TOLERANCING

(DIMENSIONAL TOLERANCES AND FITS)

OVERVIEW

Interchangeable manufacturing requires effective size control by the designer because, in mass production, all parts must fit together properly, regardless of where they are made.

For example, an automobile manufacturer might subcontract parts manufacturing to other companies— both parts for new automobiles and replacement parts for repairs. All parts must be enough alike that each can fit properly in any assembly.

The maximum acceptable amount that an actual part feature can vary from a specified dimension is called ***tolerance.*** On technical drawings, tolerances specify the degree of accuracy required for the provided dimensions.

Parts can be made to very precise dimensions, even to thousandths of a millimeter—as in gage blocks—but highly accurate parts are extremely expensive to produce and there is still some variation between the exact dimension and the actual size of the part. Fortunately, perfectly exact sizes are not needed. The accuracy needed in a part depends on its function.

One aspect of quality is determined by manufacturing tolerances. Products with small variations in shape may fit together more precisely and command higher prices. However, it would not be practical for all products to be manufactured to high precision.

Tolerancing is an extension of dimensioning. It allows you to specify a range of accuracy for the shape, size, and position of every feature of a product, so that the manufactured parts will fit together and function properly when assembled. CAD software provide features for dimensioning, tolerancing, and checking fits and interferences that aid in the tolerancing process. To effectively provide tolerances in your drawings and CAD models, you must :

- **Understand the fit required between mating parts.**
- **Have a clear picture of how inspection measurements are performed.**
- **Be able to apply tolerance symbols to a drawing or model.**
- **Apply functional tolerancing to individual part features.**

Tolerance

Tolerance is the total amount a specific dimension is permitted to vary. Tolerances are specified so that any two mating parts will fit together. To keep part cost low, specify a tolerance as large as possible that still permits satisfactory function of the part.

TOLERANCE TYPES

There are two types of tolerances:

i) General Tolerances
Includes dimensional tolerances and fits
(Boyut toleransları ve alıştırma toleransları)

ii) Geometric Tolerances
Includes tolerances of shape/form and location/position
(Şekil ve konum toleransları

TERMS AND DEFINITIONS

TS 1845:1996, ISO 286-1:1988, BS EN 20286-1:1993

Shaft (Mil)
A term used, according to convention, to describe an external feature of a workpiece, including features which are not cylindrical.

Basic shaft (Esas-Normal Mil)
Shaft chosen as a basis for a shaft-basis system of fits for the purposes of the ISO system of limits and fits, a shaft the **upper deviation of which is zero**

Hole (Delik)
A term used, according to convention, to describe an internal feature of a workpiece, including features which are not cylindrical

Basic hole (Esas-Normal Delik)
Hole chosen as a basis for a hole-basis system of fits for the purposes of the ISO system of limits and fits, **a hole the lower deviation of which is zero**

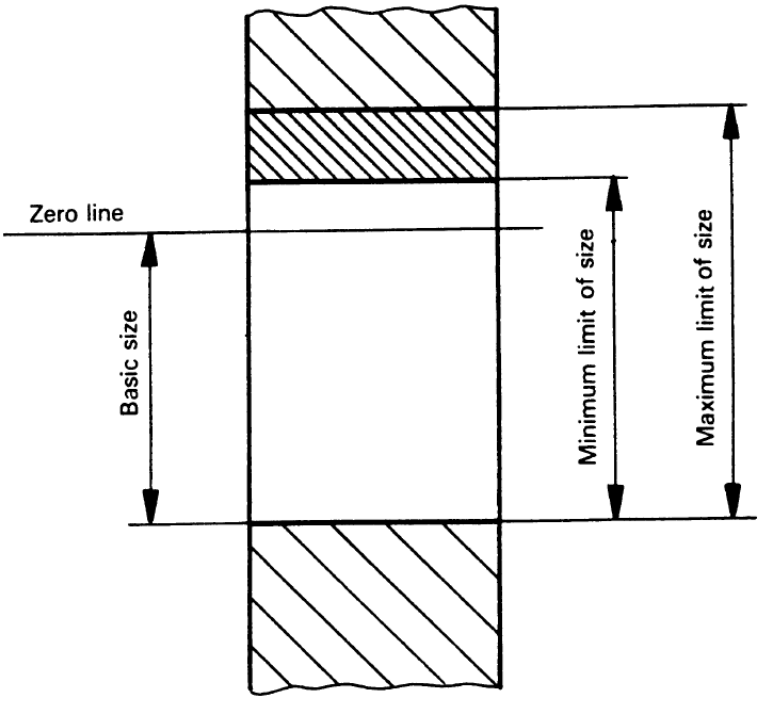
Size (Ölçü)
A number expressing, in a particular unit, the numerical value of a linear dimension.

Basic Size; Nominal size (Anma Ölçüsü-Nominal Ölçü, AÖ)
The size from which the limits of size are derived by the application of the upper and lower deviations (see following Figures). NOTE: The basic size can be a whole number or a decimal number, e.g. 32; 15; 8,75; 0,5; etc.

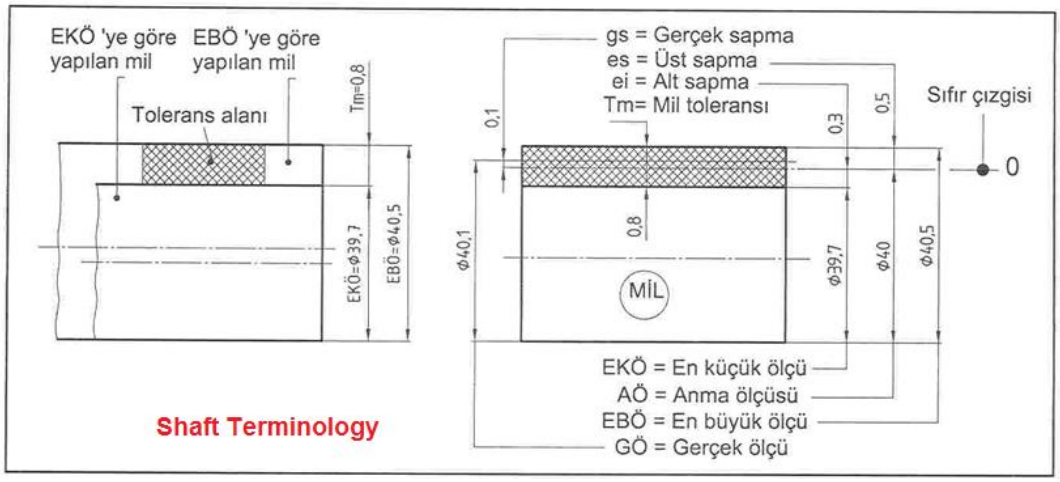
Actual size (Gerçek Ölçü, GÖ)
The size of a feature, obtained by measurement.

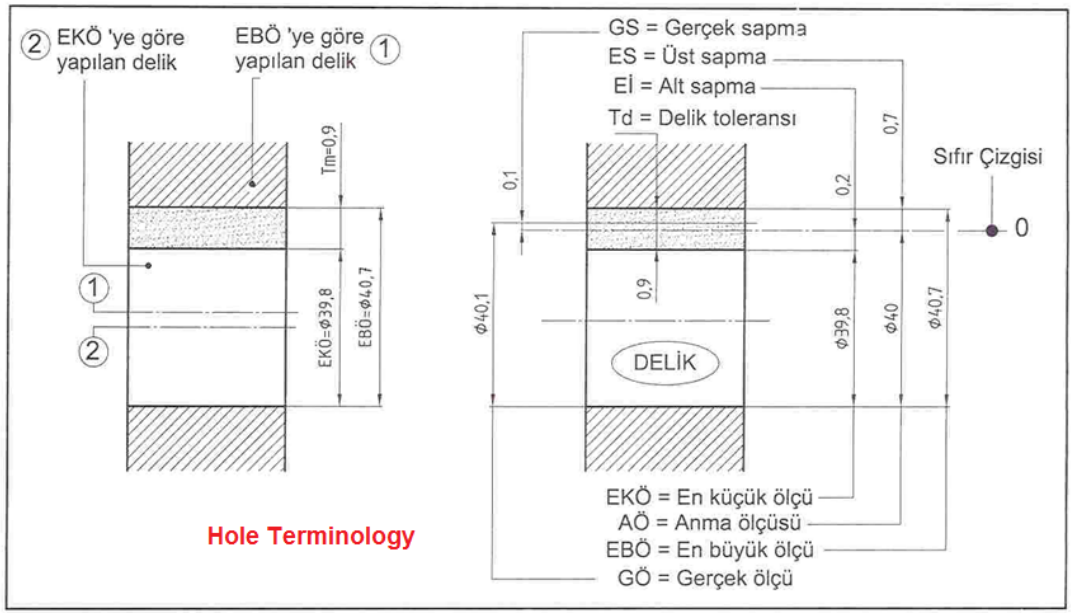
Maximum limit of size (En büyük sınır ölçüsü-En büyük ölçü, EBÖ)
The greatest permissible size of a feature (see following Figures)

Minimum limit of size (En küçük sınır ölçüsü-En küçük ölçü, EKÖ)
The smallest permissible size of a feature (see following Figures)



Basic size, and maximum and minimum limits of size

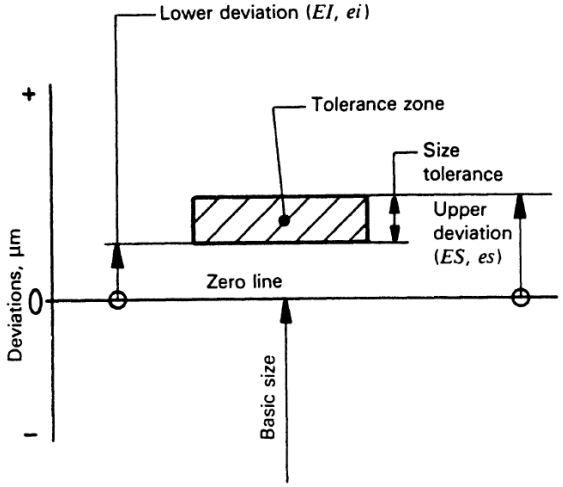




Zero line (Sıfır çizgisi)

In a graphical representation of limits and fits, the straight line, representing the basic size, to which the deviations and tolerances are referred (see above Figures)

According to convention, the zero line is drawn horizontally, with positive deviations shown above and negative deviations below (see below Figure)



Conventional representation of a tolerance zone

Deviation (Sapma)

The algebraic difference between a size (actual size, limit of size, etc.) and the corresponding basic size.

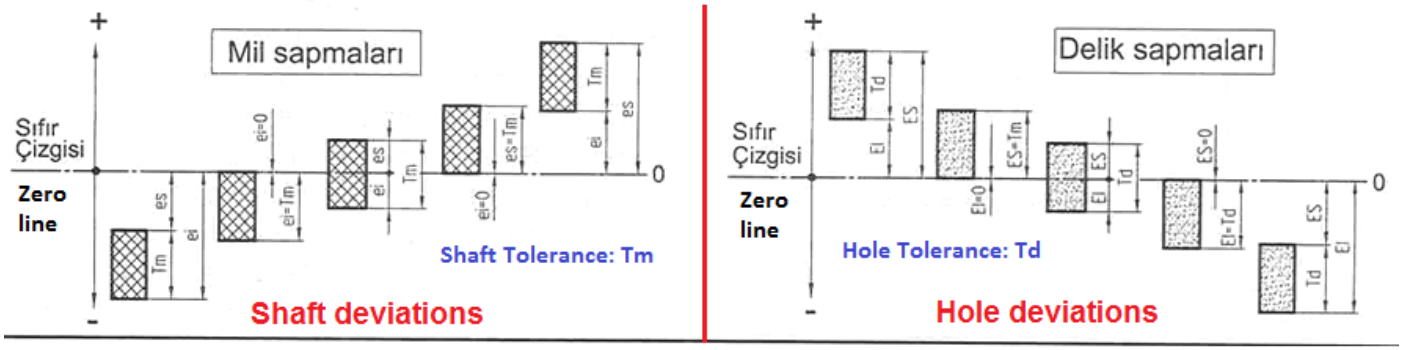
NOTE: Symbols for shaft deviations are lower case letters (*es, ei*) and symbols for hole deviations are upper case letters (*ES, EI*) (see above Figure).

Upper deviation *(Üst sapma, (ES, es))*
The algebraic difference between the maximum limit of size and the corresponding basic size (see above Figure)
ES (es) = EBÖ - AÖ

lower deviation *(Alt sapma, (EI, ei))*
The algebraic difference between the minimum limit of size and the corresponding basic size (see above Figure)
EI (ei) = EKÖ – AÖ

Actual deviation (Gerçek sapma , (GS))
The algebraic difference between the actual size and the corresponding basic size (see above Figure)
GS = GÖ – AÖ

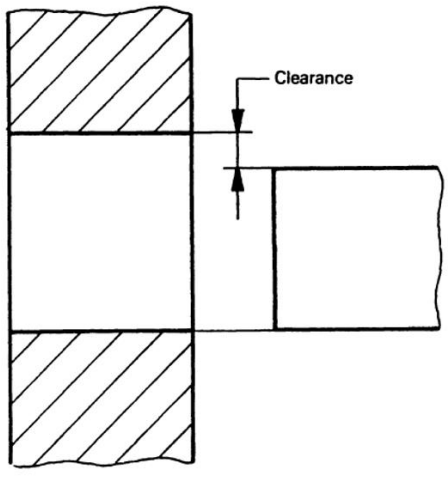
Upper and Lower deviations of holes and shafts above and below the zero line can be located as in the following Figure. Deviations above zero line are positive (+), and deviations below zero line are negative (-). These are all possible combinations of deviations according to basic size of shaft and hole.



Upper deviation : es (ES) = EBÖ – AÖ; (es: for shaft, ES: for hole)
Lower deviation: ei (Eİ) = EKÖ – AÖ; (ei: for shaft, Eİ: for hole)

Size tolerance (Ölçü toleransı, T)
The difference between the maximum limit of size and the minimum limit of size, i.e. the difference between the upper deviation and the lower deviation. NOTE: The tolerance is an absolute value without sign.
T = EBÖ – EKÖ or
T = ES (es) – EI (ei)

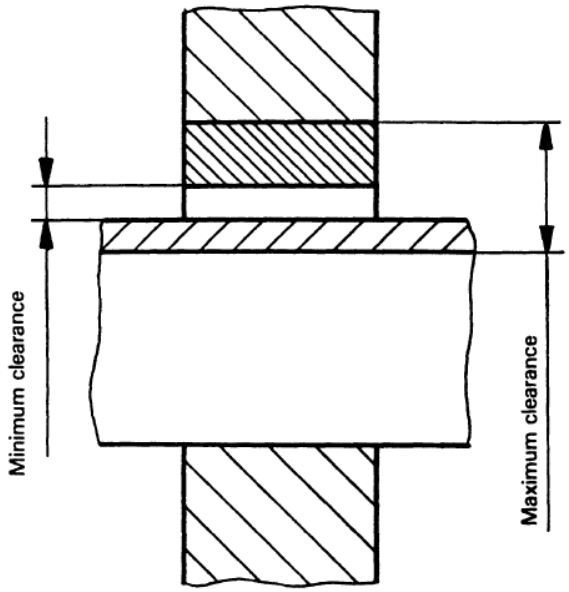
Clearance (Boşluk)
The positive (+) difference between the sizes of the hole and the shaft, before assembly, when the diameter of the shaft is smaller than the diameter of the hole (see below Figure).



