FITS AND TOLERANCES

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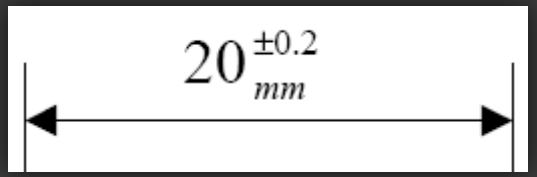
Introduction

- It is not possible to make a component to an exact size (called the 'nominal' or 'basic' size:).
- Moreover, no feature of a component can be perfect (i.e., no surface flat, no hole round etc), because of the manufacturing process.
- Thus, for efficient assembly and operation, all dimensions will have to lie within a particular tolerance range. This range will depend upon the application.

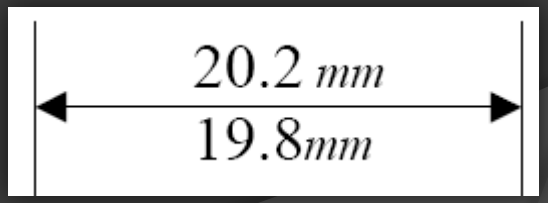
Dimensional Tolerances

- Basic size: The exact theoretical size of a part. This is the value from which limit dimensions are computed.
- Actual size: The value of the size as practically obtained by measurements.

Tolerances may be written as the nominal size followed by the permissible variation.

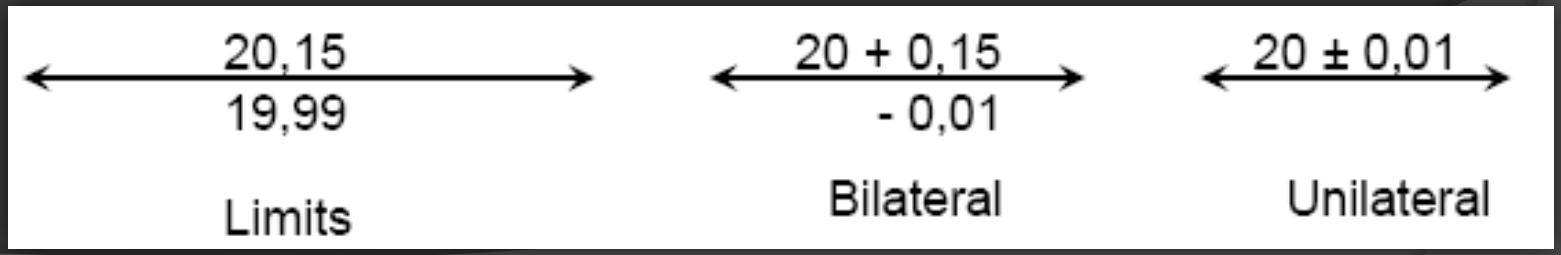


or



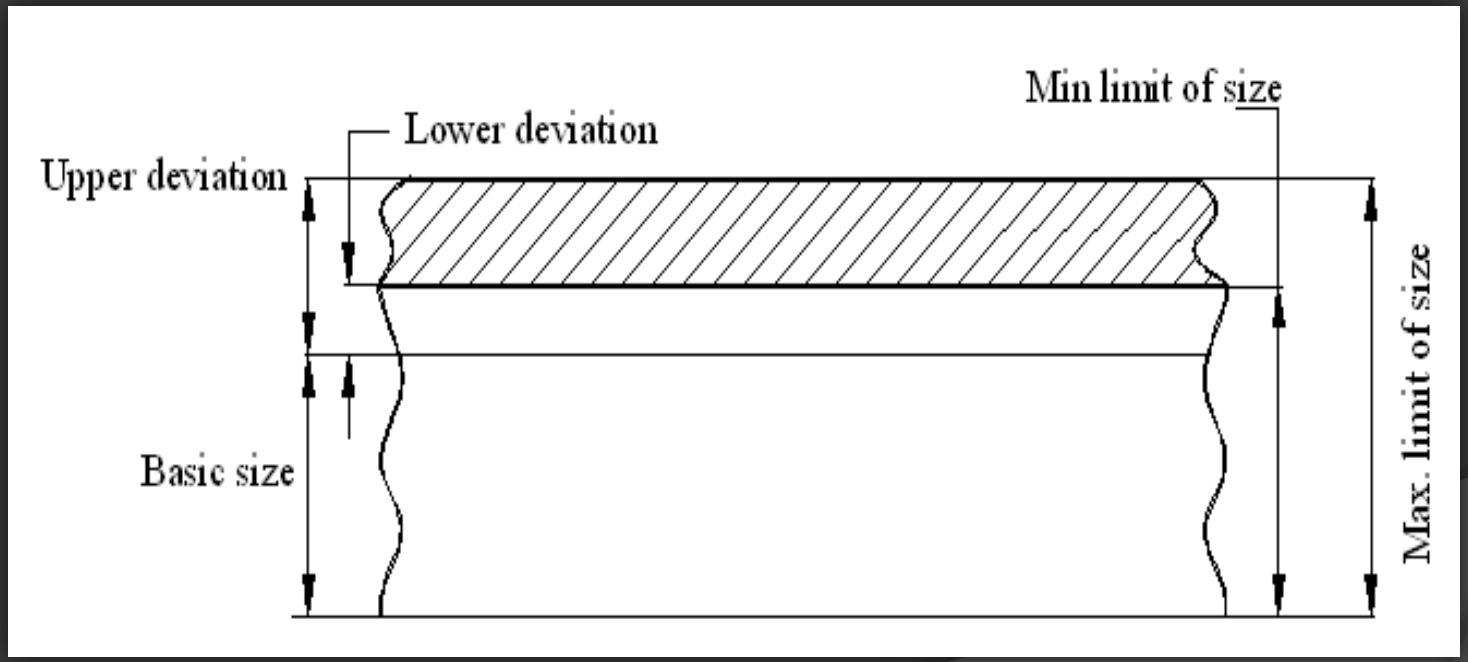
Dimensional Tolerances

- The *'upper limit'* is the largest size allowed.
- The *'lower limit'* is the smallest size allowed.
- The *'tolerance'* is the difference between the upper and lower limit.
- Where variation either side of the nominal dimension can occur, the tolerance is called bilateral. Where one tolerance is zero the tolerance is said to be unilateral.



