



ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

Elementos de Máquinas para Automação

PMR 3307 – A27

Guias lineares

2023.2



Introdução

Mancais e Guias

Mancais



- **Mancais** são elementos de máquinas que tem por função básica absorver carregamentos, e onde o movimento de **translação** em qualquer direção deve ser minimizado, deixando **livre** somente a **rotação** em torno de um eixo.

Guias



- **Guias** são elementos de máquinas que tem por função básica absorver carregamentos, e onde o movimento de **rotação** em qualquer direção deve ser minimizado, deixando **livre** somente a **translação** ao longo de um eixo.



Guias

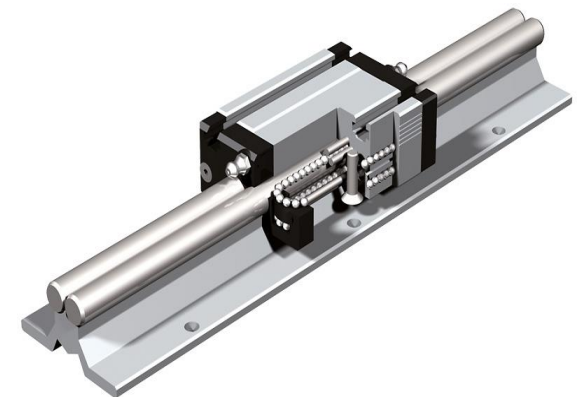
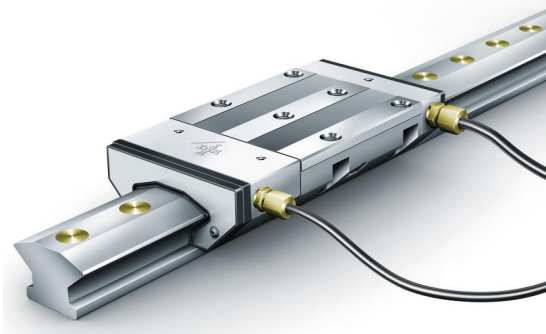
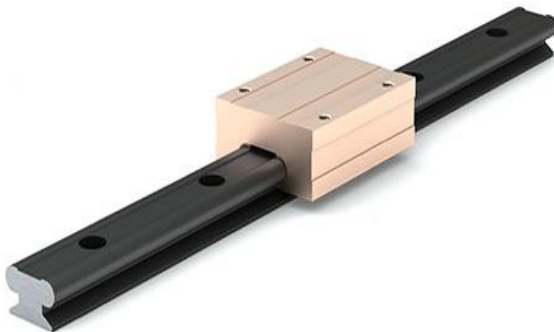
Classificação

Escorregamento

A filme fluido

Elementos rolantes

hidrostáticas



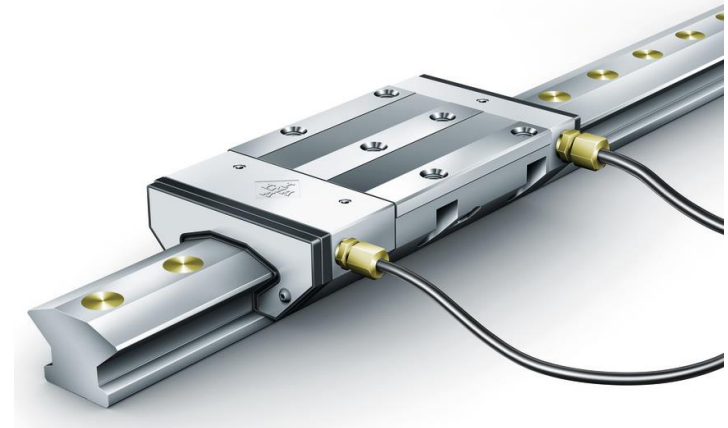


Guias

Hoje!

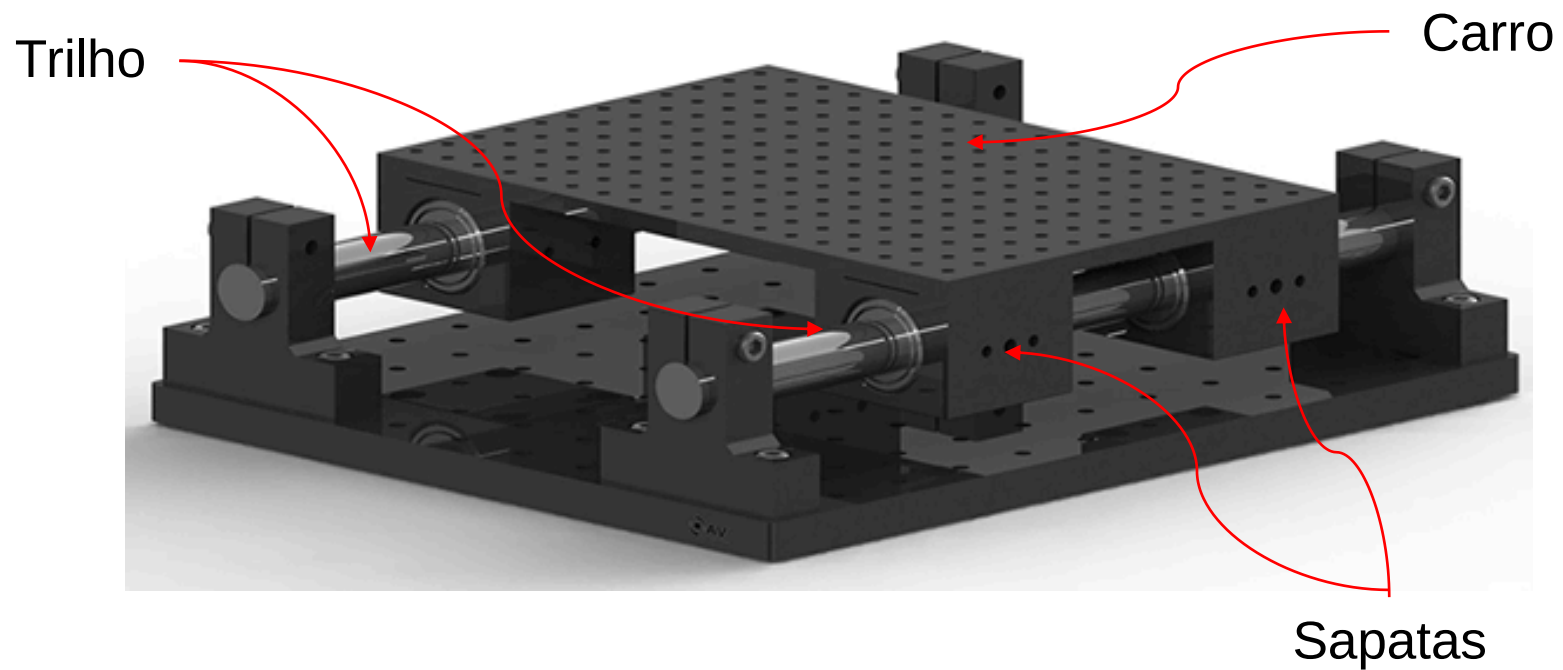
de elementos rolantes

hidrostáticas





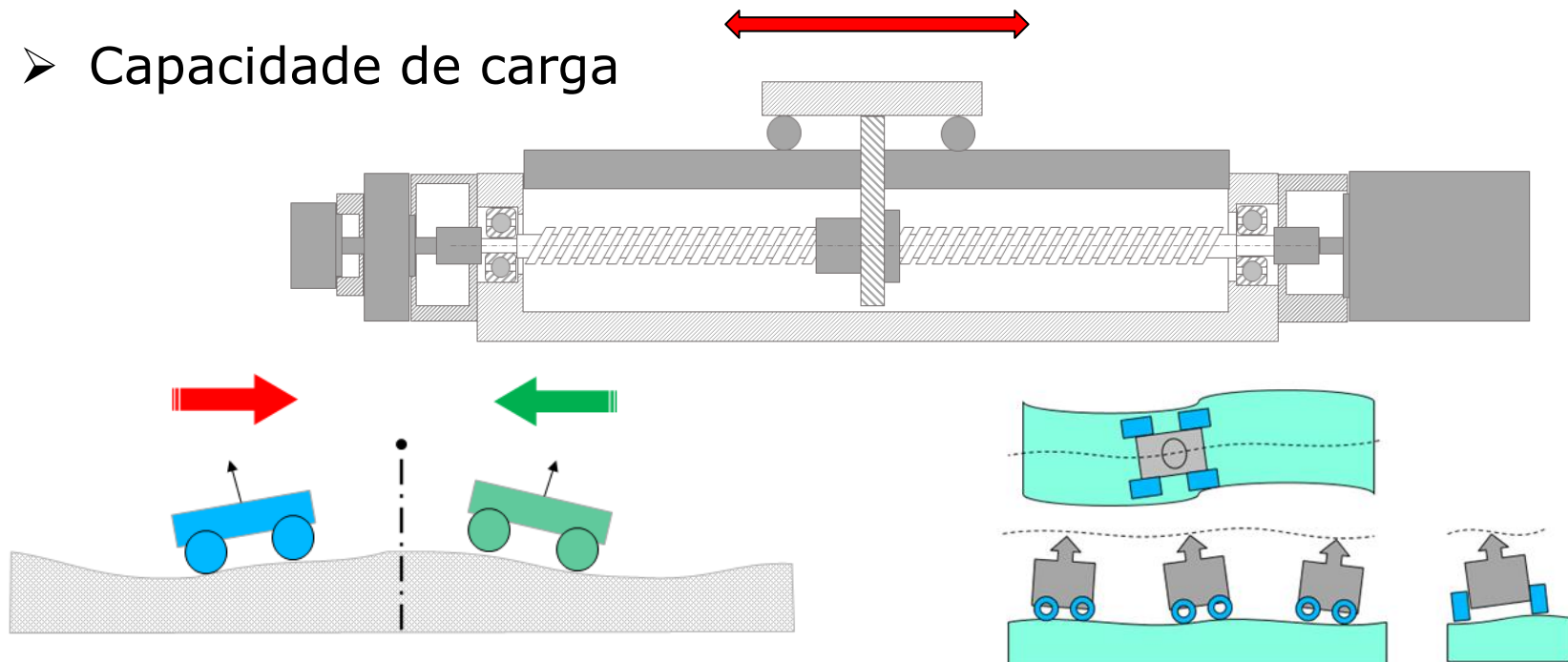
Constituintes de um guia genérica





Requisitos de um guia

- Movimento geometricamente precisos
- Posicionamento preciso e exato $\Rightarrow$ controlabilidade
- Movimento suave
- Capacidade de carga