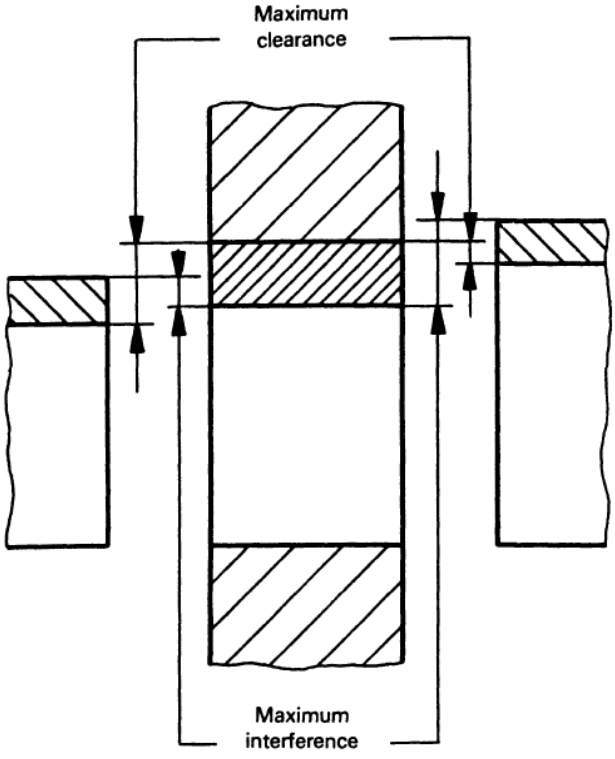
Clearance

Maximum clearance (En büyük boşluk, EBB)
In a clearance or transition fit, the positive difference between the maximum limit of size of the hole and the minimum limit of size of the shaft (see below Figures)
EBB = Hole (Delik) EBÖ – Shaft (Mil) EKÖ

Minimum clearance (En küçük boşluk, EKB)
In a clearance fit, the positive difference between the minimum limit of size of the hole and the maximum limit of size of the shaft (see below Figures)
EKB = Hole (Delik) EKÖ – Shaft (Mil) EBÖ

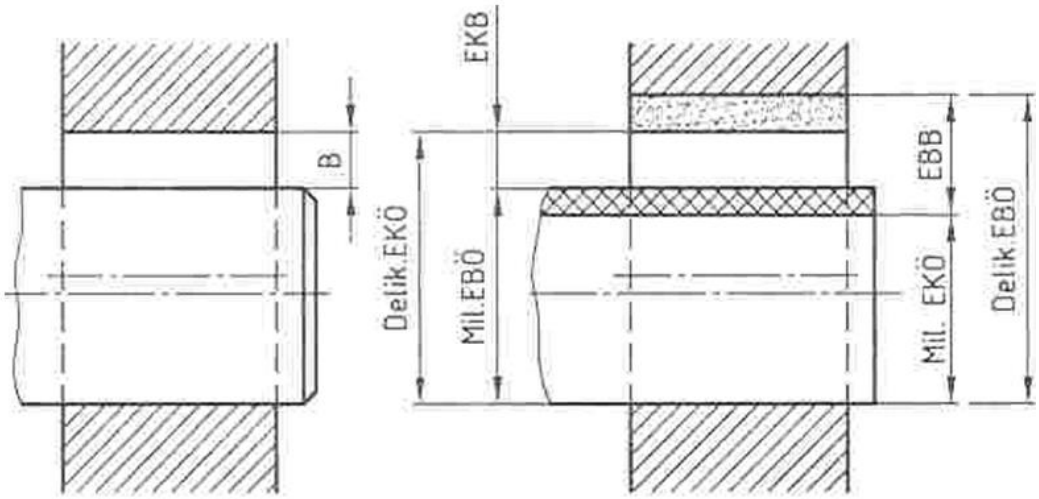


Clearance fit



Transition fit

CLEARANCE



Hole size > Shaft size ------> CLEARANCE

Clearance = Hole Size - Shaft Size (+)

Maximum Clearence = Maximum Hole Size - Minimum Shaft Size (Clearance Fit or Transition Fit)

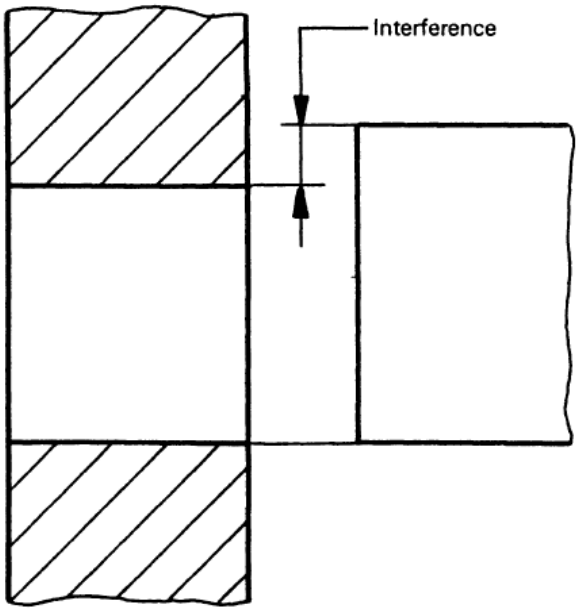
Minimum Clearence = Minimum Hole Size - Maximum Shaft Size (Clearance Fit)

EBB = Delik EBÖ – Mil EKÖ (Boşluklu veya belirsiz alıştırmada)

EKB = Delik EKÖ – Mil EBÖ (Boşluklu alıştırmada)

Interference (Sıkılık)

The negative (-) difference between the sizes of the hole and the shaft, before assembly, when the diameter of the shaft is larger than the diameter of the hole (see below Figure).



Interference

Maximum interference (En büyük sıkılık, EBS)

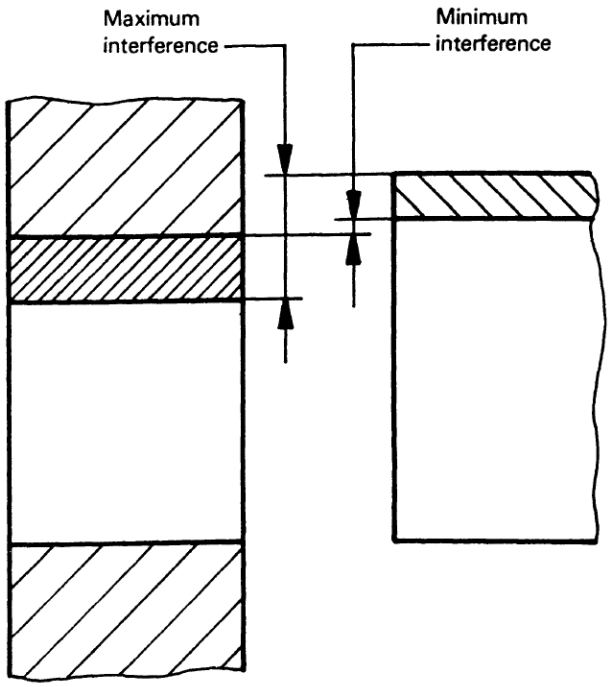
In an interference or transition fit, the negative difference, before assembly, between the minimum limit of size of the hole and the maximum limit of size of the shaft (see below Figures)

EBS = Hole (Delik) EKÖ – Shaft (Mil) EBÖ

Minimum interference (En küçük sıkılık, EKS)

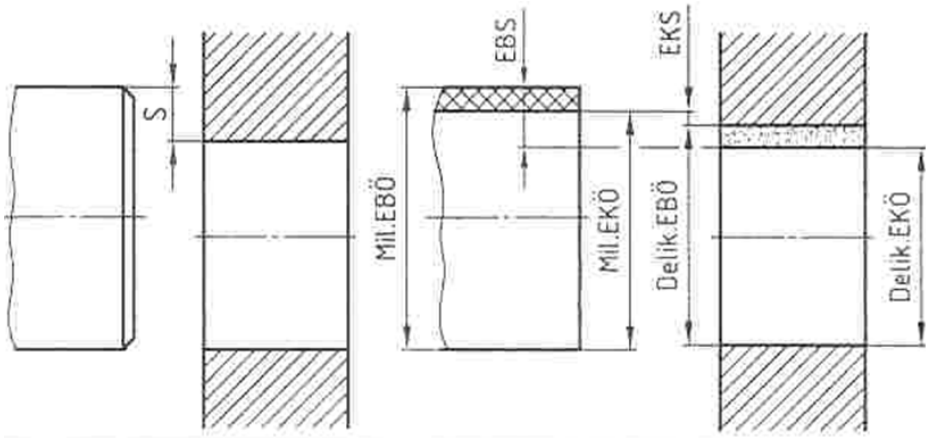
In an interference fit, the negative difference, before assembly, between the maximum limit of size of the hole and the minimum limit of size of the shaft (see below Figures)

EKS = Hole (Delik) EBÖ – Shaft (Mil) EKÖ



Interference fit

INTERFERENCE



Hole Size < Shaft Size -------> INTERFERENCE
Interference = Hole Size - Shaft Size (-)
Maximum Interference = Minimum Hole Size - Maximum Shaft Size (Interference Fit or Transition Fit)
Minimum Interference = Maximum Hole Size - Minimum Shaft Size (Interference Fit)

EBS = Delik EKÖ – Mil EBÖ (Sıkı veya belirsiz alıştırmada)
EKS = Delik EBÖ – Mil EKÖ (Sıkı alıştırmada)

Standard tolerance (Esas tolerans, IT)

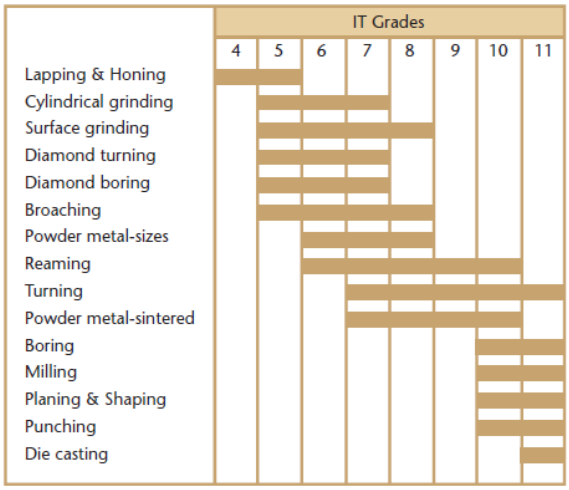
For the purposes of the ISO system of limits and fits, any tolerance belonging to this system.
NOTE: The letters of the symbol IT stand for “International Tolerance” grade.

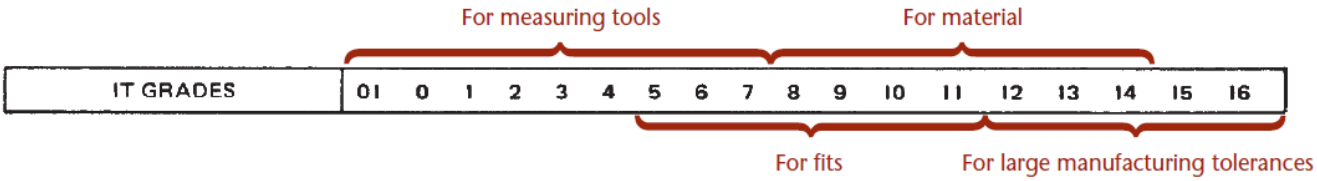
Standard tolerance grades (Esas tolerans niteliği)

For the purposes of the ISO system of limits and fits, a group of tolerances, considered as corresponding to the same level of accuracy for all basic sizes.
The standard tolerance grades are designated by the letters IT followed by a number, e.g. IT7. When the tolerance grade is associated with (a) letter(s) representing a fundamental deviation to form a tolerance class, the letters IT are omitted, e.g. h7.
NOTE: The ISO system provides for a total of 20 standard tolerance grades of which grades IT1 to IT18 are in general use. Grades IT0 and IT01 are not in general use.

The IT grades related to machining processes and practical use of the IT grades are shown in the following Figures.

International Tolerance Grades Related to Machining Processes





Practical Use of the International Tolerance Grades

	Küçük toleranslar					Orta toleranslar								Büyük toleranslar							
ISO-Nitelikleri	01	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Kullanım alanları	Mastarlar için					İş parçaları için															
						Alıştırmalar için								Çekilmiş, haddelenmiş,dövülmüş ve dökülmüş parçalar için							

Şekil 9: Tolerans niteliklerinin kullanım alanları

Standard tolerance factor (Tolerans faktörü, i)

For the purposes of the ISO system of limits and fits, a factor which is a function of the basic size, and which is used as a basis for the determination of the standard tolerances of the system.

Calculation of the standard tolerance value for each IT grade:

The standard tolerance value for each IT grade is obtained by multiplying a coefficient “k” specified for each of the IT grade with the standard tolerance factor “i”.

Standard tolerance factor “i” for the diameter groups of 1…throgh 500 mm is given by the empirical relation,

$$i = 0{,}45 \cdot \sqrt[3]{D} + 0{,}001\,D$$

and for the diameter groups of 500….through 3150 mm

$$i = 0{,}004\,D + 2{,}1$$

Here, D is the geometrical mean of the extreme sizes (min. and max. values) of the diameter group considered and given as

$$D = \sqrt{D_1 . D_2}$$

where “i” is in micrometres (µm) and D is in millimetres (mm).

Note that these relations are valid for IT5….through IT18 grades. For grades below IT5 there are other empirical relations (refer IS : 1919-193 standards).

The standard tolerance values for different IT grades can be calculated according to the following Table.
In that Table, coefficient "k" is given for each IT grade. Moreover, standard tolerance factor "i" can be calculated from above relations, as explained.

IT Grade	IT5	IT6	IT7	**IT8**	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
Standard Tolerance value (k.i)	7i	10i	16i	**25i**	40i	64i	100i	160i	250i	400i	640i	1000i	1600i	2500i

Standard tolerance values calculated and rounded at each nominal diameter group of all of 20 IT grades are given in the following Table.

Note: Tolerance values in this table are in µm. (1 µm = 0.001 mm)

Nominal size (mm) over…to (inc)	TOLERANCE GRADES (IT01 … IT18)																			
	01	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.....3	0,3	0,5	0,8	1,2	2	3	4	6	10	14	25	40	60	100	140	250	400	600	1000	1400
3.....6	0,4	0,6	1	1,5	2,5	4	5	8	12	18	30	48	73	120	180	300	480	750	1200	1800
6.....10	0,4	0,6	1	1,5	2,5	4	6	9	15	22	36	58	90	150	220	360	580	900	1500	2200
10.....18	0,5	0,8	1,2	2	3	5	8	11	18	27	43	70	110	180	270	430	700	1100	1800	2700
18.....30	0,6	1	1,5	2,5	4	6	9	13	21	33	52	84	130	210	330	520	840	1300	2100	3300
30.....50	0,6	1	1,5	2,5	4	7	11	16	25	39	62	100	160	250	390	620	1000	1600	2500	3900
50.....80	0,8	1,2	2	3	5	8	13	19	30	46	74	120	190	300	460	740	1200	1900	3000	4600
80...120	1	1,5	2,5	4	6	10	15	22	35	54	87	140	220	350	540	870	1400	2200	3500	5400
120...180	1,2	2	3,5	5	8	12	18	25	40	63	100	160	250	400	630	1000	1600	2500	4000	6300
180...250	2	3	4,5	7	10	14	20	29	46	72	115	185	290	460	720	1150	1850	2900	4600	7200
250...315	2,5	4	6	8	12	16	23	32	52	81	130	210	320	520	810	1300	2100	3200	5200	8100
315...400	3	5	7	9	13	18	25	36	57	89	140	230	360	570	890	1400	2300	3600	5700	8900
400...500	4	6	8	10	15	20	27	40	63	97	155	250	400	630	970	1550	2500	4000	6300	9700

Example : Calculate the standard tolerance value at the diameter group of (10…18) mm for IT8 grade.
Solution:

Geometrical mean formula: $D = \sqrt{D_1 D_2}$

$D = \sqrt{10.18} = 13.42\ mm$

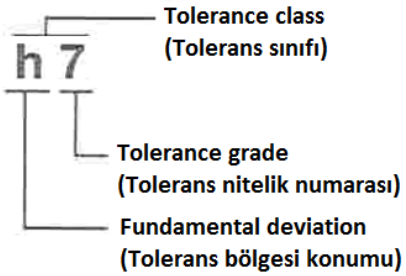
Standard tolerance factor formula: $i = 0.45 \cdot \sqrt[3]{D} + 0.001 D$

$i = 0.45 \cdot \sqrt[3]{13.42} + 0.001(13.42) = 1.083$

Standard tolerance value = k.i , (k=25 for IT8 grade)
Standard tolerance value = k.i = (25)(1.083) = 27.075≈**27 µm=0.027 mm** (tallies with the value in Table).

Tolerance class

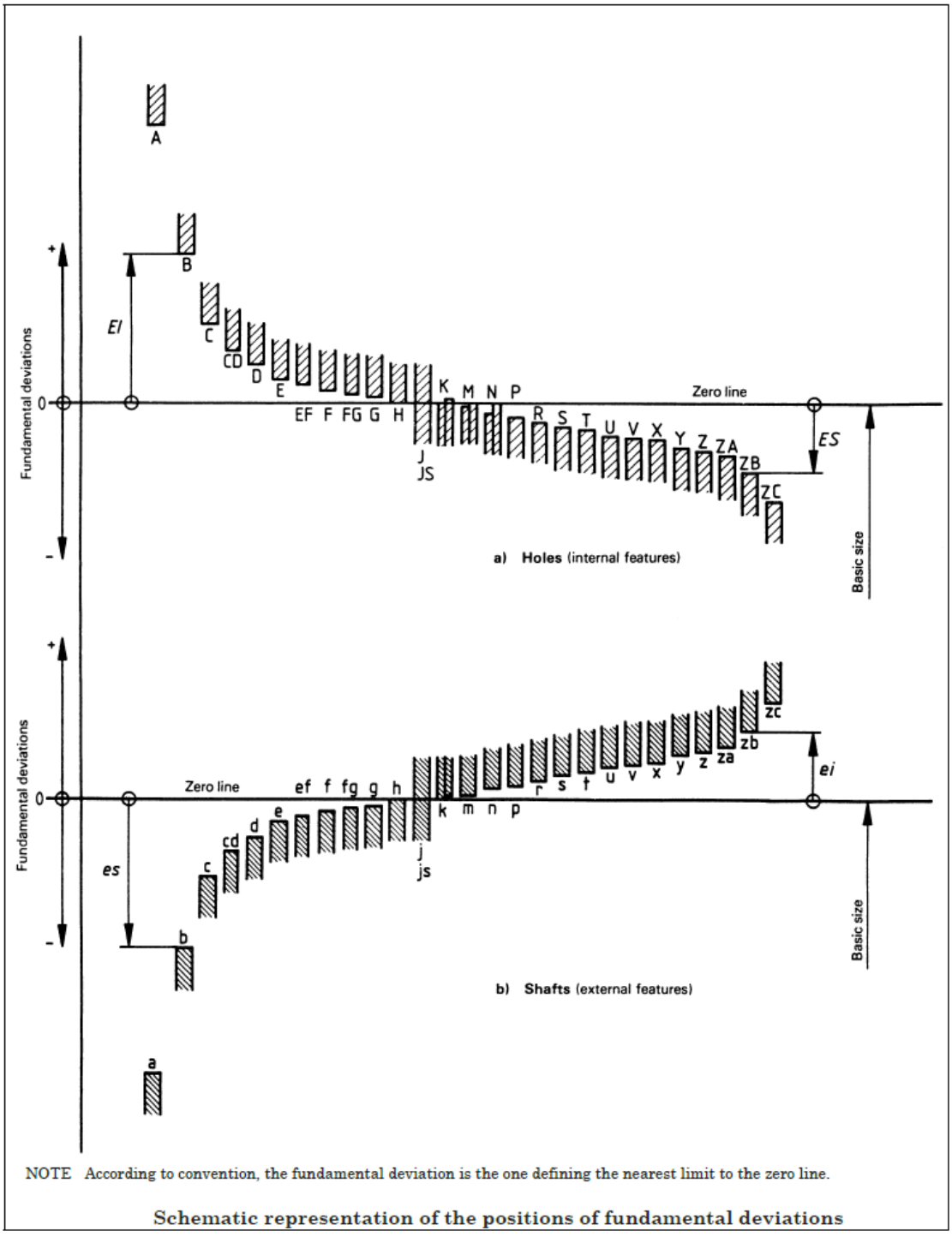
The term used for a combination of fundamental deviation and a tolerance grade, e.g. h9, D13, etc.



