Rolling-Element Bearings

Calculation and selection using SKF Bearing Catalogue

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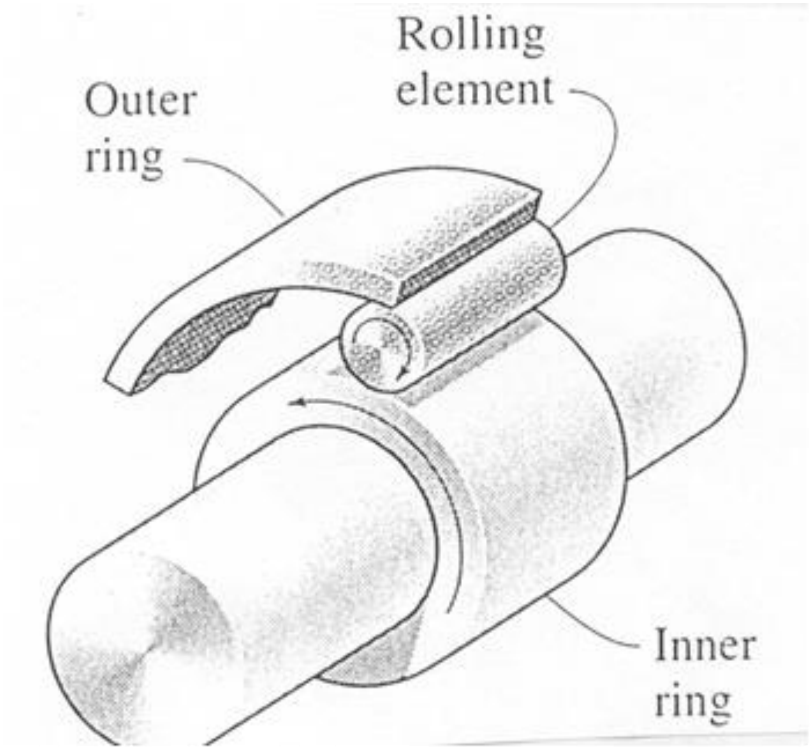
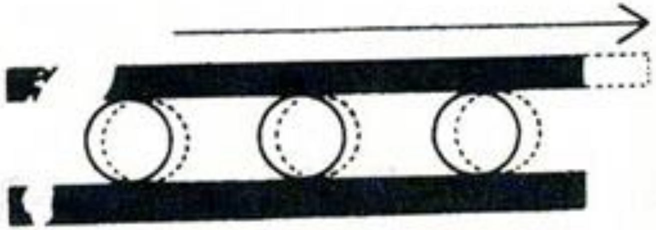
Principle of the Rolling-Element Bearings is very old.

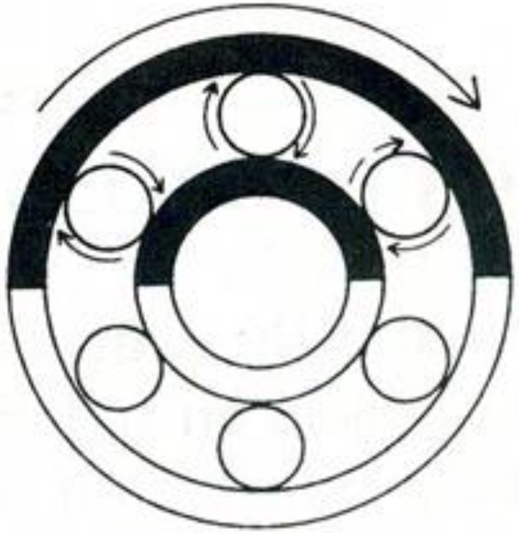


This picture shows the principle of a Rolling-Element Bearing of today.

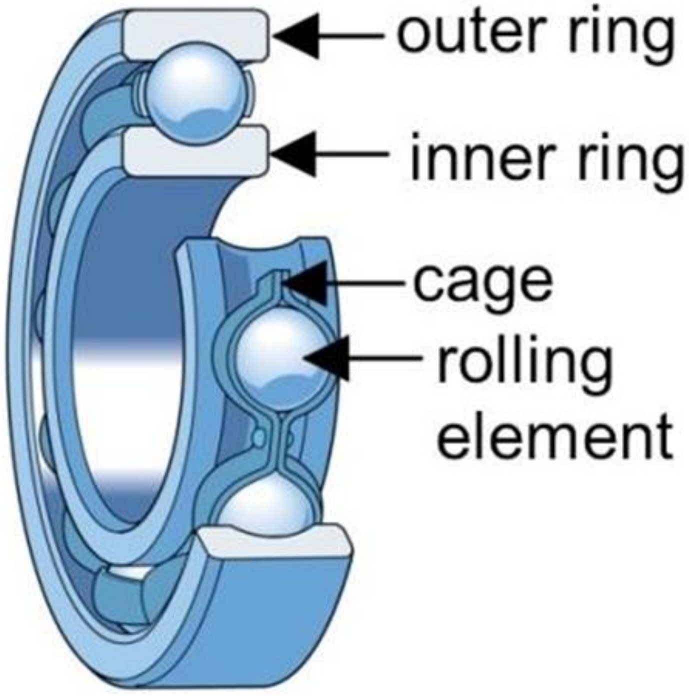
This picture shows how the people in ancient Mesopotamia moved huge stones.

With the rollers used by the Assyrians to move massive stones in 1100 BC . . .





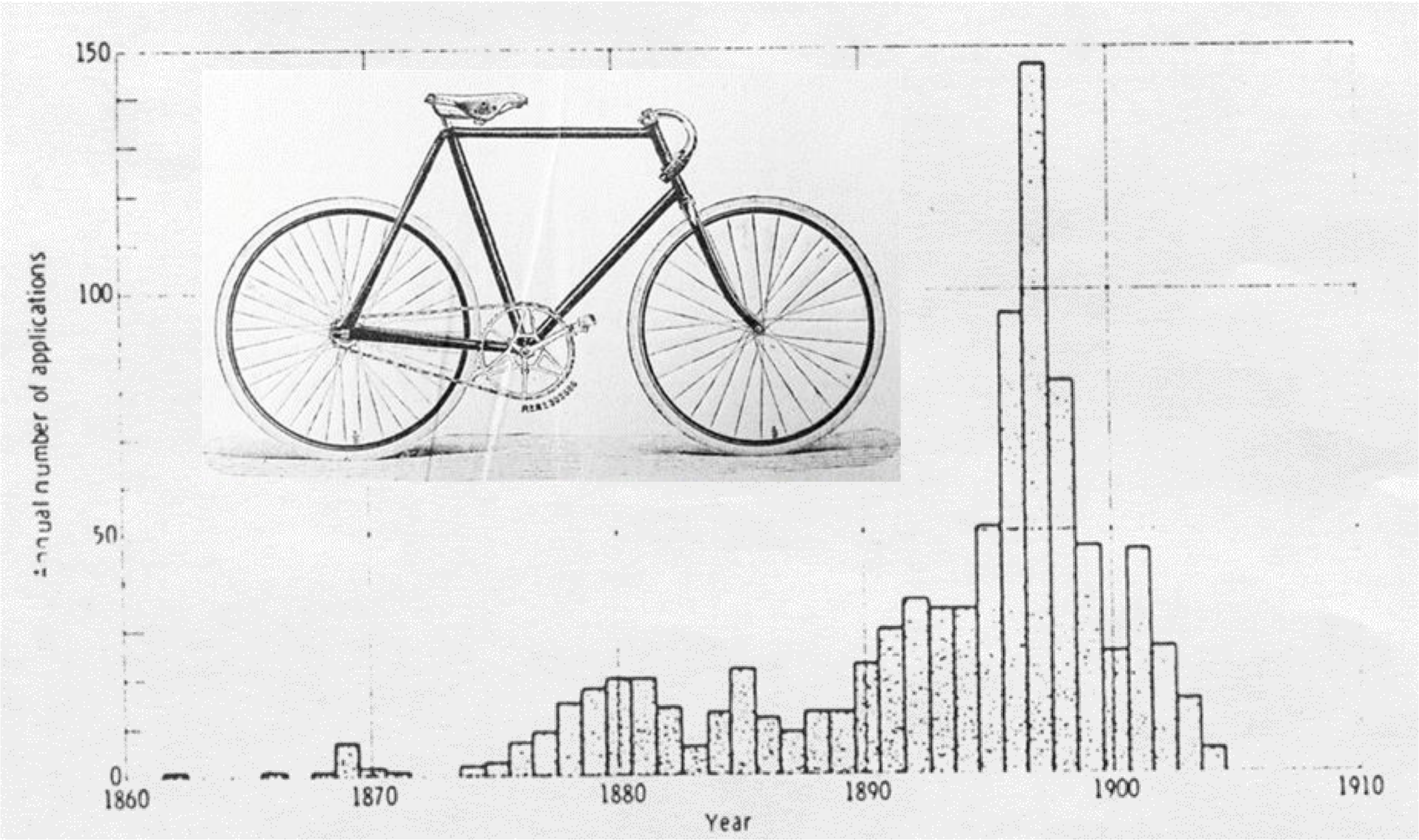
Modern Rolling Bearings



- Outer ring
- Inner ring
- Rolling Elements
  - Balls & Cage
  - Rollers & Cage

Industrial revolution

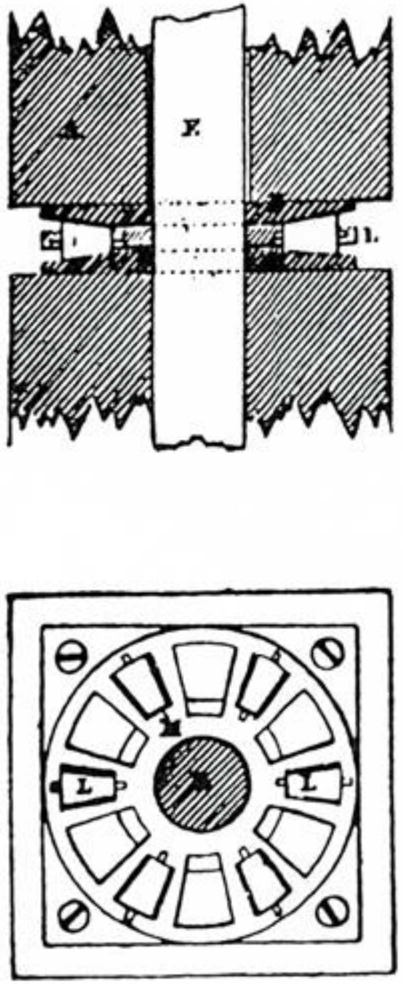
- Development of modern Bearing
- Better material and better manufacturing methods resulted in better bearings
- Big need for rolling bearings
- Sewing machines’ and bicycle manufactures the biggest bearing consumers

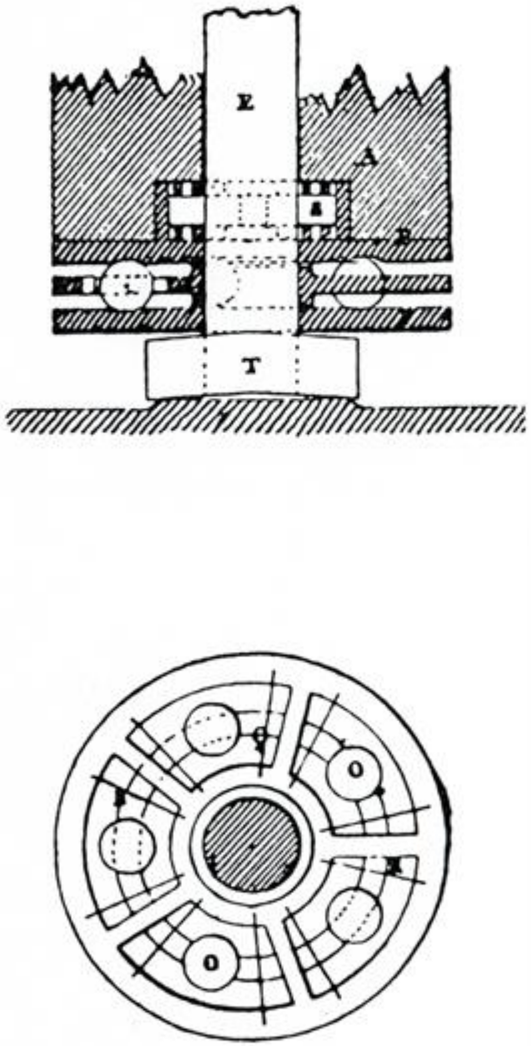


The diagram shows statistics of patents applications for bicycle bearings in England

This picture shows a drawing from a French patent of 1802.

Tapered roller
Thrust bearing
(koniskt
axialrullager)

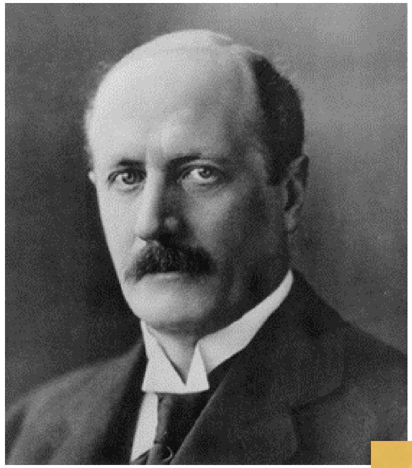


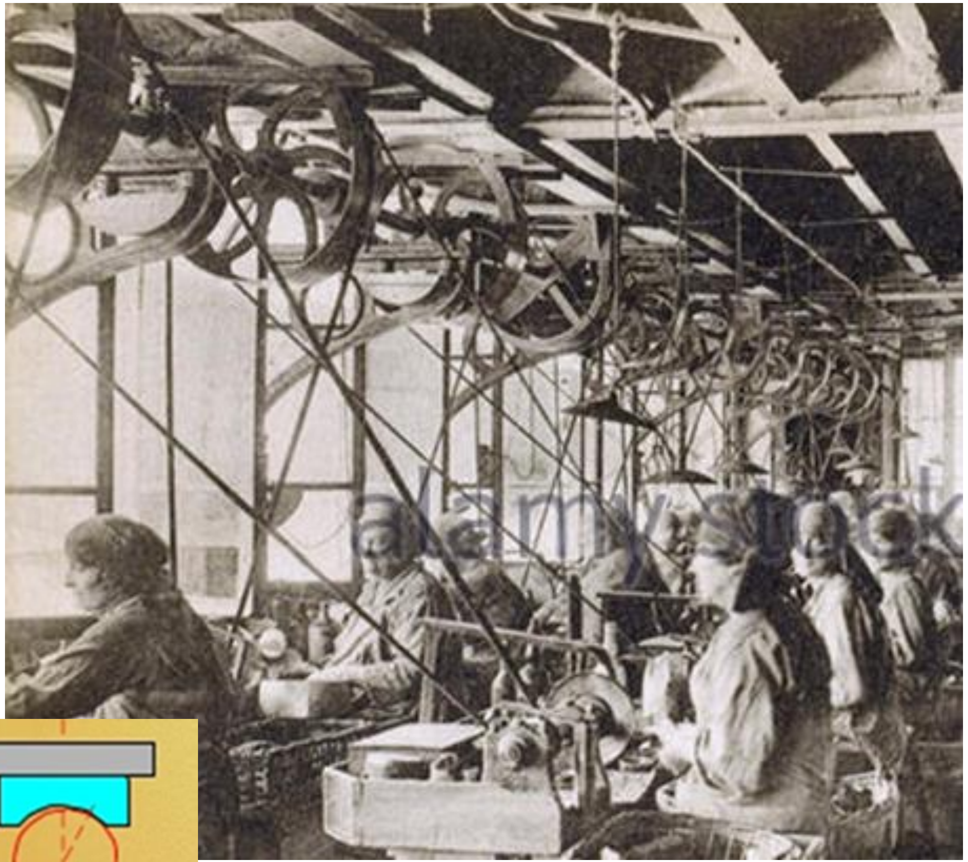


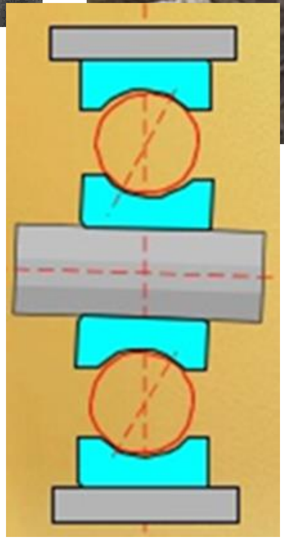
Thrust
ball bearing
(axialkullager)

Sven Wingquist and the Self-aligning ball bearing

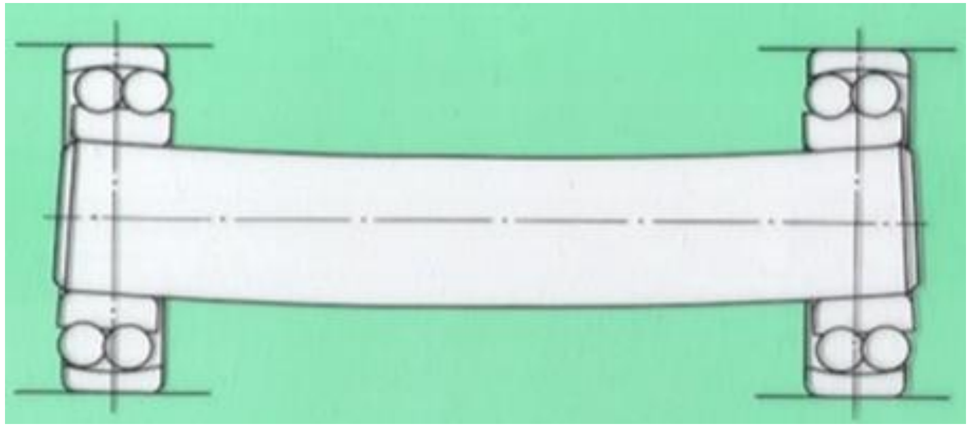
- Maintenance engineer at Gamelstadensfabriker
- Frequent failures in deep groove ball bearings
- Reason: misaligning of the shafts of belt transmissions
- Invented a new bearing to accept missaligning

