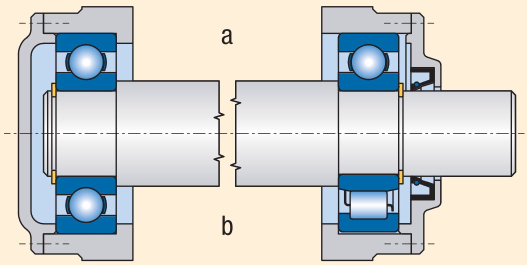
3. Bearing arrangement design

3.1 General principles of rolling bearing arrangement design

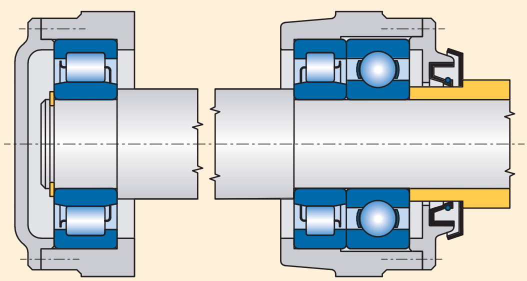
Rotating shaft or another component arranged in rolling bearings is guided by them in radial as well as in axial direction so that the basic condition, the movement uniqueness, can be fulfilled. The component should be, as far as possible, statically determined, i.e. supported in two points radially and in one point axially. A typical example of such an arrangement is in Pict. 9, where the shaft is radially guided in two bearings, one of which secures it in axial direction. The locating bearing carries the radial load and simultaneously also the axial load in both directions. Radial bearings that can accomodate combined load are mostly used as locating bearings, which carry, e.g. single row ball bearings, double row angular contact ball bearings, double row self aligning ball bearings, double row spherical roller bearings or single row angular contact ball bearings and tapered roller bearings. The two last mentioned bearing types must be mounted in pairs. The non-locating bearing carries only radial load and must permit certain displacement of the shaft in axial direction so that arising of non-desired axial preload caused by environment (temperature dillatations, production inaccuracies of connecting arrangement components, etc.) can be hindered. Axial displacement can be secured by displacement between one bearing ring and a machine part, which is directly connected with the bearing, e.g. between outer bearing ring and housing bore (see Figure 9a) or directly in the bearing (see Figure 9b).

Figure 9



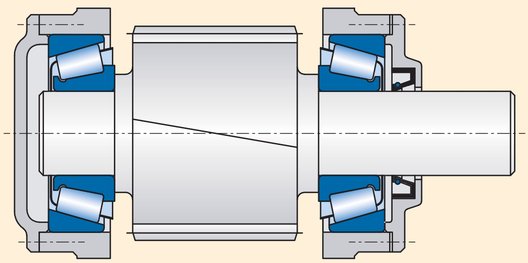
Arrangements, in which greater radial and axial loads act by higher rotational speed, should be set up so that the bearing can accommodate only radial or axial forces, see Pict. 10. In these cases it is possible to use for radial guidance some of the radial bearings and for axial guidance those radial bearings which are also able to carry axial load or a pair of these bearings, or double direction thrust bearing, or a pair of single direction thrust bearings. There is a condition where the axially locating thrust bearing should be arranged with radial clearance. Another,

Figure 10



often used solution is the arrangement of two bearings, whose design enables the accommodation both radial and axial loads. Both bearings accommodate alternately the axial load, always according to direction of force acting, and simultaneously they carry also the radial load. An example of this arrangement is shown in Figure 11. As a verified design the pair of single row tapered roller bearings or single row angular contact ball bearings are used. There can be used other bearing types which are able to carry the load both in radial and axial direction simultaneously, e.g. separable single row ball bearings or single row cylindrical roller bearings in NJ design, etc.

Figure 11



3.2 Bearing location

Radial and axial bearing location on the shaft and in the housing bore or another part has a direct connection with the whole arrangement design. When selecting the way of location, the character and acting forces magnitude, the operating temperature in the arrangement and material of mating parts must be taken into account. Mounting, dismounting and maintenance methods must be taken into consideration when designing mating parts dimensions.

3.2.1 Radial Location of Bearing

The bearing is located in radial direction on the mating cylindrical shaft and housing bore surface. In some cases, adapter or withdrawal sleeves are used by mounting on the shaft, or the bearing can be mounted directly on the tapered shaft.

The correct radial location of the bearing on the shaft significantly influences utilization of its load rating and correct function in arrangement. The following viewpoints are important:
a) safe location and uniform supporting of bearings
b) simple mounting and dismounting
c) displacement of non-locating bearing in axial direction
Basically, both bearing rings should be mounted in tight fits, because only in this way their reliable supporting around the whole periphery and radial fixing against turning can be achieved. To make mounting and dismounting easier or for moving the non-locating ring, a loose fit of one of the rings is permissible. When selecting correct radial bearing location, following influences must be taken into account.

