

# Engineering Drawing Notes

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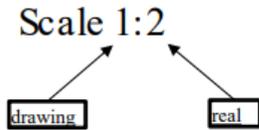
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## ISO standard list

N.	Title	N.	Title
128	Technical drawings – General principles of presentation. Part 1: introduction and index	129	Technical drawings – Indication of dimensions and tolerances. Part 1: general principles
286-1	ISO system of limits and fits. Part 1: bases of tolerances, deviations and fits	286-2	ISO system of limits and fits. Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts
406	Technical drawings – Tolerancing of linear and angular dimensions	1101	Technical drawings – Geometrical tolerancing. Tolerancing of form, orientation, location and run-out. Generalities, definitions, symbols, indications on drawings
1660	Technical drawings – Dimensioning and tolerancing of profiles	2692	Technical drawings – Geometrical tolerancing - Maximum material principle
2768-1	General tolerances – Part 1: tolerances for linear and angular dimensions without individual tolerance indications	2768-2	General tolerances – Part 2: geometrical tolerances for features without individual tolerance indications
3040	Technical drawings – Dimensioning and tolerancing – Cones	5458	Technical drawings – Geometrical tolerancing – Positional tolerancing
5459	Technical drawings – Geometrical tolerancing – Datums and datum-systems for geometrical tolerances	7083	Technical drawings – Symbols for geometrical tolerancing. Proportions and dimensions
8015	Technical drawings – Fundamentals of tolerancing principles	10578	Technical drawings – Tolerancing of orientation and location. Projected tolerance zone
10579	Technical drawings – Dimensioning and tolerancing – Non-rigid parts	13715	Technical drawings – Corners of undefined shape. Vocabulary and indications on drawings

# 1 BASIC STANDARDS

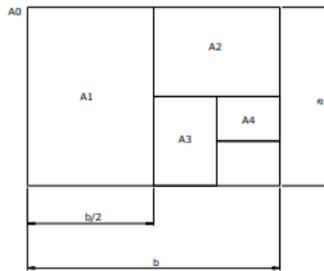
## Scale - UNI EN ISO 5455



The "Scale" word can be omitted.

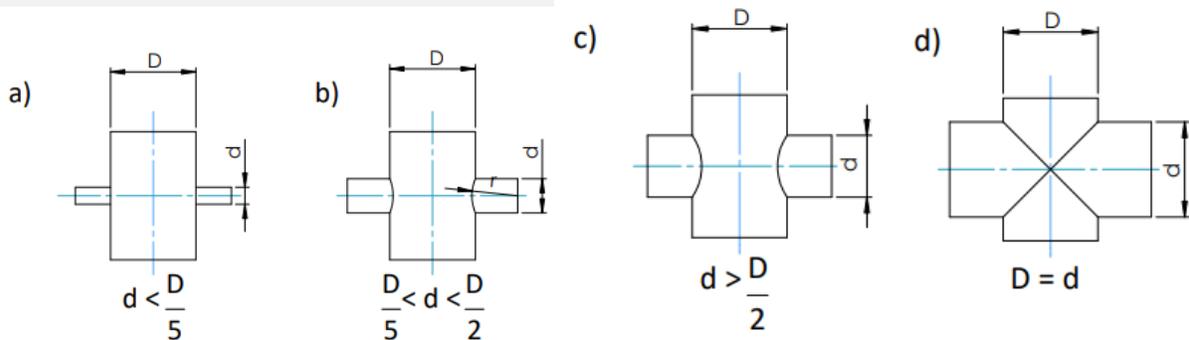
Type	Standardized scales		
Magnification	50:1	20:1	10:1
	2:1	5:1	
Natural	1:1		
	1:2	1:5	1:10
Reduction	1:20	1:50	1:100
	1:200	1:500	1:1000
	1:2000	1:5000	1:10000

## UNI EN ISO 5457 - Drawing Sheet Sizes



Size	a	b
A0	841	1189
A1	594	841
A2	420	594
A3	297	420
A4	210	297

## Cylinder to cylinder intersections I



Draw lines - UNI EN ISO 128-20 (current standard) Basic Standards

### Draw lines - UNI EN ISO 128-20 (current standard)

Fundamental linetypes

- 01 Solid line
- 02 Dashed line
- 03 Long-dashed line
- 04 Dash-dot line
- 05 Dotted line
- 06 Long-dash-short-dash line
- 07 Fine solid line
- 08 Fine dashed line
- 09 Fine dash-dot line
- 10 Fine dotted line
- 11 Fine long-dash-short-dash line
- 12 Fine long-dashed line
- 13 Fine dash-dot line
- 14 Fine dotted line
- 15 Fine long-dash-short-dash line

DT1

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Draw lines - UNI EN ISO 128-20 (current standard) Basic Standards

### Draw lines - UNI EN ISO 128-20 (current standard)

Unified thickness

Thickness	0.13	0.18	0.25	0.35	0.5	0.7	1	1.4	2
Position	1	2	3	4	5	6	7	8	9

Thin  
Thick  
Extra Thick

Fundamental lines modulations

Combinations of the fundamental lines

DT1



## Recommended dimensions

Edge size	Edge type
* +2.5 +1 +0.5 +0.3 +0.1	Edges with burr or passing permitted, undercut not permitted
+0.05 +0.02 -0.02 -0.05	Sharp edges
-0.1 -0.2 -0.5 -1 -2.5 *	Edges with undercut permitted, burr or passing not permitted

ISO 13715:2000 

## 3 TAPER & TILT

$$T = \frac{D - d}{L} = 2 \tan\left(\frac{\alpha}{2}\right)$$

Symbol for taper:

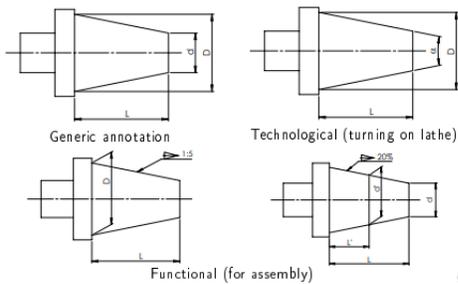


$$\text{Tilt} = \frac{H - h}{L} = \tan \beta$$

Symbol for tilt:



### Taper dimensioning



# 4 THREADS

Diameter			Threads	
Columns			Coarse pitch	Fine pitch
a	b	c		
1,6			0,35	0,2
	1,8		0,35	0,2
2			0,4	0,25
	2,2		0,45	0,25
2,5			0,45	0,35
3			0,5	0,35
	3,5		0,6	0,35
4			0,7	0,5
	4,5		0,75	0,5
5			0,8	0,5
	5,5		-	0,5
6			1	0,75
	7		1	0,75
8			1,25	0,75
	9		1,25	0,75
10			1,5	0,75
	11		1,5	0,75
12			1,75	1
	14		2	1
	15		-	1
16			2	1



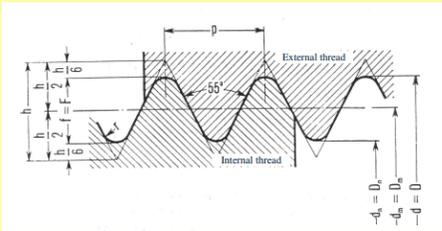
**Coarse and fine pitch**

Column description:  
 a) preferred standard diameters  
 b) to be used only in case of necessity  
 c) to be avoided, if possible.

Nominal diameter D of			Pitch P										
Col. 1 1st choice	Col. 2 2nd choice	Col. 3 3rd choice	Fine										
			coarse	3	2	1,5	1,25	1	0,75	0,5	0,35	0,25	0,2
1			0,25										0,2
1,2	1,1		0,25										0,2
	1,4		0,25										0,2
1,6			0,25										0,2
	1,8		0,35										0,2
2			0,4									0,25	
	2,2		0,45									0,25	
2,5			0,5								0,35		
3			0,6								0,35		
4			0,6							0,5			
	4,5		0,7							0,5			
5			0,75							0,5			
	5,5		0,8							0,5			
6			1							0,75			
	7		1							0,75			
8			1,25						1	0,75			
	9		1,25						1	0,75			
10			1,5						1,25	1	0,75		
	11		1,5						1,25	1	0,75		
12			1,75						1,5	1,25	1		
	14		2						1,5	1,25	1		
14			2						1,5	1,25	1		
	15		2						1,5	1,25	1		
16			2						1,5	1,25	1		
	17		2						1,5	1,25	1		
18			2,5						2	1,5	1,5		
	20		2,5						2	1,5	1,5		
24			2,5						2	1,5	1,5		
	22		3						2	1,5	1,5		
	25		3						2	1,5	1,5		

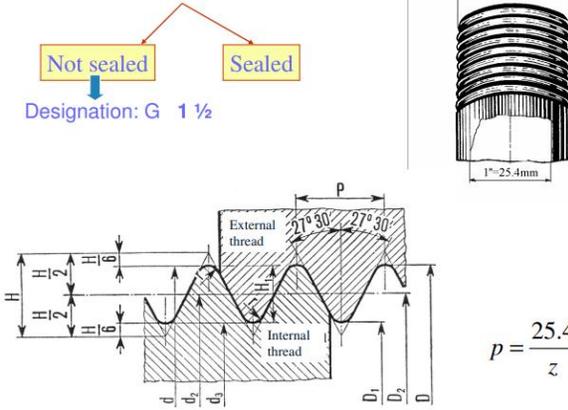
Column description:  
 a) preferred standard diameters  
 b) to be used only in case of necessity  
 c) to be avoided, if possible.

## Whitworth threading



- They are defined by major diameter of internal and external thread:  $d = D$  [inches]
- The designation requires the diameter in inches followed by the "W" letter:  $1 \frac{1}{2} W$

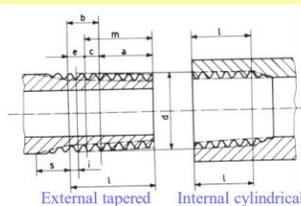
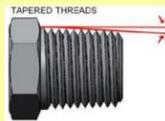
## GAS threading



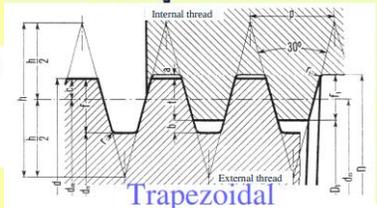
## Sealed GAS threading

### Thread designation:

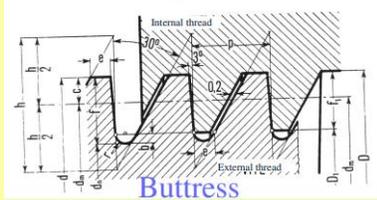
- External tapered: R (R 1/2)
- Internal cylindrical: Rp (Rp 1/2)
- Internal tapered: Rc (Rc 1/2)



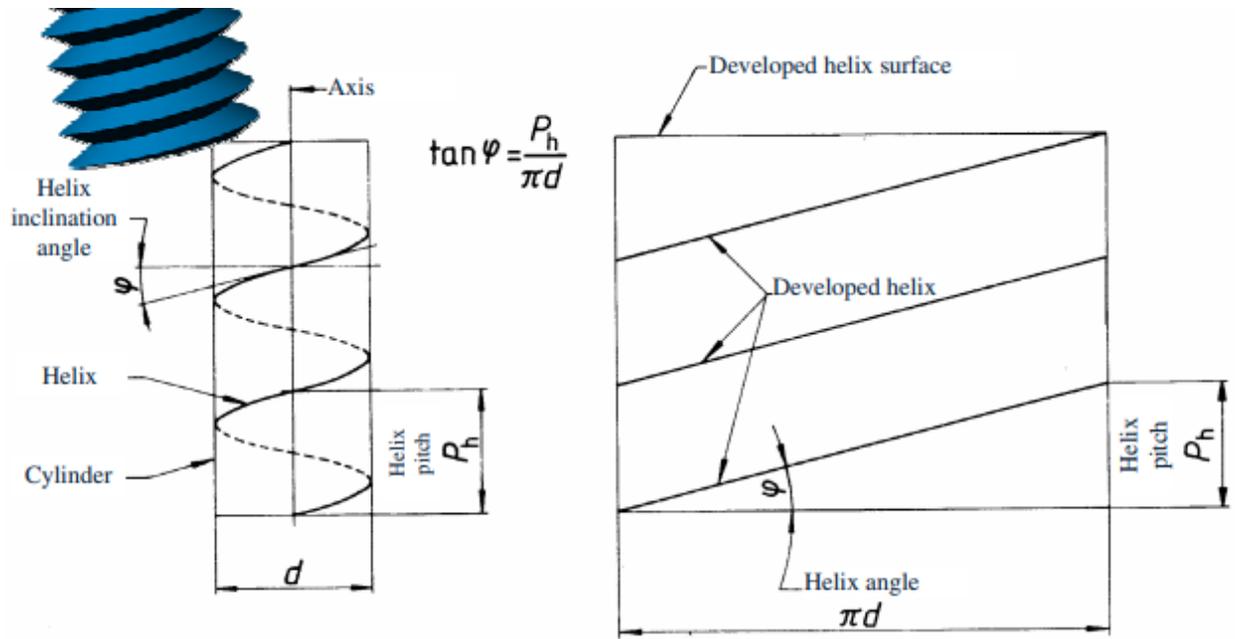
## Other profile forms



They are used for lead screws for their high efficiency in torque transmission.



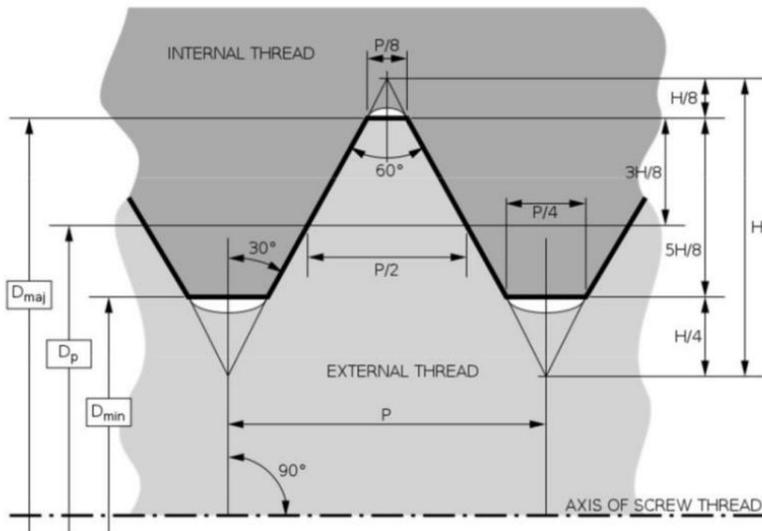
They are used for very important connections (airplane propeller). It bears relatively intense loads in the axial sense.



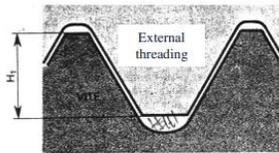
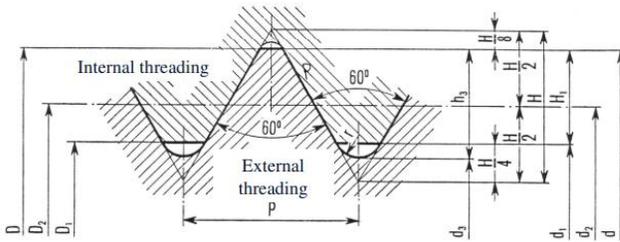
Format:  $M d \times p$

- $d$ : nominal diameter
- $p$ : thread pitch (only for fine or non-standard pitches)

## ISO metric profile



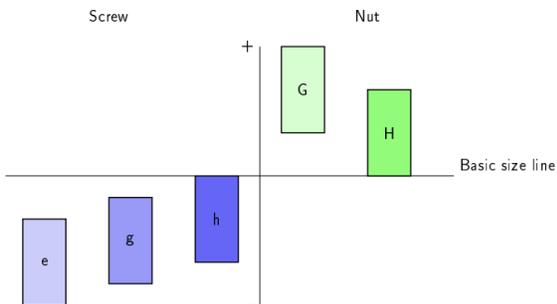
## ISO metric profile



$$H_1 = \frac{5}{8} H = 0.54127 p \quad \text{Internal threading}$$

$$h_3 = \frac{17}{24} H = 0.61343 p \quad \text{External threading}$$

### Tolerance positions



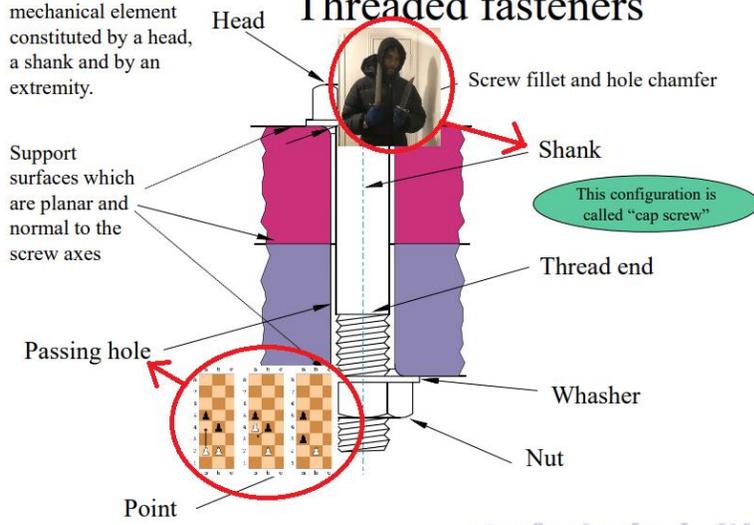
Notation examples:

M10 - 4H 5H / 4h 6h ( $r=0.135$ ):

- 4H: nut thread pitch diameter,
- 5H: nut minor diameter,
- 4h: screw thread pitch diameter,
- 6h: screw major diameter,
- ( $r=0.135$ ) minimum fillet radius at the root diameter;

The screw is a mechanical element constituted by a head, a shank and by an extremity.