Position of tolerance zone

The position of the tolerance zone with respect to the zero line, which is a function of the basic size, is designated by (an) upper case letter(s) for holes (A . . . ZC) or (a) lower case letter(s) for shafts (a . . . zc)
(see following Figure).

NOTE: To avoid confusion, the following letters are not used:
I, i; L, l; O, o; Q, q; W, w.



NOTE According to convention, the fundamental deviation is the one defining the nearest limit to the zero line.

Schematic representation of the positions of fundamental deviations

Fit (Alıştırma)

The relationship resulting from the difference, before assembly, between the sizes of the two features (the hole and the shaft) which are to be assembled.

NOTE: The two mating parts of a fit have a common basic size.

Variation of a fit (Alıştırma Toleransı, AT)

The arithmetic sum of the tolerances of the two features (the hole and the shaft) comprising the fit.

NOTE: The variation of a fit is an absolute value without sign.

$AT = T_{hole} + T_{shaft}$

$AT = T_{delik} + T_{mil}$ or

AT = EBB - EKB or

AT = EBS - EKS

Fit types

There are three general types of fits between parts:

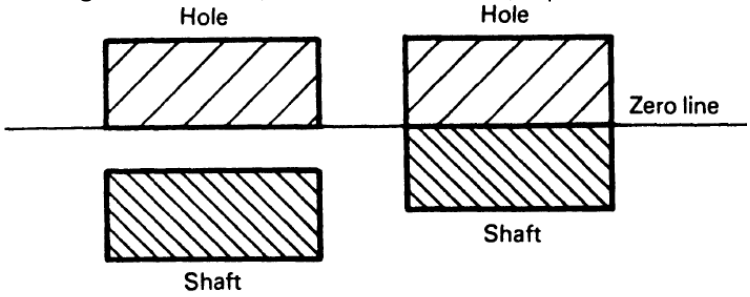
- Clearance fit (Boşluklu alıştırma-geçme)

- Interference fit (Sıkı alıştırma-geçme)

- Transition fit (Belirsiz (ara) alıştırma-geçme)

Clearance fit (Boşluklu alıştırma-geçme)

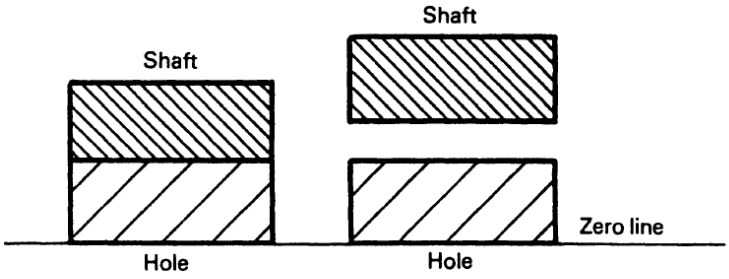
A fit that always provides a clearance between the hole and shaft when assembled, i.e. the minimum size of the hole is either greater than or, in the extreme case, equal to the maximum size of the shaft (see below Figure)



Schematic representation of clearance fits

Interference fit (Sıkı alıştırma-geçme)

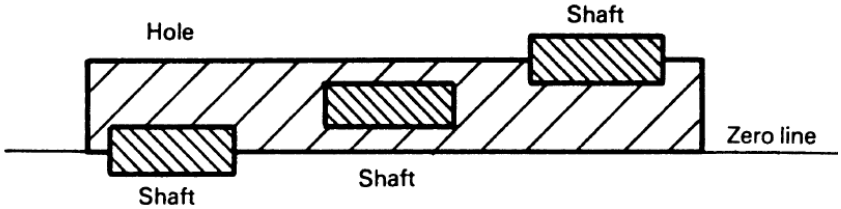
A fit which everywhere provides an interference between the hole and shaft when assembled, i.e. the maximum size of the hole is either smaller than or, in the extreme case, equal to the minimum size of the shaft (see below Figure)



Schematic representation of interference fits

Transition fit (Belirsiz (ara) alıştırma-geçme)

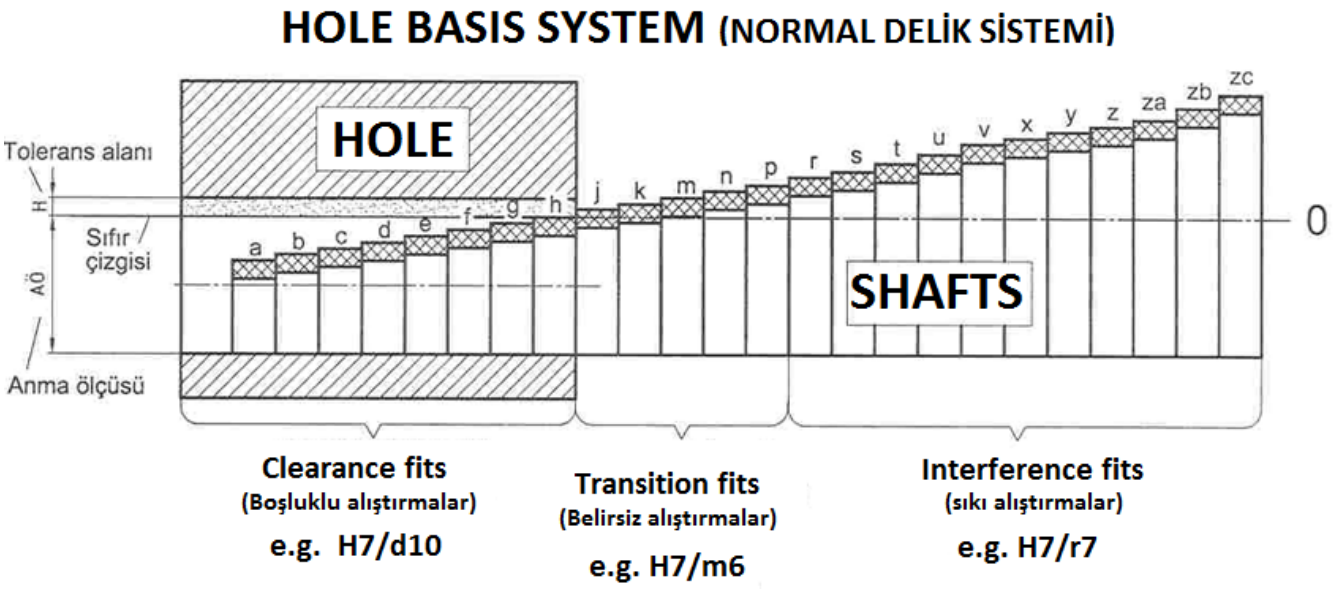
A fit which may provide either a clearance or an interference between the hole and shaft when assembled, depending on the actual sizes of the hole and shaft, i.e. the tolerance zones of the hole and the shaft overlap completely or in part (see below Figure)



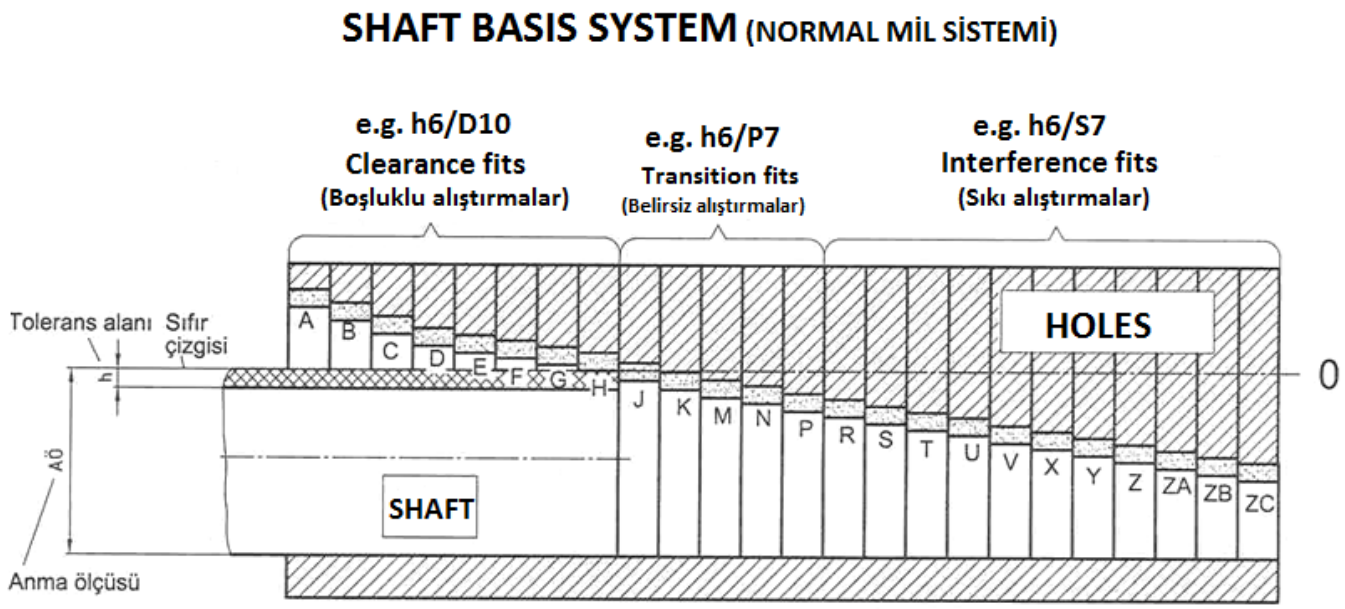
Schematic representation of transition fits

Fit system (Alıştırma sistemi)
A system of fits comprising shafts and holes belonging to a limit system.

Hole-basis system of fits (Normal delik alıştırmalar sistemi)
A system of fits in which the required clearances or interferences are obtained by associating shafts of various tolerance classes with holes of a single tolerance class (i.e. The size of the hole is kept constant and the size of the shaft is varied to get the different class of fits). The hole basis system is preferred in most cases, since standard tools like drills, reamers, broaches, etc., are used for making a hole.
For the purposes of the ISO system of limits and fits, a system of fits in which **the minimum limit of size of the hole is identical to the basic size, i.e. the lower deviation of the hole is zero (EI=0). The letter symbol for the hole for this situation is 'H'** (see below Figure). Required clearance, interference or transition fits can be obtained by varying the shaft tolerance zone from "a" to "zc" and tolerance grade for this hole.



Shaft-basis system of fits
A system of fits in which the required clearances or interferences are obtained by associating holes of various tolerance classes with shafts of a single tolerance class (i.e. The size of the shaft is kept constant and the size of the hole is varied to get the different class of fits). The shaft basis system is preferred by (*i*) industries using semi-finished shafting as raw materials, *e.g.,* textile industries, where spindles of same size are used as cold-finished shafting and (*ii*) when several parts having different fits but one nominal size is required on a single shaft.
For the purposes of the ISO system of limits and fits, a system of fits in which **the maximum limit of size of the shaft is identical to the basic size, i.e. the upper deviation of the shaft is zero (es=0).). The letter symbol for the shaft for this situation is 'h'** (see below Figure). Required clearance, interference or transition fits can be obtained by varying the hole tolerance zone from "A" to "ZC" and tolerance grade for this shaft.



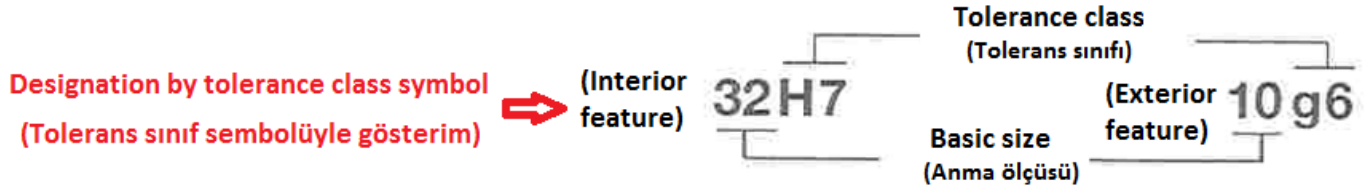
DESIGNATION of TOLERANCED INDIVIDUAL DIMENSIONS IN DRAWING

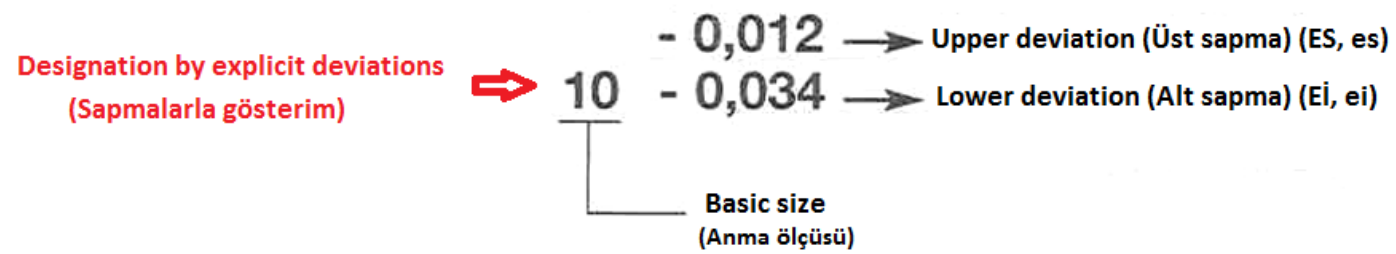
A toleranced size is

i) designated by the basic size followed by the designation of the required tolerance class (fundamental deviation letter followed by tolerance grade numeral), or

ii) designated by the basic size followed by the explicit deviations.

Examples:





$$\phi\,25H7 = \phi\,25\,^{+0.021}_{+0.000}$$

$$10H10 = 10\,^{+0.058}_{+0.000}$$

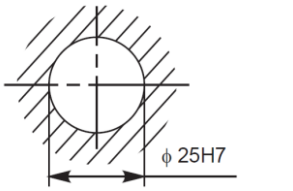
$$40C11 = 40\,^{+0.280}_{+0.120}$$

$$10h9 = 10\,^{-0.000}_{-0.036}$$

$$\phi\,25h9 = \phi\,25\,^{-0.000}_{-0.052}$$

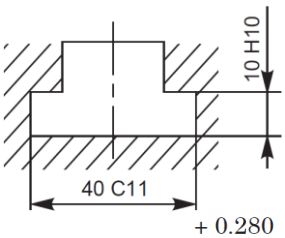
$$\phi\,40h11 = \phi\,40\,^{-0.000}_{-0.160}$$

The terms Ø25H7, 10H10 and 40C11 refer to internal features, since the terms involve capital letter symbols.



$$\phi\,25H7 = \phi\,25\,^{+0.021}_{+0.000}$$

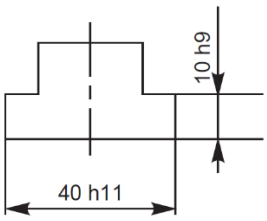
In above toleranced size, the capital letter 'H' signifies that the lower deviation of the hole is zero (hole basis system) and the number symbol 7 signifies the IT grade, the value of which is 21 microns which inturn is equal to the upper deviation.



$$40C11 = 40\,^{+0.280}_{+0.120}$$

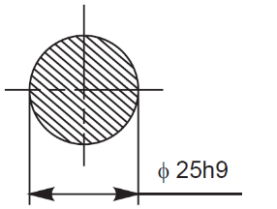
In above toleranced size, for the tolerance class C11 of the inner feature with 40 mm dimension, the lower deviations is +120 microns. The value of the tolerance, corresponding to grade 11 is 160 microns. The upper deviation is obtained by adding 160 to 120 which is equal to 280 microns or 0.28 mm.

The terms 10h9, Ø25h9 and Ø40h11 refer to external features, since the terms involve lower case letter symbols.



$$10h9 = 10\ ^{-0.000}_{-0.036}$$

In above toleranced size, the lower case letter 'h' signifies that the upper deviation of the external feature is zero (shaft basis system) and the number symbol 9 signifies the IT grade, the value of which is 36 microns which inturn is equal to the lower deviation.

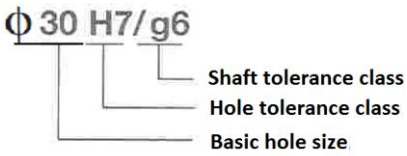


$$\phi\ 25h9 = \phi\ 25\ ^{-0.000}_{-0.052}$$

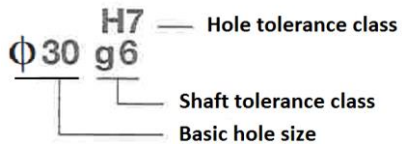
In above toleranced size, the lower case letter 'h' signifies that the upper deviation of the shaft is zero (shaft basis system) and the number symbol 9 signifies the IT grade, the value of which is 52 microns which inturn is equal to the lower deviation.

DESIGNATION of FITS IN DRAWING

When assembled parts are dimensioned, the fit is indicated by the basic size common to both the components, followed by the hole tolerance symbol first and then by the shaft tolerance symbol
Examples



or



TOLERANCE TABLES

Tables giving the commonly used tolerance classes are used in Hole and Shaft-basis system of fits. These tables are given in the following pages.

