Engineering drawing

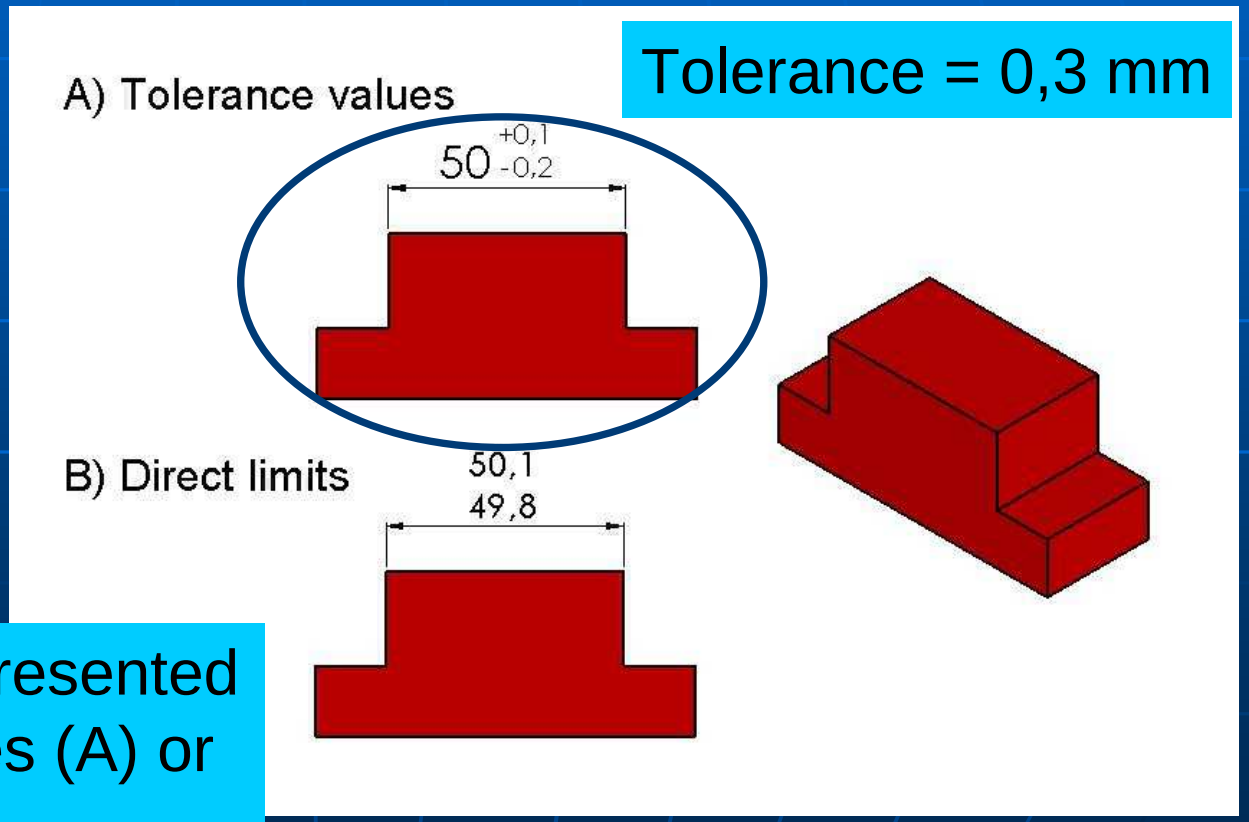
Semester I/II

Mechanical Engineering Department
Technical University of Gdańsk

Lecture 8

Representing Tolerance Values

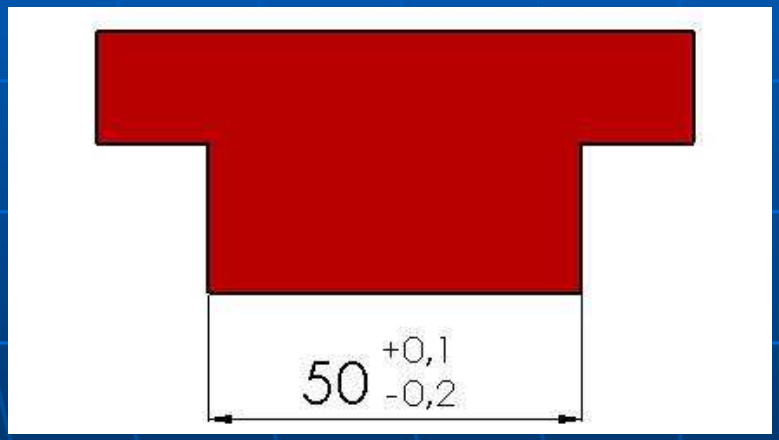
Tolerance is the total amount a dimension may vary and is the difference between the maximum and minimum limits.



Tolerances are represented as Tolerance Values (A) or as Direct Limits (B).

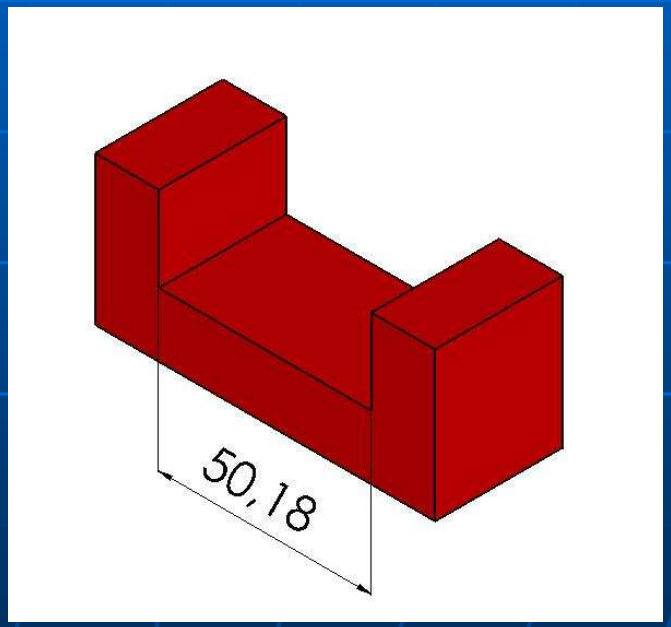
Important Terms of Toleranced Parts

Nominal Size is used to describe the general size of a part.



Engineering dimension drawing

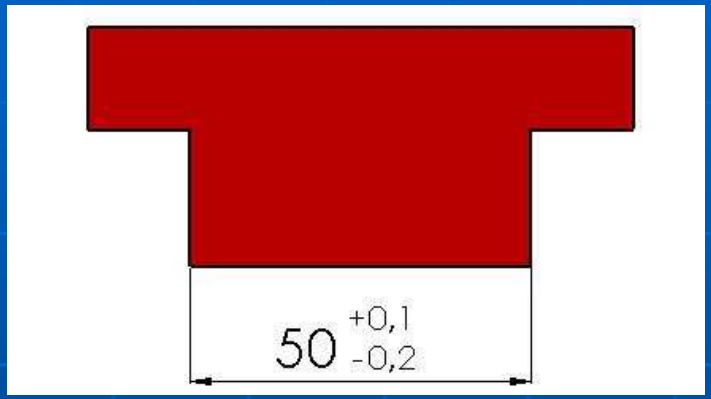
Actual Size is the measured size of the finished part after machining.