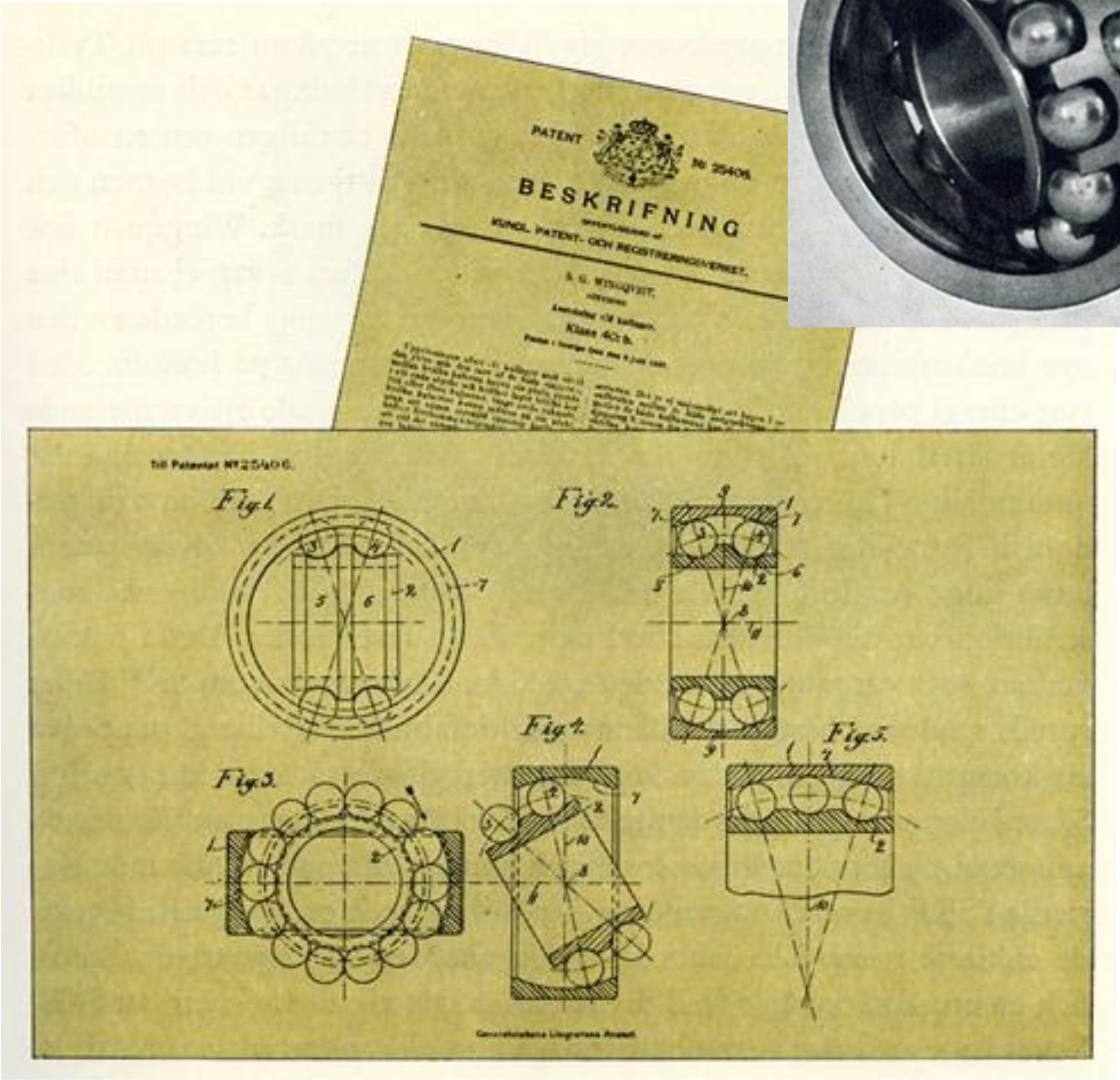


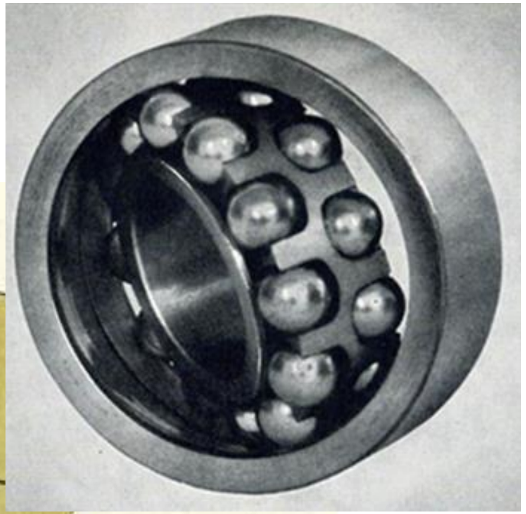




Drawing of the Swedish patent number 25406 from 1907 by Sven Wingquist.
Self-aligning ball bearing (Sfäriskt kullager)



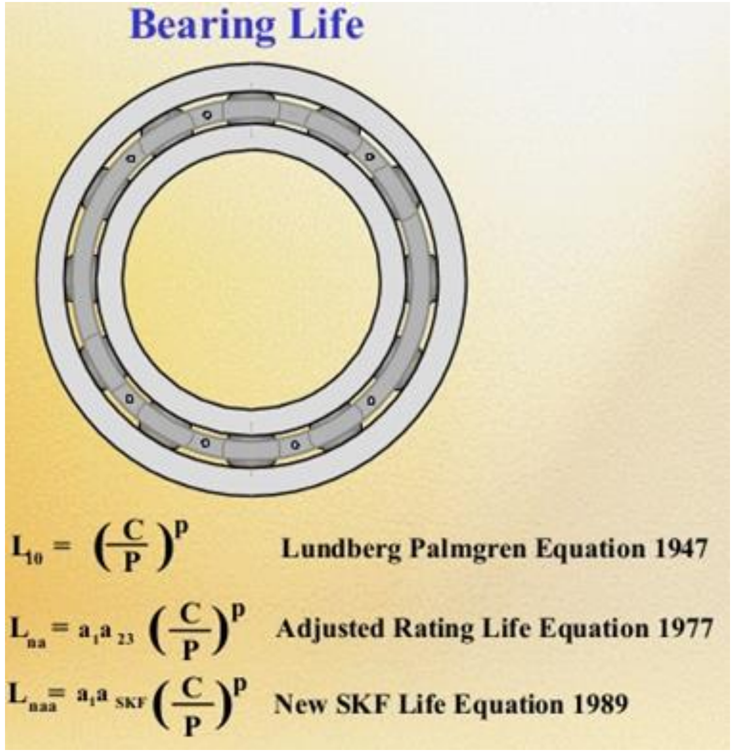


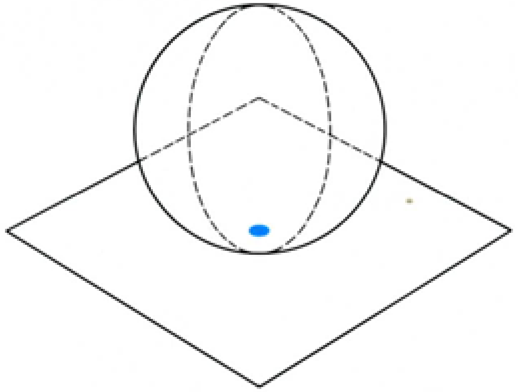


The Spherical roller bearing

- Development period: from 1919 to 1935
- Invented by Arvid Palmgren
- SKF’s research budget was bigger the research budget of whole Royal Technical Institute in Stockholm
- SKF calculations theory become world standard in 1947. (developed by Palmgren and mathematic Prof. G. Lundberg from RTI)

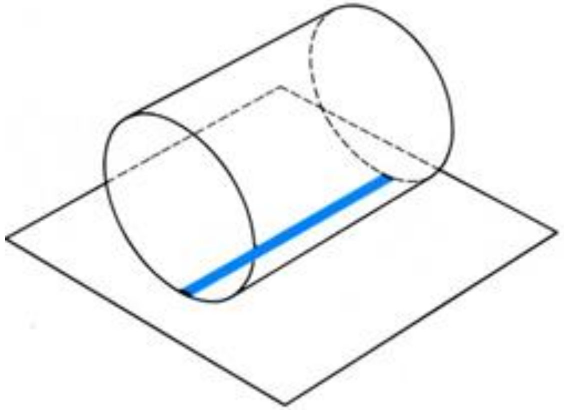
Arvid Palmgren

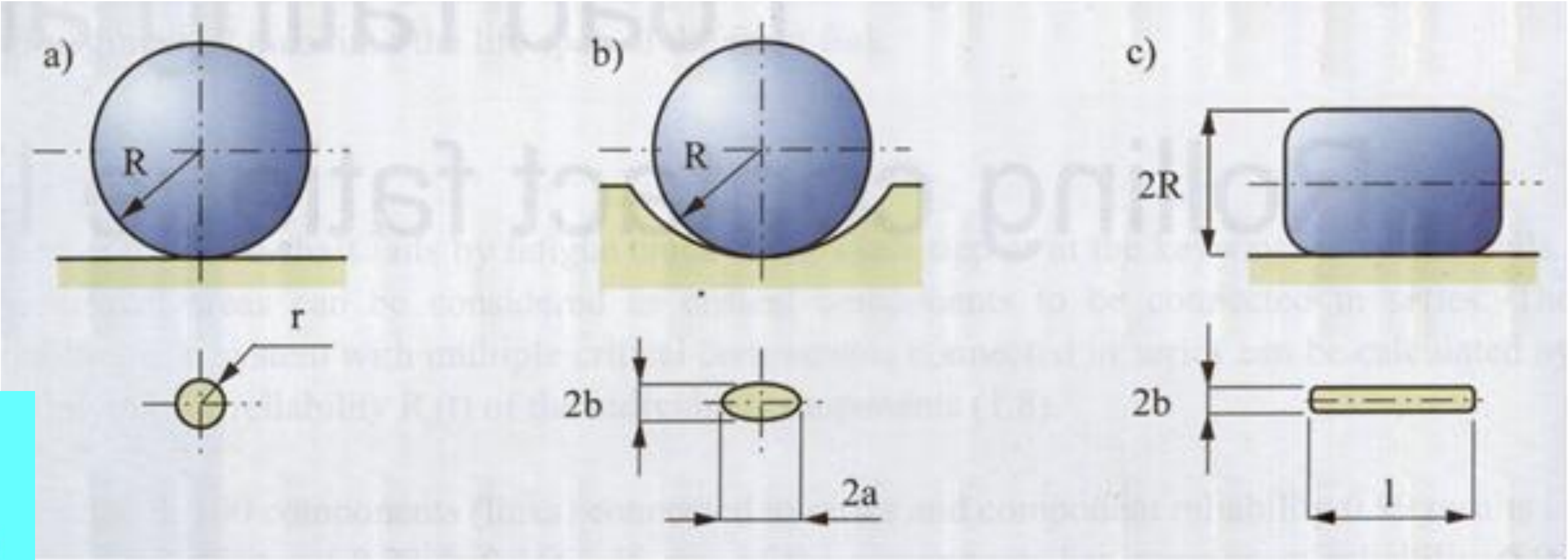


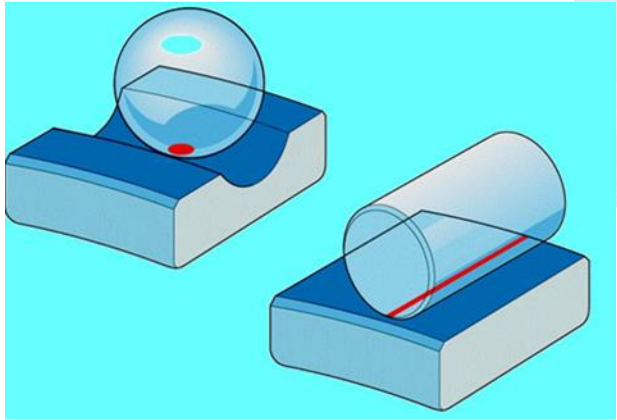


Bearings are divided in two groups dependent on rolling elements.

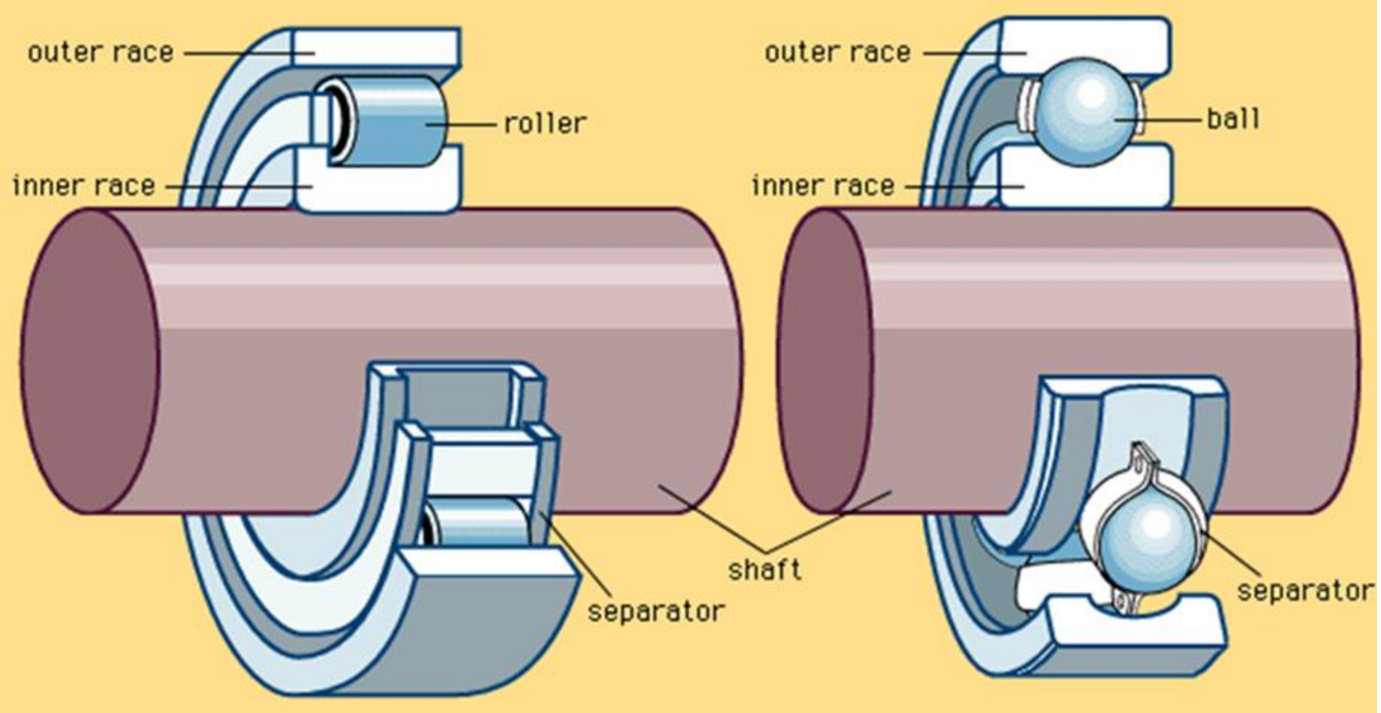
Ball Bearings & Roller Bearings

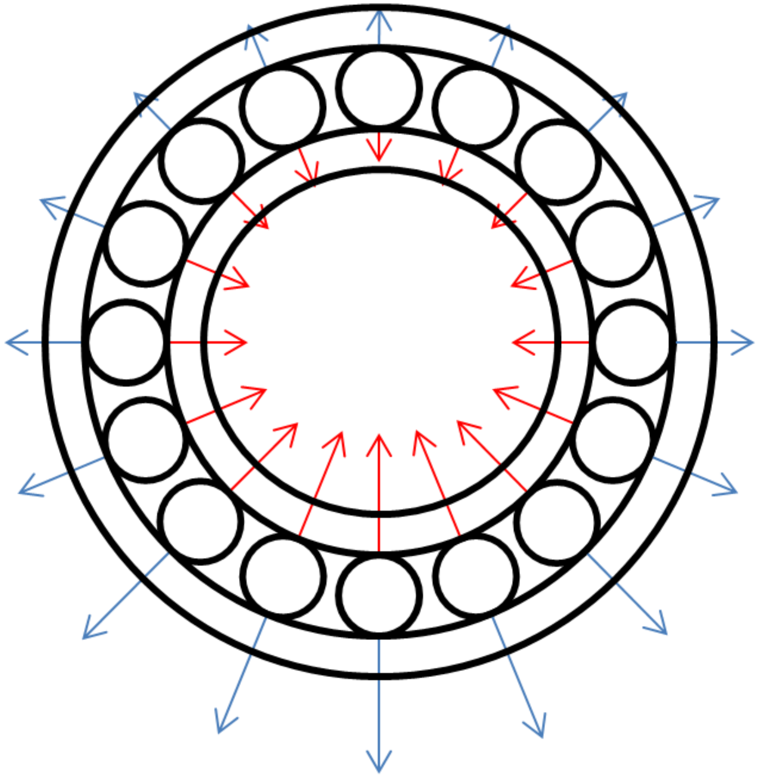


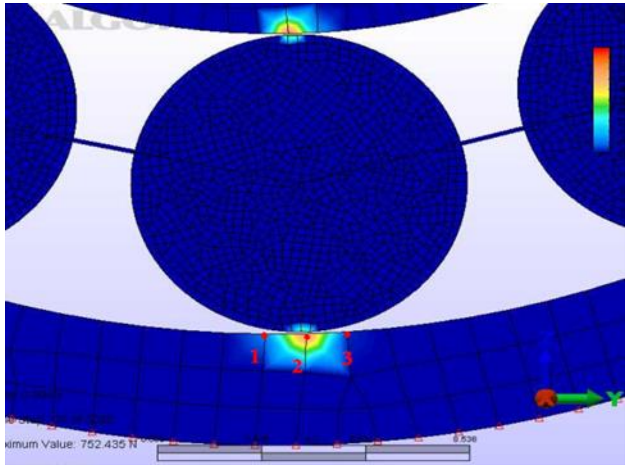




Stress concentration







Loads and bearing types

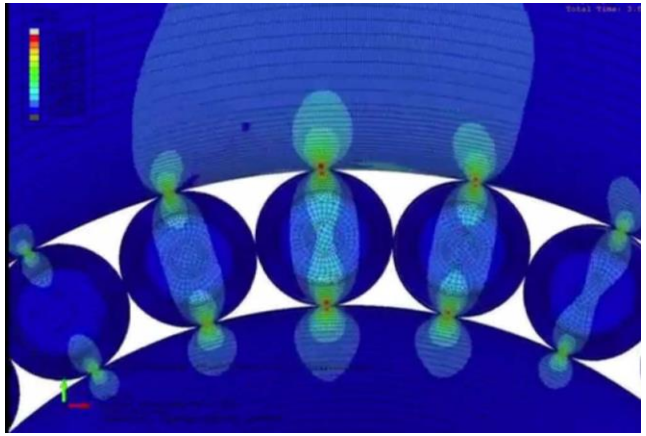
Maximum contact pressure

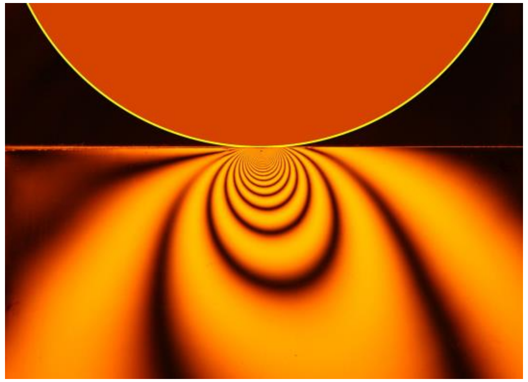
For two spheres

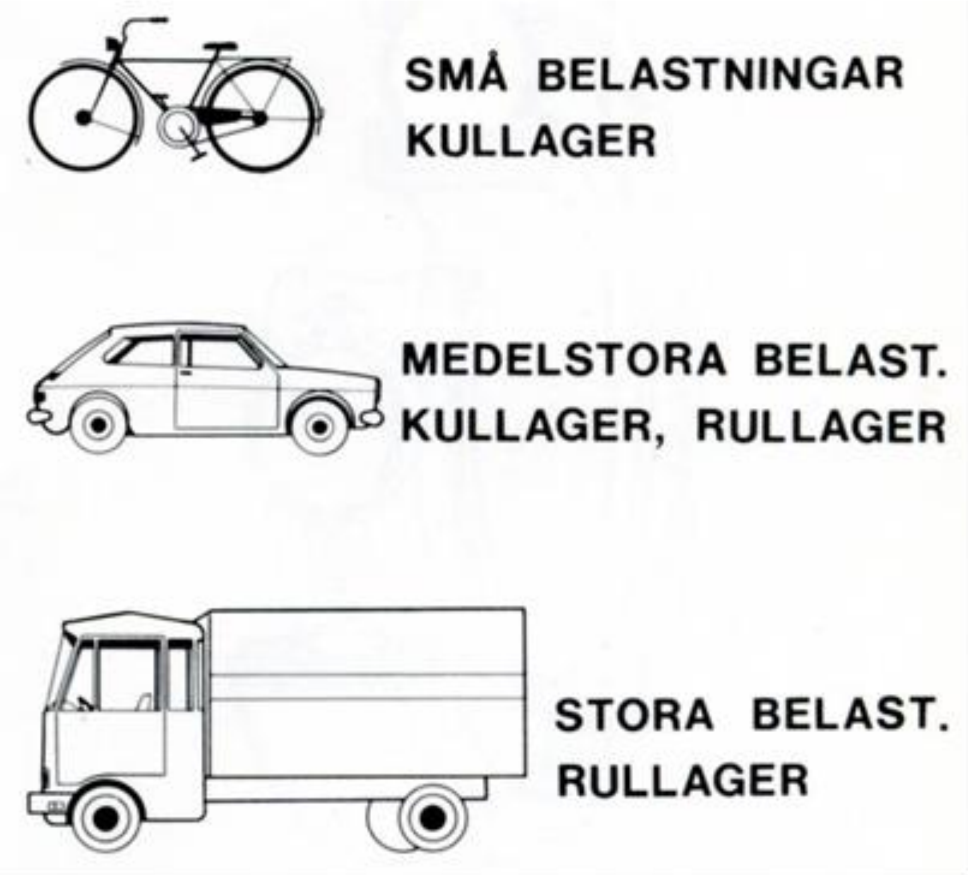
$$p_0 = 0{,}578 \cdot \sqrt[3]{\frac{F\left(\frac{1}{R_1} + \frac{1}{R_2}\right)^2}{\Delta^2}}$$

For two Cylinders

$$p_0 = 0{,}564 \cdot \sqrt{\frac{F\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}{L\Delta}}$$







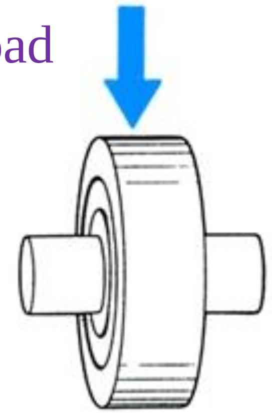
Low load
Ball bearings

Middle sized loads;
Ball or roller bearings

High load
Roller bearings

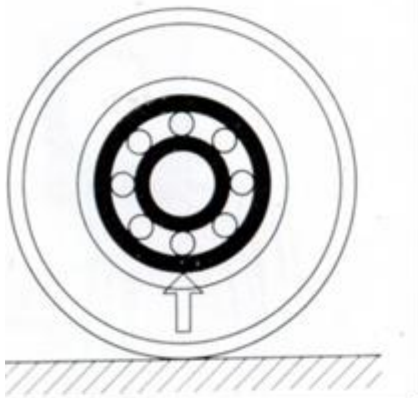
Bearings are also divided in two groups dependent on load direction.

