Computer Aided Machine Drawing

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Limits and tolerance

The manufacture of interchangeable parts require precision.

Precision is the degree of accuracy to ensure the functioning of a part as intended.

However, experience shows that it is impossible to make parts economically to the exact dimensions. This may be due to,

(*i*) inaccuracies of machines and tools (*Machine factor*),
(*ii*) inaccuracies in measurements and setting the work to the tool (*Human factor*), and
(*iii*) material requirements (*material factor*).

- The workman, therefore, must be given some allowable margin so that he can produce an economical part.
- The dimensions of which will lie between two acceptable limits, a maximum and a minimum.

Limit system

Following are some of the terms used in the limit system :

- *Tolerance*

- The permissible variation of a size is called tolerance.
- It is the difference between the maximum and minimum permissible limits of the given size (difference between upper and lower limits).
- If the variation is provided on one side of the basic size, it is termed as *unilateral tolerance*.
- Similarly, if the variation is provided on both sides of the basic size, it is known as *bilateral tolerance*.

Limit system

Following are some of the terms used in the limit system :

- *Limits*

- The two extreme permissible sizes between which the actual size is contained are called limits.

- The maximum size is called the *upper limit* and the *minimum size* is called the lower limit.

Limit system

Following are some of the terms used in the limit system :

- *Deviation*

It is the algebraic difference between a size (actual, maximum, etc.) and the corresponding *basic size* (the amount by which dimension differ from the zero line).

Limit system

Following are some of the terms used in the limit system :

- *Upper Deviation*

It is the algebraic difference between the *maximum limit* of a size and the corresponding *basic size*.

Limit system

Following are some of the terms used in the limit system :

- *Lower Deviation*

It is the algebraic difference between the *minimum limit* of the size and the corresponding *basic size*

Limit system

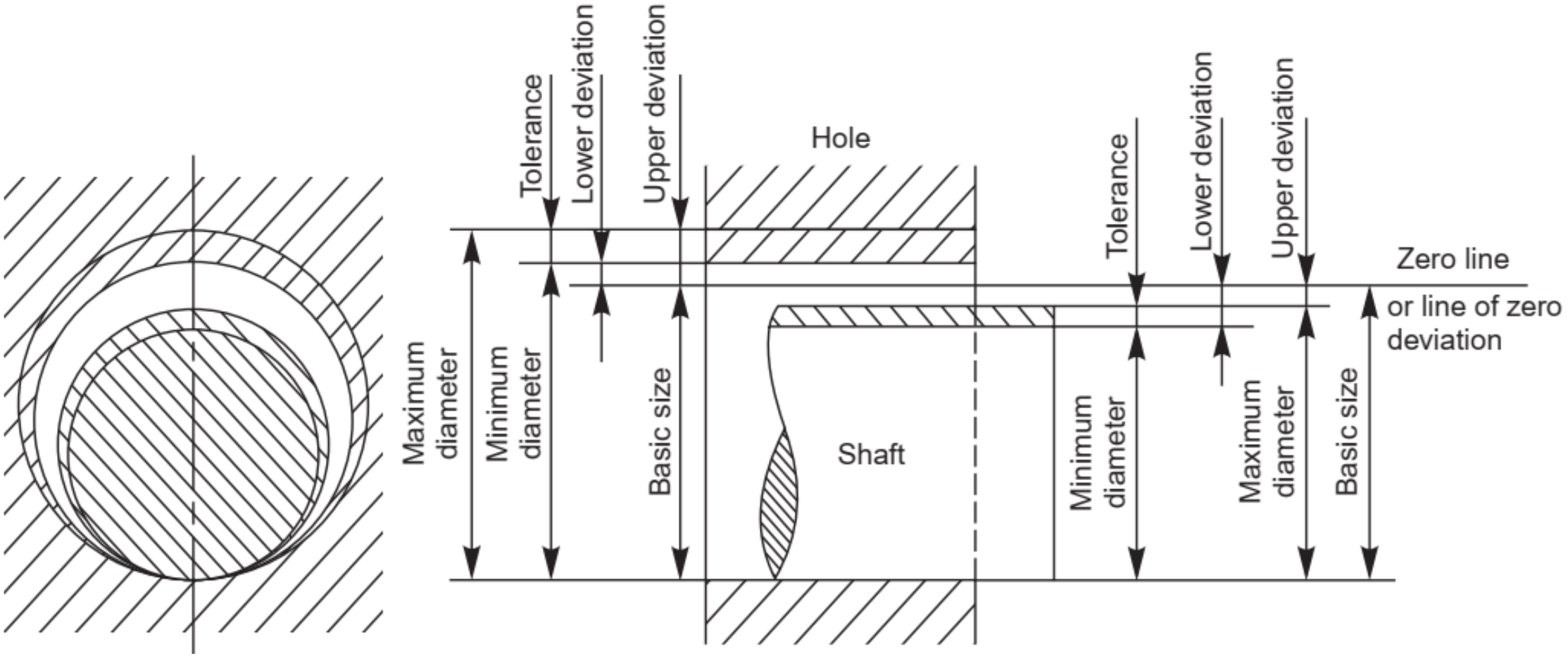
Following are some of the terms used in the limit system :

