ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Elementos de Máquinas para Automação

PMR 3307 – A12

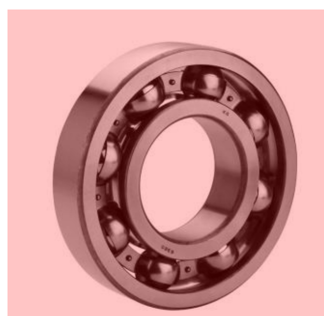
Mancais de elementos rolantes

2023.2

Mancais

classificação

- Escorregamento
- Rolamento
- Fluídicos
  - Hidrodinâmicos
  - Hidrostáticos
- Magnéticos



Mancais de rolamento

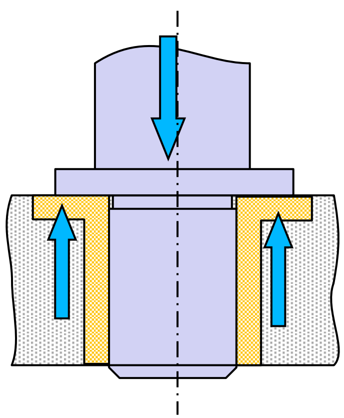
Exemplos

http://cento-kullager.se/om/

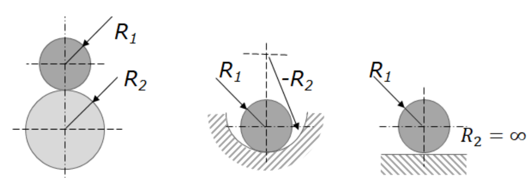
Introdução

Mancais de escorregamento

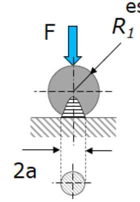
Mecânica dos sólidos



Contatos de Hertz



esfera/esfera esfera/cilindro esfera/plano



$$D = \frac{2R_1R_2}{R_1 + R_2}$$

$$E = \frac{2E_1E_2}{E_1 + E_2}$$

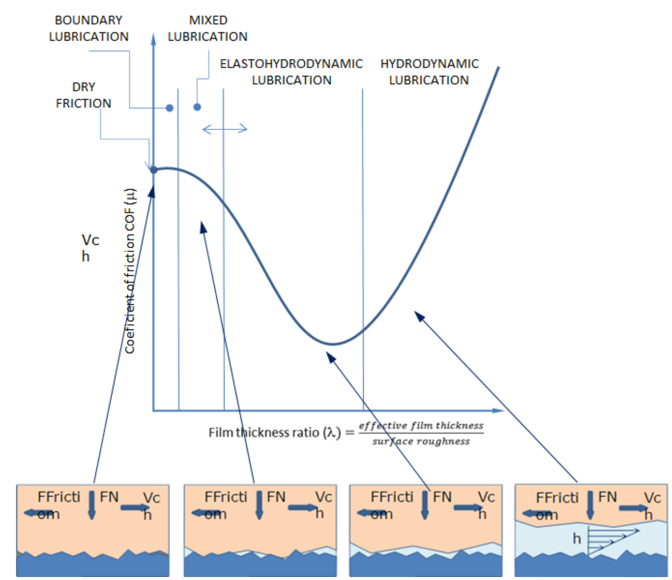
Área de contato

$$a = \sqrt[3]{\frac{0{,}75\,(1-\nu^2)F\,D}{E}}$$

Pressão de contato máxima

$$P_{max} = 1{,}5\,\frac{F}{a^2\pi}$$

Curva de Stribeck

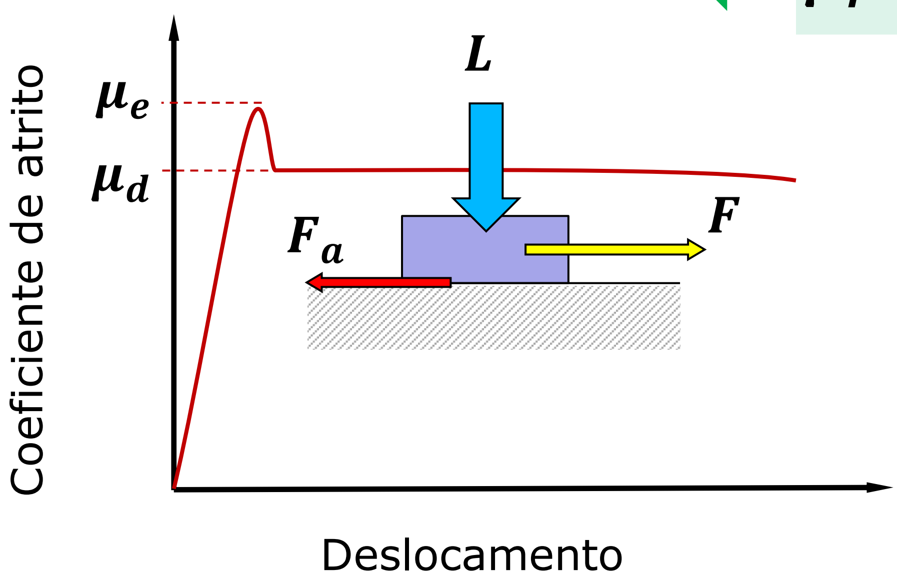


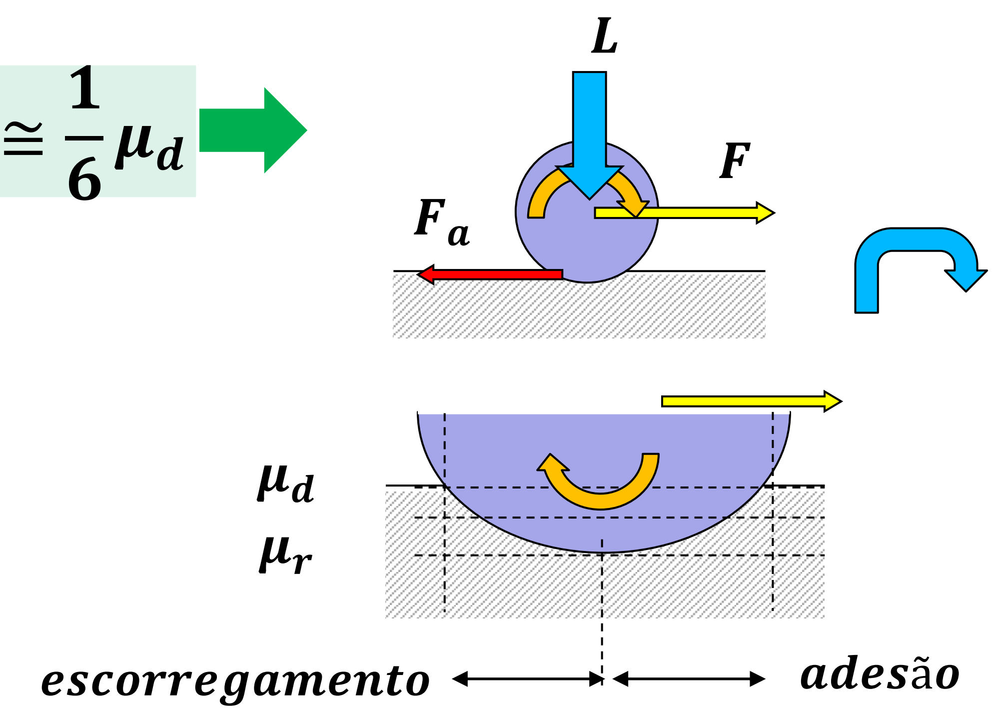
Introdução

Atrito

Atrito de escorregamento | Atrito de rolamento

$$\mu_r \cong \frac{1}{6}\mu_d$$





Mancais de rolamento

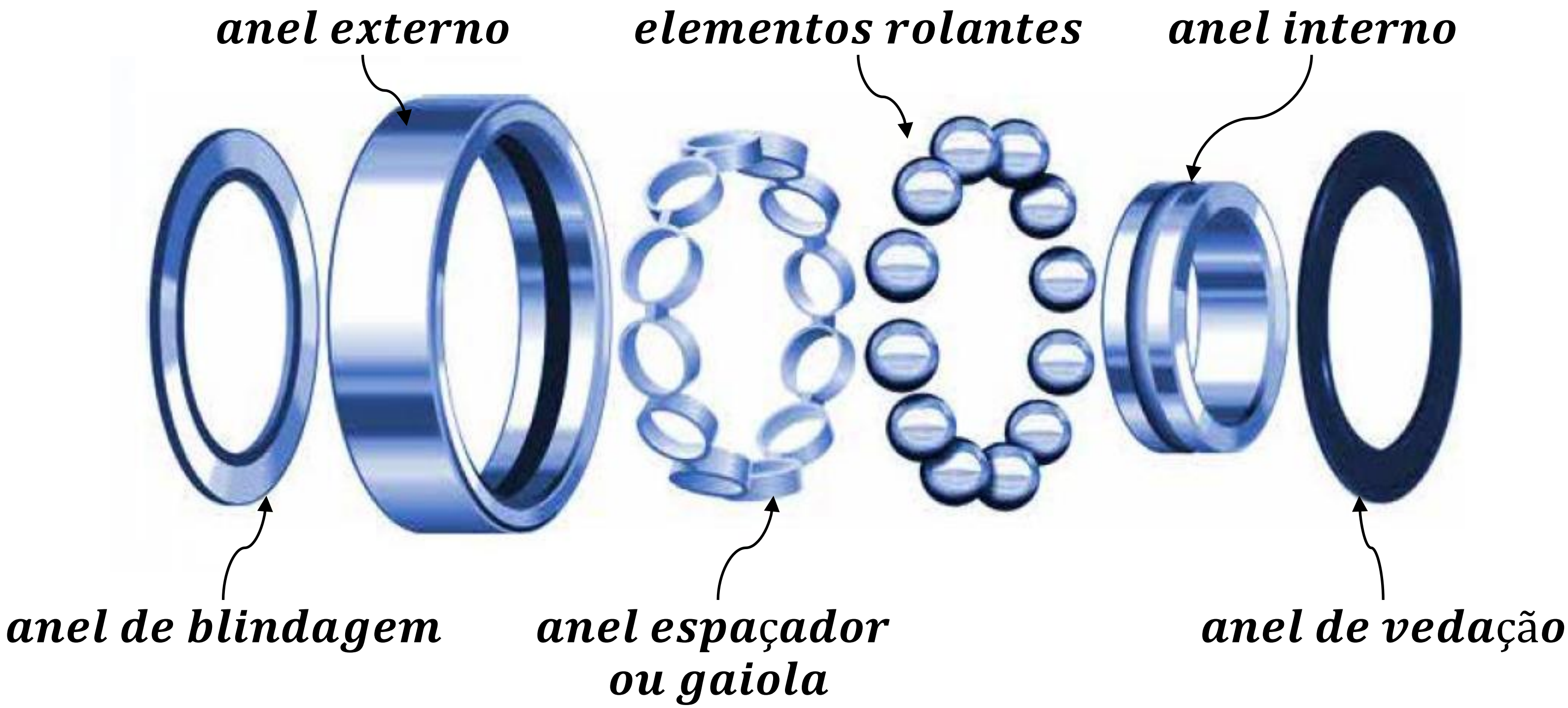
Introdução

São os tipos de mancais mais utilizados, e são caracterizados por:

- Fácil movimentação
- Baixo atrito
- Elevado nível de padronização
- Baixo custo relativo