Requisitos de um guia

- rigidez
- velocidade de trabalho
- do tipo e intensidade dos carregamentos
- dimensões para instalação
- confiabilidade
- manutenibilidade
- adaptabilidade as condições de operação
- custos
- Desgaste
- amortecimento





Guias de elementos rolantes

Características

- maior precisão de posicionamento
- Atrito de rolamento $1/6$ do atrito de escorregamento
- maior velocidade de avanço, permitindo um aumento de produtividade de 20 a 30%
- exatidão pode ser mantida por longos períodos
- Movimento sem *stick-slip*
- fácil instalação e manutenção
- suavidade de movimento
- Alta modularidade



Guias de elementos rolantes

Classes de precisão

Preloaded Assembly (Non-interchangeable)					Interchangeable
Ultra precision	Super precision	High precision	Precision	Normal	Normal
P3	P4	P5	P6	PN	PC

Grade	NSK		THK	IKO		HIWIN		STAR
	Preloaded assembly	Interchangeable type		Non-interchangeable type	Interchangeable type	Non-interchangeable type	Interchangeable type	
Normal	PN	PC	No code	No code	(No code)	C	C	N
Precision	P6	–	H	H	H	H	H	H
High precision	P5	–	P	P	P	P	P	P
Super precision	P4	–	SP	SP	–	SP	–	SP
Ultra precision	P3	–	UP	UP	–	UP	–	UP

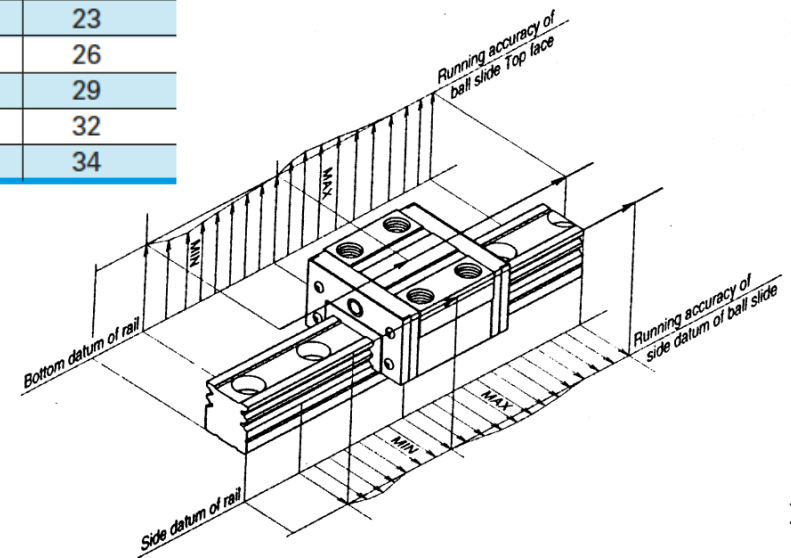


Erro de paralelismo - NSK

Table 4.2 Running parallelism of slide

Unit: μm

Accuracy grade Rail length (mm)		Preloaded assembly (not random matching)					Random-matching type	
		Ultra precision P3	Super precision P4	High precision P5	Precision grade P6	Normal grade PN	Precision grade PH	Normal grade PC
over	or less							
–	50	2	2	2	4.5	6	2	6
50	– 80	2	2	3	5	6	3	6
80	– 125	2	2	3.5	5.5	6.5	3.5	6.5
125	– 200	2	2	4	6	7	4	7
200	– 250	2	2.5	5	7	8	5	8
250	– 315	2	2.5	5	8	9	5	9
315	– 400	2	3	6	9	11	6	11
400	– 500	2	3	6	10	12	6	12
500	– 630	2	3.5	7	12	14	7	14
630	– 800	2	4.5 (4)	8	14	16	8	16
800	– 1 000	2.5	5 (4.5)	9	16	18	9	18
1 000	– 1 250	3	6 (5)	10	17	20	10	20
1 250	– 1 600	4	7 (6)	11	19	23	11	23
1 600	– 2 000	4.5	8 (7)	13	21	26	13	26
2 000	– 2 500	5	10 (8)	15	22	29	15	29
2 500	– 3 150	6	11 (9.5)	17	25	32	17	32
3 150	– 4 000	9	16	23	30	34	23	34



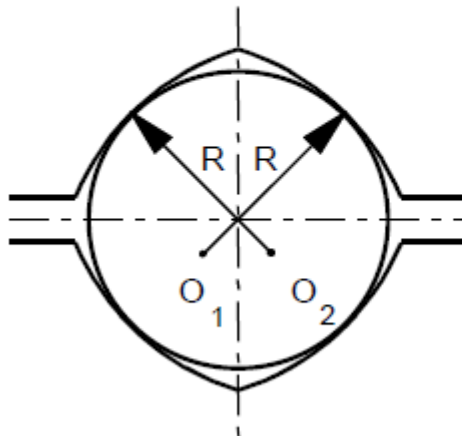


Guias de elementos rolantes

Tipo de perfiz das ranhuras

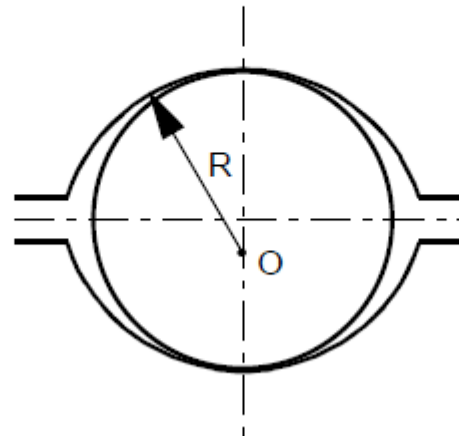
Gothic arch groove

(Consists of two arcs centered at O_1 and O_2 .)



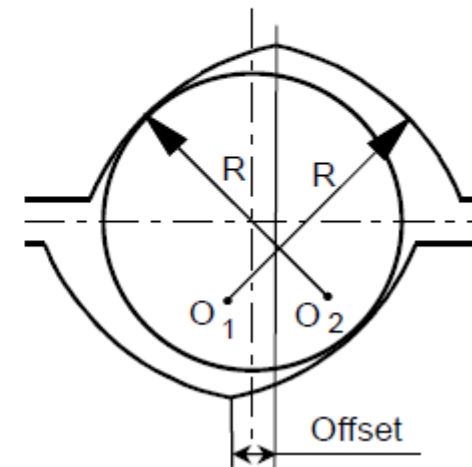
Circular arc groove

(Consists of one arc.)



Offset gothic arch groove

(Gothic arch groove of a rail is offset with that of a ball slides.)





Guias de elementos rolantes

Classificação quanto as direções do movimento

Simples



Cruzadas





Guias de elementos rolantes

As guias de elementos rolantes normalmente denominadas de guias lineares, são amplamente utilizadas em sistema de precisão.