- *Basic size (nominal size)*

- It is determined from design calculations.
- If the strength and stiffness requirements need a 50mm diameter shaft,

- Then 50mm is the basic shaft size.
- If it has to fit into a hole, then 50 mm is the basic size of the hole

Limit system



Tolerance

In this chapter we concentrates on dimensional tolerance that controls a dimensional feature such as length and diameter and it is usually bounded by upper and lower limits.

It has two types:

- Unilateral tolerance (one side)

- Bi-lateral tolerance (two sides)

The tolerance should be selected to optimize the cost without affecting a part job.

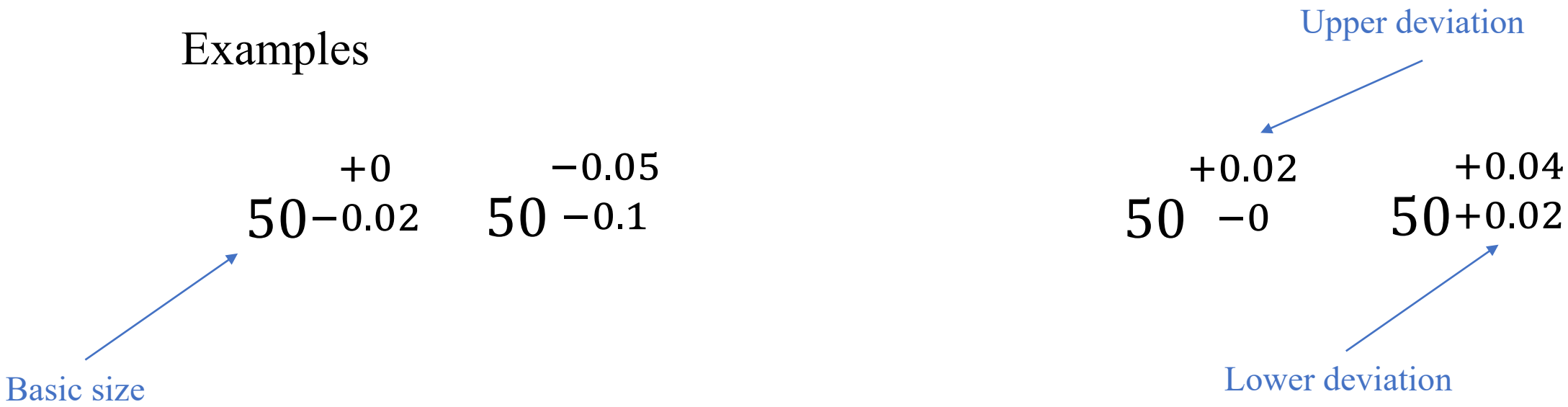
Tolerance

Unilateral tolerance (one side)

The tolerance zone always lie above or below zero line.

Examples

$50^{+0}_{-0.02}$ $50^{-0.05}_{-0.1}$



Tolerance

Bilateral tolerance (two sides)

The tolerance zone lies above and below the zero line. It is a combination between +ve and –ve deviation.