Machine part

Important Terms of Toleranced Parts

Limits – the maximum and minimum sizes shown by the tolerance dimension.

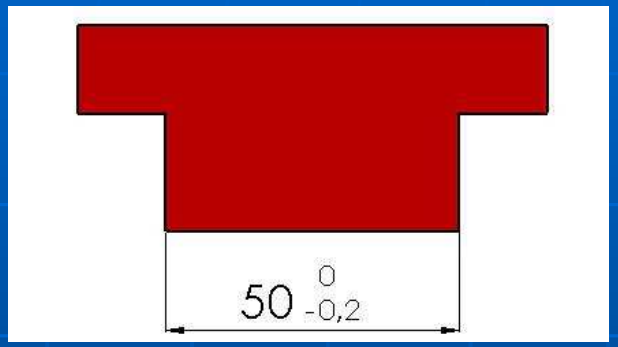


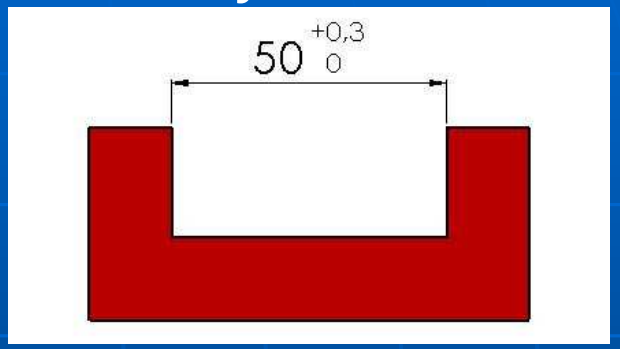
The large value on each part is the Upper Limit.
The small value on each part is the Lower Limit.
Lower deviation = -0,2 mm
Upper deviation = +0,1 mm

Tolerance – the total allowable variance in a dimension; the difference between the upper and lower limits ot the difference between the upper and lower deviations.

