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ME 1110 – Engineering Practice 1

Engineering Drawing and Design - Lecture 7

Fits and Tolerances

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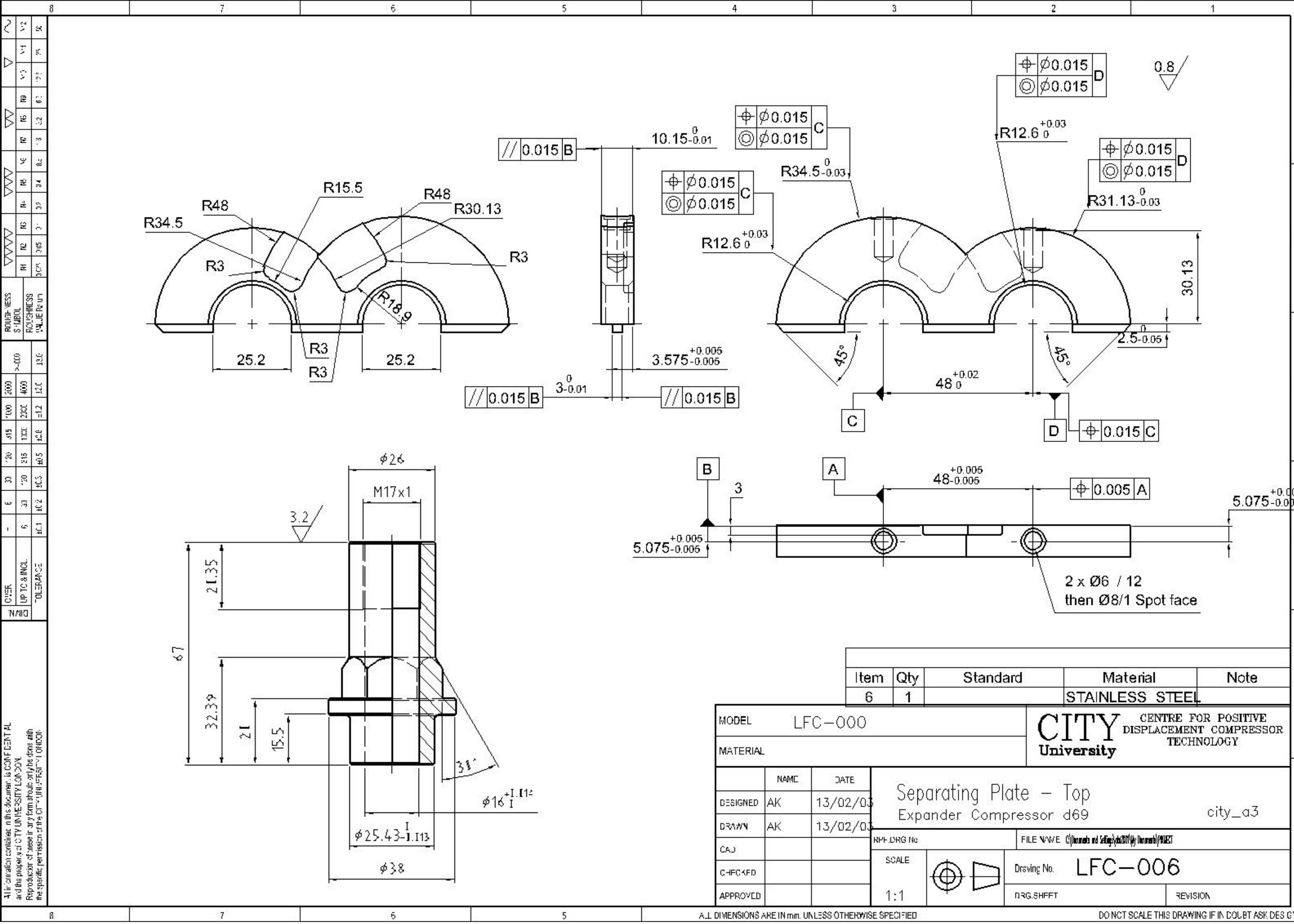
www.staff.city.ac.uk/~ra600/intro.htm

Objectives for today

- To learn about fits and tolerances
- To learn how to define tolerance in order for parts to function correctly


R48
R15.5
R48
R30.13
R34.5
R3
R3
R18.9
R3
R3
25.2
25.2
//0.015 B
10.15 0 -0.01
3.575 +0.005 -0.005
3 0 -0.01
//0.015 B
//0.015 B
⌖ ∅0.015 C
◎ ∅0.015
⌖ ∅0.015 C
◎ ∅0.015
R34.5 0 -0.03
R12.6 +0.03 0
⌖ ∅0.015 D
◎ ∅0.015
0.8
R12.6 +0.03 0
⌖ ∅0.015 D
◎ ∅0.015
R31.13 0 -0.03
30.13
2.5 0 -0.05
45°
45°
48 +0.02 0
C
D
⌖ 0.015 C
B
A
3
48 +0.005 -0.005
⌖ 0.005 A
5.075 +0.005 -0.005
5.075 +0.005 -0.005
2 x Ø6 / 12
then Ø8/1 Spot face
∅26
M17x1
3.2
21.35
67
32.39
21
15.5
31°
∅16
∅25.43
∅38
Item | Qty | Standard | Material | Note
6 | 1 | | STAINLESS STEEL |
MODEL LFC–000
MATERIAL
CITY University
CENTRE FOR POSITIVE DISPLACEMENT COMPRESSOR TECHNOLOGY
NAME DATE
DESIGNED AK 13/02/03
DRAWN AK 13/02/03
CAD
CHECKED
APPROVED
Separating Plate – Top
Expander Compressor d69
city_a3
REF.DRG No
FILE NAME
SCALE 1:1
Drawing No. LFC–006
DRG.SHEET
REVISION
ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE SPECIFIED
DO NOT SCALE THIS DRAWING IF IN DOUBT ASK DESIGNER