## Threaded fasteners



Major diameter groups		Pitch P	Screwing length			
			S	N		L
Above	Up to		(Short)	(Normal)		(Long)
			Up to	Above	Up to	Above
1.5	2.8	0.35	0.8	0.8	2.6	2.6
		0.4	1	1	3	3
		0.45	1.2	1.2	3.7	3.7
2.8	5.6	0.35	1	1	3	3
		0.5	1.5	1.5	4.5	4.5
		0.6	1.7	1.7	5	5
		0.7	2	2	6	6
		0.75	2.2	2.2	6.7	6.7
5.6	11.2	0.8	2.5	2.5	7.5	7.5
		0.75	2.4	2.4	7.1	7.1
		1	3	3	9	9
		1.25	4	4	12	12
		1.5	5	5	15	15

Diameter		Manufacturing quality									
		Precise	Medium	Coarse	Precise	Medium	Coarse	Precise	Medium	Coarse	
Screw	$d$	4	6	–	4	6	8	4	6	8	
	$d_2$	3	5	–	4	6	8	4	7	8	
Nut	$D_1$	4	5	–	5	6	7	6	7	8	
	$D_2$	4	5	–	4	6	7	6	7	8	
			S			N			L		
Screwing length group											

Screwing length	Machining Quality	Thread	Thread tolerances		
			Without coating	Phosphating or galvanic coating	High thickness galvanic coating
S Short	Precise	Screw Nut	3h, 4h 4H	– –	– –
	Medium	Screw Nut	5h, 6h   5g, 6g 5H	5g, 6g 5H	5g, 6g 5G
	Coarse	Screw Nut	– –	– –	– –
M Medium	Precise	Screw Nut	4h   4g 4H, 5H	4g 4H, 5H	4e 4G, 5G
	Medium	Screw Nut	6h   6g 6H	6g 6H	6e 6G
	Coarse	Screw Nut	8g 7H	8g 7H	8e 7G
L Long	Precise	Screw Nut	5h, 4h 4H, 5H	5h, 4h 4H, 5H	– –
	Medium	Screw Nut	7h, 6h   7g, 6g 7H	7g, 6g 7H	t6, 6e 7G
	Coarse	Screw Nut	9g, 8g 8H	9g, 8g 8H	9e, 8e 8G

## The screws

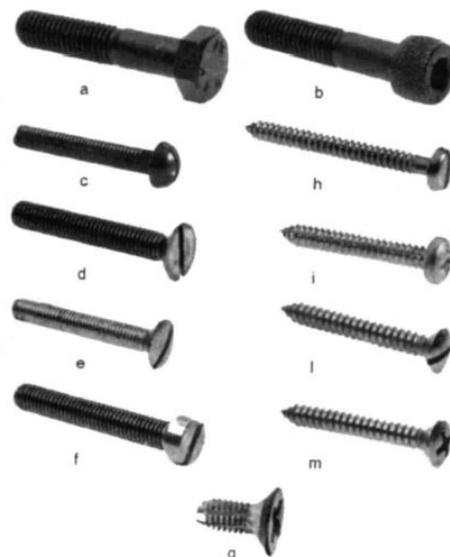
- a) Exagon head
- b) Cylindrical head (socket head screw or hex cup screw)
- c) Truss head
- d) Flat head
- e) Oval head
- f) Pan head
- g) Self drilling tapping screw
- h, i, l, m) Tapping screws with truss head and different slots

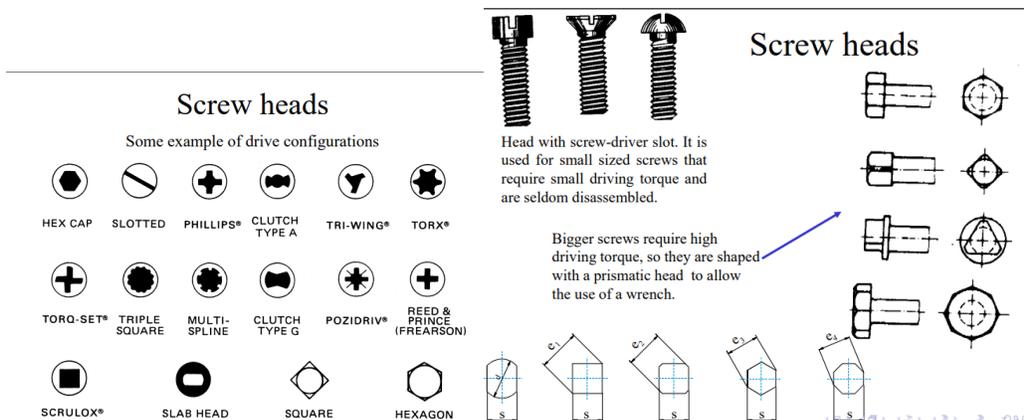
Head style is the configuration of the head of a screw

Tapping screws cut or form a mating thread when driven into a preformed hole.

The self-drilling type does not require the preformed hole. Only for steel sheets

There are several kinds of slots, different in form, which are used to drive the screw.





Space of maneuver for wrenches must be at least 60 degrees.

### Notation examples

**Screw M10x60 ISO4014 – 8.8**  
Hex head, ISO metric thread M10, coarse pitch, shank length 60mm, material: steel class 8.8

**Screw M8x30 UNI5931 – 12.9**  
Cylindrical head, hexagon socket, ISO metric thread M8, coarse pitch, shank length 30mm, material: steel class 12.9

**Nut M24x2 ISO4032 – 10**  
Normal height nut, ISO metric thread M24, fine pitch 2mm, , material: steel class 10

**Nut M24x2 ISO4032 – 10 – Burnished**  
As above, with additional indication of the surface condition.

**Nut A M10 UNI5448 – X2CrNi1811 UNI6901**  
Wing nut, type A (cold forged), ISO metric thread M10, coarse pitch, stainless steel X2CrNi1811.

### Notation examples

**Washer 10 ISO 7089**  
Plane washer for M10 screw

**Washer 12 UNI 1751**  
Spring washer for M12 screw

**Cotter pin 2,5x20 UNI EN ISO 1234**  
Cotter pin, stem diameter 2.5, length 20mm.

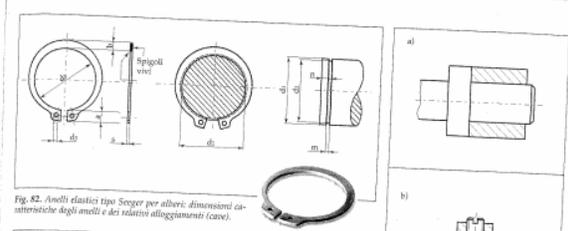


Fig. 82. Anelli elastici tipo Seeger per alberi. dimensioni caratteristiche degli anelli e dei relativi alloggiamenti (cavo).

Indicazione per la designazione	Anello				Alloggiamento			Carico assiale max N
	s	a max	b	d <sub>1</sub>	d <sub>2</sub>	m	a min	
3	0,4	1,9	0,8	2,7	2,8	0,5	0,3	230
4	0,6	2,2	0,9	3,7	3,8	0,7	0,45	300
5	0,7	2,7	1,3	5,6	5,7	0,8	0,65	380
6	0,8	3,2	1,5	7,4	7,6	0,9	0,8	480
7	1,0	3,8	1,8	9,4	9,6	1,1	1,0	600
8	1,2	4,4	2,1	11,9	12,1	1,3	1,2	750
9	1,4	5,0	2,4	14,7	14,9	1,5	1,4	900
10	1,6	5,6	2,7	17,5	17,7	1,7	1,6	1050
11	1,8	6,2	3,0	20,3	20,5	1,9	1,8	1200
12	2,0	6,8	3,3	23,1	23,3	2,1	2,0	1350
13	2,2	7,4	3,6	25,9	26,1	2,3	2,2	1500
14	2,4	8,0	3,9	28,7	28,9	2,5	2,4	1650
15	2,6	8,6	4,2	31,5	31,7	2,7	2,6	1800
16	2,8	9,2	4,5	34,3	34,5	2,9	2,8	1950
17	3,0	9,8	4,8	37,1	37,3	3,1	3,0	2100
18	3,2	10,4	5,1	39,9	40,1	3,3	3,2	2250
19	3,4	11,0	5,4	42,7	42,9	3,5	3,4	2400
20	3,6	11,6	5,7	45,5	45,7	3,7	3,6	2550
21	3,8	12,2	6,0	48,3	48,5	3,9	3,8	2700
22	4,0	12,8	6,3	51,1	51,3	4,1	4,0	2850
23	4,2	13,4	6,6	53,9	54,1	4,3	4,2	3000
24	4,4	14,0	6,9	56,7	56,9	4,5	4,4	3150
25	4,6	14,6	7,2	59,5	59,7	4,7	4,6	3300
26	4,8	15,2	7,5	62,3	62,5	4,9	4,8	3450
27	5,0	15,8	7,8	65,1	65,3	5,1	5,0	3600
28	5,2	16,4	8,1	67,9	68,1	5,3	5,2	3750
29	5,4	17,0	8,4	70,7	70,9	5,5	5,4	3900
30	5,6	17,6	8,7	73,5	73,7	5,7	5,6	4050
31	5,8	18,2	9,0	76,3	76,5	5,9	5,8	4200
32	6,0	18,8	9,3	79,1	79,3	6,1	6,0	4350
33	6,2	19,4	9,6	81,9	82,1	6,3	6,2	4500
34	6,4	20,0	9,9	84,7	84,9	6,5	6,4	4650
35	6,6	20,6	10,2	87,5	87,7	6,7	6,6	4800
36	6,8	21,2	10,5	90,3	90,5	6,9	6,8	4950
37	7,0	21,8	10,8	93,1	93,3	7,1	7,0	5100
38	7,2	22,4	11,1	95,9	96,1	7,3	7,2	5250
39	7,4	23,0	11,4	98,7	98,9	7,5	7,4	5400
40	7,6	23,6	11,7	101,5	101,7	7,7	7,6	5550
41	7,8	24,2	12,0	104,3	104,5	7,9	7,8	5700
42	8,0	24,8	12,3	107,1	107,3	8,1	8,0	5850
43	8,2	25,4	12,6	109,9	110,1	8,3	8,2	6000
44	8,4	26,0	12,9	112,7	112,9	8,5	8,4	6150
45	8,6	26,6	13,2	115,5	115,7	8,7	8,6	6300
46	8,8	27,2	13,5	118,3	118,5	8,9	8,8	6450
47	9,0	27,8	13,8	121,1	121,3	9,1	9,0	6600
48	9,2	28,4	14,1	123,9	124,1	9,3	9,2	6750

Tab. XX. Dimensioni di anelli elastici per alberi, tipo di figura 82 (UNI 7435).

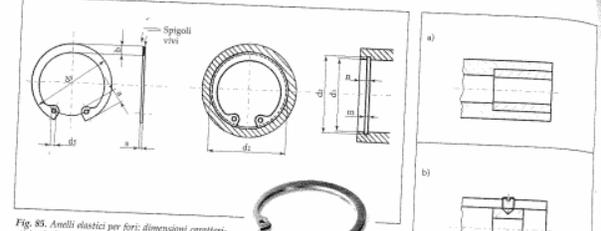


Fig. 85. Anelli elastici per fori: dimensioni caratteristiche degli anelli e degli alloggiamenti.

Indicazione per la designazione	Anello				Alloggiamento			Carico assiale max N
	s	a max	b	d <sub>1</sub>	d <sub>2</sub>	m	a min	
8	0,8	2,4	1,1	8,7	8,4	0,9	0,6	1280
9	1,0	2,8	1,3	9,8	9,4	1,1	0,75	1440
10	1,2	3,2	1,4	10,8	10,4	1,3	0,9	1600
11	1,4	3,6	1,5	11,8	11,4	1,5	1,1	1760
12	1,6	4,0	1,7	13	12,5	1,7	1,2	1920
13	1,8	4,4	1,8	14,1	13,6	1,9	1,3	2080
14	2,0	4,8	1,9	15,1	14,6	2,1	1,4	2240
15	2,2	5,2	2	16,2	15,7	2,3	1,5	2400
16	2,4	5,6	2,1	17,3	16,8	2,5	1,6	2560
17	2,6	6,0	2,2	18,3	17,8	2,7	1,7	2720
18	2,8	6,4	2,3	19,5	19	2,9	1,8	2880
19	3,0	6,8	2,4	20,5	20	3,1	1,9	3040
20	3,2	7,2	2,5	21,5	21	3,3	2,0	3200
21	3,4	7,6	2,6	22,5	22	3,5	2,1	3360
22	3,6	8,0	2,7	23,5	23	3,7	2,2	3520
23	3,8	8,4	2,8	24,5	24	3,9	2,3	3680
24	4,0	8,8	2,9	25,5	25	4,1	2,4	3840
25	4,2	9,2	3,0	26,5	26	4,3	2,5	4000
26	4,4	9,6	3,1	27,5	27	4,5	2,6	4160
27	4,6	10,0	3,2	28,5	28	4,7	2,7	4320
28	4,8	10,4	3,3	29,5	29	4,9	2,8	4480
29	5,0	10,8	3,4	30,5	30	5,1	2,9	4640
30	5,2	11,2	3,5	31,5	31	5,3	3,0	4800
31	5,4	11,6	3,6	32,5	32	5,5	3,1	4960
32	5,6	12,0	3,7	33,5	33	5,7	3,2	5120
33	5,8	12,4	3,8	34,5	34	5,9	3,3	5280
34	6,0	12,8	3,9	35,5	35	6,1	3,4	5440
35	6,2	13,2	4,0	36,5	36	6,3	3,5	5600
36	6,4	13,6	4,1	37,5	37	6,5	3,6	5760
37	6,6	14,0	4,2	38,5	38	6,7	3,7	5920
38	6,8	14,4	4,3	39,5	39	6,9	3,8	6080
39	7,0	14,8	4,4	40,5	40	7,1	3,9	6240
40	7,2	15,2	4,5	41,5	41	7,3	4,0	6400
41	7,4	15,6	4,6	42,5	42	7,5	4,1	6560
42	7,6	16,0	4,7	43,5	43	7,7	4,2	6720
43	7,8	16,4	4,8	44,5	44	7,9	4,3	6880
44	8,0	16,8	4,9	45,5	45	8,1	4,4	7040
45	8,2	17,2	5,0	46,5	46	8,3	4,5	7200
46	8,4	17,6	5,1	47,5	47	8,5	4,6	7360
47	8,6	18,0	5,2	48,5	48	8,7	4,7	7520
48	8,8	18,4	5,3	49,5	49	8,9	4,8	7680

Tab. XXI. Anelli elastici per fori del tipo di figura 85 (UNI 7437).

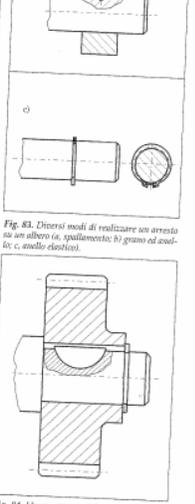


Fig. 83. Diversi modi di realizzare un arresto su un albero (a, spallamento; b, grano ad anello; c, anello elastico).

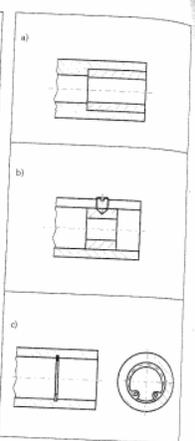


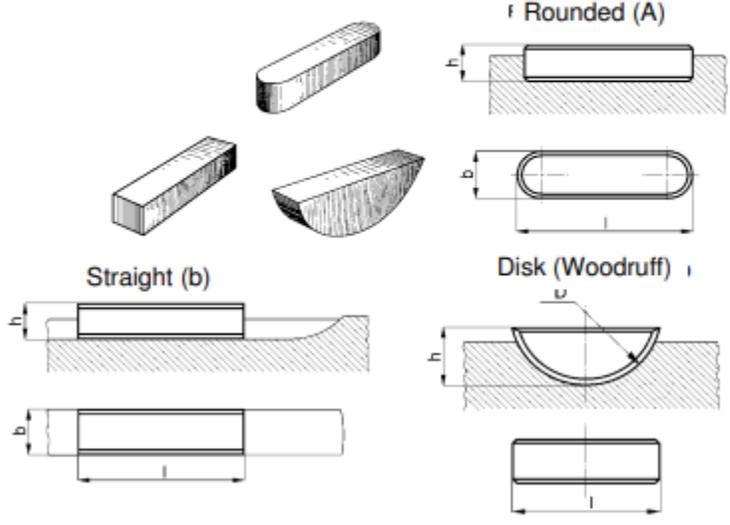
Fig. 86. Diversi modi di realizzare un arresto in un foro (a, spallamento; b, grano; c, anello elastico).



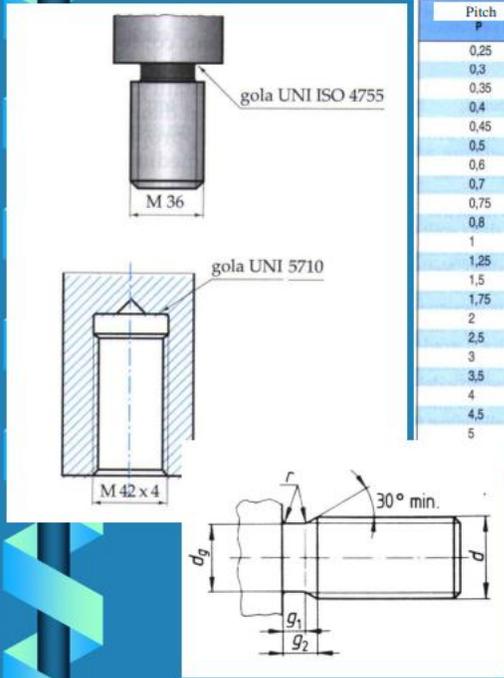
Fig. 87. Diversi tipi di anelli elastici a sezione costante.