Dimensional Tolerances

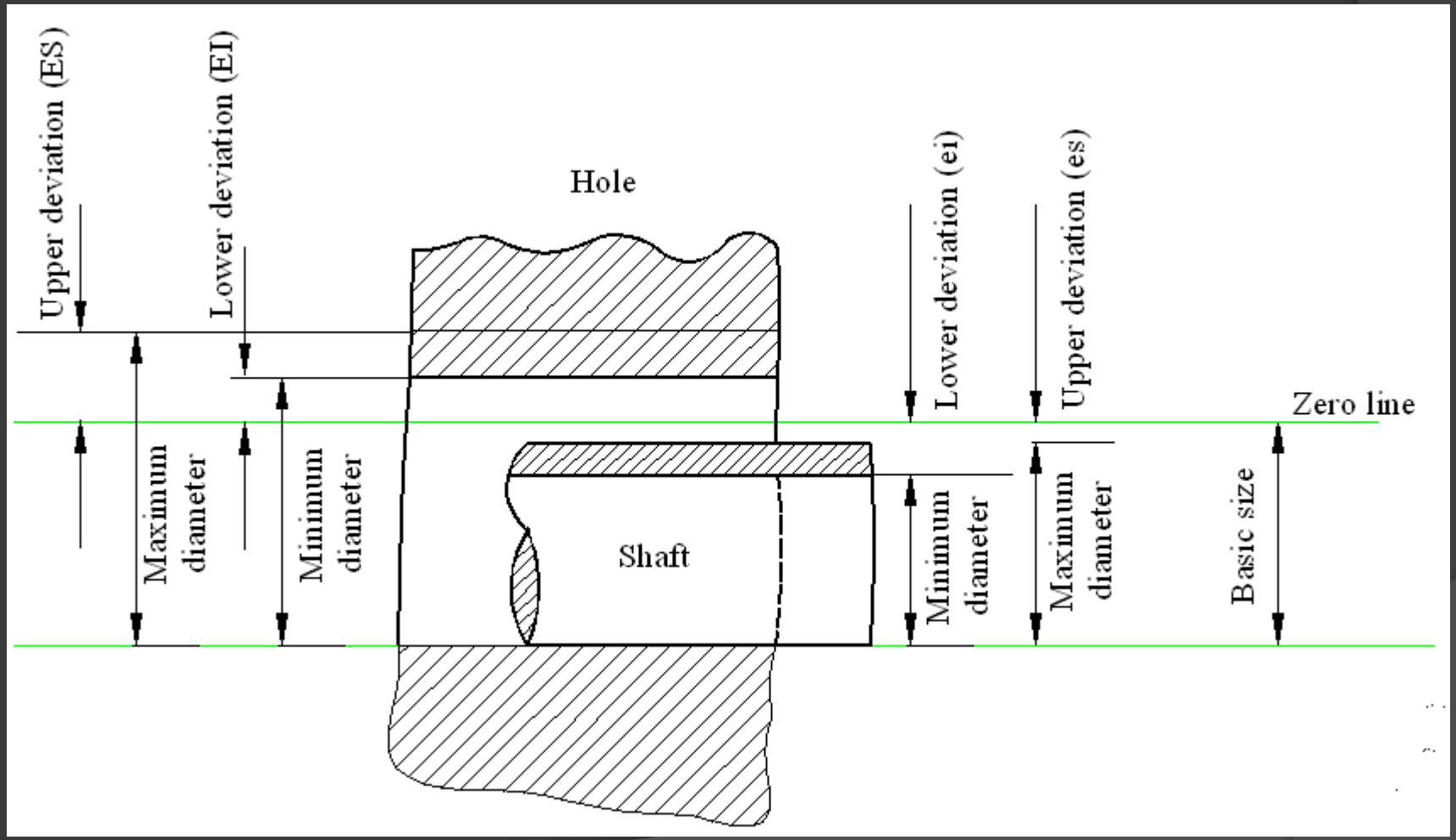
- *'Deviation'* is the algebraic difference between a size and the corresponding 'basic' or 'nominal' size.



Dimensional Tolerances

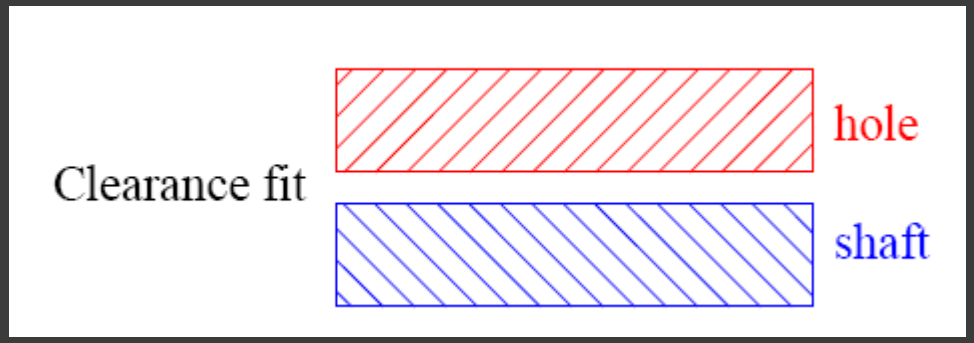
- *Zero line*: The zero line is the line of zero deviation and represents the basic size.
- *Upper deviation*: Algebraical difference between the maximum limit of size and the corresponding basic size.
- *Lower deviation*: Algebraical difference between the minimum limit of size and the corresponding basic size.

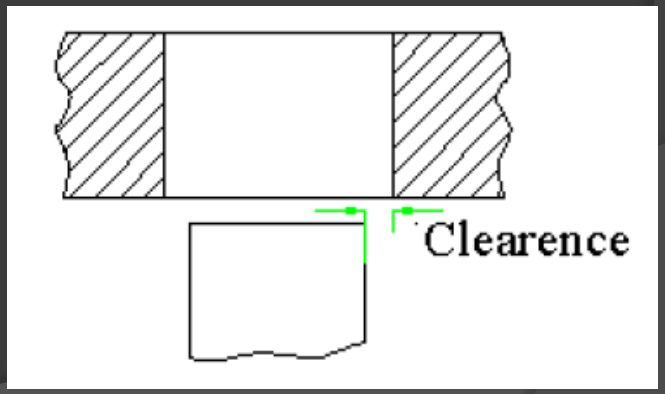
Hole and Shaft Systems



Hole and Shaft Systems

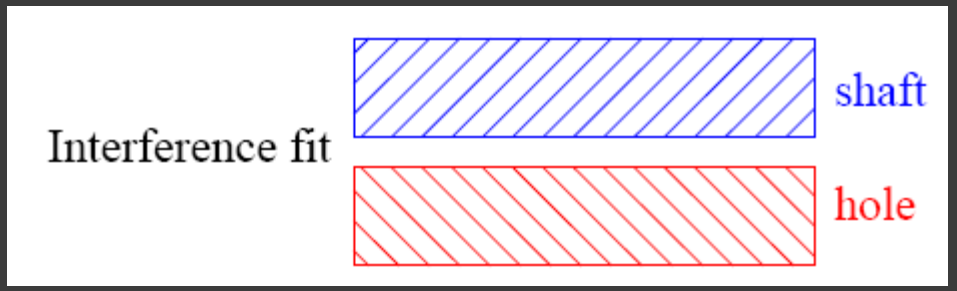
- *'Fit'* describes the working condition between a mating shaft and hole.
- *'Clearance':* Shaft always smaller than the hole - allows movement (the tolerance zone of the hole is entirely above that of the shaft).