ISO Alıştırmaları Sapma Değerleri — TS 1845 - (DIN 7154 T1)

Normal Delik Sistemi — Ölçüler µm cinsinden (1µ = 0,001 mm)

Anma ölçüleri aralıkları ...'den ... dahil mm.	Delik	Miller					Delik	Miller								
	H6	p 5	n 5	k 6	j 6	h 5	H7	s 6	r 6	n 6	m 6	k 6	j 6	h 6	g 6	f 6
1...3	+ 6 0	+ 10 + 6	+ 8 + 4	+ 6 0	+ 4 - 2	0 - 4	+ 10 0	+ 20 + 14	+ 16 + 10	+ 10 + 4	+ 8 + 2	+ 6 0	+ 4 -2	0 - 6	- 2 - 8	- 6 - 16
3...6	+ 8 0	+ 17 + 12	+ 13 + 18	+ 9 + 1	+ 6 - 2	0 - 5	+ 12 0	+ 27 + 19	+ 23 + 15	+ 16 + 8	+ 12 + 4	+ 9 + 1	+ 6 - 2	0 - 8	- 4 - 12	- 10 - 22
6...10	+ 9 0	+ 21 + 15	+ 16 + 10	+ 10 + 1	+ 7 - 2	0 - 6	+ 15 0	+ 32 + 23	+ 28 + 19	+ 19 + 10	+ 15 + 6	+ 10 + 1	+ 7 - 2	0 - 9	- 5 - 14	- 13 - 28
10...14 14...18	+11 0	+ 26 + 18	+ 20 + 12	+ 12 + 1	+ 8 - 3	0 - 8	+ 18 0	+ 39 + 28	+ 34 + 23	+ 23 + 12	+ 18 + 7	+ 12 + 1	+ 8 -3	0 - 11	- 6 - 17	- 16 - 34
18...24 24...30	+13 0	+ 31 + 22	+ 24 + 15	+ 15 + 2	+ 9 - 4	0 - 9	+ 21 0	+ 48 + 35	+ 41 + 28	+ 28 + 15	+ 21 + 8	+ 15 + 2	+ 9 - 4	0 - 13	- 7 - 20	- 20 - 41
30...40 40...50	+16 0	+ 37 + 26	+ 28 + 17	+ 18 + 2	+ 11 - 5	0 - 11	+ 25 0	+ 59 + 43	+ 50 + 34	+ 33 + 17	+ 25 + 9	+ 18 + 2	+ 11 - 5	0 - 16	- 9 - 25	- 25 - 50
50...65 65...80	+19 0	+ 45 + 32	+ 33 + 20	+ 21 + 2	+ 12 - 7	0 - 13	+ 30 0	+ 72 + 53 + 78 + 59	+ 60 + 41 + 62 + 43	+ 39 + 20	+ 30 + 11	+ 21 + 2	+ 12 - 7	0 - 19	- 10 - 29	- 30 - 60
80...100 100...120	+ 22 0	+ 52 + 37	+ 38 + 23	+ 25 + 3	+ 13 - 9	0 - 15	+ 35 0	+ 93 + 71 + 101 + 79	+ 73 + 51 + 76 + 54	+ 45 + 23	+ 35 + 13	+ 25 + 3	+ 13 - 9	0 - 22	- 12 - 34	- 36 - 71
120...140 140...160 160...180	+ 25 0	+ 61 + 43	+ 45 + 27	+ 28 + 3	+ 14 - 11	0 - 18	+ 40 0	+ 93 + 71 + 125 + 100 + 133 + 108	+ 73 + 51 + 90 + 65 + 93 + 68	+ 52 + 27	+ 40 + 15	+ 28 + 3	+ 14 - 11	0 - 25	- 14 - 39	- 43 - 83
180...200 200...225 225...250	+ 29 0	+ 70 + 50	+ 51 + 31	+ 33 + 4	+ 16 - 13	0 - 20	+ 46 0	+151 +122 + 159 + 130 + 169 + 140	+106 + 77 + 109 +80 +113 + 84	+ 60 + 31	+ 46 + 17	+ 33 + 4	+ 16 - 13	0 - 29	+ 15 - 44	+ 50 - 96
250...280 280...315	+ 32 0	+ 79 + 56	+ 57 + 34	+ 36 + 4	+ 16 - 16	0 - 23	+ 52 0	+ 190 + 158 + 202 + 170	+ 126 + 94 +130 + 98	+ 66 + 34	+ 52 + 20	+ 36 + 4	+ 16 - 16	0 - 32	+ 16 - 16	+ 16 - 16
315...355 355...400	+ 36 0	+ 87 + 62	+ 62 + 37	+ 40 + 4	+ 18 - 18	0 - 25	+ 57 0	+ 226 + 190 + 244 + 208	+ 144 + 108 +150 +114	+ 73 + 37	+ 57 + 21	+ 40 + 4	+ 18 - 18	0 - 36	- 17 - 49	- 56 - 108
400...450 450...500	+ 40 0	+ 95 + 67	+ 67 + 40	+ 45 + 5	+ 20 - 20	0 - 27	+ 63 0	+ 272 + 232 + 292 + 252	+ 166 + 126 +172 +132	+ 80 + 40	+ 63 + 23	+ 45 + 5	+ 20 - 20	0 - 40	- 20 - 60	- 68 - 131

ISO Alıştırmaları Sapma Değerleri — TS 1845 - (DIN 7154 T1)

Normal Delik Sistemi — Ölçüler µm cinsinden (1µ = 0,001 mm)

Anma ölçüleri aralıkları ...'den ... dahil mm.	Delik	Miller					Delik	Miller				
	H8	x 8	u 8	h 9	e 8	d 9	H11	h 9	h 11	d 9	c 11	a 11
1...3	+ 14 0	+ 34 + 20	– –	0 - 25	- 14 - 28	- 20 - 45	+ 60 0	0 - 25	0 - 60	- 20 - 45	- 60 - 120	- 270 - 330
3...6	+ 18 0	+ 46 + 28	– –	0 - 30	- 20 - 38	- 30 - 60	+ 75 0	0 - 30	0 - 75	- 30 - 60	- 70 - 145	- 270 - 345
6...10	+ 22 0	+ 56 + 34	– –	0 - 36	- 25 - 47	- 40 - 76	+ 90 0	0 - 36	0 - 90	- 40 - 76	- 80 - 170	- 280 - 370
10...14	+ 27 0	+ 67 + 40	– –	0 - 43	- 32 - 59	- 50 - 93	+ 110 0	0 - 43	0 - 110	- 50 - 93	- 95 - 205	- 290 - 400
14...18		+ 72 + 45	– –									
18...24	+ 33 0	+ 87 + 54	– –	0 - 52	- 40 - 73	- 65 - 117	+ 130 0	0 - 52	0 - 130	- 65 - 117	- 110 - 240	- 300 - 430
24...30		+ 97 + 64	+ 81 + 48									
30...40	+ 39 0	+ 119 + 80	+ 99 + 60	0 - 62	- 50 - 89	- 80 - 142	+ 160 0	0 - 62	0 - 160	- 80 - 142	- 120 - 280	- 310 - 470
40...50		+ 97 + 64	+ 109 + 70								- 130 - 290	- 320 - 480
50...65	+ 46 0	+ 162 + 122	+ 133 + 87	0 - 74	- 60 - 106	- 100 - 174	+ 190 0	0 - 74	0 - 190	- 100 - 174	- 140 - 330	- 340 - 530
65...80		+ 192 + 146	+ 148 + 102								- 150 - 340	- 360 - 550
80...100	+ 54 0	+ 232 + 178	+ 178 + 124	0 - 87	- 72 - 126	- 120 - 207	+ 220 0	0 - 87	0 - 220	- 120 - 207	- 170 - 390	- 380 - 600
100...120		+ 264 + 210	+ 198 + 144								- 180 - 400	- 410 - 630
120...140	+ 63 0	+ 311 + 248	+ 233 + 170	0 - 100	- 85 - 148	- 145 - 245	+ 250 0	0 - 100	0 - 250	- 145 - 245	- 200 - 450	- 460 - 710
140...160		+ 343 + 280	+ 253 + 190								- 210 - 460	- 520 - 770
160...180		+ 373 + 310	+ 273 + 210								- 230 - 480	- 580 - 830
180...200	+ 72 0	+ 422 + 350	+ 308 + 236	0 - 115	- 100 - 172	- 170 - 285	+ 290 0	0 - 115	0 - 290	- 170 - 285	- 240 - 530	- 660 - 950
200...225		+ 457 + 385	+ 330 + 258								- 260 - 550	- 740 -1030
225...250		+ 497 + 425	+ 356 + 284								- 280 - 570	- 820 -1110
250...280	+ 81 0	+ 556 + 475	+ 396 + 315	0 - 130	- 110 - 191	- 190 - 320	+ 320 0	0 - 130	0 - 320	- 190 - 320	- 300 - 620	- 920 -1240
280...315		+ 606 + 525	+ 431 + 350								- 330 - 650	-1050 -1370
315...355	+ 89 0	+ 679 + 590	+ 479 + 390	0 - 140	- 125 - 214	- 210 - 350	+ 360 0	0 - 140	0 - 360	- 210 - 350	- 360 - 720	-1200 -1560
355...400			+ 524 + 435								- 400 - 760	-1350 -1710
400...450	+ 97 0	– –	+ 587 + 490	0 - 155	- 135 - 232	- 230 - 385	+ 400 0	0 - 155	0 - 400	- 230 - 385	- 440 - 840	-1500 -1900
450...500		+ – –	+ 637 + 540								- 480 - 880	-1650 -2050

ISO Alıştırmaları Sapma Değerleri — TS 1845 - (DIN 7155 T1)

Normal Mil Sistemi — Ölçüler µm cinsinden (1µ = 0,001 mm)

Anma ölçüleri aralıkları ...'den ... dahil mm.	Mil	Delikler					Mil	Delikler							
	h5	P6	N6	M6	J6	H6	h6	S7	R7	N7	M7	K7	J7	H7	G7	F7
1...3	0 - 4	- 6 - 12	- 4 - 10	- 2 - 8	+ 2 - 4	+ 6 0	0 - 6	- 14 - 24	- 10 - 20	- 4 - 14	- 2 - 12	0 - 10	+ 4 - 6	+ 10 0	+ 12 + 2	+ 16 + 6
3...6	0 - 5	- 9 - 17	- 5 - 13	- 1 - 9	+ 5 - 3	+ 8 0	0 - 8	- 15 - 27	- 11 - 23	- 4 - 16	0 - 12	+ 3 - 9	+ 6 - 6	+ 12 0	+ 16 + 4	+ 22 + 10
6...10	0 - 6	- 12 - 21	- 7 - 16	- 3 - 12	+ 5 - 4	+ 9 0	0 - 9	- 17 - 32	- 13 - 28	- 4 - 19	0 - 15	+ 5 - 10	+ 8 - 7	+ 15 0	+ 20 + 5	+ 28 + 13
10...18	0 - 8	- 15 - 26	- 9 - 20	- 4 - 15	+ 6 - 5	+ 11 0	0 - 11	- 21 - 39	- 16 - 34	- 5 - 23	0 - 18	+ 6 - 12	+ 10 - 8	+ 18 0	+ 24 + 6	+ 34 + 16
18...30	0 - 9	- 18 - 31	- 11 - 21	- 4 - 17	+ 8 - 5	+ 13 0	0 - 13	- 27 - 48	- 20 - 41	- 7 - 28	0 - 21	+6 - 15	+ 12 - 9	+ 21 0	+ 28 + 7	+ 41 + 20
30...40	0 - 11	- 21 - 37	- 12 - 28	- 4 - 20	+ 10 - 6	+ 16 0	0 - 16	- 34 - 59	- 25 - 50	- 8 - 33	0 - 25	+ 7 - 18	+ 14 - 11	+ 25 0	+ 34 + 9	+ 50 + 25
40...50																
50...65	0 - 13	- 26 - 45	- 14 - 33	- 5 - 24	+ 13 - 6	+ 19 0	0 - 19	- 42 - 72	- 30 - 60	- 9 - 39	0 - 30	+ 9 - 21	+ 18 - 12	+ 30 0	+ 40 + 10	+ 60 + 30
65...80								- 48 - 78	- 32 - 62							
80...100	0 - 15	- 30 - 52	- 16 - 38	- 6 - 28	+ 16 - 6	+ 22 0	0 - 22	- 58 - 93	- 38 - 73	- 10 - 45	0 - 35	+ 10 - 25	+ 22 - 13	+ 35 0	+ 47 + 12	+ 71 + 36
100...120								- 66 - 101	- 41 - 76							
120...140	0 - 18	- 36 - 61	- 20 - 45	- 8 - 33	+ 18 - 7	+ 25 0	0 - 25	- 77 - 117	- 48 - 88	- 12 - 52	0 - 40	+ 12 - 28	+ 26 - 14	+ 40 0	+ 54 + 14	+ 83 + 43
140...160								- 85 - 125	- 50 - 90							
160...180								- 93 - 133	-53 - 93							
180...200	0 - 20	- 41 - 70	- 22 - 51	- 8 - 37	+ 22 - 7	+ 29 0	0 - 29	- 105 - 151	- 60 - 106	- 14 - 60	0 - 46	+ 13 - 33	+ 30 - 16	+ 46 0	+ 61 + 15	+ 96 + 50
200...225								- 113 - 159	- 63 - 109							
225...250								- 123 - 169	- 67 - 113							
250...280	0 - 23	- 47 - 79	- 25 - 57	- 9 - 41	+ 25 - 7	+ 32 0	0 - 32	- 138 - 190	- 74 - 126	- 14 - 66	0 - 52	+ 16 - 36	+ 36 - 16	+ 52 0	+ 69 + 17	+ 108 + 56
280...315								- 150 - 202	- 78 - 130							
315...355	0 - 25	- 51 - 87	- 26 - 62	- 10 - 46	+ 29 - 7	+ 36 0	0 - 36	- 169 - 226	- 87 - 144	- 16 - 73	0 - 57	+ 17 - 40	+ 39 - 18	+ 57 0	+ 75 + 18	+ 119 + 62
355...400								- 187 - 244	- 93 - 150							
400...450	0 - 27	- 55 - 95	- 27 - 67	- 10 - 50	+ 33 - 7	+ 40 0	0 - 40	- 209 - 272	-103 - 166	- 17 - 80	0 - 63	+ 18 - 45	+ 43 - 20	+ 63 0	+ 83 + 20	+ 131 + 68
450...500								- 229 - 292	-109 - 172							

ISO Alıştırmaları Sapma Değerleri — TS 1845 - (DIN 7155 T1)

Normal Mil Sistemi — Ölçüler µm cinsinden (1µ = 0,001 mm)

Anma ölçüleri aralıkları ...'den ... dahil mm.	Mil h9	Delikler H 8	Delikler H 11	Delikler F 8	Delikler E 9	Delikler D 10	Delikler C 11	Mil h11	Delikler H 11	Delikler D 11	Delikler C 11	Delikler A 11
1...3	0 - 25	+ 14 0	+ 60 0	+ 20 + 6	+ 39 + 14	+ 60 + 20	+120 + 60	0 - 60	+ 60 0	+ 80 + 20	+ 120 + 60	+ 330 + 270
3...6	0 - 30	+ 18 0	+ 75 0	+ 28 + 10	+ 50 + 20	+ 78 + 30	+145 + 70	0 - 75	+ 75 0	+ 105 + 30	+ 145 + 70	+ 345 + 270
6...10	0 - 36	+ 22 0	+ 90 0	+ 35 + 13	+ 61 + 25	+ 98 + 40	+170 + 80	0 - 90	+ 90 0	+ 130 + 40	+ 170 + 80	+ 370 + 280
10...18	0 - 43	+ 27 0	+ 110 0	+ 43 + 16	+ 75 + 32	+ 120 + 50	+205 + 95	0 - 110	+ 110 0	+ 160 + 50	+ 205 + 95	+ 400 + 290
18...30	0 - 52	+ 33 0	+ 130 0	+ 53 + 20	+ 92 + 40	+ 149 + 65	+240 +110	0 - 130	+ 130 0	+ 195 + 65	+ 240 + 110	+ 430 + 300
30...40	0 - 62	+ 39 0	+ 160 0	+ 64 + 25	+ 112 + 50	+ 180 + 80	+ 280 + 120	0 - 160	+ 160 0	+ 240 + 80	+ 280 + 120	+ 470 + 310
40...50							+ 290 + 130				+ 290 + 130	+ 480 + 320
50...65	0 - 74	+ 46 0	+ 190 0	+ 76 + 30	+ 134 + 60	+ 220 + 100	+ 330 + 140	0 - 190	+ 190 0	+ 290 + 100	+ 330 + 140	+ 530 + 340
65...80							+ 340 + 150				+ 340 + 150	+ 550 + 360
80...100	0 - 87	+ 54 0	+ 220 0	+ 90 + 36	+ 159 + 70	+ 260 + 120	+ 290 + 170	0 - 220	+ 220 0	+ 340 + 120	+ 390 + 170	+ 600 + 380
100...120							+ 400 + 180				+ 400 + 180	+ 630 + 410
120...140	0 - 100	+ 63 0	+ 250 0	+ 106 + 43	+ 185 + 85	+ 305 + 145	+ 450 + 200	0 - 250	+ 250 0	+ 395 + 145	+ 450 + 200	+ 710 + 460
140...160							+ 460 + 210				+ 460 + 210	+ 770 + 520
160...180							+ 480 + 230				+ 480 + 230	+ 830 + 580
180...200	0 - 115	+ 72 0	+ 290 0	+ 122 + 50	+ 215 + 100	+ 355 + 170	+ 530 + 240	0 - 290	+ 290 0	+ 460 + 170	+ 530 + 240	+ 950 + 660
200...225							+ 550 + 260				+ 550 + 260	+ 1030 + 740
225...250							+ 570 + 280				+ 570 + 280	+ 1110 + 820
250...280	0 - 130	+ 81 0	+ 320 0	+ 137 + 56	+ 240 + 110	+ 400 + 190	+ 620 + 300	0 - 320	+ 320 0	+ 510 + 190	+ 620 + 300	+ 1240 + 920
280...315							+ 650 + 330				+ 650 + 330	+ 1370 + 1050
315...355	0 - 140	+ 89 0	+ 360 0	+ 151 + 62	+ 265 + 125	+ 440 + 210	+ 720 + 360	0 - 360	+ 360 0	+ 570 + 210	+ 720 + 360	+ 1560 + 1200
355...400							+ 760 + 400				+ 760 + 400	+ 1710 + 1350
400...450	0 - 155	+ 97 0	+ 400 0	+ 165 + 68	+ 290 + 135	+ 480 + 230	+ 840 + 440	0 - 400	+ 400 0	+ 630 + 230	+ 840 + 440	+ 1900 + 1500
450...500							+ 880 + 480				+ 880 + 480	+ 2050 + 1650

PREFERRED FITS

Following Tables taken from different sources give the types of either the hole-basis or shaft-basis preferred fits (clearance, transition, and interference).