Examples

$$50^{+0.02}_{-0.02}$$

$$50\ ^{+0.05}_{-0.1}$$

Upper limit is 50.02
Lower limit is 49.98

Fundamental Tolerance

Defines the position of tolerance zone in relation to the zero line (basic size).
There are 25 types of fundamental tolerances:

Holes	Shafts
A, B, C, D, E, F, G, H, Js, J, K, M, N, P, R, S, T, U, V, X, Y, Z, Za, Zb, Zc	a, b, c, d, e, f, g, h, js, j, k, m, n, p, r, s, t, u, v, x, y, z, za, zb, zc
Excluded letters I, L,O, Q, W	*Excluded letters* i, l,o, q, w

Fit

Is the degree of tightness between two mating parts.

It is classified into three categories:

- Clearance fit
- Transition fit, and
- Interference fit

Fit

- *Clearance fit:*

The upper limit of shaft is less than the lower limit of hole. The tolerance zone of both shaft and hole allows a clearance between them.

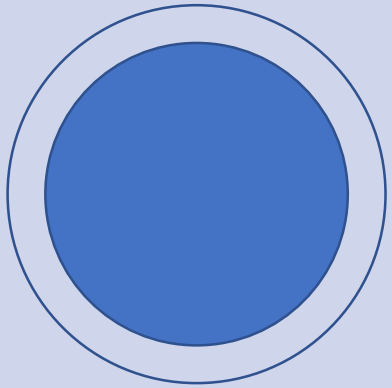
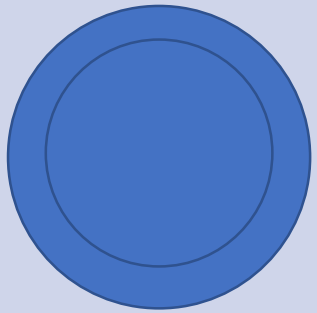
- *Interference fit:*

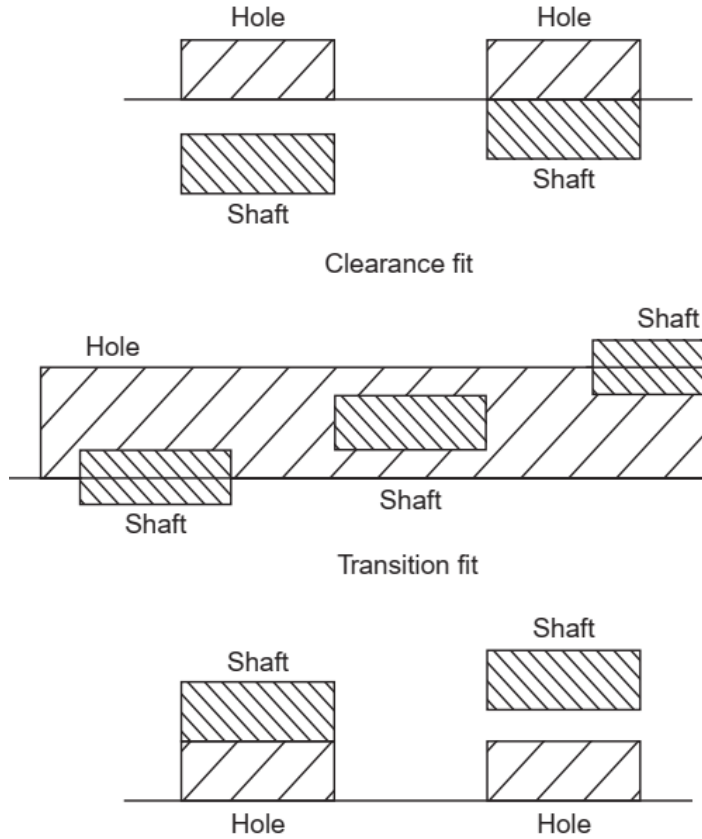
Upper limit if hole is less than lower limit of shaft. The tolerance zone between shaft and hole allows interference between them.

