

A Solution to Many Problems

The tasks

- Driving
- Transporting
- Positioning

Length

Load capacities and moments

Static load

Travel speed

Precision

Linear motion system
with drive unit

Switch mounting arrangements

Multiple axis unit

Accessories

Documentation

Up to 2860 mm

Load capacity C up to 180,600 N
Dyn. longitudinal moment load capacity M_L up to 24,740 Nm
Dyn. torsional moment load capacity M_t up to 27,090 Nm

Up to 2500 kg

Up to 1.6 m/s

Repeatability up to 0.005 mm
Positioning accuracy up to 0.01 mm
Linear guidance accuracy up to 0.007 mm

AC servo motor or stepping motor with mount,
coupling or timing belt side drive; complete with
controller and control system

Mechanical and proximity switches
over the entire travel range

Combination option provided by connectors

Sliding blocks

Moment of friction measurement, Lead deviation
Travel accuracy, Positioning accuracy

The solution

Ball Rail Tables

Product Overview

Ball Rail Tables are precision, ready-to-mount guidance systems with high performance characteristics and compact dimensions. Practical combination options and the modular construction principle make a wide range of economical applications possible. Fast delivery is a matter of course.

Outstanding features

- Oil and temperature resistant bellows mounting through mechanical clamping of the last folds.
- Easy motor attachment via locating feature and fastening threads.
- High travel speeds over long linear distances due to Ball Rail Systems, large screw diameters and leads, and double floating bearings.
- No loss of load capacity thanks to rigid table design, reference edge for runner blocks, parallel drilled nut mounting.
- Increased load-bearing capacity generally permits the use of a smaller Ball Rail Table.
- Low-cost maintenance of the four runner blocks and the Precision Ball Screw Assembly. Lubrication via one central lubrication point. A lube port is readily accessible on each side of the carriage. Suitable for grease lubrication only.
- High precision ball runner blocks.
- Switches adjustable over the entire travel range. Can be mounted either internally, protected by the bellows, or externally, in freely accessible positions.
- Rapid mounting thanks to machined reference edge on the base plate.
- Integrated components protected by high-quality, welded, oil- and moisture-resistant bellows.

Structural design

- Base plate made from precision machined aluminum profile or steel with reference edge in finely graduated length increments
- Guideway: Ball Rail Systems with four long runner blocks per carriage
- Precision ball screw drive in tolerance grade 7 with zero-backlash nut system
- Aluminum fixed bearing end-plate with two-row, preloaded angular-contact thrust ball bearing
- Floating bearing end-plate with double floating bearing system
- Carriage made of machined aluminum profile or steel in various lengths

Attachments

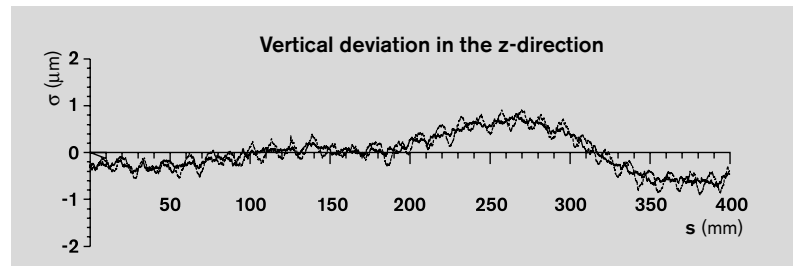
- Bellows
- Internal glass scale
- Internal or external mechanically operated switch
- Internal or external proximity switch
- Socket with mating plug for the switches
- Aluminum profile cable duct
- Timing belt side drive or motor mount and coupling for attachment of the motor
- 3-phase stepping motors
- Maintenance-free digital AC servo motors with integrated brake and attached feedback

High precision ball runner blocks (available from 3rd quarter 2008)