- Podem ser de projeto específico ou comerciais

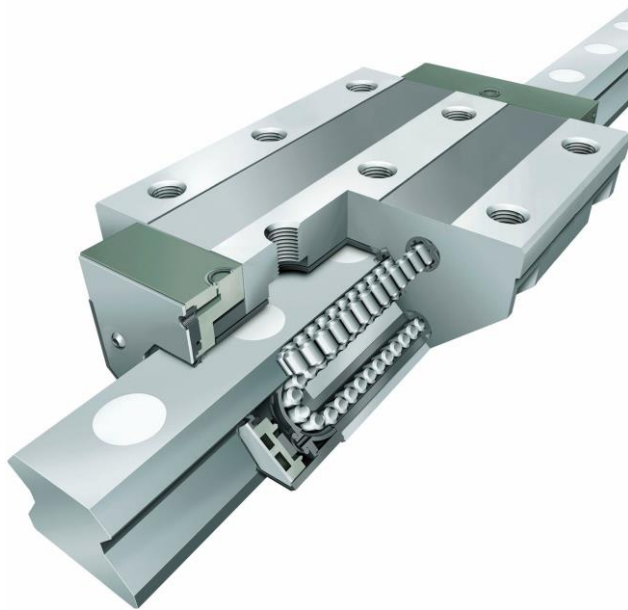




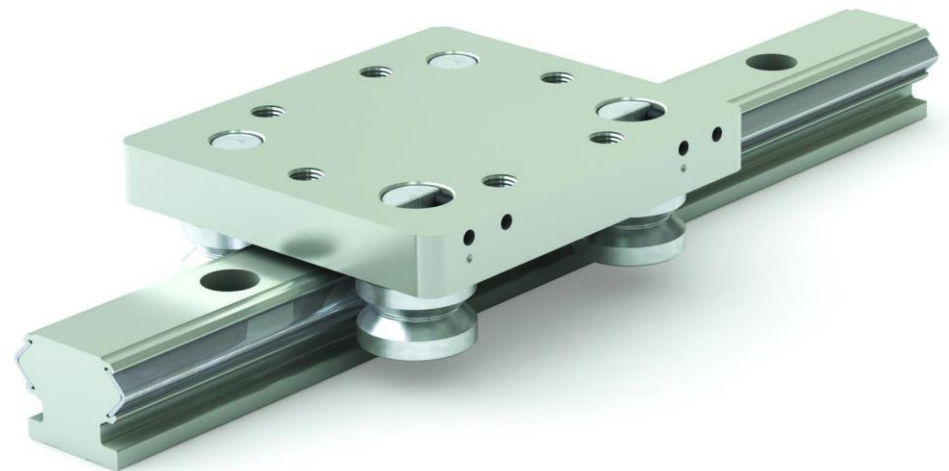
Guias de elementos rolantes

Formas construtivas

Elementos internos



Elementos externos



<http://www.pbcllinear.com/Blog/Easy-Access-Preload-Adjustment-Feature-Patented>



Guias de elementos rolantes

Classificação quanto ao padrão do movimento

Linear

Circular





Guias de elementos rolantes

Formas construtivas

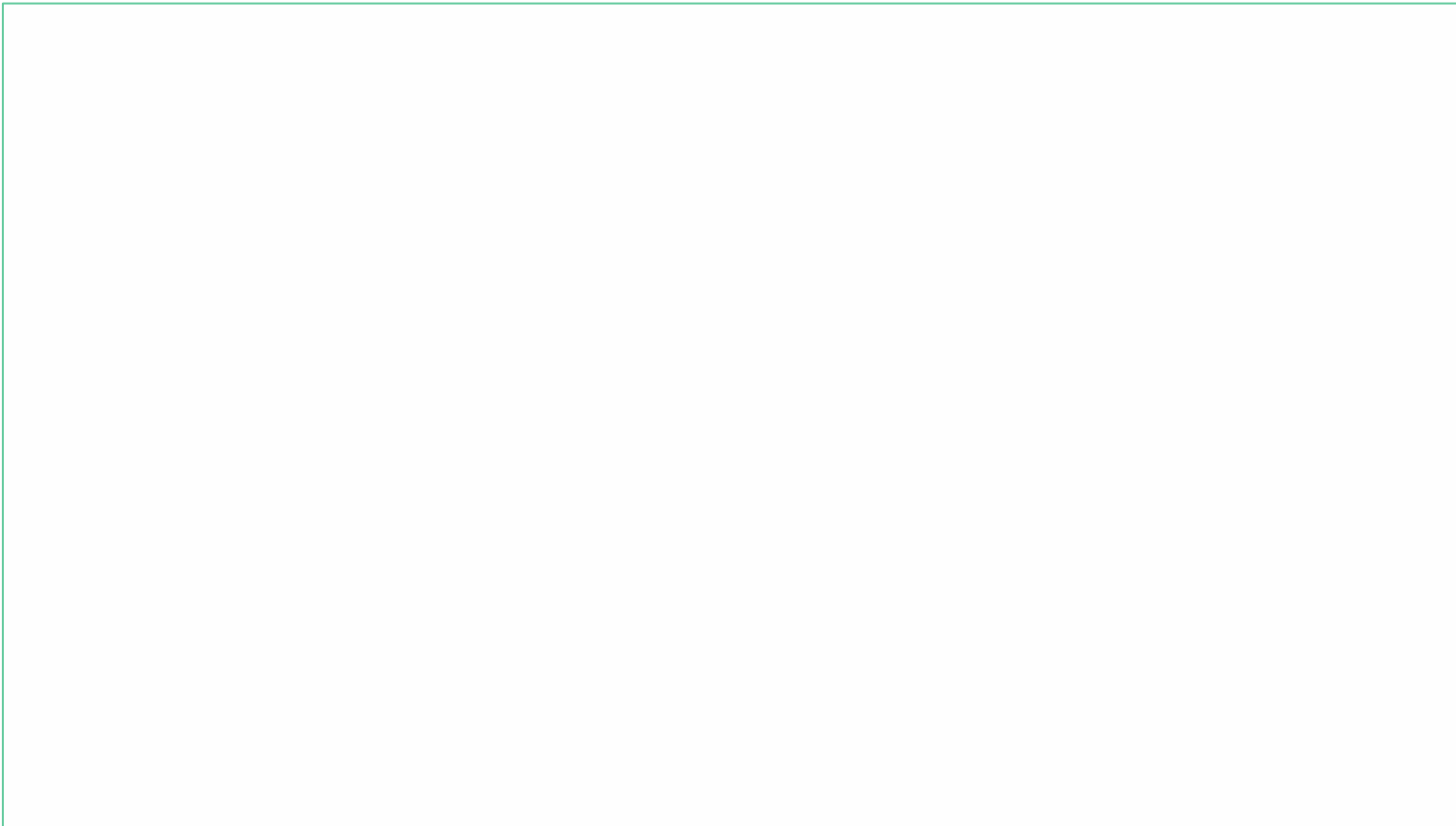
cilíndricas

prismáticas





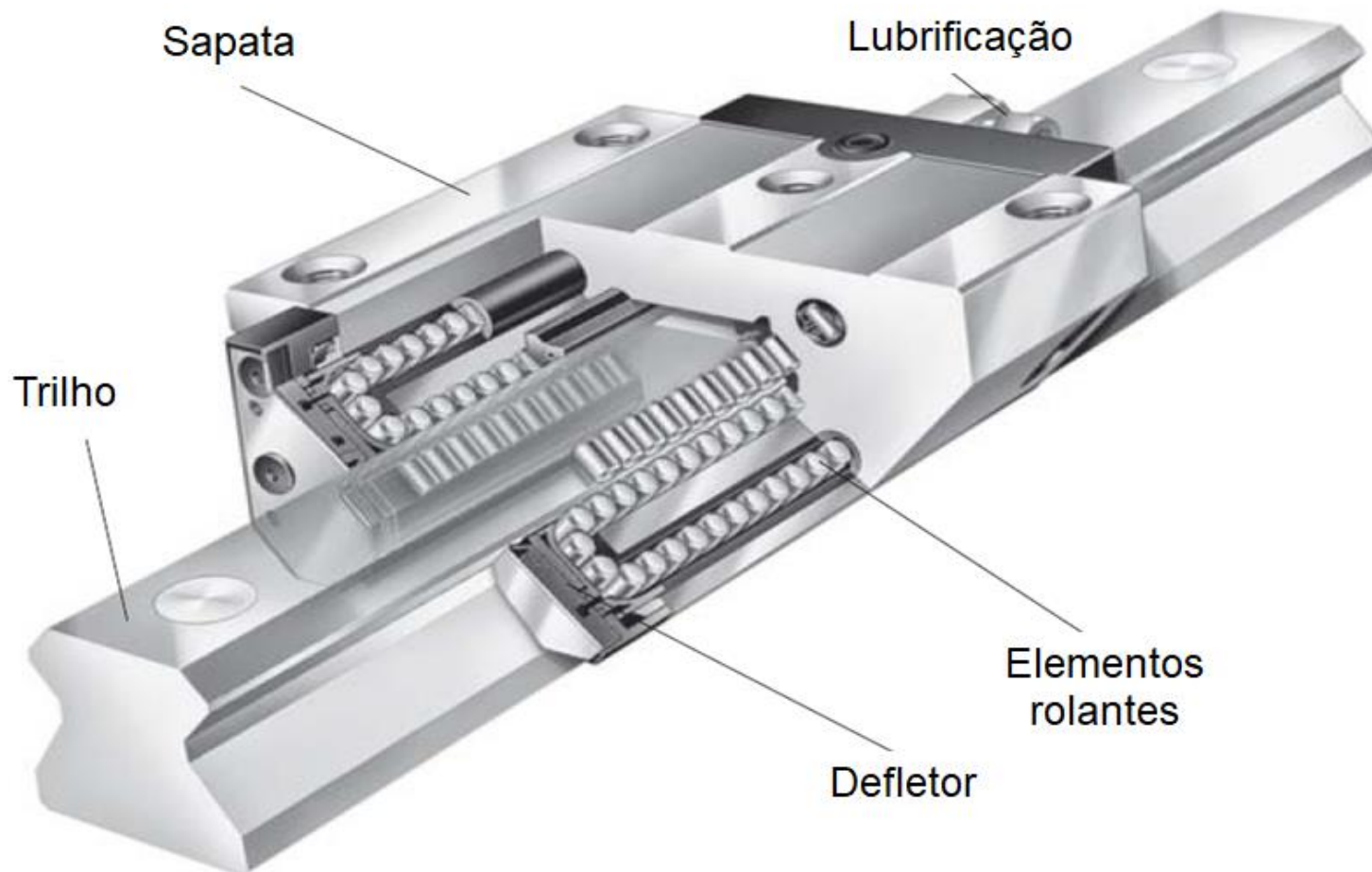
Guias de elementos rolantes