Fits should be selected from these Tables for mating parts where possible.

PREFERRED FITS (Giesecke, ASME B4.2-1978)

ISO Symbol				
	Hole Basis	Shaft Basis*	Description	
Clearance Fits	H11/c11	C11/h11	**Loose-running** fit for wide commercial tolerances or allowances on external members.	More Clearance →
	H9/d9	D9/h9	**Free-running** fit not for use where accuracy is essential, but good for large temperature variations, high running speeds, or heavy journal pressures.	
	H8/f7	F8/h7	**Close-running** fit for running on accurate machines and for accurate location at moderate speeds and journal pressures.	
Transition Fits	H7/g6	G7/h6	**Sliding** fit not intended to run freely, but to move and turn freely and locate accurately.	
	H7/h6	H7/h6	**Locational clearance** fit provides snug fit for locating stationary parts; but can be freely assembled and disassembled.	
	H7/k6	K7/h6	**Locational transition** fit for accurate location, a compromise between clearance and interference.	← More interference
Interference Fits	H7/n6	N7/h6	**Locational transition** fit for more accurate location where greater interference is permissible.	
	H7/p6	P7/h6	**Locational interference** fit for parts requiring rigidity and alignment with prime accuracy of location but without special bore pressure requirements.	
	H7/s6	S7/h6	**Medium drive** fit for ordinary steel parts or shrink fits on light sections, the tightest fit usable with cast iron.	
	H7/u6	U7/h6	**Force** fit suitable for parts that can be highly stressed or for shrink fits where the heavy pressing forces required are impractical.	

**The transition and interference shaft-basis fits shown do not convert to exactly the same hole-basis fit conditions for basic sizes in the range from 0 through 3 mm. Interference fit P7/h6 converts to a transition fit H7/p6 in the above size range.*

Types of fits with symbols and applications Machine Drawing (K. L. Narayana et.al.)

Type of fit	*Symbol of fit*	*Examples of application*
Interference fit		
Shrink fit	H8/u8	Wheel sets, tyres, bronze crowns on worm wheel
Heavy drive fit	H7/s6	hubs, couplings under certain conditions, etc.
Press fit	H7/r6	Coupling on shaft ends, bearing bushes in hubs, valve
Medium press fit	H7/p6	seats, gear wheels.
Transition fit		
Light press fit	H7/n6	Gears and worm wheels, bearing bushes, shaft and wheel assembly with feather key.
Force fit	H7/m6	Parts on machine tools that must be changed without damage, *e.g.,* gears, belt pulleys, couplings, fit bolts, inner ring of ball bearings.
Push fit	H7/k6	Belt pulleys, brake pulleys, gears and couplings as well as inner rings of ball bearings on shafts for average loading conditions.
Easy push fit	H7/j6	Parts which are to be frequently dismantled but are secured by keys, *e.g.,* pulleys, hand-wheels, bushes, bearing shells, pistons on piston rods, change gear trains.
Clearance fit		
Precision sliding fit	H7/h6	Sealing rings, bearing covers, milling cutters on milling mandrels, other easily removable parts.
Close running fit	H7/g6	Spline shafts, clutches, movable gears in change gear trains, etc.
Normal running fit	H7/f7	Sleeve bearings with high revolution, bearings on machine tool spindles.
Easy running fit	H8/e8	Sleeve bearings with medium revolution, grease lubricated bearings of wheel boxes, gears sliding on shafts, sliding blocks.
Loose running fit	H8/d9	Sleeve bearings with low revolution, plastic material bearings.
Slide running fit	H8/c11	Oil seals (Simmerrings) with metal housing (fit in housing and contact surface on shaft), multi-spline shafts.

Following Table gives equivalent fits on the hole basis and shaft basis systems to obtain the same fit.

Equivalent fits on the hole basis and shaft basis systems (Machine Drawing, K. L. Narayana et. al.)

Clearance		*Transition*		*Interference*	
Hole basis	*Shaft basis*	*Hole basis*	*Shaft basis*	*Hole basis*	*Shaft basis*
H7 – c8	C8 – h7	H6 – j5	J6 – h5	H6 – n5	N6 – h5
H8 – c9	C9 – h8	H7 – j6	J7 – h6		
H11 – c11	C11 – h11	H8 – j7	J8 – h7	H6 – p5	P6 – h5
				H7 – p6	p7 – h6
H7 – d8	D8 – h7	H6 – k5	K6 – h5		
H8 – d9	D9 – h8	H7 – k6	K7 – h6	H6 – r5	R6 – h5
H11 – d11	D11 – h11	H8 – k7	K8 – h7	H7 – r6	R7 – h6
H6 – e7	E7 – h6	H6 – m5	M6 – h5	H6 – s5	S6 – h5
H7 – e8	E8 – h7	H7 – m6	M7 – h6	H7 – s6	S7 – h6
H8 – e8	E8 – h8	H8 – m7	M8 – h7	H8 – s7	S8 – h7
H6 – f6	F6 – h6	H7 – n6	N7 – h6	H6 – t5	T6 – h5
H7 – f7	F7 – h7	H8 – n7	N8 – h7	H7 – t6	T7 – h6
H8 – f8	F8 – h8			H8 – t7	T8 – h7
		H8 – p7	P8 – h7		
H6 – g5	G6 – h5			H6 – u5	U6 – h5
H7 – g6	G7 – h6	H8 – r7	R8 – h7	H7 – u6	U7 – h6
H8 – g7	G8 – h7			H8 – u7	U8 – h7

ÇİZELME 15.2 ISO ALIŞTIRMA DERECELERİ VE KARŞILIKLARI

Alıştırma derecesi	Normal delik		Geçmeler	Normal mil	
	İşaretler			İşaretler	
Adı	Delik	Mil		Delik	Mil
Hassas alıştırma	H6		**Hareketsiz geçmeler**		
		p5	Sıkı geçme	P6	
		n5	Çakma geçme	N6	
		k6	Tutuk geçme	K6	h5
		j6	Kakma geçme	J6	
			Hareketli geçmeler		
		h5	Kaygın geçme	H6	
İnce alıştırma	H7		**Hareketsiz geçmeler**		
		s6/r6(*)	Preste geçme	S7	
		n6	Sıkı geçme	N7	
		m6	Çakma geçme	M7	
		k6	Tutuk geçme	K7	
		j6	Kakma geçme	J7	h6
			Hareketli geçmeler		
		h6	Kaygın geçme	H7	
		g6	Yarım döner geçme	G7	
		f7	Döner geçme	F7	
		e8	Serbest döner geçme	E8	
		d9	Serbest geçme	D9	
Orta alıştırma	H8		**Hareketli geçmeler**		
		h9	Kaygın geçme	H8	
		f8	Döner geçme	F8	h8
		d10	Serbest geçme	D10	h9
Kaba alıştırma	H11		**Hareketli geçmeler**		
		h11	Kaba geçme 1	H11	
		d11	» » 2	D11	h11
		c11	» » 3	C11	
		a11	» » 4	A11	

(*) s6 160 mm ye kadar, r6 160 mm den yukarı çaplar için kullanılır.

ÇİZELGE 15.3 MAKİNA YAPIMINDA TERCİH EDİLEN ISO ALIŞTIRMALARI

Normal Delik	Normal Mil	Geçmenin Konumu	Kullanıldığı Yerler
H8/x8 veya u8 H7/s6 H7/r6	R7/h6 S7/h6	Pres geçmeler	1) Büyük tutukluk kuvveti için, dişli çark, volan ve teker göbekleri, mil flenşleri. 2) Orta tutukluk kuvveti için, kavrama göbekleri, GG - göbekleri üzerine bronz yataklar; gövde, tekerlek ve piston kollarında yataklar (s6 büyük, r6 küçük çaplar) için.
H7/n6	N7/h6	Sıkı geçme. Presle yapılır.	Motor miline geçen endüviler ve göbeğe geçen dişliler. Mil üzerine geçen göbekler ve yataklar için.
H7/m6	M7/h6	Çakma geçme. Çekiçle oldukça zor yapılabilir.	Bir defaya mahsus olmak üzere makina ve elektrik motoru millerine (d=55 ilâ 120 mm) geçirilmiş kasnaklar, kavramalar ve dişliler için.
H7/k6	K7/h6	Tutuk geçme. Çeçişle rahatça yapılabilir.	Kasnaklar, kavramalar, dişliler, kamalı volanlar, rulmanlı yatakların iç bilezikleri, sabit tekerlekler ve kollar için.
H7/j6	J7/h6	Kakma geçme. Tokmak veya elle yapılabilir.	Kolayca çıkarılması gereken kasnaklar, dişliler, tekerlekler, yataklar v b. için.
H7/h6	H7/h6	Kaygın geçme. Yağlanırsa elle geçirilebilir.	Sık sık sökülüp takılması gereken tekerler, tezgâhların hareketli kısımları, yatakların dış bilezikleri, kavramalar ve boru merkezleme flenşleri için.
H8/h9	H8/h9	Kaygın geçme. Kuvvet sarfetmeden kayabilen geçme parçaları.	Mil üzerinde hareket eden transmisyon hareket bilezikleri, kayış kasnakları, el tutamakları, dişliler, kavramalar, v.b. için.
H7/g6	G7/h6	Tutuk döner geçme. Fark edilmeyecek kadar bir boşlukla kaydırılabilir.	Kayabilir dişliler, kavramalar, piston kolu yatağı, ölçme cihazları silindirleri için.
H7/f7	F8/h6	Döner geçme. Fark edilecek kadar boşluk vardır.	Takım tezgâhlarının ana yatakları, krank milleri ve piston kolları yatakları, bütün regülatör yatakları, kaygan muflar v.b. için.

ÇİZELGE 15.3 MAKİNA YAPIMINDA TERCİH EDİLEN ISO ALIŞTIRMALARI

Normal Delik	Normal Mil	Geçmenin Konumu	Kullanıldığı Yerler
H8/f7	F8/h9	Döner geçme. Fark edilir derecede boşluk vardır.	Krank millerinin ana yatakları, piston kolu yatakları, kaygın yataklar için.
H8/e8	E8/h8	Hafif döner geçme Oldukça büyük boşluk vardır.	Takım tezgâhlarında çok yataklı miller için.
H8/d9	D9/h8	Serbest döner geçme. Çok fazla boşluk vardır.	Vinçlerin ve transmisyonların uzun millerindeki yataklar, avara kasnaklar, Ziraat makinaları yatakları, salmastra kutuları için.
H9/d10	D10/h9	Serbest döner geçme. Çok fazla boşluk vardır.	Kamalar ve kama yuvalarında, Nakil vasıtaları ve ziraat makinalarının aks burçları, transmisyon yatakları avara kasnaklar için.
H11/h11	H11/h11	Kaba geçme 1. Parçalar az boşlukla ve büyük toleransla içice geçebilir.	Ziraat makinalarında miller üzerine vidalanmış, çakılmış veya sıkıştırılmış parçalar, ara burçları, menteşe primleri için.
H11/d11	D11/h11	Kaba geçme 2. Büyük toleranslı.	Büyük toleranslı parçaların hareketlerini devamlı olarak temin etmek için.
H11/c11	C11/h11	Kaba geçme 3. Büyük boşluk ve büyük toleranslı.	Kısa transmisyon milleri, kapatma pimleri, v.b. için.
H11/a11	A11/h11	Kaba geçme 4. Büyük tolerans ve büyük boşluk.	Lokomotif regülatör milleri, yay ve fren çubukları için.

Turkish meanings of fit descriptions are given in the following.

Tutuk döner geçme: Sliding fit

Döner geçme: Running fit

Serbest döner geçme: Free-running fit

Hafif döner geçme: Close-running fit

Kaba geçme: Loose- running fit

Kaygan geçme: Locational clearance fit

Tutuk, çakma, kakma geçme: Locational transition fit

Sıkı geçme: Locational interference fit

Pres geçme: Force or shrink fit

Examples for using Tolerance Tables

Example: 30H7/g6 fit is given between a hole and a shaft. Determine
- the upper and lower deviation limits for the hole and the shaft,
- maximum limit of size for the hole and the shaft
- size tolerance for the hole and the shaft
- fit type between the hole and the shaft
- maximum and minimum clearances (interferences) for the fit
- variation of fit

Solution:
-Basic dimension for the interior and exterior parts (hole and shaft) is 30 mm.
-Capital letter "H" designates the hole basis system of fit is used for the mating hole and the shaft. Therefore, hole-basis Table (see following table) is to be used.
Follow across from the group of 24…30 mm for the basic size of 30 mm to H7.
Upper and lower deviations for the hole are +21 µm = +0,021 mm and 0 µm = 0,000 mm respectively.
The upper and lower deviation for the shaft are found in the g6 column. They are -7 µm = -0,007 mm and -20 µm = -0,020 mm respectively.

NORMAL DELİK SİSTEMİ

Anma ölçüsü mm	DELİK	Geçen miller					DELİK	Geçen miller							
	H6	p5	n5	k6	j6	h5	H7	s6	r6	n6	m6	k6	j6	h6	g6
1...3															
3...6															
6...10															
10...14															
14...18															
18...24															
24...30							+21 0								-7 -20
30...40															
40...50															
50...65															

Hole:
ES = +0,021 mm (Upper deviation for hole, found from Table)
EI = 0,000 mm (Lower deviation for hole, found from Table)
ES = EBÖ – AÖ
EBÖ = ES + AÖ = 0,021 + 30 =30,021 mm (Maximum limit of size for hole)
EI = EKÖ – AÖ
EKÖ = EI + AÖ = 0,000 + 30 =30,000 mm (Minimum limit of size for hole)
T = EBÖ – EKÖ =30,021-30,000=0,021 mm (Size tolerance for hole) or
T = ES – EI = +0,021- 0,000=0,021 mm (Size tolerance for hole)

Shaft:

es = -0,007 mm (Upper deviation for shaft, found from Table)
ei = -0,020 mm (lower deviation for shaft, found from Table)
es = EBÖ – AÖ
EBÖ = es + AÖ = -0,007 + 30 =29,993 mm (Maximum limit of size for shaft)
ei = EKÖ – AÖ
EKÖ = ei + AÖ = -0,020 + 30 =29,980 mm (Minimum limit of size for shaft)
T = EBÖ – EKÖ =29,993-29,980=0,013 mm (Size tolerance for shaft) or
T = es – ei = -0,007 – (-0,020) =0,013 mm (Size tolerance for shaft)

Fit :

Fit type is clearance because Shaft EBÖ < Hole EKÖ

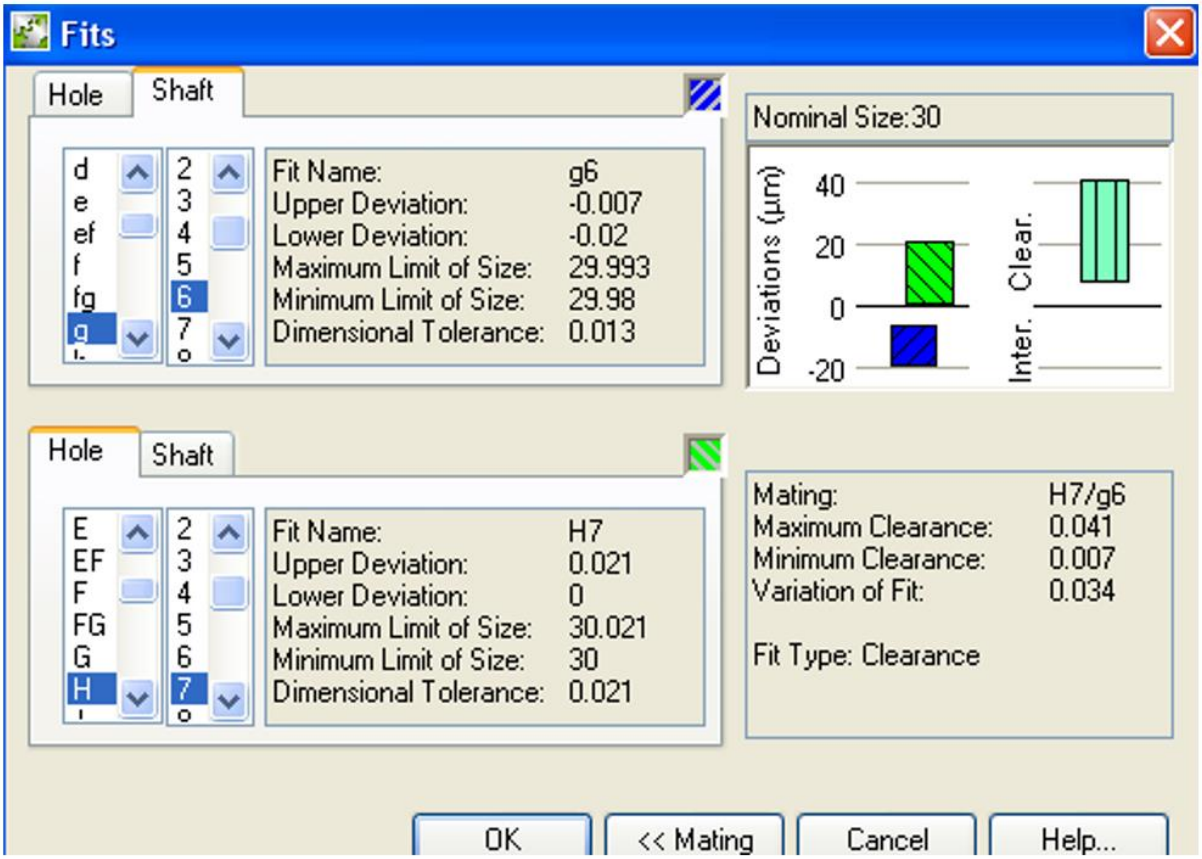
EBB = Hole EBÖ – Shaft EKÖ = 30,021-29,980 = 0,041 mm (Maximum clearance)
EKB = Hole EKÖ – Shaft EBÖ = 30,000-29,993 = 0,007 mm (Minimum clearance)

AT = T_{hole} + T_{shaft} = 0,021 + 0,013 = 0,034 mm (Variation of fit) or
AT = EBB - EKB = 0,041 – 0,007 = 0,034 mm (Variation of fit)

All of these results can be obtained in AutoCAD Mechanical program as follows:

For The Hole 30^{+21}_{0} or **30H7**

For The Shaft $30^{-0.007}_{-0.020}$ or **30g6**



Example: 50K7/h6 fit is given between a hole and a shaft. Determine
- the upper and lower deviation limits for the hole and the shaft,

Solution:
-Basic dimension for the interior and exterior parts (hole and shaft) is 50 mm.
-lowercase letter “h” designates the shaft basis system of fit is used for the mating hole and the shaft. Therefore, hole-basis Table is to be used.