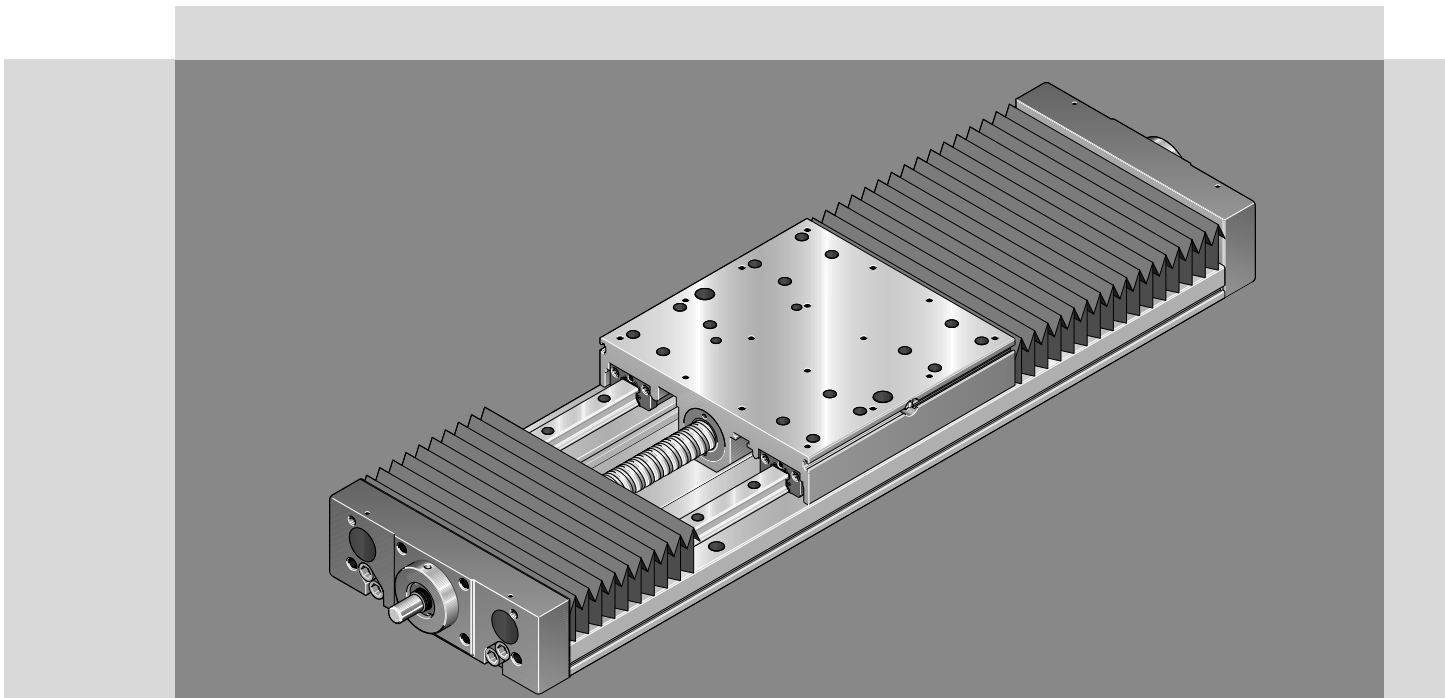


Direct comparison of the travel accuracy of two ball runner blocks

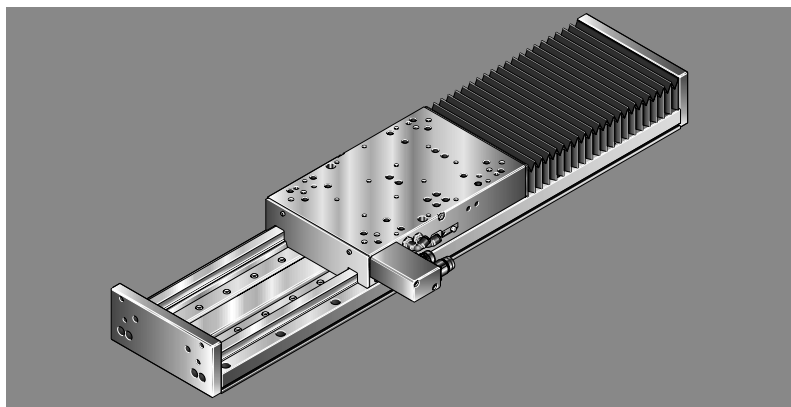
The graph clearly shows that the short-wave inaccuracies (dashed line) can be very significantly reduced by the new, innovative design of the entry zone (continuous line).



Drive controllers and control systems



For Ball Rail Tables with two ball rail systems and linear motor, see separate catalog "Ball Rail Tables TKL."

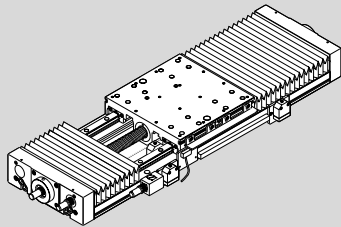


Product Overview

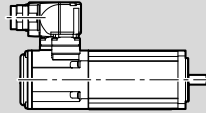
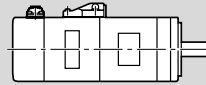
Motor selection based on drive controllers and control system

Several motor-controller combinations are available in order to provide the most cost-effective solution for every customer application.

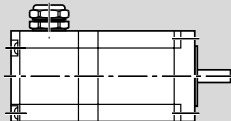
When sizing the drive, always consider the motor-controller combination. For more detailed information on motors and control systems, please refer to the catalogs "ECODRIVE Cs" and "IndraDrive for Linear Motion Systems."