Guias de elementos rolantes

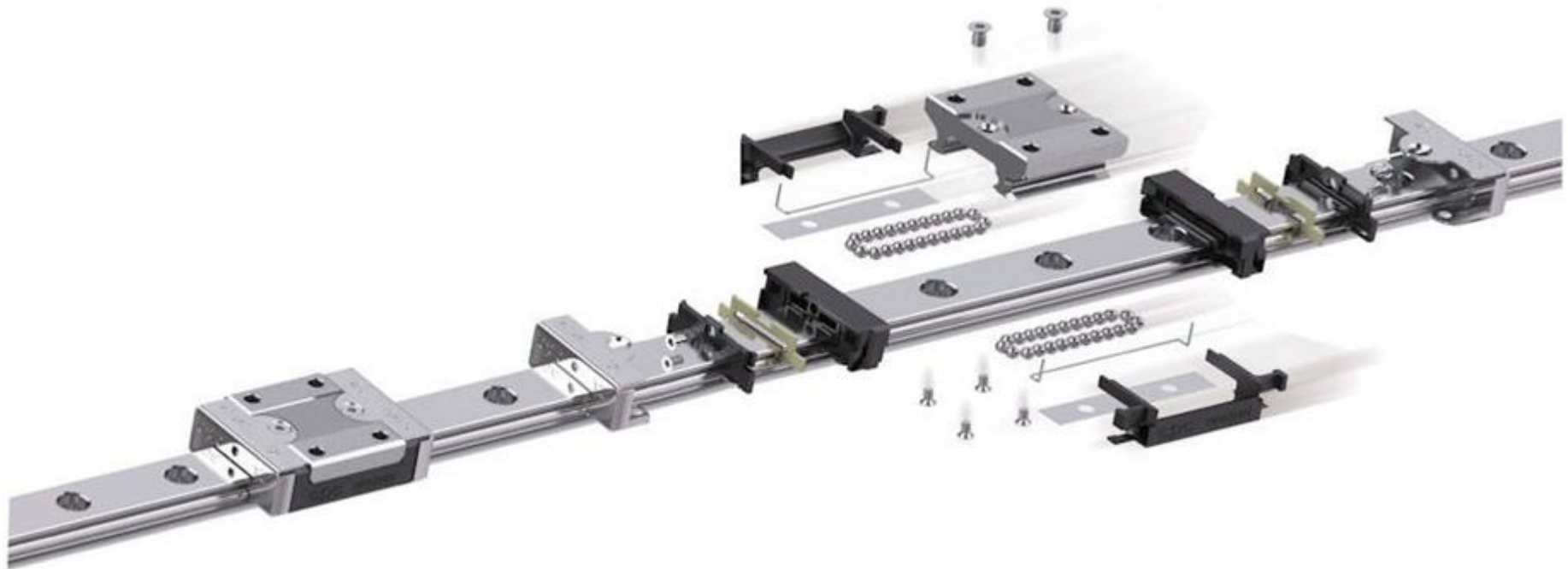
Constituintes





Guias de elementos rolantes

Constituintes





Guias de elementos rolantes

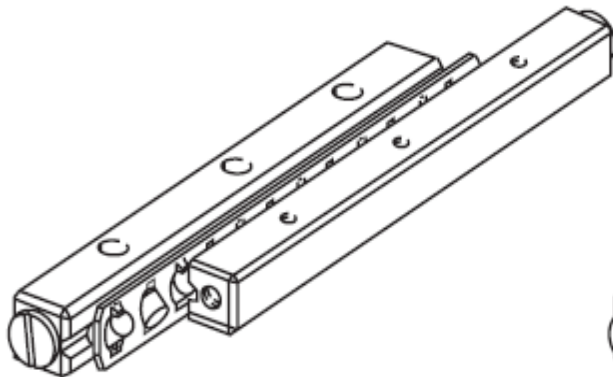
Vídeo – Frank Dynamic

Franke Dynamic
Double rail with cassette

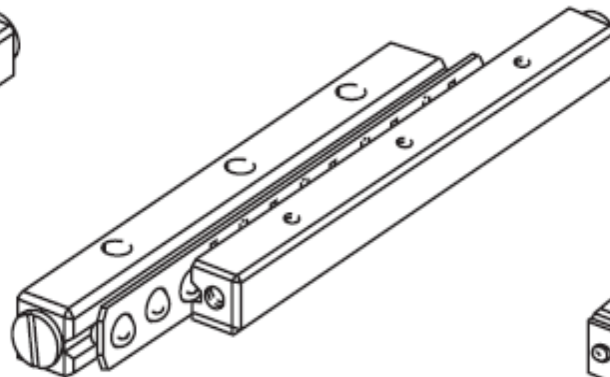


Guias de elementos rolantes

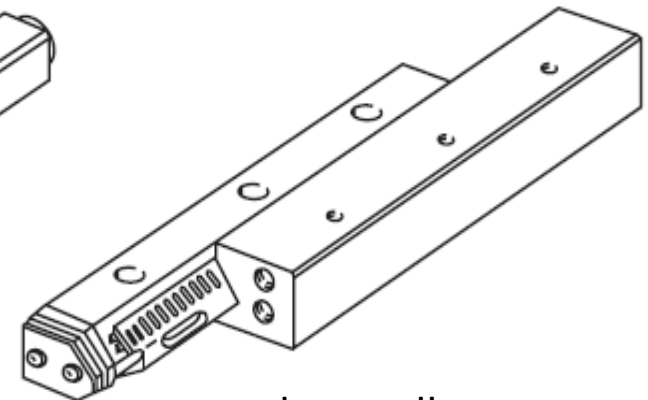
Formas construtivas



rolos cruzados



esferas

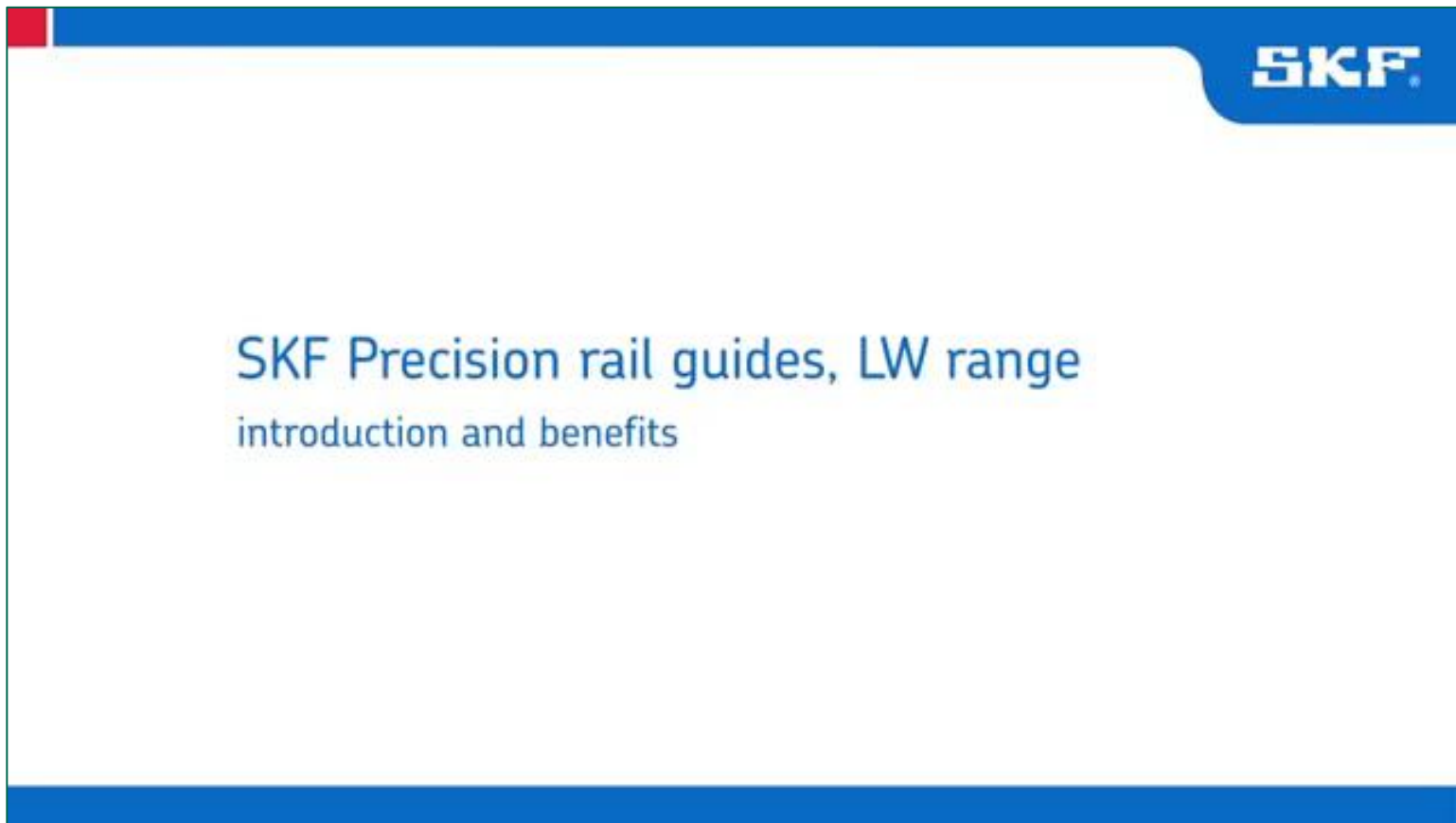


rolos agulhas



Guias de elementos rolantes

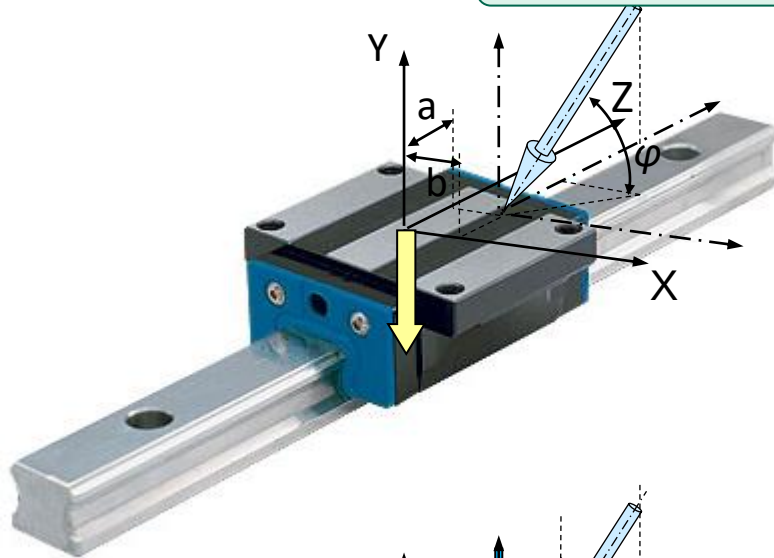
Vídeo – SKF