For shaft $\boxed{\begin{matrix}0\\-16\end{matrix}}$ $50^{0}_{-0.016}$ or **50h6**

For hole $\boxed{\begin{matrix}+7\\-18\end{matrix}}$ $50^{+0.007}_{-0.018}$ or **50K7**

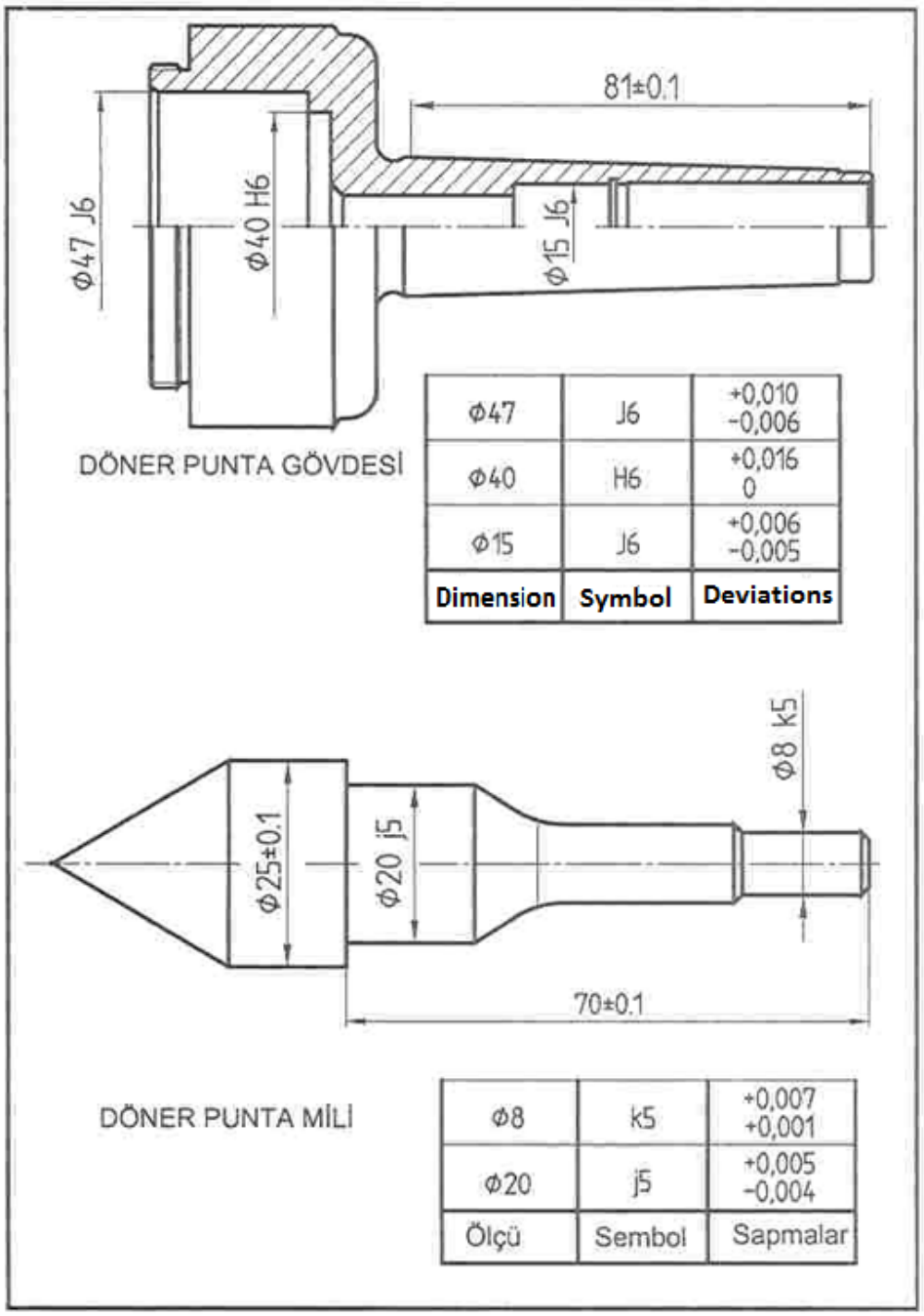
Example: 25H7/h6 fit is given between a hole and a shaft. Determine
- the upper and lower deviation limits for the hole and the shaft,

Solution:
-Basic dimension for the interior and exterior parts (hole and shaft) is 25 mm.
-Capital letter “H” designates the hole basis system, whereas lowercase letter “h” designates the shaft basis system. Therefore, both Tables can be used.

For shaft $\boxed{\begin{matrix}0\\-13\end{matrix}}$ $25^{0}_{-0.013}$ or **25h6**

For hole $\boxed{\begin{matrix}+21\\0\end{matrix}}$ $25^{+0.021}_{0}$ or **25H7**

DESIGNATION of TOLERANCED INDIVIDUAL DIMENSIONS IN DRAWING (EXAMPLES)



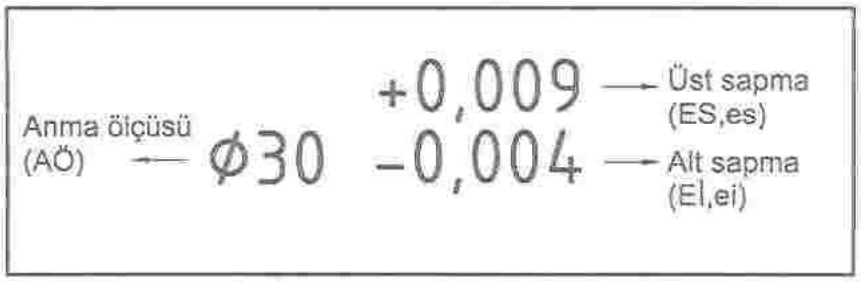
Dimension	Symbol	Deviations
Φ47	J6	+0,010 -0,006
Φ40	H6	+0,016 0
Φ15	J6	+0,006 -0,005

Ölçü	Sembol	Sapmalar
Φ8	k5	+0,007 +0,001
Φ20	j5	+0,005 -0,004

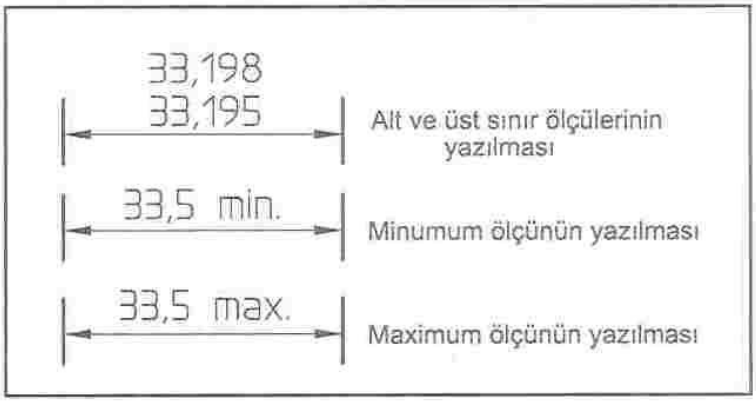
If the deviations for the toleranced dimensions are shown with only tolerance classes (J6, H6, etc.), then corresponding deviations should be given in a fit list placed at a suitable location (generally above the title block!). This can be done in AutoCAD Mechanical.

Dimen.	Fit		
Φ47	J6	+0.01 -0.006	47.01 46.994
Φ40	H6	+0.016 0	40.016 40
Φ15	J6	+0.006 -0.005	15.006 14.995

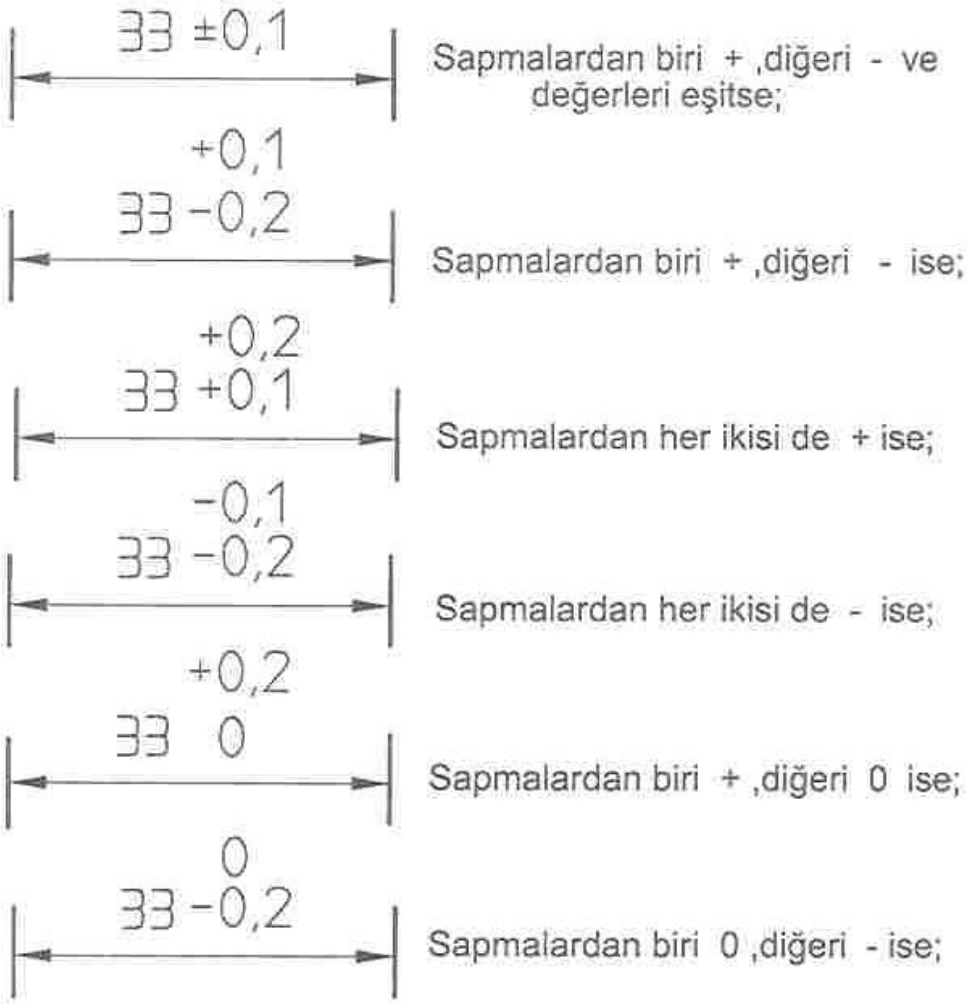
Designation of Deviations



Designation of Limit Sizes

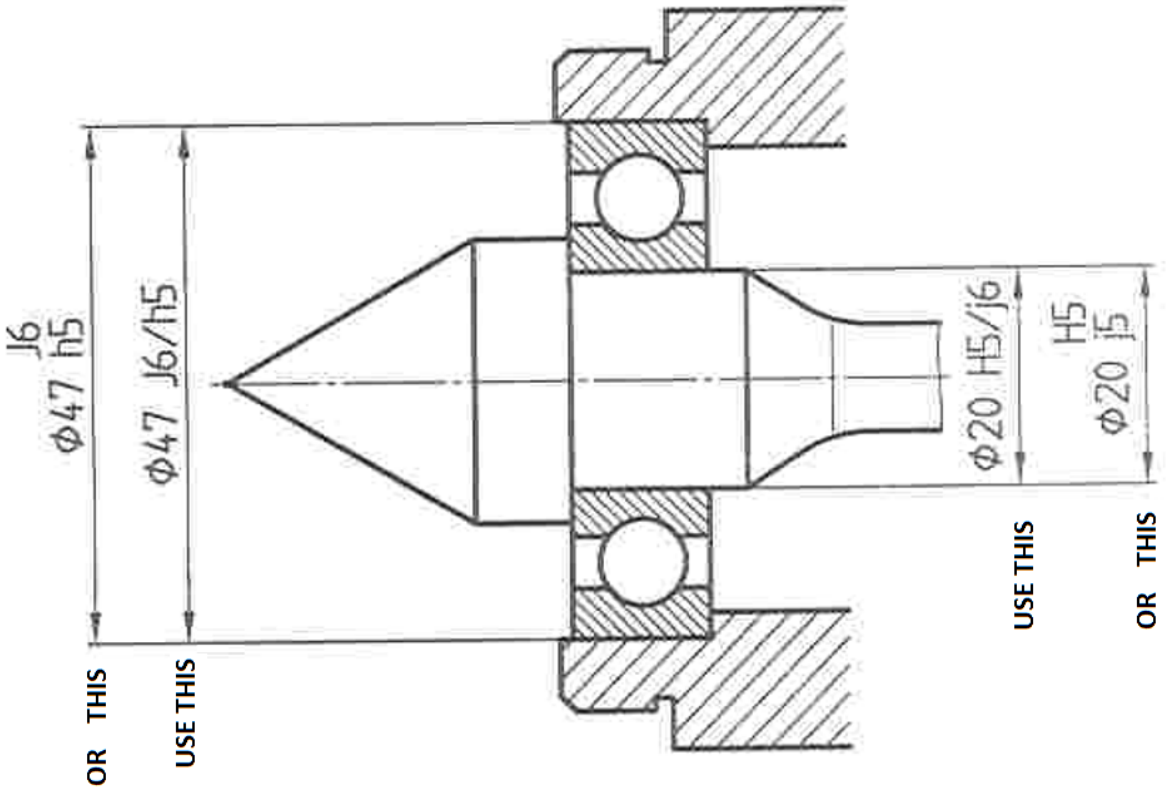


Designation of different deviations (No use of IT Grades)