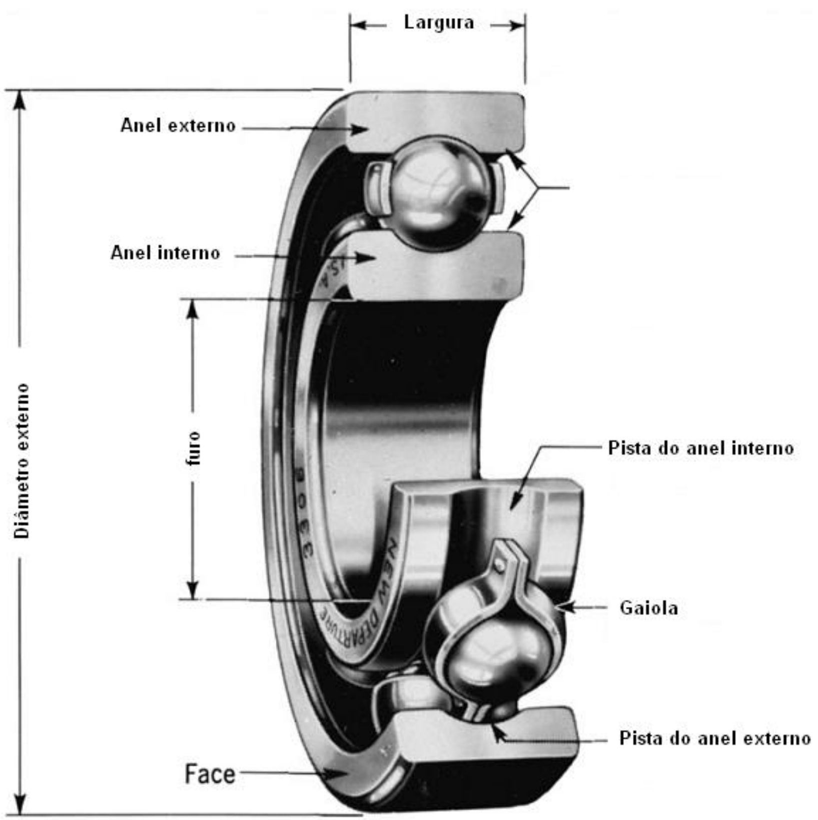
Mancais de rolamento

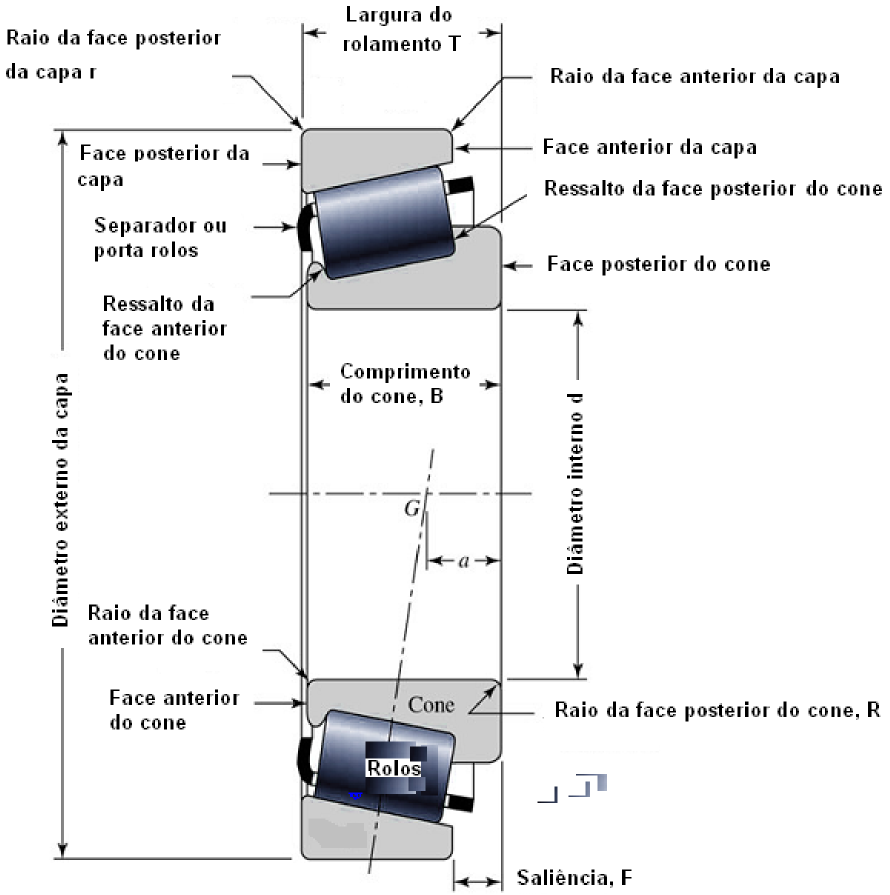
Constituintes



Mancais de rolamento

Nomenclatura

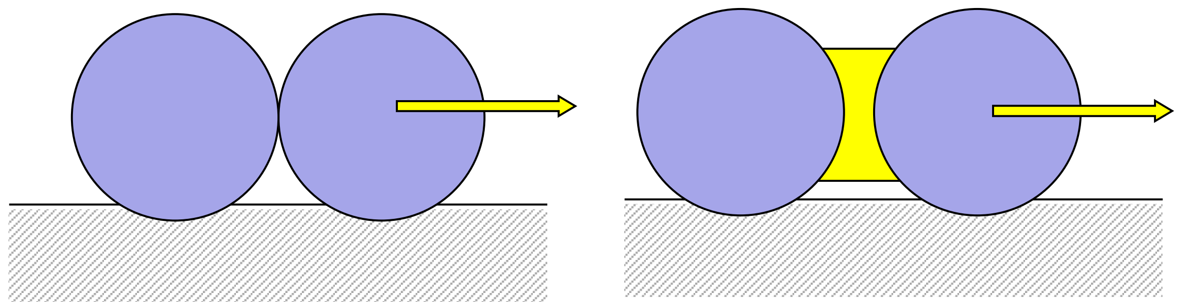


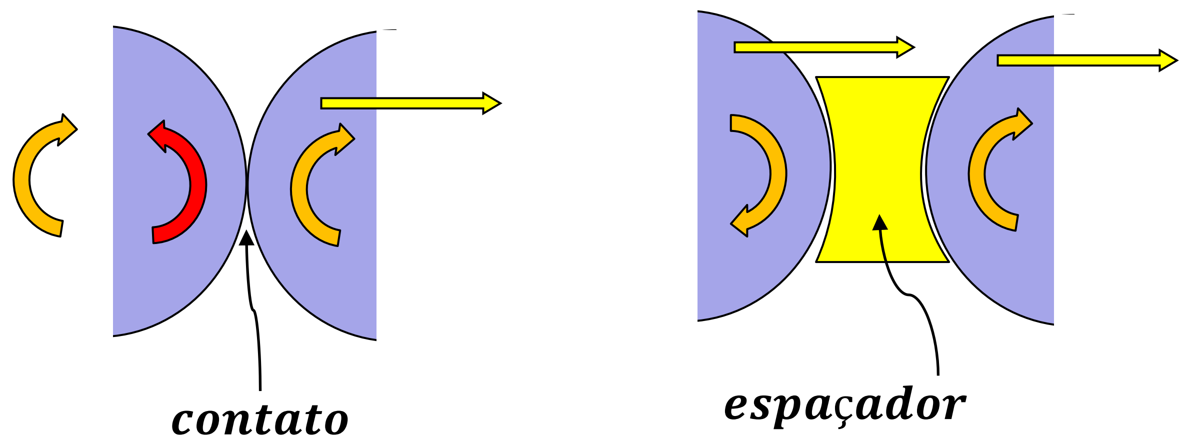


Mancais de rolamento

Espaçador

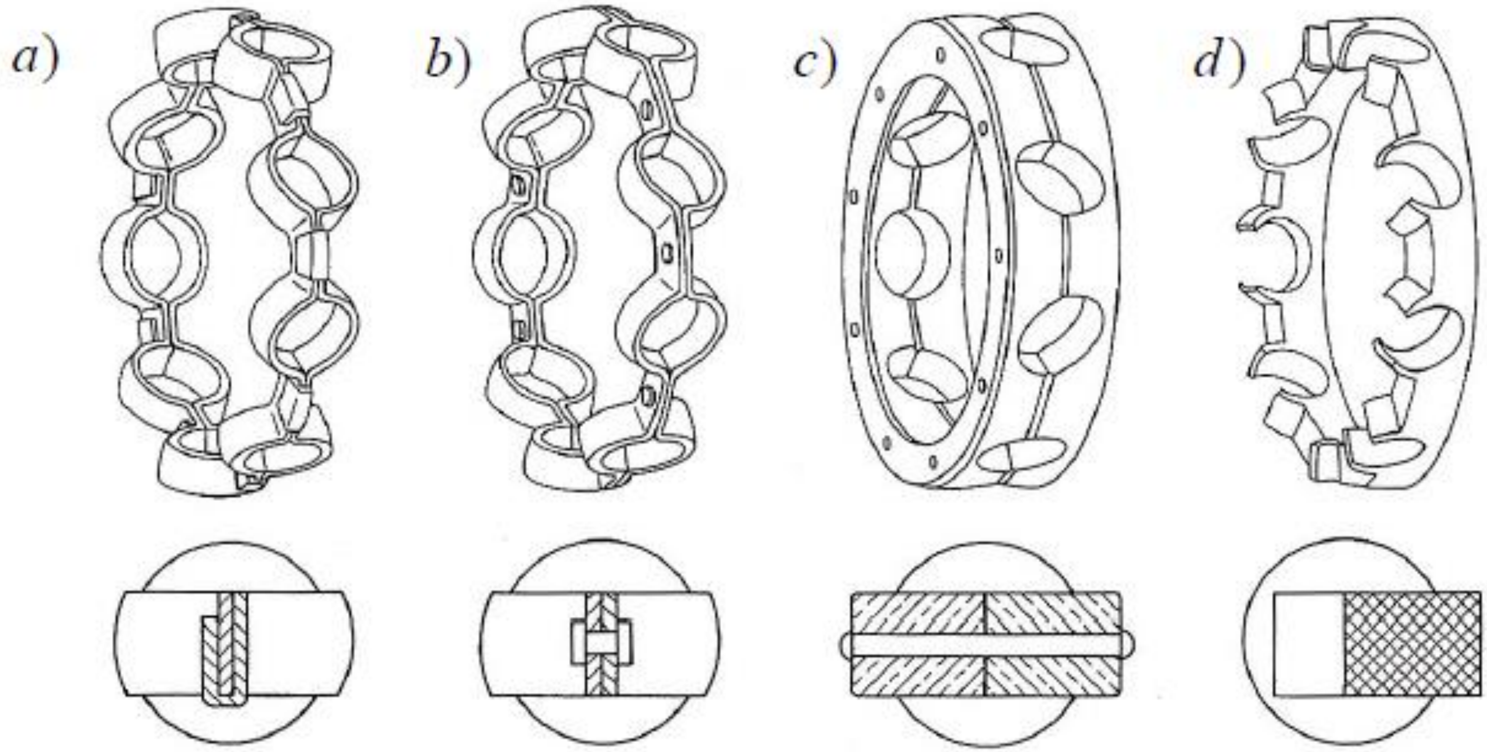
anel espaçador ou gaiola





Mancais de rolamento

Espaçador



gaiola costurada

gaiola rebitada

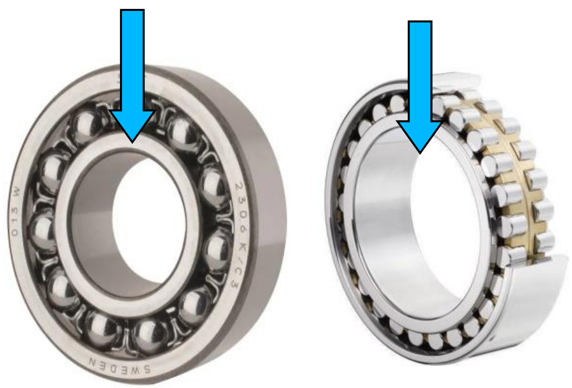
gaiola maciça

gaiola injetada

Mancais de rolamento

Carregamentos

Radiais



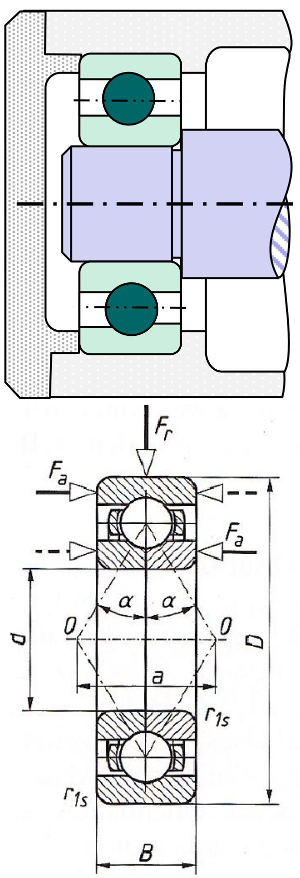
Radiais/Axiais

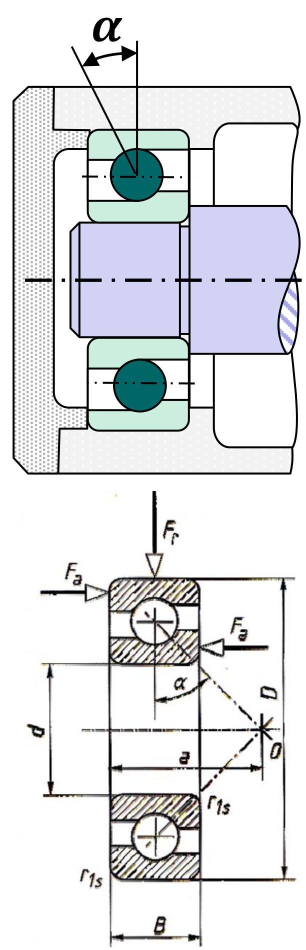
Axiais

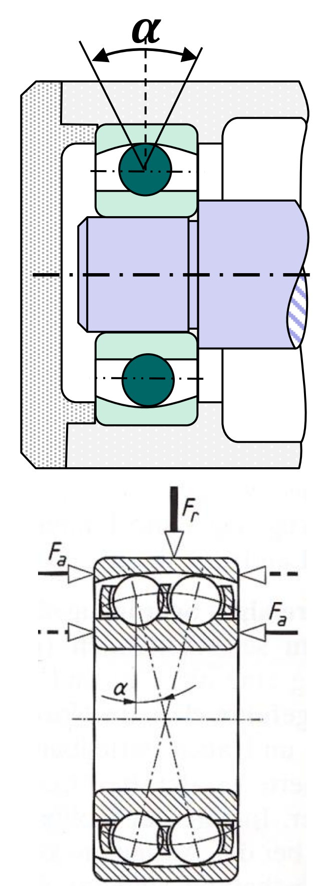
Mancais de rolamento

Radiais de esfera

rígidos	De contato angular	autocompensadores