Radial load

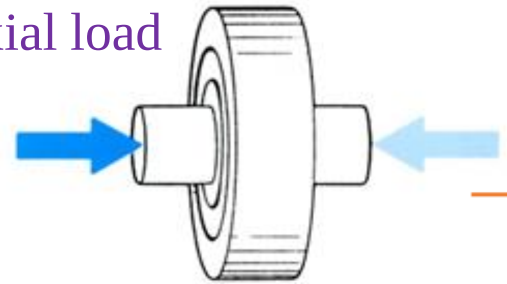


Radial bearings
(radiallager)

Example

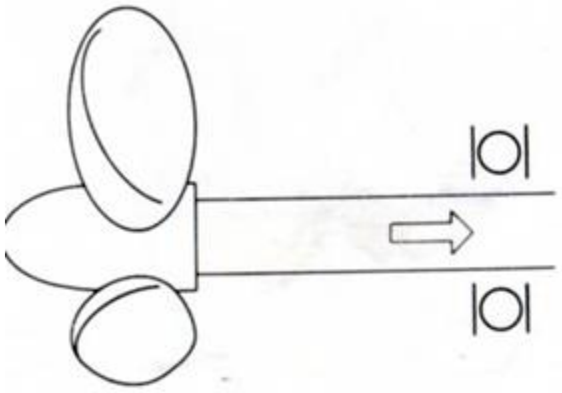


Axial load



Thrust bearings
(axiallager)

Example



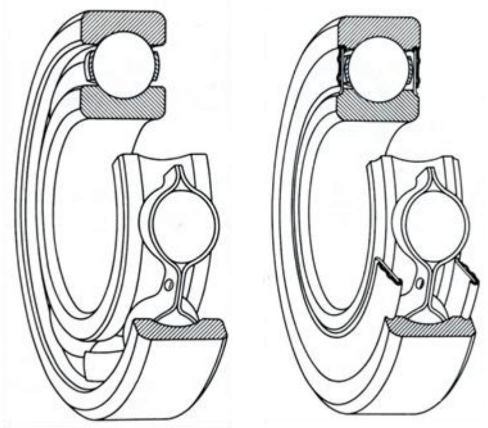
Three groups of Rolling Element Bearing (Rolling Bearings)

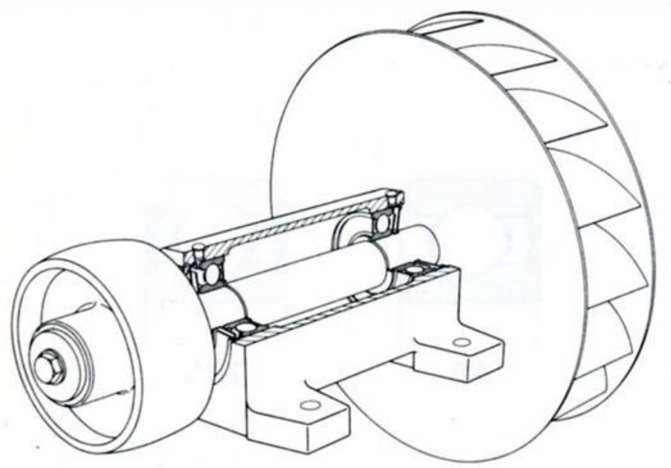
1. Radial Ball Bearings

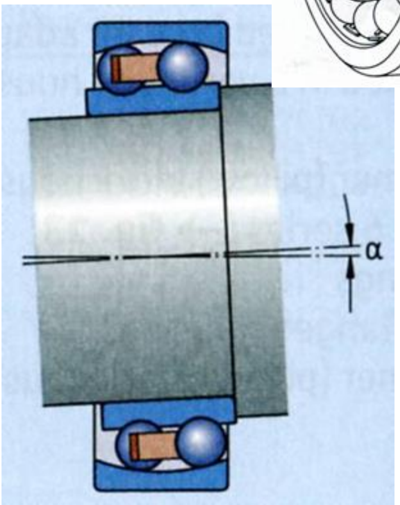
Deep groove ball bearing

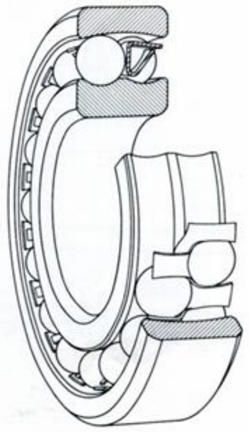
Self-aligning ball bearing

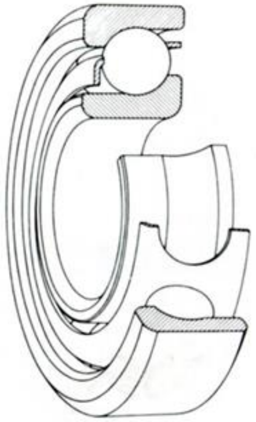
Angular contact ball bearing

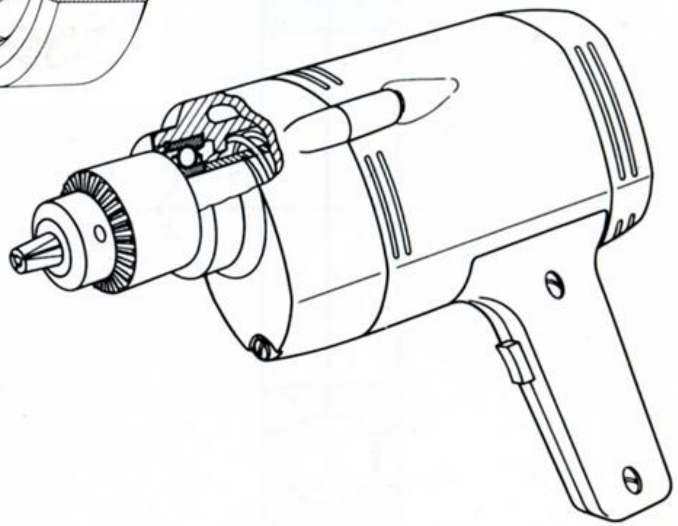






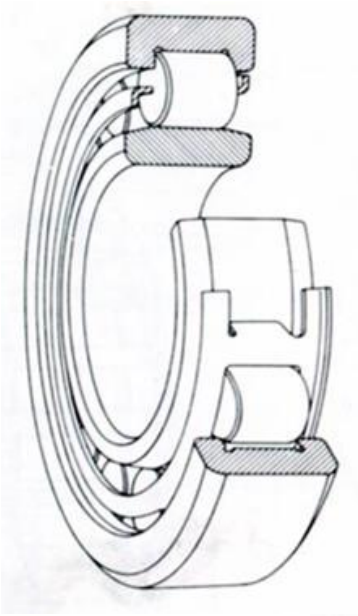


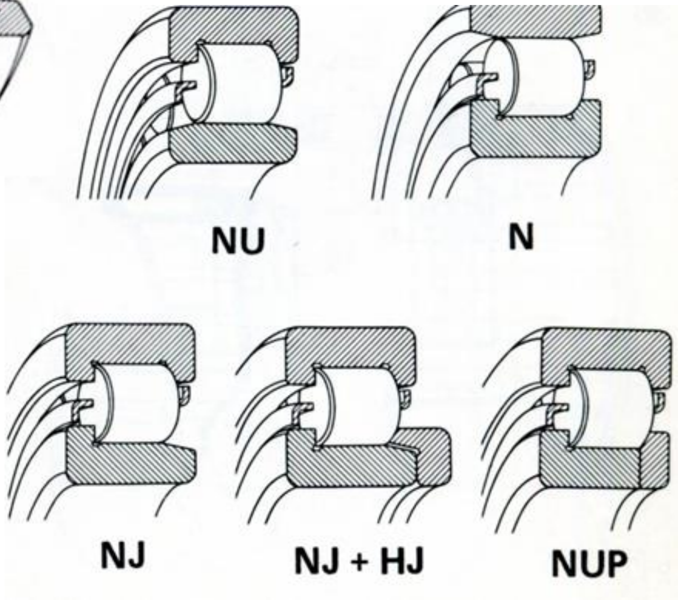


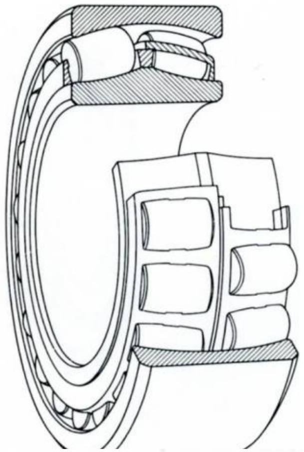


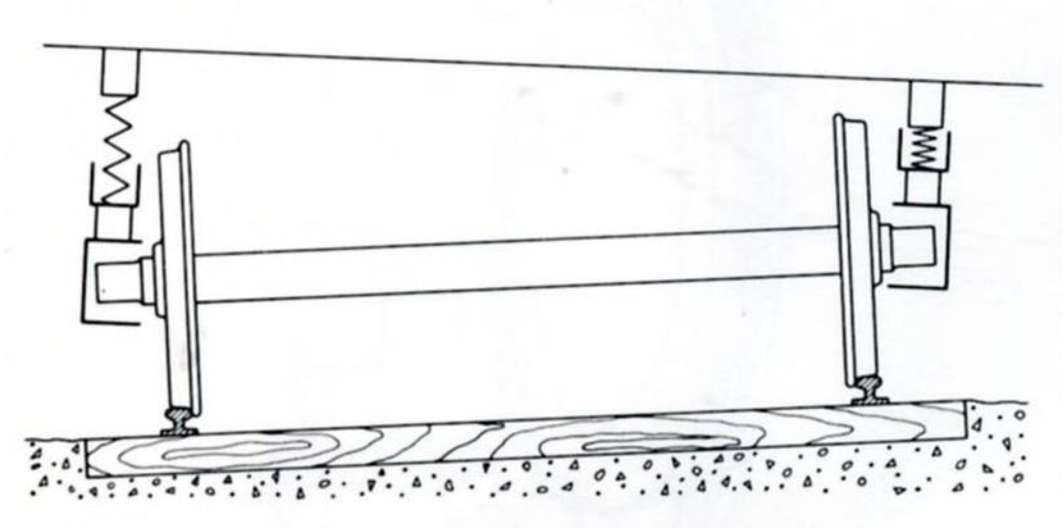
2. Radial Roller Bearings

Cylindrical Roller Bearing & Spherical Roller Bearing

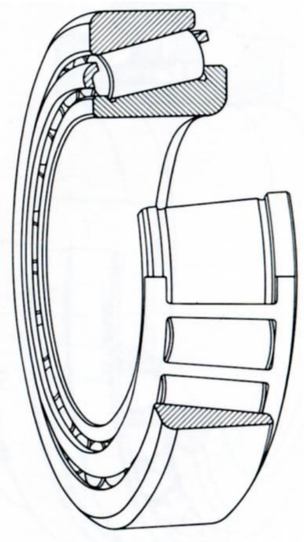


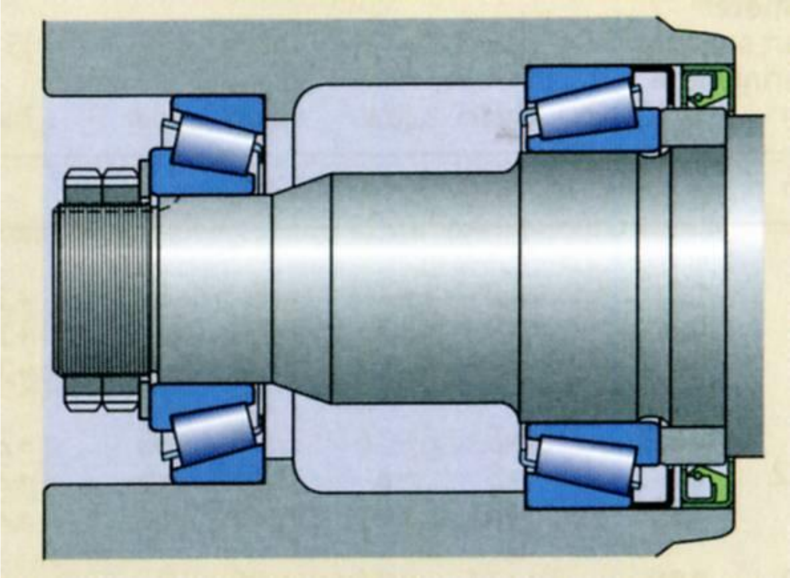


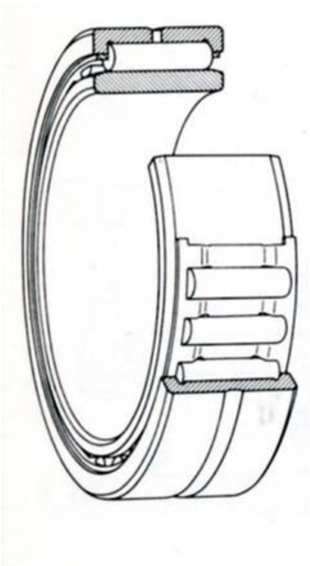


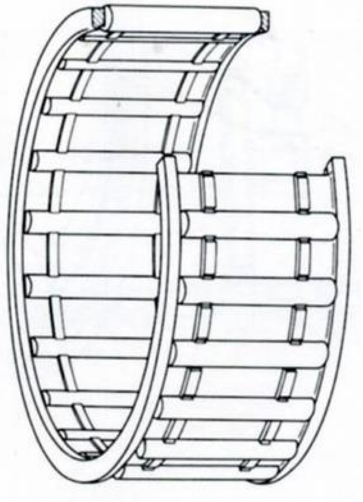


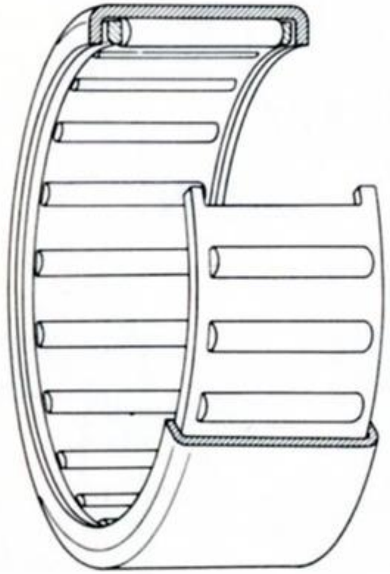
Tapered Roller Bearing & Needle Roller Bearing