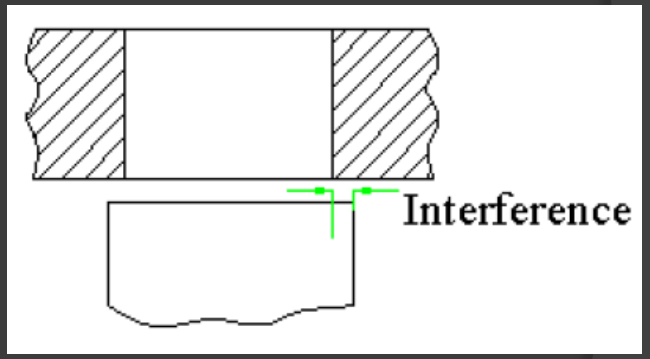




Hole and Shaft Systems

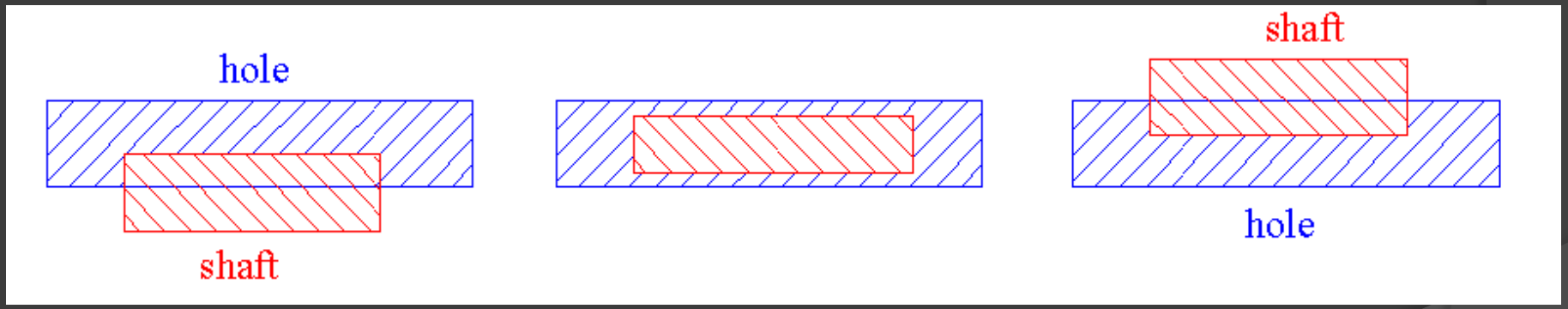
- *'Interference':* Shaft always bigger than the hole - provides fixing.





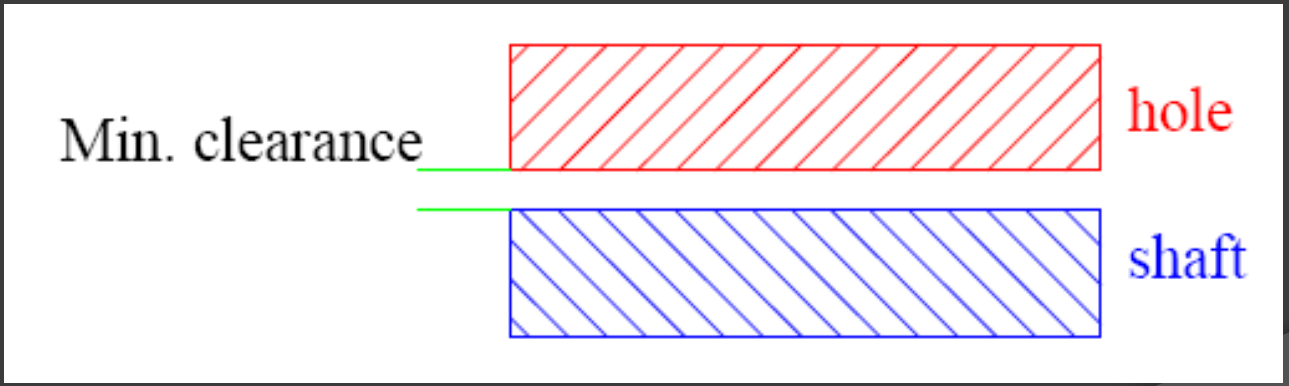
Hole and Shaft Systems

- *'Transition':* May provide either clearance or interference. (the tolerance zones of the hole and the shaft overlap)



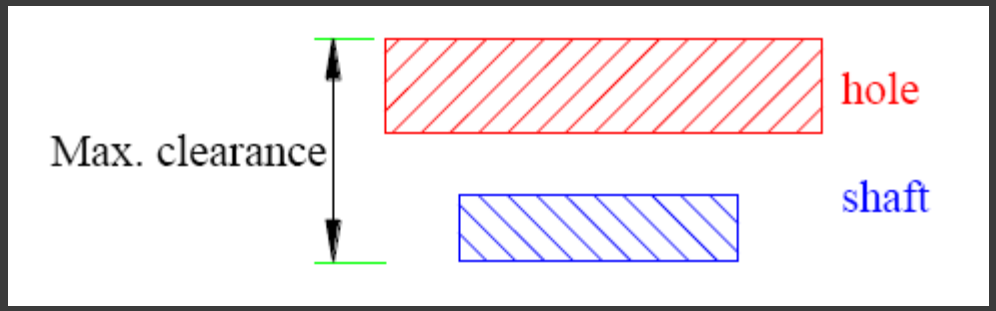
Hole and Shaft Systems

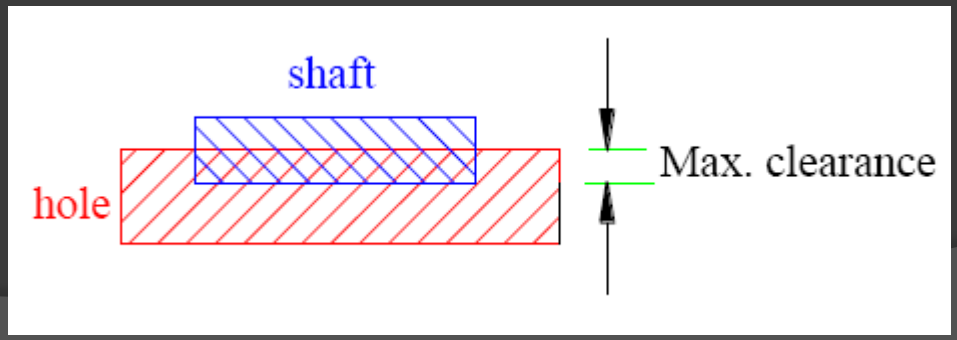
- *Minimum clearance*: In a clearance fit, difference between the minimum size of the hole and the maximum size of the shaft.