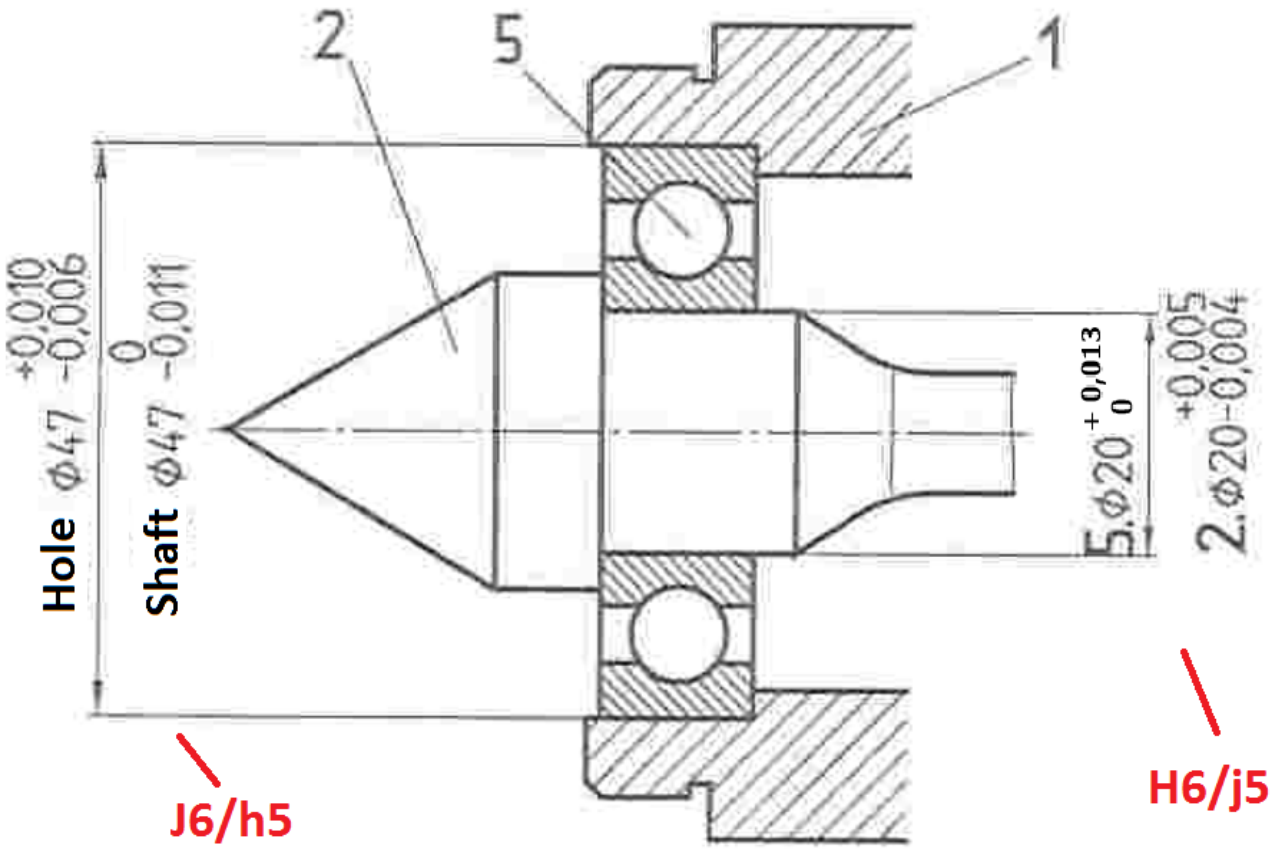


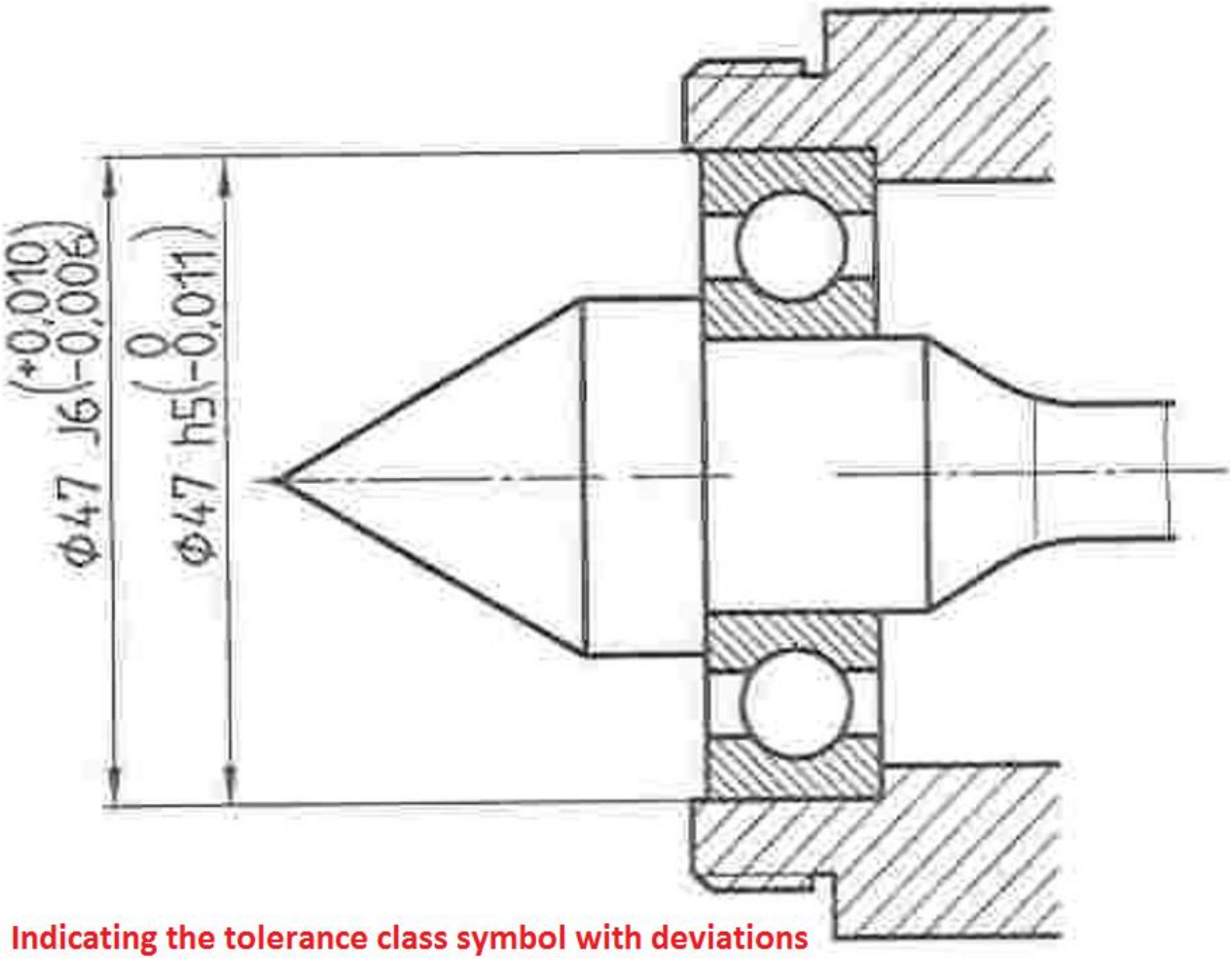
DESIGNATION of TOLERANCED ASSEMBLED PARTS IN DRAWING (EXAMPLES)

When assembled parts are dimensioned, the fit is indicated by the basic size common to both the components, followed by the hole tolerance symbol first and then by the shaft tolerance symbol (*e.g.*, ϕ 25 H7/*h*6, etc.,).



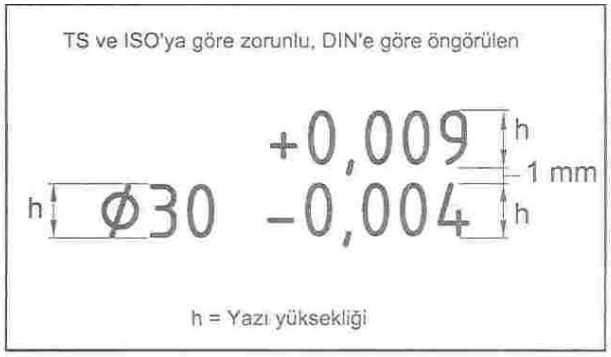
NOTE: USE ONLY ONE OF THE METHODS FOR INDICATING THE TOLERANCED DIMENSIONS THROUGHOUT THE DRAWING



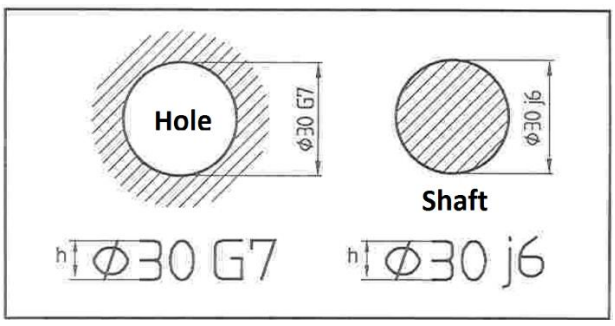


Indicating the tolerance class symbol with deviations

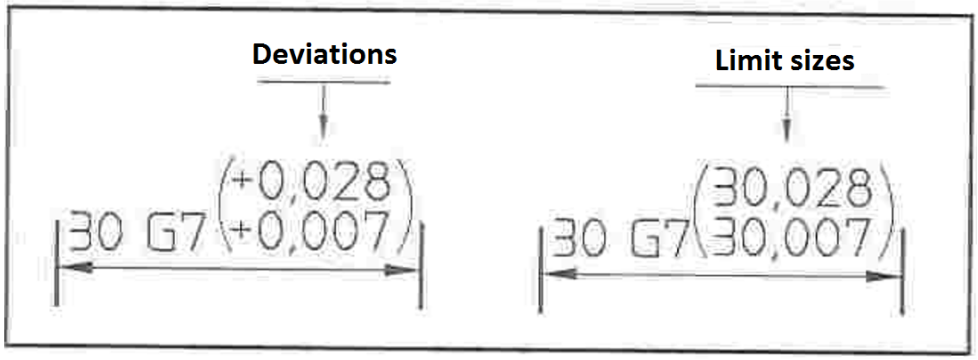
Letter Sizes



Symbol and Letter Sizes



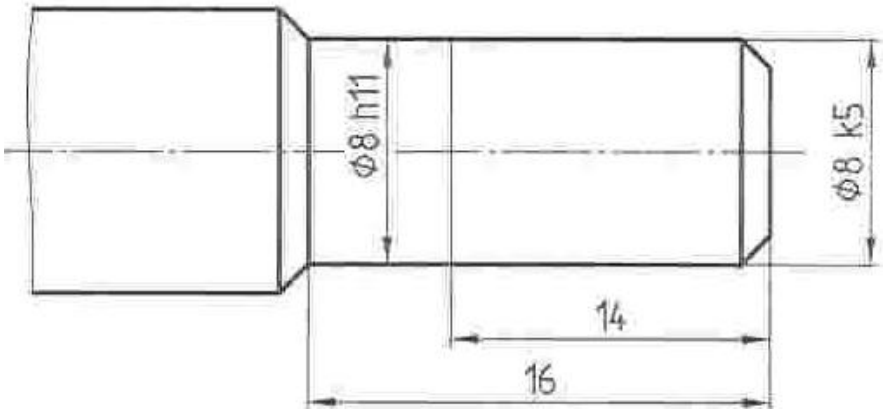
Designation of deviations and limit sizes



Deviations and limit (min. and max) sizes are put in parantheses

Designation of two different tolerances on the same size

In this case the dimension to which the tolerance belongs is to be indicated. See following Figure.



GENERAL TOLERANCE NOTES:

For the sizes to which the tolerances are not assigned, tolerances should be given according to one of the following clauses. Therefore, corresponding clause should be written near (preferably above) the title block.

General tolerance ± …… mm
(Genel tolerans: ±…. mm)

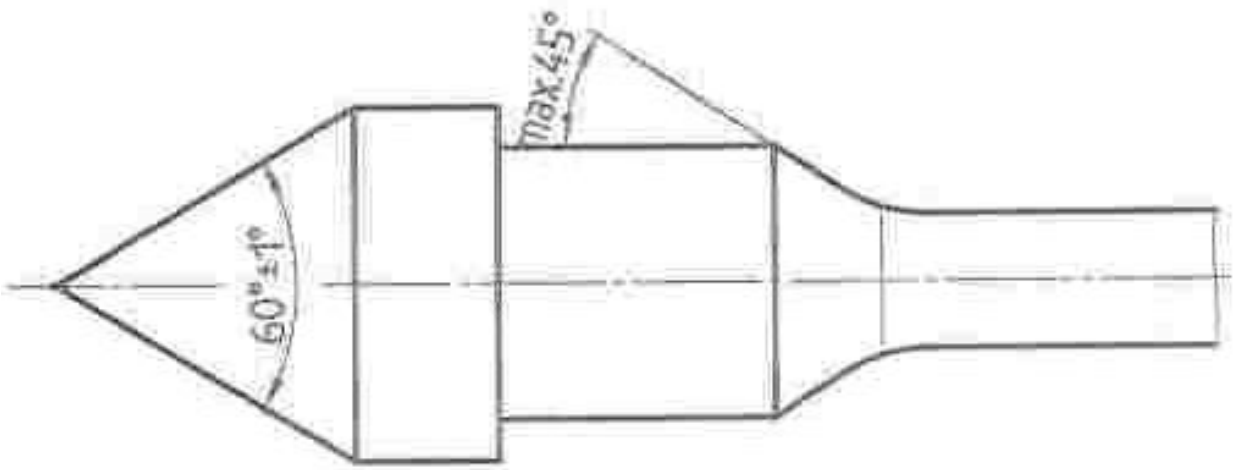
All tolerances ± …… mm unless otherwise noted.
(Toleransı verilmeyen ölçülerde tolerans: ± …… mm'dir).

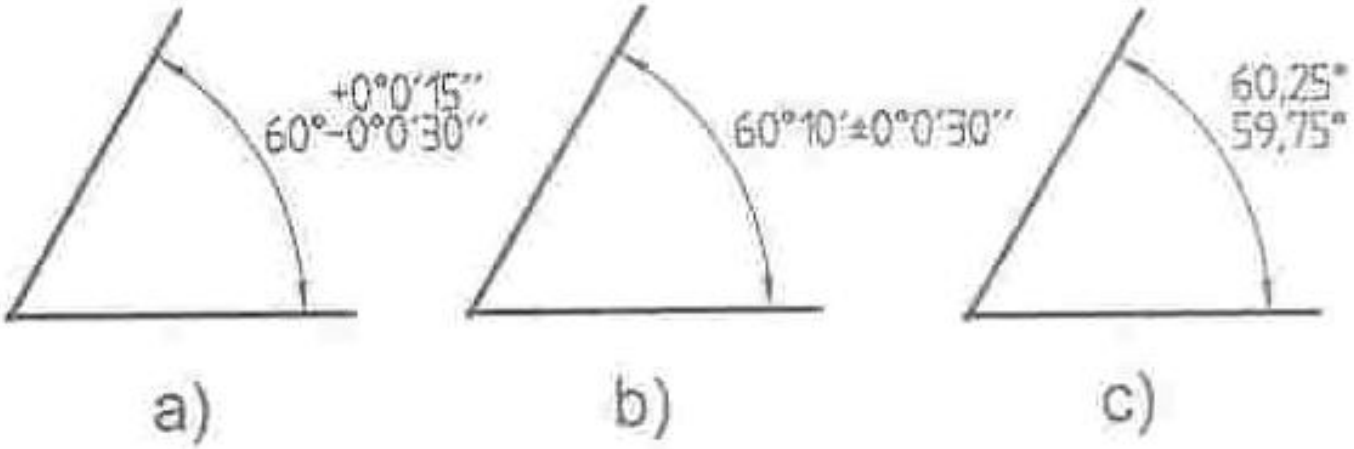
All tolerances according to TS1980-f unless otherwise noted.
All tolerances according to TS1980-m unless otherwise noted.
All tolerances according to TS1980-c unless otherwise noted.
(Diğer toleranslar TS1980-f'e göre)
(Diğer toleranslar TS1980-m'e göre)
(Diğer toleranslar TS1980-c'e göre)

Note: The linear dimension tolerances are given in Turkish standards (TS1980) as in the following Table.

Tolerans kalitesi	Boyutlar						
	0,5-3	3-6	3-30	30-120	120-400	400-10	1000-2000
f (ince)	±0,05	±0,05	±0,1	±0,15	±0,2	±0,3	±0,5
m (orta)	±0,1	±0,1	±0,2	±0,3	±0,5	±0,8	±1,2
c (kaba)	±0,2	±0,3	±0,5	±0,8	±1,2	±2	±3

Designation of Angular Dimension Tolerances

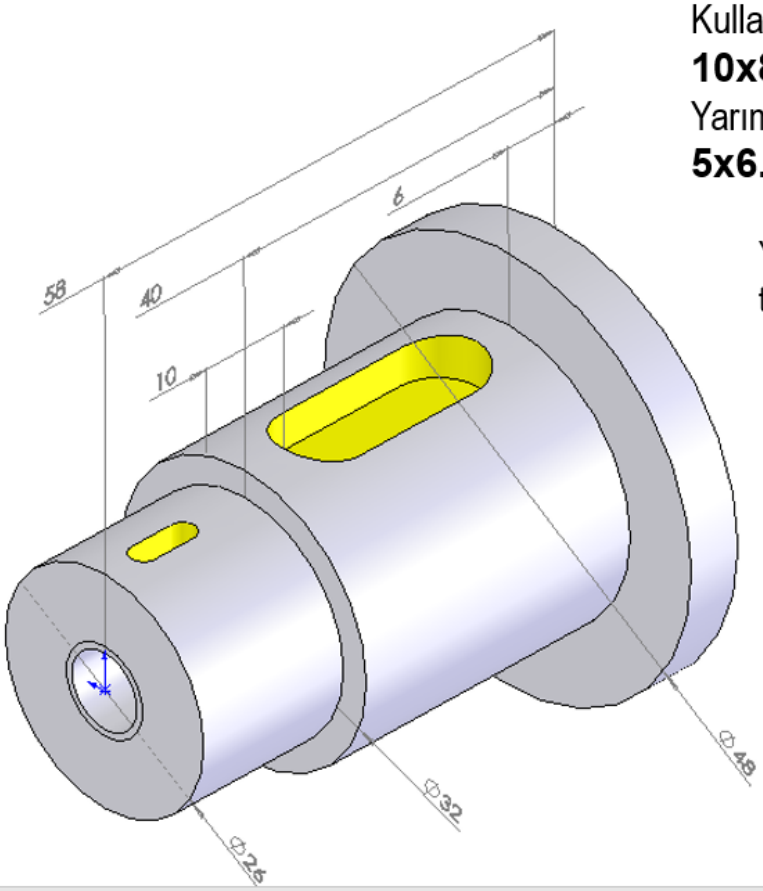




SOME EXERCISES

ÖRNEK

Aşağıdaki milin, kama seçimlerini de dikkate alarak yapım resmini çiziniz.