- *Transition fit:*

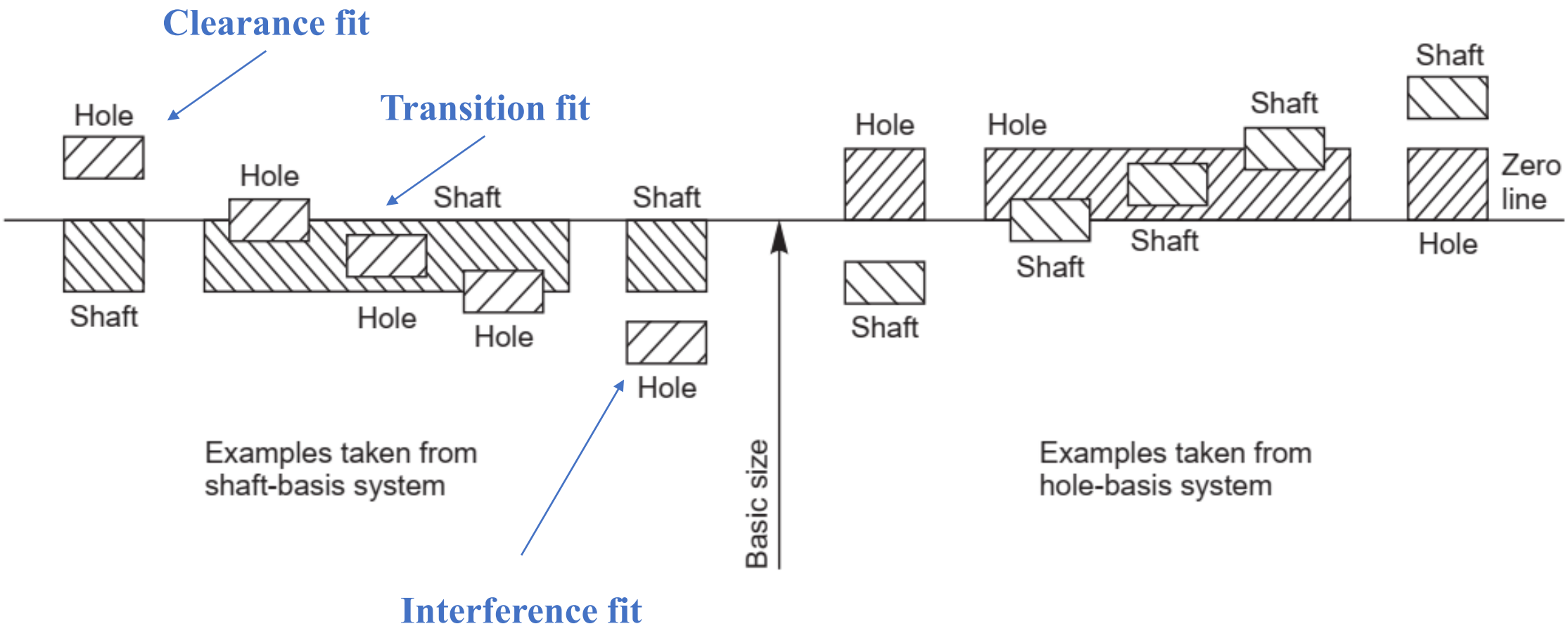
Tolerance zone of hole overlapping the tolerance zone of shaft.

Fit

Clearance Fit	Interference Fit	Transition Fit
		There is a common zone between the hole and shaft tolerances, so it can result in clearance or interference fit.