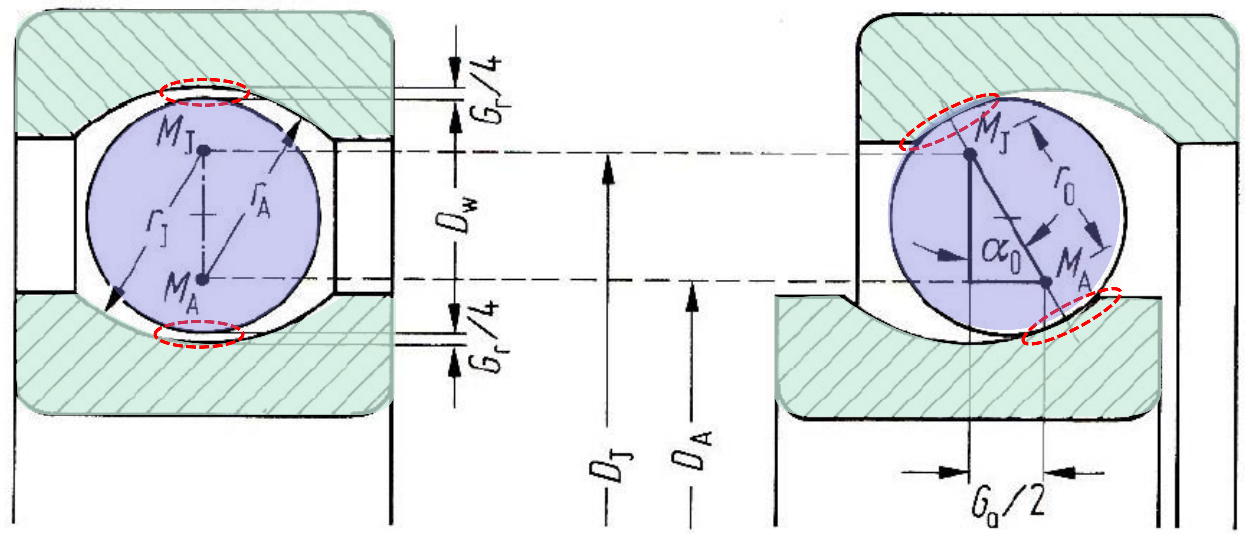




Mancais de rolamento

Radiais de esfera

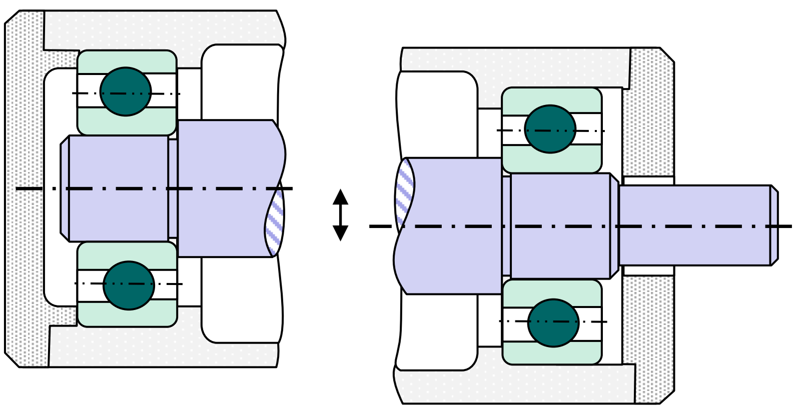
rígidos × De contato angular



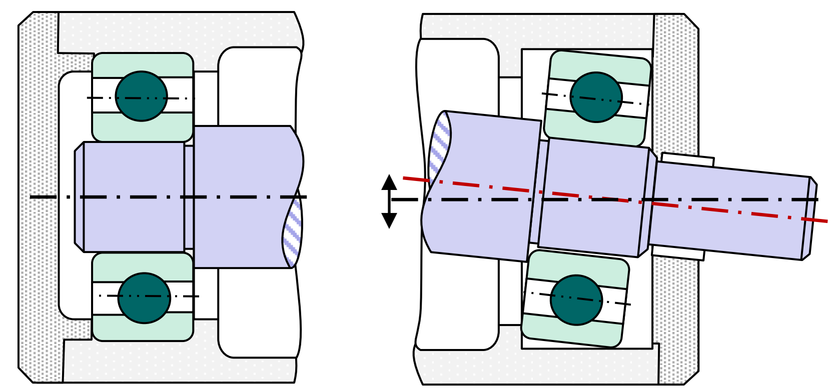
Mancais de rolamento

Quando usar mancais autocompensadores

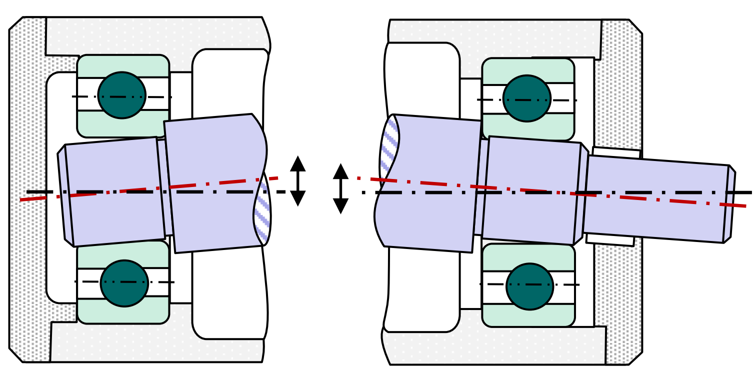
Desalinhamento



Montagem errada



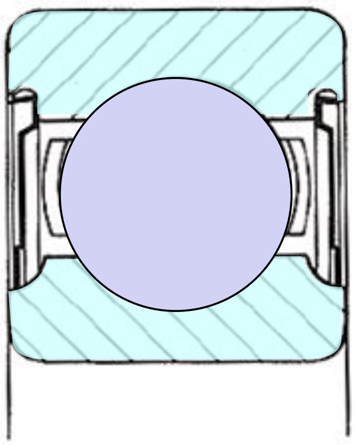
Flexão dos eixos

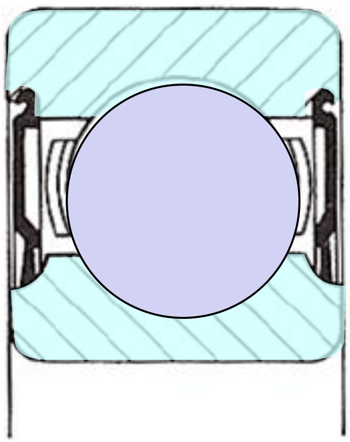


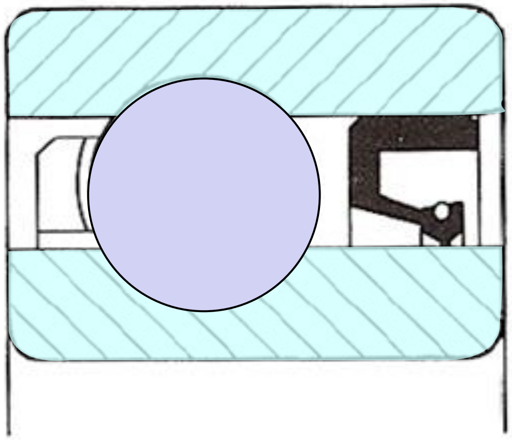
Mancais de rolamento

proteção

vedados | blindados | selados

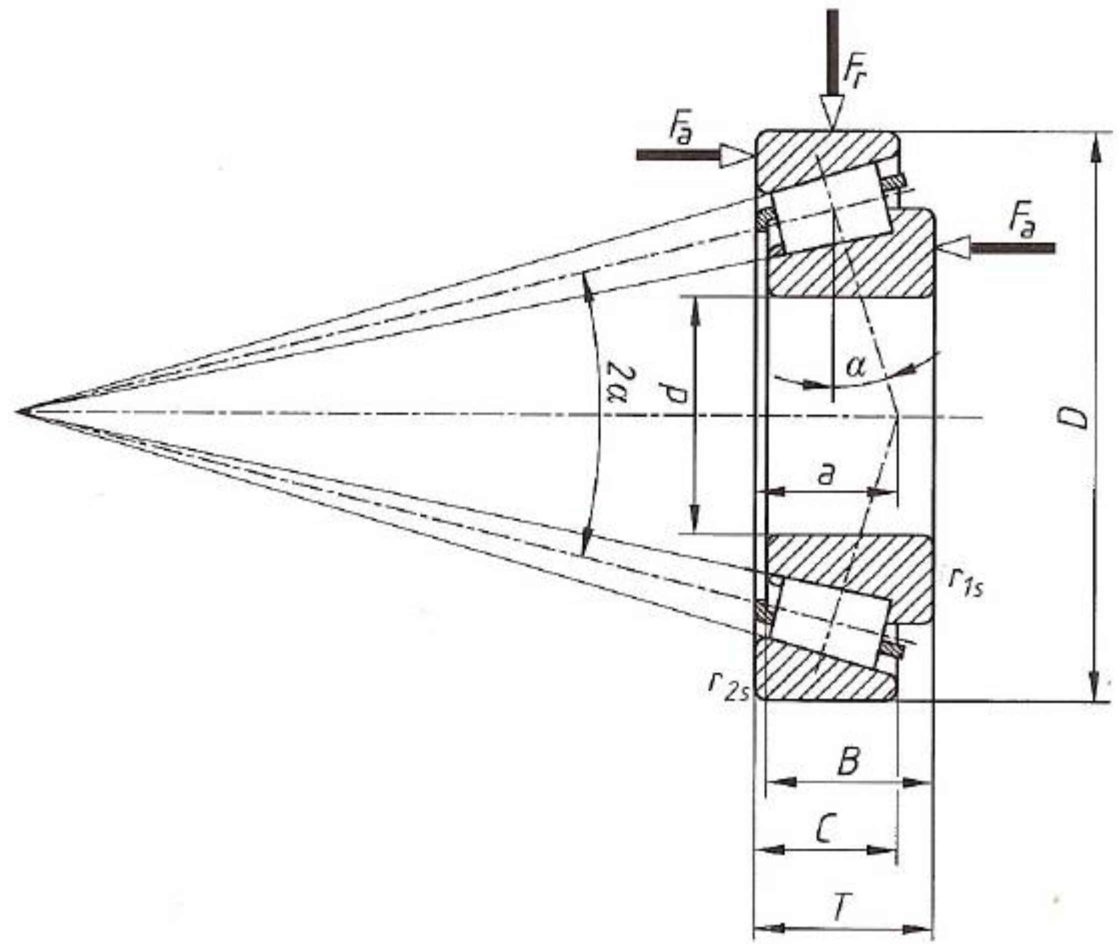






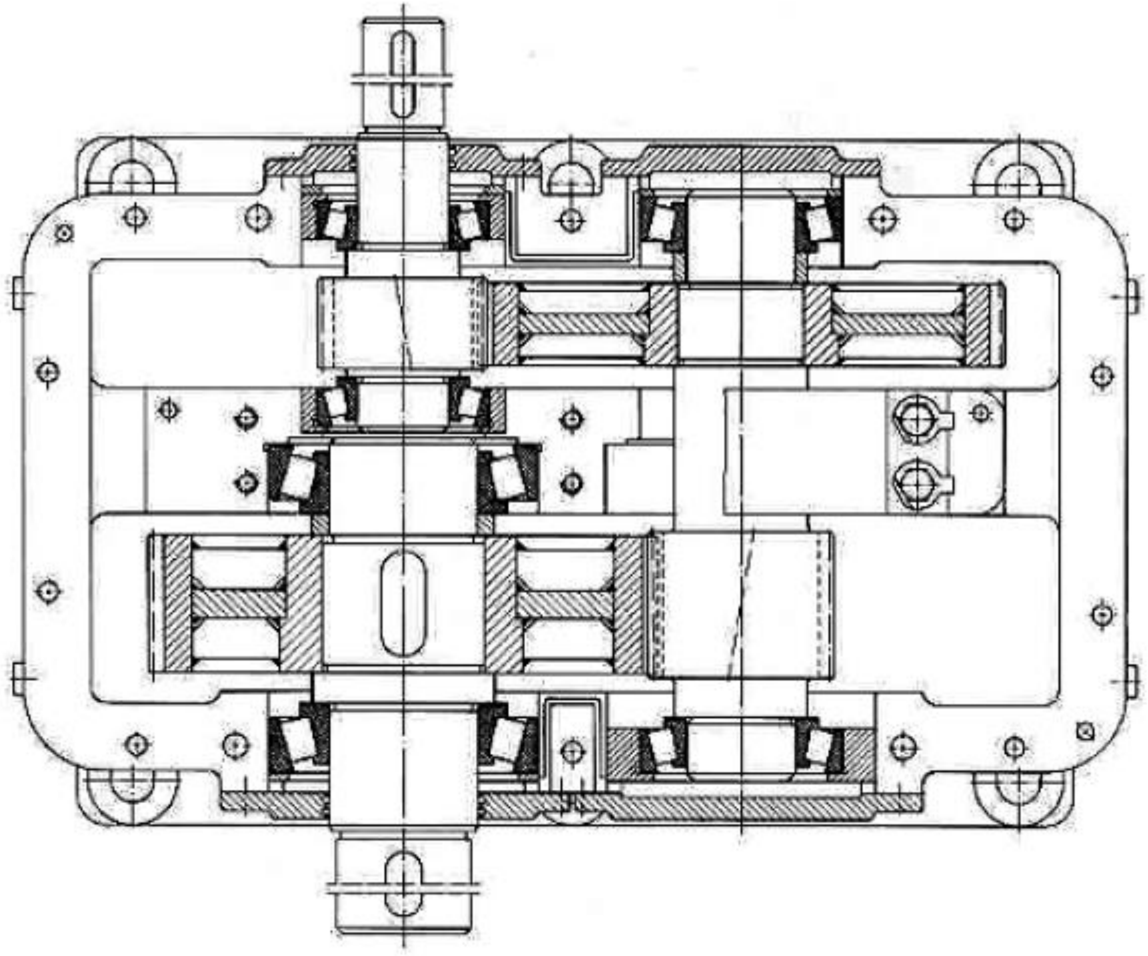
Mancais de rolamento

Rolos cônicos



Mancais de rolamento

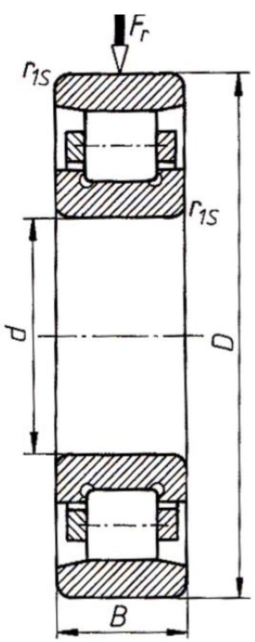
Exemplo do uso de mancais de rolo cônicos