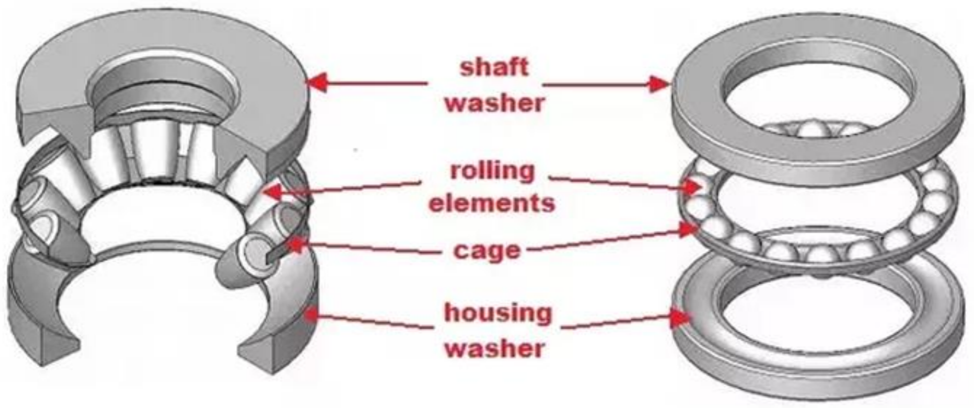


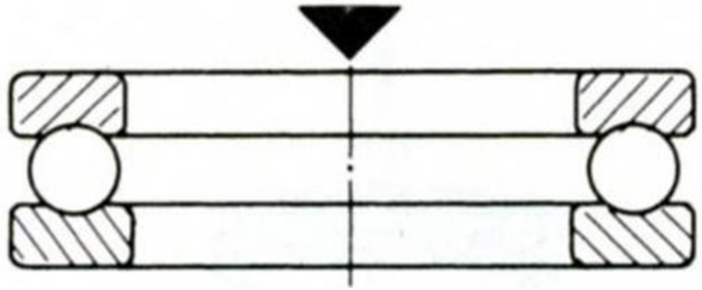


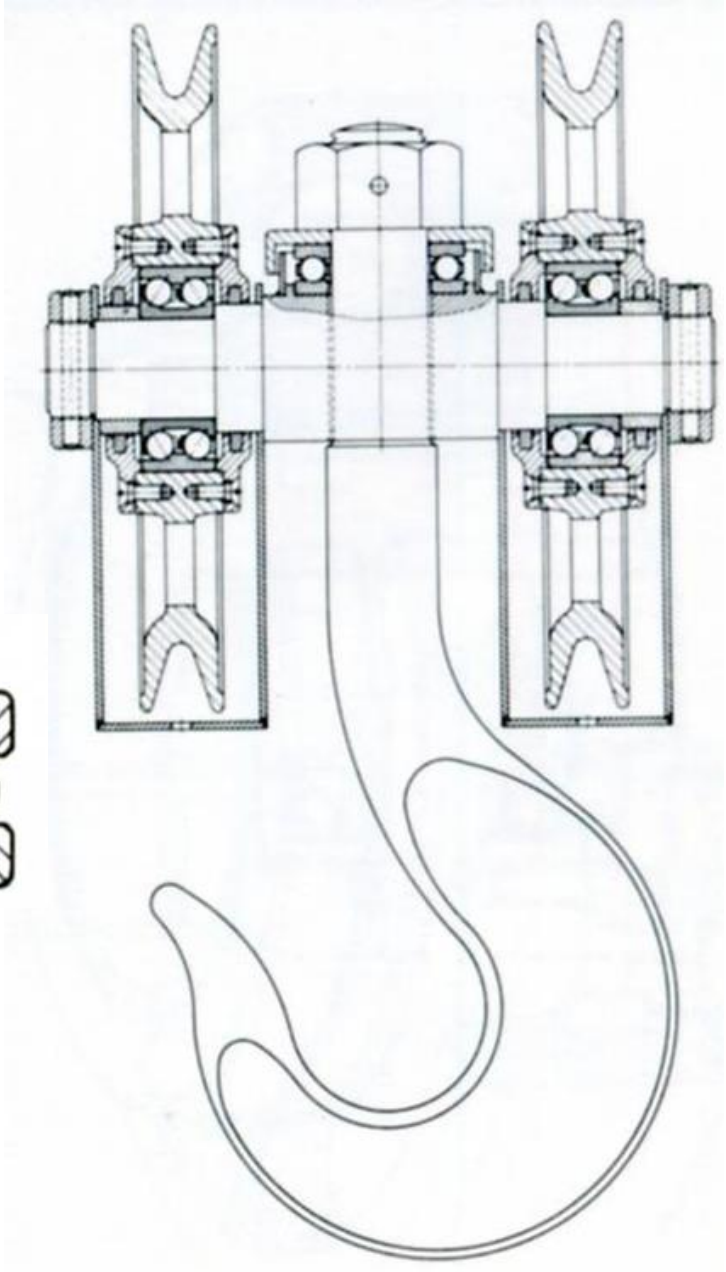


3. Thrust (axial) Bearings

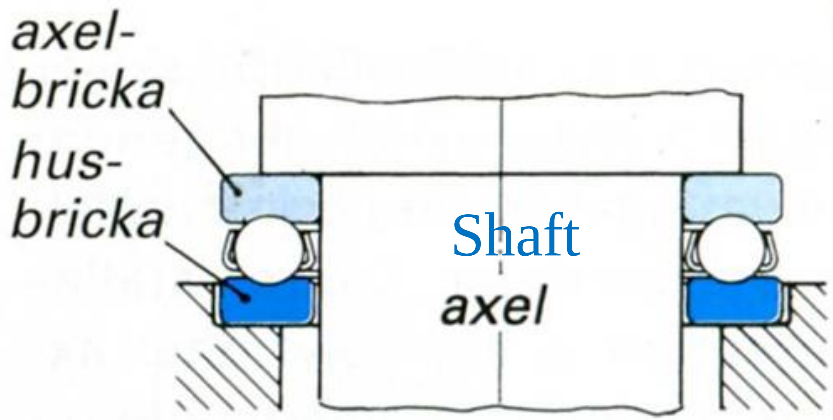
Shaft washer, Housing washer, Rolling element, and cage



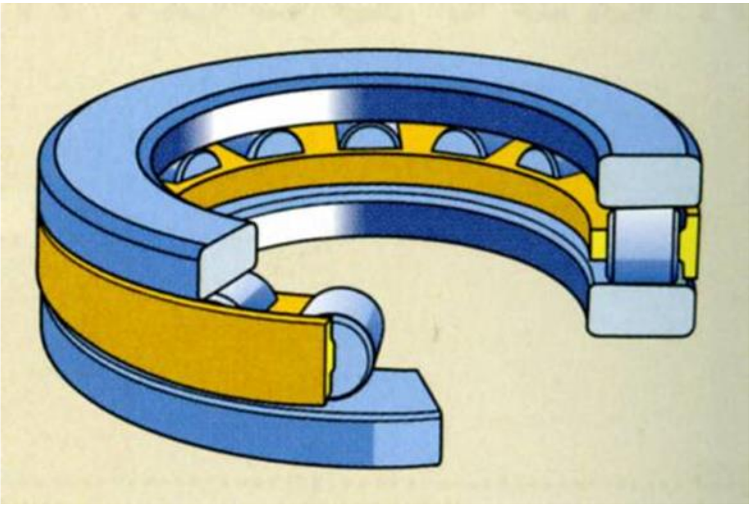


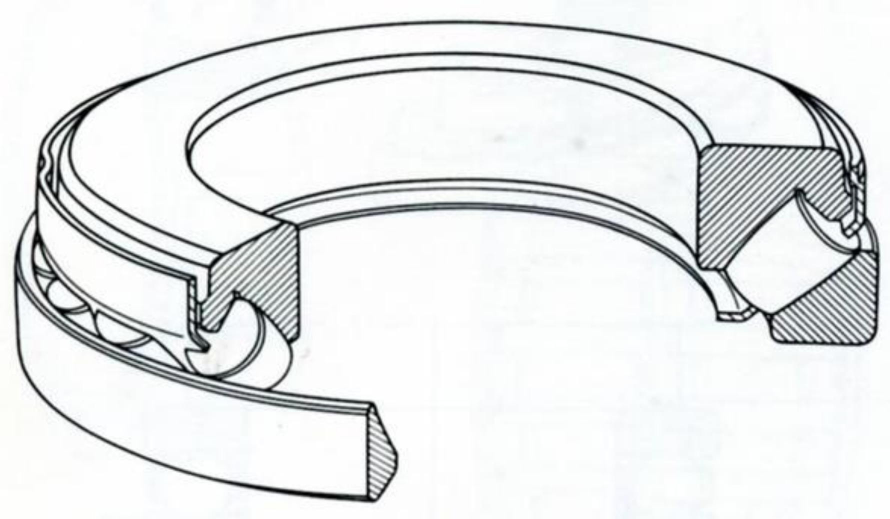


Shaft
washer
Housing
washer

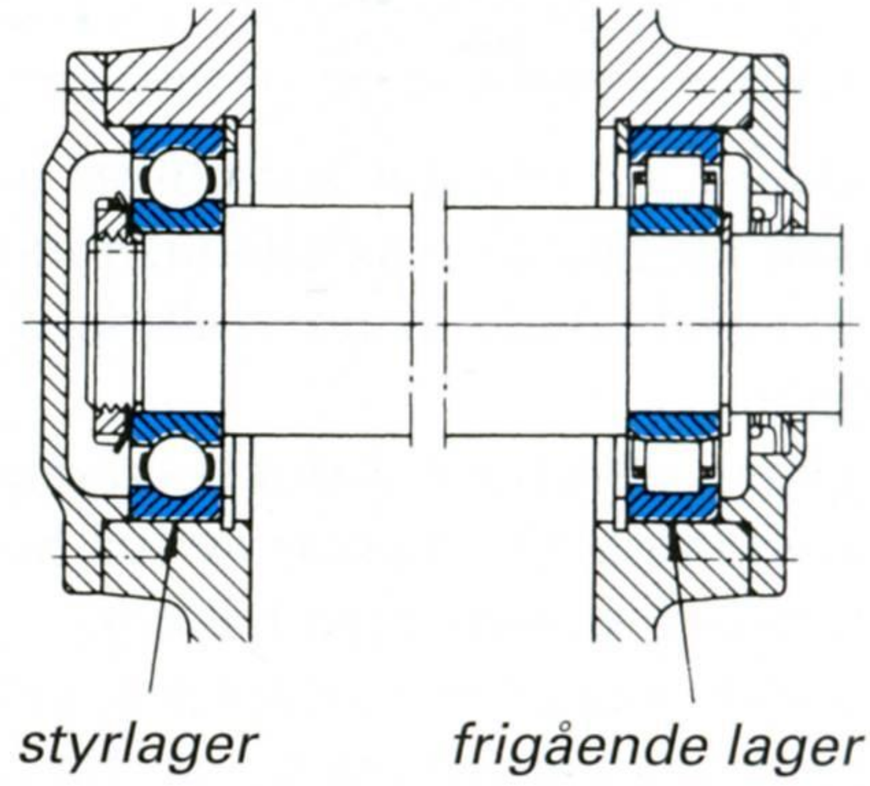


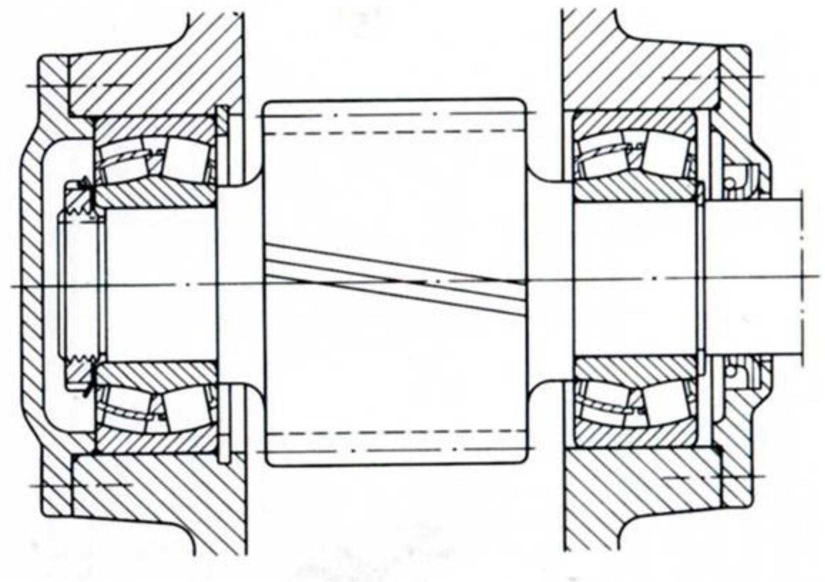
Thrust ball bearing, Cylindrical roller thrust bearing & Spherical roller thrust bearing

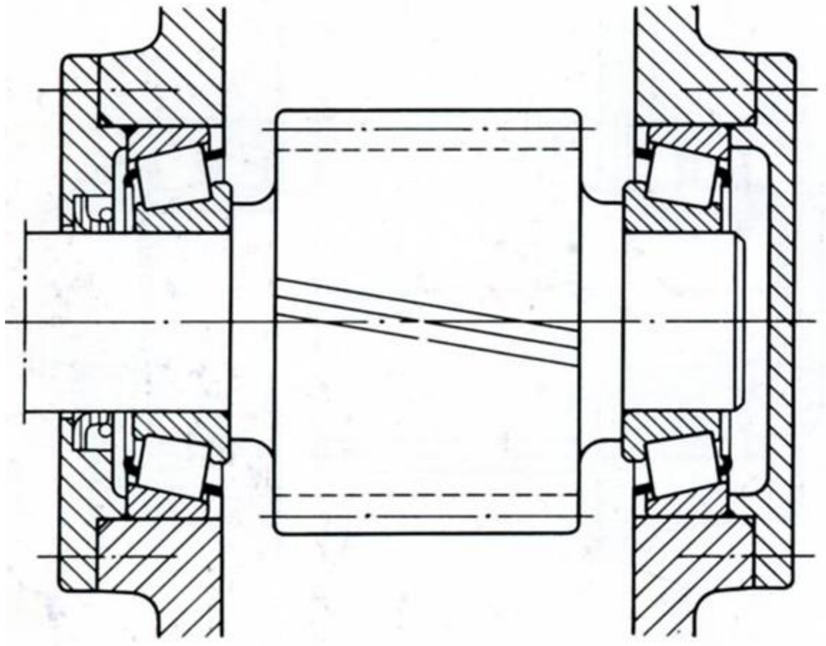




Use of bearings

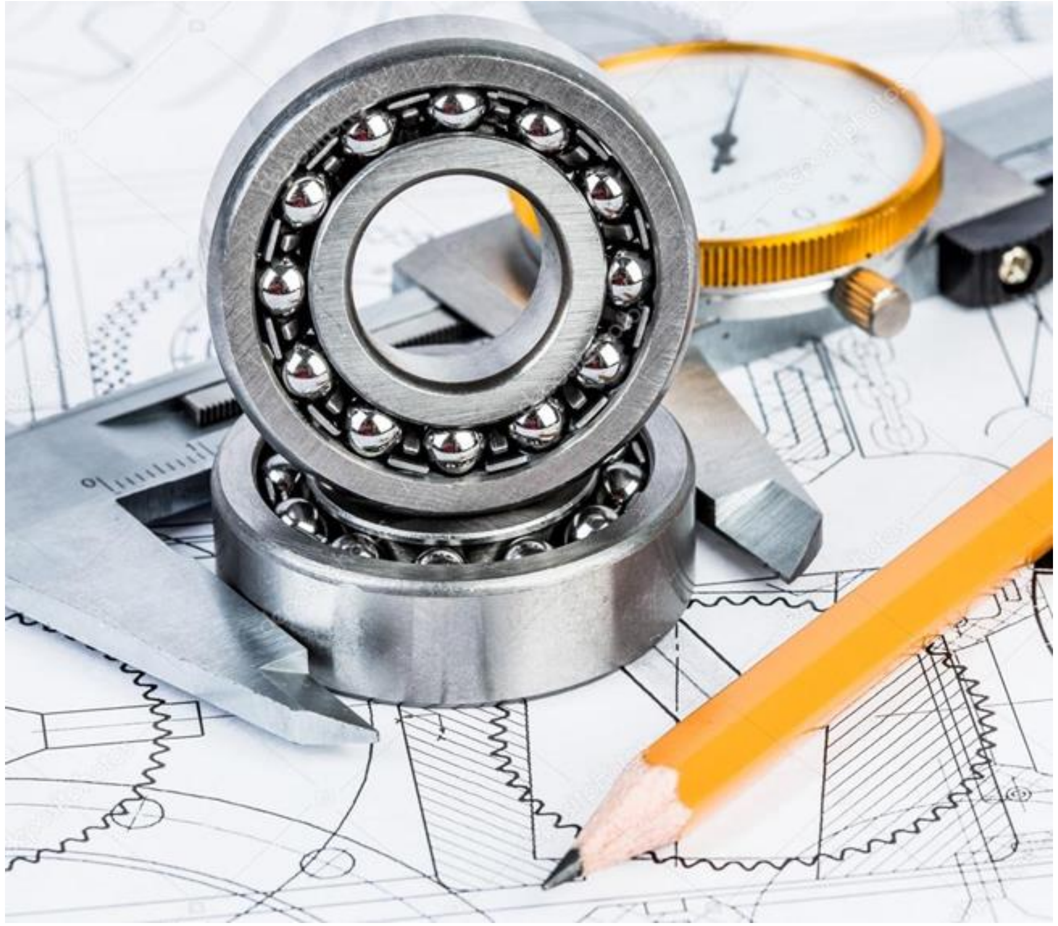






Selecting bearing size using the life equations

(SKF p. 64-65)



1. Basic rating life (p. 64):

$$L_{10} = \left(\frac{C}{P}\right)^p \quad \text{or} \quad L_{10} = \frac{1000000}{60 \cdot n}\left(\frac{C}{P}\right)^p$$

$$L_{10h} = \frac{1\,000\,000}{60\ n}\left(\frac{C}{P}\right)^p$$ **Lundberg Palmgren Equation 1947**

L_{10} = basic rating life (at 90% reliability),
millions of revolutions

L_{10h} = basic rating life (at 90% reliability),
operating hours

p = exponent of the life equation
p = 3 for ball bearings
p = 10/3 for roller bearings

n = rotational speed, rpm

1. SKF rating life (p. 65):

a_1 = life adjustment factor for reliability (table 1, p. 65)

$$L_{nm} = a_1 \cdot a_{SKF} \left(\frac{C}{P} \right)^p$$

$$L_{nmh} = a_1 \cdot a_{SKF} \frac{1000000}{60 \cdot n} \left(\frac{C}{P} \right)^p$$

L_{nm} = SKF rating life (at 100-n% reliability), millions of revolutions

L_{nmh} = SKF rating life (at 100-n% reliability), operating hours

p = exponent of the life equation
- p = 3 for ball bearings
- p = 10/3 for roller bearings

n = rotational speed, rpm

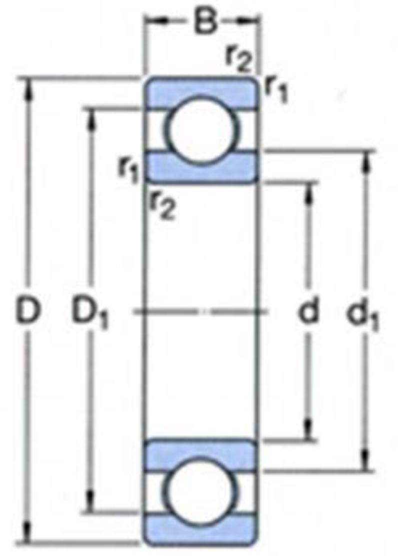
Table 1

Values for life adjustment factor a_1

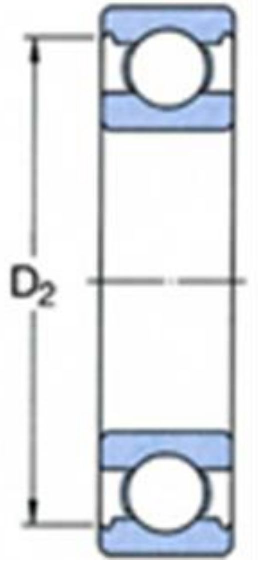
Reliability	Failure probability n	SKF rating life L_{nm}	Factor a_1
%	%	million revolutions	–
90	10	L_{10m}	1
95	5	L_{5m}	0,64
96	4	L_{4m}	0,55
97	3	L_{3m}	0,47
98	2	L_{2m}	0,37
99	1	L_{1m}	0,25

C = basic dynamic load rating, kN.