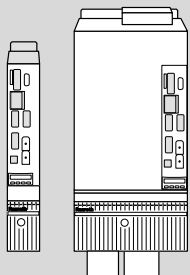


Digital AC servo motors

**MSK****MSM**

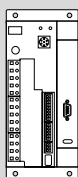
3-phase stepping motors

**VRDM 397
VRDM 3910
VRDM 3913**



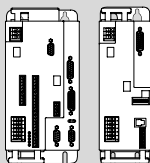
IndraDrive C

Digital controller
Power unit HCS
Control unit CSH



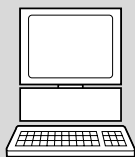
DKC

Digital controller
ECODRIVE Cs
Compact and dynamic solution
for lower power ranges



Twin Line

Power electronics
Stepping motor output stage with
or without integrated controller



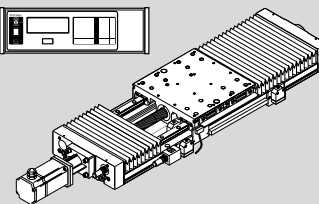
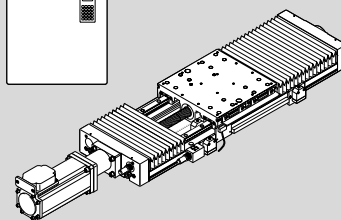
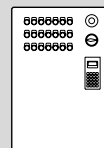
PC

PC controller board
Stepping motor controller



**PROFI-
step**

**Single- and multi-axis
positioning control with
power output module**
The complete solution



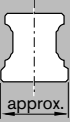
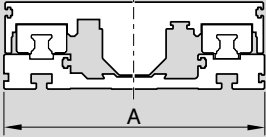
Ball Rail Tables can be supplied complete with motor, controller and control system.

Product Overview

Type designation



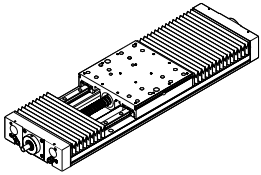

The Ball Rail Tables are designated according to **type** and **size**.

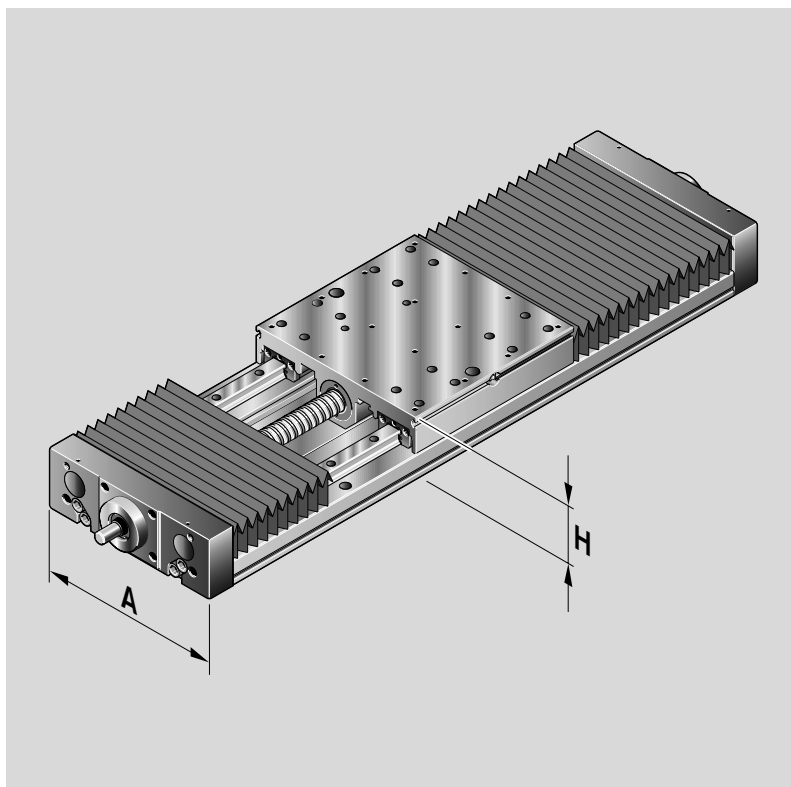
Types also cover the equivalent designs without drive units.

		Type	Size
Ball Rail Table (example) =		T K K	20-225 A
System	= Ball Rail Table (T)		
Guideway	= Ball Rail System (K)		
Drive unit	= Ball Screw Drive (K)		
Dimensions of guideway	= 		
Frame size	= 		
Material	= Aluminum profile Steel		

Type designation, sizes

Ball Rail Tables

Type	Guideway	Drive unit	Ball Rail Table
TKK	 Ball Rail Systems	 without drive unit	
		 Ball Screw Drive	



Size	Dimensions A x H (mm)	L _{max}	Dyn. load capacity C (N)
TKK 15 - 155 Al	155 x 60	2860	25 300
TKK 20 - 225 Al	225 x 75	2860	79 200
TKK 20 - 225 St		2380	
TKK 20 - 225 Al	225 x 105	2860	
TKK 30 - 325 Al	325 x 90	2860	129 960
TKK 30 - 325 St		2380	
TKK 30 - 325 Al	325 x 120	2860	
TKK 35 - 455 Al	455 x 120	2860	180 600