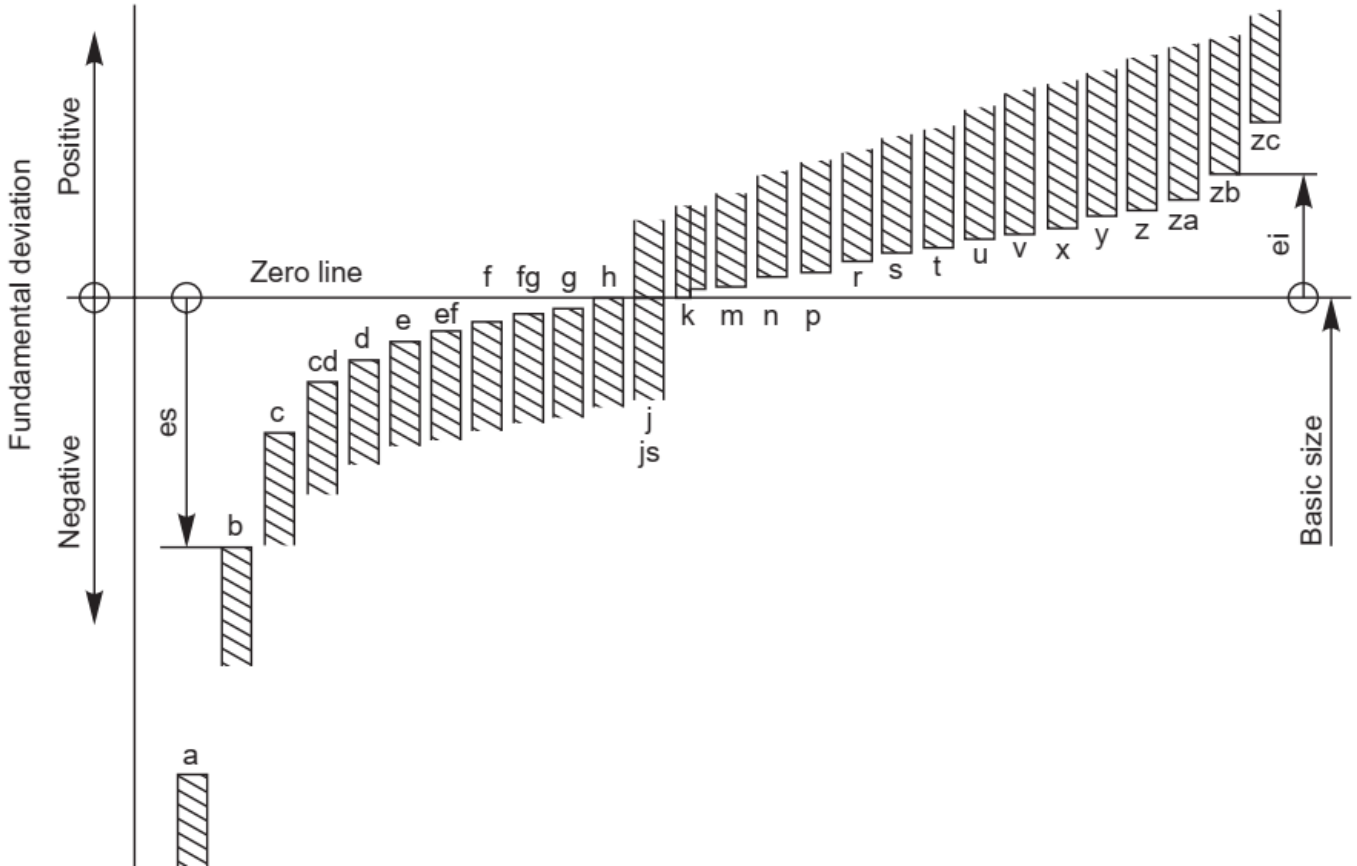


Shaft basis Vs hole basis systems



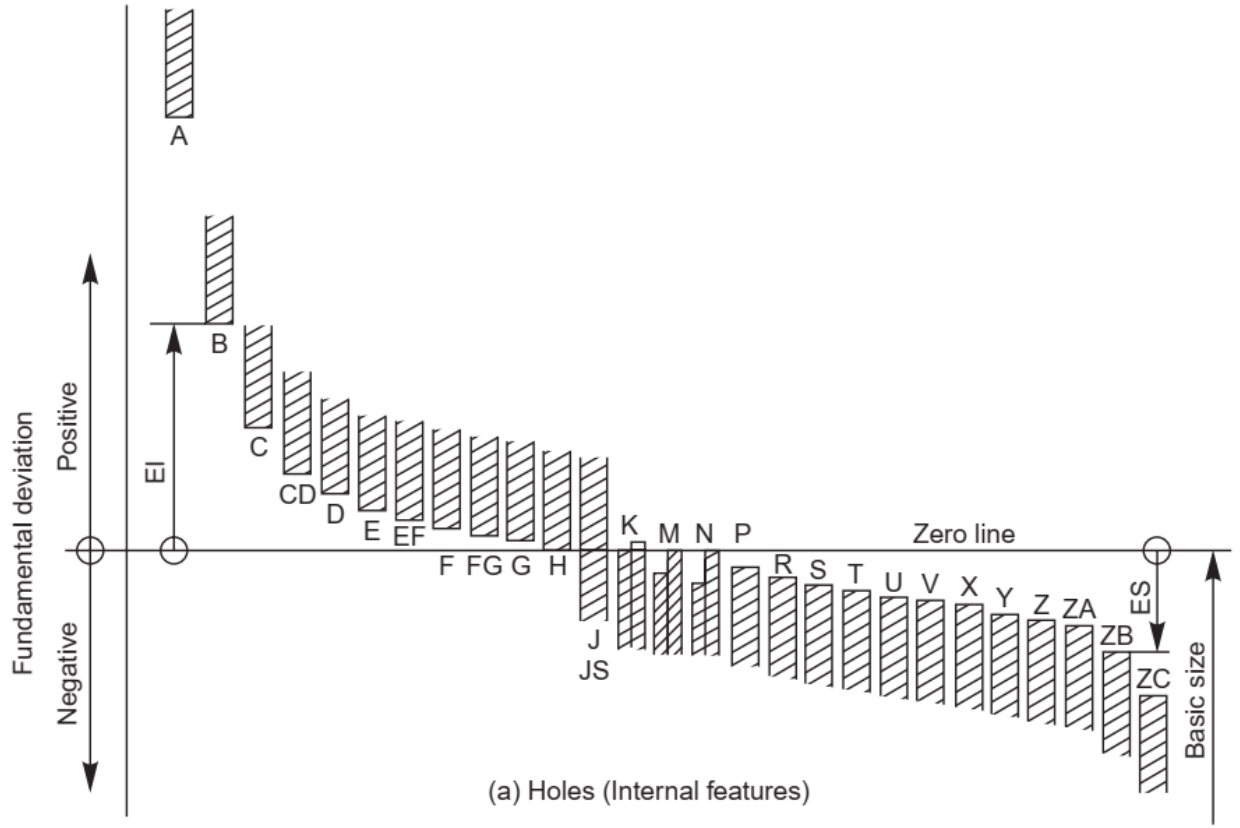
Shaft basis Vs hole basis systems

In shaft basis system of limits and fits fundamental deviation of shaft always will be *h*



Shaft basis Vs hole basis systems

In hole basis system of limits and fits fundamental deviation of hole always will be *H*



Limits and fits interpretation

$50\ H6\ g7$

50 – basic size/ nominal size
H – the fundamental tolerance for hole
6 – hole tolerance grade
g – the fundamental tolerance for shaft
7 – shaft tolerance grade

The H fundamental tolerance for hole refers to hole basis system

Limits and fits interpretation

$50\ H6\ g7$

mm

SIZE		H16	H15	H14	H13	H12	H11	H10	H9	H8	H7	H6	H5	H4	H3	H2	H1
OVER	0	0.600	0.400	0.250	0.140	0.100	0.060	0.040	0.025	0.014	0.010	0.006	0.004	0.003	0.002	0.001	0.0008
TO	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	3	0.750	0.480	0.300	0.180	0.120	0.075	0.048	0.030	0.018	0.012	0.008	0.005	0.004	0.003	0.002	0.0010
TO	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	6	0.900	0.580	0.360	0.220	0.150	0.090	0.058	0.036	0.022	0.015	0.009	0.006	0.004	0.003	0.002	0.0010