Tolerancing

- Definition:
  - » Allowance for specific variation in the size and geometry of a part
- Why is tolerancing necessary?
  - » It is impossible to manufacture a part to an exact size or geometry
  - » Since variation from the drawing is inevitable the acceptable degree of variation must be specified
  - » Large variation may affect the functionality of the part
  - » Small variation will effect the cost of the part
    - requires precise manufacturing
    - requires inspection and the rejection of parts

Tolerance Declaration

Tolerance can be expressed in different ways:

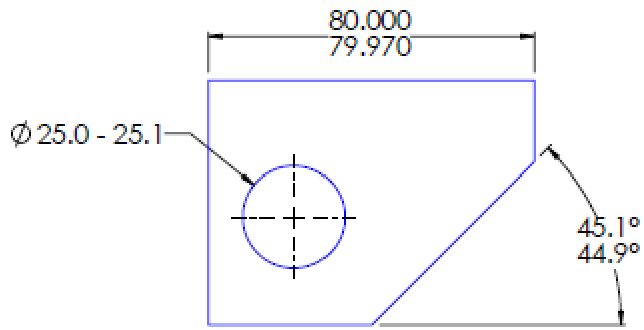
1. Direct tolerancing method (size)
   - » Limits specifying the allowed variation in each dimension (length, width, height, diameter, etc.) are given on the drawing

2. General tolerance note
   - » Notes like “ALL DIMENSIONS HELD TO ± 0.05”

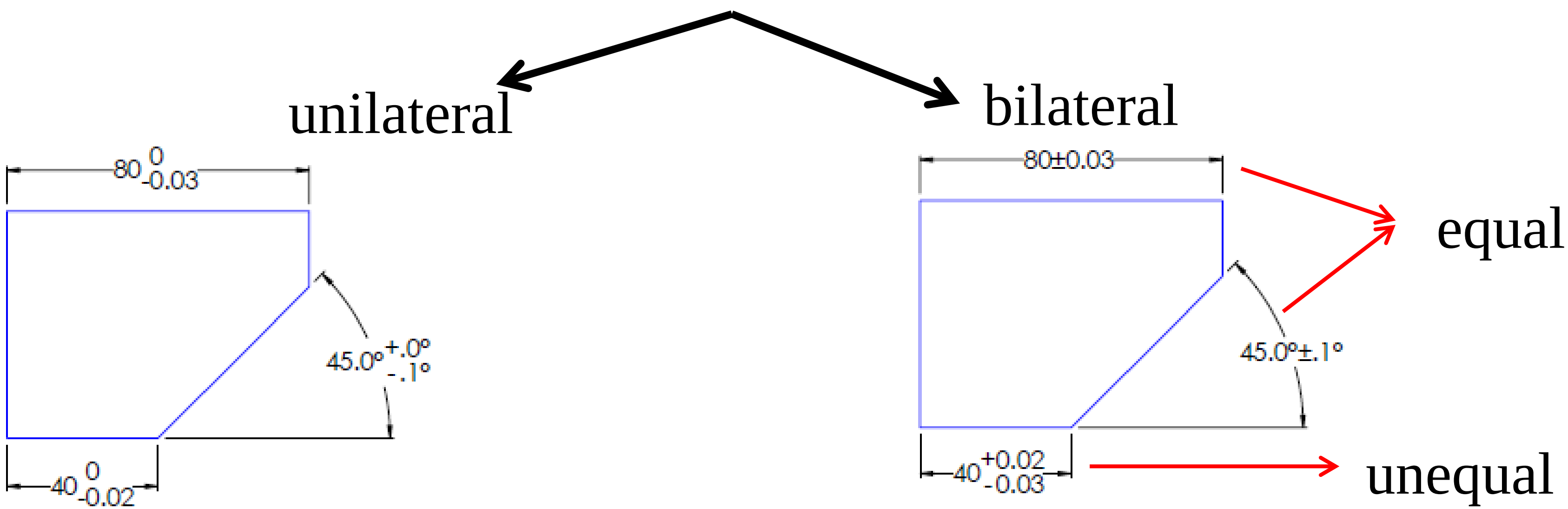
3. Geometric tolerancing
   - » Allows for specification of tolerance for the geometry of a part separate from its size
   - » GDT (Geometric Dimensioning and Tolerancing) uses special symbols to control different geometric features of a part