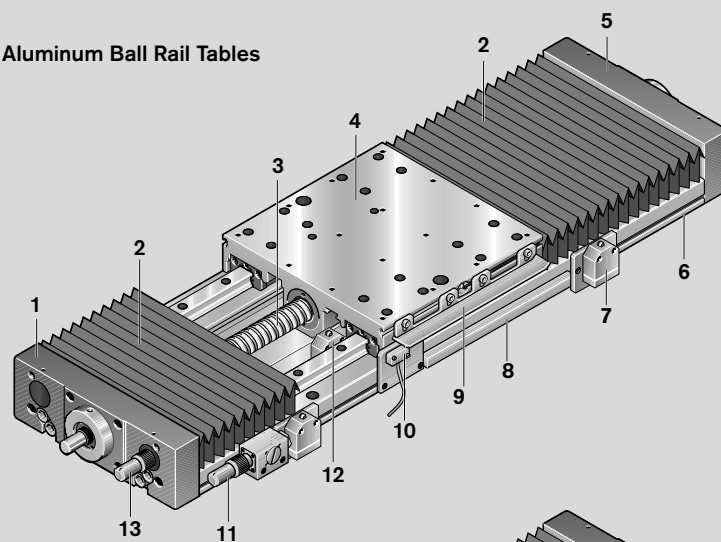
Structural Design

- 1 Fixed bearing end-plate
- 2 Bellows, two-part
- 3 Ball screw with zero-backlash single nut
- 4 Carriage with 4 long runner blocks
- 5 Floating bearing end-plate
- 6 Base plate

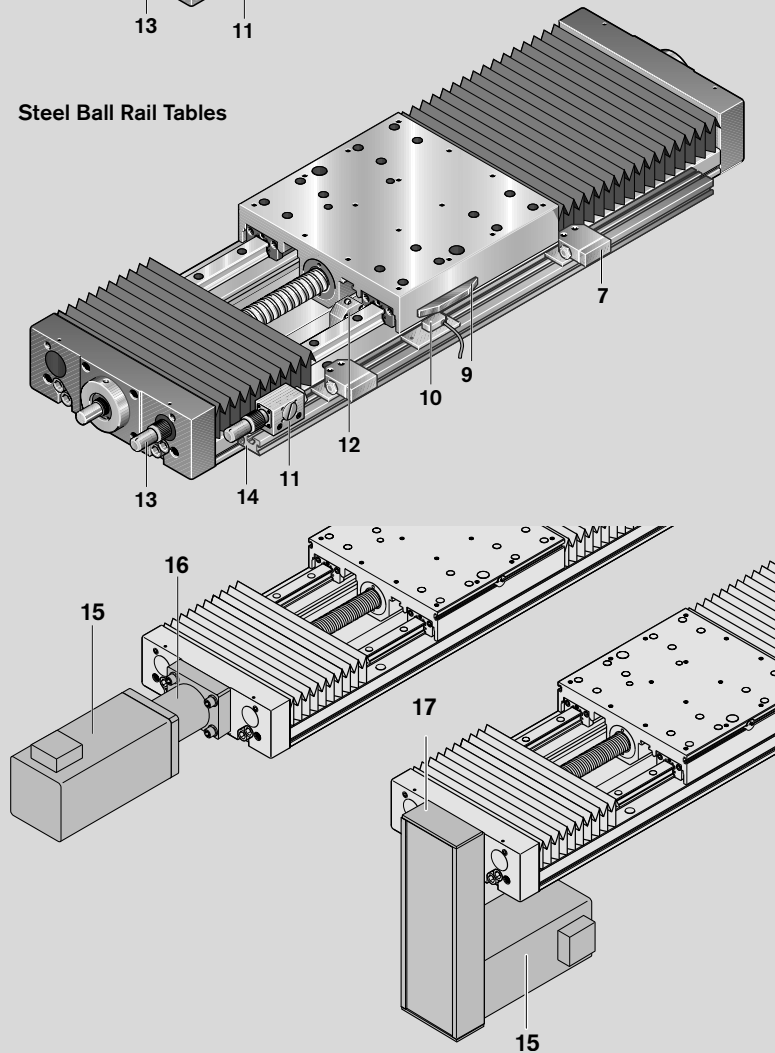
Attachments

- 7 Mechanical switch, external
- 8 Cable duct
- 9 Switching cam
- 10 Proximity switch, external
- 11 Socket-plug for external switches
- 12 Mechanical and proximity switches, internal
- 13 Socket-plug for internal switches
- 14 Profiled support
- 15 Motor
- 16 Motor mount and coupling
- 17 Timing belt side drive