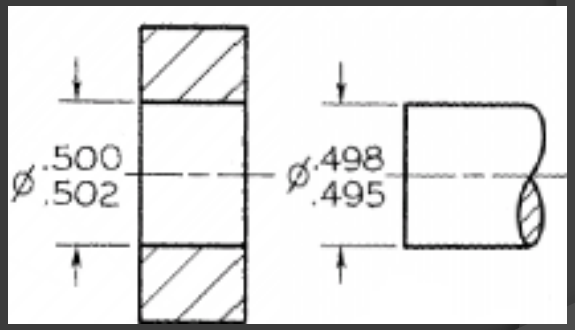
Hole and Shaft Systems

- *Maximum clearance*: In a clearance or a transition fit, difference between the maximum size of the hole and the minimum size of the shaft.





Ex:

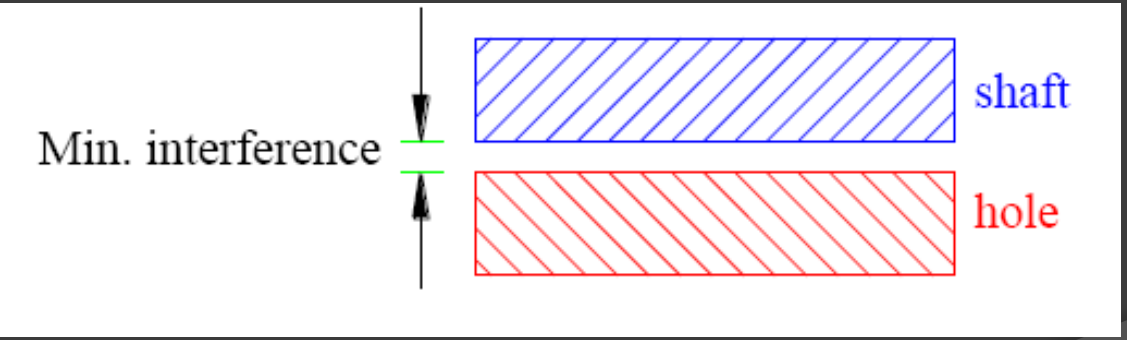


Minimum clearance:
0.500"-0.498" = 0.002"

Maximum clearance: 0.502" – 0.495" = 0.007"

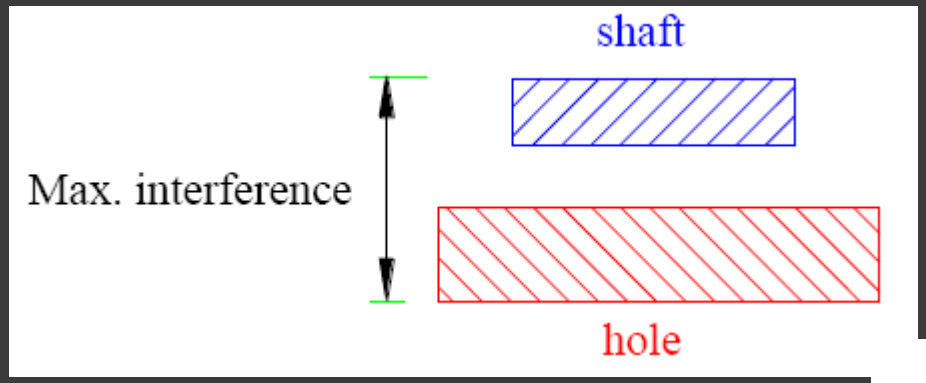
Hole and Shaft Systems

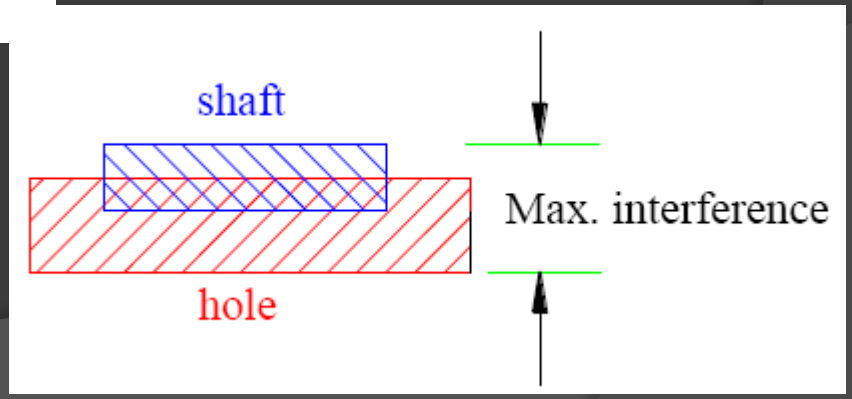
- *Minimum interference*: In an interference fit, magnitude of the (negative) difference between the maximum size of the hole and the minimum size of the shaft, before assembly.



Hole and Shaft Systems

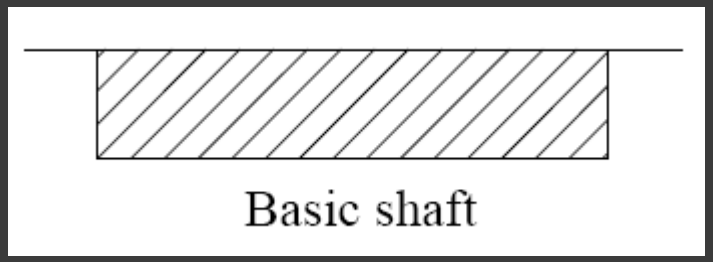
- *Maximum interference*: Magnitude of the (negative) difference between the minimum size of the hole and the maximum size of the shaft, before **assembly.**



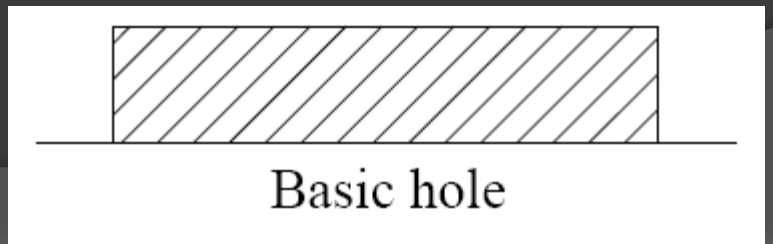


Hole and Shaft Systems

- *Basic shaft*: It is the shaft, the upper deviation of which is zero. It is the shaft chosen, as a basis for a shaft basis system of fit.