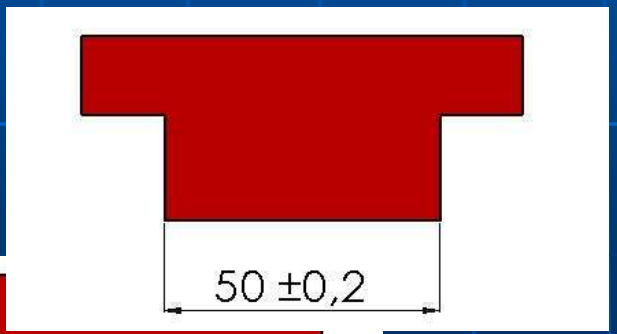
Tolerancing systems

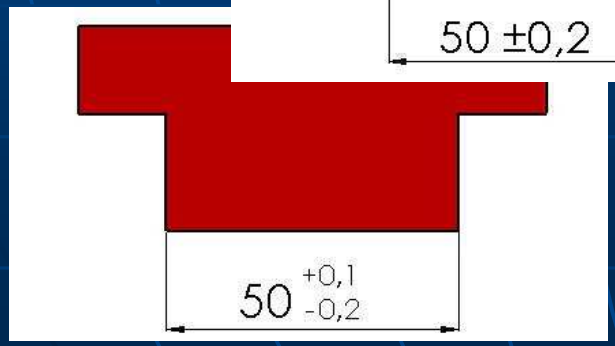
Unilateral tolerance system

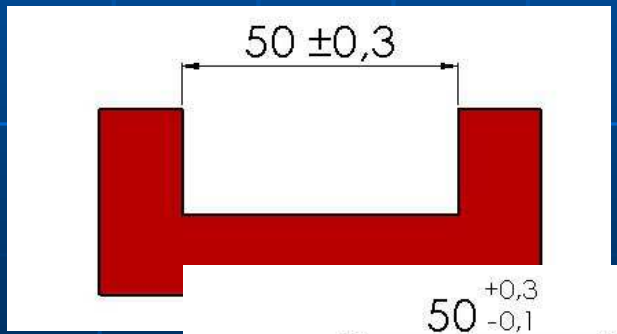


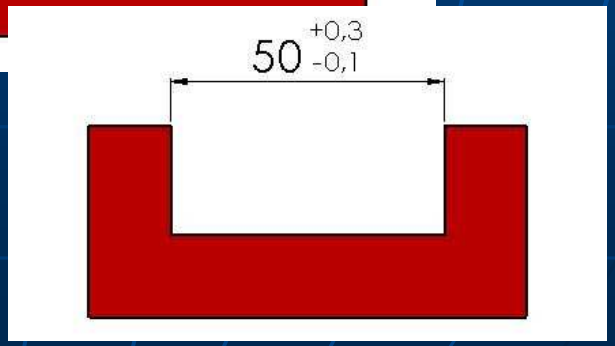


Bilateral tolerance system





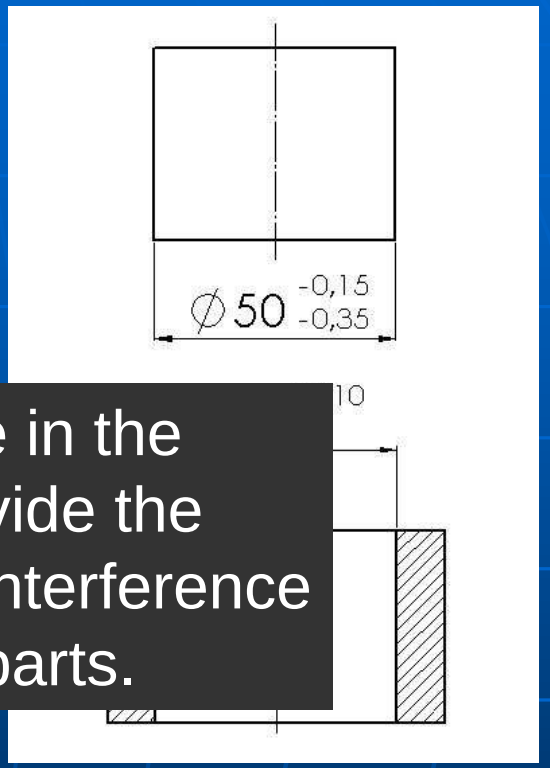




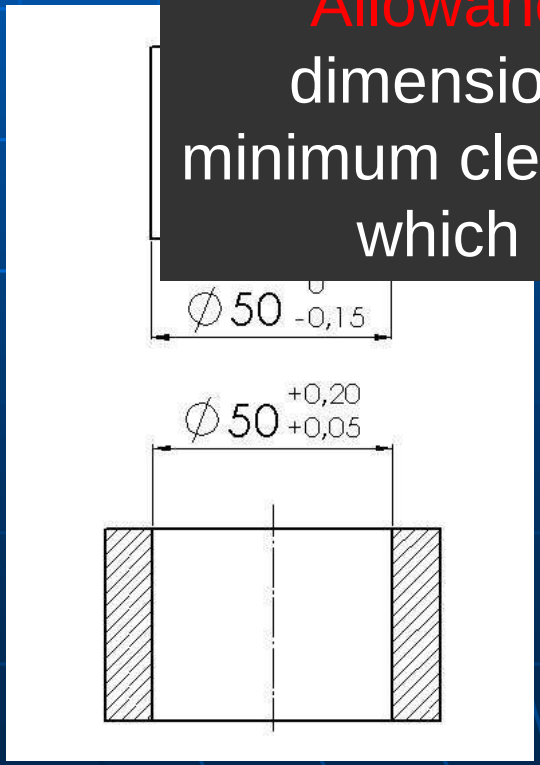
Tolerancing systems

Basic hole method

In this method the hole is considered as the basic size and the size of the shaft is determined by subtracting the allowance from the hole size



Allowance – intentional difference in the dimensions of mating parts to provide the minimum clearance or the maximum interference which is intended between the parts.



Basic shaft method

In this method the shaft is considered as the basic size and the size of the hole is determined by subtracting the allowance from the shaft size

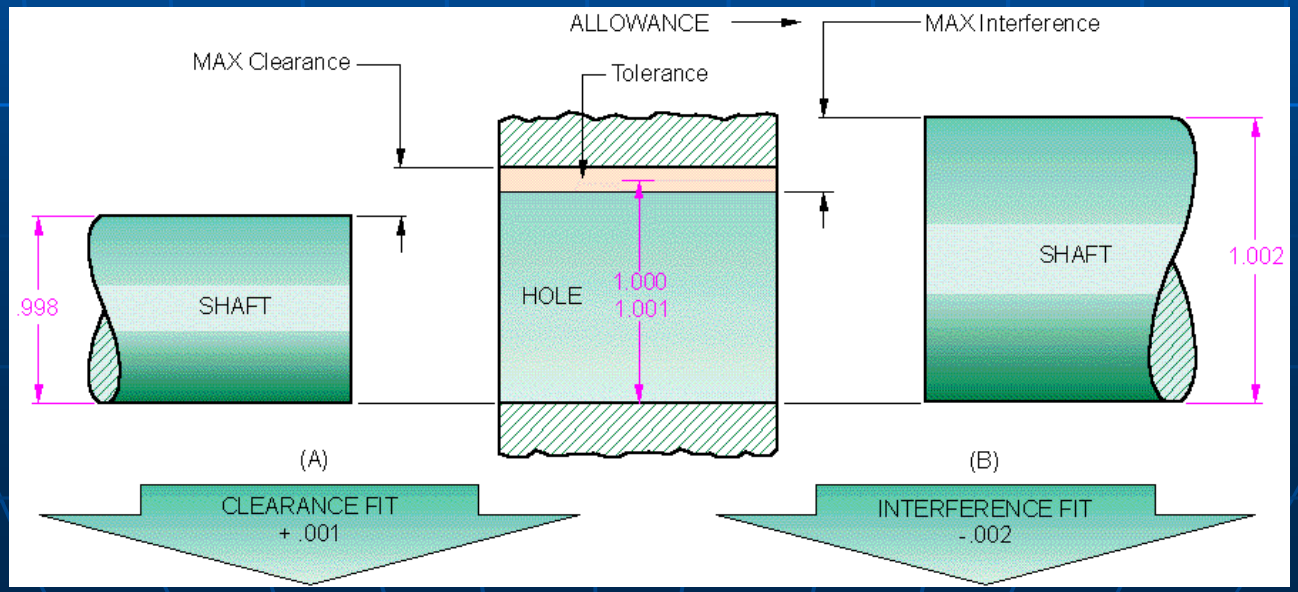
Nominal Sizes		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance	
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm
—	3	+60 0	-60 -120	+25 0	-20 0	+25 0	-14 -39	+14 0	-6 -16	+10 -	-2 -8	+10 0	-6 0
3	6	+ 75 0	-70 -145	+30 0	-30 -78	+30 0	-20 -50	+18 0	-10 -22	+12 0	-4 -12	+12 0	-8 0
6	10	+ 90 0	-80 -170	+36 0	-40 -98	+36 0	-25 -61	+22 0	-13 -28	+15 0	-5 -14	+15 0	-9 0
10	18	+ 110 0	-95 -205	+43 0	-50 -120	+43 0	-32 -75	+27 0	-16 -34	+18 0	-6 -17	+18 0	-11 0
18	30	+ 130 0	-110 -240	+52 0	-65 -149	+52 0	-40 -92	+33 0	-20 -41	+21 0	-7 -20	+21 0	-13 0
30	40	+ 160 0	-120 -280	+62	-80	+62	-50	+39	-25	+25	-9	+25	-16
40	50	+ 160 0	-130 -290	0	-180	0	-112	0	-50	0	-25	0	0
50	65	+ 190 0	-130 -330	+74	-100	+76	-60	+46	-30	+30	-12	+30	-19
65	80	+190 0	-150 -340	0	-220	0	-134	0	-60	0	-34	0	0
80	100	+220 0	-170 -390	+87	-120	+87	-72	+54	-36	+35	-12	+35	-22
100	120	+220 0	-180 -400	0	-260	0	-159	0	-71	0	-34	0	0
120	140	+250 0	-200 -450										
140	160	+250 0	-210 -460	+100 0	-145 -305	+100 0	-84 -185	+63 0	-43 -83	+40 0	-14 -39	+40 0	-25 0
160	180	+250 0	-230 -480										
180	200	+290 0	-240 -530										
200	225	+290 0	-260 -550	+115 0	-170 -355	+115 0	-100 -215	-72 0	-50 -96	+46 0	-15 -44	+46 0	-29 0
225	250	+290 0	-280 -570										
250	280	+320 0	-300 -620	+130	-190	+130	-190	+130	-110	+81	-96	+52	-17
280	315	+320 0	-330 -650	0	-400	0	-400	0	-240	0	-108	0	-49
315	355	+360 0	-360 -720	+140	-210	+140	-135	+89	-62	+57	-18	+57	-36
355	400	+360 0	-400 -760	0	-440	0	-265	0	-119	0	-54	0	0
400	450	+400 0	-440 840	+155	-230	+155	-135	+97	-68	+63	-20	+63	-40
450	500	+400 0	-480 -850	0	-480	0	-290	0	-131	0	-60	0	0

Tolerancing systems – fit types

A Clearance Fit occurs when two toleranced mating parts will always leave a space or clearance when assembled.