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed[1)]	Mass	Designations Bearing capped on both sides	one side
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
45	85	19	32,5	20,4	0,865	18 000	10 000	0,43	E2.6209-2Z	–
cont.	85	19	35,1	21,6	0,915	17 000	8 500	0,43	* 6209-2Z	* 6209-Z
	85	19	35,1	21,6	0,915	–	5 000	0,43	* 6209-2RS1	* 6209-RS1
	85	23	33,2	21,6	0,915	–	5 000	0,51	62209-2RS1	–

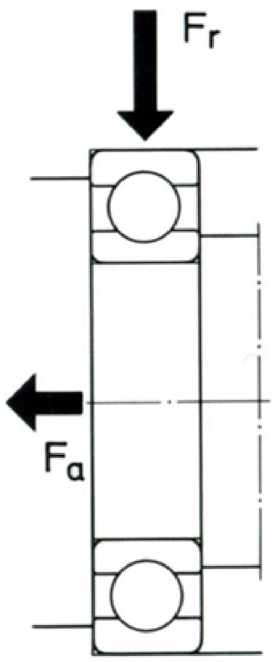


Dimensions				Abutment and fillet dimensions				Calculation factors	
d	d_1 ~	D_2 ~	$r_{1,2}$ min.	d_a min.	d_a max.	D_a max.	r_a max.	k_r	f_0
mm				mm				–	
45	57,6	75,2	1,1	52	57,5	78	1	0,025	14
cont.	57,6	75,2	1,1	52	57,5	78	1	0,025	14
	57,6	75,2	1,1	52	57,5	78	1	0,025	14
	57,6	75,2	1,1	52	57,5	78	1	0,025	14

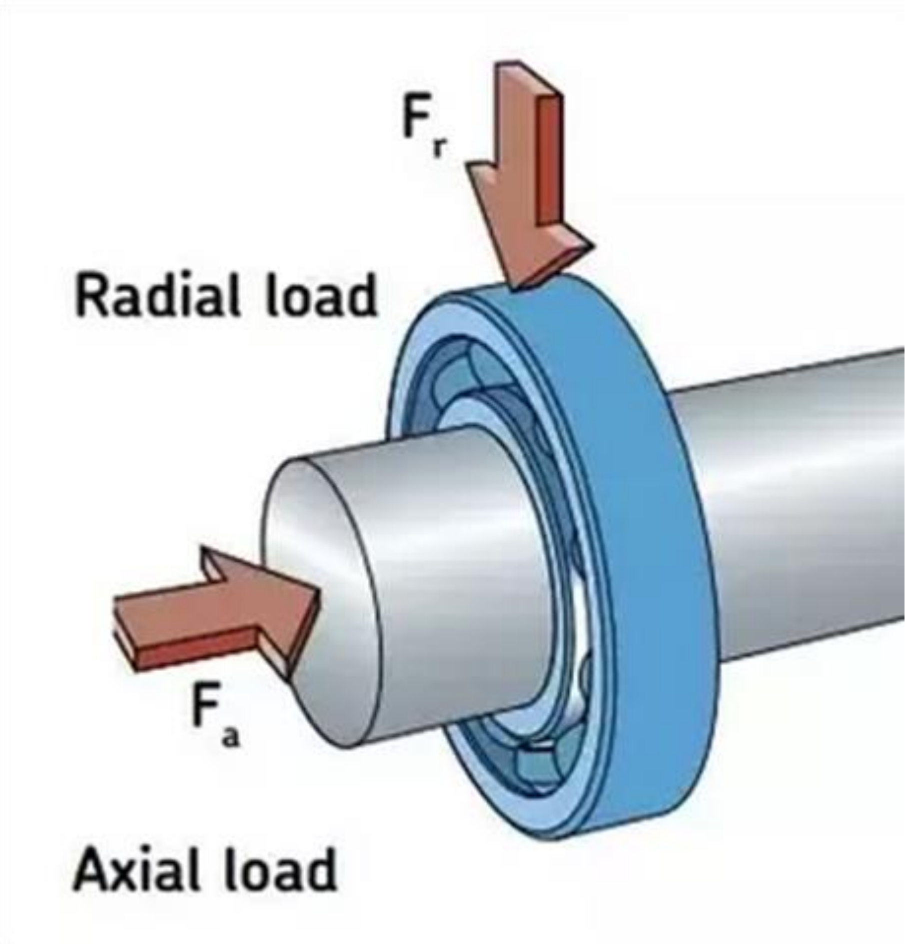


P = equivalent dynamic bearing load, kN

$$P = XF_r + YF_a$$



F_r = actual radial bearing load, N
F_a = actual axial bearing load, N
X = radial load factor
Y = axial load factor

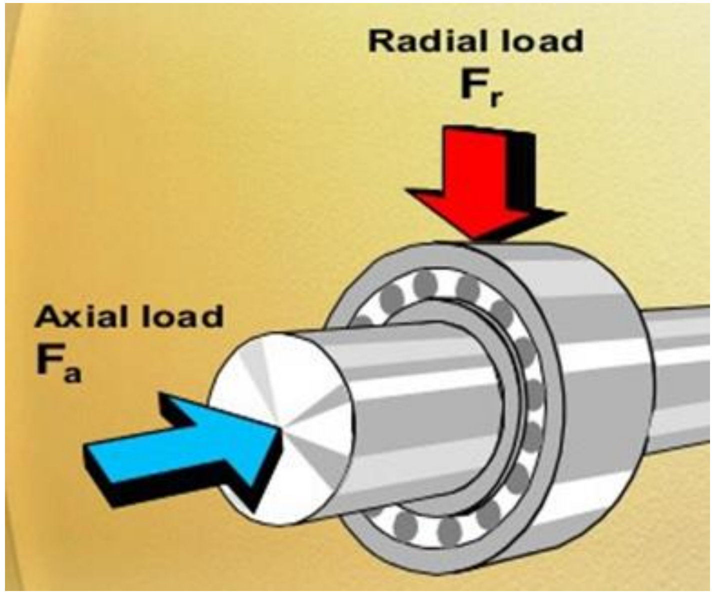


There are different equations to calculate the equivalent dynamic bearing load

Example: Self-aligning ball bearing (SKF p. 544)

Equivalent dynamic bearing load	
	$F_a/F_r \le e \rightarrow P = F_r + Y_1 F_a$
	$F_a/F_r > e \rightarrow P = 0{,}65\, F_r + Y_2 F_a$

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designations Bearing with cylindrical bore	tapered bore
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	–	
35	72	17	19	6	0,31	20 000	13 000	0,32	1207 ETN9	1207 EKTN9
	72	23	30,2	8,8	0,455	18 000	12 000	0,4	2207 ETN9	2207 EKTN9
	80	21	26,5	8,5	0,43	16 000	11 000	0,51	1307 ETN9	1307 EKTN9
	80	31	39,7	11,2	0,59	16 000	12 000	0,68	2307 ETN9	2307 EKTN9



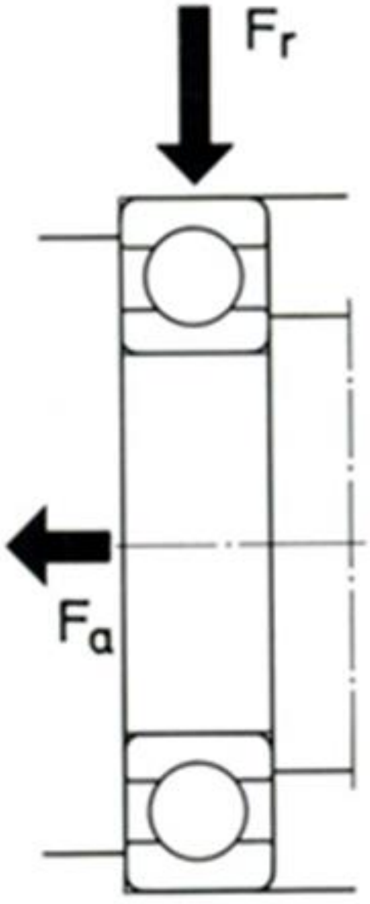
Dimensions				Abutment and fillet dimensions			Calculation factors				
d	d_2 ~	D_1 ~	$r_{1,2}$ min.	d_a min.	D_a max.	r_a max.	k_r	e	Y_1	Y_2	Y_0
mm				mm			–				
35	47	62,3	1,1	42	65	1,1	0,04	0,23	2,7	4,2	2,8
	45,3	64,2	1,1	42	65	1,1	0,045	0,31	2	3,1	2,2
	51,5	69,5	1,5	44	71	1,5	0,04	0,25	2,5	3,9	2,5
	46,5	68,4	1,5	44	71	1,5	0,05	0,46	1,35	2,1	1,4

Sample problem:

A deep groove ball bearing, SKF 6214, with normal clearance is loaded by a radial load F_r = 7000 N and an axial load F_a = 2000 N. Calculate the operating life according to SKF´s rating life equation for:

a. Sealed bearing
b. Unsealed bearings.

The rotational speed is 1250 rpm. For the unsealed bearing use SKF lubricating grease LGMT 2. The degree of contamination η_c is estimated to 0,2. The operating temperature is estimated to 55°C in both cases.



F_r = 7000 N,
F_a = 2000 N,
n = 1250 rpm

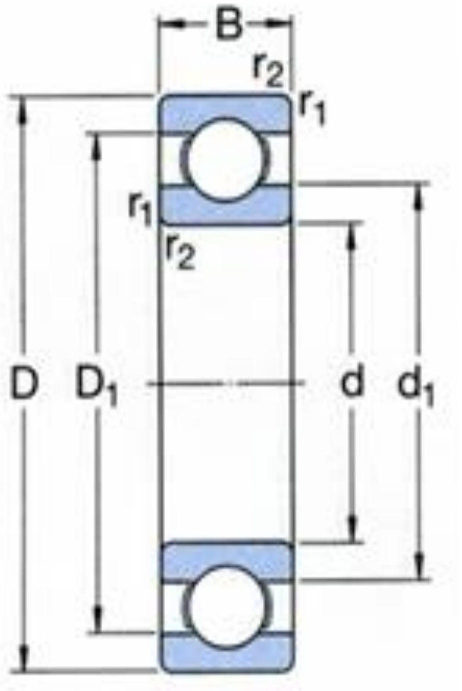
t = 55°C

Unsealed bearing: use SKF lubricating grease LGMT 2

$\eta_c = 0{,}2$

SKF 6214 (SKF p. 330)

Principal dimensions			Basic load ratings dynamic	static	Fatigue load limit	Speed ratings Reference speed	Limiting speed	Mass	Designation
d	D	B	C	C_0	P_u				
mm			kN		kN	r/min		kg	–
60	78	10	11,9	11,4	0,49	17 000	11 000	0,11	61812
	85	13	16,5	14,3	0,6	16 000	10 000	0,2	61912
	95	11	20,8	15	0,735	15 000	9 500	0,29	* 16012
	95	18	30,7	23,2	0,98	15 000	9 500	0,41	* 6012
	110	22	55,3	36	1,53	13 000	8 000	0,78	* 6212
	130	31	85,2	52	2,2	11 000	7 000	1,7	* 6312
	150	35	108	69,5	2,9	10 000	6 300	2,85	6412
65	85	10	12,4	12,7	0,54	16 000	10 000	0,13	61813
	90	13	17,4	16	0,68	15 000	9 500	0,22	61913
	100	11	22,5	19,6	0,83	14 000	9 000	0,3	* 16013
	100	18	31,9	25	1,06	14 000	9 000	0,44	* 6013
	120	23	58,5	40,5	1,73	12 000	7 500	1	* 6213
	140	33	97,5	60	2,5	10 000	6 700	2,1	* 6313
	160	37	119	78	3,15	9 500	6 000	3,35	6413
70	90	10	12,4	13,2	0,56	15 000	9 000	0,14	61814
	100	16	23,8	21,2	0,9	14 000	8 500	0,35	61914
	110	13	29,1	25	1,06	13 000	8 000	0,44	* 16014
	110	20	39,7	31	1,32	13 000	8 000	0,61	* 6014
	125	24	63,7	45	1,9	11 000	7 000	1,1	* 6214
	150	35	111	68	2,75	9 500	6 300	2,55	* 6314
	180	42	143	104	3,9	8 500	5 300	4,95	6414



$C = 63{,}7$ kN

$C_0 = 45$ kN

$P_u = 1{,}9$ kN

$d = 70$ mm

$D = 125$ mm

SKF 6214 (SKF p. 331)

Dimensions					Abutment and fillet dimensions			Calculation facto	
d	d_1 ~	D_1 ~	D_2 ~	$r_{1,2}$ min.	d_a min.	D_a max.	r_a max.	k_r	f_0
mm					mm			–	
60	65,6	72,4	–	0,3	62	76	0,3	0,015	17
	68,2	76,8	–	1	64,6	80,4	1	0,02	16
	72	83	–	0,6	63,2	91,8	0,6	0,02	14
	71,3	83,7	86,5	1,1	66	89	1	0,025	16
	75,5	94,6	98	1,5	69	101	1,5	0,025	14
	81,8	108	113	2,1	72	118	2	0,03	13
	88,1	122	–	2,1	74	136	2	0,035	12
65	71,6	78,4	–	0,6	68,2	81,8	0,6	0,015	17
	73,2	81,8	–	1	69,6	85,4	1	0,02	17
	76,5	88,4	–	0,6	68,2	96,8	0,6	0,02	16
	76,3	88,7	91,5	1,1	71	94	1	0,025	16
	83,3	103	106	1,5	74	111	1,5	0,025	15
	88,3	117	122	2,1	77	128	2	0,03	13
	94	131	–	2,1	79	146	2	0,035	12
70	76,6	83,4	–	0,6	73,2	86,8	0,6	0,015	17
	79,7	90,3	–	1	74,6	95,4	1	0,02	16
	83,3	96,8	–	0,6	73,2	106	0,6	0,02	16
	82,8	97,2	99,9	1,1	76	104	1	0,025	16
	87	108	111	1,5	79	116	1,5	0,025	15
	94,9	125	130	2,1	82	138	2	0,03	13
	103	146	–	3	86	164	2,5	0,035	12

$f_0 = 15$

P = equivalent dynamic bearing load, kN

(SKF p. 316)

Equivalent dynamic bearing load	
	$F_a/F_r \le e \rightarrow P = F_r$
	$F_a/F_r > e \rightarrow P = X F_r + Y F_a$

(SKF p. 315, normal clearance)

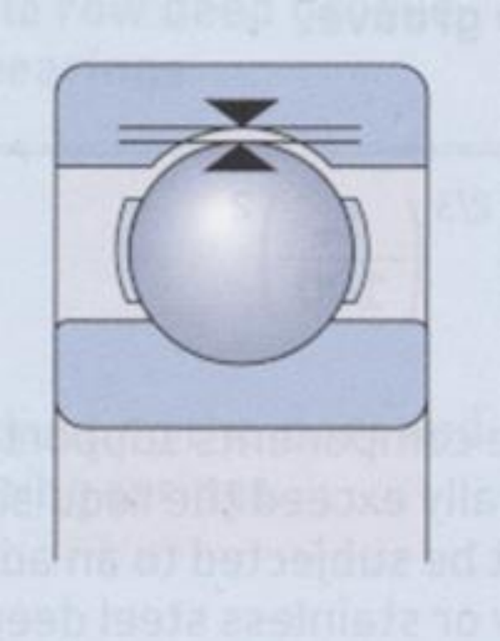


Table 8

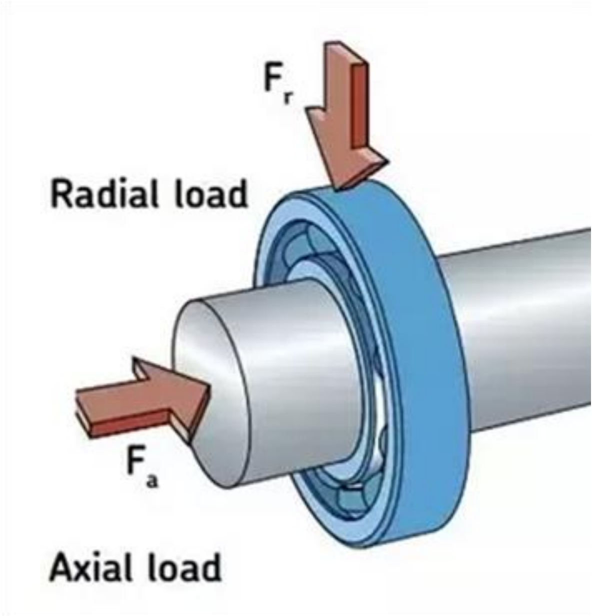
Calculation factors for deep groove ball bearings

$f_0 F_a/C_0$	Single row and double row bearings Normal clearance			Single row bearings C3 clearance			C4 clearance		
	e	X	Y	e	X	Y	e	X	Y
0,172	0,19	0,56	2,3	0,29	0,46	1,88	0,38	0,44	1,47
0,345	0,22	0,56	1,99	0,32	0,46	1,71	0,4	0,44	1,4
0,689	0,26	0,56	1,71	0,36	0,46	1,52	0,43	0,44	1,3
1,03	0,28	0,56	1,55	0,38	0,46	1,41	0,46	0,44	1,23
1,38	0,3	0,56	1,45	0,4	0,46	1,34	0,47	0,44	1,19
2,07	0,34	0,56	1,31	0,44	0,46	1,23	0,5	0,44	1,12
3,45	0,38	0,56	1,15	0,49	0,46	1,1	0,55	0,44	1,02
5,17	0,42	0,56	1,04	0,54	0,46	1,01	0,56	0,44	1
6,89	0,44	0,56	1	0,54	0,46	1	0,56	0,44	1

$f_0 F_a/C_0 = 15 \times 2000/45000 \approx 0{,}67 \quad \Rightarrow \quad \begin{cases} e \approx 0{,}26 \\ X = 0{,}56 \\ Y = 1{,}71 \end{cases}$

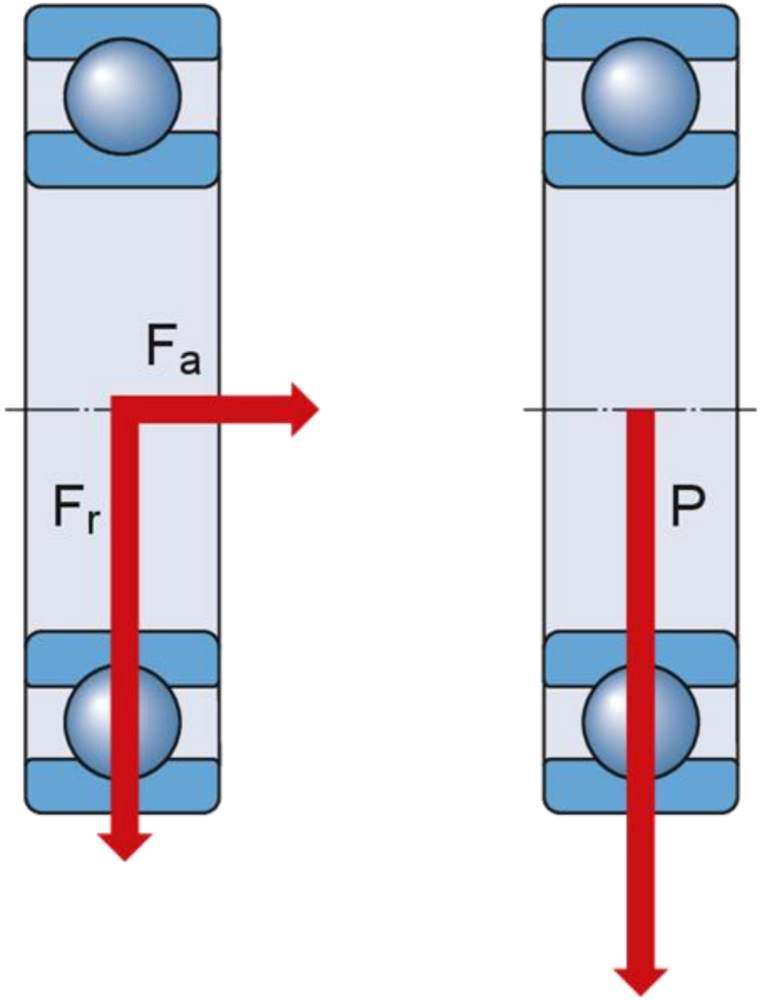
$F_a/F_r = 2000/7000 = 0{,}29$

$e \approx 0{,}26$



$F_a/F_r > e \Rightarrow P = XF_r + YF_a =$

$0{,}56 \cdot 7000 + 1{,}71 \cdot 2000 = 7340\ N$



$P = 7340\ N = 7{,}34\ kN$

a_{SKF} = SKF life modification factor

(diagram 1-4, SKF p. 66-69)