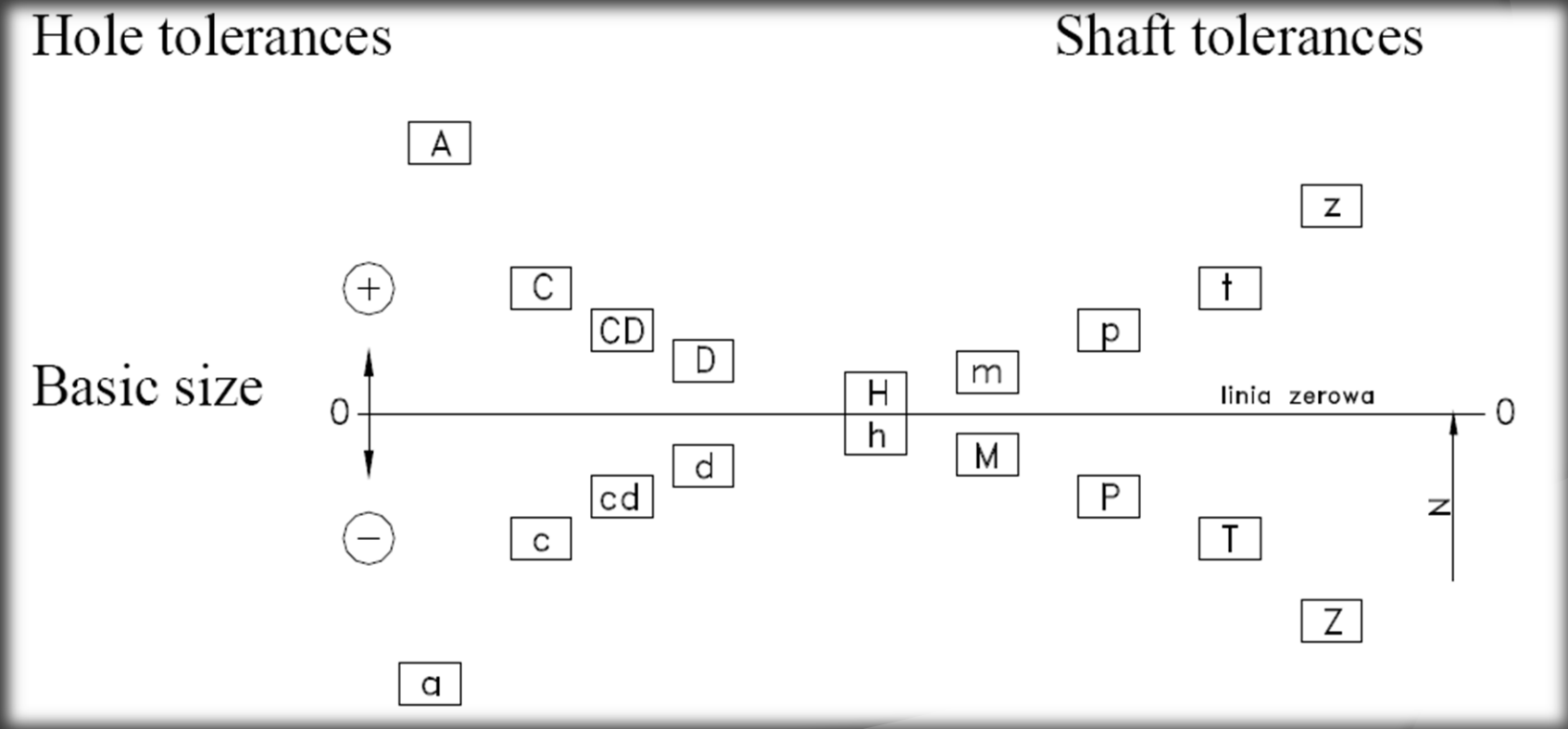


- *Basic hole:* It is the hole, the lower deviation of which is zero. It is the hole chosen, as a basis for a hole basis system of fit.