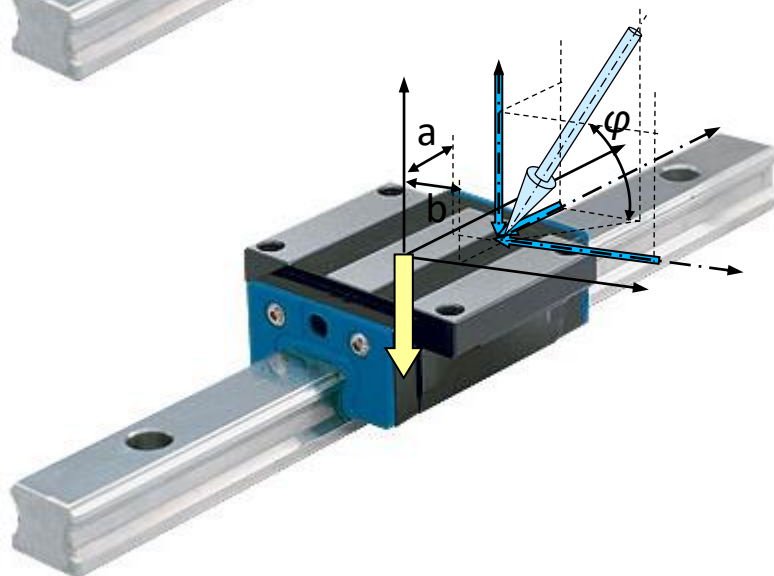


Guias de elementos rolantes

Dimensionamento



- Identifique a resultante das forças atuantes e sua direção

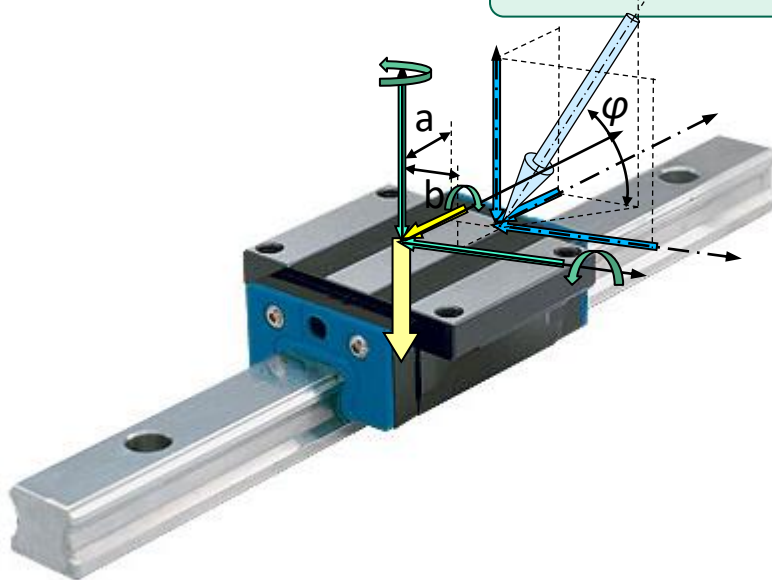


- Decomponha ortogonalmente a resultante das forças atuantes

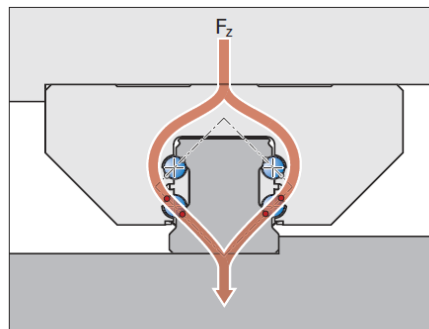


Guias de elementos rolantes

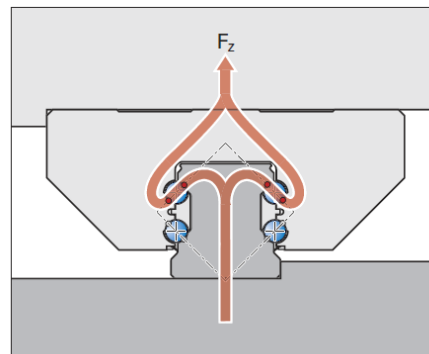
Dimensionamento



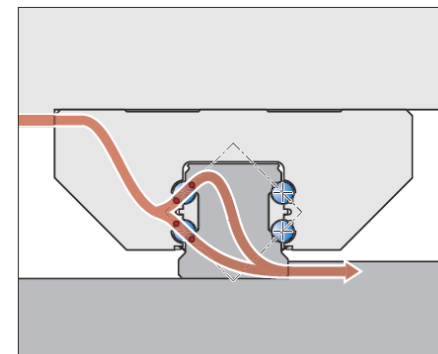
- Ao contrário das guias de escorregamento, guias de elementos rolantes dependem fortemente da configuração dos elementos rolante e da direção das forças