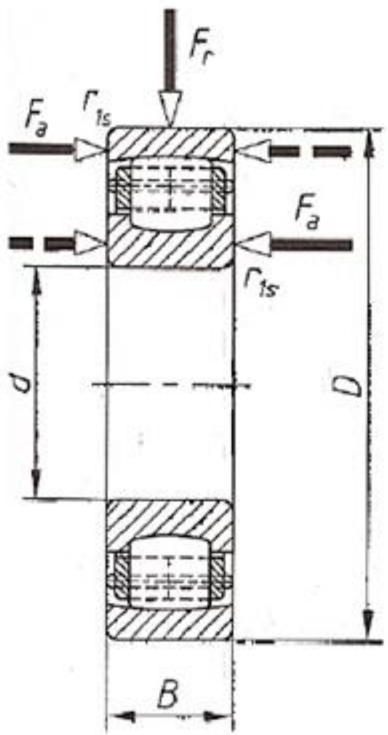


Mancais de rolamento

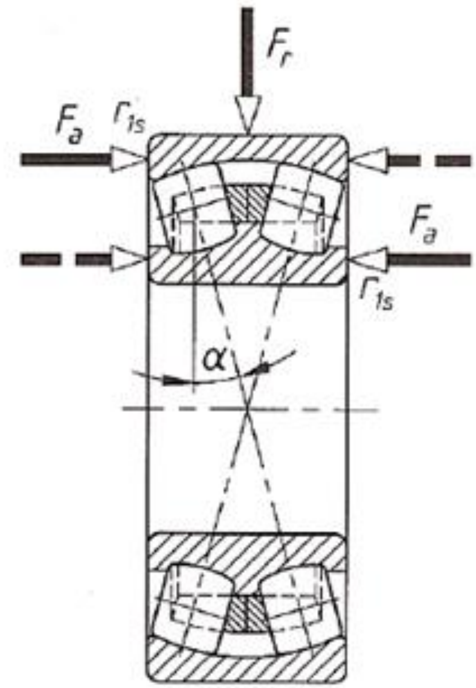
de rolo radiais

rígidos



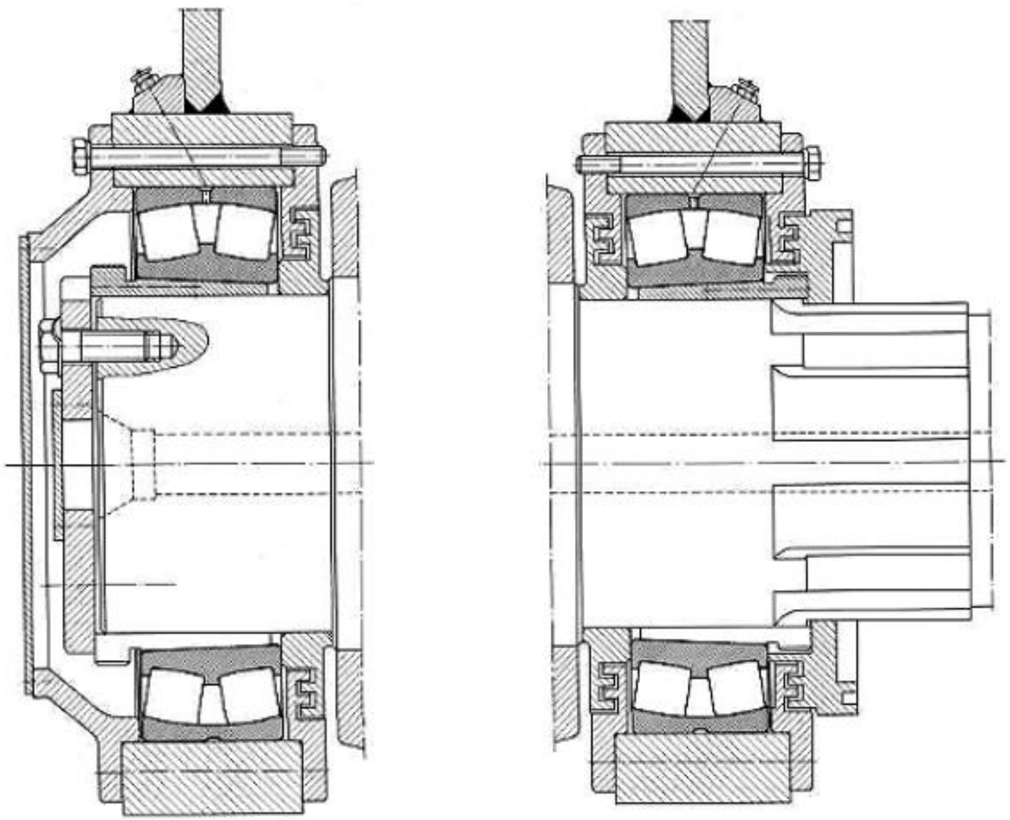


autocompensadores



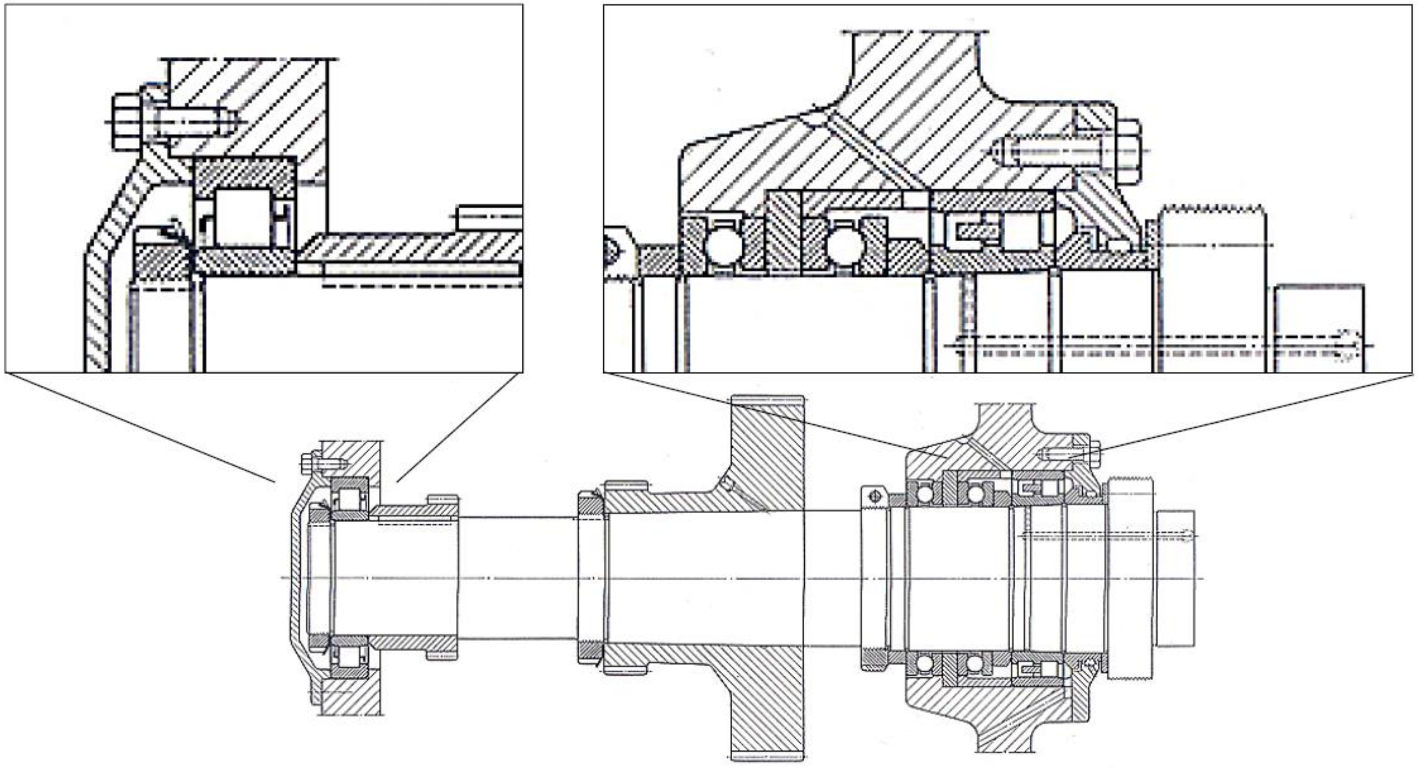
Mancais de rolamento

Exemplo do uso de mancais de rolo radiais autocompensadores



Mancais de rolamento

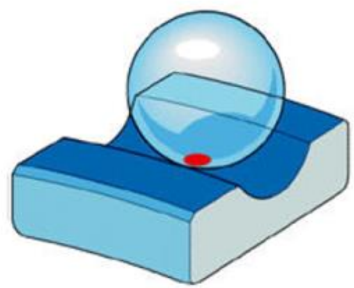
Exemplo do uso de mancais radiais de rolo e de esfera

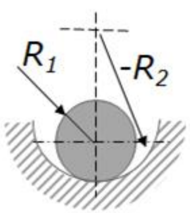


Mancais de rolamento

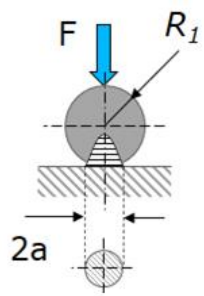
Classificação quanto a forma do elemento rolante

esféricos





esfera/cilindro



$$D = \frac{2R_1R_2}{R_1 + R_2}$$

$$E = \frac{2E_1E_2}{E_1 + E_2}$$

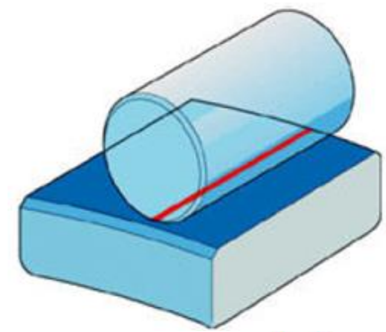
Área de contato

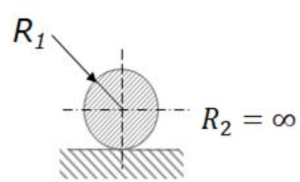
$$a = \sqrt[3]{\frac{0{,}75\,(1-\nu^2)F\,D}{E}}$$