Hole and Shaft Systems

Standard fits are a way of specifying a fit between a hole and a shaft

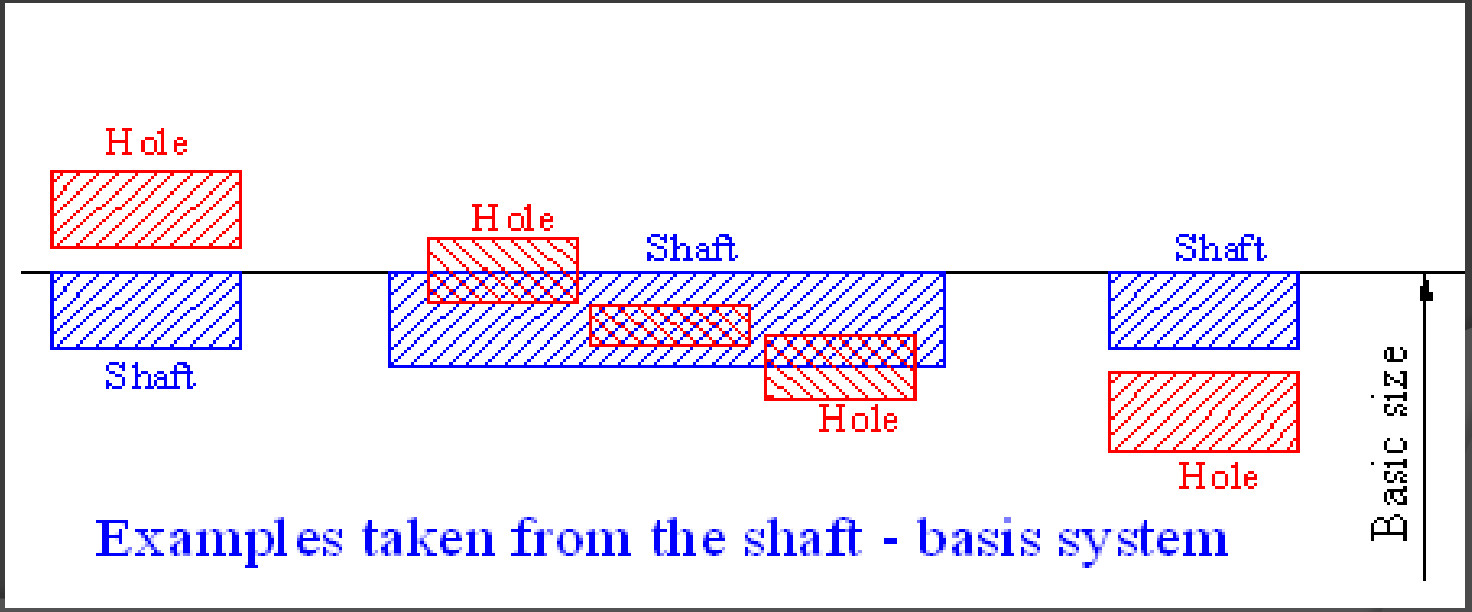


'Tolerance position letters' are used, capitals for hole (internal) dimensions and lower case for shaft (external) dimensions.

Hole and Shaft Systems

Shaft basis system of fits:

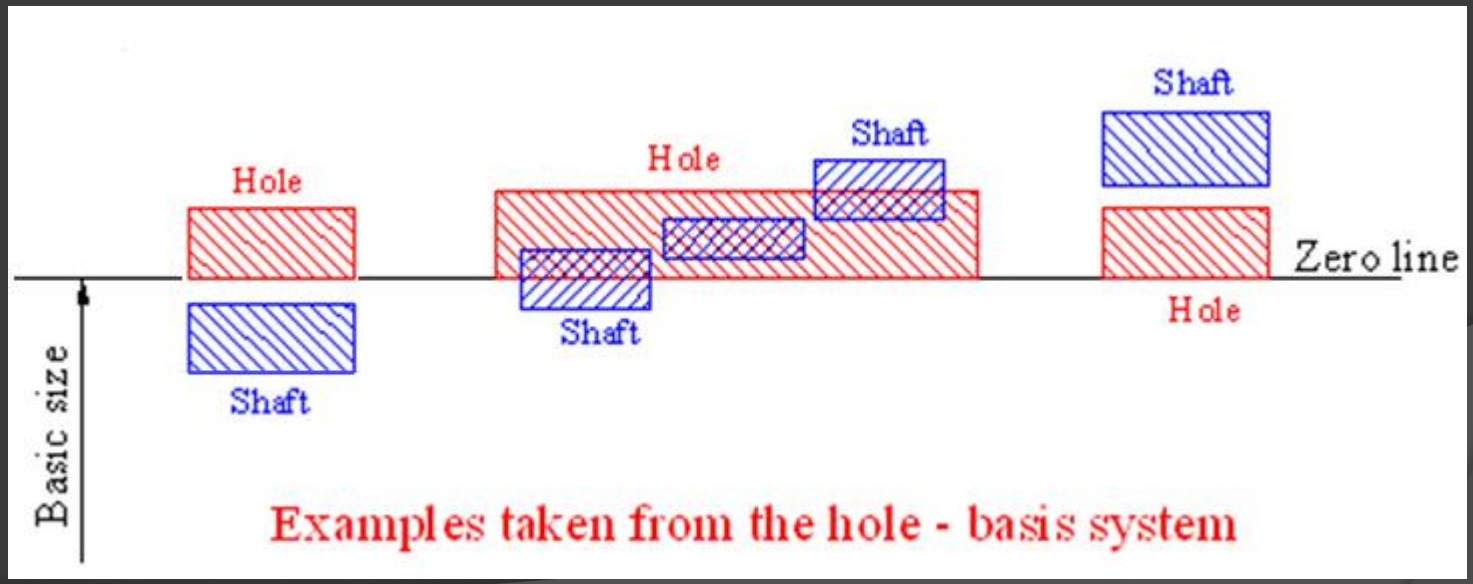
System of fits in which different clearances and interferences are obtained by associating various holes with a single basic shaft.



Hole and Shaft Systems

Hole basis system of fits:

System of fits in which different clearances and interferences are obtained by associating various shafts with a single basic hole.



Hole and Shaft Systems

Tolerance of a basic size for specific tolerance grade

The tolerance of a size is defined as the difference between the upper and lower limit dimensions of the part.

The system ISO implements 20 grades of accuracy. Each of the tolerances of this system is marked "IT" with attached grade of accuracy (IT01, IT0, IT1 ... IT18).

- IT01 to IT6 For production of gauges and measuring instruments
- IT5 to IT12 For fits in precision and general engineering

Hole and Shaft Systems

Tolerance mark consists of a letter marking the basic deviation and a number marking the tolerance grade (e.g. H10, h8, E5). (a capital letter for holes and a small letter for shafts). Ex: 45 g7

P.S. Tolerances of the hole and shaft should not differ by more than two grades. Ex: Hole 45 H8, Shaft 45 g6 (or g7)

Hole and Shaft Systems

In the hole basis system, The desired clearances and interferences in the fit are achieved by combinations of various shaft tolerance zones with the hole tolerance zone **"H".**

In the shaft basis system, The desired clearances and interferences in the fit are achieved by combinations of various hole tolerance zones with the shaft tolerance zone **"h".**

The hole basis system is used preferably
(soft standard part, ex: rolling bearing)

Hole and Shaft Systems

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

Example: 45 H7 g6

Possibly 45 H7 – g6

Or <u>45 H7/g6</u>

Designation: Shaft: 45 g6 → $\varphi 45 \begin{matrix} -0{,}009 \\ -0{,}025 \end{matrix}$