Aluminum Ball Rail Tables



Steel Ball Rail Tables



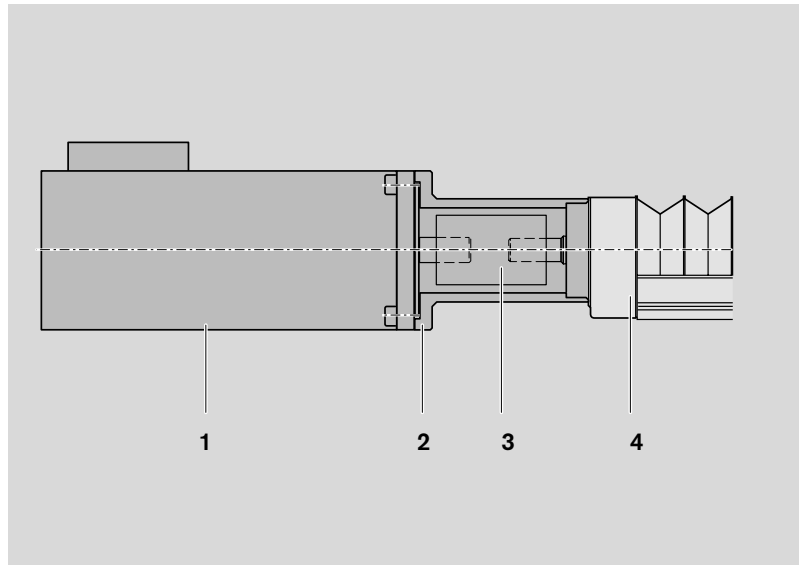
Motor mount and coupling

A motor can be attached to all Ball Rail Tables by means of a motor mount and coupling.

The motor mount serves to fasten the motor to the Ball Rail Table and acts as a closed housing for the coupling. The motor's drive torque is transmitted stress-free through the coupling to the Ball Rail Table's drive shaft.

Our standard couplings compensate for the thermal expansion of the system. If other makes of couplings are used, their thermal expansion must be taken into account.

- 1 Motor
- 2 Motor mount
- 3 Coupling
- 4 Ball Rail Table



Timing belt side drive

All Ball Rail Tables offer the option of attaching the motor via a side drive with timing belt.

This makes the overall length shorter than when attaching the motor with a motor mount and coupling.

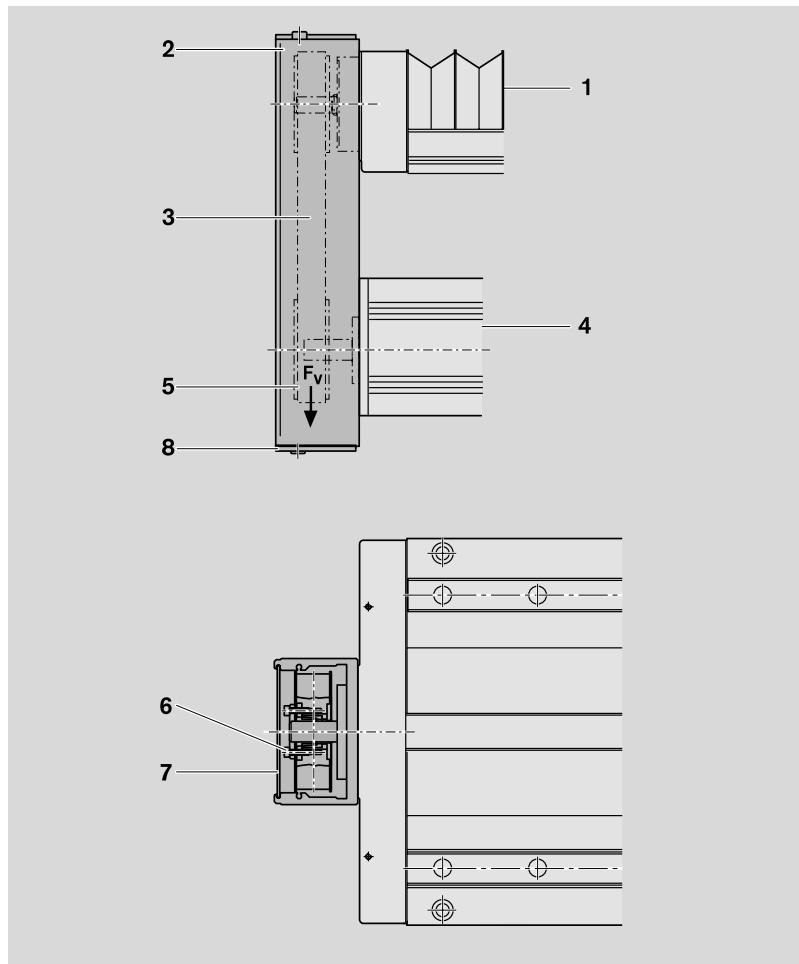
The compact, closed housing serves as protection for the belt and as a motor bracket. Different gear ratios are available:

- $i = 1$
- $i = 1.5$
- $i = 2$

The timing belt side drive can be mounted in four different directions:

- below, above (RV05 and RV06)
- left, right (RV01 to RV04)

- 1 Ball Rail Table
- 2 Housing made of drawn, anodized aluminum profile
- 3 Toothed belt
- 4 AC servo motor
- 5 Pre-tensioning of the toothed belt:
Apply pretensioning force F_v to motor (F_v will be indicated on delivery)
- 6 Belt pulleys attached using tensioning units
- 7 Cover plate
- 8 End cover



Fixing, Accuracy

General notes on mounting

The aluminum Ball Rail Tables can be secured from above or below.