Circumferential Load - occurs if the respective bearing ring rotates and the load direction is not changed or if the ring rotates and the load does not rotate. The bearing ring periphery is gradually loaded during one revolution. In this case the loaded bearing ring must be always fitted with necessary interference fit.

Point Load - occurs when the bearing ring does not rotate and the external force is constantly directed into the same ring raceway point or if the ring and load rotate at the same rotating speed. The ring subjected to point load can be mounted with loose fit, if the conditions require it.

Indeterminate Load - occurs if the ring is subjected to varying external forces at which directions and load changes cannot be determined (e.g. unbalanced mass, shocks, etc.). Under these conditions in most applications bearings with greater radial clearance should be used.

Load Magnitude - directly influences selection of the interference fit (higher load - larger interference), especially in cases of impact loads. A firm fitting on the shaft or in the housing causes ring deformation, and as a result reduction of radial clearance arises. To secure the necessary radial clearance in the firm arrangement, it is necessary to use bearings with greater radial clerarance. Resulting clearance after mounting depends on the bearing type and its dimension.

Bearing Size and Type - determines the size of necessary interference fit of the fitted ring. For smaller sized bearings smaller interference fits are selected, and vice versa. Relatively smaller interferences are used, e.g. for the same sizes of ball bearings in comparison with the cylindrical roller, tapered roller or spherical roller bearings.

Material and Design of Mating Components must be taken into account when determining their production tolerance. Results of practical experience are shown in the following tables. In cases where bearings are mounted into housings made of light metal alloys or on journals of hollow shafts, arrangements with higher interference are selected.
Split housings are not suitable for arrangements with higher interferences, because there is danger of the bearing pinching in the dividing plane.

Heating generating in the bearing can cause loosening of the interference on the journal and turning of the ring. In the housing a converse case can come into being. The heating causes clearance decreasing and subsequently limiting and even stopping of the axial displacement of the non-locating bearing ring. That is why we pay a great deal of attention to this fact when designing an arrangement.

Fitting Accuracy from the point of view of its tolerances and geometric shapes is important because it can be transmitted towards the bearing ring raceways and defines the arrangement accuracy. When using bearings with normal tolerance class, the tolerance of journal seating surface IT6 is selected, and for housing seating surface tolerance IT7. For smaller dimensioned ball and cylindrical roller bearings it is possible to use for the journal tolerance IT5 and housing bore IT6. For bearings in higher tolerance classes, for arrangements with high requirements on accuracy, e.g. spindels of machine tools, the least tolerance class IT5 is recommended for the shaft and for housing IT6. Permissible ovality and conicity deviation and permissible lateral bearing runout of supporting surfaces must be in reference to axis smaller than the diameter tolerance of the journal and bore. With higher bearing tolerance class also requirements on the seating surface accuracy increase. Recommended values are shown in tables 28 and 29.

Mounting and Dismounting of bearings, if one of the rings is arranged with a loose fit it is simple. If, because of operational reasons, it is necessary to arrange both of the rings with an interference, a suitable bearing type should be selected, e.g. a separable bearing (tapered roller, cylindrical roller, needle roller bearing) or a bearing with tapered bore. Journals for sleeve arrangements of bearings with tapered bore can be in tolerance class h9 or h10, geometric shape should be in tolerance class IT5 or IT7 according to arrangement requirements.

Recommended Shape Accuracies of Bearing Seating Fits			Tab. 28
Bearing Tolerance Class	Fitting Location	Permissible Ovality Deviation	Permissible Lateral Runout of Carrying Surfaces in Reference to Axis
P0, P6	shaft	IT5/2	IT3
	housing	IT6/2	IT4
P5, P4	shaft	IT3/2	IT2
	housing	IT4/2	IT3

Standard Tolerances IT2 to IT6						Tab. 29
Nominal Diameter		Tolerance Class				
over	incl.	IT2	IT3	IT4	IT5	IT6
mm		µm				
6	10	1,5	2,5	4	6	9
10	18	2	3	5	8	11
18	30	2,5	4	6	9	13
30	50	2,5	4	7	11	16
50	80	3	5	8	13	19
80	120	4	6	10	15	22
120	180	5	8	12	18	25
180	250	7	10	14	20	29
250	315	8	12	16	23	32
315	400	9	13	18	25	36
400	500	10	15	20	27	40

Axial Displacement of Non-Locating Bearing Rings must be secured by all operation conditions. When using a non-separable bearing, displacement of the stationary loaded ring is reached by its fitting with clearance (moveable). In light metal alloy housings it is necessary, if the outer ring is fitted with clearance, to put a steel bush in the bore.

A reliable displacibility in axial direction is reached by using cylindrical roller bearing type N and NU or radial needle bearing. Recommended journal and bore diameter tolerances of the mating components for radial and thrust bearings are shown in tables 30 to 35.