Force flow under a down load F_z



Force flow under a lift-off load F_z

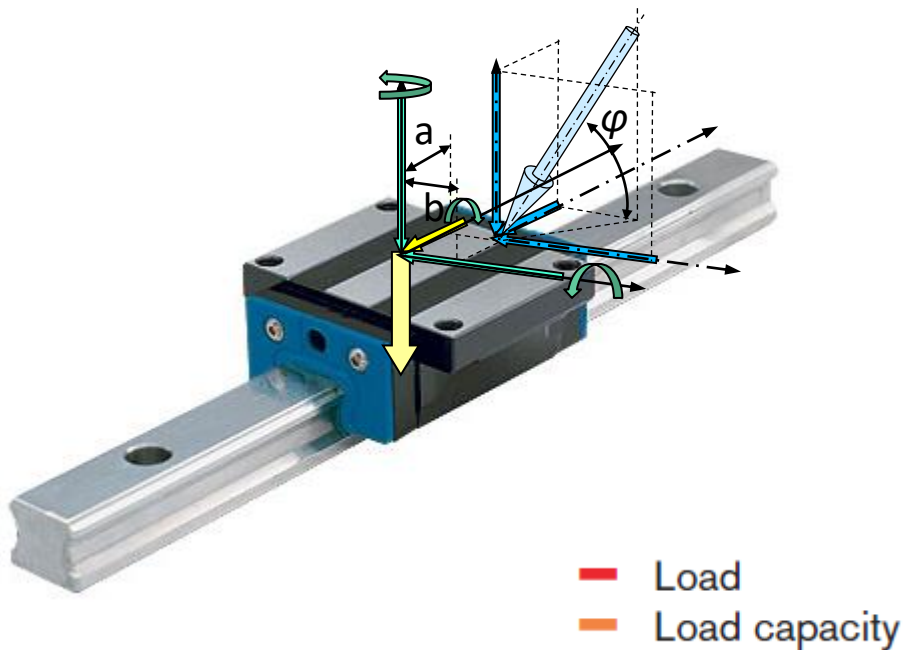


Force flow under a side load F_y

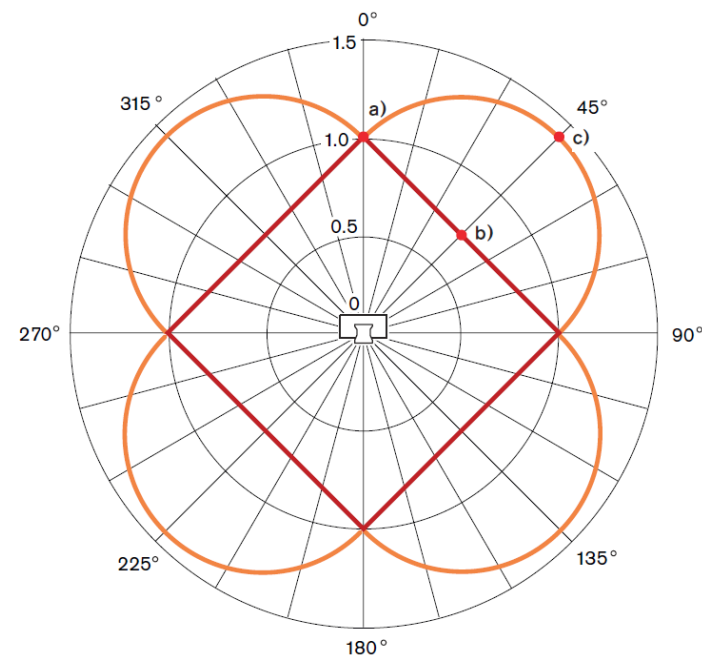


Guias de elementos rolantes

Dimensionamento



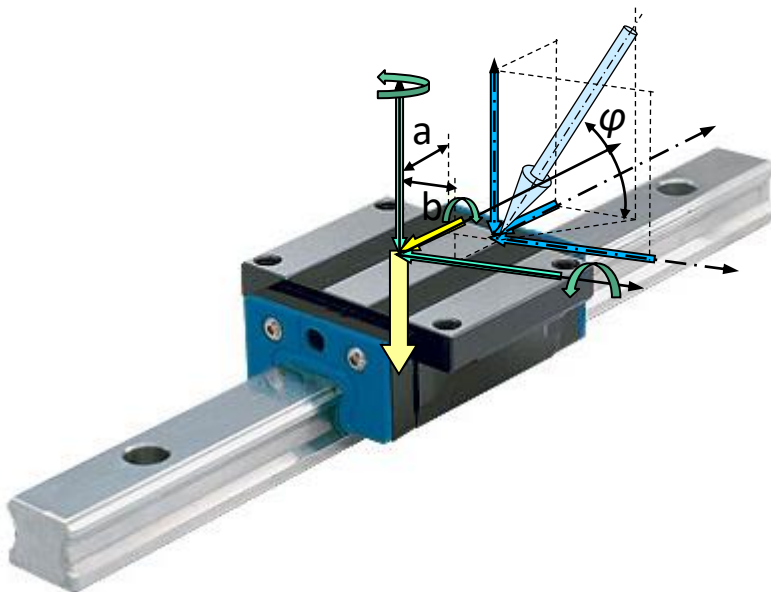
- Carregamento e capacidade de carga para mesma vida, sob diferentes direções de carregamentos





Guias de elementos rolantes

Dimensionamento



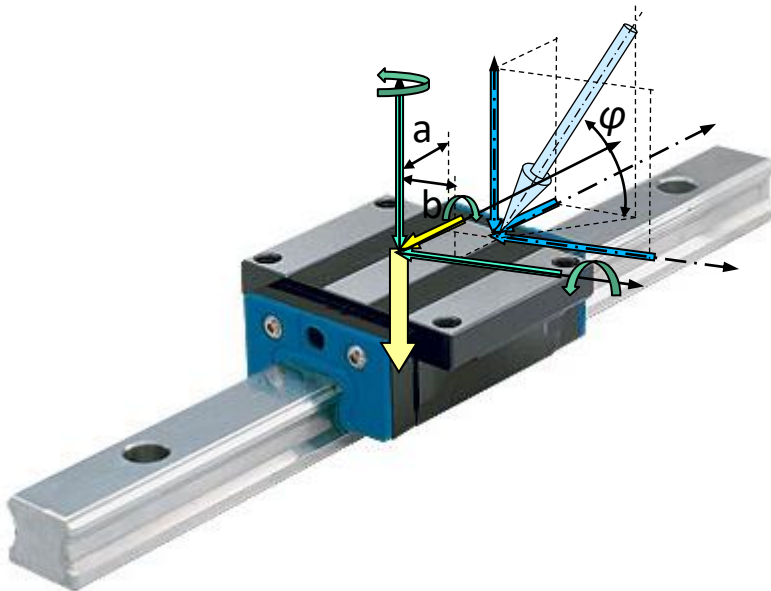
➤ Classes de pré carregamento

Preload class Code	Version	Preload class factor X_{pr} (-)	Application area
C0	Without preload (with clearance)	0	For particularly smooth-running guide systems with the lowest possible friction and a minimum of external influences.
C1	Slight preload 0.02 C (2% of C) For roller rail systems (RRS): 0.03 C (3% of C)	0.02 0.03 (RRS)	For zero-clearance guide systems with low external loads and low requirements on overall rigidity.
C2	Medium preload 0.08 C (8% of C)	0.08	For precise guide systems with both high external loading and high demands on overall rigidity; also recommended for single-rail systems. Above-average moment loads can be absorbed without significant elastic deflection.
C3	High preload 0.13 C (13% of C)	0.13	For highly rigid guide systems such as required in precision machine tools or forming/molding machines. Above-average loads and moments can be absorbed with the least possible elastic deflection.



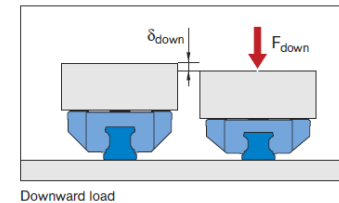
Guias de elementos rolantes

Dimensionamento



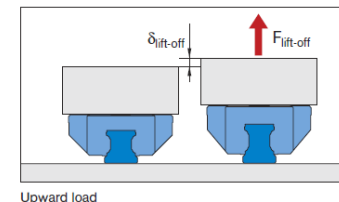
➤ Considerações sobre a deflexão

$$(3-5) \quad c_{\text{down}} = \frac{F_{\text{down}}}{\delta_{\text{down}}}$$

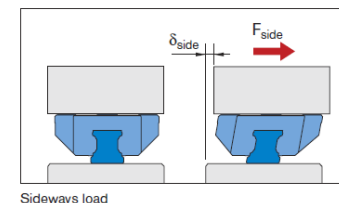


F = load resulting from a force (N)
 δ = elastic deflection in the direction of loading (μm)
 c = rigidity in the direction of loading ($\text{N}/\mu\text{m}$)

$$(3-6) \quad c_{\text{lift-off}} = \frac{F_{\text{lift-off}}}{\delta_{\text{lift-off}}}$$



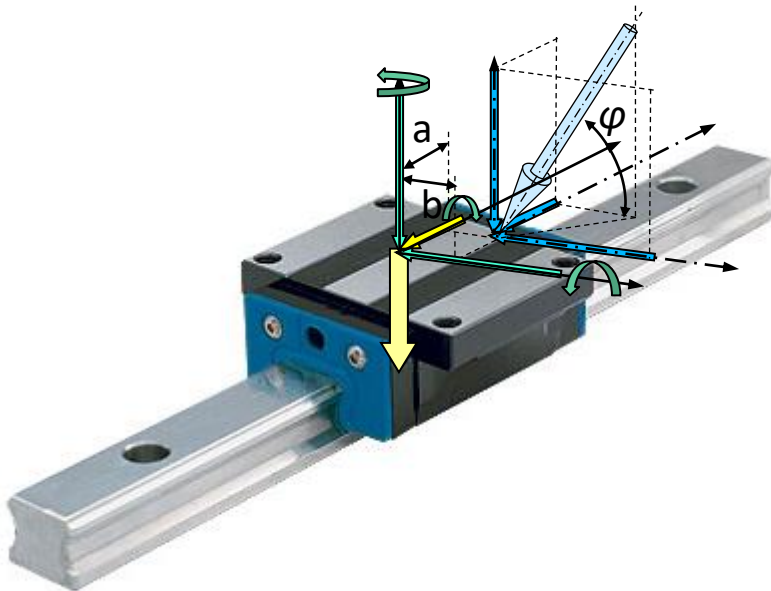
$$(3-7) \quad c_{\text{side}} = \frac{F_{\text{side}}}{\delta_{\text{side}}}$$