# Keys : types

Available shapes: **Straight (B shape), Rounded (A shape), Disk (Woodruff shape)** suitable for mounting at the end of tapered shafts.



# Undercuts: drawing representation



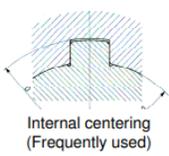
Pitch P	$d$ h12 (H13)*	$g_1$ min.	$g_2$ (-3P)	$r$ =
0,25	d - 0,4	0,4	0,75	0,12
0,3	d - 0,5	0,5	0,9	0,16
0,35	d - 0,6	0,6	1,05	0,16
0,4	d - 0,7	0,6	1,2	0,2
0,45	d - 0,7	0,7	1,35	0,2
0,5	d - 0,8	0,8	1,5	0,2
0,6	d - 1	0,9	1,8	0,4
0,7	d - 1,1	1,1	2,1	0,4
0,75	d - 1,2	1,2	2,25	0,4
0,8	d - 1,3	1,3	2,4	0,4
1	d - 1,6	1,6	3	0,6
1,25	d - 2	2	3,75	0,6
1,5	d - 2,3	2,5	4,5	0,8
1,75	d - 2,6	3	5,25	1
2	d - 3	3,4	6	1
2,5	d - 3,6	4,4	7,5	1,2
3	d - 4,4	5,2	9	1,6
3,5	d - 5	6,2	10,5	1,6
4	d - 5,7	7	12	2
4,5	d - 6,4	8	13,5	2,5
5	d - 7	9	15	2,5
	d - 7,7	11	17,5	3,2
	d - 8,3	11	18	3,2

Table: ISO 4755

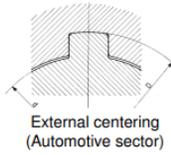
## Splines

The Centering regards which shaft surface is contacting the hub surface and allow the power transmission. It can be on:

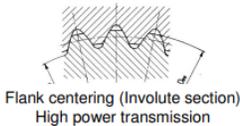
- **Internal surface**
- **External surface**
- **Flanks**



Internal centering  
(Frequently used)



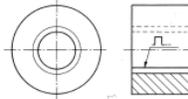
External centering  
(Automotive sector)



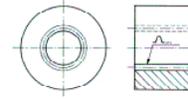
Flank centering (Involute section)  
High power transmission

## Conventional representation

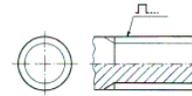
Following UNI ISO 6413



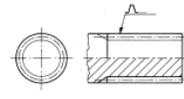
Spline hub  
Parallel flanks



Spline hub  
With involute flanks



Spline shaft  
Parallel flanks



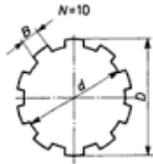
Spline shaft  
With involute flanks

# Spline definition

UNI 8953 (parallel flanks with internal centering)

To define the spline dimensions it mandatory to specify in the following order:  
 # of teeth X; inner spline diameter, external spline diameter, assembly condition (shaft), surface and thermal treatment (hub)

UNI 8953 – 6 X 23 X 26 S



SHAFT

- S (sliding)
- SC (sliding under load condition)
- F (fixed)

HUB

- NT (not treated after broaching)
- T (treated after broaching)

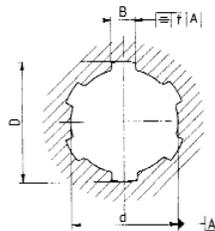
d mm	Serie leggera			Denti		Serie media			Denti	
	Grandezza	D	B	N°		Grandezza	D	B	N°	
11	—	—	—	—		6× 11× 14	14	3	6	
13	—	—	—	—		6× 13× 16	16	3,5	6	
16	—	—	—	—		6× 16× 20	20	4	6	
18	—	—	—	—		6× 18× 22	22	5	6	
21	—	—	—	—		6× 21× 25	25	5	6	
23	6× 23× 26	26	6	6		6× 23× 28	28	6	6	
26	6× 26× 30	30	6	6		6× 26× 32	32	6	6	
28	6× 28× 32	32	7	6		6× 28× 34	34	7	6	
32	8× 32× 36	36	6	8		8× 32× 38	38	6	8	
36	8× 36× 40	40	7	8		8× 36× 42	42	7	8	
42	8× 42× 46	46	8	8		8× 42× 48	48	8	8	
46	8× 46× 50	50	9	8		8× 46× 54	54	9	8	
52	8× 52× 58	58	10	8		8× 52× 60	60	10	8	
56	8× 56× 62	62	10	8		8× 56× 65	65	10	8	
62	8× 62× 68	68	12	10		8× 62× 72	72	12	8	
72	10× 72× 78	78	12	10		10× 72× 82	82	12	10	
82	10× 82× 88	88	12	10		10× 82× 92	92	12	10	
92	10× 92× 98	98	14	10		10× 92× 102	102	14	10	
102	10× 102× 108	108	16	10		10× 102× 112	112	16	10	
112	10× 112× 120	120	18	10		10× 112× 125	125	18	10	

# Tolerances

UNI 8953 also defines tolerances

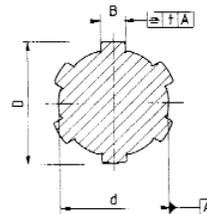
Tolleranze sulle dimensioni

Tolleranze sul mozzo						Tolleranze sull'albero			Tipo di montaggio
non trattato dopo brocciatura (NT)			trattato dopo brocciatura (T)			B	D	d	
B	D	d	B	D	d				
H9	H10	H7	H11	H10	H7	d10	a11	i7	Scorrevole (S)
						f9	a11	g7	Scorrevole sotto carico (SC)
						h10	a11	h7	Fisso (F)



Tolleranze di simmetria

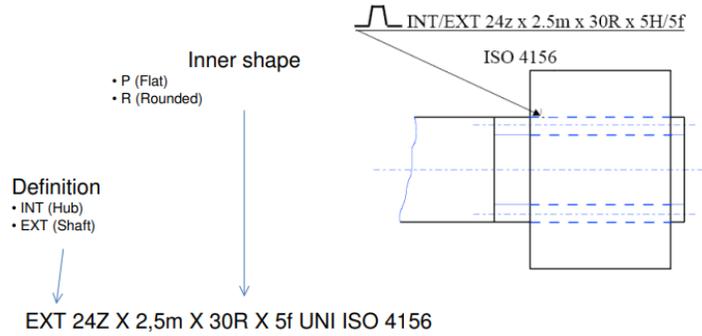
Larghezza del vano e spessore	3	3,5 - 4 - 5 - 6	7 - 8 - 9 - 10	12 - 14 - 16 - 18
Tolleranza di simmetria t	0,010 (IT 7)	0,012 (IT 7)	0,015 (IT 7)	0,018 (IT 7)



# Spline definition

UNI ISO 4156 (involute profile, flank centering)

To define the spline dimensions it mandatory to specify in the following order:  
# of teeth X; modulus, pressure angle, inner shape, tolerance, norm reference



## 5 DIMENSIONAL TOLERANCES



$$i = 0.45\sqrt[3]{D} + 0.001D$$

$$D = \sqrt{D_{lower}D_{upper}}$$

$$\Delta = IT_n - IT_{(n-1)}$$

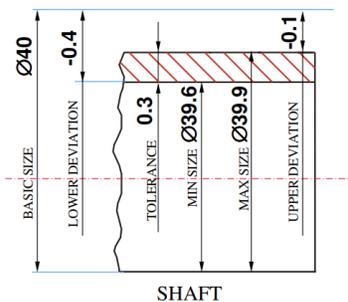
$$IT = E_s - E_i$$

$$R_a = \frac{1}{n} \sum_{i=1}^n y_i$$

$$R_a = \frac{1}{l} \int_l^l |y(x)| dx$$

### Deviations (shaft)

The deviation is an algebraic difference between a size (maximum and minimum limit of size) and the corresponding basic size.



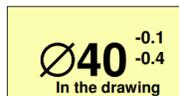
$$IT = d_{max} - d_{min} = 39.9 - 39.6 = 0.3$$

$$IT = es - ei$$

$$IT = -0.1 - (-0.4) = 0.3$$

$$es = d_{max} - d_n = 39.9 - 40 = -0.1$$

$$ei = d_{min} - d_n = 39.6 - 40 = -0.4$$



## Deviations (hole)

The deviation is an algebraic difference between a size (maximum and minimum limit of size) and the corresponding basic size.

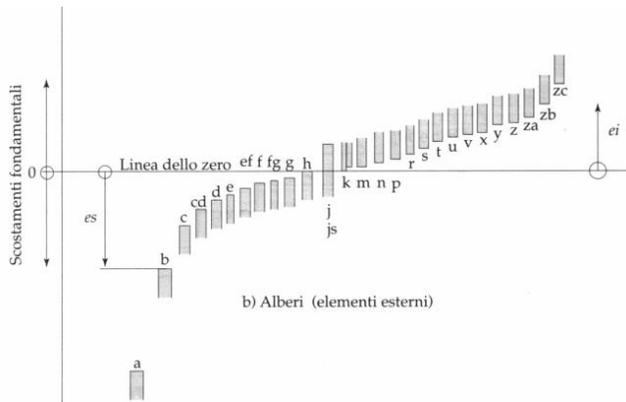
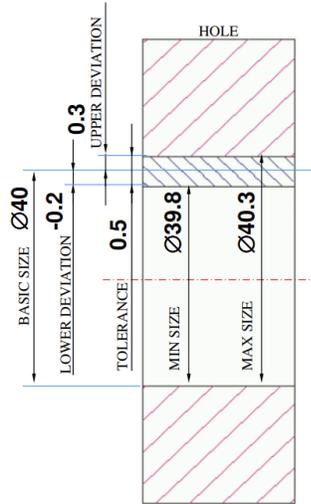
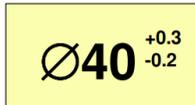
$$IT = D_{max} - D_{min} = 40.3 - 39.8 = 0.5$$

$$Es = D_{max} - D_n = 40.3 - 40 = 0.3$$

$$Ei = D_{min} - D_n = 39.8 - 40 = -0.2$$

$$IT = Es - Ei$$

$$IT = 0.3 - (-0.2) = 0.5$$



Dimensional class		Tolerance grade																	
mm		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
Beyond	Up to	Tolerances																	
		μm									mm								
-	3	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,60	1	1,4
3	6	1	1,5	2,5	4	5	8	12	18	30	48	75	0,12	0,18	0,3	0,48	0,75	1,2	1,8
6	10	1	1,5	2,5	4	6	9	15	22	36	58	90	0,15	0,22	0,36	0,58	0,9	1,5	2,2
10	18	1,2	2	3	5	8	11	18	27	43	70	110	0,18	0,27	0,43	0,7	1,1	1,8	2,7
18	30	1,5	2,5	4	6	9	13	21	33	52	84	130	0,21	0,33	0,52	0,84	1,3	2,1	3,3
30	50	1,5	2,5	4	7	11	16	25	39	62	100	160	0,25	0,39	0,62	1	1,6	2,5	3,9
50	80	2	3	5	8	13	19	30	46	74	120	190	0,3	0,46	0,74	1,2	1,9	3	4,6
80	120	2,5	4	6	10	15	22	35	54	87	140	220	0,35	0,54	0,87	1,4	2,2	3,5	5,4
120	180	3,5	5	8	12	18	25	40	63	100	160	250	0,4	0,63	1	1,6	2,5	4	6,3
180	250	4,5	7	10	14	20	29	46	72	115	185	290	0,46	0,72	1,15	1,85	2,9	4,6	7,2
250	315	6	8	12	16	23	32	52	81	130	210	320	0,52	0,81	1,3	2,1	3,2	5,2	8,1
315	400	7	9	13	18	25	36	57	89	140	230	360	0,57	0,89	1,4	2,3	3,6	5,7	8,9
400	500	8	10	15	20	27	40	63	97	155	250	400	0,63	0,97	1,55	2,5	4	6,3	9,7
500	630	9	11	16	22	32	44	70	110	175	280	440	0,7	1,1	1,75	2,8	4,4	7	11
630	800	10	13	18	25	36	50	80	125	200	320	500	0,8	1,25	2	3,2	5	8	12,5
800	1000	11	15	21	28	40	56	90	140	230	360	560	0,9	1,4	2,3	3,6	5,6	9	14
1000	1250	13	18	24	33	47	66	105	165	260	420	660	1,05	1,65	2,6	4,2	6,6	10,5	16,5
1250	1600	15	21	29	39	55	78	125	195	310	500	780	1,25	1,95	3,1	5	7,8	12,5	19,5
1600	2000	18	25	35	46	65	92	150	230	370	600	920	1,5	2,3	3,7	6	9,2	15	23
2000	2500	22	30	41	55	78	110	175	280	440	700	1100	1,75	2,8	4,4	7	11	17,5	28
2500	3150	26	36	50	68	96	135	210	330	540	860	1350	2,1	3,3	5,4	8,6	13,5	21	33

Tolerance numerical values

## Tolerance values definition

The values of the tolerances corresponding to the grades from IT5 to IT18 for basic sizes up to 500 mm are calculated with the unity of tolerance  $i$ .

Tolerance unit:

$$i = 0.45\sqrt[3]{D} + 0.001D$$

Where D is the geometric mean of the extreme dimensions of the group.

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

Basic size		Standardized tolerance grades																	
		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
oltre	fino a	Formule (risultati in micrometri)																	
—	500	—	—	—	—	7i	10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i	1600i	2500i
500	3 150	2i	2,7i	3,7i	5i	7i	10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i	1600i	2500i

1) Vedere A 3.2.1.

## SHAFT DEVIATIONS

Basic size	Upper deviations $e_s$											Lower deviations $e_i$																			
	Tolerance grades (all)											IT5 IT6	IT7	IT8	IT4 IT7	up to IT3 beyond IT7	Tolerance grades (all)														
	Beyond	Up to	a <sup>1)</sup>	b <sup>1)</sup>	c	cd	d	e	ef	f	fg	g	h	js <sup>2)</sup>	j	k	m	n	p	r	s	t	u	v	x	y	z	za	zb	zc	
—	3 <sup>1)</sup>	-270	-140	-60	-34	-20	-14	-10	-6	-4	-2	0		-2	-4	-6	0	0	+2	+4	+6	+10	+14	+18	+20		+26	+32	+40	+60	
3	6	-270	-140	-70	-46	-30	-20	-14	-10	-6	-4	0		-2	-4	+1	0	0	+4	+8	+12	+15	+19	+23	+28	+35	+42	+50	+80		
6	10	-280	-150	-80	-56	-40	-25	-18	-13	-8	-5	0		-2	-5	+1	0	0	+6	+10	+15	+19	+23	+28	+34	+42	+52	+67	+97		
10	14	-290	-150	-95		-50	-32		-16		-6	0		-3	-6	+1	0	0	+7	+12	+18	+23	+28	+33	+39	+45	+50	+64	+90	+130	
14	18																														
18	24	-300	-160	-110		-65	-40		-20		-7	0		-4	-8	+2	0	0	+8	+15	+22	+28	+35	+41	+48	+55	+64	+75	+88	+118	
24	30																														
30	40	-310	-170	-120		-80	-50		-25		-9	0		-5	-10	+2	0	0	+9	+17	+26	+34	+43	+48	+54	+60	+68	+80	+94	+114	
40	50	-320	-180	-130		-90	-55		-30		-10	0		-7	-12	+2	0	0	+11	+20	+32	+41	+53	+66	+87	+102	+122	+144	+172	+210	
50	65	-340	-190	-140		-100	-60		-30		-10	0		-9	-15	+3	0	0	+13	+23	+37	+51	+71	+91	+124	+146	+178	+214	+258	+310	
65	80	-360	-200	-150		-110	-65		-35		-11	0		-11	-18	+3	0	0	+15	+27	+43	+63	+92	+122	+170	+202	+248	+300	+365	+470	
80	100	-380	-220	-170		-120	-72		-36		-12	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
100	120	-410	-240	-180		-130	-78		-40		-14	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
120	140	-460	-260	-200		-145	-85		-43		-14	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
140	160	-520	-280	-210		-155	-90		-45		-15	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
160	180	-580	-310	-230		-165	-95		-48		-15	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
180	200	-660	-340	-240		-175	-100		-50		-15	0		-13	-21	+4	0	0	+17	+31	+50	+77	+122	+166	+236	+284	+350	+425	+520	+640	
200	225	-740	-380	-260		-185	-105		-53		-16	0		-16	-26	+4	0	0	+20	+34	+56	+98	+170	+240	+350	+425	+525	+650	+790	+1000	
225	250	-820	-420	-280		-195	-110		-56		-17	0		-16	-26	+4	0	0	+20	+34	+56	+98	+170	+240	+350	+425	+525	+650	+790	+1000	
250	280	-920	-480	-300		-210	-115		-60		-17	0		-18	-29	+4	0	0	+21	+37	+62	+114	+208	+294	+435	+530	+660	+820	+1000	+1300	
280	315	-1050	-540	-330		-220	-120		-62		-18	0		-18	-29	+4	0	0	+21	+37	+62	+114	+208	+294	+435	+530	+660	+820	+1000	+1300	
315	355	-1200	-600	-360		-230	-125		-65		-18	0		-20	-32	+5	0	0	+23	+40	+68	+132	+252	+360	+540	+660	+820	+1000	+1300	+1600	
355	400	-1350	-660	-400		-240	-130		-68		-19	0		-20	-32	+5	0	0	+23	+40	+68	+132	+252	+360	+540	+660	+820	+1000	+1300	+1600	
400	450	-1500	-760	-440		-250	-135		-70		-19	0		-20	-32	+5	0	0	+23	+40	+68	+132	+252	+360	+540	+660	+820	+1000	+1300	+1600	
450	500	-1650	-840	-480		-260	-140		-72		-20	0		-20	-32	+5	0	0	+23	+40	+68	+132	+252	+360	+540	+660	+820	+1000	+1300	+1600	
500	560					-260	-145		-76		-22	0		-20	-32	+5	0	0	+26	+44	+78	+155	+280	+400	+600	+740	+900	+1100	+1400		
560	630					-270	-150		-80		-24	0		-20	-32	+5	0	0	+30	+50	+88	+175	+310	+450	+660	+840	+1000	+1300	+1600		
630	710					-290	-160		-86		-26	0		-20	-32	+5	0	0	+34	+56	+100	+210	+330	+470	+680	+940	+1150	+1450	+1800		
710	800					-320	-170		-92		-28	0		-20	-32	+5	0	0	+40	+66	+120	+250	+370	+520	+780	+1050	+1350	+1700	+2100		
800	900					-350	-180		-98		-28	0		-20	-32	+5	0	0	+48	+78	+140	+300	+420	+580	+840	+1150	+1500	+1900	+2400		
900	1000					-390	-220		-110		-30	0		-20	-32	+5	0	0	+58	+92	+170	+400	+520	+720	+1050	+1400	+1800	+2300	+2900		
1000	1120					-430	-240		-120		-32	0		-20	-32	+5	0	0	+68	+110	+195	+440	+580	+800	+1100	+1450	+1900	+2400	+3000		
1120	1250					-480	-260		-130		-34	0		-20	-32	+5	0	0	+76	+135	+240	+550	+720	+1000	+1350	+1800	+2300	+2900	+3600		
1250	1400					-520	-290		-145		-38	0		-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
1400	1600													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
1600	1800													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
1800	2000													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
2000	2240													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
2240	2500													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
2500	2800													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		
2800	3150													-20	-32	+5	0	0	+80	+140	+260	+580	+780	+1050	+1400	+1850	+2400	+3000	+3700		