Radial Bearing Shaft Diameter Tolerances (Valid for Solid Steel Shafts)					Tab. 30
		Journal Diameter [mm]			
Operating Conditions	Arrangement Examples	Ball Bearings	Cylindrical, Needle,[1] Tapered Roller Bearings	Spherical Roller Bearings	Tolerance
Inner Ring Point Load					
Light and Normal Load Pr ≤ 0,15 Cr	Free wheels, sheaves, belt pulleys	All Diameters			g6 [2]
Heavy Impact Load Pr > 0,15 Cr	Industrial truck wheels, tension pulleys	All Diameters			h6
Inner Ring Circumferential Load or Indeterminate Load					
Light and Variable Load Pr ≤ 0,07 Cr	Transport equipments, ventilators	(18) to 100	≤40	-	i6
		(100) to 200	(40) to 140	-	k6
Normal and Heavy Load Pr > 0,07 Cr	General enginnering, electric motors, turbines, pumps, combustion motors, gear boxes, woodworking machines	≤18	-	-	j5
		(18) to 100	≤40	≤40	k5 (k6) [3]
		(100) to 140	(40) to 100	(40) to 65	m5 (m6) [3]
		(140) to 200	(100) to 140	(65) to 100	m6
		(200) to 500	(140) to 200	(100) to 140	n6
		>500	>200	>140	p6
Extremely Heavy Load, Impacts Complicated Operating Conditions Pr > 0,15 Cr	Axle bearings for railway vehicles, traction motors, rolling mills	-	50 to 140	50 to 140	n6 [4]
		-	(140) to 500	(140) to 500	p6 [4]
		-	>500	>500	r6 (p6) [4]
High Arrangement Accuracy under Light Load Pr ≤ 0,07 Cr	Machine tools	≤18	-	-	h5 [5]
		(18) to 100	≤40	-	j5 [5]
		(100) to 200	(40) to 140	-	k5 [5]
		-	(140) to 200	-	m5
Exclusively Axial Load		All Diameters			j6
Bearings with Tapered Bore and Adapter or Withdrawal Sleeve					
All Kinds of Load	General arrangements, axle bearings for railway vehicles	All Diameters			h9/IT5
	Not complicated arrangements				h10/IT7

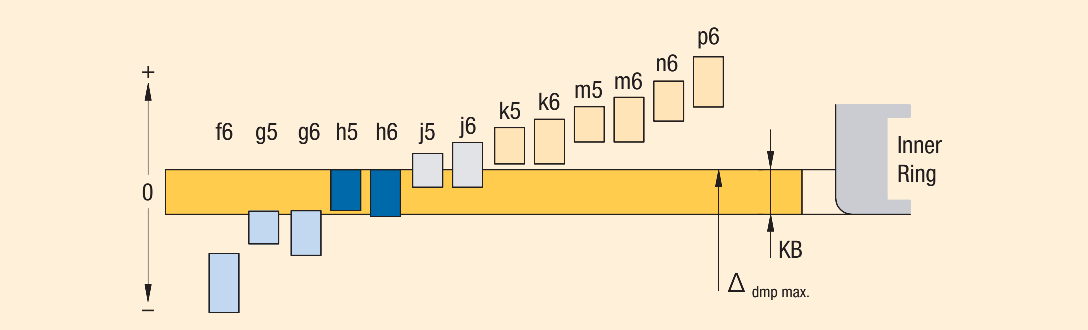
1) It is necesseary to consult with the producer the tolerances for needle roller bearings without rings.
2) Tolerance f6 can be selected for securing axial displacibility.
3) Tolerances in brackets are selected usually for single row tapered roller bearings or at low rotational speeds where tolerance dispersion is not significant.
4) It is necessary to use bearings with higher radial clearance than normal.
5) It is necesseary to consult with the producer the tolerances for single row ball bearings in tolerance classes P5 and P4.

Housing Bore Diameter Tolerances for Radial Bearings (Valid for Steel, Cast and Cast Steel Housings)				Tab. 31
Operating Conditions	**Displacibility of Outer Ring**	**Housing**	**Arrangement Examples**	**Tolerance**
Outer Ring Circumferential Load				
Heavy Impact Load Pr > 0,15 Cr Thin Walled Housings	not dispacable	one-part	Wheel hubs with cylindrical roller bearings, big end bearings	P7
Normal and Heavy Load Pr > 0,07 Cr	not dispacable	one-part	Wheel hubs with ball bearings, crane travel wheels, crankshaft bearings	N7
Light and Variable Load Pr ≤ 0,07 Cr	not dispacable	one-part	Conveyor rollers, tension pulleys	M7
Indeterminate Load				
Heavy Impact Load Pr > 0,15 Cr	not dispacable	one-part	Traction motors	M7
Heavy and Normal Load Pr > 0,07 Cr	As a rule, not displacable	one-part	Electric motors, pumps, crankshafts	K7
Light and Varying Load Pr ≤ 0,07 Cr	As a rule, displacable	one-part	Electric motors, pumps, crankshafts	J7
Accurate Arrangement				
Light Load Pr ≤ 0,07 Cr	As a rule, not displacable	one-part	Cylindrical roller bearings for machine tools ball bearings for machine tools. Small electric motors	K6 [1)]
	Displacable			J6 [2)]
	Easily displacable			H6
Outer Ring Point Load				
Any Load	Easily displacable	One-part or two-part	General engineering, axle bearings of railway vehicles	H7 [3)]
Light and Normal Load Pr ≤ 0,15 Cr	Easily displacable	One-part or two-part	General engineering, less complicated engineering	H8
			Drying rollers of paperworking machines, big electric motors	G7 [4)]