Direct Tolerancing method

(1) Limit Dimensioning



(2) Deviation tolerancing



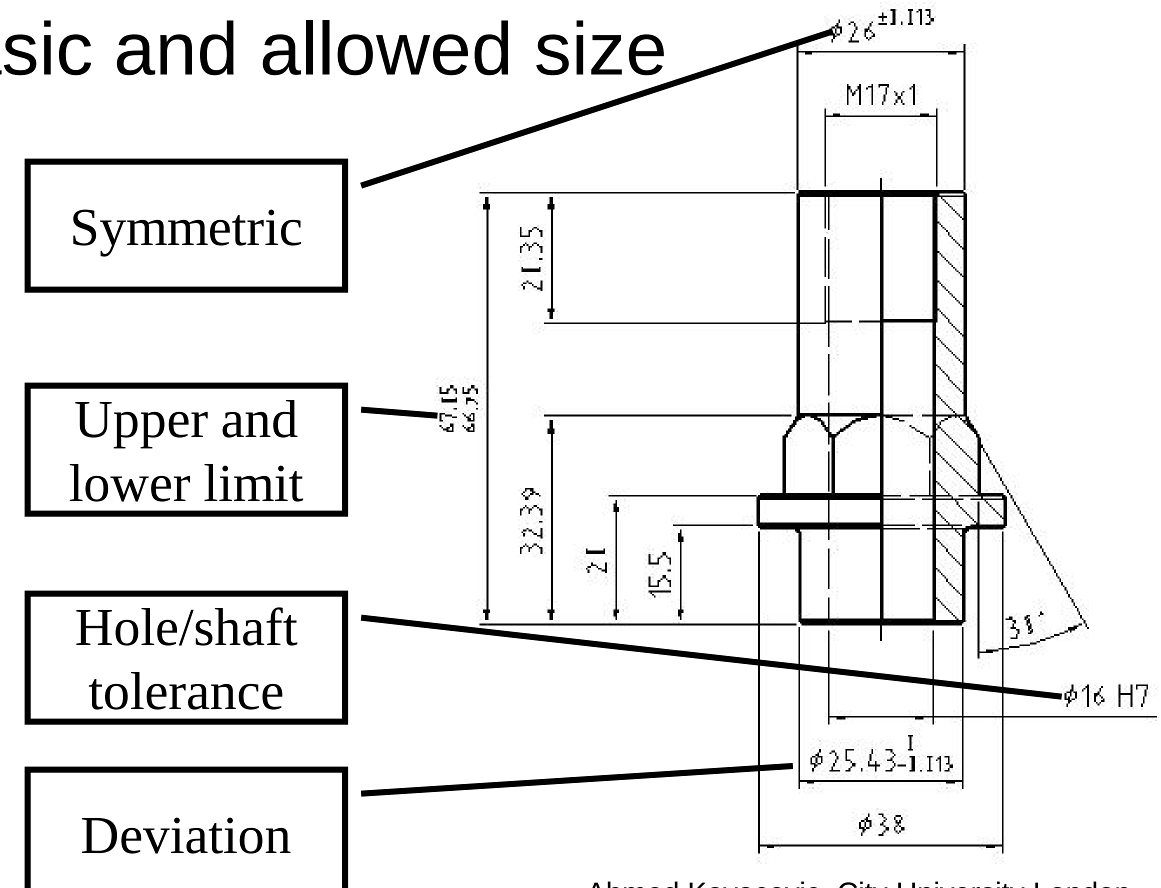
Tolerancing - Terminology

1 Basic Size:- From which limits are fixed

Deviation:- Difference - between the basic and allowed size

2 Max Limit

3 Min Limit



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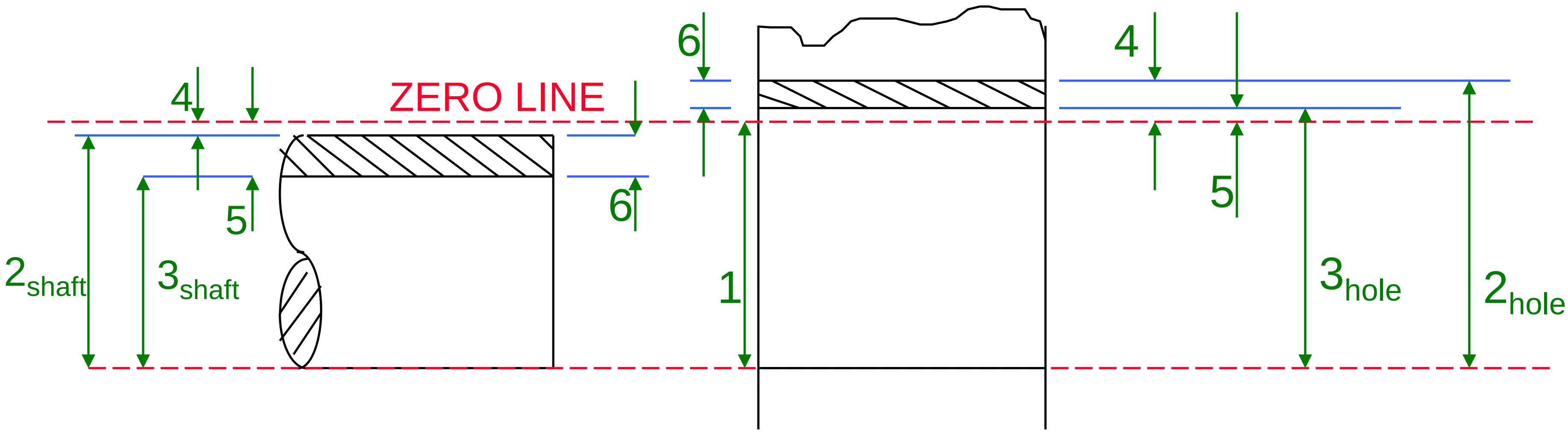
BS4500: ISO Units

- A system of 18 grades and tolerances related to part size ranges (i.e. basic size range)
- These standard tolerances are related to the zero line by a letter code i.e. deviation

	Nominal Sizes (mm)										
over	1	3	6	10	18	30	50	80	120	180	250
inc.	3	6	10	18	30	50	80	120	180	250	315
Grade											
1	0.8	1	1	1.2	1.5	1.5	2	2.5	3.5	4.5	6
2	1.2	1.5	1.5	2	2.5	2.5	3	4	5	7	8
3	2	2.5	2.5	3	4	4	5	6	8	10	12
4	3	4	4	5	6	7	8	10	12	14	16
5	4	5	6	8	9	11	13	15	18	20	23
6	6	8	9	11	13	16	19	22	25	29	32
7	10	12	15	18	21	25	30	35	40	46	52
8	14	18	22	27	33	39	46	54	63	72	81
9	25	30	36	43	52	62	74	87	100	115	130
10	40	48	58	70	84	100	120	140	160	185	210
11	60	75	90	110	130	160	190	220	250	290	320
12	100	120	150	180	210	250	300	350	400	460	520
13	140	180	220	270	330	390	460	540	630	720	810
14	250	300	360	430	520	620	740	870	1000	1150	1300