An Interference Fit occurs when two toleranced mating parts will always interfere when assembled.

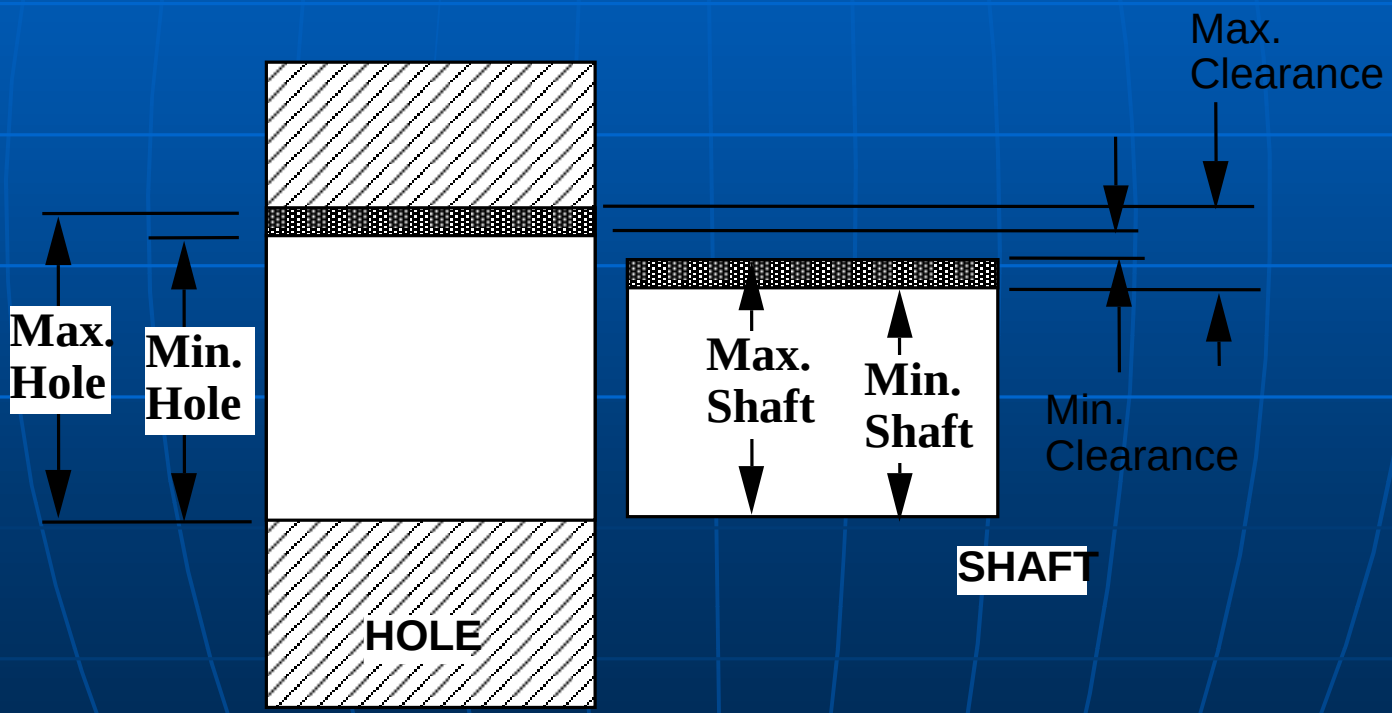
Transition fit – A transition fit might be either a clearance or interference fit. That is, a shaft may be either larger or smaller than the hole in a mating part



Tolerancing systems – fit types

Clearance Fits

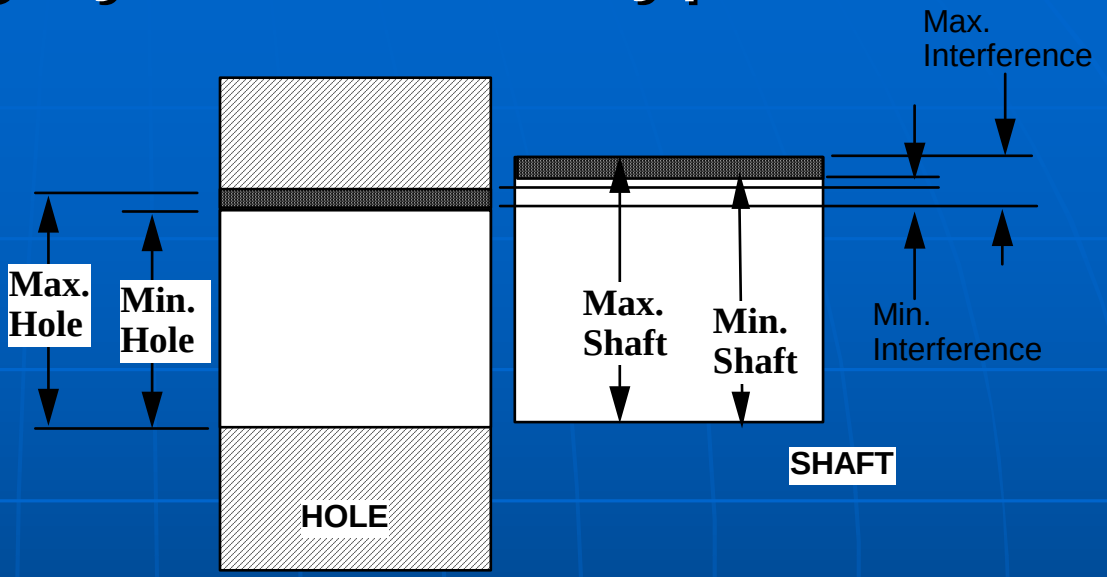
The largest permitted shaft diameter is smaller than the diameter of the smallest hole



Tolerancing systems – fit types

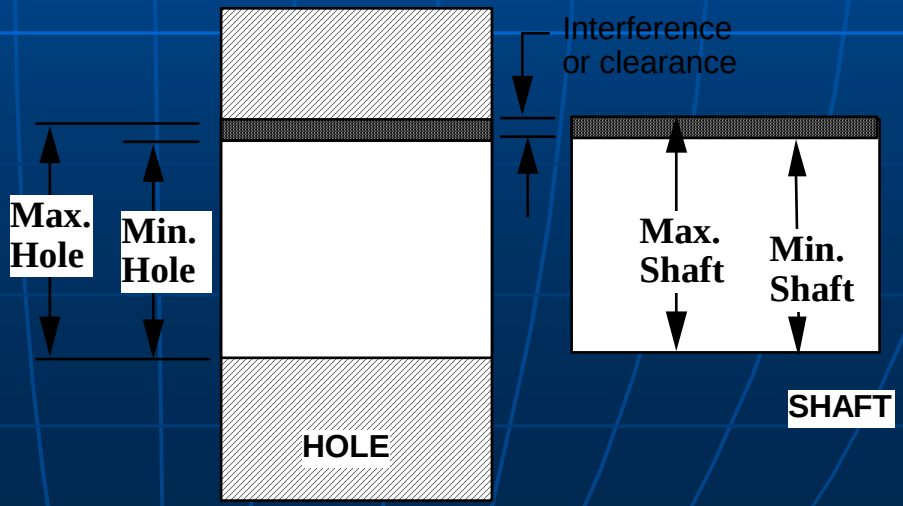
Interference Fits

The minimum permitted diameter of the shaft is larger than the maximum diameter of the hole