1) For heavy loads tighter tolerances are selected - M6 or N6. For cylindrical roller bearings with tapered bore tolerances K5 or M5.
2) It is necesseary to consult with the producer the tolerances for single row ball bearings in tolerances P5 and P4.
3) For bearings with outer diameter D < 250 mm, with temperature difference between outer ring and housing over 10°C, tolerance G7 is selected.
4) For bearings with outer diameter D > 250 mm, with temperature difference between outer ring and housing over 10°C, tolerance F7 is selected.

Journal Diameter Tolerances for Thrust Bearings				Tab. 32
Bearing Type	**Load**		**Journal Diamter [mm]**	**Tolerance**
Thrust Ball Bearings	Exclusively Axial Load		All Diameters	j6
Thrust Spherical Roller Bearings	Exclusively Axial Load		All Diameters	j6
	Simultaneously Axial and Radial Load	Point shafting ring loading	All Diameters	j6
		Circumferential shaft ring loading or not specified loading type	≤ 200	k6
			(200) to 400	m6
			> 400	n6

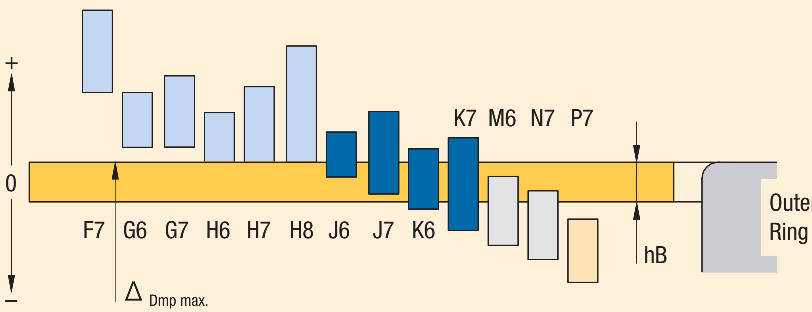
Object Bore Tolerances for Thrust Bearings				Tab. 33
Bearing Type	**Load**		**Note**	**Tolerance**
Thrust Ball Bearings	Exclusively Axial Load		In common arrangement housing washer can have clearance	H8
			Housing washer mounted with radial clearance	-
Thrust Spherical Roller Bearings	Exclusively Axial Load		In common arrangement housing washer can have clearance	H8
			Housing washer mounted with radial clearance	-
	Simultaneously Axial and Radial Load	Stationary Load or Indeterminite Load of Housing Washer		H7
		Rotating Load of Housing Washer		M7



Journal Diameter Tolerance Limiting Deviations																Tab. 34a	
Journal Nominal Diameter		f6		g5		g6		h5		h6		j5		j6(js6)		k5	
over	incl.	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
mm		µm															
1	3	-6	-12	-2	-6	-2	-8	0	-4	0	-6	+ 2	-2	+4	-2	+4	0
3	6	-10	-18	-4	-9	-4	-12	0	-5	0	-8	+3	-2	+ 6	-2	+ 6	+ 1
6	10	-13	-22	-5	-11	-5	-14	0	-6	0	-9	+4	-2	+ 7	-2	+ 7	+ 1
10	18	-16	-27	-6	-14	-6	-17	0	-8	0	-11	+ 5	-3	+ 8	-3	+ 9	+ 1
18	30	-20	-33	-7	-16	-7	-20	0	-9	0	-13	+ 5	-4	+ 9	-4	+ 11	+ 2
30	50	-25	-41	-9	-20	-9	-25	0	-11	0	-16	+ 6	-5	+ 11	-5	+ 13	+ 2
50	80	-30	-49	-10	-23	-10	-29	0	-13	0	-19	+ 6	-7	+ 12	-7	+ 15	+ 2
80	120	-36	-58	-12	-27	-12	-34	0	-15	0	-22	+ 6	-9	+ 13	-9	+ 18	+3
120	180	-43	-68	-14	-32	-14	-39	0	-18	0	-25	+ 7	-11	+ 14	-11	+ 21	+3
180	250	-50	-79	-15	-35	-15	-44	0	-20	0	-29	+ 7	-13	+ 16	-13	+ 24	+4
250	315	-56	-88	-17	-40	-17	-49	0	-23	0	-32	+ 7	-16	+ 16	-16	+ 27	+4
315	400	-62	-98	-18	-43	-18	-54	0	-25	0	-36	+ 7	-18	+ 18	-18	+ 29	+4
400	500	-68	-108	-20	-47	-20	-60	0	-27	0	-40	+ 7	-20	+ 20	-20	+32	+ 5
500	630	-76	-120	-	-	-22	-66	-	-	0	-44	-	-	+ 22	-22	-	-
630	800	-80	-130	-	-	-24	-74	-	-	0	-50	-	-	+ 25	-25	-	-
800	1000	-86	-142	-	-	-26	-82	-	-	0	-56	-	-	+ 28	-28	-	-
1000	1250	-98	-164	-	-	-28	-94	-	-	0	-66	-	-	+33	-33	-	-