TO	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	10	1.100	0.700	0.430	0.270	0.180	0.110	0.070	0.043	0.027	0.018	0.011	0.008	0.005	0.003	0.002	0.0012
TO	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	14	1.100	0.700	0.430	0.270	0.180	0.110	0.070	0.043	0.027	0.018	0.011	0.008	0.005	0.003	0.002	0.0012
TO	18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	18	1.300	0.840	0.520	0.330	0.210	0.130	0.084	0.052	0.033	0.021	0.013	0.009	0.006	0.004	0.003	0.0015
TO	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	24	1.300	0.840	0.520	0.330	0.210	0.130	0.084	0.052	0.033	0.021	0.013	0.009	0.006	0.004	0.003	0.0015
TO	30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	30	1.600	1.000	0.620	0.390	0.250	0.160	0.100	0.062	0.039	0.025	0.016	0.011	0.007	0.004	0.003	0.0015
TO	40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	40	1.600	1.000	0.620	0.390	0.250	0.160	0.100	0.062	0.039	0.025	0.016	0.011	0.007	0.004	0.003	0.0015
TO	50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
OVER	50	1.900	1.200	0.740	0.460	0.300	0.190	0.120	0.074	0.046	0.030	0.019	0.013	0.008	0.005	0.003	0.0020
TO	65	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000