Tolerance and Fits - terminology



1 Basic Size - From which limits are fixed

Deviation - Difference - The basic and the another size

2 Max Limit - Of size permissible

3 Min Limit - Of size permissible

4 Upper deviation - 1-2

5 Lower deviation - 1-3

6 Tolerance - 2-3 or 4-5

To differentiate between holes and shafts, upper and lower case letters are used

H – Holes; h - Shafts

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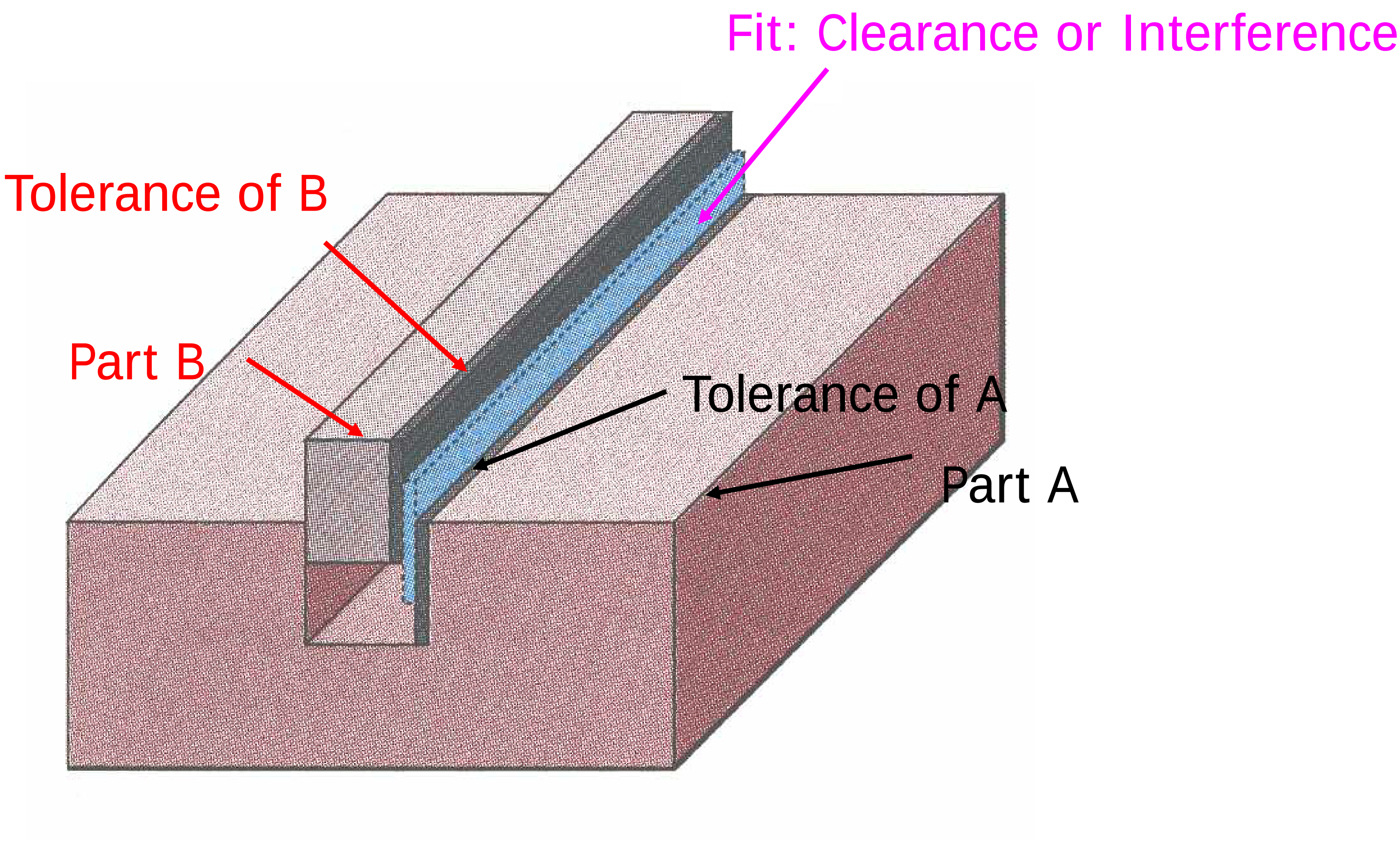
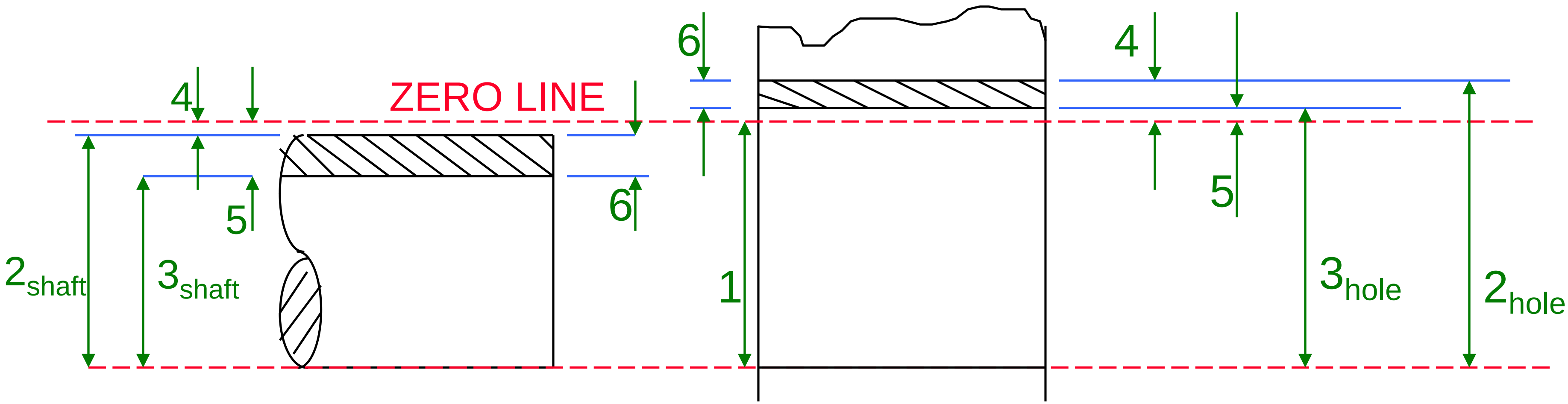
Fitting Two Parts