Journal Diameter Tolerance Limiting Deviations																Tab. 34b	
Journal Nominal Diameter		k6		m5		m6		n6		p6		h9[1]		h10[1]		IT5	IT7
over	incl.	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower		
mm		µm															
1	3	+ 6	0	+ 6	+ 2	+8	+ 2	+ 10	+4	+ 12	+6	0	-25	0	-40	4	10
3	6	+ 9	+ 1	+ 9	+4	+ 12	+4	+ 16	+ 8	+ 20	+ 12	0	-30	0	-48	5	12
6	10	+ 10	+ 1	+ 12	+ 6	+ 15	+ 6	+ 19	+ 10	+ 24	+ 15	0	-36	0	-58	6	15
10	18	+ 12	+ 1	+ 15	+ 7	+ 18	+ 7	+ 23	+ 12	+ 29	+ 18	0	-43	0	-70	8	18
18	30	+ 15	+ 2	+ 17	+ 8	+ 21	+ 8	+ 28	+ 15	+35	+ 22	0	-52	0	-84	9	21
30	50	+ 18	+ 2	+20	+ 9	+ 25	+ 9	+33	+ 17	+42	+ 26	0	-62	0	-100	11	25
50	80	+ 21	+2	+ 24	+ 11	+30	+ 11	+39	+ 20	+ 51	+32	0	-74	0	-120	13	30
80	120	+ 25	+3	+ 28	+ 13	+35	+ 13	+45	+ 23	+ 59	+37	0	-87	0	-140	15	35
120	180	+ 28	+3	+33	+ 15	+40	+ 15	+ 52	+ 27	+ 68	+43	0	-100	0	-160	18	40
180	250	+33	+4	+37	+ 17	+46	+ 17	+ 60	+31	+ 79	+ 50	0	-115	0	-185	20	46
250	315	+36	+4	+43	+ 20	+ 52	+ 20	+ 66	+34	+ 88	+ 56	0	-130	0	-210	23	52
315	400	+40	+4	+46	+ 21	+ 57	+ 21	+ 73	+37	+ 98	+ 62	0	-140	0	-230	25	57
400	500	+45	+ 5	+ 50	+ 23	+ 63	+ 23	+ 80	+40	+ 108	+ 68	0	-155	0	-250	27	63
500	630	+44	0	-	-	+ 70	+ 26	+ 88	+44	+ 122	+ 78	0	-175	0	-280	30	70
630	800	+ 50	0	-	-	+ 80	+30	+ 100	+ 50	+ 138	+ 88	0	-200	0	-320	35	80
800	1000	+ 56	0	-	-	+ 90	+34	+ 112	+ 56	+ 156	+ 100	0	-230	0	-360	40	90
1000	1250	+ 66	0	-	-	+ 106	+40	+ 132	+ 66	+ 186	+ 120	0	-260	0	-420	46	105

1) For journals made in tolerance h9 and H10 for bearings with adapter or withdrawal sleeves deviations of roundness and cylindricity must not exceed basic tolerances IT5 and IT7.