Fundamental  
deviations for  
shafts

# HOLE DEVIATIONS

Basic size		Lower deviations Ei											Upper deviations Es																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
		Tolerance grades (all)											Tolerance grades (>IT7)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
mm	in	A)	B)	C	CD	D	E	EF	F	FG	G	H	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18	IT19	IT20	IT21	IT22	IT23	IT24	IT25	IT26	IT27	IT28	IT29	IT30	IT31	IT32																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
3	3	+270	+140	+60	+34	+20	+14	+10	+6	+4	+2	0	+2	+4	+6	0	0	-2	-2	-4	-4	-6	-6	-10	-10	-14	-14	-18	-18	-22	-22	-26	-26	-30	-30	-34	-34	-38	-38	-42	-42	-46	-46	-50	-50	-54	-54	-58	-58	-62	-62	-66	-66	-70	-70	-74	-74	-78	-78	-82	-82	-86	-86	-90	-90	-94	-94	-98	-98	-102	-102	-106	-106	-110	-110	-114	-114	-118	-118	-122	-122	-126	-126	-130	-130	-134	-134	-138	-138	-142	-142	-146	-146	-150	-150	-154	-154	-158	-158	-162	-162	-166	-166	-170	-170	-174	-174	-178	-178	-182	-182	-186	-186	-190	-190	-194	-194	-198	-198	-202	-202	-206	-206	-210	-210	-214	-214	-218	-218	-222	-222	-226	-226	-230	-230	-234	-234	-238	-238	-242	-242	-246	-246	-250	-250	-254	-254	-258	-258	-262	-262	-266	-266	-270	-270	-274	-274	-278	-278	-282	-282	-286	-286	-290	-290	-294	-294	-298	-298	-302	-302	-306	-306	-310	-310	-314	-314	-318	-318	-322	-322	-326	-326	-330	-330	-334	-334	-338	-338	-342	-342	-346	-346	-350	-350	-354	-354	-358	-358	-362	-362	-366	-366	-370	-370	-374	-374	-378	-378	-382	-382	-386	-386	-390	-390	-394	-394	-398	-398	-402	-402	-406	-406	-410	-410	-414	-414	-418	-418	-422	-422	-426	-426	-430	-430	-434	-434	-438	-438	-442	-442	-446	-446	-450	-450	-454	-454	-458	-458	-462	-462	-466	-466	-470	-470	-474	-474	-478	-478	-482	-482	-486	-486	-490	-490	-494	-494	-498	-498	-502	-502	-506	-506	-510	-510	-514	-514	-518	-518	-522	-522	-526	-526	-530	-530	-534	-534	-538	-538	-542	-542	-546	-546	-550	-550	-554	-554	-558	-558	-562	-562	-566	-566	-570	-570	-574	-574	-578	-578	-582	-582	-586	-586	-590	-590	-594	-594	-598	-598	-602	-602	-606	-606	-610	-610	-614	-614	-618	-618	-622	-622	-626	-626	-630	-630	-634	-634	-638	-638	-642	-642	-646	-646	-650	-650	-654	-654	-658	-658	-662	-662	-666	-666	-670	-670	-674	-674	-678	-678	-682	-682	-686	-686	-690	-690	-694	-694	-698	-698	-702	-702	-706	-706	-710	-710	-714	-714	-718	-718	-722	-722	-726	-726	-730	-730	-734	-734	-738	-738	-742	-742	-746	-746	-750	-750	-754	-754	-758	-758	-762	-762	-766	-766	-770	-770	-774	-774	-778	-778	-782	-782	-786	-786	-790	-790	-794	-794	-798	-798	-802	-802	-806	-806	-810	-810	-814	-814	-818	-818	-822	-822	-826	-826	-830	-830	-834	-834	-838	-838	-842	-842	-846	-846	-850	-850	-854	-854	-858	-858	-862	-862	-866	-866	-870	-870	-874	-874	-878	-878	-882	-882	-886	-886	-890	-890	-894	-894	-898	-898	-902	-902	-906	-906	-910	-910	-914	-914	-918	-918	-922	-922	-926	-926	-930	-930	-934	-934	-938	-938	-942	-942	-946	-946	-950	-950	-954	-954	-958	-958	-962	-962	-966	-966	-970	-970	-974	-974	-978	-978	-982	-982	-986	-986	-990	-990	-994	-994	-998	-998	-1002	-1002	-1006	-1006	-1010	-1010	-1014	-1014	-1018	-1018	-1022	-1022	-1026	-1026	-1030	-1030	-1034	-1034	-1038	-1038	-1042	-1042	-1046	-1046	-1050	-1050	-1054	-1054	-1058	-1058	-1062	-1062	-1066	-1066	-1070	-1070	-1074	-1074	-1078	-1078	-1082	-1082	-1086	-1086	-1090	-1090	-1094	-1094	-1098	-1098	-1102	-1102	-1106	-1106	-1110	-1110	-1114	-1114	-1118	-1118	-1122	-1122	-1126	-1126	-1130	-1130	-1134	-1134	-1138	-1138	-1142	-1142	-1146	-1146	-1150	-1150	-1154	-1154	-1158	-1158	-1162	-1162	-1166	-1166	-1170	-1170	-1174	-1174	-1178	-1178	-1182	-1182	-1186	-1186	-1190	-1190	-1194	-1194	-1198	-1198	-1202	-1202	-1206	-1206	-1210	-1210	-1214	-1214	-1218	-1218	-1222	-1222	-1226	-1226	-1230	-1230	-1234	-1234	-1238	-1238	-1242	-1242	-1246	-1246	-1250	-1250	-1254	-1254	-1258	-1258	-1262	-1262	-1266	-1266	-1270	-1270	-1274	-1274	-1278	-1278	-1282	-1282	-1286	-1286	-1290	-1290	-1294	-1294	-1298	-1298	-1302	-1302	-1306	-1306	-1310	-1310	-1314	-1314	-1318	-1318	-1322	-1322	-1326	-1326	-1330	-1330	-1334	-1334	-1338	-1338	-1342	-1342	-1346	-1346	-1350	-1350	-1354	-1354	-1358	-1358	-1362	-1362	-1366	-1366	-1370	-1370	-1374	-1374	-1378	-1378	-1382	-1382	-1386	-1386	-1390	-1390	-1394	-1394	-1398	-1398	-1402	-1402	-1406	-1406	-1410	-1410	-1414	-1414	-1418	-1418	-1422	-1422	-1426	-1426	-1430	-1430	-1434	-1434	-1438	-1438	-1442	-1442	-1446	-1446	-1450	-1450	-1454	-1454	-1458	-1458	-1462	-1462	-1466	-1466	-1470	-1470	-1474	-1474	-1478	-1478	-1482	-1482	-1486	-1486	-1490	-1490	-1494	-1494	-1498	-1498	-1502	-1502	-1506	-1506	-1510	-1510	-1514	-1514	-1518	-1518	-1522	-1522	-1526	-1526	-1530	-1530	-1534	-1534	-1538	-1538	-1542	-1542	-1546	-1546	-1550	-1550	-1554	-1554	-1558	-1558	-1562	-1562	-1566	-1566	-1570	-1570	-1574	-1574	-1578	-1578	-1582	-1582	-1586	-1586	-1590	-1590	-1594	-1594	-1598	-1598	-1602	-1602	-1606	-1606	-1610	-1610	-1614	-1614	-1618	-1618	-1622	-1622	-1626	-1626	-1630	-1630	-1634	-1634	-1638	-1638	-1642	-1642	-1646	-1646	-1650	-1650	-1654	-1654	-1658	-1658	-1662	-1662	-1666	-1666	-1670	-1670	-1674	-1674	-1678	-1678	-1682	-1682	-1686	-1686	-1690	-1690	-1694	-1694	-1698	-1698	-1702	-1702	-1706	-1706	-1710	-1710	-1714	-1714	-1718	-1718	-1722	-1722	-1726	-1726	-1730	-1730	-1734	-1734	-1738	-1738	-1742	-1742	-1746	-1746	-1750	-1750	-1754	-1754	-1758	-1758	-1762	-1762	-1766	-1766	-1770	-1770	-1774	-1774	-1778	-1778	-1782	-1782	-1786	-1786	-1790	-1790	-1794	-1794	-1798	-1798	-1802	-1802	-1806	-1806	-1810	-1810	-1814	-1814	-1818	-1818	-1822	-1822	-1826	-1826	-1830	-1830	-1834	-1834	-1838	-1838	-1842	-1842	-1846	-1846	-1850	-1850	-1854	-1854	-1858	-1858	-1862	-1862	-1866	-1866	-1870	-1870	-1874	-1874	-1878	-1878	-1882	-1882	-1886	-1886	-1890	-1890	-1894	-1894	-1898	-1898	-1902	-1902	-1906	-1906	-1910	-1910	-1914	-1914	-1918	-1918	-1922	-1922	-1926	-1926	-1930	-1930	-1934	-1934	-1938	-1938	-1942	-1942	-1946	-1946	-1950	-1950	-1954	-1954	-1958	-1958	-1962	-1962	-1966	-1966	-1970	-1970	-1974	-1974	-1978	-1978	-1982	-1982	-1986	-1986	-1990	-1990	-1994	-1994	-1998	-1998	-2002	-2002	-2006	-2006	-2010	-2010	-2014	-2014	-2018	-2018	-2022	-2022	-2026	-2026	-2030	-2030	-2034	-2034	-2038	-2038	-2042	-2042	-2046	-2046	-2050	-2050	-2054	-2054	-2058	-2058	-2062	-2062	-2066	-2066	-2070	-2070	-2074	-2074	-2078	-2078	-2082	-2082	-2086	-2086	-2090	-2090	-2094	-2094	-2098	-2098	-2102	-2102	-2106	-2106	-2110	-2110	-2114	-2114	-2118	-2118	-2122	-2122	-2126	-2126	-2130	-2130	-2134	-2134	-2138	-2138	-2142	-2142	-2146	-2146	-2150	-2150	-2154	-2154	-2158	-2158	-2162	-2162	-2166	-2166	-2170	-2170	-2174	-2174	-2178	-2178	-2182	-2182	-2186	-2186	-2190	-2190	-2194	-2194	-2198	-2198	-2202	-2202	-2206	-2206	-2210	-2210	-2214	-2214	-2218	-2218	-2222	-2222	-2226	-2226	-2230	-2230	-2234	-2234	-2238	-2238	-2242	-2242	-2246	-2246	-2250	-2250	-2254	-2254	-2258	-2258	-2262	-2262	-2266	-2266	-2270	-2270	-2274	-2274	-2278	-2278	-2282	-2282	-2286	-2286	-2290	-2290	-2294	-2294	-2298	-2298	-2302	-2302	-2306	-2306	-2310	-2310	-2314	-2314	-2318	-2318	-2322	-2322	-2326	-2326	-2330	-2330	-2334	-2334	-2338	-2338	-2342	-2342	-2346	-2346	-2350	-2350	-2354	-2354	-2358	-2358	-2362	-2362	-2366	-2366	-2370	-2370	-2374	-2374	-2378	-2378	-2382	-2382	-2386	-2386	-2390	-2390	-2394	-2394	-2398	-2398	-2402	-2402	-2406	-2406	-2410	-2410	-2414	-2414	-2418	-2418	-2422	-2422	-2426	-2426	-2430	-2430	-2434	-2434	-2438	-2438	-2442	-2442	-2446	-2446	-2450	-2450	-2454

## Tables of General DIMENSIONAL tolerances UNI EN 22768-1

Tolerance class		Limit deviations for fundamental dimensions range							
		Linear dimensions							
Designation	Denomination	From 0,5 to a 3	From 3 to 6	From 6 to 30	From 30 to 120	From 120 to 400	From 400 to 1000	From 1000 to 2000	From 2000 to 4000
f	Fine	± 0,05	± 0,05	± 0,1	± 0,15	± 0,2	± 0,3	± 0,5	-
m	Middle	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2
c	Coarse	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2	± 3	± 4
v	Very coarse	-	± 0,5	± 1	± 1,5	± 2,5	± 4	± 6	± 8

### General tolerances for chamfers and fillets

Tolerance class		Limit deviations for fundamental dimensions range		
		Linear dimensions		
Designation	Denomination	From 0,5 <sup>1)</sup> to 3	Above 3 to 6	above 6
f	Fine	± 0,2	± 0,5	± 1
m	Middle			
c	Coarse	± 0,4	± 1	± 2
v	Very coarse			

### General tolerances for angular dimensions

Tolerance class		Deviations are function of the length range (in mm) of the shorter side of the considered angle.				
Designation	Denomination	Up to 10	Above 10 to 50	Above 50 to 120	Above 120 to 400	Above 400
f	Fine	± 1°	± 0°30'	± 0°20'	± 0°10'	± 0°5'
m	Middle					
c	Coarse	± 1°30'	± 1°	± 0°30'	± 0°15'	± 0°10'
v	Very coarse	± 3°	± 2°	± 1°	± 0°30'	± 0°20'

### Recommended fits

#### Clearance:

H/f → free or loose running fits, high speed, poor centering

H/g → Medium and close running fits, normal speed, perfect centering

H/h → precision running fits, very slow speed, very precise, lubrication

#### Transition fits (small interference)

H/j,k,m → assembled by hands, not suited for power transmission

#### Interference

H/n,p → fixed, assembling with temperature difference, suitable for power transmission

# Recommended fits

## Running and sliding fits

	FIT	Application	Example
Precision ↑	H6/g8 H6/g9 H7/js11	Free running fit	Slide
	H7/f8 H7/f7 H8/f7 H8/f9	Medium running fit	Shaft/bush fit Piston/cylinder fit
Precision ↑	H6/g6 H7/g6	Close running fit	Rotating fits with good centering
	H6/h5 H6/h6 H7/h6 H7/h7	Precision running fit	Shaft and (brass) bush fit With good lubrication

Navigation icons: back, forward, search, etc.

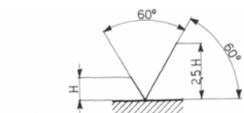
## End presentation

# Recommended fits

## Locational interference fits

	FIT	Application	Example
Precision ↑	H8/js5 H8/js6 H7/js6	Light drive fit	Cylindrical locating pin
	H6/k5 H7/k6 H6/k6	Medium drive fit	Bush assembly into hub housing
Precision ↑	H6/p5 H7/p7 H7/k6	Heavy drive fit	Piston/piston pin fits
	H7/u9 H7/u7	Hot force fit	Drive bush for tools

## Drawings indications



Basic graphic symbol. It can be used alone only when its meaning is specified apart

The surface must be obtained by chip-removal

The surface must be obtained without chip-removal. The symbol without other indication can be used to specify a surface that must be left as obtained in a previous machining operation, or without chip removal.

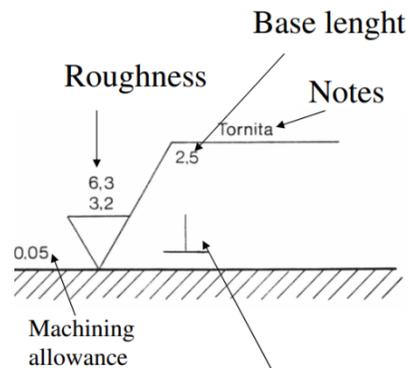
Symbol indicating a particular characteristic of a surface state. That characteristic must be written instead of dots.



