+28 +7	+53 +20	+92 +40	+149 +65	+240 +110	+290 +160	+430 +300
Over 24 up to 30																																		
Over 30 up to 40	+59 +43	+50 +34	+42 +26	+33 +17	+18 +2	+8 -8	0 -16	0 -25	0 -62	0 -160	-9 -25	-25 -50	-50 -89	-80 -142	-120 -280	-170 -330	-310 -470	-34 -59	-25 -50	-17 -42	-8 -33	+7 -18	+12.5 -12.5	+25 0	+39 0	+62 0	+160 0	+34 +9	+64 +25	+112 +50	+180 +80	+280 +120	+330 +170	+470 +310
Over 40 up to 50															-130 -290	-180 -340	-320 -480															+290 +130	+340 +180	+480 +320
Over 50 up to 65	+72 +53	+60 +41	+51 +32	+39 +20	+21 +2	+9.5 -9.5	0 -19	0 -30	0 -74	0 -190	-10 -29	-30 -60	-60 -106	-100 -174	-140 -330	-190 -380	-340 -530	-42 -72	-30 -60	-21 -51	-9 -39	+9 -21	+15 -15	+30 0	+46 0	+74 0	+190 0	+40 +10	+76 +30	+134 +60	+220 +100	+330 +140	+380 +190	+530 +340
Over 65 up to 80	+78 +59	+62 +43													-150 -340	-200 -390	-360 -550	-48 -78	-32 -62													+340 +150	+390 +200	+550 +360
Over 80 up to 100	+93 +71	+73 +51	+59 +37	+45 +23	+25 +3	+11 -11	0 -22	0 -35	0 -87	0 -220	-12 -34	-36 -71	-72 -126	-120 -207	-170 -390	-220 -440	-380 -600	-58 -93	-38 -73	-24 -59	-10 -45	+10 -25	+17.5 -17.5	+35 0	+54 0	+87 0	+220 0	+47 +12	+90 +36	+159 +72	+260 +120	+390 +170	+440 +220	+600 +380
Over 100 up to 120	+101 +79	+76 +54													-180 -400	-240 -460	-410 -630	-66 -101	-41 -76													+400 +180	+460 +240	+630 +410
Over 120 up to 140	+117 +92	+88 +63	+68 +43	+52 +27	+28 +3	+12.5 -12.5	0 -25	0 -40	0 -100	0 -250	-14 -39	-43 -83	-85 -148	-145 -245	-200 -450	-260 -510	-460 -710	-77 -117	-48 -88	-28 -68	-12 -52	+12 -28	+20 -20	+40 0	+63 0	+100 0	+250 0	+54 +14	+106 +43	+185 +85	+305 +145	+450 +200	+510 +260	+710 +460
Over 140 up to 160	+125 +100	+90 +65													-210 -460	-280 -530	-520 -770	-85 -125	-50 -90													+460 +210	+530 +280	+770 +520
Over 160 up to 180	+133 +108	+93 +68													-230 -480	-310 -560	-580 -830	-93 -133	-53 -93													+480 +230	+560 +310	+830 +580
Over 180 up to 200	+151 +122	+106 +77	+79 +50	+60 +31	+33 +4	+14.5 -14.5	0 -29	0 -46	0 -115	0 -290	-15 -44	-50 -96	-100 -172	-170 -285	-240 -530	-340 -630	-660 -950	-105 -151	-60 -106	-33 -79	-14 -60	+13 -33	+23 -23	+46 0	+72 0	+115 0	+290 0	+61 +15	+122 +50	+215 +100	+355 +170	+530 +240	+630 +340	+950 +660
Over 200 up to 225	+159 +130	+109 +80													-260 -550	-380 -670	-740 -1030	-113 -159	-63 -109													+550 +260	+670 +380	+1030 +740
Over 225 up to 250	+169 +140	+113 +84													-280 -570	-420 -710	-820 -1110	-123 -169	-67 -113													+570 +280	+710 +420	+1110 +820
Over 250 up to 280	+190 +158	+126 +94	+88 +56	+66 +34	+36 +4	+16 -16	0 -32	0 -52	0 -130	0 -320	-17 -49	-56 -108	-110 -191	-190 -320	-300 -620	-480 -800	-920 -1240	-138 -190	-74 -126	-36 -88	-14 -66	+16 -36	+26 -26	+52 0	+81 0	+130 0	+320 0	+69 +17	+137 +56	+240 +110	+400 +190	+620 +300	+800 +480	+1240 +920
Over 280 up to 315	+202 +170	+130 +98													-330 -650	-540 -860	-1050 -1370	-150 -202	-78 -130													+650 +330	+860 +540	+1370 +1050
Over 315 up to 355	+226 +190	+144 +108	+98 +62	+73 +37	+40 +4	+18 -18	0 -36	0 -57	0 -140	0 -360	-18 -54	-62 -119	-125 -214	-210 -350	-360 -720	-600 -960	-1200 -1560	-169 -226	-87 -144	-41 -98	-16 -73	+17 -40	+28.5 -28.5	+57 0	+89 0	+140 0	+360 0	+75 +18	+151 +62	+265 +125	+440 +210	+720 +360	+960 +600	+1500 +1200
Over 355 up to 400	+244 +208	+150 +114													-400 -760	-680 -1040	-1350 -1710	-187 -244	-93 -150													+760 +400	+1040 +680	+1710 +1350
Over 400 up to 450	+272 +232	+166 +126	+108 +68	+80 +40	+45 +5	+20 -20	0 -40	0 -63	0 -155	0 -400	-20 -60	-68 -131	-135 -232	-230 -385	-440 -840	-760 -1160	-1500 -1900	-209 -272	-103 -166	-45 -108	-17 -80	+18 -45	+31.5 -31.5	+63 0	+97 0	+155 0	+400 0	+83 +20	+165 +68	+290 +135	+480 +230	+840 +440	+1160 +760	+1900 +1500
Over 450 up to 500	+292 +252	+172 +132													-480 -880	-840 -1240	-1650 -2050	-229 -292	-109 -172													+880 +480	+1240 +840	+2050 +1650