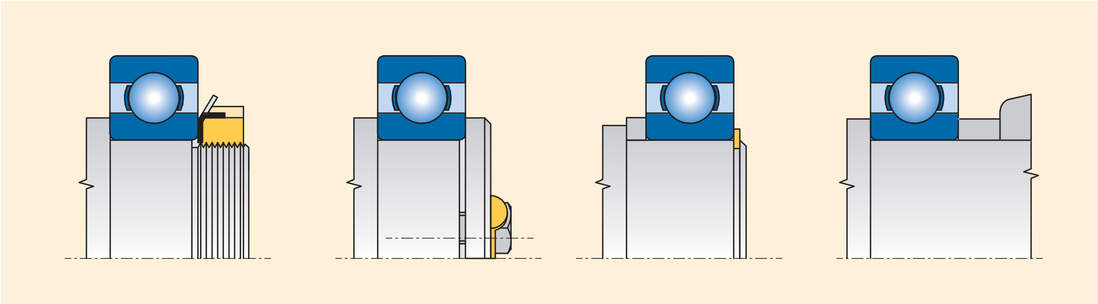
Bore Diameter Tolerance Limiting Deviations														Tab. 35a	
Bore Nominal Diameter		F7		G6		G7		H6		H7		H8		J6(Js6)	
over	incl.	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
mm		µm													
6	10	+ 28	+ 13	+ 14	+ 5	+ 20	+5	+9	0	+ 15	0	+ 22	0	+ 5	-4
10	18	+34	+ 16	+ 17	+ 6	+ 24	+6	+ 11	0	+ 18	0	+ 27	0	+ 6	-5
18	30	+41	+ 20	+ 20	+ 7	+ 28	+7	+ 13	0	+ 21	0	+33	0	+ 8	-5
30	50	+ 50	+ 25	+ 25	+ 9	+34	+9	+ 16	0	+ 25	0	+39	0	+ 10	-6
50	80	+ 60	+30	+ 29	+ 10	+40	+ 10	+ 19	0	+30	0	+46	0	+ 13	-6
80	120	+ 71	+36	+34	+ 12	+47	+ 12	+ 22	0	+35	0	+ 54	0	+ 16	-6
120	180	+ 83	+43	+39	+ 14	+ 54	+ 14	+ 25	0	+40	0	+ 63	0	+ 18	-7
180	250	+ 96	+50	+44	+ 15	+ 61	+ 15	+ 29	0	+46	0	+ 72	0	+ 22	-7
250	315	+ 108	+56	+49	+ 17	+ 69	+ 17	+32	0	+ 52	0	+ 81	0	+ 25	-7
315	400	+ 119	+62	+ 54	+ 18	+ 75	+ 18	+36	0	+ 57	0	+ 89	0	+ 29	-7
400	500	+ 131	+ 68	+ 60	+20	+ 83	+ 20	+40	0	+ 63	0	+ 97	0	+33	-7
500	630	+ 146	+ 76	+66	+22	+ 92	+ 22	+44	0	+ 70	0	+ 110	0	+ 22	-22
630	800	+ 160	+ 80	+ 74	+ 24	+ 104	+ 24	+ 50	0	+ 80	0	+ 125	0	+ 25	-25
800	1000	+ 176	+ 86	+ 82	+26	+ 116	+ 26	+ 56	0	+ 90	0	+ 140	0	+ 28	-28
1000	1250	+ 203	+98	+ 94	+ 28	+ 133	+ 28	+ 66	0	+ 105	0	+ 165	0	+33	-33
1250	1600	+ 235	+ 110	+ 108	+30	+ 155	+30	+ 78	0	+ 125	0	+ 195	0	+39	-39

Bore Diameter Tolerance Limiting Deviations														Tab. 35b	
Bore Nominal Diameter		J7(Js7)		K6		K7		M6		M7		N7		P7	
over	incl.	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
mm		µm													
6	10	+ 8	-7	+ 2	-7	+ 5	-10	-3	-12	0	-15	-4	-19	-9	-24
10	18	+ 10	-8	+ 2	-9	+ 6	-12	-4	-15	0	-18	-5	-23	-11	-29
18	30	+ 12	-9	+ 2	-11	+ 6	-15	-4	-17	0	-21	-7	-28	-14	-35
30	50	+ 14	-11	+3	-13	+ 7	-18	-4	-20	0	-25	-8	-33	-17	-42
50	80	+ 18	-12	+4	-15	+ 9	-21	-5	-24	0	-30	-9	-39	-21	-51
80	120	+ 22	-13	+4	-18	+ 10	-25	-6	-28	0	-35	-10	-45	-24	-59
120	180	+ 25	-14	+4	-21	+ 12	-28	-8	-33	0	-40	-12	-52	-28	-68
180	250	+30	-16	+ 5	-24	+ 13	-33	-8	-37	0	-46	-14	-60	-33	-79
250	315	+36	-16	+ 5	-27	+ 16	-36	-9	-41	0	-52	-14	-66	-36	-88
315	400	+39	-18	+7	-29	+ 17	-40	-10	-46	0	-57	-16	-73	-41	-98
400	500	+43	-20	+ 8	-32	+ 18	-45	-10	-50	0	-63	-17	-80	-45	-108
500	630	+35	-35	0	-44	0	-70	-26	-70	-26	-96	-44	-114	-78	-148
630	800	+40	-40	0	-50	0	-80	-30	-80	-30	-110	-50	-130	-88	-168
800	1000	+45	-45	0	-56	0	-90	-34	-90	-34	-124	-56	-146	-100	-190
1000	1250	+ 52	-52	0	-66	0	-105	-40	-106	-40	-145	-66	-171	-120	-225
1250	1600	+ 62	-62	0	-78	0	-125	-48	-126	-48	-173	-78	-203	-140	-265