The steel Ball Rail Tables can only be mounted by bolting from above.

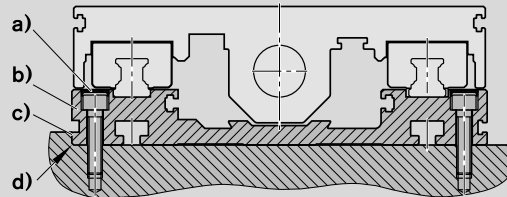
In both versions, a reference edge is built into the base plate to help align the unit. Mounting hole plugs are included with the unit.

For installation dimensions, see the relevant dimension drawings.

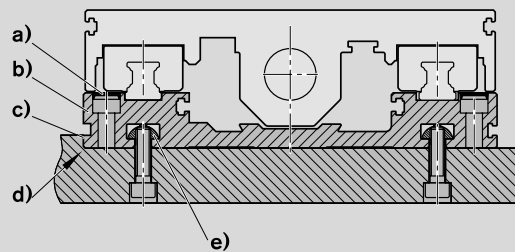
- a) Plug
- b) Base plate
- c) Reference edge
- d) $R_{max.} 0.3$
- e) Nut for T-slot (see accessories)

Aluminum Ball Rail Tables

Fixing from above

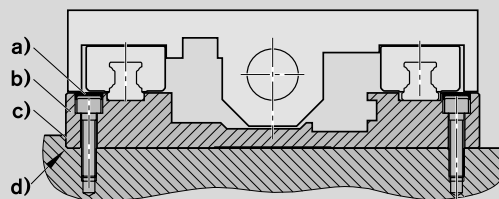


Fixing from below



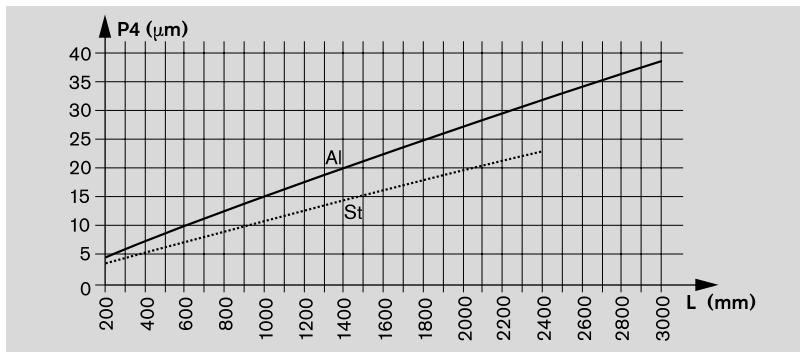
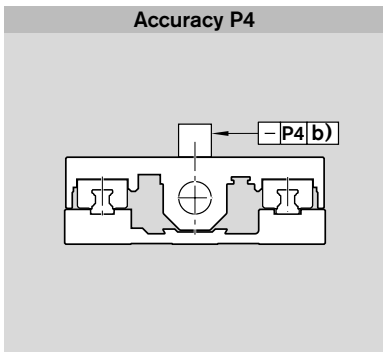
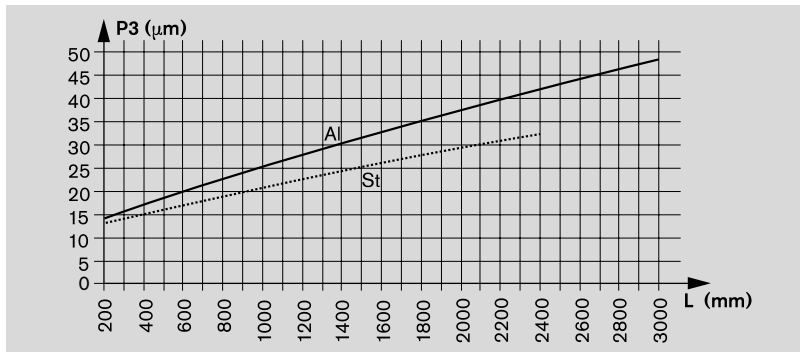
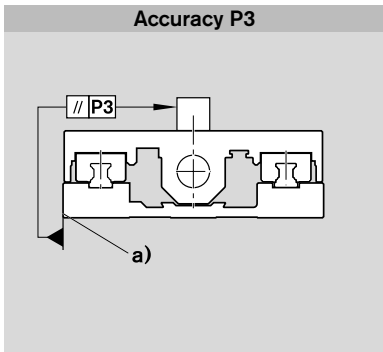
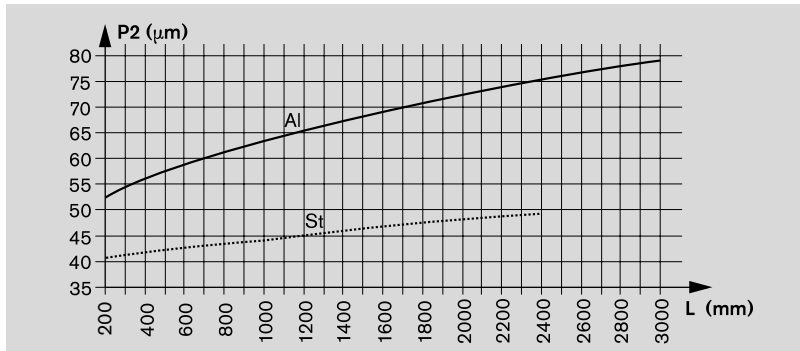
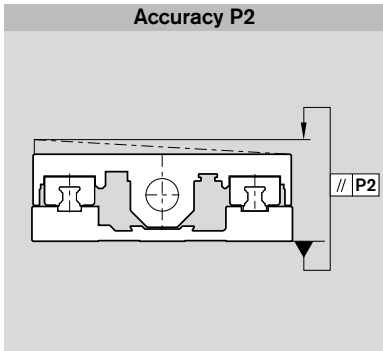
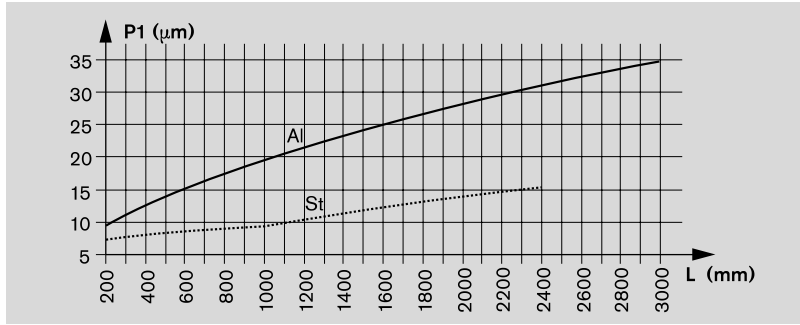
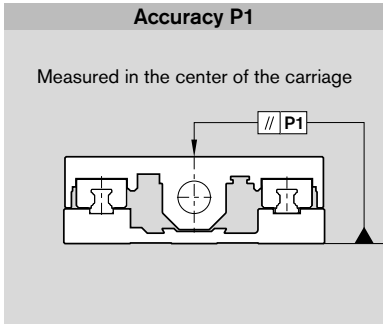
Steel Ball Rail Tables