Transition Fits

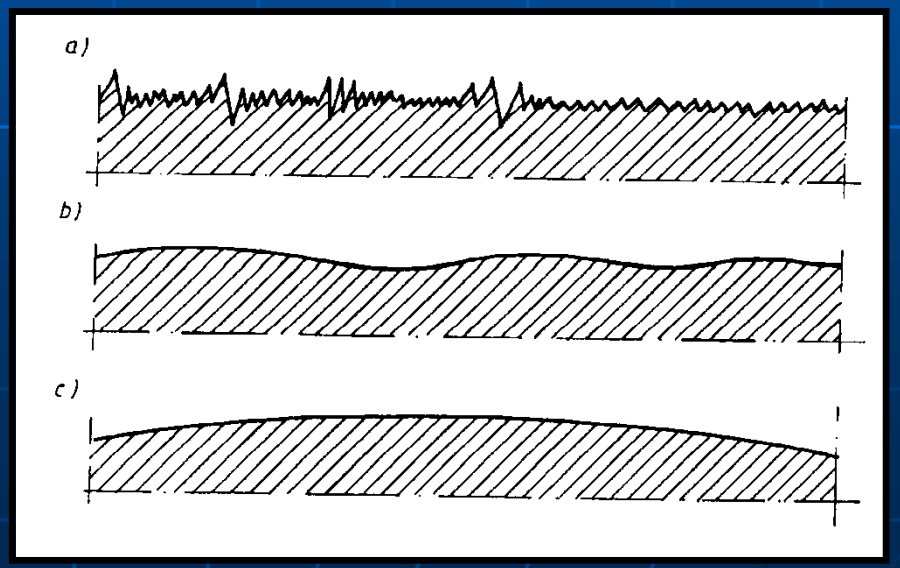
The diameter of the largest allowable hole is greater than that of the smallest shaft, but the smallest hole is smaller than the largest shaft



Surface roughness

The finish of a surface determines its quality as to smoothness, surface marks and the like, whereas tolerance refers to size and position only.

Roughness may be defined as the closely spaced surface irregularities produced by machining or grinding operations.



Surface roughness

Ra – the average arithmetic deviation of a profile from a mean line (roughness value)

Znormalizowane wartości parametru R_a [µm] (1 µm = 0,001 mm)

0,008	0,08	0,8	8	80
0,01	0,1	1	10	100
0,012	0,125	1,25	12,5	125
0,016	0,16	1,6	16	160
0,02	0,2	2	20	200
0,025	0,25	2,5	25	250
0,032	0,32	3,2	32	320
0,04	0,4	4	40	400
0,05	0,5	5	50	
0,063	0,63	6,3	63	

Parameter **R_a** is a basic parameter.

R_a values are standardized.

Surface roughness

Rz – the average maximum height of the profile

(It averages the height of the five highest peaks and the depth of the five lowest valleys over the measuring length, using an unfiltered profile)

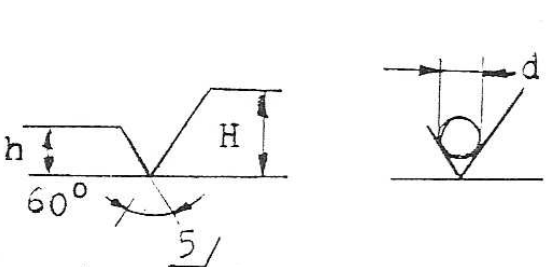
Znormalizowane wartości parametru R_z [µm] (1 µm = 0,001 mm)

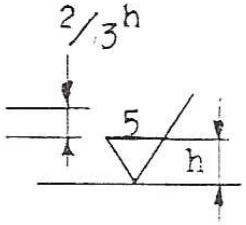
0,04	0,4	4	40	400
0,05	0,5	5	50	500
0,063	0,63	6,3	63	630
0,08	0,8	8	80	800
0,1	1	10	100	1000
0,125	1,25	12,5	125	1250
0,16	1,6	16	160	1600
0,2	2	20	200	2000
0,25	2,5	25	250	
0,32	3,2	32	320	

Parameter **R_z** is an auxiliary parameter.

R_z values are standardized.

Surface roughness



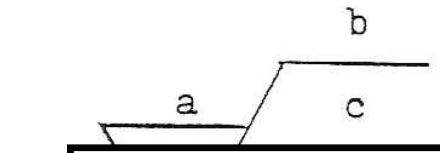


d 2/3 h

H = (1,5÷3)h

h - height of letters

The sign ▽ indicates that the surface should be machined and the average roughness height should not be larger than 5 μm (5×10^{-6} m).



a) Roughness value

b) Method, treatment , coating

c) Sampling length

▽ - machining method not defined

▽ - machine (cutting) machining

▽ - machining is forbiden - required roughness has to be obtained by means of other method

10 / 2,5 ▽ - roughness between 2,5 and 10 μm

grinding, turning ▽ - required method of machining

0.63 ▽ grinding = -required direction surface after machining

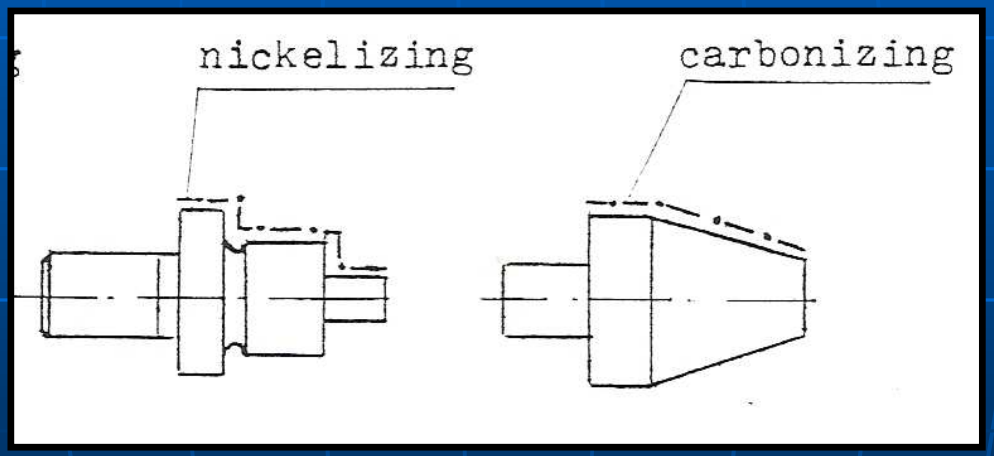
Surface roughness

Process	Ra [μm]
Turning	1,25 - 10
Milling	2,5 - 10
Drilling	5 - 10
Grinding	0,16 - 0,63
Polishing	0,04 - 0,16