Pressão de contato máxima

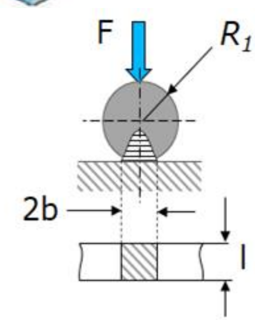
$$P_{max} = 1{,}5\,\frac{F}{a^2\pi}$$

Cilíndricos/cônicos





cilindro/plano



$$E = \frac{2E_1E_2}{E_1 + E_2}$$

$$D = \frac{2R_1R_2}{R_1 + R_2}$$

Área de contato

$$b = \sqrt[2]{\frac{4\,F\,D(1-\nu^2)}{\pi\,E\,l}}$$

Pressão de contato máxima

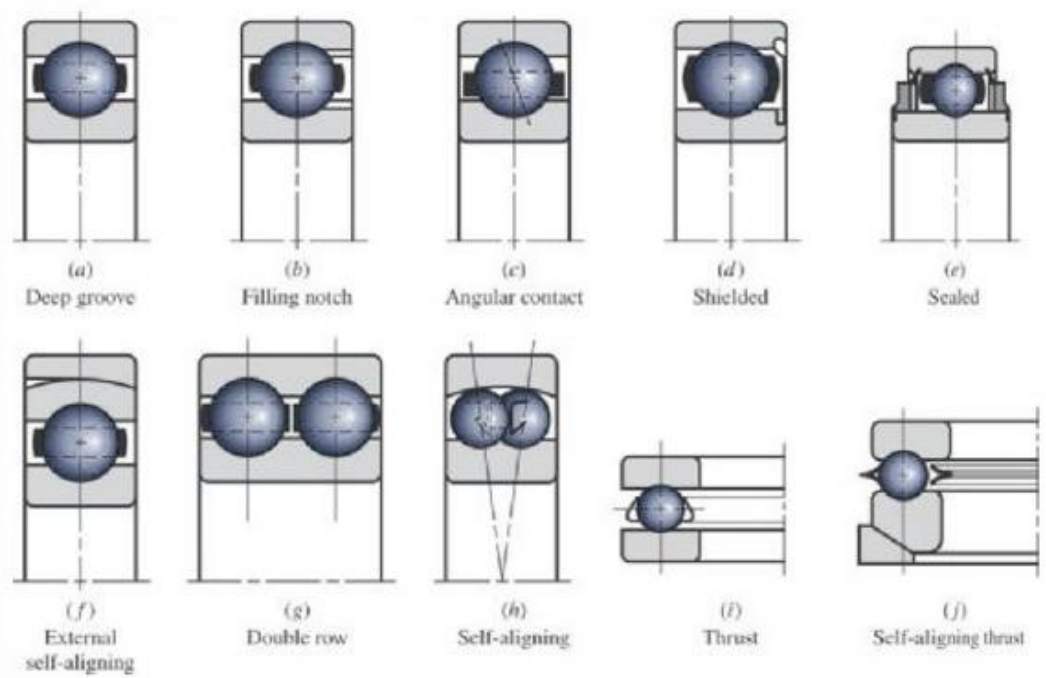
$$P_{max} = \frac{2F}{\pi\,b\,l}$$

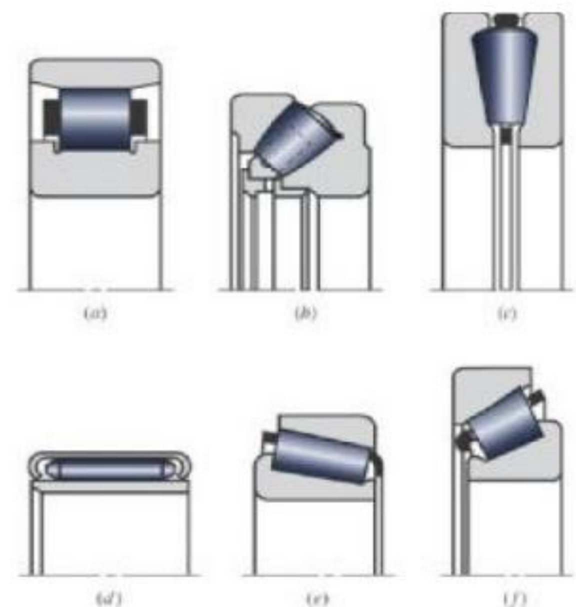
Mancais de rolamento

Tipos de elementos rolante

esféricos

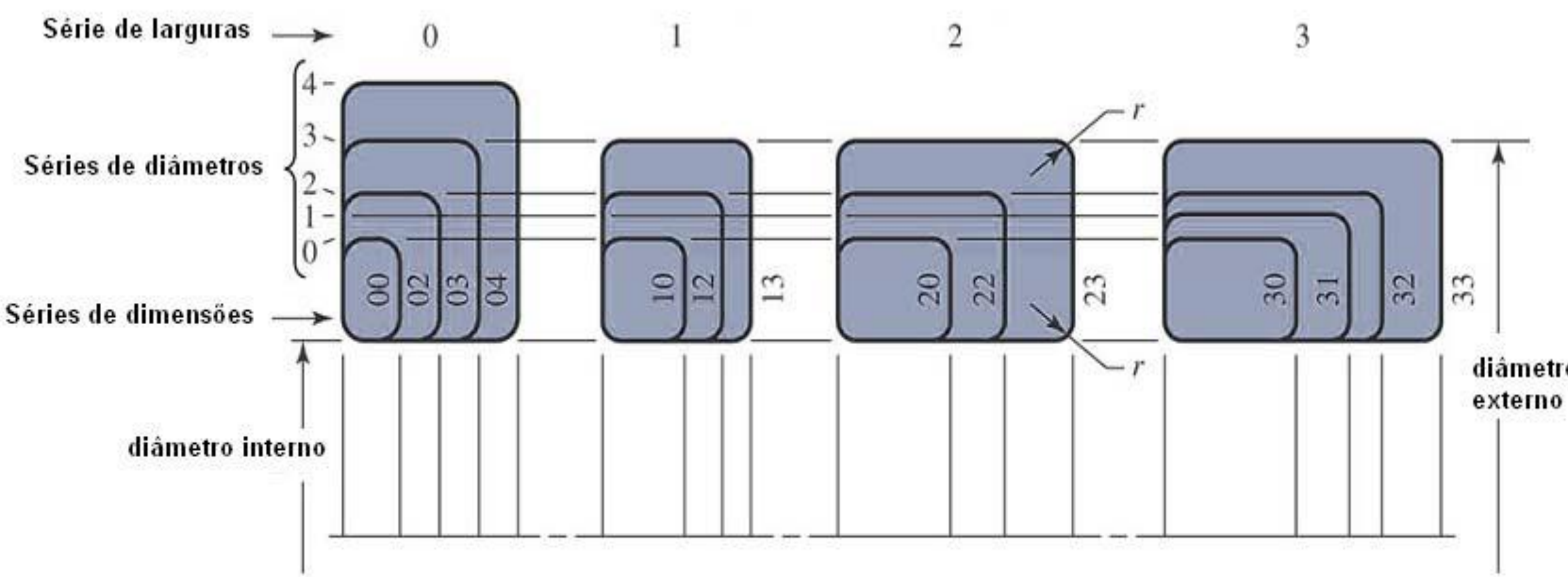
Cilíndricos/cônicos





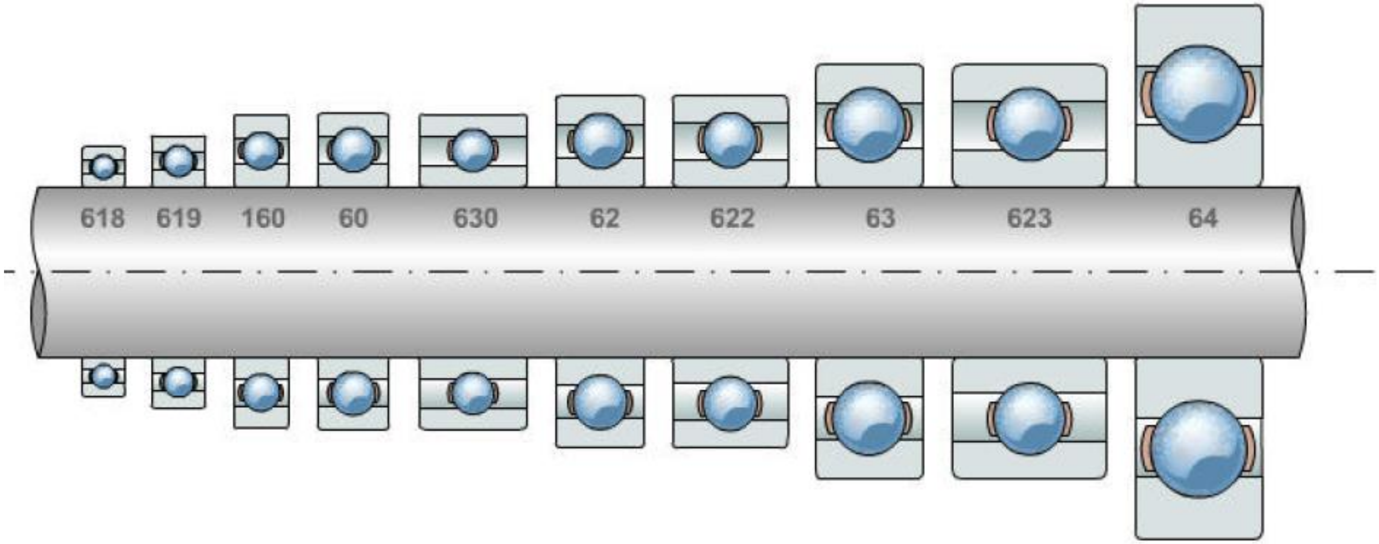
Mancais de rolamento

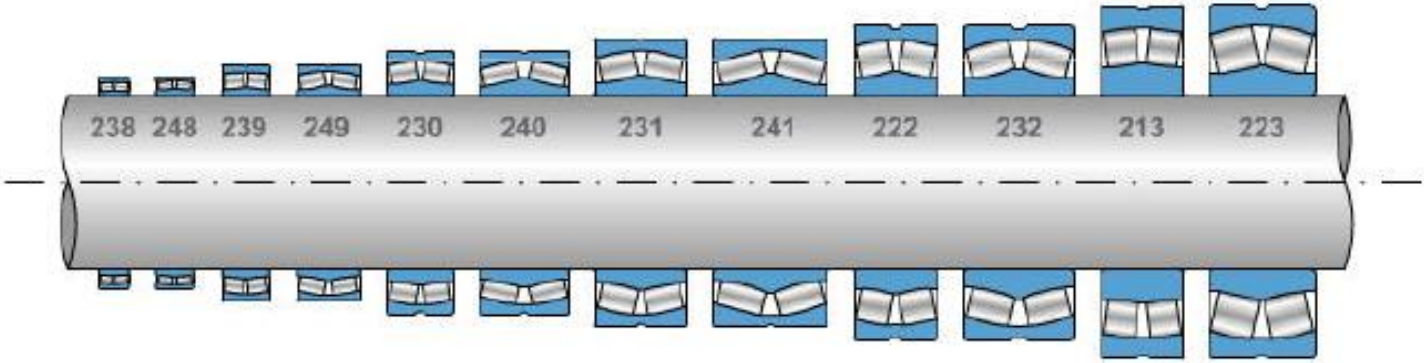
Classes de dimensões



Mancais de rolamento

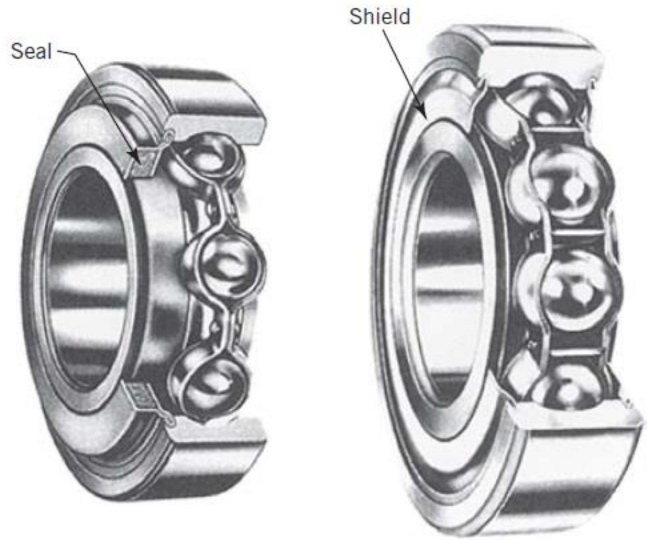
Classes de dimensões

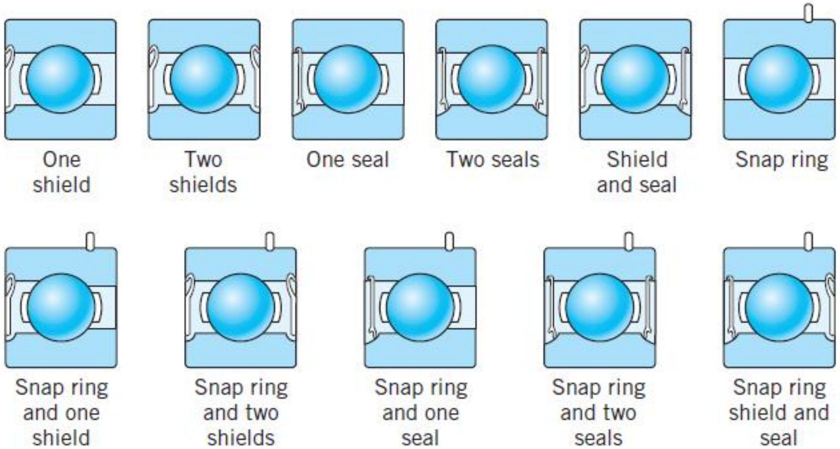




Mancais de rolamento

Classes de dimensões





Mancais de rolamento

Precisão

Tolerâncias geométricas e dimensionais

- Tolerances for bore and outside diameters, ring and bearing width
- Tolerances for inscribed and circumscribed circle diameters of rollers
- Tolerances for chamfer dimensions
- Tolerances for width variation
- Tolerances for tapered bore diameters

Precisão de giro (radial e axial)

- Permissible radial run-out of inner and outer rings
- Permissible face run-out with raceway inner and outer rings
- Permissible inner ring face run-out with bore
- Permissible outer ring variation of outside surface generatrix inclination with face
- Permissible raceway-to-back-face thickness variation of thrust bearings

Mancais de rolamento

Classes de tolerâncias

ABEC SYSTEM	ISO SYSTEM	DIN SYSTEM
ABEC 1	Normal	P0
ABEC 3	Class 6	P6
ABEC 5	Class 5	P5
ABEC 7	Class 4	P4
ABEC 9	Class 2	P2

System bearing type			Precision bearing class			
Metric	Timken	Tapered roller bearings	C	B	A	AA
		Crossed roller bearings	S	P	–	–
	ISO/DIN	All bearing types	P5	P4	P2	–
	ABMA	Non-tapered roller bearings	RBEC 5	RBEC 7	RBEC 9	–
		Ball bearings	ABEC 5	ABEC 7	ABEC 9	–
		Tapered roller bearings	C	B	A	–

http://www.timken.com/pt-br/products/Documents/Super-Precision-Bearings-for-Machine-Tool-Applications-Catalog.pdf

Mancais de rolamento

Classes de tolerâncias

Referenced from ANSI/ABMA Std. 20

Inner Ring: 0.6mm < d ≤ 2.5mm — Unit: μm

Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	Δd_{mp}		Δ_{ds}		K_{ia}	S_d	S_{ia}	ΔB_s		V_{Bs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-8	-	-	10	-	15	0	-40	12
3	0	-7	-	-	5	-	10	0	-40	12
5	0	-5	-	-	4	7	7	0	-40	5
7	0	-4	0	-4	2.5	3	3	0	-40	2.5
9	0	-2.5	0	-2.5	1.5	1.5	1.5	0	-40	1.5

Inner Ring: 2.5mm < d ≤ 10mm — Unit: μm

Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	Δd_{mp}		Δ_{ds}		K_{ia}	S_d	S_{ia}	ΔB_s		V_{Bs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-8	-	-	10	-	20	0	-120	15
3	0	-7	-	-	6	-	15	0	-120	15
5	0	-5	-	-	4	7	7	0	-40	5
7	0	-4	0	-4	2.5	3	3	0	-40	2.5
9	0	-2.5	0	-2.5	1.5	1.5	1.5	0	-40	1.5

Inner Ring: 10mm < d ≤ 18mm — Unit: μm

Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	Δd_{mp}		Δ_{ds}		K_{ia}	S_d	S_{ia}	ΔB_s		V_{Bs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-8	-	-	10	-	20	0	-120	20
3	0	-7	-	-	7	-	20	0	-120	20
5	0	-5	-	-	4	7	7	0	-80	5
7	0	-4	0	-4	2.5	3	3	0	-80	2.5
9	0	-2.5	0	-2.5	1.5	1.5	1.5	0	-80	1.5

Referenced from ANSI/ABMA Std. 20.0

Outer Ring: 2.5mm < D ≤ 6mm — Unit: μm

Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	ΔD_{mp}		ΔD_s		K_{ea}	S_D	S_{ea}	ΔC_s		V_{Cs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-8	-	-	15	-	15	0	-40	12
3	0	-7	-	-	8	-	10	0	-40	12
5	0	-5	-	-	5	8	8	0	-40	5
7	0	-4	0	-4	3	4	5	0	-40	2.5
9	0	-2.5	0	-2.5	1.5	1.5	1.5	0	-40	1.5

Outer Ring: 6mm < D ≤ 18mm — Unit: μm

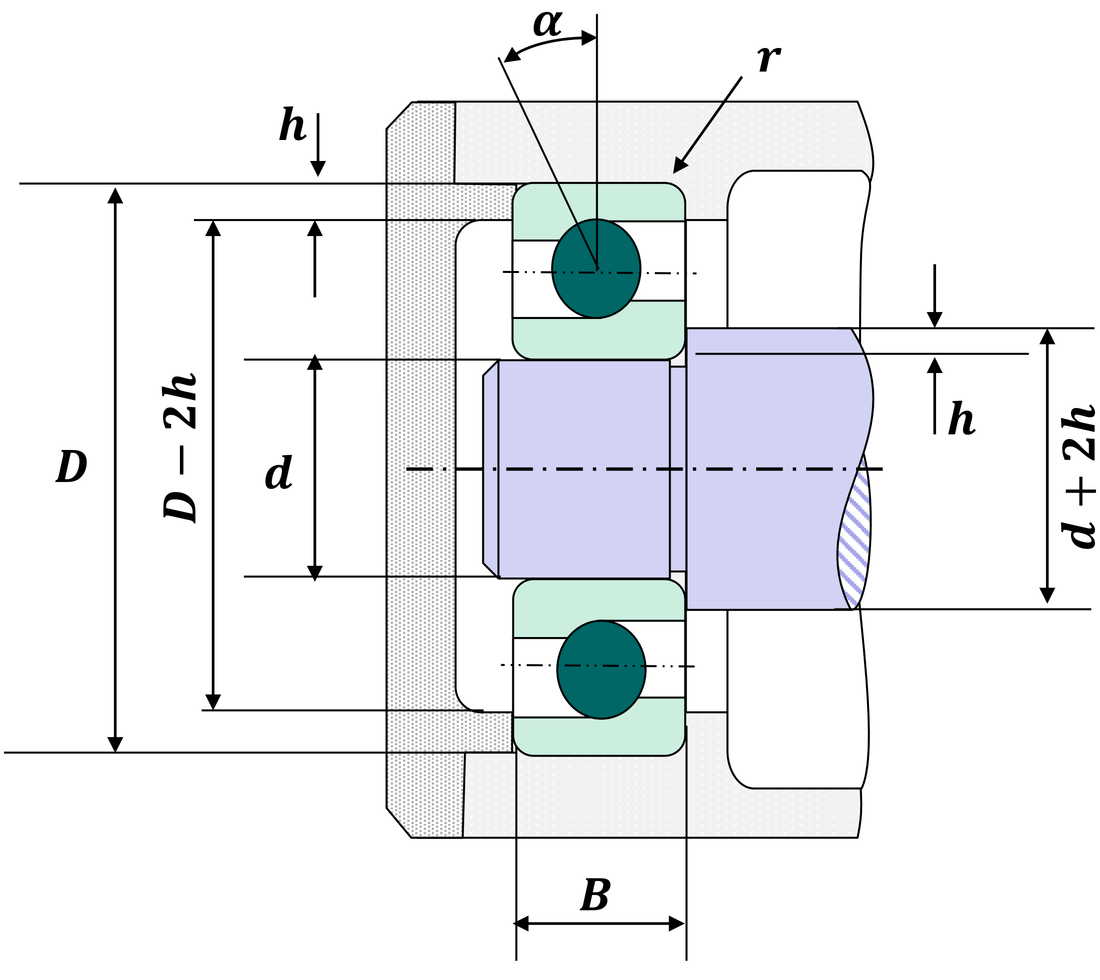
Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	ΔD_{mp}		ΔD_s		K_{ea}	S_D	S_{ea}	ΔC_s		V_{Cs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-8	-	-	15	-	20	0	-120	15
3	0	-7	-	-	8	-	15	0	-120	15
5	0	-5	-	-	5	8	8	0	-40	5
7	0	-4	0	-4	3	4	5	0	-40	2.5
9	0	-2.5	0	-2.5	1.5	1.5	1.5	0	-40	1.5

Outer Ring: 18mm < D ≤ 30mm — Unit: μm

Grade	Dimensional Difference				Radial Runout	Perpendicularity	Axial Runout	Dimensional Difference of Width		Variation of Width
	ΔD_{mp}		ΔD_s		K_{ea}	S_D	S_{ea}	ΔC_s		V_{Cs}
ABEC	High	Low	High	Low	MAX	MAX	MAX	High	Low	MAX
1	0	-9	-	-	15	-	25	0	-120	20
3	0	-8	-	-	9	-	15	0	-120	20
5	0	-6	-	-	6	8	8	0	-80	5
7	0	-5	0	-5	4	4	5	0	-80	2.5
9	0	-4	0	-4	2.5	1.5	2.5	0	-80	1.5

Mancais de rolamento

Dimensionamento



Mancais de rolamento

Dimensionamento

$capacidade\ nominal$

$$L = L_R\left(\frac{C}{F_r}\right)^{3{,}33}$$

$Vida\ correspondente\ a\ 9X10^6 rotações$

$Vida\ correspondente\ ao\ carregamento\ radial\ F_r$

$$C_{req} = F_R\left(\frac{L}{L_r}\right)^{0{,}3}$$

$Capacidade\ nominal\ corrigida\ em\ função\ da\ aplicação$

Mancais de rolamento

Dimensionamento

Bearing Rated Capacities, C, for $L_R = 90 \times 10^6$

Revolution Life with 90 Percent Reliability

	Radial Ball, $\alpha = 0°$			Angular Ball, $\alpha = 25°$			Roller		
Bore (mm)	100 Xlt (kN)	200 lt (kN)	300 med (kN)	100 Xlt (kN)	200 lt (kN)	300 med (kN)	1000 Xlt (kN)	1200 lt (kN)	1300 med (kN)
10	1.02	1.42	1.90	1.02	1.10	1.88			
12	1.12	1.42	2.46	1.10	1.54	2.05			
15	1.22	1.56	3.05	1.28	1.66	2.85			
17	1.32	2.70	3.75	1.36	2.20	3.55	2.12	3.80	4.90
20	2.25	3.35	5.30	2.20	3.05	5.80	3.30	4.40	6.20
25	2.45	3.65	5.90	2.65	3.25	7.20	3.70	5.50	8.50
30	3.35	5.40	8.80	3.60	6.00	8.80	2.40[a]	8.30	10.0
35	4.20	8.50	10.6	4.75	8.20	11.0	3.10[a]	9.30	13.1
40	4.50	9.40	12.6	4.95	9.90	13.2	7.20	11.1	16.5
45	5.80	9.10	14.8	6.30	10.4	16.4	7.40	12.2	20.9
50	6.10	9.70	15.8	6.60	11.0	19.2	5.10[a]	12.5	24.5
55	8.20	12.0	18.0	9.00	13.6	21.5	11.3	14.9	27.1
60	8.70	13.6	20.0	9.70	16.4	24.0	12.0	18.9	32.5
65	9.10	16.0	22.0	10.2	19.2	26.5	12.2	21.1	38.3
70	11.6	17.0	24.5	13.4	19.2	29.5		23.6	44.0
75	12.2	17.0	25.5	13.8	20.0	32.5		23.6	45.4
80	14.2	18.4	28.0	16.6	22.5	35.5	17.3	26.2	51.6
85	15.0	22.5	30.0	17.2	26.5	38.5	18.0	30.7	55.2
90	17.2	25.0	32.5	20.0	28.0	41.5		37.4	65.8
95	18.0	27.5	38.0	21.0	31.0	45.5		44.0	65.8
100	18.0	30.5	40.5	21.5	34.5		20.9	48.0	72.9
105	21.0	32.0	43.5	24.5	37.5			49.8	84.5
110	23.5	35.0	46.0	27.5	41.0	55.0	29.4	54.3	85.4
120	24.5	37.5		28.5	44.5			61.4	100.1
130	29.5	41.0		33.5	48.0	71.0	48.9	69.4	120.1
140	30.5	47.5		35.0	56.0			77.4	131.2
150	34.5			39.0	62.0		58.7	83.6	
160								113.4	
180	47.0			54.0			97.9	140.1	
200								162.4	
220								211.3	
240								258.0	