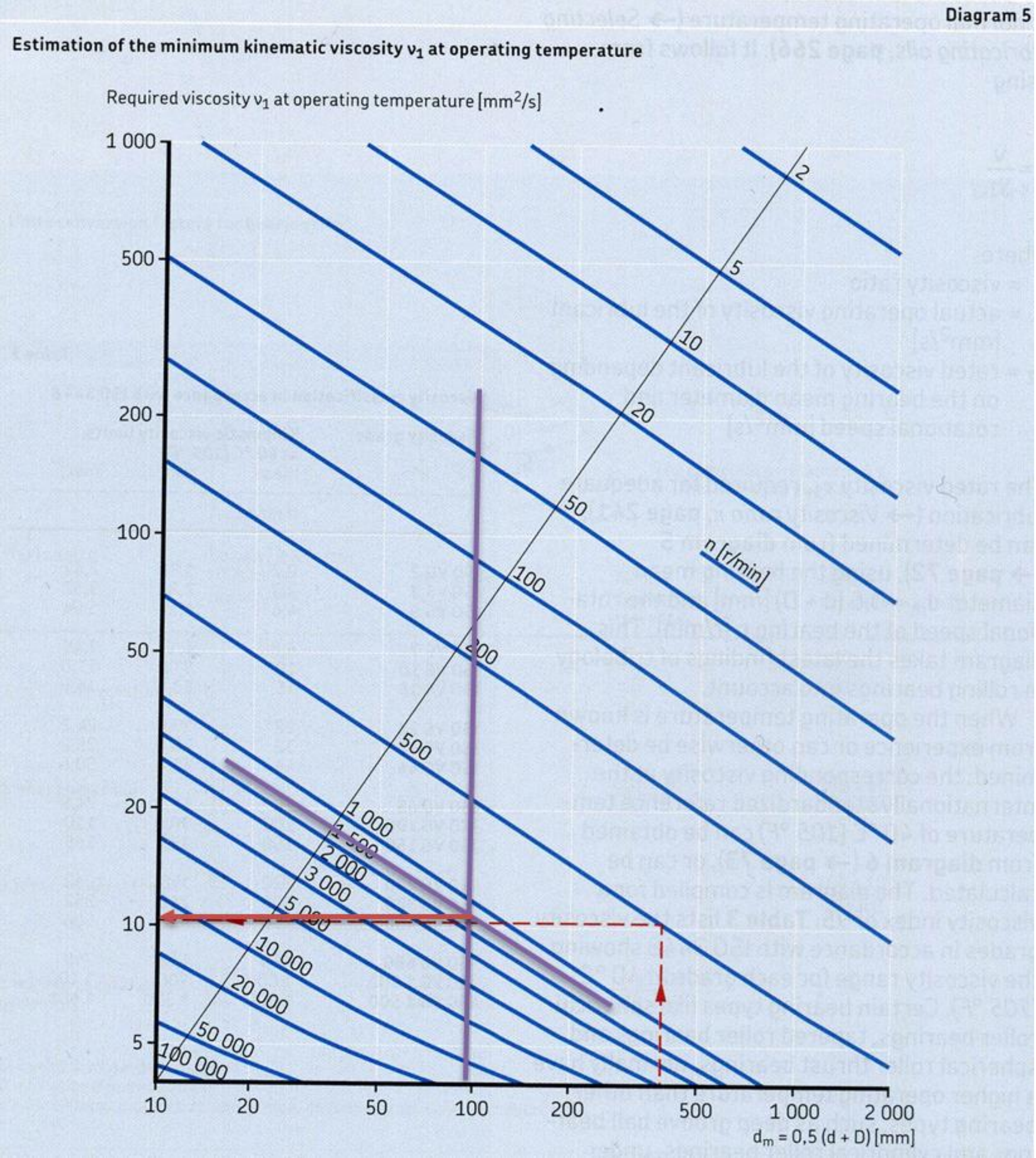
But first, we have to follow some steps:

Step 1: required kinematic Viscosity ν_1

(Diagram 5,SKF p.72)

$$d_m = (d+D)/2 = (70 + 125)/2$$

$$\left.\begin{array}{l} \text{or } d_m = 97{,}5 \text{ mm} \\ n = 1250 \text{ rpm} \end{array}\right\} \Rightarrow \nu_1 \approx 11 \text{ mm}^2/\text{s}$$

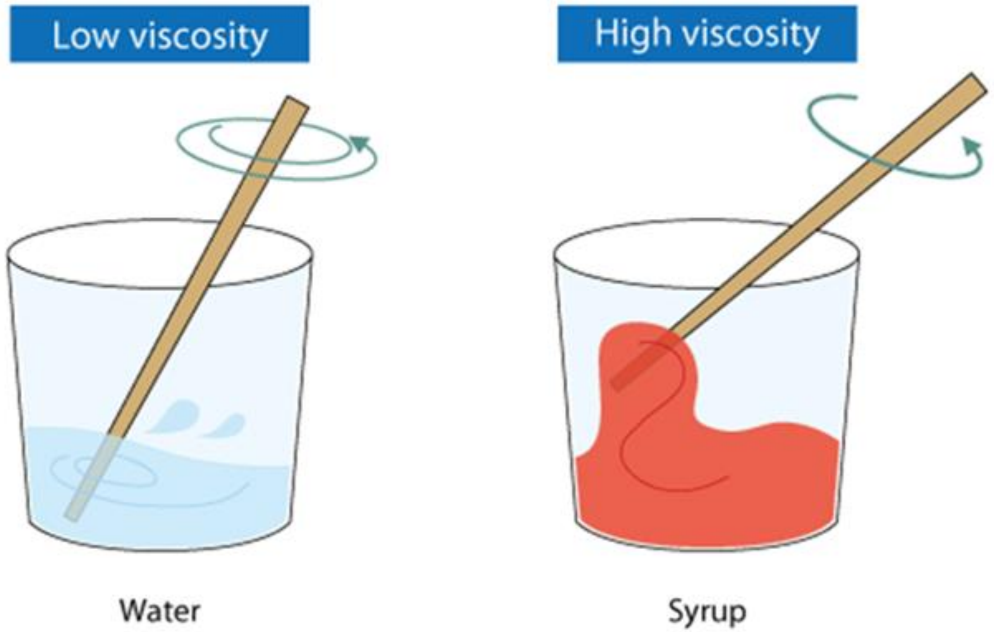


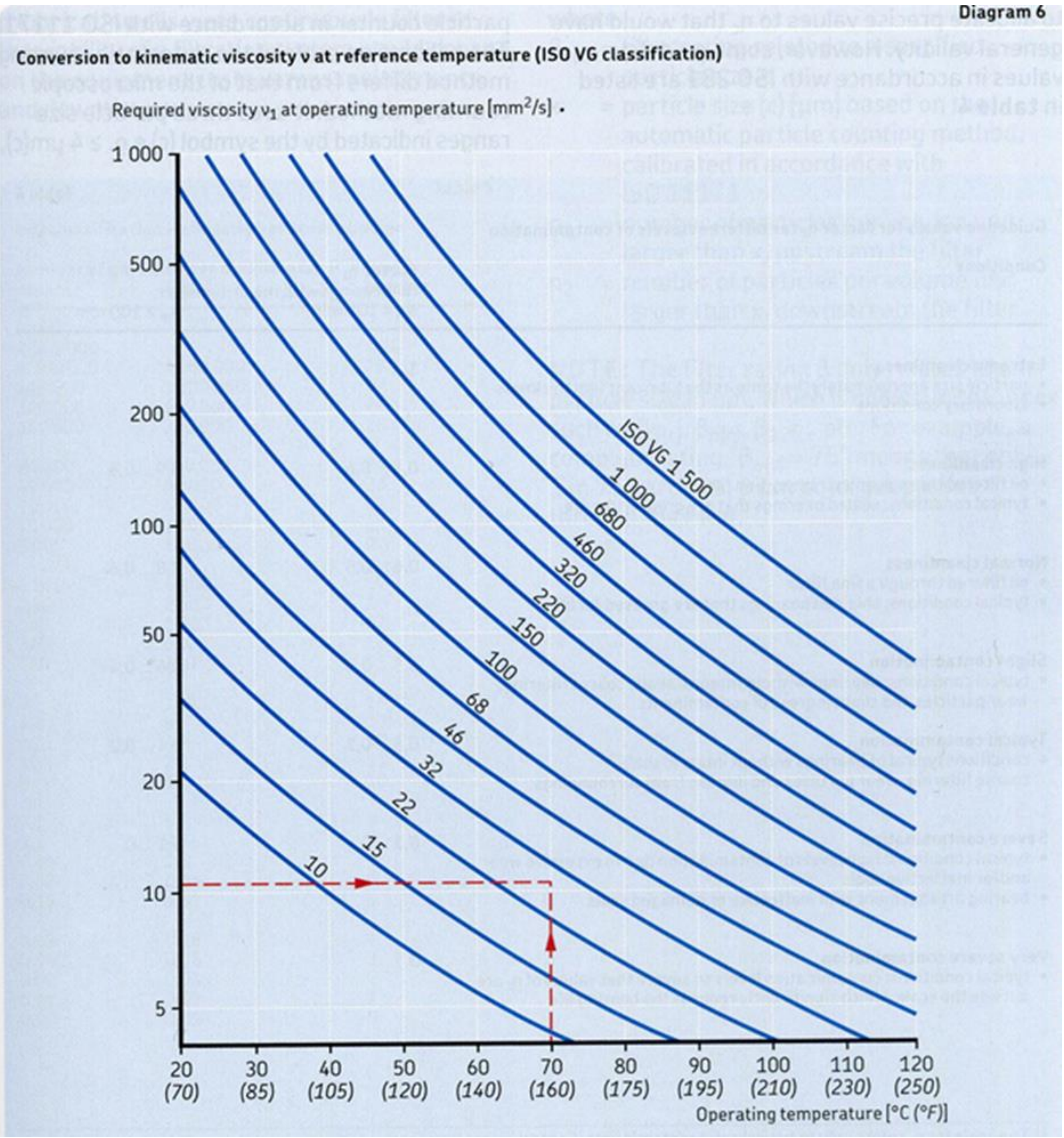
Step 2:

Actual viscosity

ISO-Oils

(Diagram 6, SKF p.73)





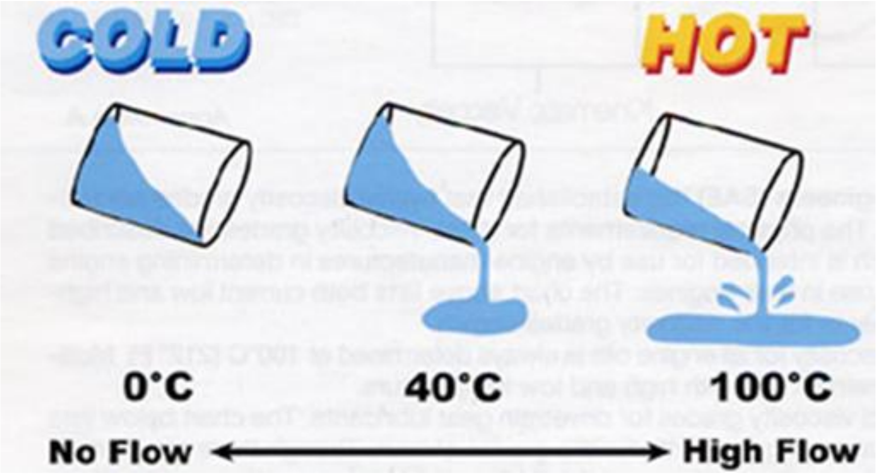
Step 2: Actual viscosity

SKF greases – LGMT 2

(Table 4, SKF p.250)

SKF greases – technical specifications and characteristics

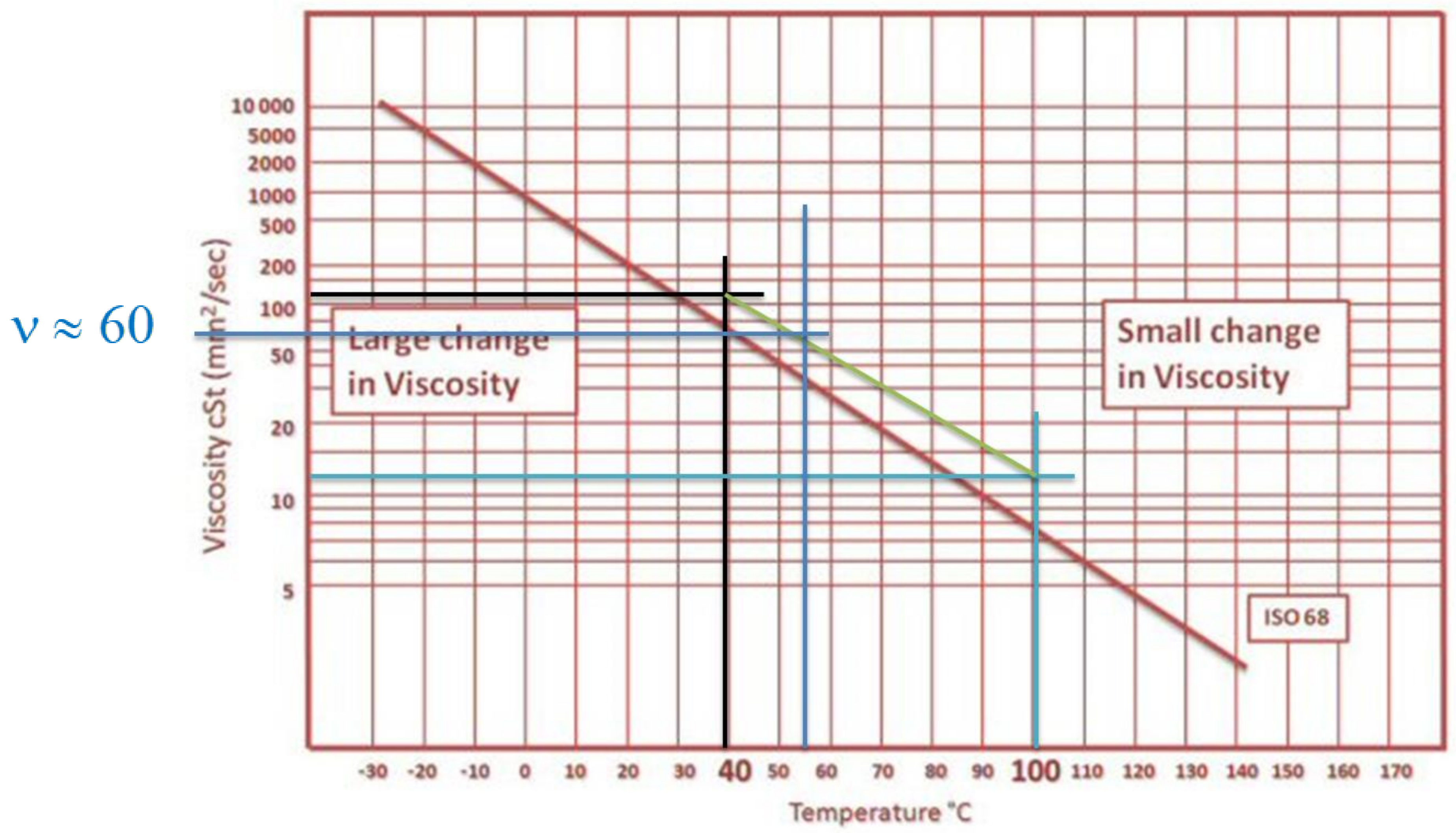
Designation	Description	Temperature	Speed	Load	NLGI class	Temperature range[1) LTL	Temperature range[1) HTPL	Base oil viscosity at 40 °C (105 °F)	Base oil viscosity at 100 °C (210 °F)
–	–	–	–	–	–	°C/°F		mm²/s	
LGMT 2	General purpose, industrial and automotive	M	M	L to M	2	–30 *–20*	120 *250*	110	11
LGMT 3	General purpose, industrial and automotive	M	M	L to M	3	–30 *–20*	120 *250*	120	12
LGEP 2	Extreme pressure, heavy load	M	L to M	H	2	–20 *–5*	110 *230*	200	16
LGWA 2	Wide temperature[3)], extreme pressure	M to H	L to M	L to H	2	–30 *–20*	140 *285*	185	15
LGFP 2	Food compatible	M	M	L to M	2	–20 *–5*	110 *230*	130	7,3



Viscosity at 40°C for LGMT 2 is 110 mm²/s

Viscosity at 100°C for LGMT 2 is 110 mm²/s

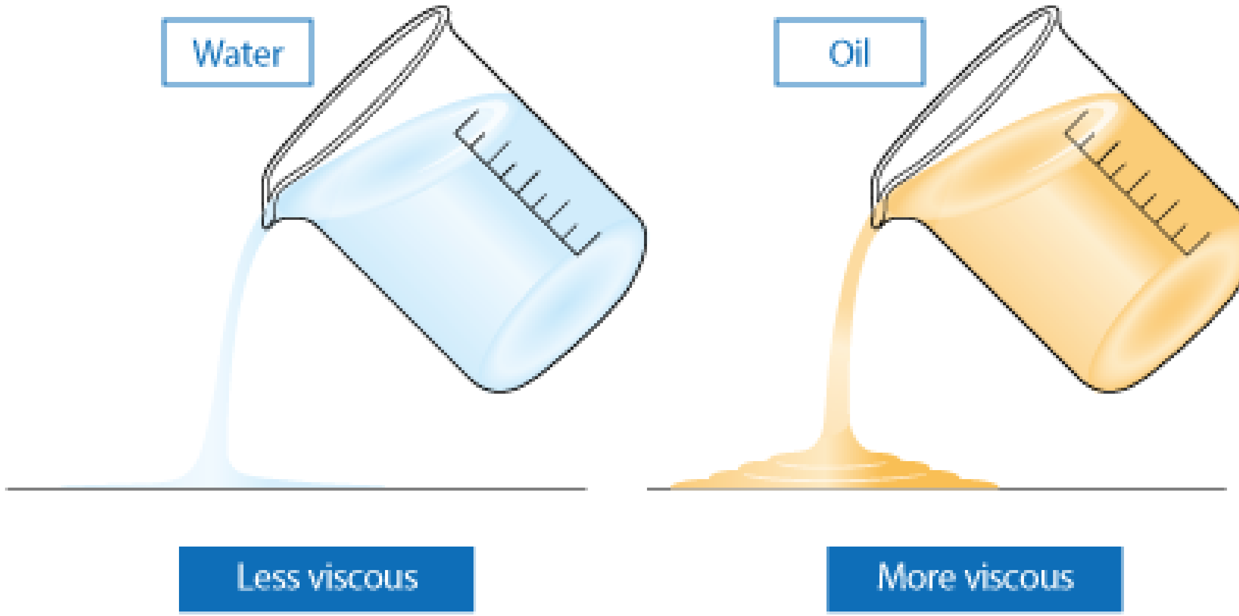
Diagram with logarithmic scale on y-axis



$\nu \approx 60\ \text{mm}^2/\text{s}$ (at 55°C, operating temperature)

Step 3:

Viscosity ratio $\kappa = \nu/\nu_1 \approx 60/11 \approx 5{,}4$



Step 4: to find factor η_c for different levels of contaminations

(Table 4, SKF p. 74)

a. Sealed bearing

$d_m = 97{,}5 \sim 100$ mm

$\eta_c = 0{,}8$

Table 4

Guideline values for factor η_c for different levels of contamination

Conditions	Factor η_c [1)] for bearings with mean diameter $d_m < 100$ mm	$d_m \geq 100$ mm
Extreme cleanliness • particle size approximately the same as the lubricant film thickness • laboratory conditions	1	1
High cleanliness • oil filtered through an extremely fine filter • typical conditions: sealed bearings that are greased for life	0,8 ... 0,6	0,9 ... 0,8
Normal cleanliness • oil filtered through a fine filter • typical conditions: shielded bearings that are greased for life	0,6 ... 0,5	0,8 ... 0,6
Slight contamination • typical conditions: bearings without integral seals, coarse filtering, wear particles and slight ingress of contaminants	0,5 ... 0,3	0,6 ... 0,4
Typical contamination • conditions typical of bearings without integral seals, coarse filtering, wear particles and ingress from surroundings	0,3 ... 0,1	0,4 ... 0,2
Severe contamination • typical conditions: high levels of contamination due to excessive wear and/or ineffective seals • bearing arrangement with ineffective or damaged seals	0,1 ... 0	0,1 ... 0
Very severe contamination • typical conditions: contamination levels so severe that values of η_c are outside the scale, which significantly reduces the bearing life	0	0

1) The scale for η_c refers only to typical solid contaminants. Contaminants like water or other fluids detrimental to bearing life is not included. Due to strong abrasive wear in highly contaminated environments ($\eta_c = 0$) the useful life of a bearing can be significantly shorter than the rated life.