Limits and fits interpretation

$50\ H6\ g7$

SIZE		g9	g8	g7
OVER	0	-0.002	-0.002	-0.002
TO	3	-0.027	-0.016	-0.012
OVER	3	-0.004	-0.004	-0.004
TO	6	-0.034	-0.022	-0.016
OVER	6	-0.005	-0.005	-0.005
TO	10	-0.041	-0.027	-0.020
OVER	10	-0.006	-0.006	-0.006
TO	14	-0.049	-0.033	-0.024
OVER	14	-0.006	-0.006	-0.006
TO	18	-0.049	-0.033	-0.024
OVER	18	-0.007	-0.007	-0.007
TO	24	-0.059	-0.040	-0.028
OVER	24	-0.007	-0.007	-0.007
TO	30	-0.059	-0.040	-0.028
OVER	30	-0.009	-0.009	-0.009
TO	40	-0.071	-0.048	-0.034
OVER	40	-0.009	-0.009	-0.009
TO	50	-0.071	-0.048	-0.034
OVER	50	-0.010	-0.010	-0.010
TO	65	-0.084	-0.056	-0.040

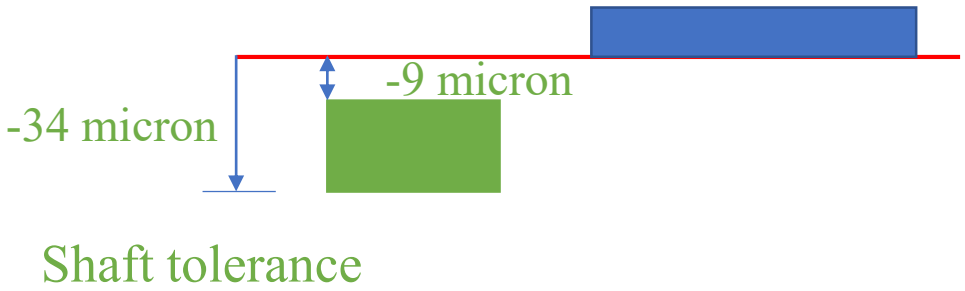
Limits and fits interpretation

$50\ H6\ g7$

+ve

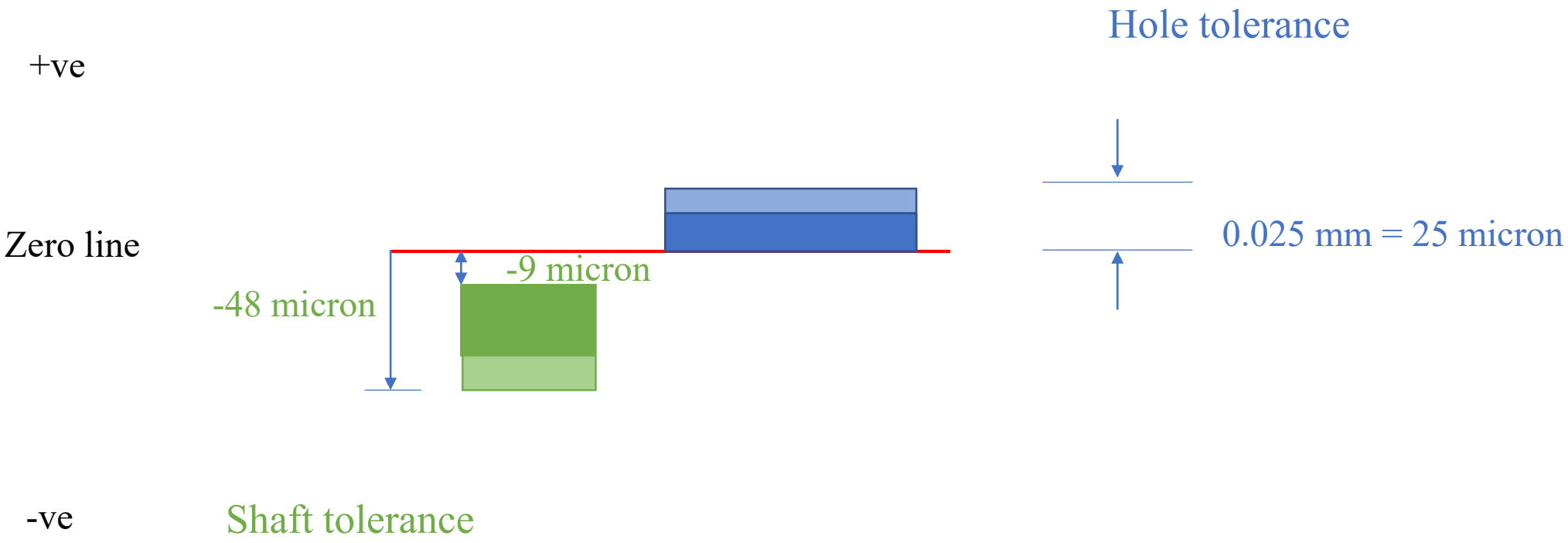
Zero line

-ve



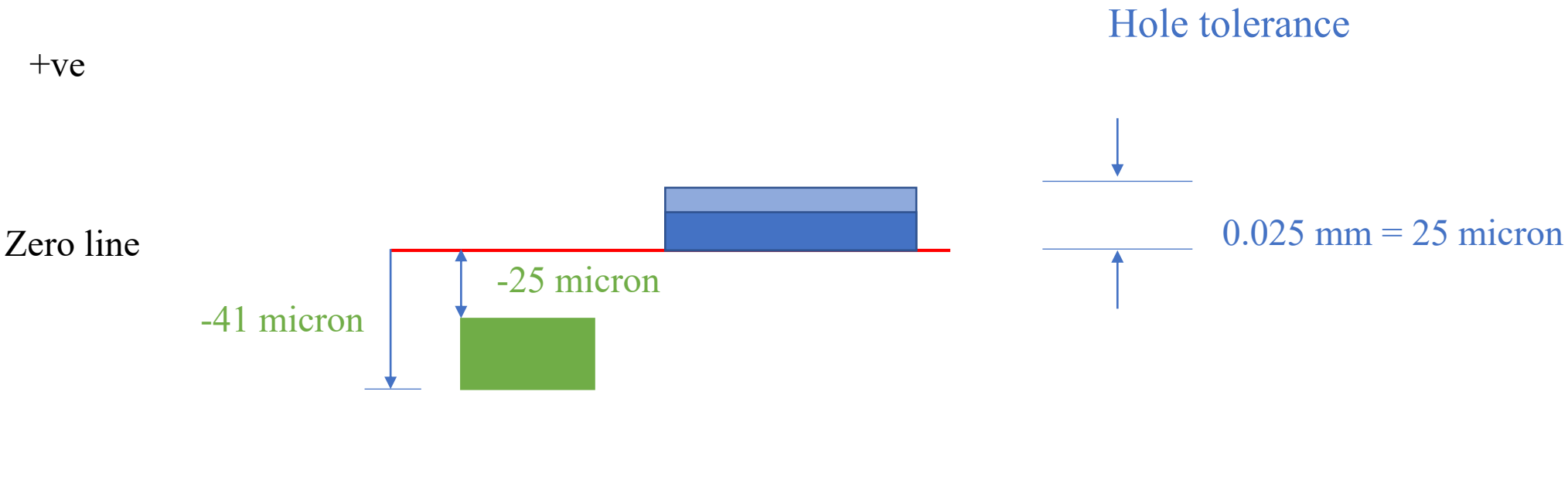
Limits and fits interpretation

$50\ H7\ g8$



Limits and fits interpretation

$50\ H7\ f6$



All these tolerances are hole basis and represents a clearance fit.

Limits and fits interpretation