UNI 4600 symbols: 1.6, 1.6, 1.6  
Surface with maximum allowed roughness of 1.6 μm



Surface with:  
3.2 μm as maximum allowed roughness  
0.8 μm as minimum requested roughness



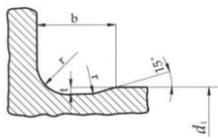
Micro-geometric irregularities orientation

Roughness Ra Mm	Applications
0.025	Active surfaces of micrometers, mirrors, gauge blocks.
0.5	Active surfaces of calipers, support surfaces for dial gauges.
0.1	Articulation pins, high precision cutting tools, superfinished bearings, watertight fits at high pressures with alternating motion, sealing surfaces without gasket.
0.2	Crankshaft supports, camshafts, connecting rod surfaces, cam surfaces, cylinder diameter of hydraulic pumps, lapped bearings, turbine shafts, watertight fits manually movable, guides of machining centers, high speed thrust bearings, shaft of turbine rotors or gearboxes.
0.4	Spline shafts, crankshaft bearings, piston external diameter, cylinder diameter, large electrical machine shafts, interference fits for press, valve stem, active surfaces of valve members and seats, crankshafts, white metal bushings, guides and sliders.
0.8	Drums, brakes, broached holes, bronze bushings, precision parts, ground gear teeth, active surface of watertight flanges without gasket, crankshafts, white metal bushings, guides and sliders, valve seats for motorbikes.
1.6	Gear faces and holes, shafts, cylinder heads, iron gear housings, piston head, active surface of flanges with metallic gaskets.
3.2	Shafts and bearings for hand transmissions, coupling surfaces of dismantlable parts (flanges, centrings)
6.3	Active surfaces of flanges with common gaskets.

Manufacturing processes	Roughness Ra ( $\mu\text{m}$ )		
	Min	Average	Max
Sand casting	4	8 – 25	50
Shell casting	1	2 – 4	8
Microfusion (lost wax)	0.4	1.5 – 3	6
Chill casting	0.8	1.5 – 4	7
Diecasting	0.4	0.8 – 1.5	4
Forging	-	8 – 25	-
Hot stamping	-	4 – 12	-
Hot rolling	6	10 – 25	50
Hot extrusion	0.5	0.8 – 12	20
Hot drawing	-	12	-
Boring	0.25	0.5 – 4	7
Broaching	0.2	0.4 – 1.5	3
Milling	0.5	0.8 – 6	12
Lapping	0.01	0.05 – 0.4	0.8
Grinding	0.025	0.1 – 1.5	6
Sawing	-	5 – 18	-
Slotting	2	4 – 8	10
Turning	0.5	0.8 – 6	12
Drilling	0.8	1.5 – 6	12

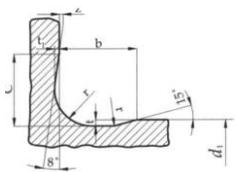
ISO tolerance grade	Cylindrical surface with diameter in mm					Planar surfaces
	d≤3	3<d≤18	18<d≤80	80<d≤250	d>250	
	Max roughness Ra (μm)					
IT6	0.2	0.32	0.5	0.8	1.25	1.25
IT7	0.32	0.5	0.8	1.25	2	2
IT8	0.5	0.8	1.25	2	3.2	3.2
IT9	0.8	1.25	2	3.2	5	5
IT10	1.25	2	3.2	5	8	8
IT11	2	3.2	5	8	12.5	12.5
IT12	3.2	5	8	12.5	20	20
IT13	5	8	12.5	20	32	32
IT14	8	12.5	20	32	50	50

## Grinding undercuts



Undercut of "E" type

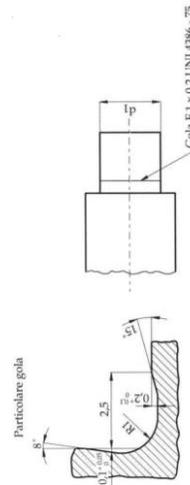
(only for cylindrical grinding)



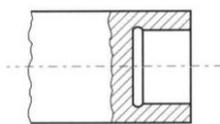
Undercut of "F" type

(to grind cylindrical diameter and shoulder)

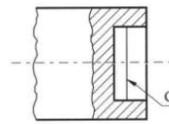
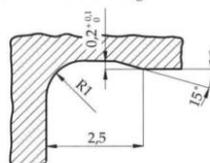
Forma	r	t+0,1 0	b	c	t <sub>1</sub> +0,05 0	Gola	Diametro
E	0,1	0,1	0,5	-	-	E 0,1 x 0,1	fino a 1,6
E	0,2	0,1	1	-	-	E 0,2 x 0,1	oltre 1,6 fino a 3
E	0,4	0,2	2	-	-	E 0,4 x 0,2	oltre 3 fino a 10
E	0,6	0,2	2	-	-	E 0,6 x 0,2	oltre 10 fino a 18
E	0,6	0,3	2,5	-	-	E 0,6 x 0,3	oltre 18 fino a 80
E	1	0,4	4	-	-	E 1 x 0,4	oltre 80
E	1	0,2	2,5	-	-	E 1 x 0,2	oltre 18 fino a 50
E	1,6	0,3	4	-	-	E 1,6 x 0,3	oltre 50 fino a 80
E	2,5	0,4	5	-	-	E 2,5 x 0,4	oltre 80 fino a 125
E	4	0,5	7	-	-	E 4 x 0,5	oltre 125
F	0,1	0,1	0,5	0,8	0,1	F 0,1 x 0,1	fino a 1,6
F	0,2	0,1	1	0,9	0,1	F 0,2 x 0,1	oltre 1,6 fino a 3
F	0,4	0,2	2	1,1	0,1	F 0,4 x 0,2	oltre 3 fino a 10
F	0,6	0,2	2	1,4	0,1	F 0,6 x 0,2	oltre 10 fino a 18
F	0,6	0,3	2,5	2,1	0,2	F 0,6 x 0,3	oltre 18 fino a 80
F	1	0,4	4	3,2	0,3	F 1 x 0,4	oltre 80
F	1	0,2	2,5	1,8	0,1	F 1 x 0,2	oltre 18 fino a 50
F	1,6	0,3	4	3,1	0,2	F 1,6 x 0,3	oltre 50 fino a 80
F	2,5	0,4	5	4,8	0,3	F 2,5 x 0,4	oltre 80 fino a 125
F	4	0,5	7	6,4	0,3	F 4 x 0,5	oltre 125



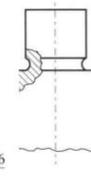
Gola E 1 x 0,2 UNI 4386-75 rugosità R di 1,6m



Particolare gola



Gola E 1 x 0,2 UNI 4386-75 Ra 1,6



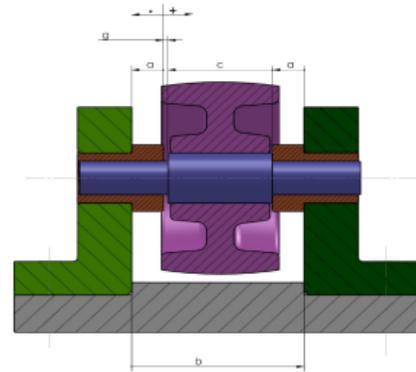
## 6 STACK-UP ANALYSIS

### Results with functional dimensions

First attempt					
Dimension	+	U.D.L.	+	L.D.L	Tolerance
	-	L.D.L.	-	U.D.L	
*a - 1st bushing head thickness	-	6.8	-	7.2	0.4
b - Base width	+	36.3	+	35.7	0.6
*a - 2nd bushing head thickness	-	6.8	-	7.2	0.4
c - Shaft length	-	21.8	-	22.2	0.4
Total:	+	0.9	-	0.9	1.8
Goal:	+	1.5	+	0.5	1
Difference:	+	0.6	+	1.4	

Tolerance synthesis					
Dimension	+	U.D.L.	+	L.D.L	Tolerance
	-	L.D.L.	-	U.D.L	
*a - 1st bushing head thickness	-	6.8	-	7 <sup>(-0.2)</sup>	0.2
b - Base width	+	36.6 <sup>(+0.2)</sup>	+	36.2 <sup>(+0.2)</sup>	0.4
*a - 2nd bushing head thickness	-	6.8	-	7 <sup>(-0.2)</sup>	0.2
c - Shaft length	-	21.5 <sup>(+0.3)</sup>	-	21.7 <sup>(+0.5)</sup>	0.2
Total:	+	1.5	-	0.5	1
Goal:	+	1.5	+	0.5	1
Difference:		0		0	

\* same recoveries applied.



$$a = 7_{-0.2}^0$$

$$b = 36_{+0.2}^{+0.6}$$

$$c = 22_{-0.5}^{-0.3}$$

### Dimensional tolerances I

ISO: In the ISO standards the dimensional and geometrical tolerances must be independently met and inspected following the **independency principle**. From this follows the necessity of explicitly declare the form tolerances on **all** the FOS. The dimensional tolerance can be expressed in three ways:

- standard limits expressed by ISO 286-1 ( $\Phi 40K8/h7$ ). The ISO/R 1938 standard requires inspection with go, no-go gauges for hole and shaft and permits the use of gauges with a **minimum** wear grade. Consequently the real measures of the FOS can differ.
- Explicit tolerance ( $\pm$ ), with the Tolleranza dimensionale esplicita ( $\pm$ ), with the possible addition of the envelope using  $\textcircled{E}$ . ISO 8015 is in force.

DT I      March 23rd, 2022      903 / 1131

GD&T - Geometrical Dimensioning and Tolerancing      Brief comparison between ASME and ISO standards

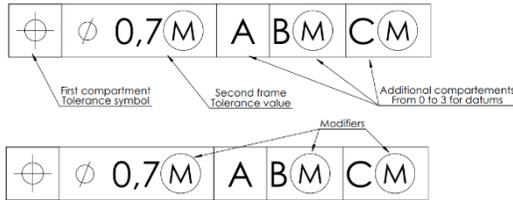
### Dimensional tolerances II

- General tolerances following ISO 2768.

ASME Y14.5M: Rule #1 is the default. The standard does not accept worn gauges.

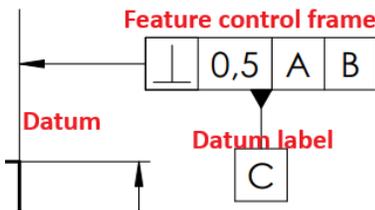
# 7 GEOMETRIC TOLERANCES

Type	Characteristic	Symbol	Datum
Form	Straightness	—	No
	Flatness	▭	
	Roundness	○	
	Cylindricity	⊘	
Orientation	Angularity	∠	Yes
	Parallelism	//	
	Perpendicularity	⊥	
Location	Position	⊕	Yes  No
	Concentricity	⊙	
	Simmetry	≡	
Profile	Profile any surface	⌒	Yes  No
	Profile any line	⌒	
Run-out	Circular run-out	↗	Yes
	Total run-out	↗↗	



List of datum target symbols

Geometry	Graphical symbol	Indication
Point	×	⊙
Line	---	X <sub>n</sub>
Rectangular area	▭	X <sub>n</sub>
Circular area	⊙	X <sub>n</sub>



Considerations:

- normally the ASME standard is less restrictive than ISO,
- but parts that complied to ISO inspection were discarded when checked following the ASME standard.

**ASME Y14.5M:** it focus on the **functionality** of the parts. High level of detail of practical applications. Botton-up approach.

**ISO:** it focus on **general theoretical aspects** regarding the geometrical description of the parts. Reduced practical detail. The **top-down** approach has been developed under the acronym GPS.

**ASME Y14.5M:** the surface to which the geometrical prescriptions are applied is intended filtered with **smoothing functions** in order to remove the effects of the **surface texture**<sup>13</sup>.

**ISO:** it does not specify if the surface texture should be considered or not.

The difference can be significant for very small tolerances, of the same order of magnitude of the surface texture.

If a planar datum feature presents a convexity form error its orientation over the gauge counterpart is not well defined.

**ISO:** if the datum's form error makes it unstable, the form error must be "equalized" determining an averaged orientation for the part.

All the geometrical requirements referred to the same datum sequence must be independently evaluated. No simultaneous requirement.

**ASME Y14.5M:** even if the datum's form error makes it unstable, every orientation can be considered valid for the **datum candidate**. All the geometrical requirements referred to the same candidate DRF must be simultaneously evaluated, respecting the datum sequence and the material modifiers. Simultaneous requirement.



Table 1 — Specification modifiers for linear size

Default →

Modifier	Description	Reference
(LP)	Two-point size	3.6.1
(LS)	Local size defined by a sphere	
(GG)	Least-squares association criterion	
(GX)	Maximum inscribed association criterion	
(GN)	Minimum circumscribed association criterion	
(GC)	Minimax association criteria	
(CC)	Circumference diameter (calculated size)	3.7.2.1.1
(CA)	Area diameter (calculated size)	3.7.2.1.2
(CV)	Volume diameter (calculated size)	
(SX)	Maximum size <sup>a</sup>	3.7.2.2.1
(SN)	Minimum size <sup>a</sup>	3.7.2.2.2
(SA)	Average size <sup>a</sup>	3.7.2.2.3
(SM)	Median size <sup>a</sup>	3.7.2.2.4
(SD)	Mid-range size <sup>a</sup>	3.7.2.2.5
(SR)	Range of sizes <sup>a</sup>	3.7.2.2.6
(SQ)	Standard deviation of sizes <sup>a</sup>	3.7.2.2.7

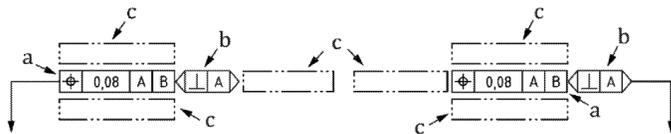
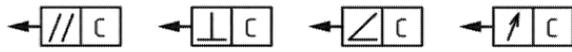
<sup>a</sup> Rank-order size can be used as a supplement to calculated portion size or global portion size or local size (see 3.7.2.2 and 6.2).

Standard Reference on Drawing	Conditions That Apply
ISO 2768-K	Invokes general geometrical tolerances
ISO 2768-K-E	Invokes general geometrical tolerances and the envelope requirement
ISO 2768-mK	Invokes general linear and angular tolerances and general geometrical tolerances
ISO 2768-mK-E	Invokes general linear and angular tolerances, general geometrical tolerances and the envelope requirement

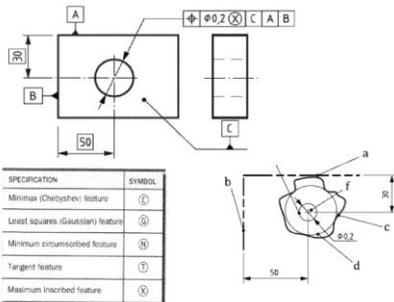
- (SX) **Statistical maXimum**
- (SN) **Statistical MiNimum**
- (SA) **Statistical Average**
- (SM) **Statistical Median**
- (SR) **Statistical Range**
- (SD) **Statistical miD-range**



DIRECTION INDICATOR OF THE ELEMENT



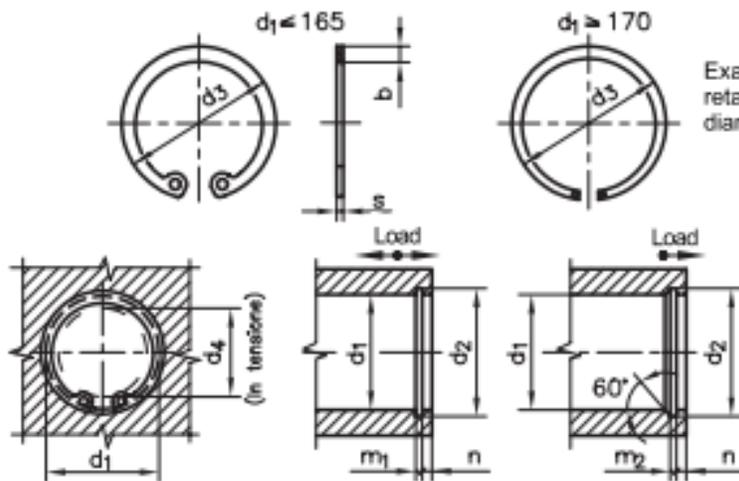
- a) Tolerance indicator
- b) Indication of planes and features
- c) Auxiliary Information