Machining and surface roughness R_a values

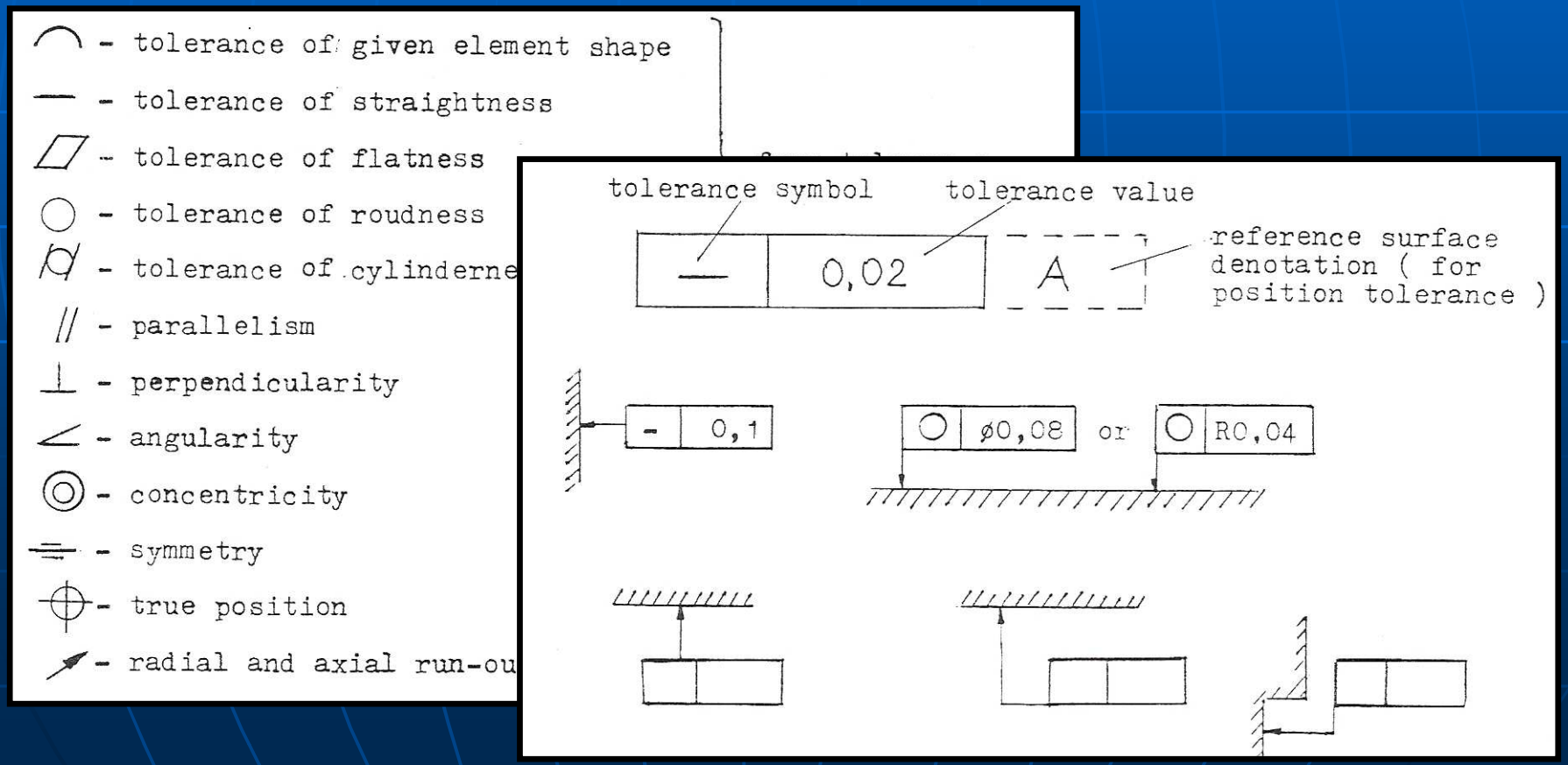
Heat treatment and surface treatment

Required heat treatment, cementation (carbonizing, hardening) or surface treatment (painting, polishing) are marked over special reference line.