Kullanılacak eğimsiz kama:
10x8x25 TS 147 (DIN 6885)
Yarımay kama:
5x6.5 TS 147/12 (DIN 6888 B)

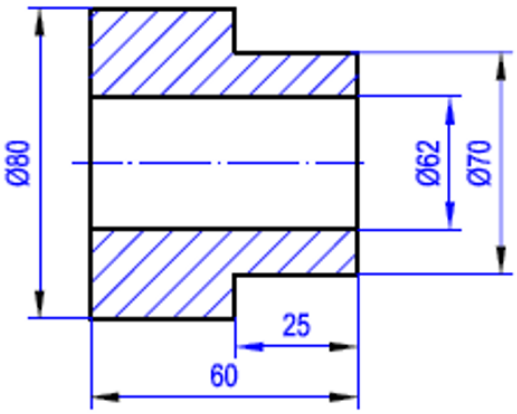
Yanda verilen parçadaki **ϕ26f7** ve **ϕ32h6** toleransları için aşağıdaki tabloyu doldurunuz?

	ϕ26f7	ϕ32h6
Üst ölçü		
Alt ölçü		
Üst sapma		
Alt Sapma		
Tolerans		

CEVAP

	ϕ26f7	**ϕ32h6**
Üst ölçü	25,98	32
Alt ölçü	25,959	31,984
Üst sapma	-0,02	0
Alt Sapma	-0,041	-0,016
Tolerans	0,021	0,016

ÖRNEK



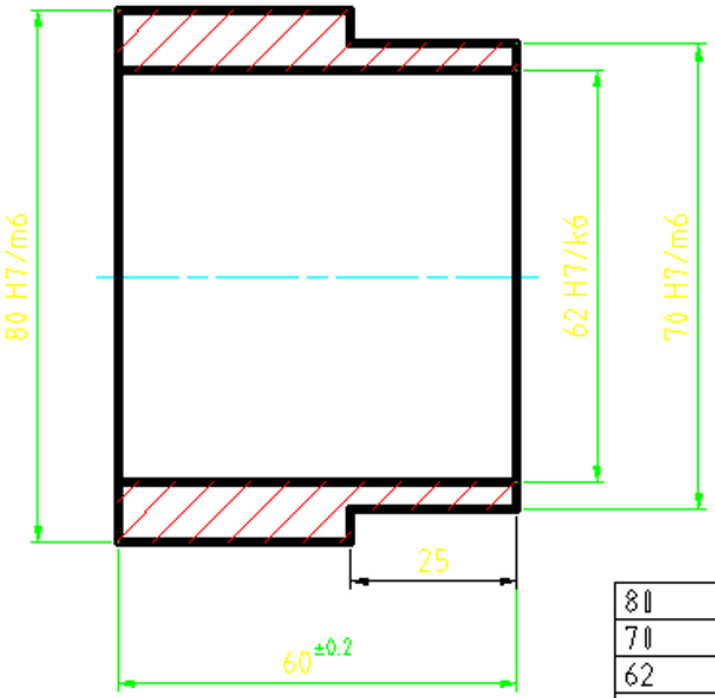
Şekil. 2' de

a- Ø80H7/m6
b- Ø62H7/k6
c- Ø70H7/m6
e- 60 mm uzunluk ölçüsünde aşağı ve yukarı ölçü farkı 0,2 dir.

Verilenler göre parçayı tekrar çizerek ölçülendiriniz.

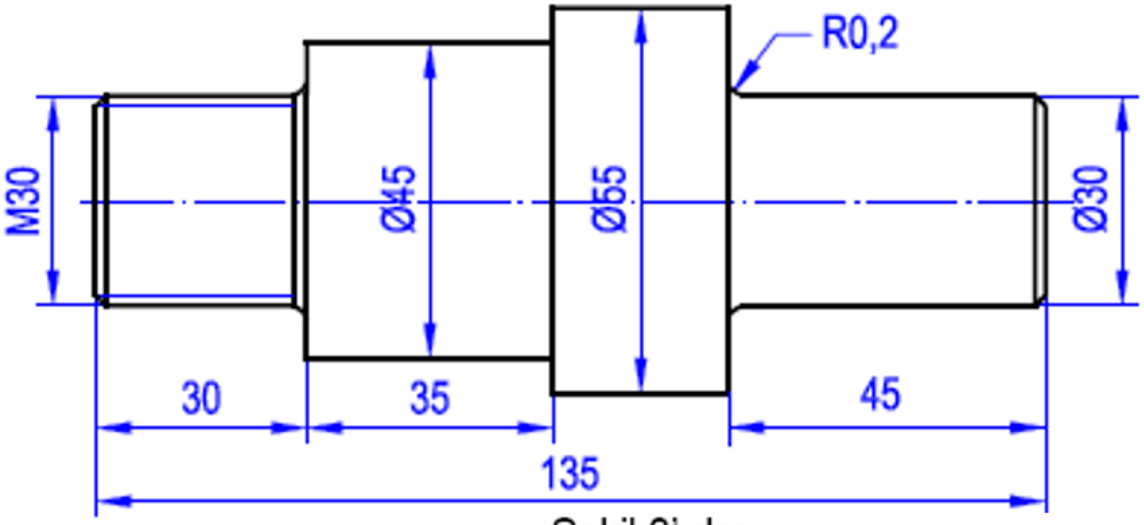
Çap ölçülerine ait en büyük ve en küçük ölçülerini tablo yaparak yazınız.

CEVAP



80	m6	+0.43 +0.011 / 80.43 80.011
70	m6	+0.43 +0.011 / 70.43 70.011
62	k6	+0.021 +0.002 / 62.021 62.002
80	H7	+0.03 0 / 80.03 80
70	H7	+0.03 0 / 70.03 70
62	H7	+0.03 0 / 62.03 62
Dimen.	Fit	

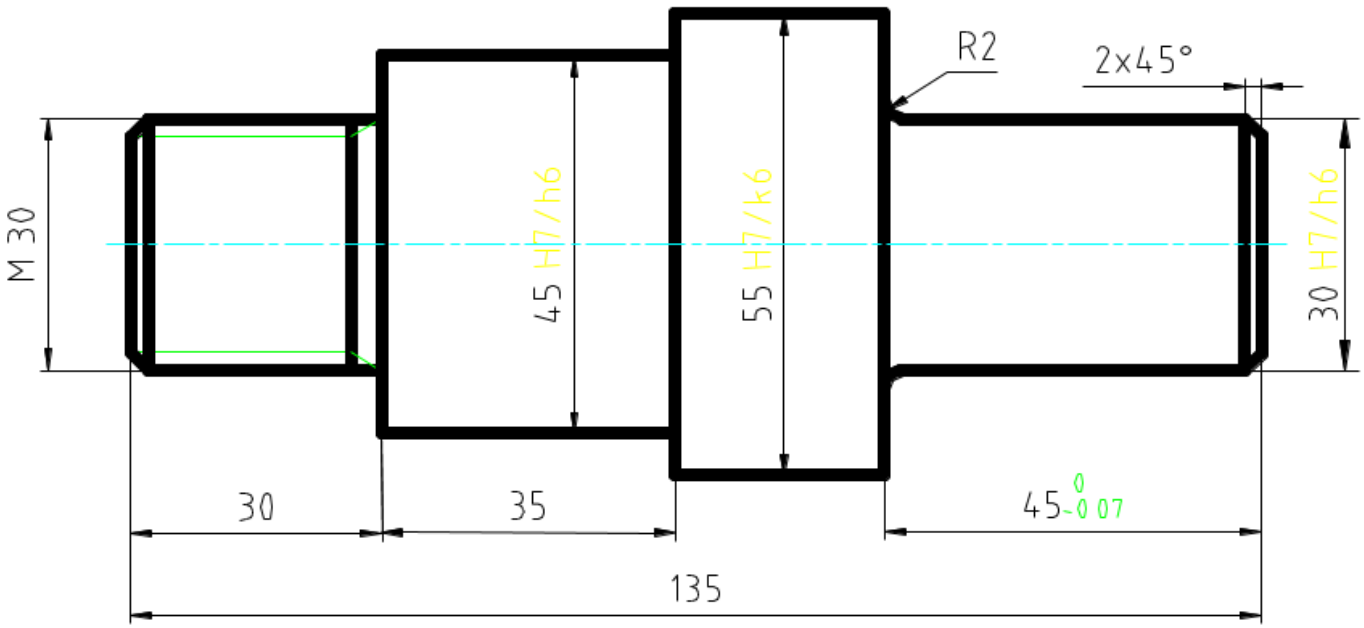
ÖRNEK



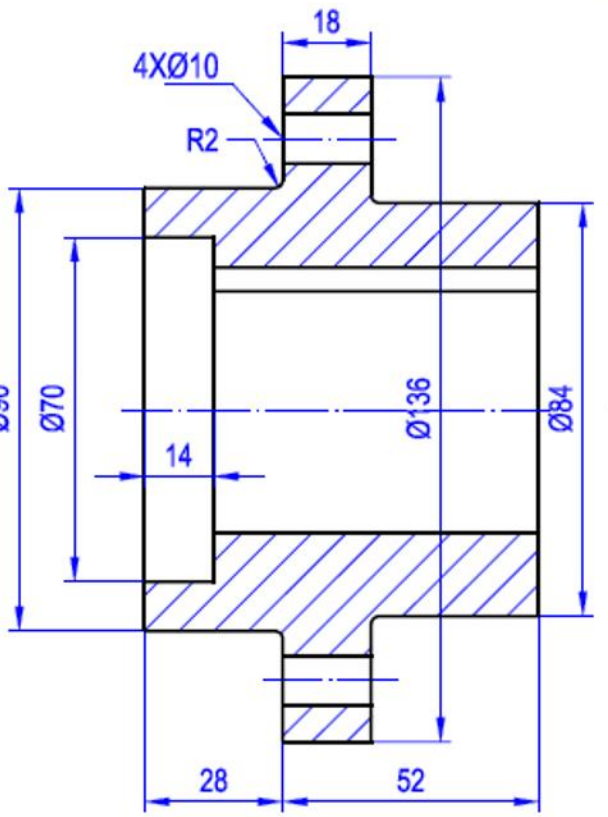
Şekil.3' de;

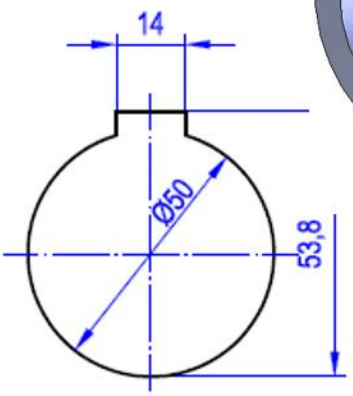
a- Ø30 ve Ø45 çapları ince alıştırma kaygan geçme (normal delik sistemi),
Ø55 ince alıştırma tutuk geçme (normal delik sistemi),
45 mm boyda yukarı ölçü farkı 0, aşağı ölçü farkı -0,07mm' dir.
Verilenlere göre parçayı tekrar çizerek ölçülendiriniz.

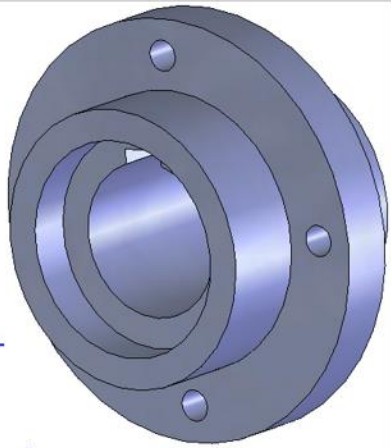
CEVAP



ÖRNEK







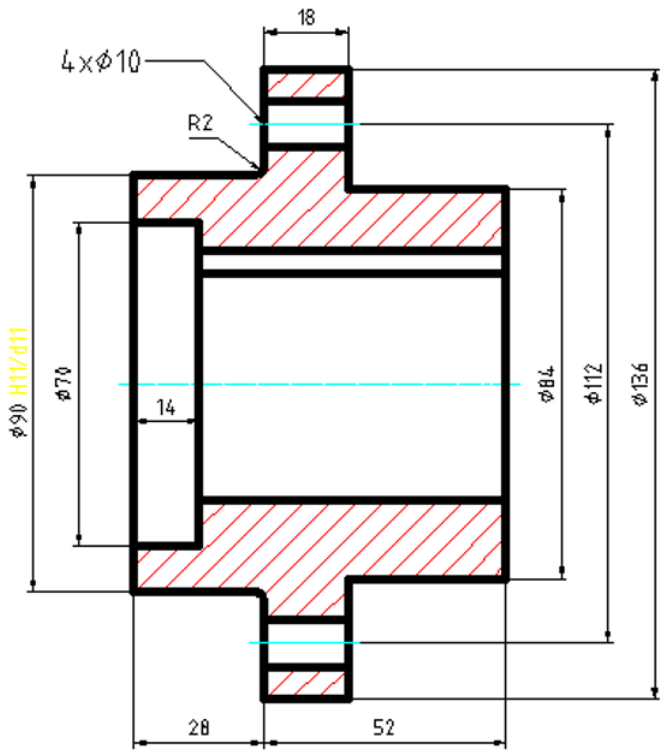
Şekil.2' de;

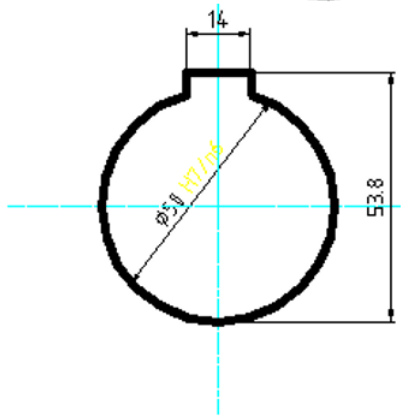
a- Ø50 mm çapa bir mil ince alıştırma sıkı geçme olarak geçecek (normal delik sistemi),

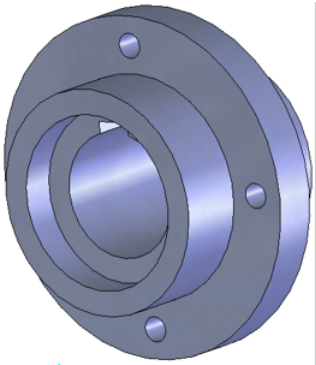
b- Ø90 mm çap, karşılığına kaba alıştırma (kaba geçme-2) olarak geçecek (normal delik sistemi),

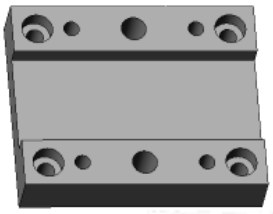
Verilenlere göre parçayı tekrar çizerek ölçülendiriniz.

CEVAP







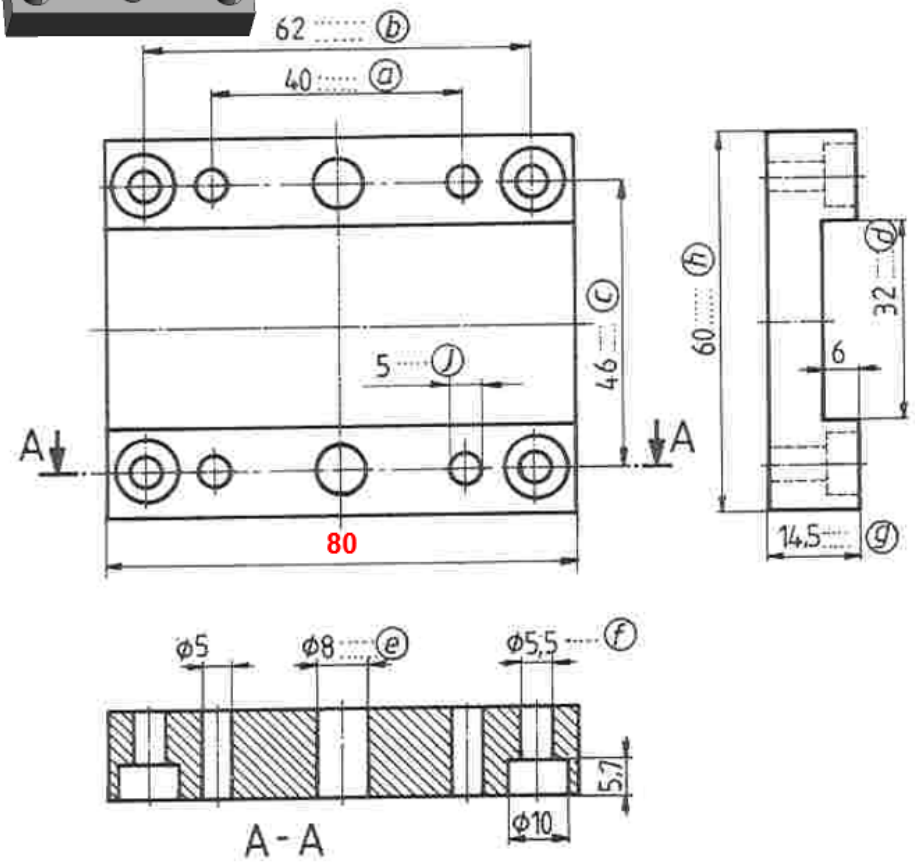


ÖRNEK SORU

Teknik Resim, s. 295 Pr. 5.4, şekil 133

NOT: 80 ölçüsü kitapta verilmemiştir.

Yan görünüşte 8 ve 5'lik delikler eksik..



Şekilde verilen kılavuz plakasında toleransları ilgili ölçülere yazınız.

a. 40 ölçüsü için ±0.05
b. 62 ölçüsü için ±0.02
c. 46 ölçüsü için +0.015 -0.010
d. 32 ölçüsü için +0.1 0
e. Ø8 ölçüsü için +0.009 0
f. Ø5.5 ölçüsü için H11
g. 14.5 ölçüsü için 0 -0.1
h. 60 ölçüsü için -0.05 -0.03
I. 5 ölçüsü için H7
j. Verilmeyen ölçülerde tolerans ±0.1

NOT: Gerekli toleranslar için **açıklama anteti** veriniz.