# 8 TABLES

<b>UNI 7435</b>																			
$d_1 \leq 9$			$d_1 = 10 \div 160$			$d_1 \geq 170$			<p>Example of designation for a retaining ring for a shaft with diameter <math>d_1 = 30</math> mm Retaining ring UNI 7435 - 30</p> <p>The maximum axial load supported by the ring is indicated in the table with the symbol <math>F_a</math></p> <p style="text-align: right;">HRC = 47 ÷ 52</p>										
$d_1$	$s$	$d_2$		$d_3$	$d_4$	$m_1$	$m_2$	$n$	$F_a$	$d_1$	$s$	$d_2$		$d_3$	$d_4$	$m_1$	$m_2$	$n$	$F_a$
		nom.	toll.			H13	min.	min.	[kN]			nom.	toll.			H13	min.	min.	[kN]
4	0,4	3,8		3,7	8,8	0,5	0,6	0,3	0,3	95	3	91,5	h12	89,5	115	3,15	3,3	5,3	128
5	0,6	4,8		4,7	10,7	0,7	0,8	0,3	0,38	100		96,5		94,5	121				135
6	0,7	5,7		5,6	12,2	0,8	0,9	0,45	0,7	105		101		98	126				162
8	0,8	7,6		7,4	15,2	0,9	1		1,2	110		106		103	132				170
9		8,6		8,6	16,4				1,38	115		111		108	138				178
10		9,6		9,3	17,6			0,6	1,53	120		116		113	143				185
12		11	h11	11	19,6			0,75	2,3	125		121		118	149			6	193
14	1	13,4		12,9	22	1,1	1,2	0,9	3,25	130		126		123	155				201
15		14,3		13,8	23,2			1,1	4	135		131		128	160				209
16		15,2		14,7	24,4			1,2	4,9	140		136		133	165				217
17		16,2		15,7	25,6			1,2	5,2	145		141		138	171				225
18		17		16,5	26,8	1,3			6,9	150	4	145		142	177	4,15	4,3		289
20	1,2	19		18,5	29		1,4	1,5	7,7	155		150		146	182				300
22		21		20,5	31,4				8,45	160		155		151	188				310
25		23,9		23,2	34,8			1,7	10,6	165		160		115,5	193				320
28		26,6		25,9	38,4			2,1	15	170		165	h13	160,5	197			7,5	329
30	1,5	28,6		27,9	41	1,6	1,7	2,1	16,2	175		170		165,5	202				338
32		30,3		29,9	43,4			2,6	21	180		175		170,5	208				345
35		33		32,2	47,2	3		3	26,7	185		180		175,5	213				338
40	1,75	37,5		36,3	53	1,85	2	3,8	38,1	190		185		180,5	219				335
45		42,5	h12	41,5	59,4				43	200		195		190,5	229				327
50		47		45,8	64,8				57	210		204		198	239				488
55	2	52		50,8	70,4	2,15	2,3		63	220		214		208	249				512
60		57		55,8	75,8			4,5	69	230		224		218	259			9	535
65		62		60,8	81,6				75	240		234		228	269				529
70	2,5	67		65,5	87,2	2,65	2,8		80,5	250	5	244		238	279	5,15	5,3		503
75		72		70,5	92,8				86	260		252		245	293				544
80		76,5		74,5	98,2				107	280		272		255	303			12	508
85	3	81,5		79,5	104	3,15	3,3	5,3	114	290		282		265	313				491
90		86,5		84,5	109				121	300		292		285	333				473

# UNI 7437



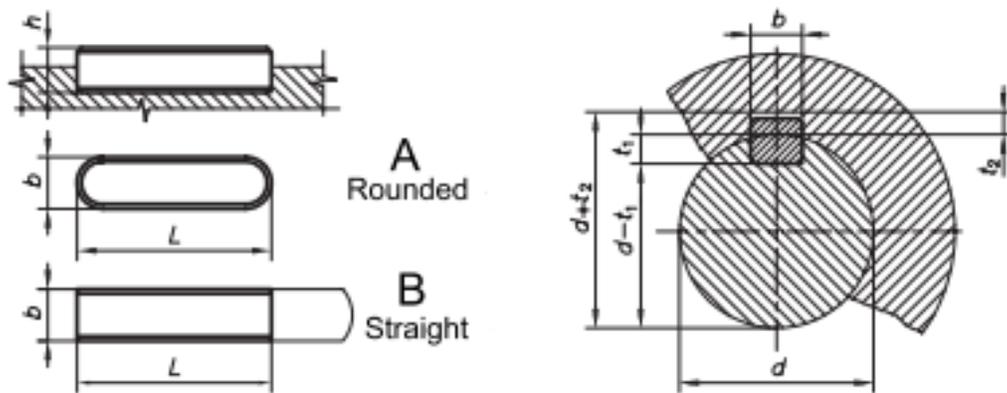
Example of designation for a retaining ring for an hole with diameter  $d_1 = 30$  mm:  
Retaining ring UNI 7437 - 30

The maximum axial load supported by the ring is indicated in the table with the symbol  $F_a$

HRC = 47 ÷ 52

$d_1$	$s$	$d_2$		$d_3$	$d_4$	$m_1$	$m_2$	$n$	$F_a$	$d_1$	$s$	$d_2$		$d_3$	$d_4$	$m_1$	$m_2$	$n$	$F_a$
		h11	nom.									toll.	h11						
15		15,7		16,2	7			1,1	4,22	95	3	98,5	H12	100,5	76,4	3,15	3,3	5,3	133
16		16,8	H11	17,3	7,7			1,2	5,15	100		103,5		105,5	81				140
17		17,8			18,3	8,4	1,1	1,2	1,2	5,47	105		109		112	85,6			
18		19		19,5	8,9			1,5	7,25	110		114		117	88,2				176
20		21		21,5	10,6			1,8	7,8	115		119		122	93			6	184
22		23		23,5	12,9			2,1	8,35	120		124		127	97				192
24		25,2		25,9	14,2			2,6	11,6	125		129		132	102				199
25		26,2		26,9	15			3	12	130		134		137	107				207
26	1,2	27,2		27,9	15,6	1,3	1,4	3,8	12,5	135		139		142	113				215
28		29,4		30,1	17,4			4,5	13,3	140		144		147	117				223
30		31,4		32,1	19,4			5,3	13,7	145		149		152	122				231
32		33,7		34,4	20,2			6	13,9	150	4	155		158	125	4,15	4,3		300
35		37		37,8	23,3			7,5	26,9	155		160		164	130				309
37	1,5	39,8		39,8	25	1,6	1,7	9	27,1	160		165		169	133				319
40		43,5		43,5	27,4			10,5	40,5	165		170		174,5	138				319
42		44,5		45,5	29,2			12	42,5	170		175	H13	179,5	145			7,5	339
45	1,75	47,5	H12	48,5	31,6	1,85	2	15	43,1	175		180		184,5	149				348
47		49,5			50,5	33,2			18	43,5	180		185		189,5	153			
50		53		54,2	36			21	60,7	185		190		194,5	157				349
52		55		56,2	37,6			24	60,3	190		195		199,5	162				340
55		58		59,2	40,4			27	63,5	200		205		209,5	171				325
58	2	61		62,2	43,2	2,15	2,3	30	61,5	210		216		222	181				500
60		63		64,2	44,4			33	62,1	220		226		232	191				522
62		65		66,2	46,4			36	61,7	230		236		242	201			9	549
70		73		74,5	53,4			42	84,2	240		246		252	211				525
72		75		76,5	55,4			48	86,5	250	5	256		262	221	5,15	5,3		505
75	2,5	78		79,5	58,4	2,65	2,8	54	90	260		268		275	227				540
80		83,5		85,5	62			60	112	280		288		295	247				500
85		88,5		90,5	66,8			66	119	290		298		305	257			12	482
90	3	93,5		95,5	71,8	3,15	3,3	72	126	300		308		315	267				465

# UNI 6604 - Parallel keys



**KEY UNI 6604 - A 22×14×160**  
 Example of designating a KEY of shape A with dimensions b×h=22×4 and length L=160

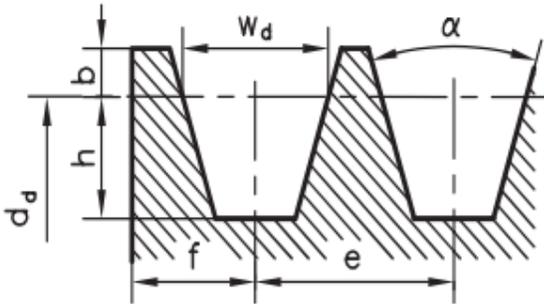
Shaft diameter <i>d</i>	KEY			KEYWAY			
	<i>b</i> × <i>h</i>	Tol. on <i>b</i>	<i>L</i>	SHAFT <i>t</i> <sub>1</sub>		HUB <i>t</i> <sub>2</sub>	
6 ÷ 8	2×2	0	6 ÷ 20	1,2	+0,1 0	1	+0,1 0
> 8 ÷ 10	3×3	-0,025	6 ÷ 36	1,8		1,4	
> 10 ÷ 12	4×4	0	8 ÷ 45	2,5		1,8	
> 12 ÷ 17	5×5	-0,030	10 ÷ 56	3	+0,2 0	2,3	+0,2 0
> 17 ÷ 22	6×6	0	14 ÷ 70	3,5		2,8	
> 22 ÷ 30	8×7	-0,036	18 ÷ 90	4		3,3	
> 30 ÷ 38	10×8	0	22 ÷ 110	4,5		3,3	
> 38 ÷ 44	12×8	-0,043	28 ÷ 140	5		3,3	
> 44 ÷ 50	14×9	0	36 ÷ 160	5,5		3,8	
> 50 ÷ 58	16×10	-0,052	45 ÷ 180	6		4,3	
> 58 ÷ 65	18×11	0	50 ÷ 200	7		4,4	
> 65 ÷ 75	20×12	-0,052	56 ÷ 220	7,5		4,9	
> 75 ÷ 85	22×14	0	63 ÷ 250	9		5,4	
> 85 ÷ 95	25×14	-0,130	70 ÷ 280	9	5,4		
> 95 ÷ 110	28×16	0	80 ÷ 320	10	6,4		
> 110 ÷ 130	32×18	-0,130	90 ÷ 360	11	+0,3 0	7,4	+0,3 0
> 130 ÷ 150	36×20	0	100 ÷ 400	12		4,4	
> 150 ÷ 170	40×22	-0,130	110 ÷ 400	13		9,4	
> 170 ÷ 200	45×25	0	125 ÷ 400	15		10,4	
> 200 ÷ 230	50×28	-0,130	140 ÷ 400	17		11,4	

Unified lengths: 6; 8; 10; 12; 14; 18; 20; 22; 25; 28; 32; 36; 40; 45; 50; 56; 63; 70; 80; 90; 100; 125; 140; 160; 180; 200; 220; 250; 280; 320; 360; 400 mm.

Tolerances on the keyway length: up to 28  $\begin{matrix} +0,2 \\ 0 \end{matrix}$  mm; above 28 up to 80  $\begin{matrix} +0,3 \\ 0 \end{matrix}$  mm; above 80  $\begin{matrix} +0,5 \\ 0 \end{matrix}$  mm.

Key tolerances: on *b* h9; on *h* h9 for square section, h11 for rectangular section  
 Keyway tolerances on *b*: for the hub D10, JS9, P9; for the shaft H9, N9, P9.

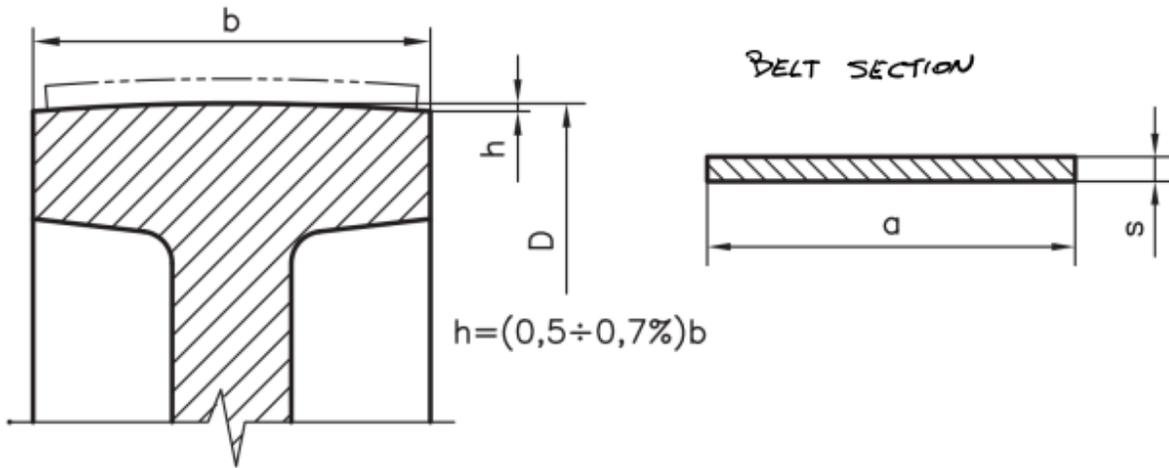
## UNI 5266 - Dimensions of the Groove for V-belt pulley



Type of profile		$W_d$	$b_{min}$	$h_{min}$	$e$	Tolerance on size "e"	$f_{min}$
Standard	Narrow						
Y	-	5,3	1,6	4,7	8	$\pm 0,3$	6
Z	SPZ	8,5	2	7 9	12	$\pm 0,3$	7
A	SPA	11	2,75	8,7 11	15	$\pm 0,3$	9
B	SPB	14	3,5	10,8 14	19	$\pm 0,4$	11,5
C	SPC	19	4,8	14,3 19	25,5	$\pm 0,5$	16
D		27	8,1	19,9	37	$\pm 0,6$	23
E		32	9,6	23,4	44,5	$\pm 0,7$	28
	3V	-	0,6	8,3	10,3	$\pm 0,4$	9
	5V	-	1,3	14	17,5	$\pm 0,4$	13
	8V	-	2,5	23	28,6	$\pm 0,4$	19

Groove profile	Reference diameters $d_d$			
	$\alpha = 38^\circ$	$\alpha = 36^\circ$	$\alpha = 34^\circ$	$\alpha = 32^\circ$
Y	-	> 60	-	$\leq 60$
Z - SPZ	> 80	-	$\leq 80$	-
A - SPA	> 118	-	$\leq 118$	-
B - SPB	> 190	-	$\leq 190$	-
C - SPC	> 315	-	$\leq 315$	-
D	> 475	$\leq 475$	-	-
E	> 600	$\leq 600$	-	-

Pulleys for flat belts are constructed with a slightly rounded outer profile to achieve belt stability on the crown