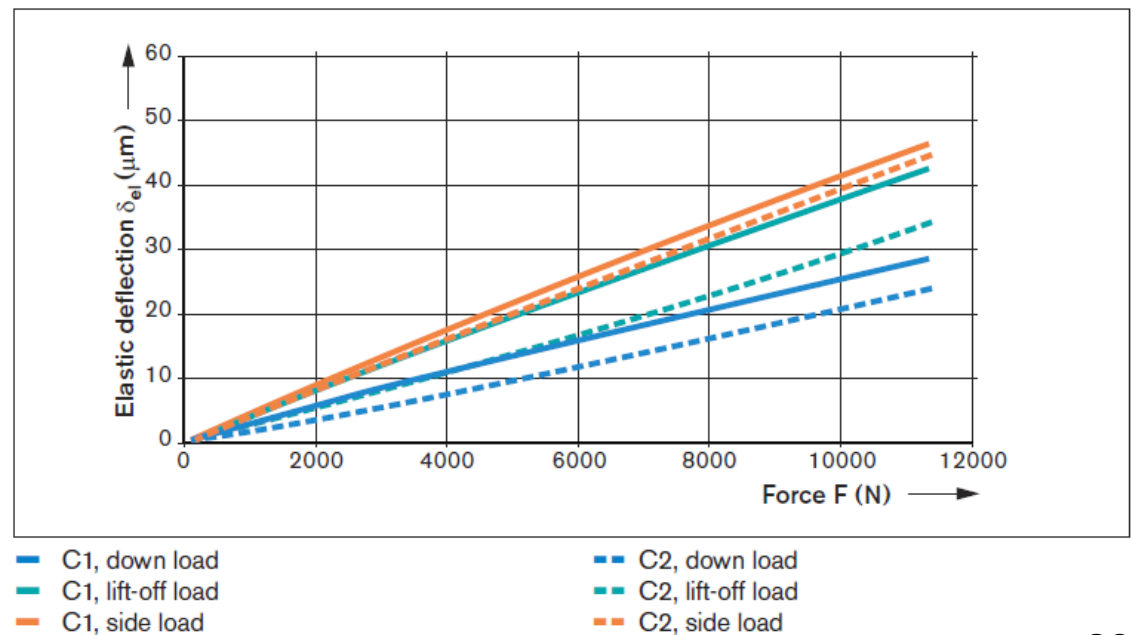


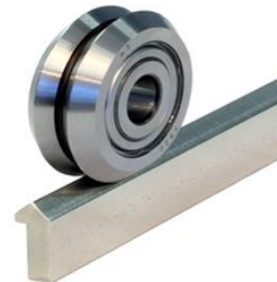
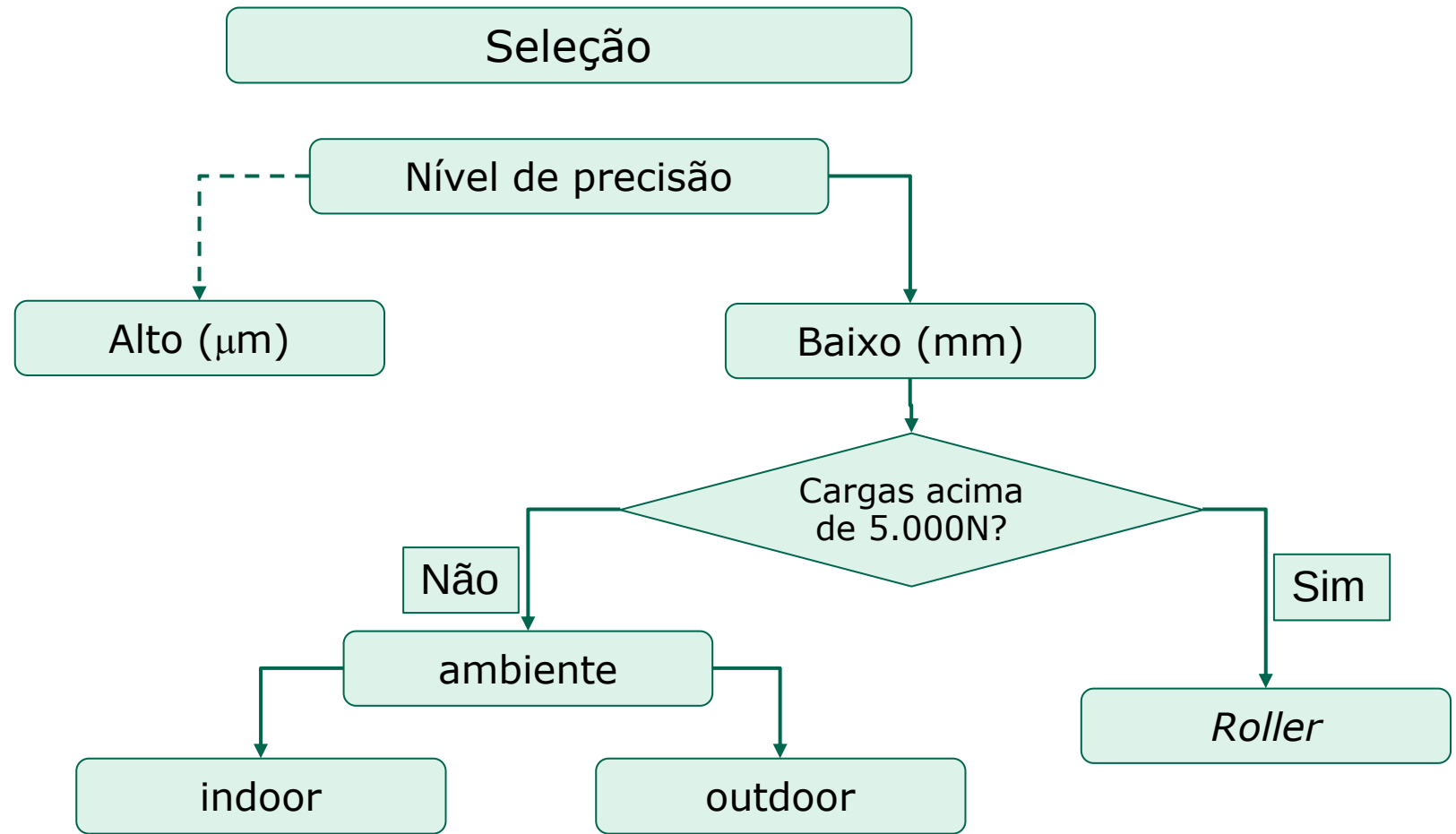
Guias de elementos rolantes