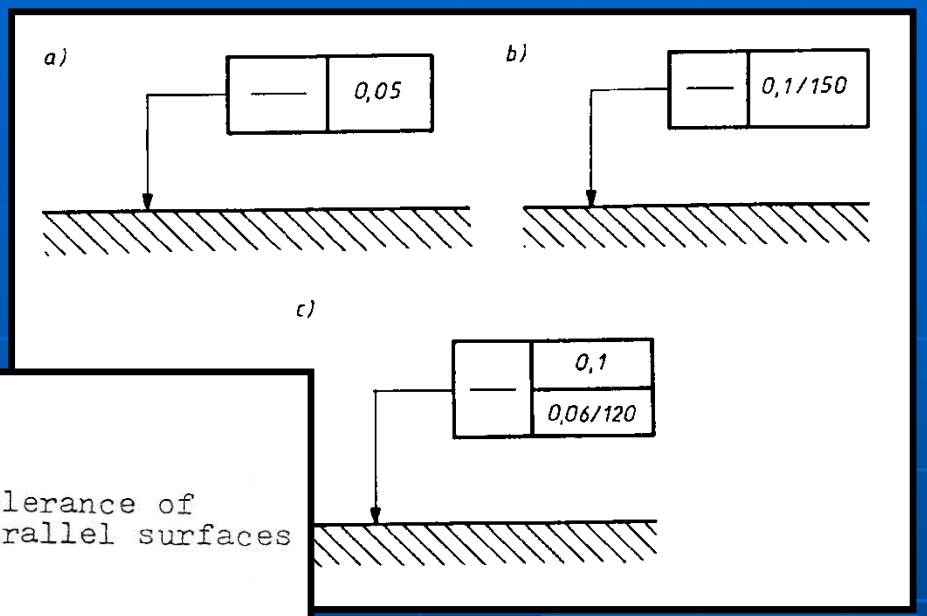
Shape – form and positional tolerancing

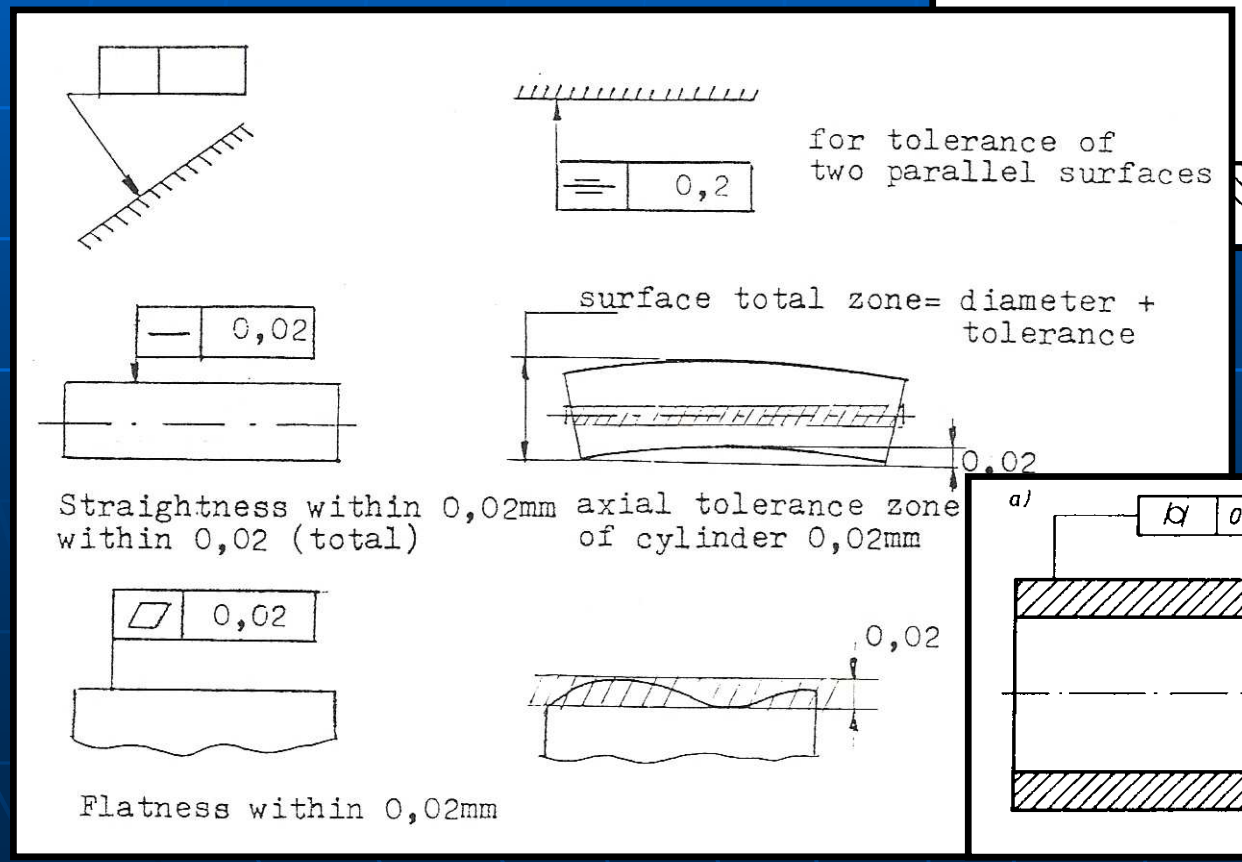
When grater accuracy of form (shape) is required, form tolerances must be specified apart from size tolerances. Such tolerances must naturally always be smaller then size tolerances.