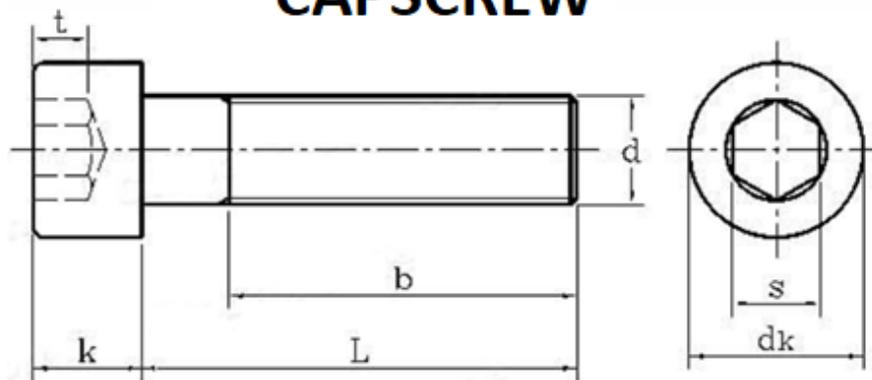


### ISO METRIC PROFILE

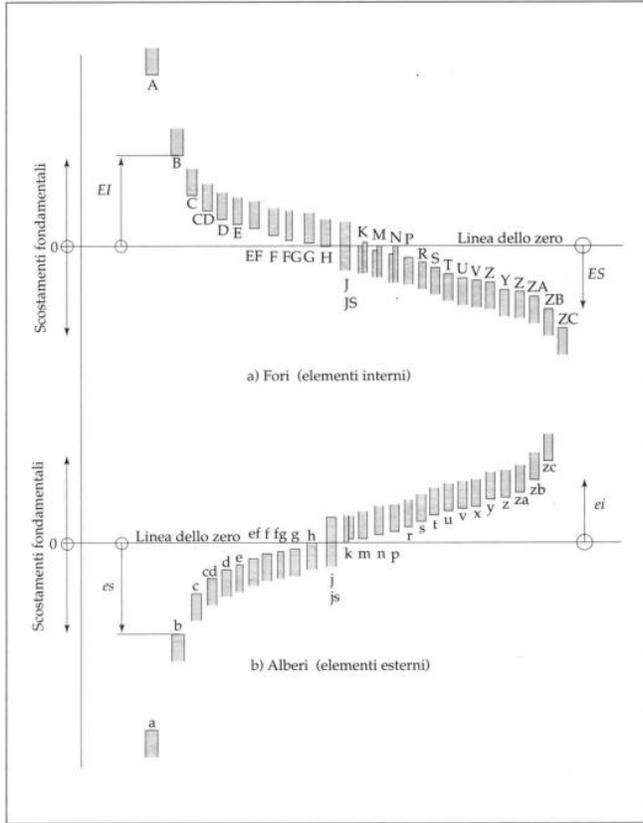
#### FILETTATURE METRICHE

COARSE PITCH			FINE PITCH		
Ø	p	Ø <sub>int</sub>	Ø	p	Ø <sub>int</sub>
M1	0,25	0,75	M2	0,25	1,75
M1,1	0,25	0,85	M2,2	0,25	3,95
M1,2	0,25	0,95	M2,5	0,25	4,50
M1,4	0,30	1,10	M2,5	0,35	2,20
M1,6	0,35	1,25	M2,5	0,35	2,20
M1,7	0,35	1,40	M3	0,35	2,65
M1,8	0,35	1,45	M3	0,35	2,65
M2	0,40	1,60	M3,5	0,35	3,50
M2,2	0,45	1,75	M3,5	0,35	3,50
M2,5	0,45	1,90	M4	0,50	5,50
M2,6	0,45	2,00	M4	0,50	5,50
M3	0,50	2,10	M4	0,50	5,50
M3,5	0,50	2,30	M4,5	0,50	6,50
M4	0,50	2,40	M4,5	0,50	6,50
M4,5	0,50	2,60	M5	0,50	7,00
M5	0,50	2,70	M5	0,50	7,00
M5,5	0,50	2,90	M6	0,50	8,00
M6	0,50	3,00	M6	0,50	8,00
M6,5	0,50	3,20	M6,5	0,50	8,50
M7	0,50	3,40	M7	0,50	9,00
M7,5	0,50	3,60	M7,5	0,50	9,50
M8	0,50	3,80	M8	0,50	10,00
M8,5	0,50	4,00	M8,5	0,50	10,50
M9	0,50	4,20	M9	0,50	11,00
M9,5	0,50	4,40	M9,5	0,50	11,50
M10	0,50	4,60	M10	0,50	12,00
M10,5	0,50	4,80	M10,5	0,50	12,50
M11	0,50	5,00	M11	0,50	13,00
M11,5	0,50	5,20	M11,5	0,50	13,50
M12	0,50	5,40	M12	0,50	14,00
M12,5	0,50	5,60	M12,5	0,50	14,50
M13	0,50	5,80	M13	0,50	15,00
M13,5	0,50	6,00	M13,5	0,50	15,50
M14	0,50	6,20	M14	0,50	16,00
M14,5	0,50	6,40	M14,5	0,50	16,50
M15	0,50	6,60	M15	0,50	17,00
M15,5	0,50	6,80	M15,5	0,50	17,50
M16	0,50	7,00	M16	0,50	18,00
M16,5	0,50	7,20	M16,5	0,50	18,50
M17	0,50	7,40	M17	0,50	19,00
M17,5	0,50	7,60	M17,5	0,50	19,50
M18	0,50	7,80	M18	0,50	20,00
M18,5	0,50	8,00	M18,5	0,50	20,50
M19	0,50	8,20	M19	0,50	21,00
M19,5	0,50	8,40	M19,5	0,50	21,50
M20	0,50	8,60	M20	0,50	22,00
M20,5	0,50	8,80	M20,5	0,50	22,50
M21	0,50	9,00	M21	0,50	23,00
M21,5	0,50	9,20	M21,5	0,50	23,50
M22	0,50	9,40	M22	0,50	24,00
M22,5	0,50	9,60	M22,5	0,50	24,50
M23	0,50	9,80	M23	0,50	25,00
M23,5	0,50	10,00	M23,5	0,50	25,50
M24	0,50	10,20	M24	0,50	26,00
M24,5	0,50	10,40	M24,5	0,50	26,50
M25	0,50	10,60	M25	0,50	27,00
M25,5	0,50	10,80	M25,5	0,50	27,50
M26	0,50	11,00	M26	0,50	28,00
M26,5	0,50	11,20	M26,5	0,50	28,50
M27	0,50	11,40	M27	0,50	29,00
M27,5	0,50	11,60	M27,5	0,50	29,50
M28	0,50	11,80	M28	0,50	30,00
M28,5	0,50	12,00	M28,5	0,50	30,50
M29	0,50	12,20	M29	0,50	31,00
M29,5	0,50	12,40	M29,5	0,50	31,50
M30	0,50	12,60	M30	0,50	32,00
M30,5	0,50	12,80	M30,5	0,50	32,50
M31	0,50	13,00	M31	0,50	33,00
M31,5	0,50	13,20	M31,5	0,50	33,50
M32	0,50	13,40	M32	0,50	34,00
M32,5	0,50	13,60	M32,5	0,50	34,50
M33	0,50	13,80	M33	0,50	35,00
M33,5	0,50	14,00	M33,5	0,50	35,50
M34	0,50	14,20	M34	0,50	36,00
M34,5	0,50	14,40	M34,5	0,50	36,50
M35	0,50	14,60	M35	0,50	37,00
M35,5	0,50	14,80	M35,5	0,50	37,50
M36	0,50	15,00	M36	0,50	38,00
M36,5	0,50	15,20	M36,5	0,50	38,50
M37	0,50	15,40	M37	0,50	39,00
M37,5	0,50	15,60	M37,5	0,50	39,50
M38	0,50	15,80	M38	0,50	40,00
M38,5	0,50	16,00	M38,5	0,50	40,50
M39	0,50	16,20	M39	0,50	41,00
M39,5	0,50	16,40	M39,5	0,50	41,50
M40	0,50	16,60	M40	0,50	42,00
M40,5	0,50	16,80	M40,5	0,50	42,50
M41	0,50	17,00	M41	0,50	43,00
M41,5	0,50	17,20	M41,5	0,50	43,50
M42	0,50	17,40	M42	0,50	44,00
M42,5	0,50	17,60	M42,5	0,50	44,50
M43	0,50	17,80	M43	0,50	45,00
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M46	0,50	19,00	M46	0,50	48,00
M46,5	0,50	19,20	M46,5	0,50	48,50
M47	0,50	19,40	M47	0,50	49,00
M47,5	0,50	19,60	M47,5	0,50	49,50
M48	0,50	19,80	M48	0,50	50,00
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M49	0,50	20,20	M49	0,50	51,00
M49,5	0,50	20,40	M49,5	0,50	51,50
M50	0,50	20,60	M50	0,50	52,00
M50,5	0,50	20,80	M50,5	0,50	52,50
M51	0,50	21,00	M51	0,50	53,00
M51,5	0,50	21,20	M51,5	0,50	53,50
M52	0,50	21,40	M52	0,50	54,00
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M54	0,50	22,20	M54	0,50	56,00
M54,5	0,50	22,40	M54,5	0,50	56,50
M55	0,50	22,60	M55	0,50	57,00
M55,5	0,50	22,80	M55,5	0,50	57,50
M56	0,50	23,00	M56	0,50	58,00
M56,5	0,50	23,20	M56,5	0,50	58,50
M57	0,50	23,40	M57	0,50	59,00
M57,5	0,50	23,60	M57,5	0,50	59,50
M58	0,50	23,80	M58	0,50	60,00
M58,5	0,50	24,00	M58,5	0,50	60,50
M59	0,50	24,20	M59	0,50	61,00
M59,5	0,50	24,40	M59,5	0,50	61,50
M60	0,50	24,60	M60	0,50	62,00
M60,5	0,50	24,80	M60,5	0,50	62,50
M61	0,50	25,00	M61	0,50	63,00
M61,5	0,50	25,20	M61,5	0,50	63,50
M62	0,50	25,40	M62	0,50	64,00
M62,5	0,50	25,60	M62,5	0,50	64,50
M63	0,50	25,80	M63	0,50	65,00
M63,5	0,50	26,00	M63,5	0,50	65,50
M64	0,50	26,20	M64	0,50	66,00
M64,5	0,50	26,40	M64,5	0,50	66,50
M65	0,50	26,60	M65	0,50	67,00
M65,5	0,50	26,80	M65,5	0,50	67,50
M66	0,50	27,00	M66	0,50	68,00
M66,5	0,50	27,20	M66,5	0,50	68,50
M67	0,50	27,40	M67	0,50	69,00
M67,5	0,50	27,60	M67,5	0,50	69,50
M68	0,50	27,80	M68	0,50	70,00
M68,5	0,50	28,00	M68,5	0,50	70,50
M69	0,50	28,20	M69	0,50	71,00
M69,5	0,50	28,40	M69,5	0,50	71,50
M70	0,50	28,60	M70	0,50	72,00
M70,5	0,50	28,80	M70,5	0,50	72,50
M71	0,50	29,00	M71	0,50	73,00
M71,5	0,50	29,20	M71,5	0,50	73,50
M72	0,50	29,40	M72	0,50	74,00
M72,5	0,50	29,60	M72,5	0,50	74,50
M73	0,50	29,80	M73	0,50	75,00
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M74	0,50	30,20	M74	0,50	76,00
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M75	0,50	30,60	M75	0,50	77,00
M75,5	0,50	30,80	M75,5	0,50	77,50
M76	0,50	31,00	M76	0,50	78,00
M76,5	0,50	31,20	M76,5	0,50	78,50
M77	0,50	31,40	M77	0,50	79,00
M77,5	0,50	31,60	M77,5	0,50	79,50
M78	0,50	31,80	M78	0,50	80,00
M78,5	0,50	32,00	M78,5	0,50	80,50
M79	0,50	32,20	M79	0,50	81,00
M79,5	0,50	32,40	M79,5	0,50	81,50
M80	0,50	32,60	M80	0,50	82,00
M80,5	0,50	32,80	M80,5	0,50	82,50
M81	0,50	33,00	M81	0,50	83,00
M81,5	0,50	33,20	M81,5	0,50	83,50
M82	0,50	33,40	M82	0,50	84,00
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M83	0,50	33,80	M83	0,50	85,00
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M84	0,50	34,20	M84	0,50	86,00
M84,5	0,50	34,40	M84,5	0,50	86,50
M85	0,50	34,60	M85	0,50	87,00
M85,5	0,50	34,80	M85,5	0,50	87,50
M86	0,50	35,00	M86	0,50	88,00
M86,5	0,50	35,20	M86,5	0,50	88,50
M87	0,50	35,40	M87	0,50	89,00
M87,5	0,50	35,60	M87,5	0,50	89,50
M88	0,50	35,80	M88	0,50	90,00
M88,5	0,50	36,00	M88,5	0,50	90,50
M89	0,50	36,20	M89	0,50	91,00
M89,5	0,50	36,40	M89,5	0,50	91,50
M90	0,50	36,60	M90	0,50	92,00
M90,5	0,50	36,80	M90,5	0,50	92,50
M91	0,50	37,00	M91	0,50	93,00
M91,5	0,50	37,20	M91,5	0,50	93,50
M92	0,50	37,40	M92	0,50	94,00
M92,5	0,50	37,60	M92,5	0,50	94,50
M93	0,50	37,80	M93	0,50	95,00
M93,5	0,50	38,00	M93,5	0,50	95,50
M94	0,50	38,20	M94	0,50	96,00
M94,5	0,50	38,40	M94,5	0,50	96,50
M95	0,50	38,60	M95	0,50	97,00
M95,5	0,50	38,80	M95,5	0,50	97,50
M96	0,50	39,00	M96	0,50	98,00
M96,5	0,50	39,20	M96,5	0,50	98,50
M97	0,50	39,40	M97	0,50	99,00
M97,5	0,50	39,60	M97,5	0,50	99,50
M98	0,50	39,80	M98	0,50	100,00
M98,5	0,50	40,00	M98,5	0,50	100,50
M99	0,50	40,20	M99	0,50	101,00
M99,5	0,50	40,40	M99,5		

# ISO 4762 SOCKET HEAD CAPSCREW



Thread, d	P	b	dk		k		s		t
			MAX	MIN	MAX	MIN	MAX	MIN	MIN
M1.6	0.35	15	3.14	2.86	1.6	1.46	1.56	1.52	0.7
M2	0.4	16	3.98	3.62	2	1.86	1.56	1.52	1
M2.5	0.45	17	4.68	4.32	2.5	2.36	2.06	2.02	1.1
M3	0.5	18	5.68	5.32	3	2.86	2.58	2.52	1.3
M4	0.7	20	7.22	6.78	4	3.82	3.08	3.02	2
M5	0.8	22	8.72	8.28	5	4.82	4.095	4.02	2.5
M6	1	24	10.22	9.78	6	5.82	5.14	5.02	3
M8	1.25	28	13.27	12.73	8	7.78	6.14	6.02	4
M10	1.5	32	16.27	15.73	10	9.64	8.175	8.025	5
M12	1.75	36	18.27	17.73	12	11.57	10.175	10.025	6
M14	2	40	21.33	20.67	14	13.57	12.212	12.032	7
M16	2	44	24.33	23.67	16	15.57	14.212	14.032	8
M20	2.5	52	30.33	29.67	20	19.48	17.23	17.05	10
M24	3	60	36.39	35.61	24	23.48	19.275	19.065	12
M30	3.5	72	45.39	44.61	30	29.48	22.275	22.065	15.5
M36	4	84	54.46	53.54	36	35.38	27.275	27.065	19
M42	4.5	96	63.46	62.54	42	41.38	32.33	32.08	24
M48	5	108	72.46	71.54	48	47.38	36.33	36.08	28
M56	5.5	124	84.54	83.46	56	55.26	41.33	41.08	34
M64	6	140	96.54	95.46	64	63.26	46.33	46.08	38



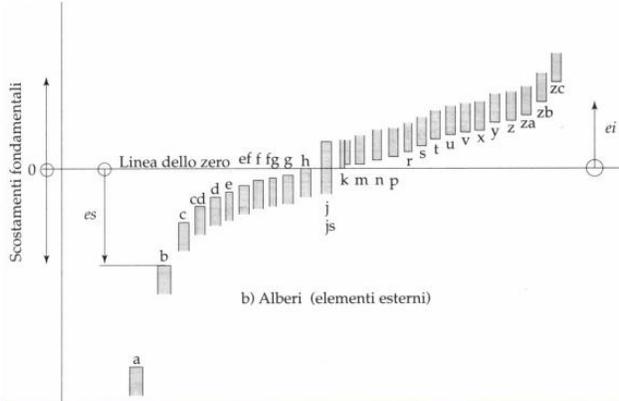
## Tolerance position

The ISO system foresees 27 positions, designated with capital letters for holes and lower case letters for the shafts. Every position is defined by one of the two deviations, that is called fundamental and defines the limit nearest to the basic size.

## SHAFT DEVIATIONS

Basic size	Upper deviations <i>es</i>													Lower deviations <i>ei</i>																		
	Tolerance grades (all)													Tolerance grades (all)																		
	IT5 to IT7													IT7 to IT13																		
Step	Up to	a <sup>1)</sup>	b <sup>1)</sup>	c	cd	d	e	ef	f	fg	g	h	js <sup>2)</sup>	j	k	m	n	p	r	s	t	u	v	x	y	z	za	zb	zc			
-	3 <sup>1)</sup>	-270	-140	-60	-34	-20	-14	-10	-6	-4	-2	0		-2	-4	-6	0	0	+2	+4	+6	+10	+14		+18	+20		+26	+32	+40	+60	
3	6	-270	-140	-70	-46	-30	-20	-14	-10	-6	-4	0		-2	-4	+1	0	+4	+8	+12	+15	+19		+23	+28		+35	+42	+50	+80		
6	10	-280	-150	-80	-56	-40	-25	-18	-13	-8	-5	0		-2	-5	+1	0	+6	+10	+15	+19	+23		+28	+34		+42	+52	+67	+97		
10	14			-290	-150	-95	-50	-32	-16	-6	0			-3	-6	+1	0	+7	+12	+18	+23	+28		+33	+39	+45	+50	+64	+90	+130		
14	18			-300	-160	-110	-55	-40	-20	-7	0			-4	-8	+2	0	+8	+15	+22	+28	+35		+41	+48	+54	+63	+73	+98	+136	+188	
18	24					-310	-170	-120	-60	-10	0			-5	-10	+2	0	+9	+17	+26	+34	+43		+48	+60	+68	+80	+94	+112	+148	+200	+274
24	30					-320	-180	-130	-80	-15	-9	0		-7	-12	+2	0	+11	+20	+32	+43	+53		+54	+70	+81	+97	+114	+136	+180	+242	+325
30	40					-340	-190	-140	-100	-20	-10	0		-7	-12	+2	0	+11	+20	+32	+43	+59		+75	+102	+120	+146	+174	+210	+274	+360	+480
40	50					-360	-200	-150	-120	-25	-12	0		-9	-15	+3	0	+13	+23	+37	+54	+71		+91	+124	+146	+178	+214	+258	+335	+445	+585
50	65					-380	-220	-170	-140	-30	-14	0		-9	-15	+3	0	+13	+23	+37	+54	+79		+104	+144	+172	+210	+254	+310	+400	+525	+690
65	80					-400	-240	-180	-160	-36	-16	0		-11	-18	+3	0	+15	+27	+43	+63	+92		+122	+170	+202	+248	+300	+365	+470	+620	+800
80	100					-420	-260	-200	-180	-43	-18	0		-11	-18	+3	0	+15	+27	+43	+65	+100		+134	+190	+228	+280	+340	+415	+535	+700	+900
100	120					-440	-280	-220	-200	-50	-20	0		-13	-21	+4	0	+17	+31	+50	+68	+108		+146	+210	+252	+310	+380	+465	+600	+780	+1000
120	140					-460	-300	-240	-220	-56	-22	0		-13	-21	+4	0	+17	+31	+50	+77	+122		+166	+236	+284	+350	+425	+520	+670	+880	+1150
140	160					-480	-320	-260	-240	-62	-24	0		-16	-26	+4	0	+20	+34	+56	+80	+130		+180	+258	+310	+385	+470	+575	+740	+960	+1250
160	180					-500	-340	-280	-260	-68	-26	0		-16	-26	+4	0	+20	+34	+56	+84	+140		+196	+284	+340	+425	+520	+640	+820	+1050	+1350
180	200					-520	-360	-300	-280	-74	-28	0		-18	-29	+4	0	+21	+37	+62	+94	+158		+218	+315	+385	+475	+580	+710	+920	+1200	+1550
200	225					-540	-380	-320	-300	-80	-30	0		-18	-29	+4	0	+21	+37	+62	+98	+170		+240	+350	+425	+525	+650	+790	+1000	+1300	+1700
225	250					-560	-400	-340	-320	-86	-32	0		-18	-29	+4	0	+21	+37	+62	+108	+190		+268	+390	+475	+590	+730	+900	+1150	+1500	+1900
250	280					-580	-420	-360	-340	-92	-34	0		-20	-32	+5	0	+23	+40	+68	+114	+206		+294	+435	+530	+660	+820	+1000	+1300	+1650	+2100
280	315					-600	-440	-380	-360	-98	-36	0		-20	-32	+5	0	+23	+40	+68	+126	+232		+330	+490	+595	+740	+920	+1100	+1450	+1850	+2400
315	355					-620	-460	-400	-380	-104	-38	0		-20	-32	+5	0	+23	+40	+68	+132	+252		+360	+540	+660	+820	+1000	+1250	+1600	+2100	+2600
355	400					-640	-480	-420	-400	-110	-40	0		-20	-32	+5	0	+23	+40	+68	+150	+280		+400	+600							
400	450					-660	-500	-440	-420	-116	-42	0		-20	-32	+5	0	+23	+40	+68	+155	+310		+450	+660							
450	500					-680	-520	-460	-440	-122	-44	0		-20	-32	+5	0	+23	+40	+68	+175	+340		+500	+740							
500	560					-700	-540	-480	-460	-128	-46	0		-20	-32	+5	0	+23	+40	+68	+185	+380		+560	+840							
560	630					-720	-560	-500	-480	-134	-48	0		-20	-32	+5	0	+23	+40	+68	+210	+430		+620	+940							
630	710					-740	-580	-520	-500	-140	-50	0		-20	-32	+5	0	+23	+40	+68	+220	+470		+680	+1050							
710	800					-760	-600	-540	-520	-146	-52	0		-20	-32	+5	0	+23	+40	+68	+250	+520		+780	+1150							
800	900					-780	-620	-560	-540	-152	-54	0		-20	-32	+5	0	+23	+40	+68	+260	+580		+840	+1300							
900	1000					-800	-640	-580	-560	-158	-56	0		-20	-32	+5	0	+23	+40	+68	+300	+640		+960	+1450							
1000	1120					-820	-660	-600	-580	-164	-58	0		-20	-32	+5	0	+23	+40	+68	+330	+720		+1050	+1600							
1120	1250					-840	-680	-620	-600	-170	-60	0		-20	-32	+5	0	+23	+40	+68	+370	+820		+1200	+1850							
1250	1400					-860	-700	-640	-620	-176	-62	0		-20	-32	+5	0	+23	+40	+68	+400	+920		+1350	+2000							
1400	1600					-880	-720	-660	-640	-182	-64	0		-20	-32	+5	0	+23	+40	+68	+440	+1000		+1500	+2300							
1600	1800					-900	-740	-680	-660	-188	-66	0		-20	-32	+5	0	+23	+40	+68	+480	+1100		+1650	+2500							
1800	2000					-920	-760	-700	-680	-194	-68	0		-20	-32	+5	0	+23	+40	+68	+550	+1250		+1900	+2900							
2000	2240					-940	-780	-720	-700	-200	-70	0		-20	-32	+5	0	+23	+40	+68	+580	+1400		+2100	+3200							
2240	2500					-960	-800	-740	-720	-206	-72	0		-20	-32	+5	0	+23	+40	+68												
2500	2800					-980	-820	-760	-740	-212	-74	0		-20	-32	+5	0	+23	+40	+68												
2800	3150					-1000	-840	-780	-760	-218	-76	0		-20	-32	+5	0	+23	+40	+68												