Dimensionamento



➤ Considerações sobre a deflexão

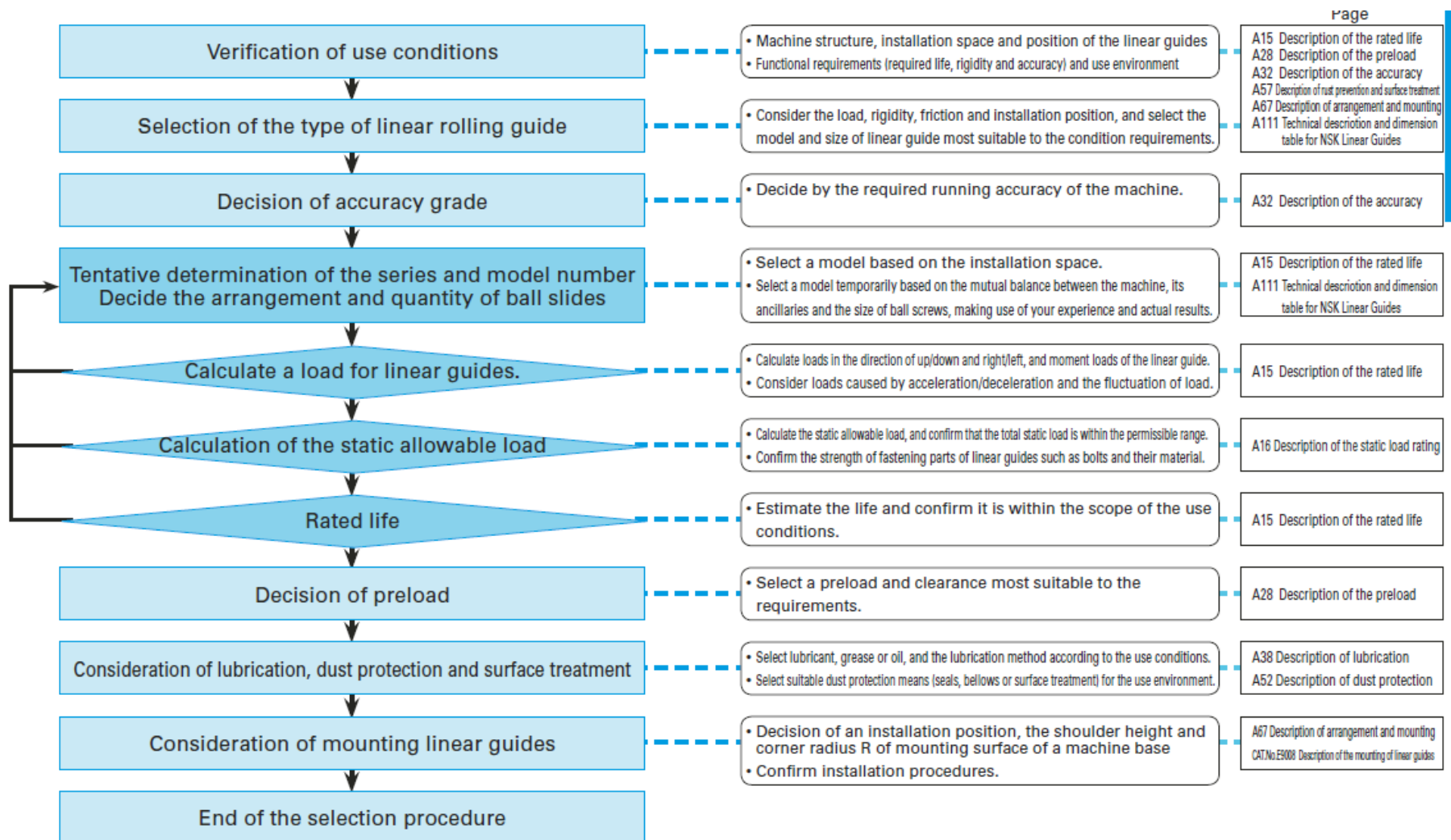








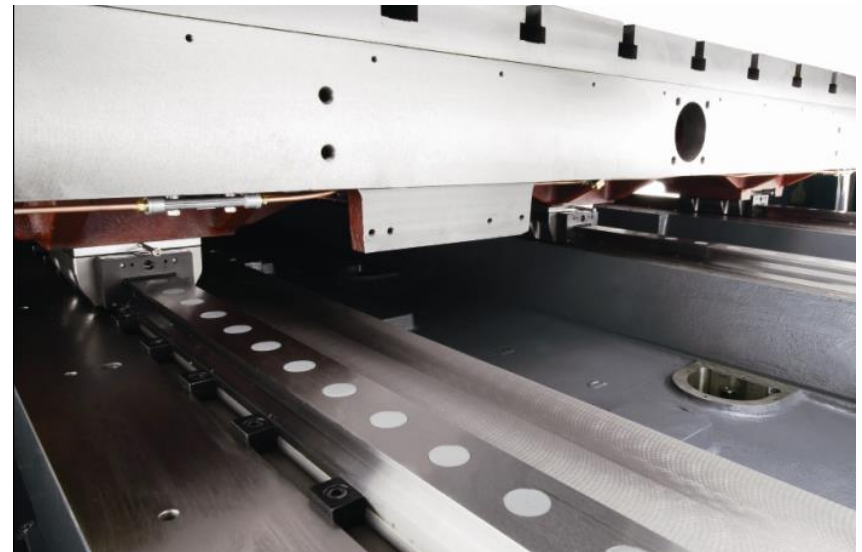
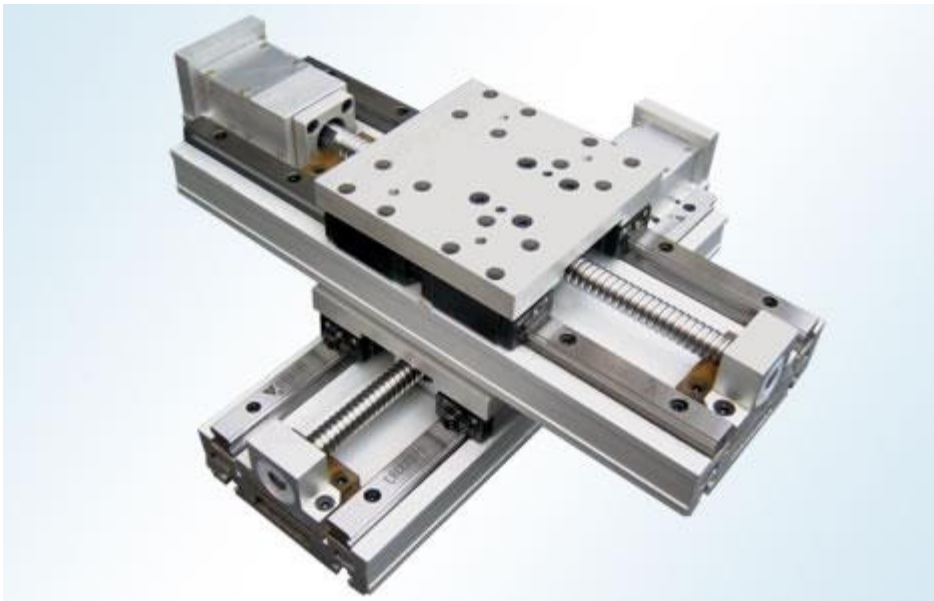
Seleção - NSK





Guias de elementos rolantes

Exemplos





Guias de elementos rolantes

Classification	Application	Accuracy grade					Preload				
		Ultra precision P3	Super precision P4	High precision P5	Precision P6	Normal PN, PC	Heavy preload Z4	Medium preload Z3	Light preload Z2	Slight preload Z1, Z2	Fine clearance Z0, ZT
Machine tools	Machining center		✓	✓	✓		✓	✓			
	Grinding machine	✓	✓	✓			✓	✓	✓		
	Lathe		✓	✓	✓		✓	✓			
	Milling machine		✓	✓	✓		✓	✓			
	Drilling machine			✓	✓		✓	✓			
	Boring machine		✓	✓	✓		✓	✓			
	Gear cutting machine		✓	✓	✓		✓	✓	✓		
	Die sinking machine		✓	✓	✓			✓	✓	✓	
	Laser beam machine		✓	✓	✓			✓	✓	✓	
	Electric discharge machine	✓	✓	✓			✓	✓			
Semiconductor processing	Wafer prober	✓						✓		✓	
	Wire bonding machine		✓	✓				✓	✓	✓	
	PCB drilling machine			✓	✓			✓	✓	✓	
	Wafer slicing machine	✓	✓						✓		
	Wafer dicing machine	✓	✓						✓		
	Chip mounter			✓	✓			✓	✓	✓	
	IC handler			✓	✓					✓	
	Scanning machine			✓	✓					✓	
	Lithographic machine	✓	✓					✓	✓	✓	
Others	Measuring/inspection apparatus	✓	✓	✓	✓					✓	
	3D measuring equipment	✓	✓	✓	✓			✓	✓	✓	
	Medical apparatus		✓	✓	✓					✓	✓
	OA equipment				✓	✓				✓	✓
	Railway cars					✓				✓	✓
	Stage systems					✓					✓
	Pneumatic equipment				✓	✓				✓	✓



Guias de elementos rolantes

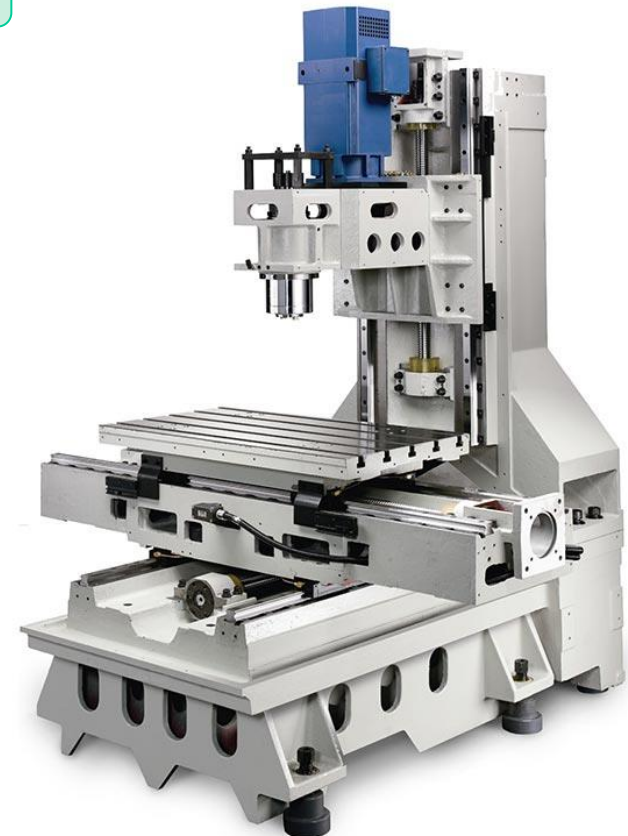
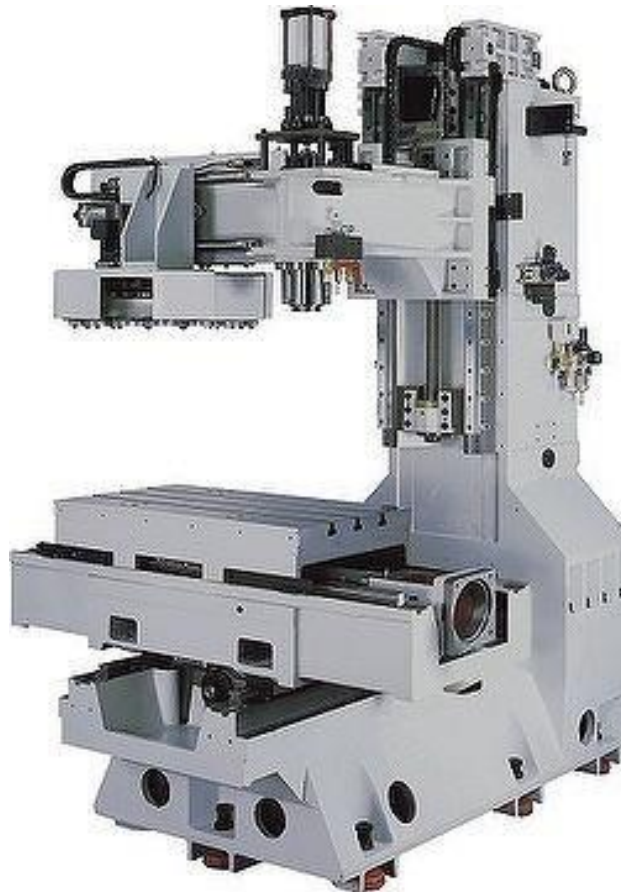
Vídeo instalação - NSK

MOTION & CONTROL™
NSK



Guias de elementos rolantes

Exemplos em M-F





ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

FIM DA AULA