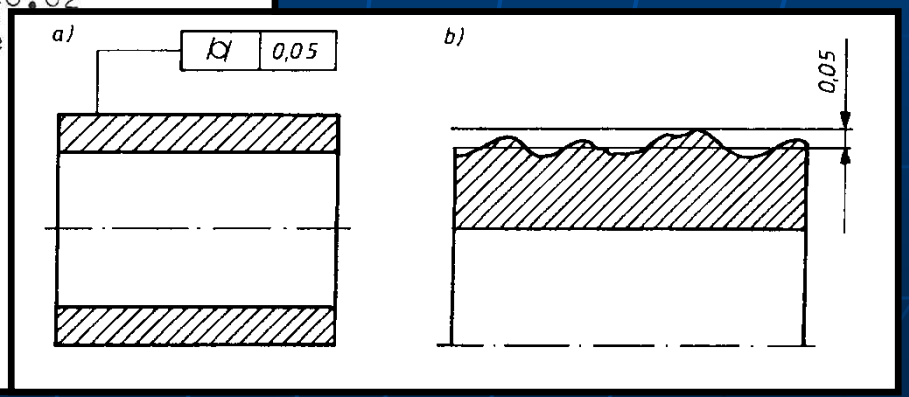
Shape – form and positional tolerancing

Shape – form deviation



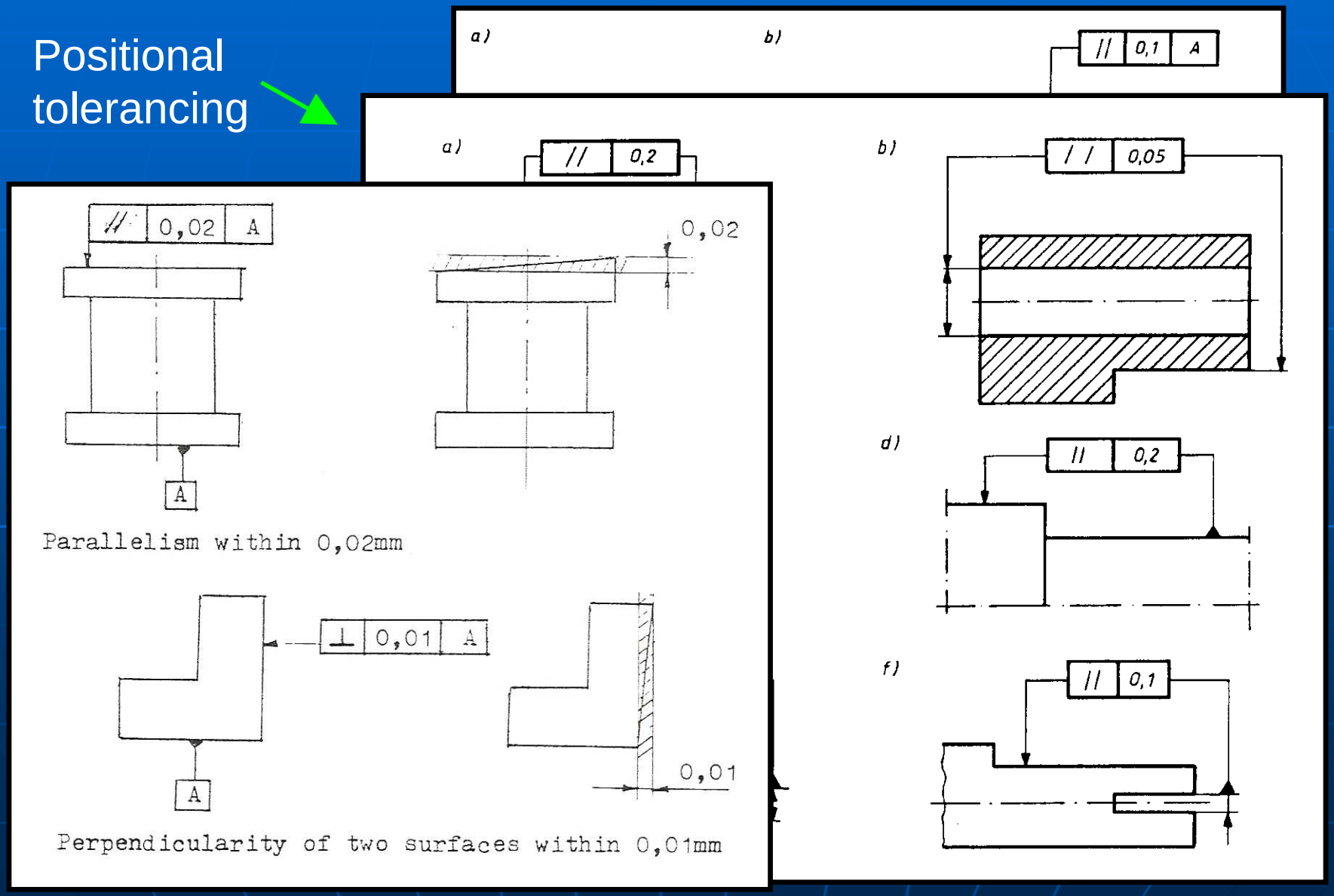


Straightness tolerance

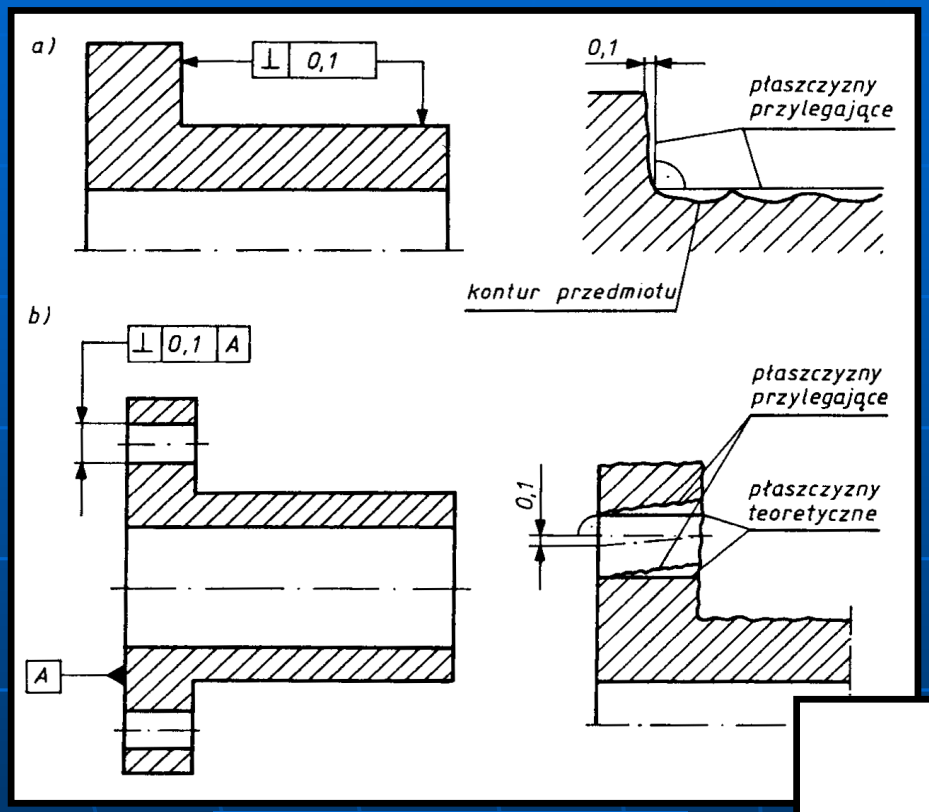


Shape – form and positional tolerancing

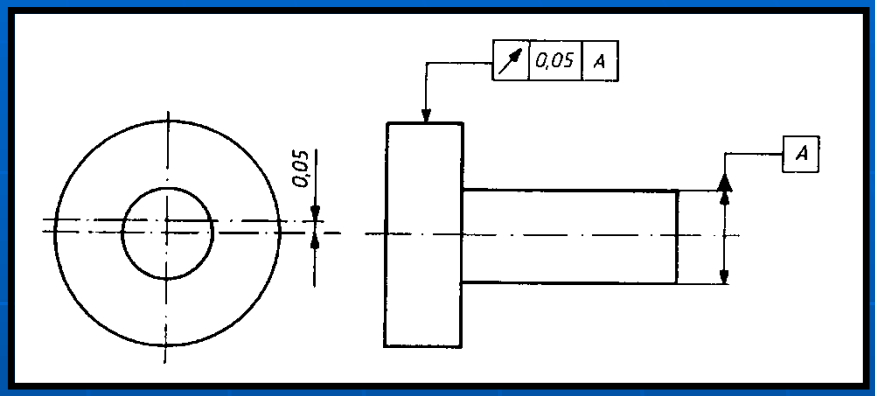
Positional tolerancing



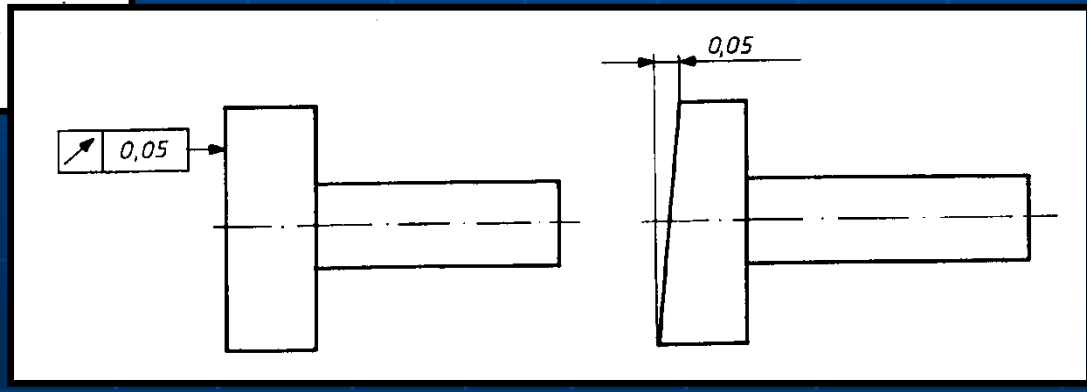
Shape – form and positional tolerancing



Perpendicularity



Radial run - out



Axial run - out