Tolerance Terminology – continue



1	Nominal Size	– a general size, common fraction
	Basic Size	– theoretical size from which limits are fixed
	Actual Size	– measured size
2,3	Limits	– maximum and minimum permissible sizes
4,5	Deviation	– max. and min. difference from a nominal size *(1-2 or 1-3)*
6	Tolerance	– total allowable variance in dimensions (*upper limit – lower limit* or *2-3 or 4-5*)

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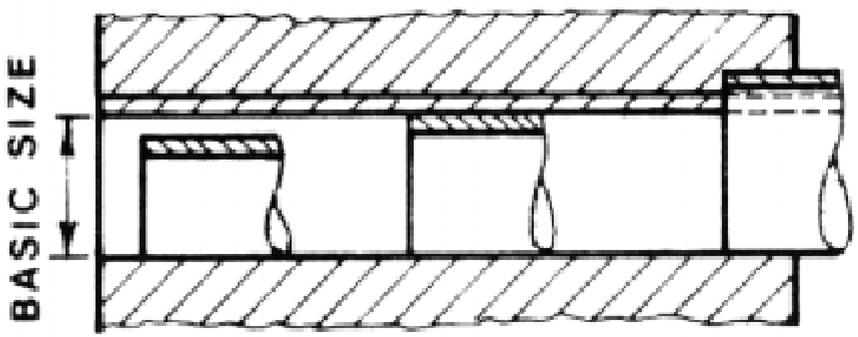
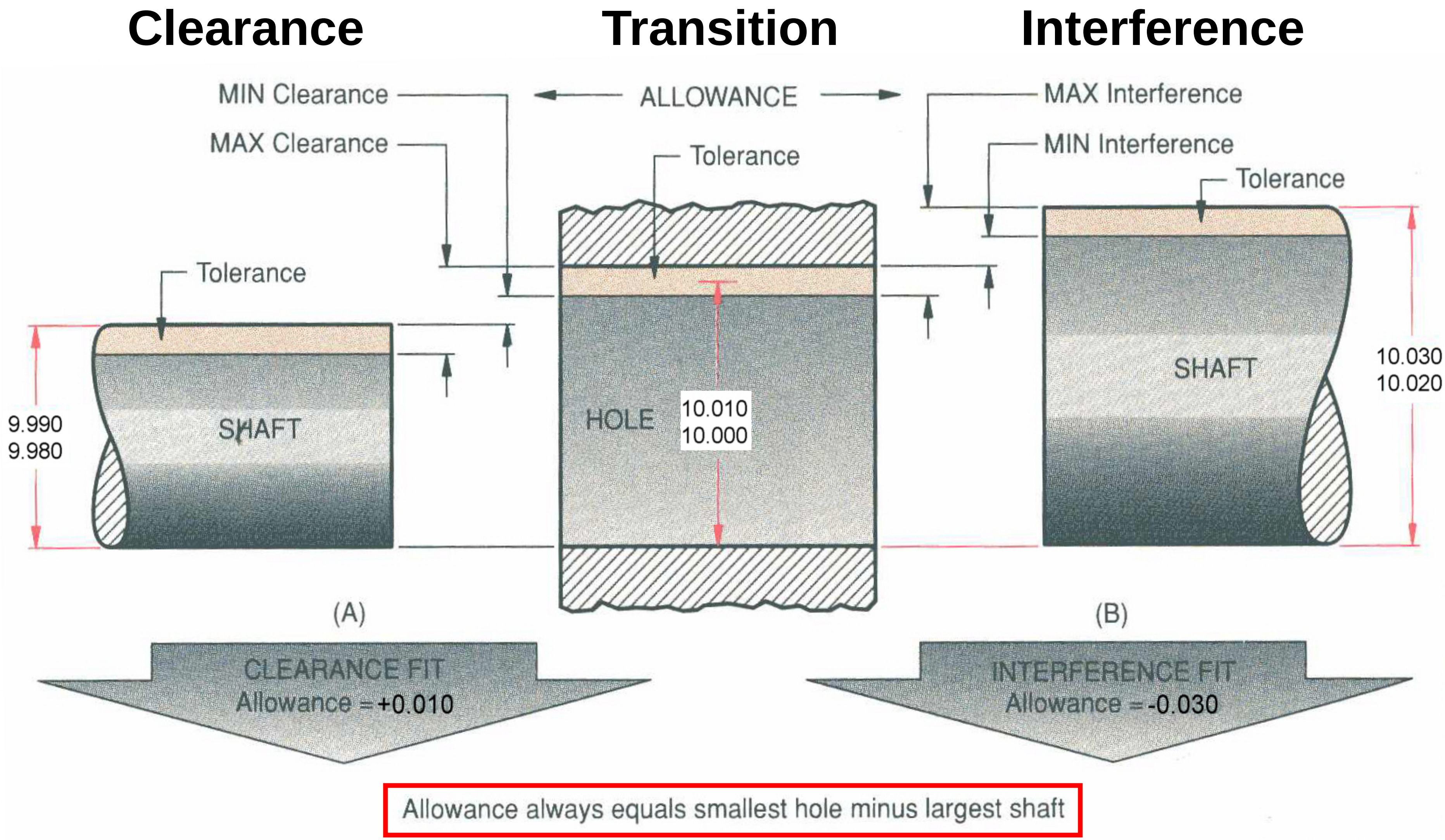
Fits