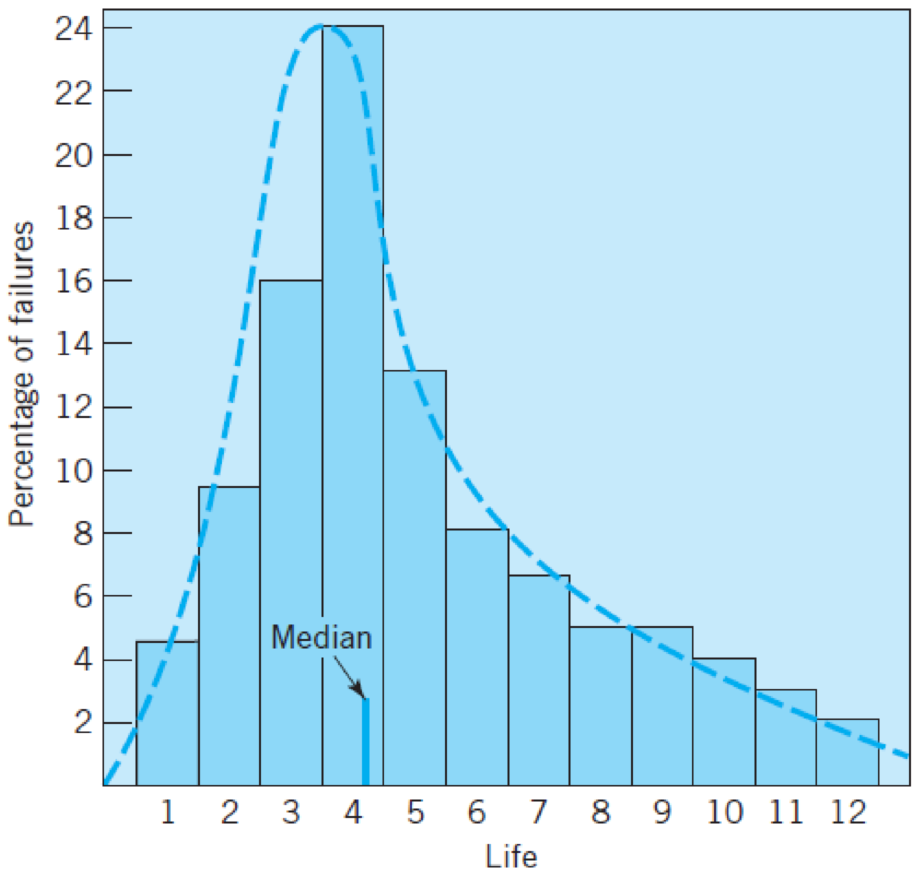
Mancais de rolamento

Dimensionamento

- A vida padrão é comumente designada como a vida L_{10}.
- A vida L_{10} corresponde a uma probabilidade de falha de 10%, isso representa que 90% dos rolamentos não falharam quando essa vida é atingida, correspondendo a 90% de confiabilidade
- Os testes mostram que a vida média de rolamentos (rolamentos de esferas em particular) é cerca de cinco vezes a vida de fadiga padrão para L_{10}
- Muitos projetos exigem mais de 90% de confiabilidade
- A probabilidade de falha de mancais de elementos rolantes não segue uma distribuiçã gaussiana, mas sim um distribuição de Weibull
- Isso leva a necessidade do ajuste da curva de vida por meio do fator de confiabilidade Kr

Mancais de rolamento

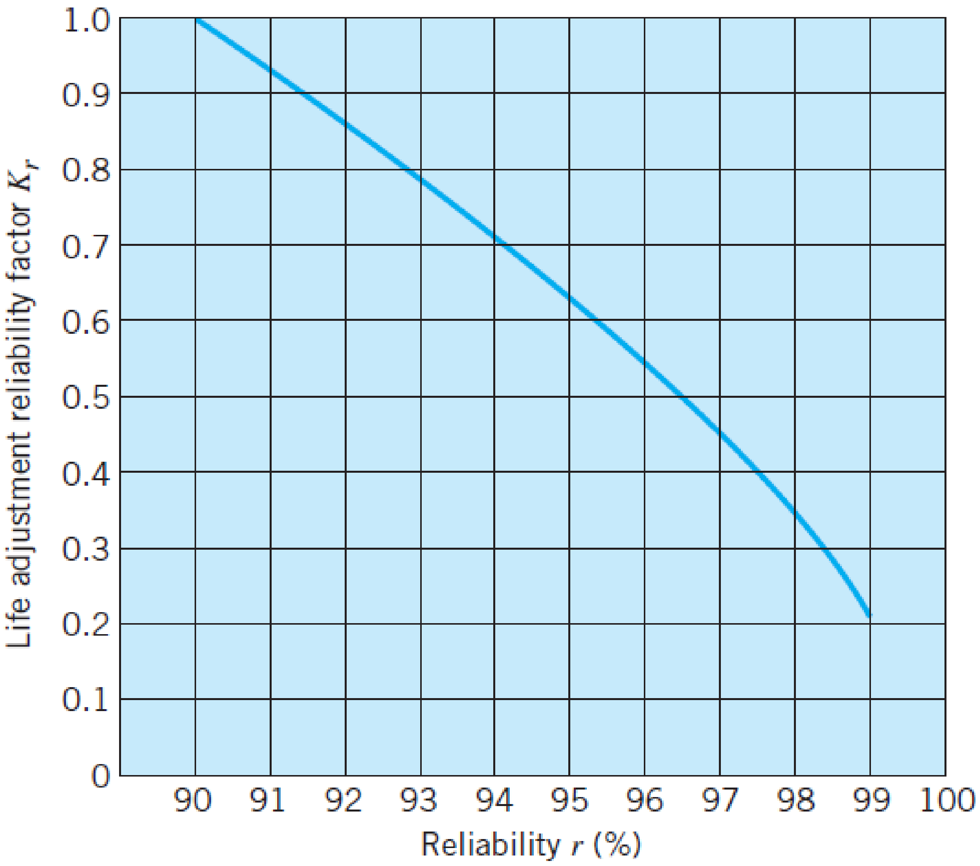
Dimensionamento



Distribuição de Weibull para vida em fadiga de mancais de elementos rolantes

Mancais de rolamento

Dimensionamento



Fator de confiabilidade Kr

Mancais de rolamento

Dimensionamento

$corrigindo\ L_r\ e\ C_{req}\ em\ termos\ de\ K_r, temos\ \Rightarrow$

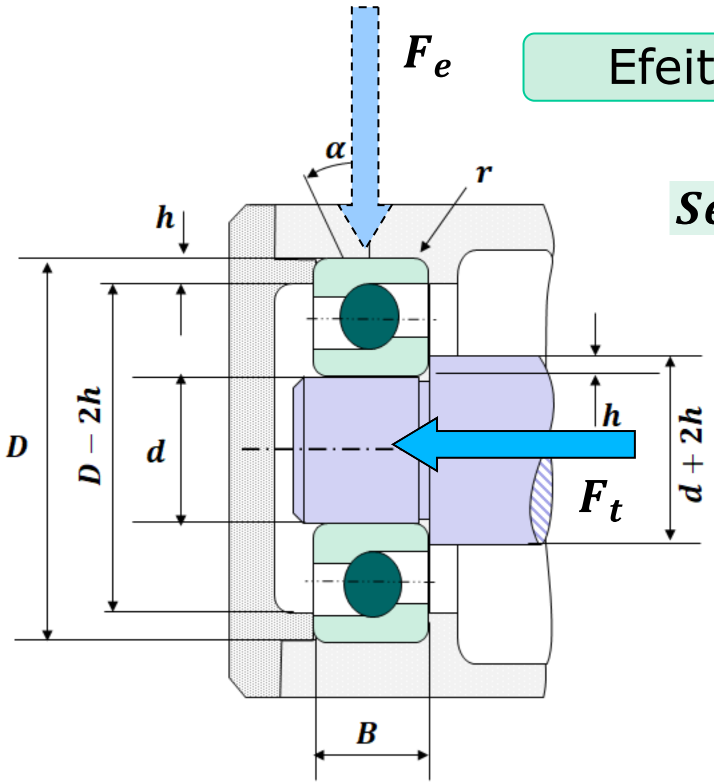
$$L = L_R\left(\frac{C}{F_r}\right)^{3,33} \Rightarrow L = K_r L_R\left(\frac{C}{F_r}\right)^{3,33}$$

$$C_{req} = F_R\left(\frac{L}{L_r}\right)^{0,3} \Rightarrow C_{req} = F_R\left(\frac{L}{K_r.L_r}\right)^{0,3}$$

Mancais de rolamento

Dimensionamento

Efeito do carregamento axial



Sendo F_e o carregamento radial equivalente

para mancais rígidos de esfera ⇒ $\alpha = 0°$

para: $0 < F_t/F_r < 0.35, \quad F_e = F_r$

para: $0.35 < F_t/F_r < 10, \quad F_e = F_r\left[1 + 1.115\left(\frac{F_t}{F_r} - 0.35\right)\right]$

para: $F_t/F_r > 10, \quad F_e = 1.176F_t$

para mancais de contato angular ⇒ $\alpha = 25°$

para: $0 < F_t/F_r < 0.68, \quad F_e = F_r$

para: $0.68 < F_t/F_r < 10, \quad F_e = F_r\left[1 + 0.870\left(\frac{F_t}{F_r} - 0.68\right)\right]$

para: $F_t/F_r > 10, \quad F_e = 0.911F_t$

Mancais de rolamento

Dimensionamento

Efeito de choques e impactos

- O dimensionamento de mancais de elementos rolantes em geral é feito para condições de carregamento uniforme.
- Na presença de choques ou impactos, o fator Ka deve ser aplicado para corrigir a vida

Factors K_a

Type of Application	Ball Bearing	Roller Bearing
Uniform load, no impact	1.0	1.0
Gearing	1.0–1.3	1.0
Light impact	1.2–1.5	1.0–1.1
Moderate impact	1.5–2.0	1.1–1.5
Heavy impact	2.0–3.0	1.5–2.0

Mancais de rolamento

Dimensionamento

corrigindo L_r *em termos de* K_a,

e espressando o carregamento em termos de F_e *temos* $\Rightarrow$

$$L = K_r L_R \left(\frac{C}{F_r}\right)^{3{,}33} \Rightarrow L = K_r L_R \left(\frac{C}{K_a . F_e}\right)^{3{,}33}$$

$$C_{req} = F_R \left(\frac{L}{K_r . L_r}\right)^{0{,}3} \Rightarrow C_{req} = K_a . F_e \left(\frac{L}{K_r . L_r}\right)^{0{,}3}$$

Mancais de rolamento

Dimensionamento

Representative Bearing Design Lives

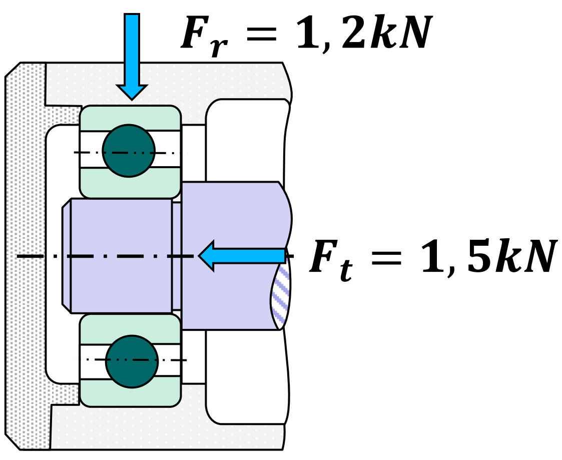
Type of Application	**Design Life (thousands of hours)**
Instruments and apparatus for infrequent use	0.1–0.5
Machines used intermittently, where service interruption is of minor importance	4–8
Machines intermittently used, where reliability is of great importance	8–14
Machines for 8-hour service, but not every day	14–20
Machines for 8-hour service, every working day	20–30
Machines for continuous 24-hour service	50–60
Machines for continuous 24-hour service where reliability is of extreme importance	100–200

Mancais de rolamento

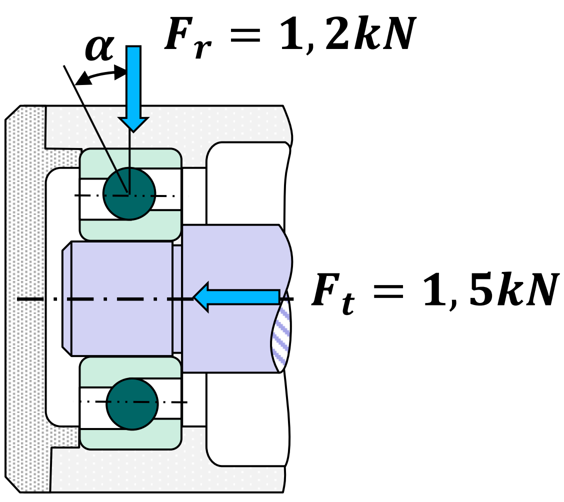
Exemplo

Selecione um rolamento de esferas para uso no eixo de um prensa industrial. A prensa operará de forma contínua em um turno de 8h/dia a 1800 rpm.

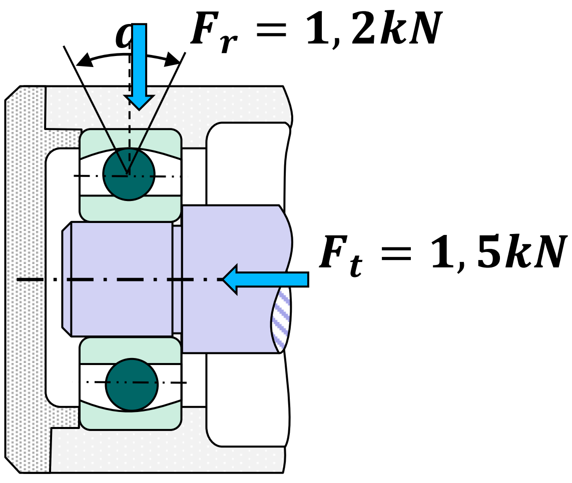
Cargas radiais e axiais são 1,2kN e 1,5kN, respectivamente, com impacto leve a moderado.