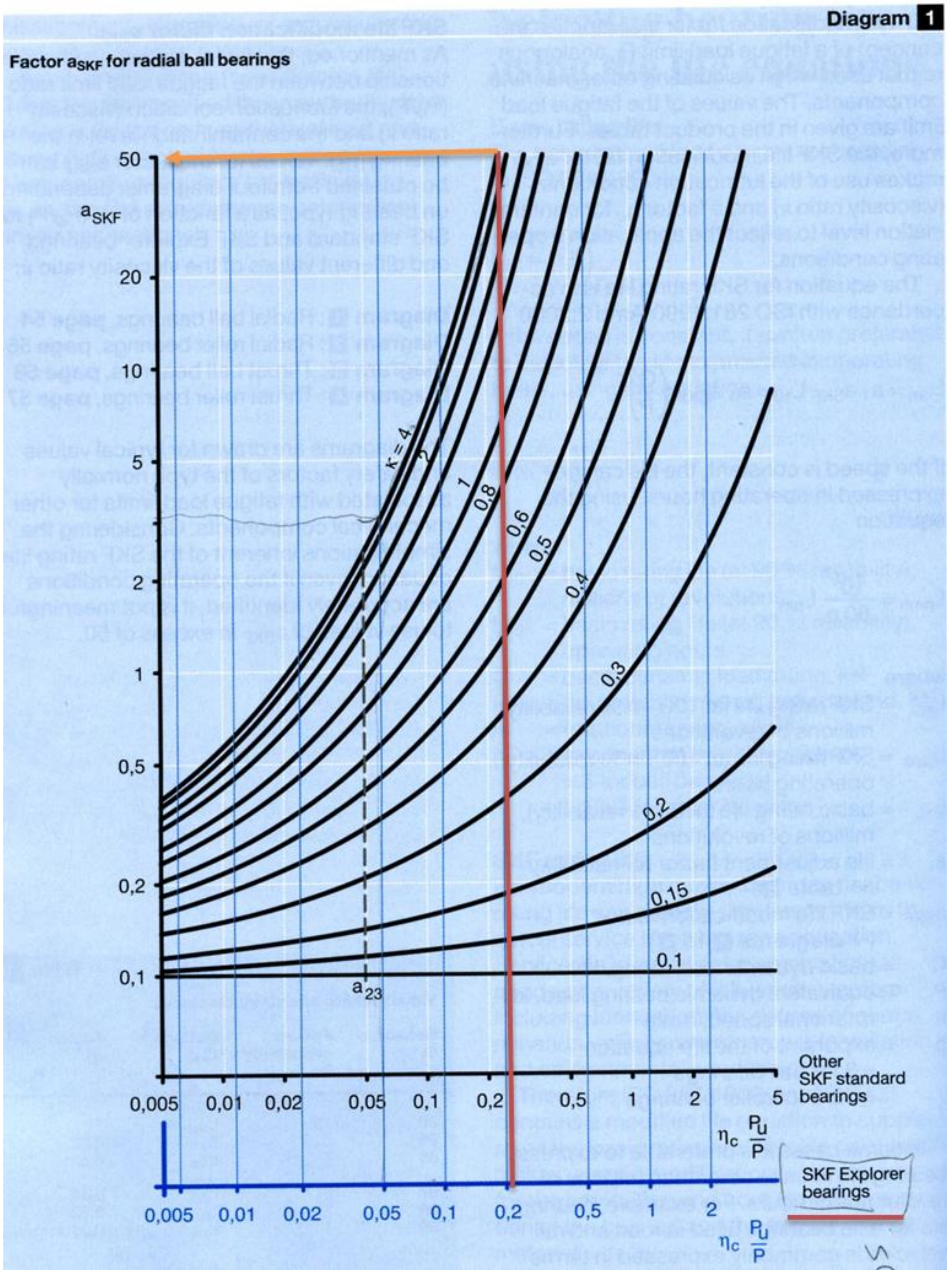
Step 5: to find a_{SKF}

(Diagram 1, SKF p. 66)

$$\eta_c(P_u/P) = 0{,}8(1900/7340) \approx 0{,}21$$

$$\kappa = 5{,}4 \quad \text{use } \kappa = 4$$

$$\Rightarrow a_{SKF} \approx 50$$



SKF rating life

$$L_{naah} = a_1 \cdot a_{SKF} \frac{1000000}{60 \cdot n} \left(\frac{C}{P} \right)^p$$

a₁ = 1 (no info. about the reliability)

p = 3 (ball bearing)

$$\mathrm{L}_{10mh} = 50 \frac{1000000}{60 \cdot 1250} \left(\frac{63{,}7}{7{,}34} \right)^3 \approx 435752 \text{hours}$$

b. Unsealed bearing

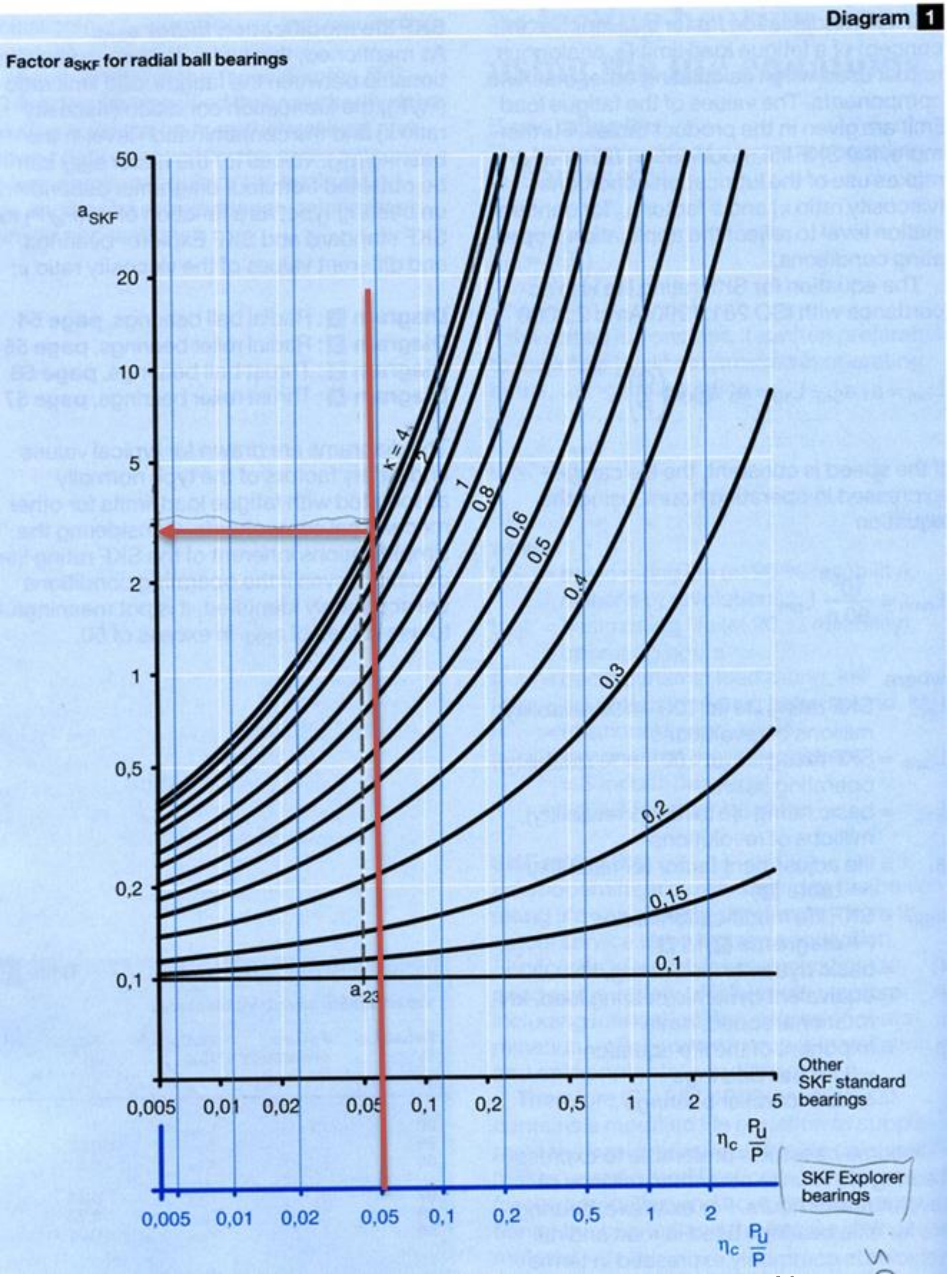
Viscosity ratio $\kappa = 5{,}4 \approx 4$

Degree of contamination is given: $\eta_c = 0{,}2$

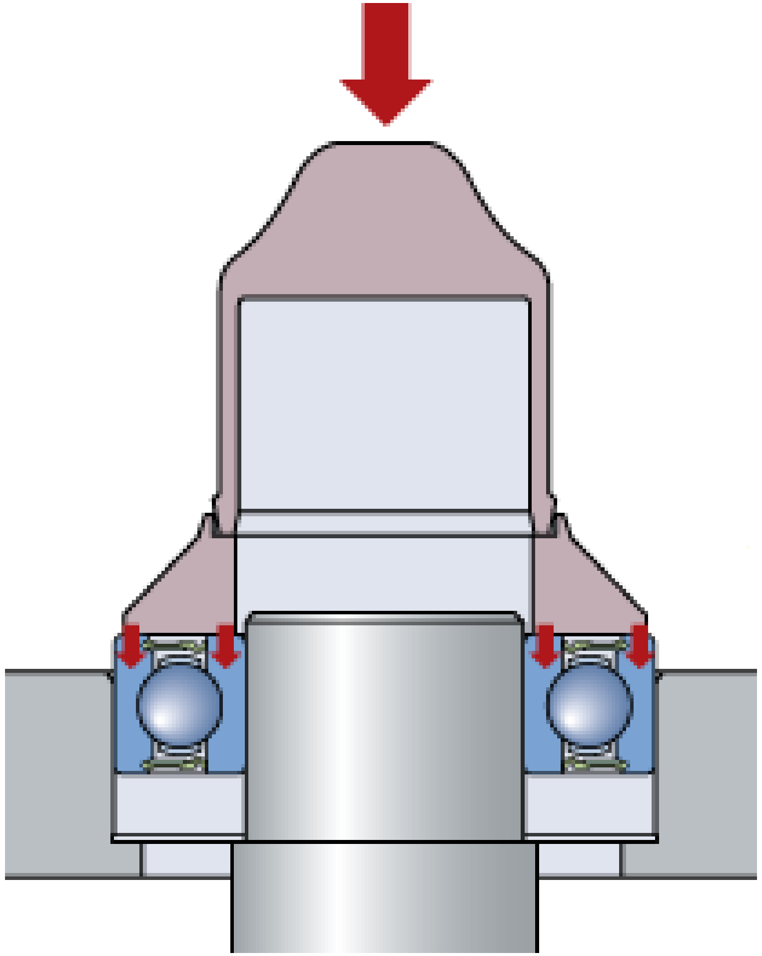
$\eta_c(P_u/P) = 0{,}2\,(1900/7340) = 0{,}052$

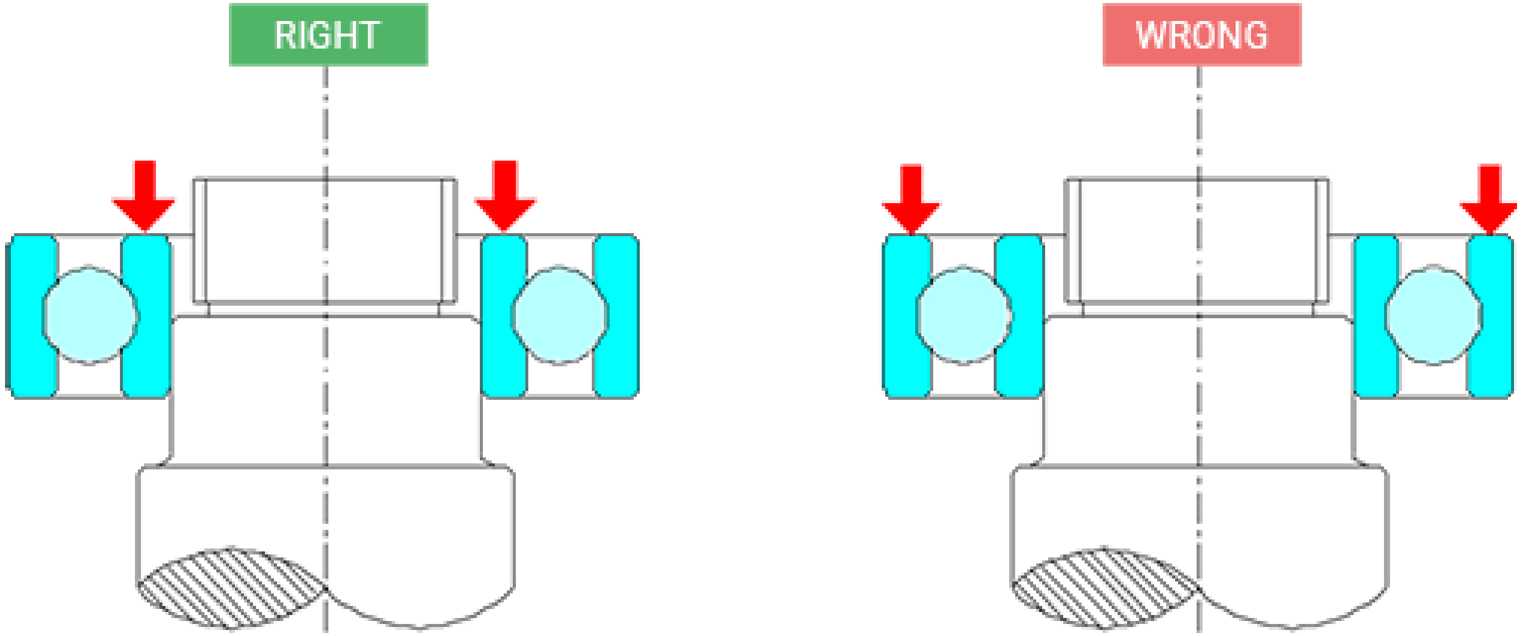
$$\Rightarrow a_{SKF} \approx 3$$

$$L_{10mh} = 3\frac{1000000}{60 \cdot 1250}\left(\frac{63{,}7}{7{,}34}\right)^3 \approx 26145\text{hours}$$



Tolerances required for mounting and running of the bearings





SKF p. 172-173. Selection of tolerance classes for shafts where bearings will be mounted SKF