- Range of tightness between two mating parts
- Types of fit
  - » Clearance fits
    - – provides clearance between two mating parts.
  - » Interference fit
    - – results in interference between mating parts
  - » Transition fits
    - – results in neither of the above



Shaft and Hole Fits



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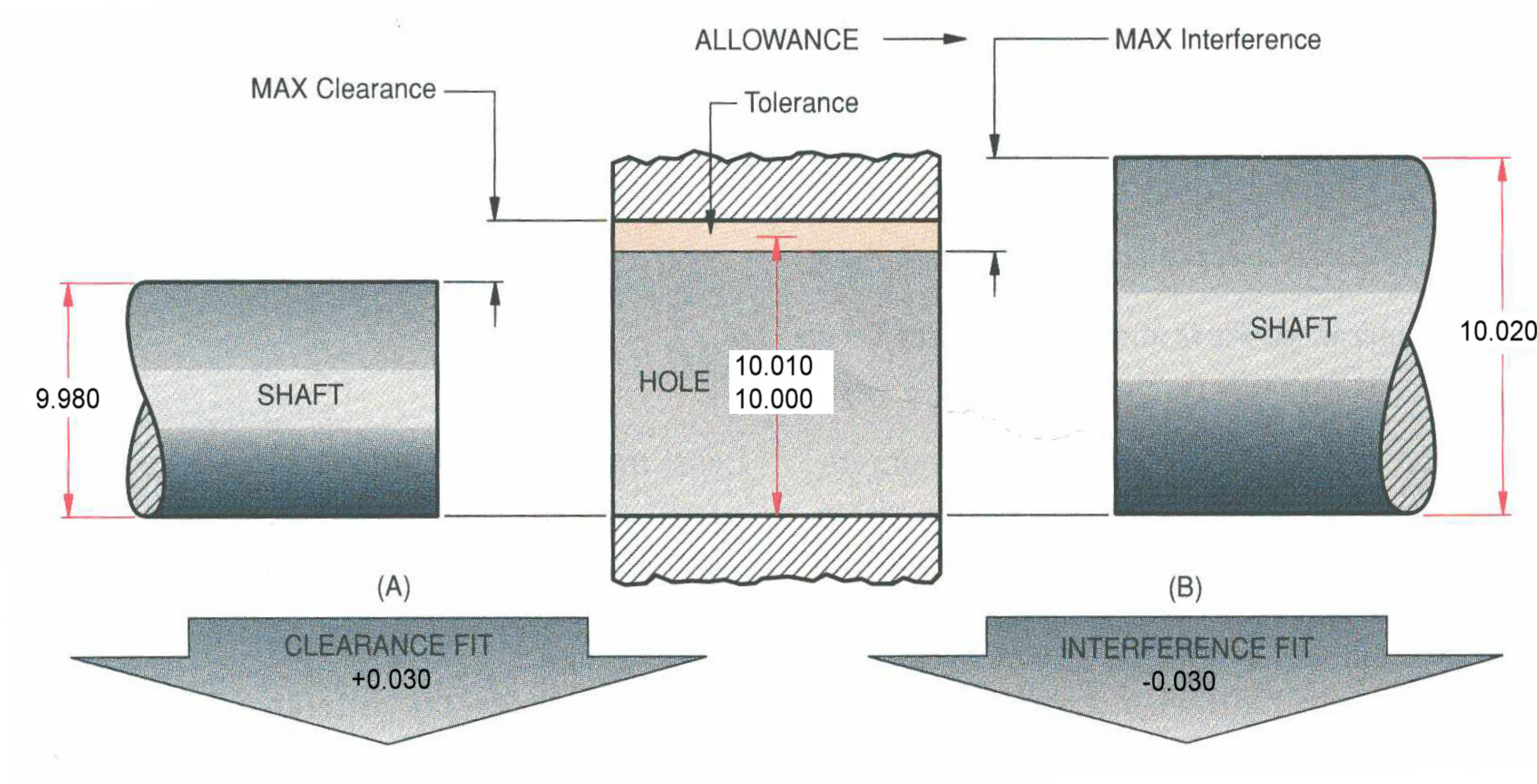
Shaft and Hole Fits