rolamento rígido de esferas



rolamento de contato angular



rolamento autocompensador

Mancais de rolamento

Exemplo

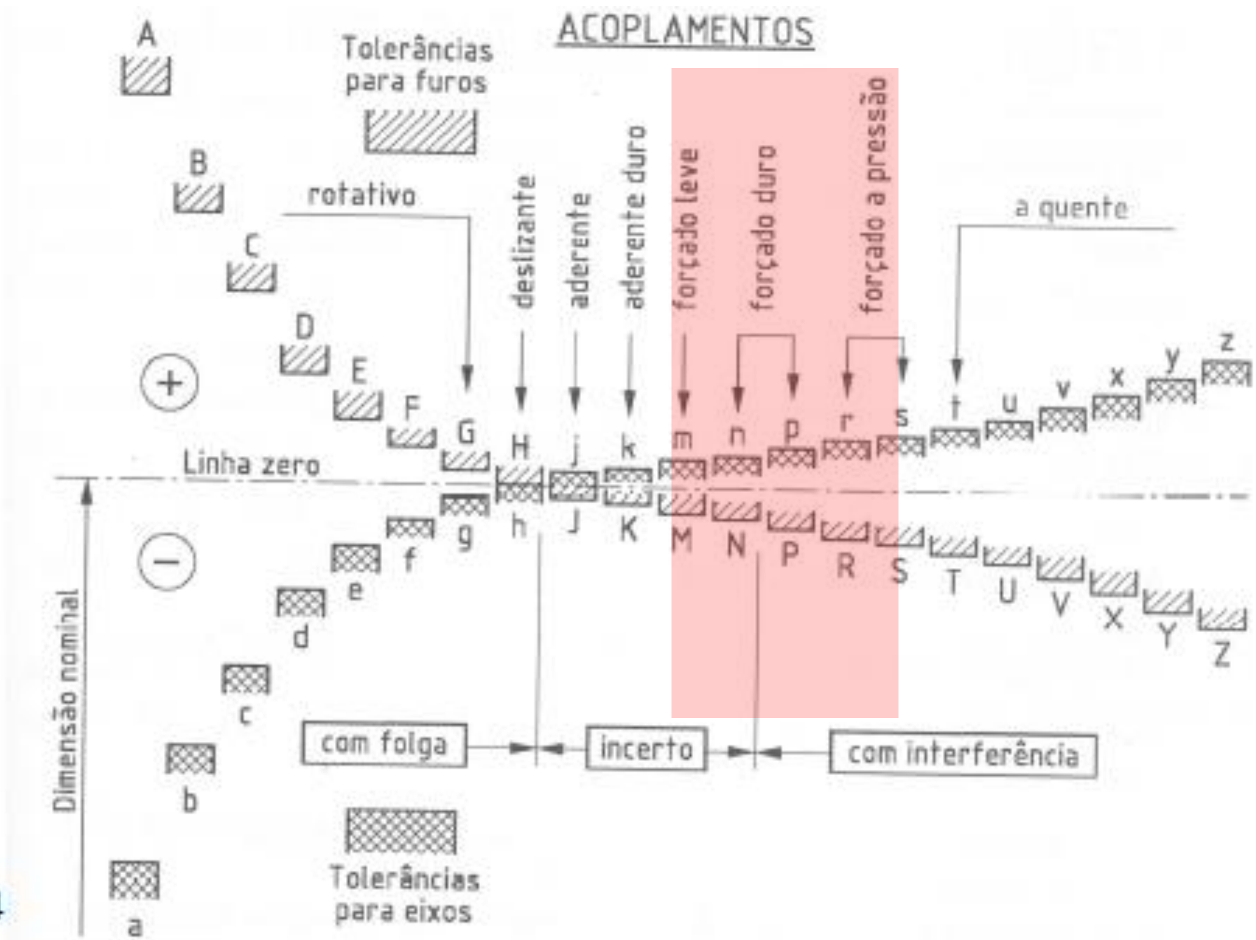


Figura 4

Campos de tolerância e ajustes mecânicos

Mancais de rolamento

Exemplo

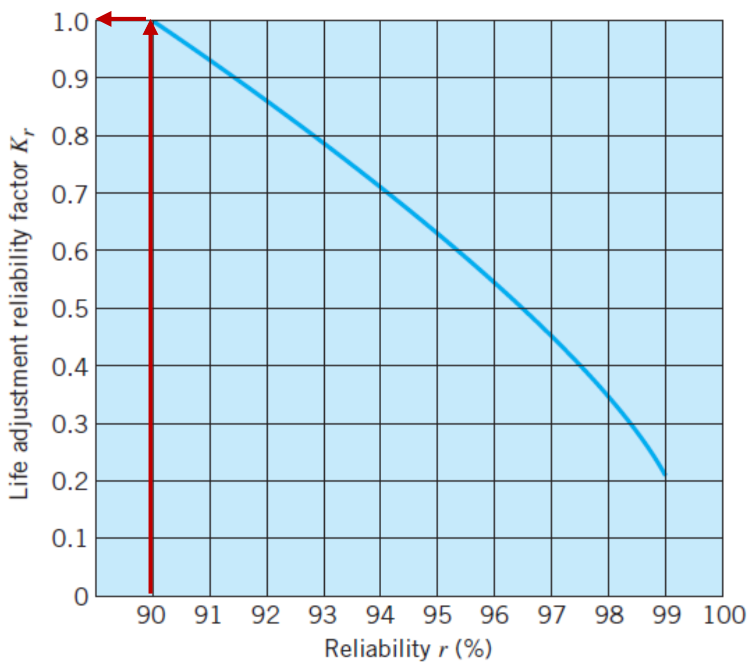
Premissas básicas:

- Projeto conservador para impacto leve a moderado.
- É necessária uma vida útil de projeto de 8 horas por dia de serviço contínuo.
- É necessária uma confiabilidade de 90%
- Tanto um rolamento de esferas radial quanto um angular podem ser selecionado. Um rolamento autocompensador vai depender da amplitude da flexão na ponta do eixo.
- A vida do rolamento de esferas varia inversamente com a potência da carga
- O ajuste prensado não afeta a vida útil do rolamento.

Mancais de rolamento

Exemplo

$Fator\ de\ confiabilidade\ K_r$



$$K_r = 1$$

$Fator\ de\ impacto\ K_a$ $\quad K_a = 1,5$

Factors K_a

Type of Application	Ball Bearing	Roller Bearing
Uniform load, no impact	1.0	1.0
Gearing	1.0–1.3	1.0
Light impact	1.2–1.5	1.0–1.1
Moderate impact	1.5–2.0	1.1–1.5
Heavy impact	2.0–3.0	1.5–2.0

$$L_r = 30X10^3\ horas$$

Representative Bearing Design Lives

Type of Application	Design Life (thousands of hours)
Instruments and apparatus for infrequent use	0.1–0.5
Machines used intermittently, where service interruption is of minor importance	4–8
Machines intermittently used, where reliability is of great importance	8–14
Machines for 8-hour service, but not every day	14–20
Machines for 8-hour service, every working day	20–30
Machines for continuous 24-hour service	50–60
Machines for continuous 24-hour service where reliability is of extreme importance	100–200

Mancais de rolamento

Exemplo

Calculando o carregamento radial equivalente F_e

$F_r = 1,2kN$

$F_t = 1,5kN$

$$\frac{F_t}{F_r} = \frac{1,5}{1,2} = 1,25$$

$para\ mancais\ rígidos\ de\ esfera \Rightarrow\ \alpha = 0°$

para: $0 < F_t/F_r < 0.35, \quad F_e = F_r$

para: $0.35 < F_t/F_r < 10, \quad F_e = F_r\left[1 + 1.115\left(\frac{F_t}{F_r} - 0.35\right)\right]$

para: $F_t/F_r > 10, \quad F_e = 1.176F_t$

$$F_e = F_r\left[1 + 1,115\left(\frac{F_t}{F_r} - 0,35\right)\right]$$

$$F_{e_{esf}} = 2,4\ kN$$

$para\ mancais\ de\ contato\ angular \Rightarrow\ \alpha = 25°$

para: $0 < F_t/F_r < 0.68, \quad F_e = F_r$

para: $0.68 < F_t/F_r < 10, \quad F_e = F_r\left[1 + 0.870\left(\frac{F_t}{F_r} - 0.68\right)\right]$

para: $F_t/F_r > 10, \quad F_e = 0.911F_t$

$$F_e = F_r\left[1 + 0,870\left(\frac{F_t}{F_r} - 0,68\right)\right]$$

$$F_{e_{cont}} = 1,8\ kN$$

Mancais de rolamento

Exemplo

$K_r = 1$

$K_a = 1,5$

$L_r = 30X10^3$

$Vida\ L\ em\ [rpm] = n\ .\ L_r\ [mim]$

$L = 1800rpm\ .\ 30X10^3 h.\ 60min/h$

$L = \ 3240X10^6\ revoluções$

$$C_{req} = K_a . F_e \left(\frac{L}{K_r . L_r} \right)^{0,3}$$

$F_{e_{esf}} = 2,4\ kN$ → $C_{req_{esf}} = 10,55kN$

$F_{e_{cont}} = 1,8\ kN$ → $C_{req_{cont}} = 7,91N$

Mancais de rolamento

Exemplo

Bearing Rated Capacities, C, for $L_R = 90 \times 10^6$ Revolution Life with 90 Percent Reliability

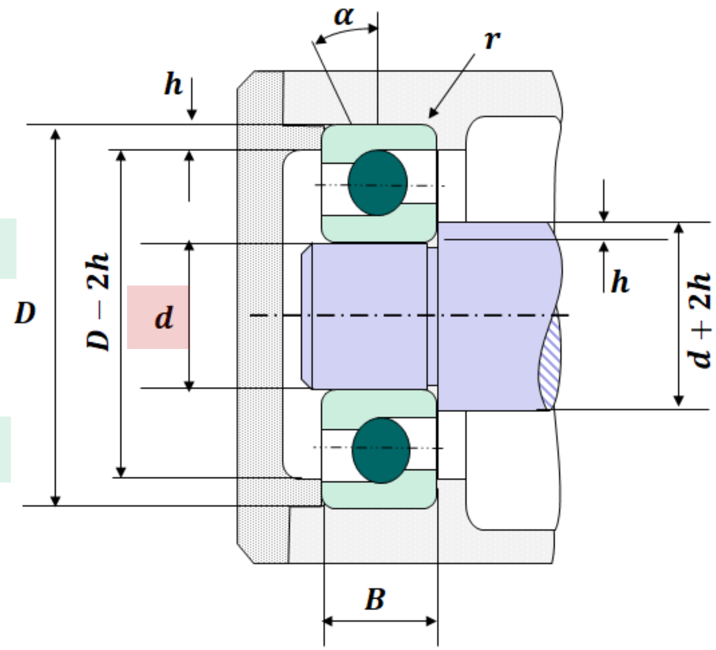
Bore (mm)	Radial Ball, $\alpha = 0°$ L00 Xlt (kN)	200 lt (kN)	300 med (kN)	Angular Ball, $\alpha = 25°$ L00 Xlt (kN)	200 lt (kN)	300 med (kN)	Roller 1000 Xlt (kN)	1200 lt (kN)	1300 med (kN)
10	1.02	1.42	1.90	1.02	1.10	1.88			
12	1.12	1.42	2.46	1.10	1.54	2.05			
15	1.22	1.56	3.05	1.28	1.66	2.85			
17	1.32	2.70	3.75	1.36	2.20	3.55	2.12	3.80	4.90
20	2.25	3.35	5.30	2.20	3.05	5.80	3.30	4.40	6.20
25	2.45	3.65	5.90	2.65	3.25	7.20 7,91	3.70	5.50	8.50
30	3.35	5.40	8.80	3.60	6.00 7,91	8.80	2.40[a]	8.30	10.0
35	4.20	8.50	10,55 10.6	4.75	8.20	11.0	3.10[a]	9.30	13[illegible]
40	4.50	9.40	12.6	4.95	9.90	13.2	7.20	11.1	16.5
45	5.80	9.10	14.8	6.30	10.4	16.4	7.40	12.2	20.9
50	6.10	9.70 10,55	15.8	6.60 7,91	11.0	19.2	5.10[a]	12.5	24.5
55	8.20	12.0	18.0	9.00	13.6	21.5	11.3	14.9	27.1
60	8.70	13.6	20.0	9.70	16.4	24.0	12.0	18.9	32.5
65	9.10 10,55	16.0	22.0	10.2	19.2	26.5	12.2	21.1	38.3
70	11.6	17.0	24.5	13.4	19.2	29.5		23.6	44.0
75	12.2	17.0	25.5	13.8	20.0	32.5		23.6	45.4