Hole : 45 H7 → $\varphi 45 \begin{matrix} 0{,}025 \\ 0 \end{matrix}$

Clearance Fit

Hole and Shaft Systems

Example of tables

Basic Size (mm)												
Over	Incl.	b9	c9	d8	d9	e7	e8	e9	f6	f7	f8	g5	g6
–	3	−140 −165	−60 −85	−20 −34	−20 −45	−14 −24	−14 −28	−14 −39	−6 −12	−6 −16	−6 −20	−2 −6	−2 −8
3	6	−140 −170	−70 −100	−30 −48	−30 −60	−20 −32	−20 −38	−20 −50	−10 −18	−10 −22	−10 −28	−4 −9	−4 −12
6	10	−150 −186	−80 −116	−40 −62	−40 −76	−25 −40	−25 −47	−25 −61	−13 −22	−13 −28	−13 −35	−5 −11	−5 −14
10	14	−150 −193	−95 −138	−50 −77	−50 −93	−32 −50	−32 −59	−32 −75	−16 −27	−16 −34	−16 −43	−6 −14	−6 −17
14	18												
18	24	−160 −212	−110 −162	−65 −98	−65 −117	−40 −61	−40 −73	−40 −92	−20 −33	−20 −41	−20 −53	−7 −16	−7 −20
24	30												
30	40	−170 −232	−120 −182	−80 −119	−80 −142	−50 −75	−50 −89	−50 −112	−25 −41	−25 −50	−25 −64	−9 −20	−9 −25
40	50	−180 −242	−130 −192										
50	65	−190 −264	−140 −214	−100 −146	−100 −174	−60 −90	−60 −106	−60 −134	−30 −49	−30 −60	−30 −76	−10 −23	−10 −29
65	80	−200 −274	−150 −224										

Basic Size (mm)																
Over	Incl.	B10	C9	C10	D8	D9	D10	E7	E8	E9	F6	F7	F8	G6	G7	H6	H7
–	3	+180 +140	+85 +60	+100 +60	+34 +20	+45 +20	+60 +20	+24 +14	+28 +14	+39 +14	+12 +6	+16 +6	+20 +6	+8 +2	+12 +2	+6 0	+10 0
3	6	+188 +140	+100 +70	+118 +70	+48 +30	+60 +30	+78 +30	+32 +20	+38 +20	+50 +20	+18 +10	+22 +10	+28 +10	+12 +4	+16 +4	+8 0	+12 0
6	10	+208 +150	+116 +80	+138 +80	+62 +40	+76 +40	+98 +40	+40 +25	+47 +25	+61 +25	+22 +13	+28 +13	+35 +13	+14 +5	+20 +5	+9 0	+15 0
10	14	+220 +150	+138 +95	+165 +95	+77 +50	+93 +50	+120 +50	+50 +32	+59 +32	+75 +32	+27 +16	+34 +16	+43 +16	+17 +6	+24 +6	+11 0	+18 0
14	18																
18	24	+244 +160	+162 +110	+194 +110	+98 +65	+117 +65	+149 +65	+61 +40	+73 +40	+92 +40	+33 +20	+41 +20	+53 +20	+20 +7	+28 +7	+13 0	+21 0
24	30																
30	40	+270 +170	+182 +120	+220 +120	+119	+142	+180	+75	+89	+112	+41	+50	+64	+25	+34	+16	+25
40	50	+280 +180	+192 +130	+230 +130	+80	+80	+80	+50	+50	+50	+25	+25	+25	+9	+9	0	0
50	65	+310 +190	+214 +140	+260 +140	+146	+174	+220	+90	+106	+134	+49	+60	+76	+29	+40	+19	+30
65	80	+320 +200	+224 +150	+270 +150	+100	+100	+100	+60	+60	+60	+30	+30	+30	+10	+10	0	0

Hole and Shaft Systems

Example: 45 H7/n6

Designation: Shaft: 45 n6 → φ45 $^{+0,033}_{+0,017}$

Hole : 45 H7 → φ45 $^{0,025}_{0}$

Interferance Fit

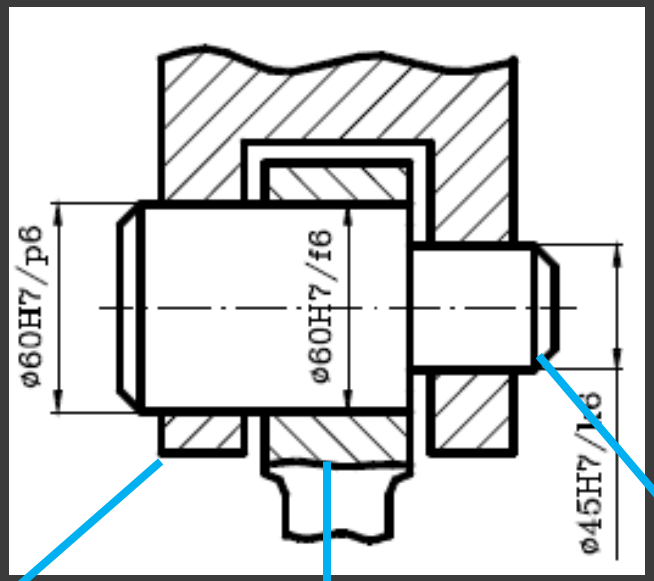
Example: 45 H7/k6

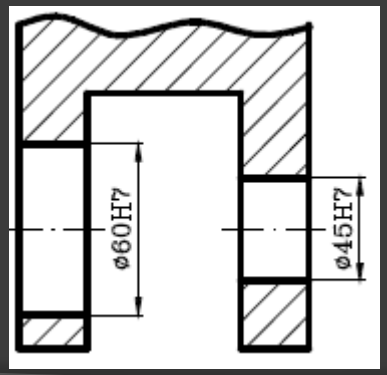
Designation: Shaft: 45 k6 → φ45 $^{+0,002}_{+0,018}$