Foundamental deviations for shafts



## Tolerance position: for shafts

- from a to h the fundamental deviation is the Upper deviation, and is negative
- from j to zc the fundamental deviation is the Lower deviation, and it is positive
- h is position of a shaft whose superior deviation is zero

in j and k the fundamental deviation vary with quality (IT Grade)  
 for j, only the tolerances 5, 6, 7 and 8 are allowed. For js it is allowed only for the dimensions up to 3 mm  
 for k, only the qualities from 4 to 7 are allowed (<3 and >7)  
 for js the tolerance zone is symmetrical about the basic size line  
 for t, only the dimension from 24 up to 500 mm are allowed

## HOLE DEVIATIONS

Basic size	Lower deviations Ei													Upper deviations Es																		
	Tolerance grades (all)													Tolerance grades (>IT7)																		
	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18						
3	+270	+140	+60	+34	+20	+14	+10	+6	+4	+2	0	0	+2	+4	+6	0	0	-2	-4	-6	-10	-14	-18	-20	-26	-32	-40	-60				
6	+270	+140	+70	+46	+30	+20	+14	+10	+6	+4	0	0	+5	+8	+10	-1+Δ	-1+Δ	-4+Δ	-4	-8+Δ	0	-12	-15	-19	-23	-28	-35	-42	-50	-80		
10	+280	+150	+80	+56	+40	+25	+18	+13	+8	+5	0	0	+5	+8	+12	-1+Δ	-1+Δ	-6+Δ	-6	-10+Δ	0	-15	-19	-23	-28	-34	-42	-52	-67	-97		
14	+290	+150	+95		+50	+32		+16			0	0	+6	+10	+15	-1+Δ	-1+Δ	-7+Δ	-7	-12+Δ	0	-18	-23	-28	-33	-39	-45	-50	-64	-90	-130	
18	+300	+160	+110		+65	+40		+20			0	0	+8	+12	+20	-2+Δ	-2+Δ	-8+Δ	-8	-15+Δ	0	-22	-28	-35	-41	-47	-54	-63	-73	-88	-108	-150
24	+310	+170	+120		+80	+50		+25			0	0	+10	+14	+24	-2+Δ	-2+Δ	-9+Δ	-9	-17+Δ	0	-26	-34	-43	-48	-55	-64	-75	-88	-108	-136	-188
30	+320	+180	+130		+95	+60		+30			0	0	+13	+18	+28	-2+Δ	-2+Δ	-11+Δ	-11	-20+Δ	0	-32	-41	-51	-58	-67	-78	-91	-108	-130	-160	-210
40	+330	+190	+140		+110	+70		+36			0	0	+16	+22	+34	-3+Δ	-3+Δ	-13+Δ	-13	-23+Δ	0	-37	-47	-57	-65	-75	-87	-100	-118	-140	-170	-220
50	+340	+200	+150		+125	+80		+43			0	0	+18	+26	+41	-3+Δ	-3+Δ	-15+Δ	-15	-27+Δ	0	-43	-53	-63	-72	-82	-95	-110	-128	-150	-180	-230
65	+360	+200	+150		+145	+85		+50			0	0	+22	+30	+47	-4+Δ	-4+Δ	-17+Δ	-17	-31+Δ	0	-50	-60	-70	-80	-90	-105	-120	-140	-170	-200	-250
80	+380	+220	+170		+170	+100		+56			0	0	+25	+36	+55	-4+Δ	-4+Δ	-20+Δ	-20	-34+Δ	0	-56	-66	-76	-86	-96	-110	-125	-145	-175	-205	-255
100	+410	+240	+180		+190	+110		+62			0	0	+29	+39	+60	-4+Δ	-4+Δ	-21+Δ	-21	-37+Δ	0	-62	-72	-82	-92	-102	-115	-130	-150	-180	-210	-260
120	+460	+260	+200		+210	+125		+68			0	0	+33	+43	+66	-5+Δ	-5+Δ	-23+Δ	-23	-40+Δ	0	-68	-78	-88	-98	-108	-120	-135	-155	-185	-215	-265
140	+520	+280	+210		+230	+135		+76			0	0						-25	-44		-76	-86	-96	-106	-116	-125	-135	-150	-170	-200	-230	-280
160	+580	+310	+230		+260	+145		+80			0	0						-30	-50		-88	-98	-108	-118	-128	-135	-145	-160	-180	-210	-240	-290
180	+660	+340	+240		+290	+160		+86			0	0						-34	-56		-100	-110	-120	-130	-140	-145	-155	-170	-190	-220	-250	-300
200	+740	+380	+260		+320	+170		+88			0	0						-40	-66		-120	-130	-140	-150	-160	-165	-175	-190	-210	-240	-270	-320
225	+820	+420	+280		+350	+185		+98			0	0						-48	-78		-140	-150	-160	-170	-180	-185	-195	-210	-230	-260	-290	-340
250	+920	+480	+300		+390	+220		+110			0	0						-58	-92		-170	-180	-190	-200	-210	-215	-225	-240	-260	-290	-320	-370
280	+1050	+540	+330		+430	+240		+120			0	0						-68	-110		-200	-210	-220	-230	-240	-245	-255	-270	-290	-320	-350	-400
315	+1200	+600	+360		+480	+260		+130			0	0						-78	-135		-240	-250	-260	-270	-280	-285	-295	-310	-330	-360	-390	-440
355	+1350	+680	+400		+520	+290		+145			0	0						-88	-150		-280	-290	-300	-310	-320	-325	-335	-350	-370	-400	-430	-480
400	+1500	+760	+440		+560	+320		+155			0	0						-98	-165		-320	-330	-340	-350	-360	-365	-375	-390	-410	-440	-470	-520
450	+1650	+840	+480		+600	+350		+165			0	0						-108	-180		-360	-370	-380	-390	-400	-405	-415	-430	-450	-480	-510	-560
500					+640	+380		+175			0	0						-118	-195		-400	-410	-420	-430	-440	-445	-455	-470	-490	-520	-550	-600
560					+680	+410		+185			0	0						-128	-210		-440	-450	-460	-470	-480	-485	-495	-510	-530	-560	-590	-640
630					+720	+440		+195			0	0						-138	-225		-480	-490	-500	-510	-520	-525	-535	-550	-570	-600	-630	-680
710					+760	+470		+205			0	0						-148	-240		-520	-530	-540	-550	-560	-565	-575	-590	-610	-640	-670	-720
800					+800	+500		+215			0	0						-158	-255		-560	-570	-580	-590	-600	-605	-615	-630	-650	-680	-710	-760
900					+840	+530		+225			0	0						-168	-270		-600	-610	-620	-630	-640	-645	-655	-670	-690	-720	-750	-800
1000					+880	+560		+235			0	0						-178	-285		-640	-650	-660	-670	-680	-685	-695	-710	-730	-760	-790	-840
1120					+920	+590		+245			0	0						-188	-300		-680	-690	-700	-710	-720	-725	-735	-750	-770	-800	-830	-880
1250					+960	+620		+255			0	0						-198	-315		-720	-730	-740	-750	-760	-765	-775	-790	-810	-840	-870	-920
1400					+1000	+650		+265			0	0						-208	-330		-760	-770	-780	-790	-800	-805	-815	-830	-850	-880	-910	-960
1400					+1040	+680		+275			0	0						-218	-345		-800	-810	-820	-830	-840	-845	-855	-870	-890	-920	-950	-1000
1600					+1080	+710		+285			0	0						-228	-360		-840	-850	-860	-870	-880	-885	-895	-910	-930	-960	-990	-1040
1800					+1120	+740		+295			0	0						-238	-375		-880	-890	-900	-910	-920	-925	-935	-950	-970	-1000	-1030	-1080
2000					+1160	+770		+305			0	0						-248	-390		-920	-930	-940	-950	-960	-965	-975	-990	-1010	-1040	-1070	-1120
2200					+1200	+800		+315			0	0						-258	-405		-960	-970	-980	-990	-1000	-1005	-1015	-1030	-1050	-1080	-1110	-1160
2500					+1240	+830		+325			0	0						-268	-420		-1000	-1010	-1020	-1030	-1040	-1045	-1055	-1070	-1090	-1120	-1150	-1200
2800					+1280	+860		+335			0	0						-278	-435		-1040	-1050	-1060	-1070	-1080	-1085	-1095	-1110	-1130	-1160	-1190	-1240

Foundamental deviation for holes

$$\Delta = IT_n - IT_{(n-1)}$$

Dimensional  
class

Tolerance grade

mm		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
Beyond	Up to	Tolerances																	
		$\mu\text{m}$										mm							
-	3	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,60	1	1,4
3	6	1	1,5	2,5	4	5	8	12	18	30	48	75	0,12	0,18	0,3	0,48	0,75	1,2	1,8
6	10	1	1,5	2,5	4	6	9	15	22	36	58	90	0,15	0,22	0,36	0,58	0,9	1,5	2,2
10	18	1,2	2	3	5	8	11	18	27	43	70	110	0,18	0,27	0,43	0,7	1,1	1,8	2,7
18	30	1,5	2,5	4	6	9	13	21	33	52	84	130	0,21	0,33	0,52	0,84	1,3	2,1	3,3
30	50	1,5	2,5	4	7	11	16	25	39	62	100	160	0,25	0,39	0,62	1	1,6	2,5	3,9
50	80	2	3	5	8	13	19	30	46	74	120	190	0,3	0,46	0,74	1,2	1,9	3	4,6
80	120	2,5	4	6	10	15	22	35	54	87	140	220	0,35	0,54	0,87	1,4	2,2	3,5	5,4
120	180	3,5	5	8	12	18	25	40	63	100	160	250	0,4	0,63	1	1,6	2,5	4	6,3
180	250	4,5	7	10	14	20	29	46	72	115	185	290	0,46	0,72	1,15	1,85	2,9	4,6	7,2
250	315	6	8	12	16	23	32	52	81	130	210	320	0,52	0,81	1,3	2,1	3,2	5,2	8,1
315	400	7	9	13	18	25	36	57	89	140	230	360	0,57	0,89	1,4	2,3	3,6	5,7	8,9
400	500	8	10	15	20	27	40	63	97	155	250	400	0,63	0,97	1,55	2,5	4	6,3	9,7
500	630	9	11	16	22	32	44	70	110	175	280	440	0,7	1,1	1,75	2,8	4,4	7	11
630	800	10	13	18	25	36	50	80	125	200	320	500	0,8	1,25	2	3,2	5	8	12,5
800	1000	11	15	21	28	40	56	90	140	230	360	560	0,9	1,4	2,3	3,6	5,6	9	14
1000	1250	13	18	24	33	47	66	105	165	260	420	660	1,05	1,65	2,6	4,2	6,6	10,5	16,5
1250	1600	15	21	29	39	55	78	125	195	310	500	780	1,25	1,95	3,1	5	7,8	12,5	19,5
1600	2000	18	25	35	46	65	92	150	230	370	600	920	1,5	2,3	3,7	6	9,2	15	23
2000	2500	22	30	41	55	78	110	175	280	440	700	1100	1,75	2,8	4,4	7	11	17,5	28
2500	3150	26	36	50	68	96	135	210	330	540	860	1350	2,1	3,3	5,4	8,6	13,5	21	33

Tolerance  
numerical  
values

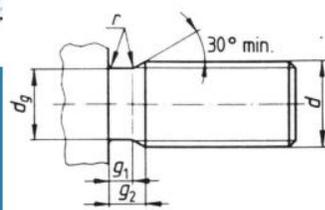
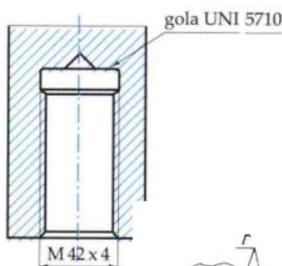
## Screwing lengths

Major diameter groups		Pitch P	Screwing length			
			S (Short)	N (Normal)		L (Long)
Above	Up to		Up to	Above	Up to	Above
1.5	2.8	0.35	0.8	0.8	2.6	2.6
		0.4	1	1	3	3
		0.45	1.2	1.2	3.7	3.7
2.8	5.6	0.35	1	1	3	3
		0.5	1.5	1.5	4.5	4.5
		0.6	1.7	1.7	5	5
		0.7	2	2	6	6
		0.75	2.2	2.2	6.7	6.7
5.6	11.2	0.8	2.5	2.5	7.5	7.5
		0.75	2.4	2.4	7.1	7.1
		1	3	3	9	9
		1.25	4	4	12	12
		1.5	5	5	15	15

# Resulting tolerances

Screwing length	Machining Quality	Thread	Thread tolerances		
			Without coating	Phosphating or galvanic coating	High thickness galvanic coating
S Short	Precise	Screw Nut	3h, 4h 4H	- -	- -
	Medium	Screw Nut	5h, 6h   5g, 6g 5H	5g, 6g 5H	5g, 6g 5G
	Coarse	Screw Nut	- -	- -	- -
M Medium	Precise	Screw Nut	4h   4g 4H, 5H	4g 4H, 5H	4e 4G, 5G
	Medium	Screw Nut	6h   6g 6H	6g 6H	6e 6G
	Coarse	Screw Nut	8g 7H	8g 7H	8e 7G
L Long	Precise	Screw Nut	5h, 4h 4H, 5H	5h, 4h 4H, 5H	- -
	Medium	Screw Nut	7h, 6h   7g, 6g 7H	7g, 6g 7H	t6, 6e 7G
	Coarse	Screw Nut	9g, 8g 8H	9g, 8g 8H	9e, 8e 8G

## Undercuts: drawing representation



Pitch P	d h12 (h13)*	g <sub>min.</sub>	g <sub>max.</sub> (-3P)	r -
0.25	d - 0.4	0.4	0.75	0.12
0.3	d - 0.5	0.5	0.9	0.16
0.35	d - 0.6	0.6	1.05	0.16
0.4	d - 0.7	0.6	1.2	0.2
0.45	d - 0.7	0.7	1.35	0.2
0.5	d - 0.8	0.8	1.5	0.2
0.6	d - 1	0.9	1.8	0.4
0.7	d - 1.1	1.1	2.1	0.4
0.75	d - 1.2	1.2	2.25	0.4
0.8	d - 1.3	1.3	2.4	0.4
1	d - 1.6	1.6	3	0.6
1.25	d - 2	2	3.75	0.6
1.5	d - 2.3	2.5	4.5	0.8
1.75	d - 2.6	3	5.25	1
2	d - 3	3.4	6	1
2.5	d - 3.6	4.4	7.5	1.2
3	d - 4.4	5.2	9	1.6
3.5	d - 5	6.2	10.5	1.6
4	d - 5.7	7	12	2
4.5	d - 6.4	8	13.5	2.5
5	d - 7	9	15	2.5
	d - 7.7	11	17.5	3.2
	d - 8.3	11	18	3.2

Table: ISO 4755