$$C_{req_{esf}} = 10,55kN$$

$$C_{req_{cont}} = 7,91N$$

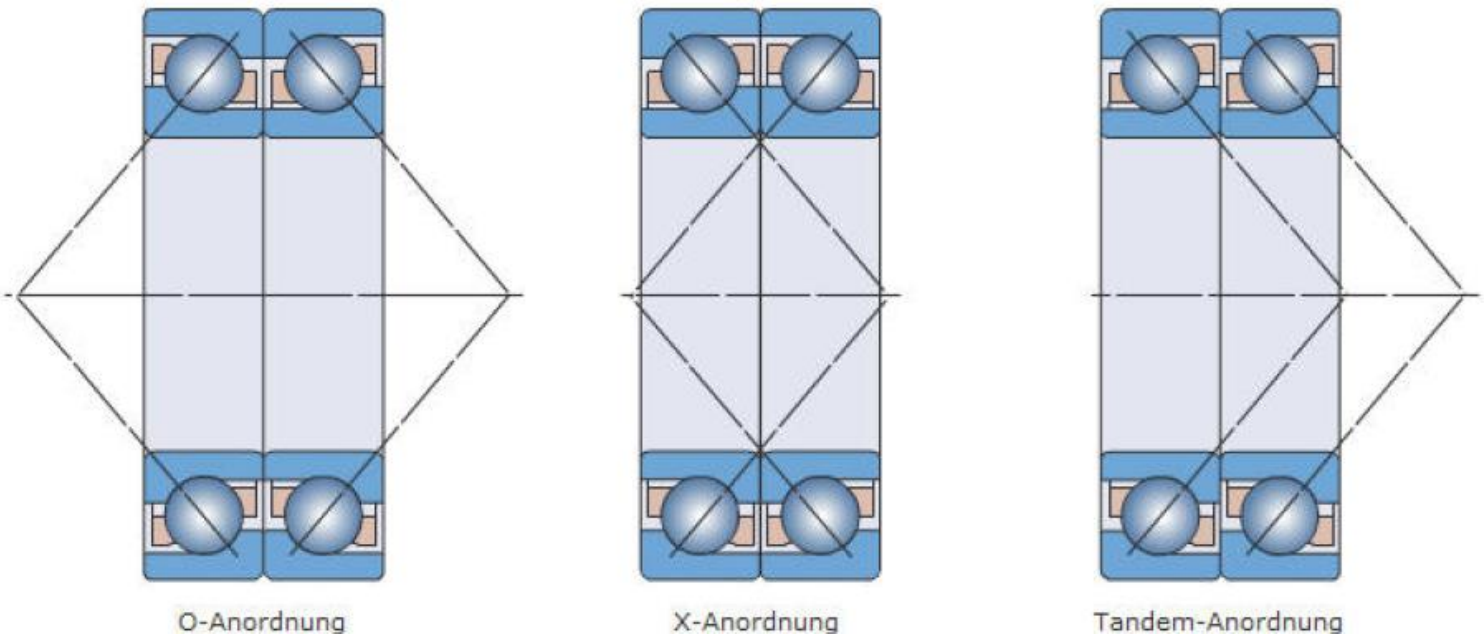
$$d_{cont} = 55mm$$

$$d_{esf} = 70mm$$



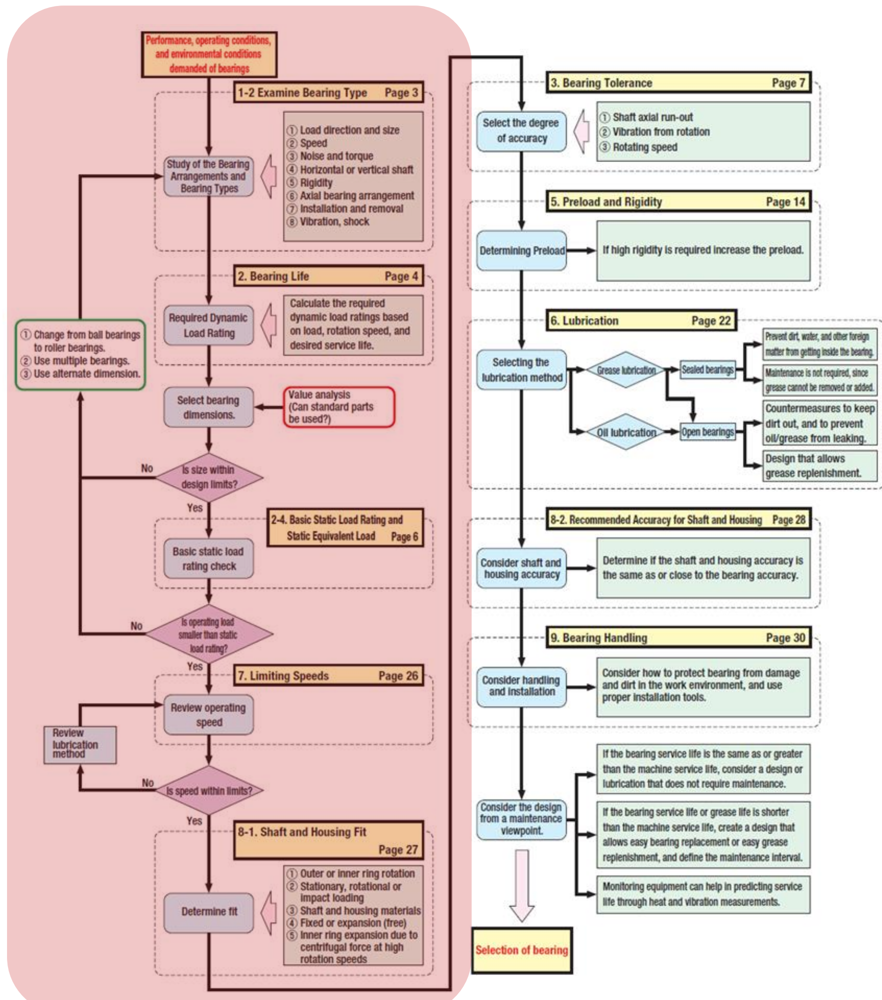
Mancais de rolamento

Considerações de montagem

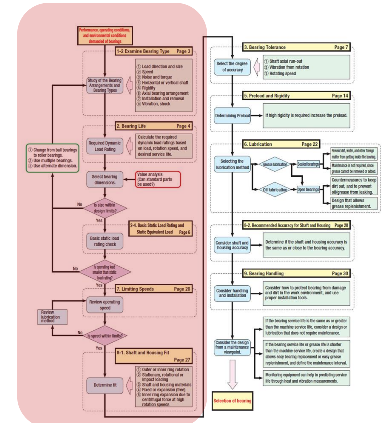


Mancais de rolamento

Seleção

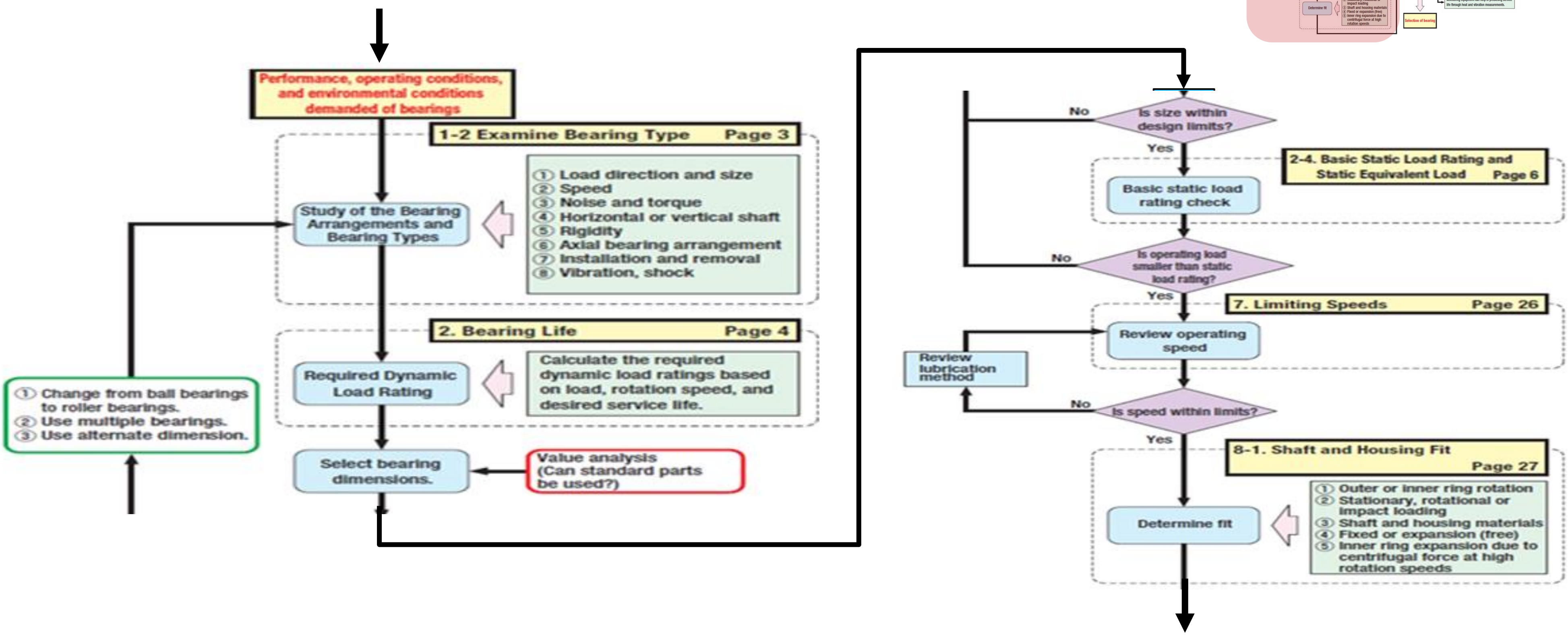


https://www.nachi-fujikoshi.co.jp/eng/web/pdf/B1031E-5.pdf



Mancais de rolamento

Seleção



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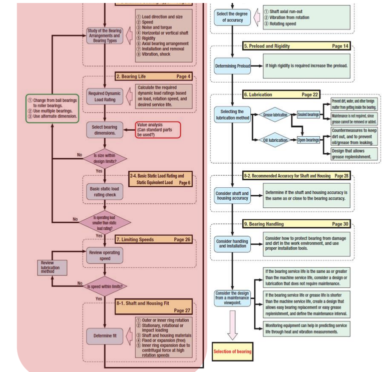
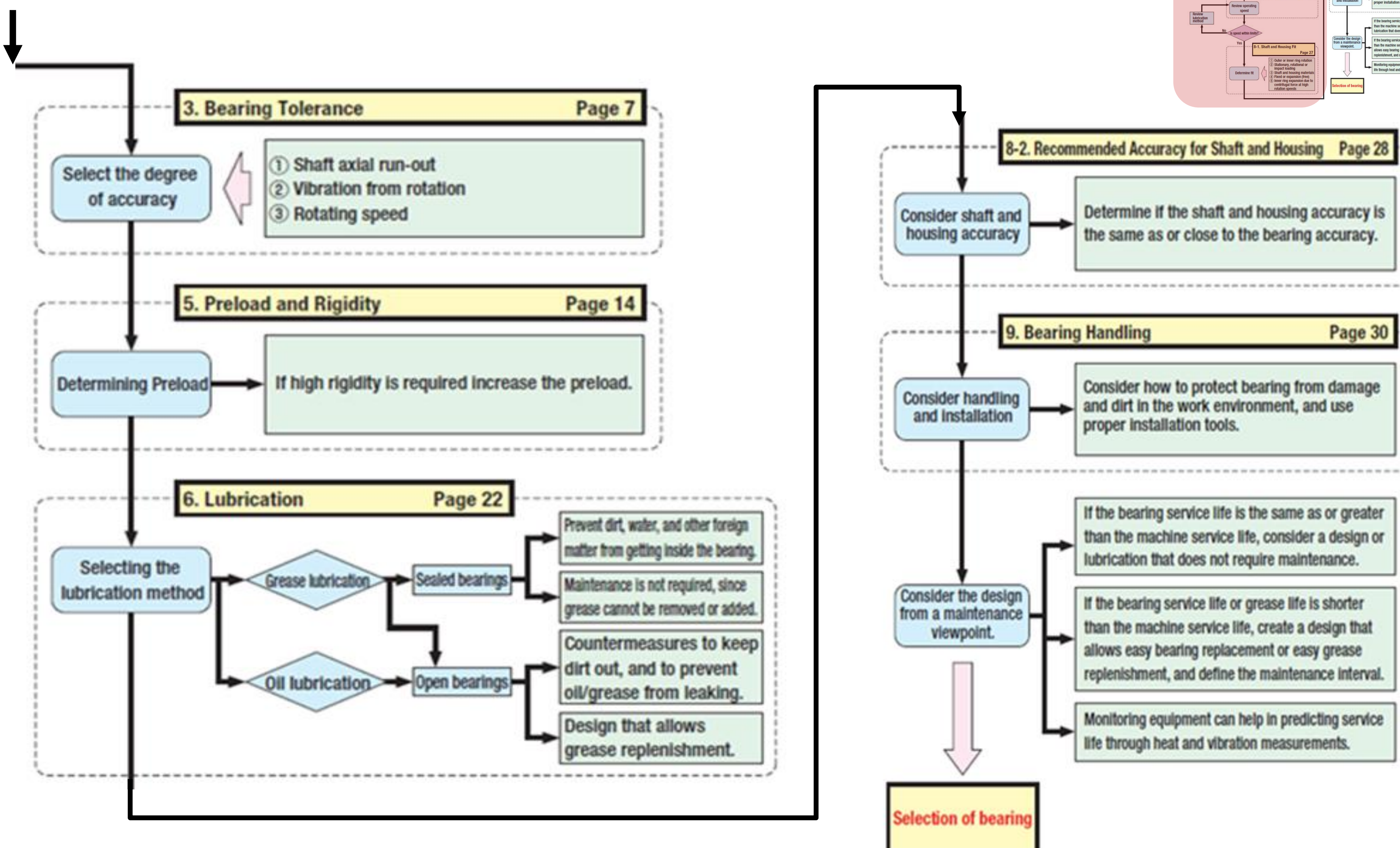
Mancais de rolamento

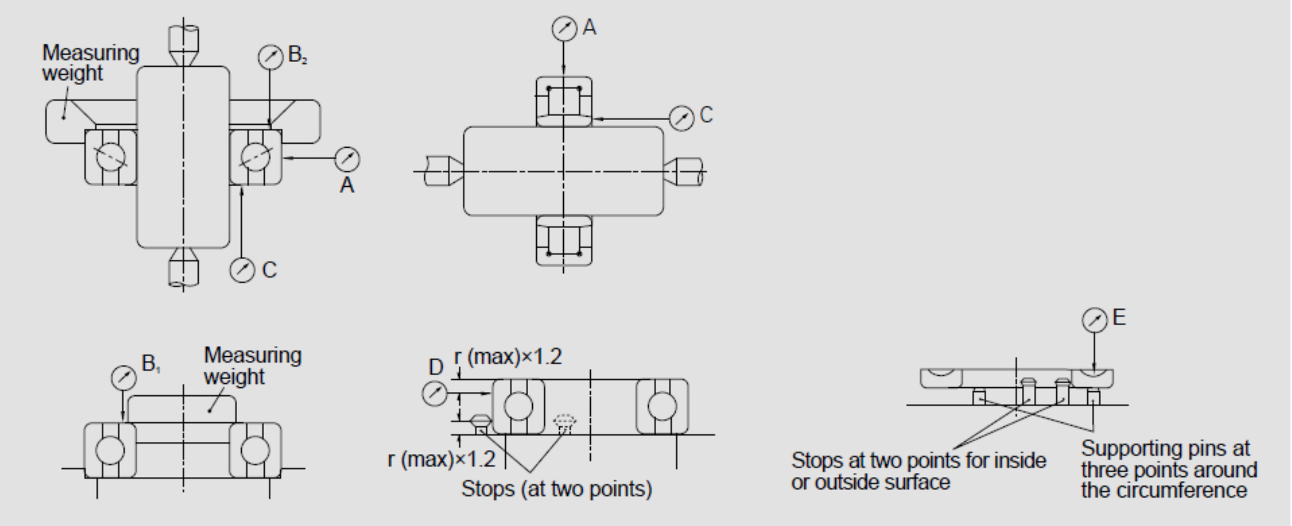
Seleção





Mancais de rolamento

Erros de movimento



Running accuracy	Inner ring	Outer ring	Measuring point
K_{ia}	rotating	stationary	A
K_{ea}	stationary	rotating	A
S_{ia}	rotating	stationary	B_1
S_{ea}	stationary	rotating	B_2
S_d	rotating	stationary	C
S_D	–	rotating	D
S_i , S_e	Only the shaft or housing or central washer is to be rotated		E

https://www.nskeurope.com/downloads/literature_bearing/EN-TI-0112-FINAL.pdf

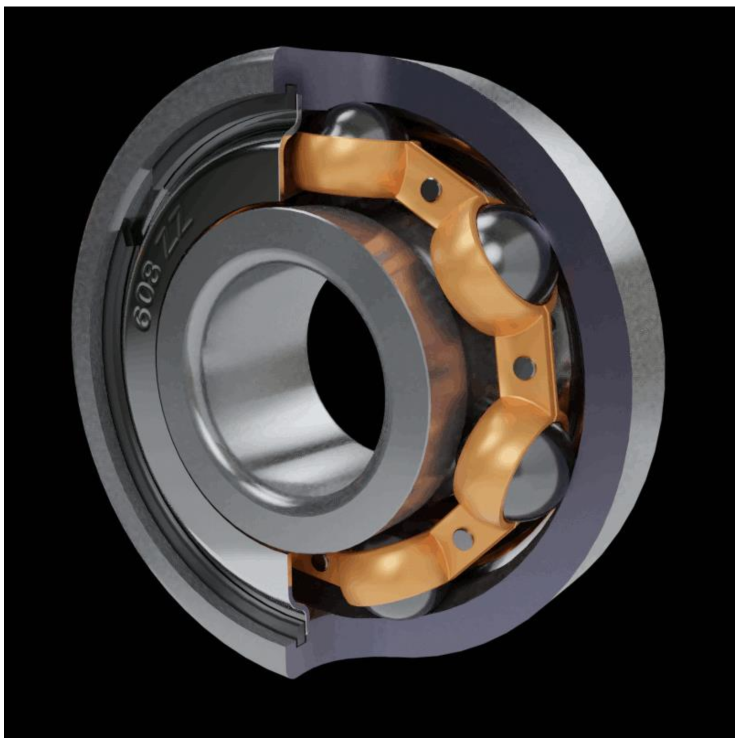
Mancais de rolamento

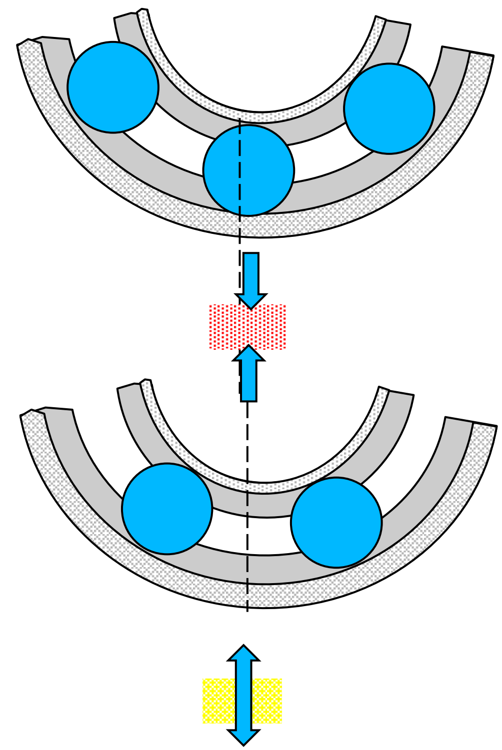
Falhas em mancais de rolamento

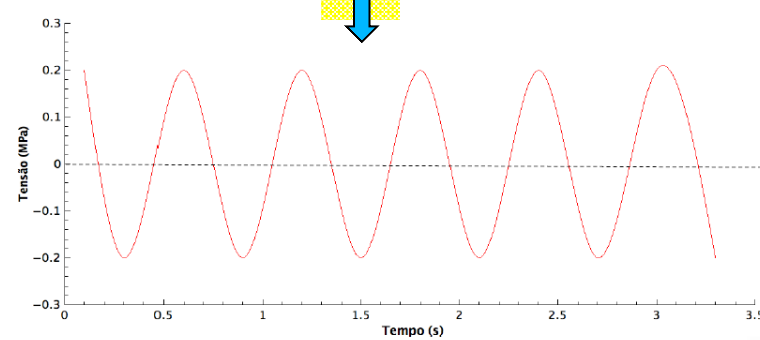
- Desalinhamento
- Flexão dos eixos
- Contaminação na interface
- Montagem errada
- Acabamento superficial
- Ciclo de carregamento
- Condições de lubrificação
- Velocidade de operação
- Tipo de lubrificante
- Choques
- Material do mancal
- Sobrecargas
- Tipo de elemento
- Tipo de mancal
- Seleção errada

Mancais de rolamento

Falhas em mancais de rolamento







Mancais de rolamento

Falhas em mancais de rolamento

FIM DA AULA