Clearance | Transition | Interference



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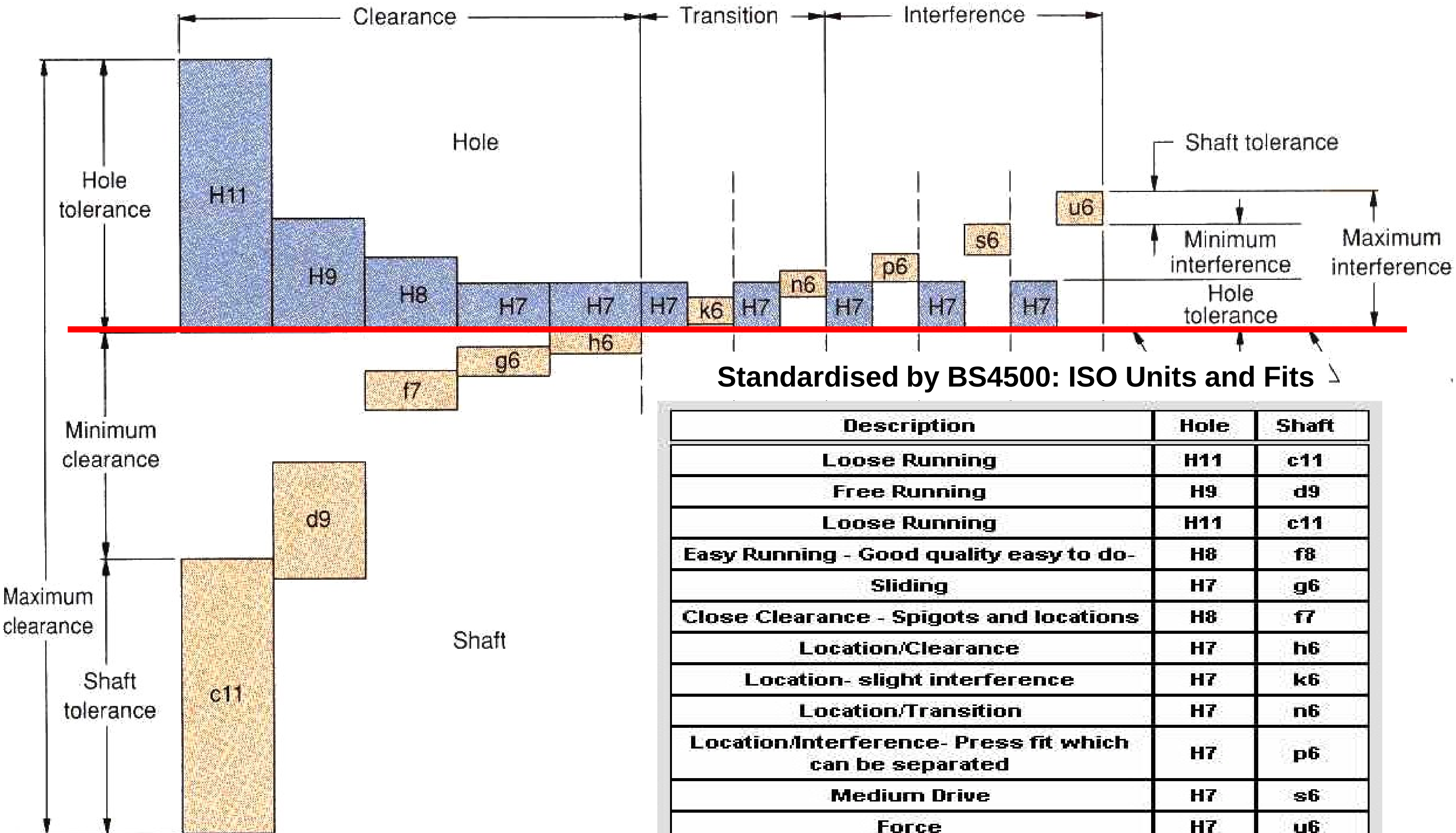
Preferred Hole Basis System of Fits



Standardised by BS4500: ISO Units and Fits

Description	Hole	Shaft
Loose Running	H11	c11
Free Running	H9	d9
Loose Running	H11	c11
Easy Running - Good quality easy to do-	H8	f8
Sliding	H7	g6
Close Clearance - Spigots and locations	H8	f7
Location/Clearance	H7	h6
Location- slight interference	H7	k6
Location/Transition	H7	n6
Location/Interference- Press fit which can be separated	H7	p6
Medium Drive	H7	s6
Force	H7	u6

Basic Hole System or Hole Basis

- Definition of the "Basic Hole System":
  - » The "minimum size" of the hole is equal to the "basic size" of the fit

- Example:
  If the nominal size of a fit is 10 mm, then the minimum size of the hole in the system will be 10mm