Fixing from above



Accuracy

All accuracy data apply to the unit when screwed down and assume an ideal flat mounting base surface. Irregularities in the mounting base surface are not taken into account in the values given below.



a) Reference edge b) Longitudinal

Technical Data

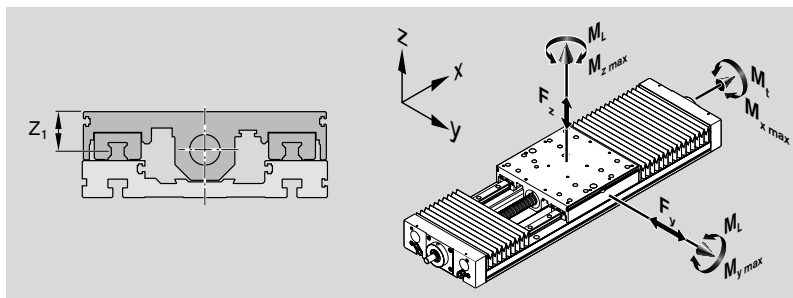
General system data

Size	Ball screw $d_0 \times P$ (mm)	Dynamic load capacity C (N)		Dynamic load moments (Nm)		Maximum loads (N)				
		Guideway	Ball screw	Fixed bearing	M_t	M_L	$F_{z1 \max}$	$F_{z2 \max}$	$F_{y \max}$	
TKK 15-155 Al	without		–	–						
	16 x 10	25300	9600	17000	1330	1140	2027	24000	16920	6000
	16 x 16		9300							
	20 x 5		14300							
	20 x 20		13300							
TKK 20-225 Al					$L_{ca} = 150$	$L_{ca} = 220$				
TKK 20-225 St					$L_{ca} = 220$	$L_{ca} = 320$				
TKK 30-325 Al	without		–	–						
	20 x 5	79200	14300	17000	6340	5073	9037	79200	32160	19800
	20 x 20		13300							
	25 x 5		15900							
	25 x 10		15700							
	25 x 25 ¹⁾		14700							
TKK 30-325 St					$L_{ca} = 320$	$L_{ca} = 450$				
TKK 35-455 Al	without		–	–						
	32 x 5	129960	21600	26000	14940	11890	20330	123200	89040	30800
	32 x 10		31700							
	32 x 20		19700							
	32 x 32		19500							
					$L_{ca} = 450$					
TKK 35-455 Al	without		–	–						
	40 x 5	180600	29100	29000	27090	24740		163200	88080	40800
	40 x 10		50000							
	40 x 20		37900							
	40 x 40		37000							

1) Al only

Maximum permissible loads

Size	Dimension (mm)	Z_1
TKK 15-155		23.7
TKK 20-225		36.6
TKK 30-325		48.5
TKK 35-455		65.5



Notes on dynamic load capacities and moments

Determination of the dynamic load capacities and moments is based on a travel life of 100,000 m. Often only 50,000 m are actually stipulated.