3.2.2 Axial Securing of Bearing

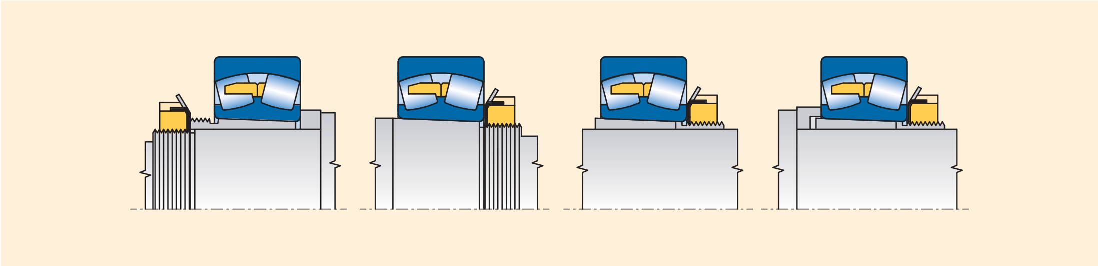
Inner bearing ring with cylindrical bore arranged on the journal with interference fit (fixed) is usually secured in the axial direction by means of a locknut, end-plate or snap ring, when the other face is usually supported by the shaft shoulder. Surrounding parts are used as abutment faces for inner rings, and if necessary, spacing rings are inserted between this component and bearing inner ring. Examples of axial bearing securing are shown in Figure12.

Figure 12



Examples of axial locating of bearings with tapered bore seated directly on the tapered journal or by means of an adapter or withdrawal sleeve are in Figure 13.

Figure 13



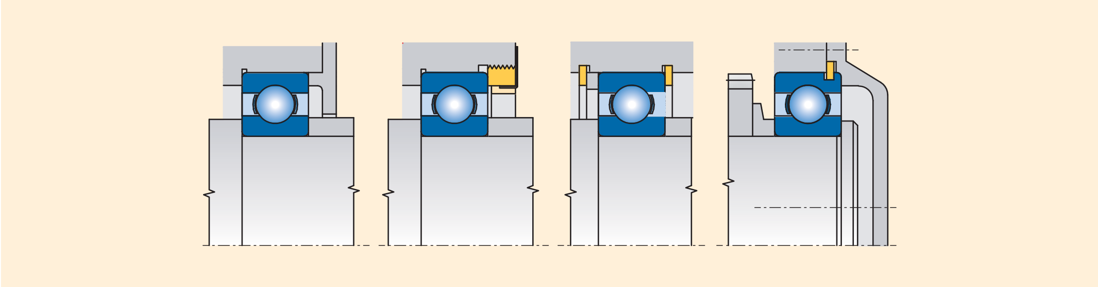
Permissible bearing axial load fixed by an adapter sleeve on smooth shafts without bearing resting on the shaft shoulder is calculated according to equation:

$$F_a = 3.B.d$$

F_a	- permissible bearing axial load	[N]
B	- bearing width	[mm]
d	- bearing bore diameter	[mm]

If the axial displacement of the outer ring in the housing is not required, then we can use solution, when the face supporting or seating surface of the bearing cover, nut or snap ring are used. Bearings with grooves for snap ring (NR) do not require much space and their securing is simple. Examples - see Figure 14.

Figure 14



Abutment dimensions for each bearing shown in this publication are in the dimension tables.

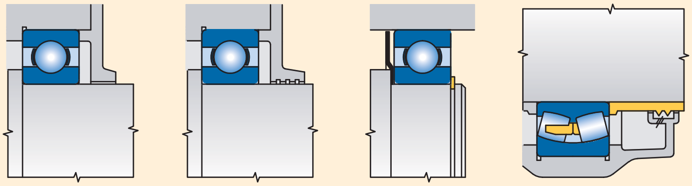
3.3 Sealing

Sealing of the bearing space is very important, because damaging materials which can be found in the bearing environment influence it and often can cause its breakdown. Sealing also has an opposite function - it prevents the lubricant leaking out of the bearing and arrangement space.That is why sealing must always be designed with regard to operating conditions of machines or equipments, arrangement design, lubricating method, maintenance possibility and economic questions concerning production and utilization.

3.3.1 Non-Contact Sealing

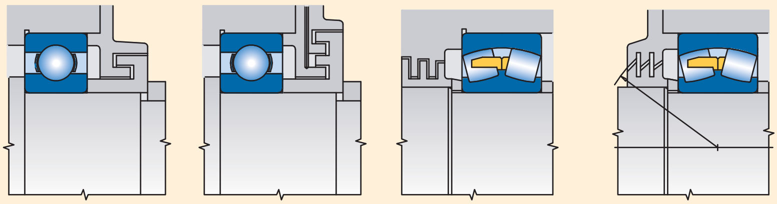
Between non-rotating and rotating parts there is only a narrow gap when using this sealing. It is filled with grease. Using this sealing, wear of components from friction does not occur and that is why this sealing can be used for the highest rotational speeds and for high operating temperatures.Examples of a gap sealing are in Figure 15.