Fundamental deviations for shafts

BASIC SIZES	UPPER-DEVIATION LETTER					LOWER-DEVIATION LETTER				
	c	d	f	g	h	k	n	p	s	u
0–3	−0.060	−0.020	−0.006	−0.002	0	0	+0.004	+0.006	+0.014	+0.018
3–6	−0.070	−0.030	−0.010	−0.004	0	+0.001	+0.008	+0.012	+0.019	+0.023
6–10	−0.080	−0.040	−0.013	−0.005	0	+0.001	+0.010	+0.015	+0.023	+0.028
10–14	−0.095	−0.050	−0.016	−0.006	0	+0.001	+0.012	+0.018	+0.028	+0.033
14–18	−0.095	−0.050	−0.016	−0.006	0	+0.001	+0.012	+0.018	+0.028	+0.033
18–24	−0.110	−0.065	−0.020	−0.007	0	+0.002	+0.015	+0.022	+0.035	+0.041
24–30	−0.110	−0.065	−0.020	−0.007	0	+0.002	+0.015	+0.022	+0.035	+0.048
30–40	−0.120	−0.080	−0.025	−0.009	0	+0.002	+0.017	+0.026	+0.043	+0.060
40–50	−0.130	−0.080	−0.025	−0.009	0	+0.002	+0.017	+0.026	+0.043	+0.070
50–65	−0.140	−0.100	−0.030	−0.010	0	+0.002	+0.020	+0.032	+0.053	+0.087
65–80	−0.150	−0.100	−0.030	−0.010	0	+0.002	+0.020	+0.032	+0.059	+0.102
80–100	−0.170	−0.120	−0.036	−0.012	0	+0.003	+0.023	+0.037	+0.071	+0.124
100–120	−0.180	−0.120	−0.036	−0.012	0	+0.003	+0.023	+0.037	+0.079	+0.144
120–140	−0.200	−0.145	−0.043	−0.014	0	+0.003	+0.027	+0.043	+0.092	+0.170
140–160	−0.210	−0.145	−0.043	−0.014	0	+0.003	+0.027	+0.043	+0.100	+0.190
160–180	−0.230	−0.145	−0.043	−0.014	0	+0.003	+0.027	+0.043	+0.108	+0.210
180–200	−0.240	−0.170	−0.050	−0.015	0	+0.004	+0.031	+0.050	+0.122	+0.236
200–225	−0.260	−0.170	−0.050	−0.015	0	+0.004	+0.031	+0.050	+0.130	+0.258
225–250	−0.280	−0.170	−0.050	−0.015	0	+0.004	+0.031	+0.050	+0.140	+0.284
250–280	−0.300	−0.190	−0.056	−0.017	0	+0.004	+0.034	+0.056	+0.158	+0.315
280–315	−0.330	−0.190	−0.056	−0.017	0	+0.004	+0.034	+0.056	+0.170	+0.350
315–355	−0.360	−0.210	−0.062	−0.018	0	+0.004	+0.037	+0.062	+0.190	+0.390
355–400	−0.400	−0.210	−0.062	−0.018	0	+0.004	+0.037	+0.062	+0.208	+0.435

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Fit Calculations

- Clearance = Hole – Shaft
- $C_{max} = H_{max} – S_{min}$
- $C_{min} = H_{min} – S_{max}$
- If:
  - » Both C_{max} and $C_{min} > 0$ - ***Clearance fit***
  - » Both C_{max} and $C_{min} < 0$ - ***Interference fit***
  - » $C_{max} > 0$ and $C_{min} < 0$ - ***Transition fit***
- Allowance = $H_{min} – S_{max} = C_{min}$
- System tolerance: $T_S = C_{max} - C_{min} = \Sigma Ti$

Example

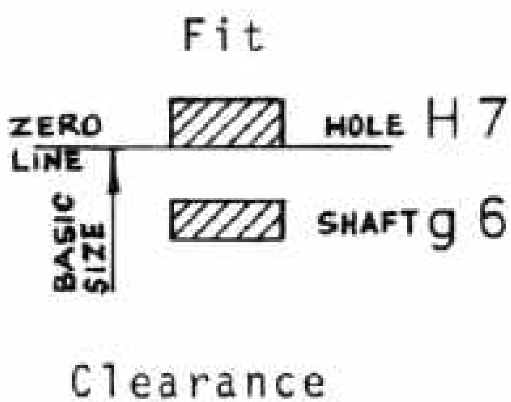
ISO Tolerance Grades

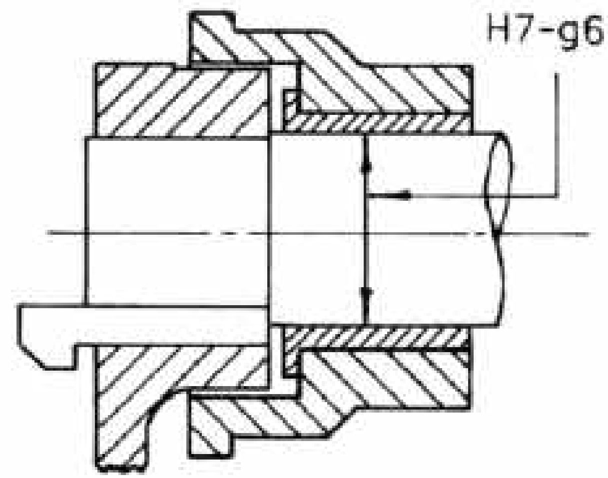
Fundamental Deviations

The design of the assembly requires a 'Close fit', class H7 - g6, between the shaft and the bush that it rotates in. The 'Close fit' is a clearance fit and ensures ability to rotate and locate accurately.

Using the BS4500A Data Sheet complete the table given below determining the max. and min. working limits for the diameter of the hole (bush) and shaft running in the bush using:

- Class of fit: **H7 - g6**
- Basic size of **40**mm
- Basic size of **90**mm
- Basic size of your own choice





Homework

Max Clearance $C_{max}=0.050$

Min Clearance $C_{min}=0.009$

Allowance $= C_{min}$

System Tol: $T_S = 0.041$

Hole					Shaft				
Basic size	Upper tol.	Lower tol.	Max. size	Min. size	Basic size	Upper tol.	Lower tol.	Max. size	Min. size
10	+0.015	0	10.015	10.000	10	-0.005	-0.014	9.995	9.986
40	+0.025	0	40.025	40.000	40	-0.009	-0.025	39.991	39.975
90					90				

Exercise DrE-5

- Groups of 5. Each group has one assembly with several parts.
- Measure parts in the assembly together.
- Each member of the group will have to do his/her own part.
- Make sketch - drawing with all required dimensions, tolerances and surface finish notes.
- This sketch has to be approved and as such used as the basis for CAD-1 exercise.
- 2 week exercise