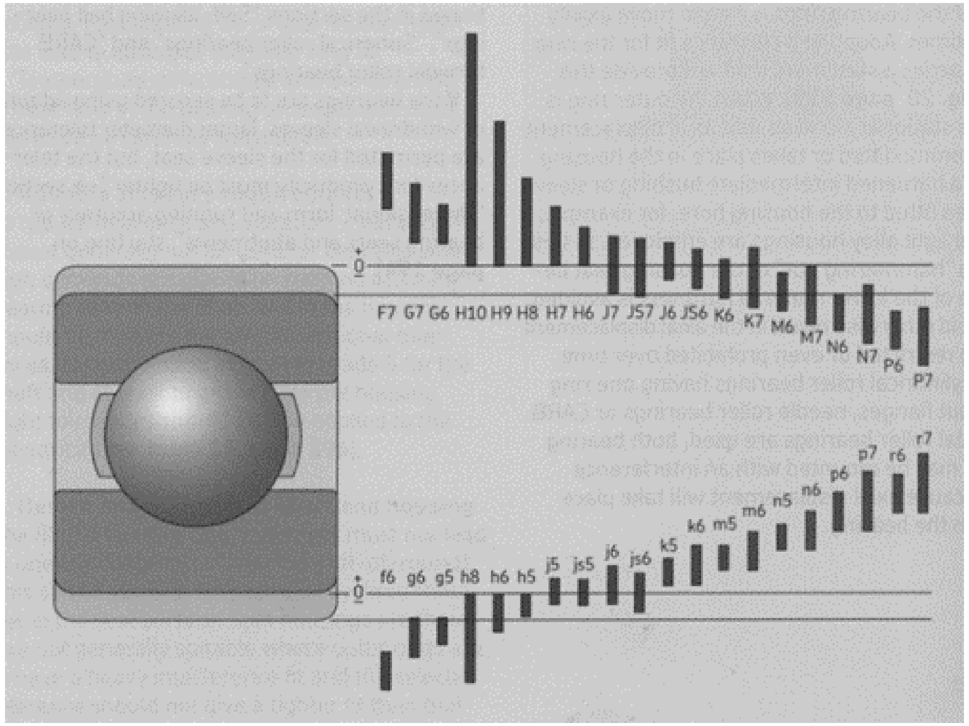


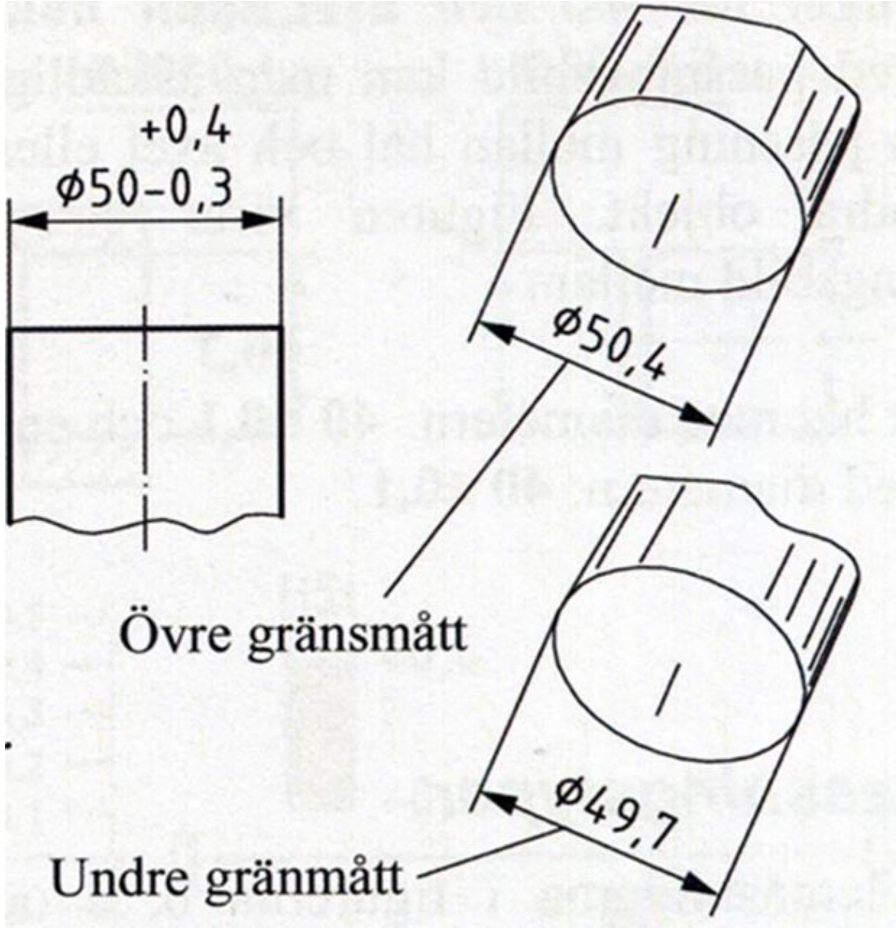
Table 2

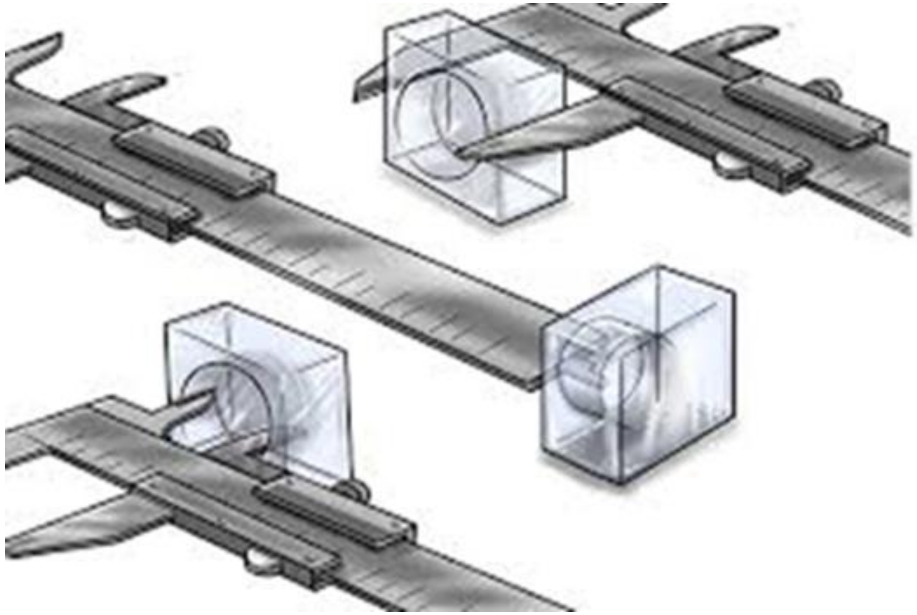
Fits for solid steel shafts

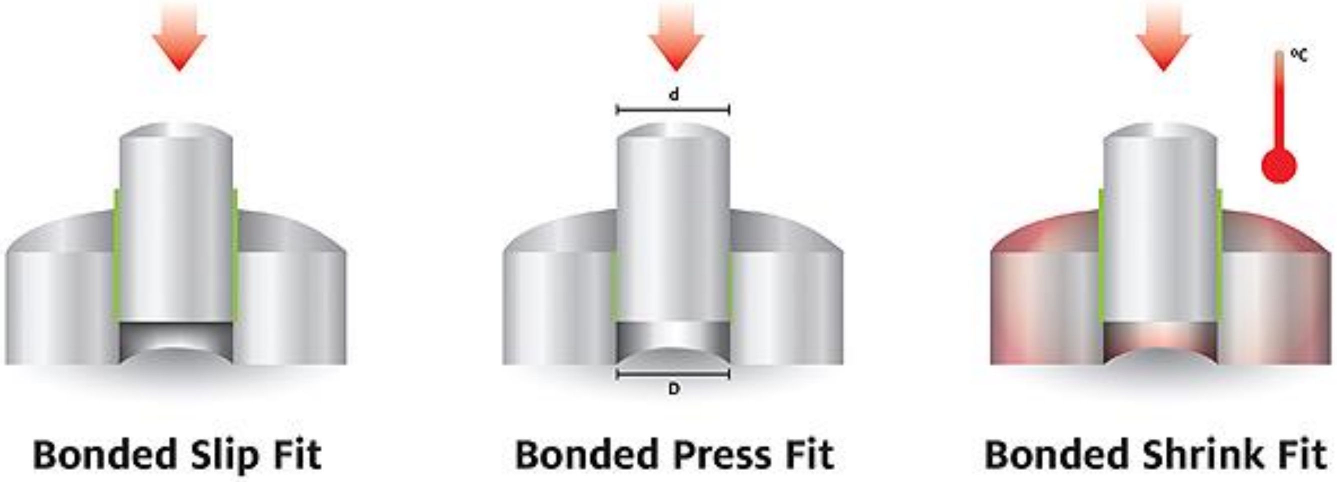
Radial bearings with cylindrical bore

Conditions	Examples	Shaft diameter, mm Ball bearings[1]	Cylindrical roller bearings	Tapered roller bearings	CARB and spherical roller bearings	Tolerance class
Rotating inner ring load or direction of load indeterminate						
Light and variable loads (P ≤ 0,05 C)	Conveyors, lightly loaded gearbox bearings	≤ 17	–	–	–	js5 (h5)[2]
		(17) to 100	≤ 25	≤ 25	–	j6 (j5)[2]
		(100) to 140	(25) to 60	(25) to 60	–	k6
		–	(60) to 140	(60) to 140	–	m6
Normal to heavy loads (P > 0,05 C)	Bearing applications generally, electric motors, turbines, pumps, gearing, wood-working machines, wind mills	≤ 10	–	–	–	js5
		(10) to 17	–	–	–	j5 (js5)[2]
		(17) to 100	–	–	< 25	k5[3]
		–	≤ 30	≤ 40	–	k6
		(100) to 140	(30) to 50	–	25 to 40	m5
		(140) to 200	–	(40) to 65	–	m6
		–	(50) to 65	–	(40) to 60	n5[4]
		(200) to 500	(65) to 100	(65) to 200	(60) to 100	n6[4]
		–	(100) to 280	(200) to 360	(100) to 200	p6[5]
		> 500	–	–	–	p7[4]
		–	(280) to 500	(360) to 500	(200) to 500	r6[4]
		–	> 500	> 500	> 500	r7[4]
Heavy to very heavy loads and shock loads with difficult working conditions (P > 0,1 C)	Axleboxes for heavy railway vehicles, traction motors, rolling mills	–	(50) to 65	–	(50) to 70	n5[4]
		–	(65) to 85	(50) to 110	–	n6[4]
		–	(85) to 140	(110) to 200	(70) to 140	p6[6]
		–	(140) to 300	(200) to 500	(140) to 280	r6[7]
		–	(300) to 500	–	(280) to 400	$s6_{min} \pm IT6/2$[6][8]
		–	> 500	> 500	> 400	$s7_{min} \pm IT7/2$[6][8]
High demands on running accuracy with light loads (P ≤ 0,05 C)	Machine tools	8 to 240	–	–	–	js4
		–	25 to 40	25 to 40	–	js4 (j5)[9]
		–	(40) to 140	(40) to 140	–	k4 (k5)[9]
		–	(140) to 200	(140) to 200	–	m5
		–	(200) to 500	(200) to 500	–	n5

Tolerances and fits



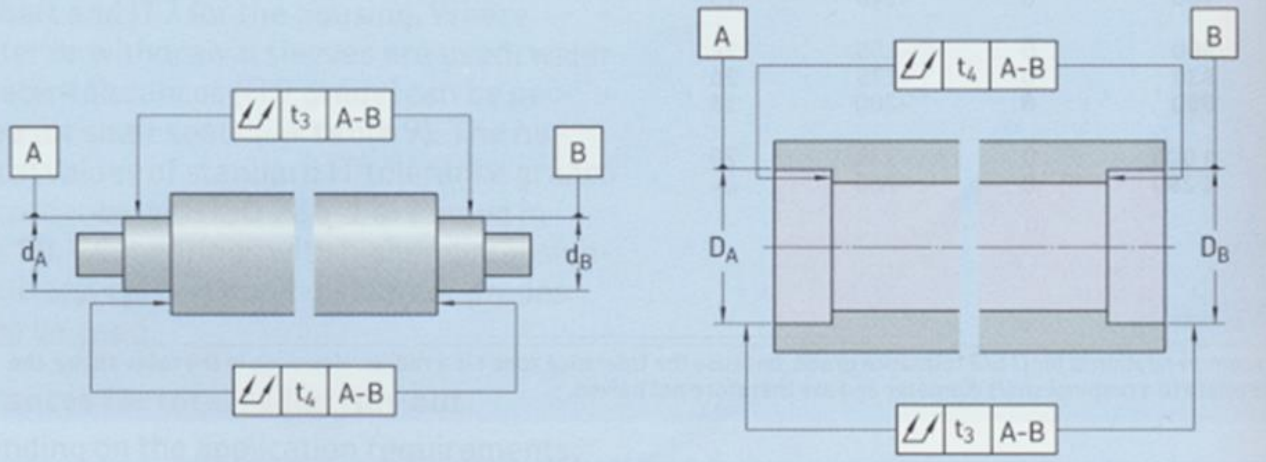




SKF table 11, p. 202 Geometrical tolerances (form tolerances).

Table 11

Geometrical tolerances for bearing seats on shafts and in housings



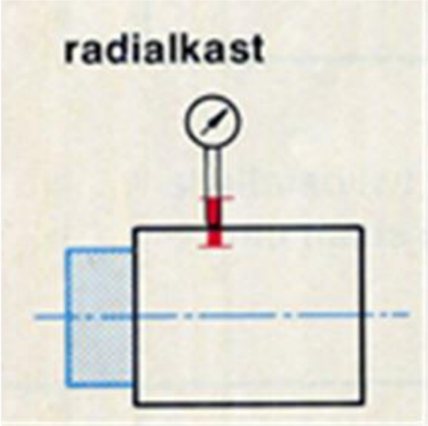
Surface Characteristic	Symbol for geometrical characteristic	tolerance zone	**Permissible deviations** Bearings of tolerance class[1)] Normal, CLN	P6	P5	
Cylindrical seat						
Total radial run-out	⌰	t_3	IT5/2	IT4/2	IT3/2	IT2/2
Flat abutment						
Total axial run-out	⌰	t_4	IT5	IT4	IT3	IT2

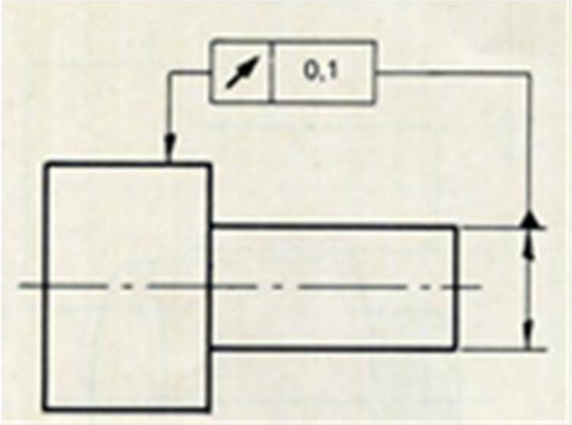
International Tolerance Grades or IT Grades

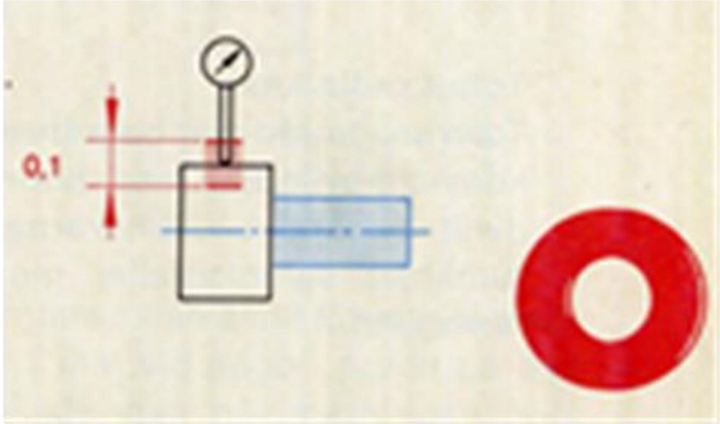
Basmått mm		Toleransvidd																			
		µm												mm							
över	t.o.m.	IT01	IT0	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
	1	0,3	0,5	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14					
1	3	0,3	0,5	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,6	1	1,4
3	6	0,4	0,6	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	0,4	0,6	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	0,5	0,8	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	0,6	1	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	0,6	1	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	0,8	1,2	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	1	1,5	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	1,2	2	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	2	3	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	2,5	4	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	3	5	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	4	6	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

Run-outs

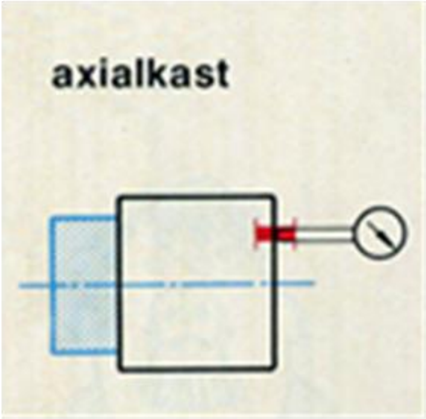
- Radial

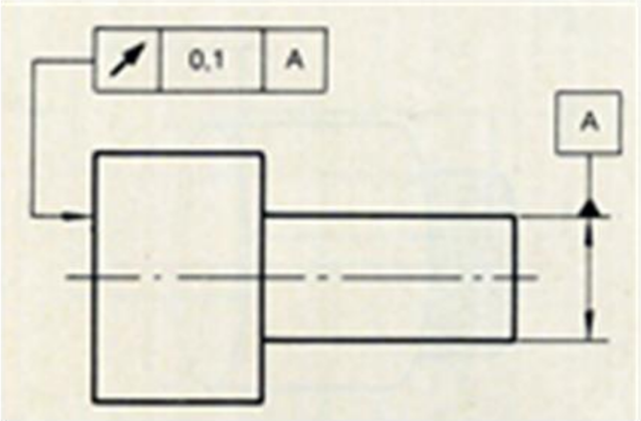


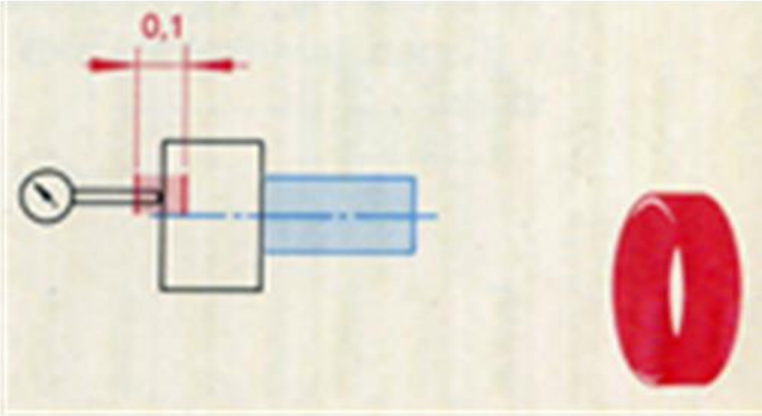




- Axial

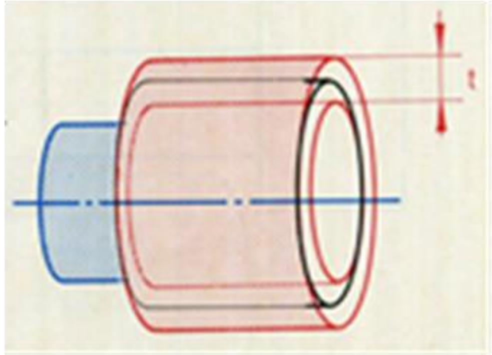


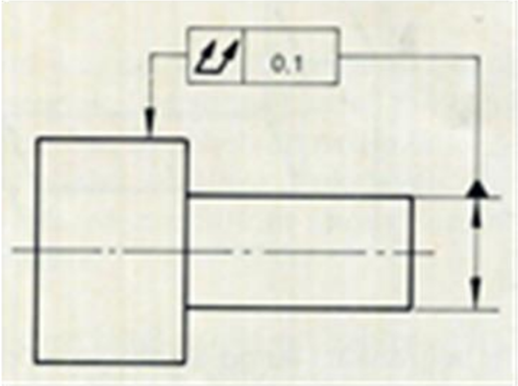


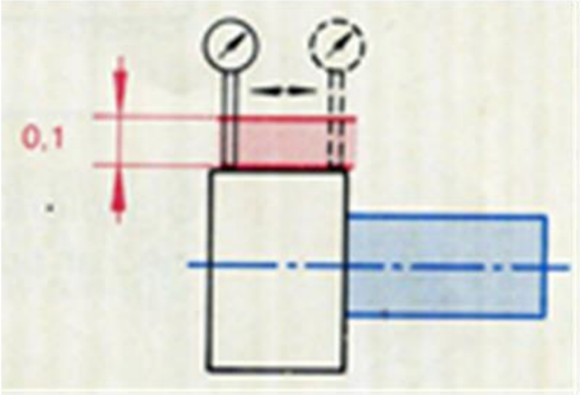


Total run-outs

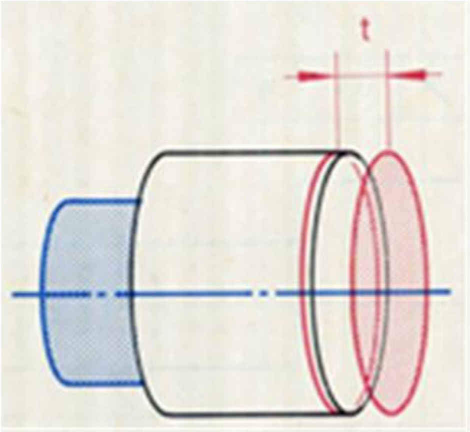
- Total radial

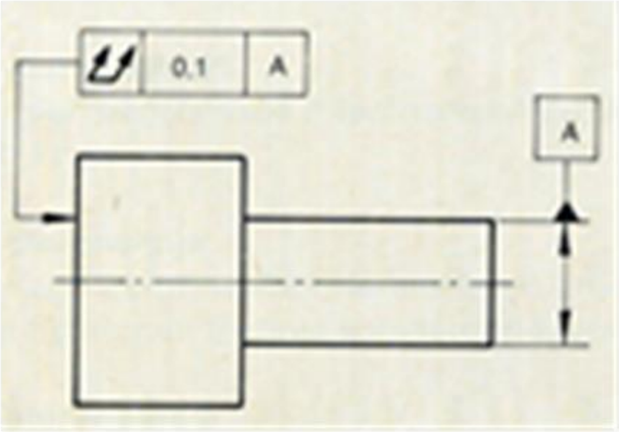


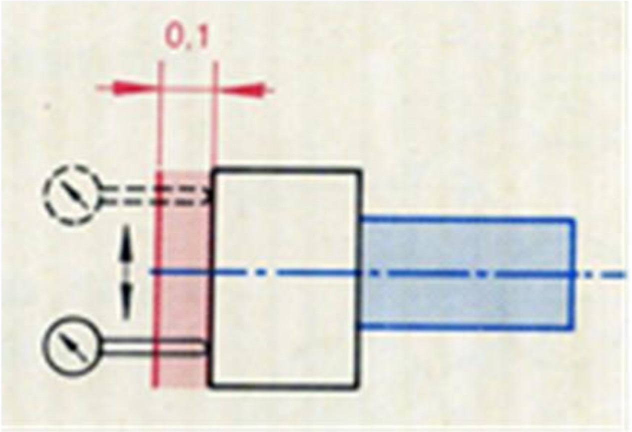




- Total axial







Have a safe Rolling