Figure 15



Another very effective sealing is the labyrinth sealing which can improve the sealing effect by a greater number of labyrinths or prolongation of sealing gaps. Examples - see Figure 16.

Figure 16



3.3.2 Rubbing Sealing

Rubbing sealing is created of elastic or soft, but sufficiently impermiable material, which is inserted between the rotating and firm part. Such a sealing is usually cheap and is suitable for various designs. The disadvantage is the sliding friction of the contacting surfaces, and there fore there is limited utilization for high rotational speeds. Sealing with a felt ring is the simplest (Figure 17). It is suitable for operating temperature - 40° to +160°C and for peripheral speeds to 7 $m.s^{-1}$ and sliding surface roughness max. Ra = 0,16, hardness min. 45 HRC or hard chromium plating. Dimensions of the felt rings are given by corresponding national standards.

A very wide-spread way of sealing is sealing with shaft washers (see Figure 18). Radial shaft sealwashers are made of rubber or other suitable plastic reinforced by steel sheet reinforcement. According to the material used they are suitable for operating temperature from -30° to +160°C. Permissible peripheral speed depends on sliding surface roughness:

- to 2 $m.s^{-1}$ is roughness max. Ra= 0,8,
- to 4 $m.s^{-1}$ is roughness max. Ra= 0,4,
- to 12 $m.s^{-1}$ is roughness max. Ra= 0,2.

Figure 17

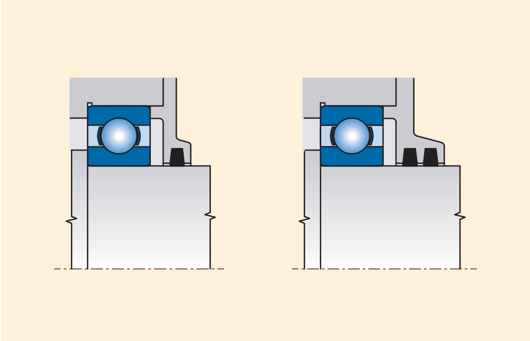
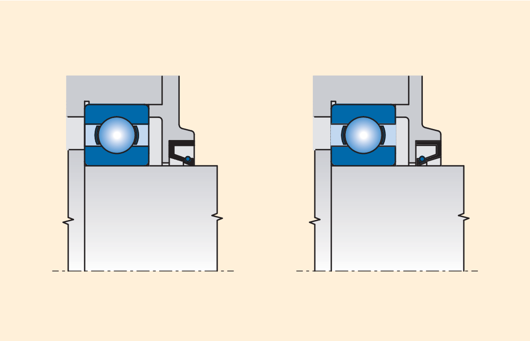
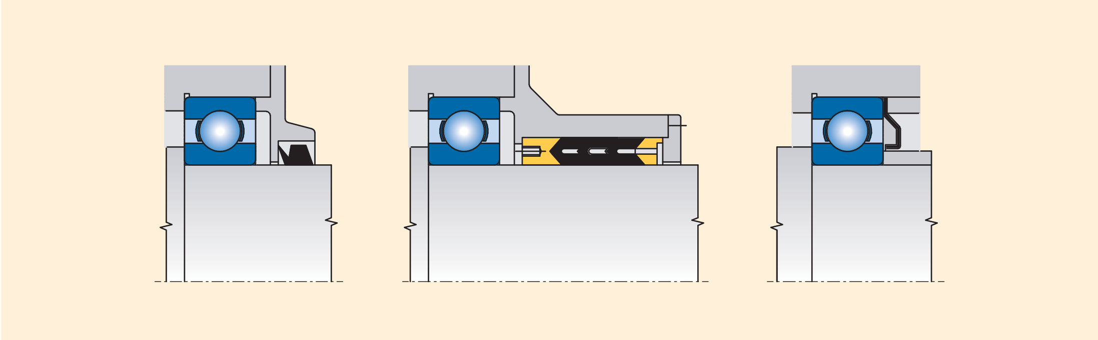


Figure 18



Except for mentioned most commonly used sealing rings there are rubbing sealing designs which use the just formed sealing rings made of rubber, plastic, etc., or special spring rings. This sealing is chosen either for applications with high requirements on bearing space sealing (great environment pollution, high temperature, chemical substance influence), or for economic reasons by mass or series production. Examples (see Figure 19).

Figure 19



3.3.3 Combined Sealing

Increase sealing effect can be reached by non-contact and rubbing sealing combination. Such a sealing is recommended for wet and polluted environment. Example - see Figure 20.

Figure 20