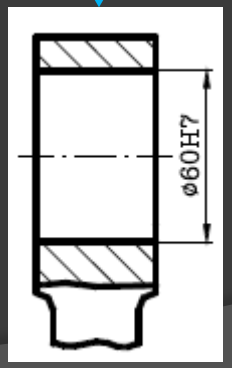
Hole : 45 H7 → φ45 $^{0,025}_{0}$

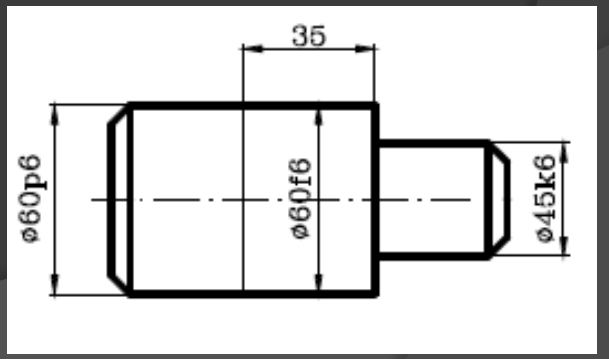
Transition Fit

Hole and Shaft Systems

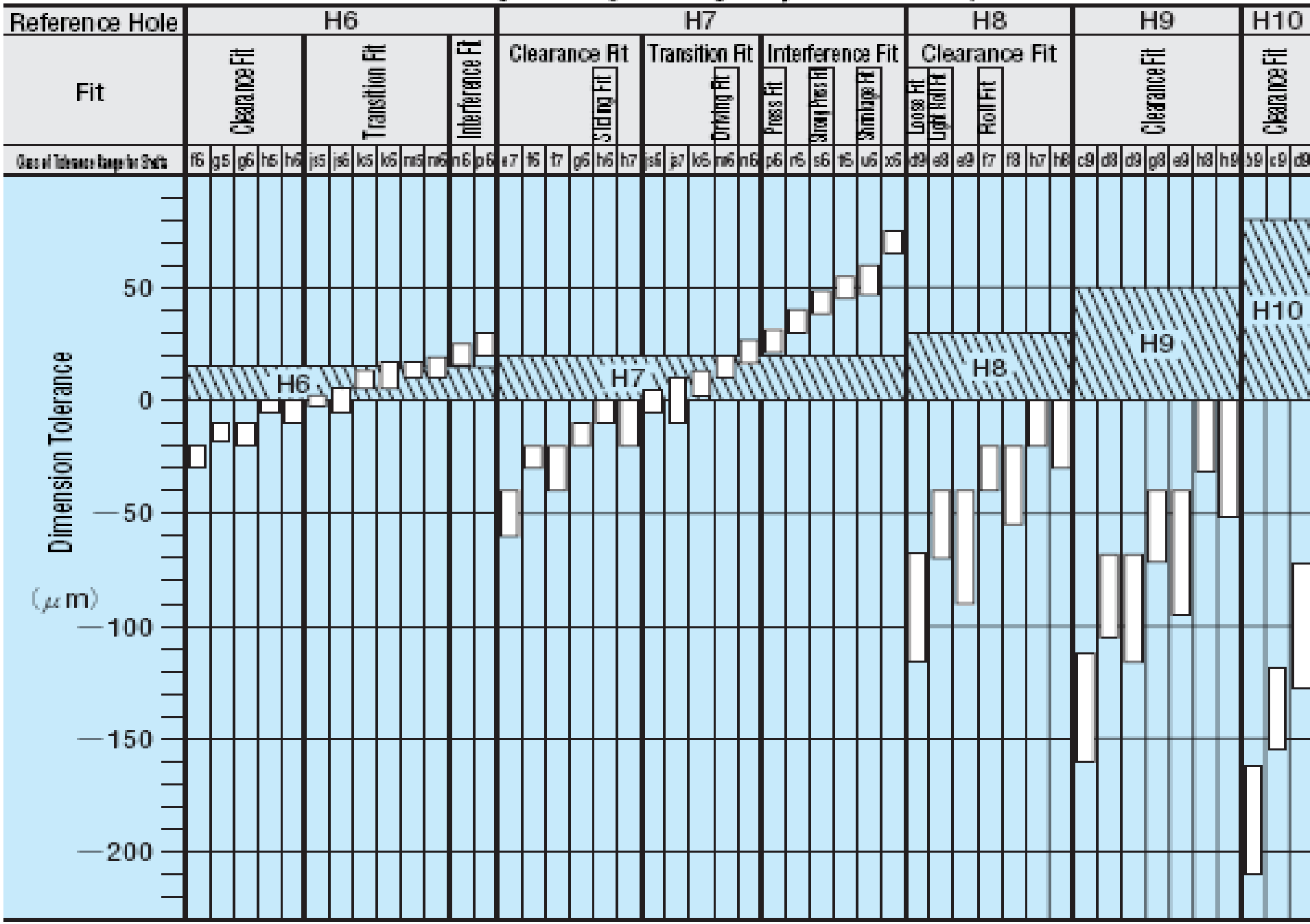








1.2 Interrelation between Tolerance Ranges-Fitting with Regularly Used Hole Adopted as Reference



* Values in cases where the measurement exceeds the reference, 18 mm, but does not exceed 30 mm.

Hole and Shaft Systems

Preferred fits designed for preferred use in the USA are defined in ANSI B4.2.

Clearance fits:

H11/c11, H9/d9, H8/f7, H7/g6, H7/h6, C11/h11, D9/h9, F8/h7, G7/h6

Transition fits:

H7/k6, H7/n6, K7/h6, N7/h6

Interference fits:

H7/p6, H7/s6, H7/u6, P7/h6, S7/h6, U7/h6

Hole and Shaft Systems

Some preferred fits - applications:

Clearance fits

H11/c11, C11/h11

Fits with great clearances. Use: Fits of parts exposed to corrosive effects, contamination with dust and thermal or mechanical deformations.

H9/d9, D10/h9

Running fits with greater clearances without any special requirements for accuracy of guiding shafts. Use: Multiple fits of shafts of production and piston machines, parts rotating very rarely or only swinging.

Hole and Shaft Systems

Some preferred fits - applications:

Clearance fits

H9/e9, H8/e8, E9/h9,

Running fits with greater clearances without any special requirements for fit accuracy. Use: Fits of long shafts, e.g. in agricultural machines, bearings of pumps

H8/f7, H7/f7,F8/h6

Running fits with smaller clearances with general requirements for fit accuracy. Use: Main fits of machine tools. General fits of shafts, regulator bearings, machine tools, sliding rods.

Hole and Shaft Systems

Clearance fits

H7/g6, G7/h6

Running fits with very small clearances for accurate guiding of shafts.

Use: Parts of machine tools, sliding gears and clutch disks, rods sliding in bearings

H7/h6

Sliding fits with very small clearances for precise guiding and centring of parts. Mounting by sliding on without use of any great force

Use: Precise guiding of machines, exchangeable wheels, roller guides.

Hole and Shaft Systems

Transition fits

H7/j6

Tight fits with small clearances or negligible interference. The parts can be assembled or disassembled manually. Use: Easily dismountable fits of hubs of gears,

H7/k6, K7/h6

Similar fits with small clearances or small interferences. The parts can be assembled or disassembled without great force using a rubber mallet. Use: Demountable fits of hubs of gears, clutches, brake disks.

H7/n6, N7/h6

Fixed fits with negligible clearances or small interferences. Mounting of fits using pressing and light force. Use: armatures of electric motors on shafts

Hole and Shaft Systems

Interferance fits

H7/p6, H7/r6, P7/h6

Pressed fits with guaranteed interference. Assembly of the parts can be carried out using cold pressing. Use: Hubs of clutch disks, bearing bushings.

H7/s6, S7/h6,

Pressed fits with medium interference. Assembly of parts using hot pressing. Assembly using cold pressing only with use of large forces. Use: Permanent coupling of gears with shafts, bearing bushings.