For comparison: Multiply values **C**, **M_t** and **M_L** from the table by 1.26. Load ratings for the ball screw as per DIN 69051.

Technical Data

Weight

Weight data does not include motor and switch attachments.

L = length in mm

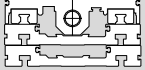
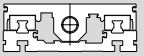
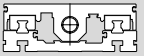
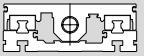
m_{ca} = moved mass

Al = aluminum

St = steel

oA = without drive (without ball screw and end-plates)

mA = with drive (ball screw)

Size	Weight (kg)		Base plate, high	
	Base plate, low			
TKK 15-155 Al	oA	$0.01 \cdot L + m_{ca} - 0.3$		
	mA	$0.0124 \cdot L + m_{ca} + 2$		
TKK 20-225 Al	oA	$0.015 \cdot L + m_{ca} - 0.4$	oA	$0.026 \cdot L + m_{ca} - 0.4$
	mA	$0.018 \cdot L + m_{ca} + 3$	mA	$0.029 \cdot L + m_{ca} + 3$
TKK 20-225 St	oA	$0.040 \cdot L + m_{ca} - 0.4$		
	mA	$0.043 \cdot L + m_{ca} + 3$		
TKK 30-325 Al	oA	$0.029 \cdot L + m_{ca} - 1$	oA	$0.048 \cdot L + m_{ca} - 1$
	mA	$0.035 \cdot L + m_{ca} + 5$	mA	$0.054 \cdot L + m_{ca} + 5$
TKK 30-325 St	oA	$0.070 \cdot L + m_{ca} - 1$		
	mA	$0.076 \cdot L + m_{ca} + 5$		
TKK 35-455 Al	oA	$0.056 \cdot L + m_{ca} - 2.5$		
	mA	$0.066 \cdot L + m_{ca} + 12$		

Friction moments

and constants $k_{J\text{ fix}}$, $k_{J\text{ var}}$, $k_{J\text{ m}}$
at the motor journal M_{Rs}

d_0 = nominal diameter

of ball screw

(mm)

P = lead of ball screw

(mm)

Size	Ball screw size $d_0 \times P$	Constants				Friction moment M_{Rs} (Nm) for guideway preload	
		$k_{J\text{ fix}}$ Short carriage	Long carriage	$k_{J\text{ var}}$	$k_{J\text{ m}}$	2%	8%
TKK 15-155	16 x 10	10.5	12.3	0.039	2.53	0.56	0.58
	16 x 16	19.6	24.2	0.039	6.48	0.58	0.61
	20 x 5	13.6	14.1	0.100	0.63	0.64	0.65
	20 x 20	35.5	42.5	0.100	10.13	0.72	0.75
TKK 20-225 Al	20 x 5	16.6	17.9	0.100	0.63	0.66	0.68
	20 x 20	83.1	103.3	0.100	10.13	0.82	0.90
	25 x 5	35.4	36.6	0.256	0.63	0.82	0.84
	25 x 10	48.7	53.7	0.256	2.53	0.88	0.92
TKK 20-225 St	25 x 25	139.3	170.9	0.235	15.83	1.08	1.17
	20 x 5	20.4	23.5	0.100	0.63	0.66	0.68
	20 x 20	143.9	194.5	0.100	10.13	0.82	0.90
	25 x 5	39.2	42.3	0.256	0.63	0.82	0.84
TKK 30-325 Al	25 x 10	63.9	76.5	0.256	2.53	0.88	0.92
	32 x 5	110.0	113.8	0.712	0.63	1.10	1.12
	32 x 10	142.3	157.5	0.712	2.53	1.29	1.32
	32 x 20	265.3	326.1	0.667	10.13	1.21	1.27
TKK 30-325 St	32 x 32	534	689.6	0.667	25.94	1.36	1.46
	32 x 5	120.5	128.0	0.712	0.63	1.10	1.12
	32 x 10	184.1	214.3	0.712	2.53	1.29	1.32
	32 x 20	432.5	553.0	0.667	10.13	1.21	1.27
TKK 35-455	32 x 32	962.0	1270.6	0.667	25.94	1.36	1.46
	40 x 5	319.2		1.783	0.63	1.66	1.68
	40 x 10	368.2		1.607	2.53	2.32	2.35
	40 x 20	679.7		1.607	10.13	2.24	2.29
	40 x 40	1926.0		1.607	40.53	2.59	2.69

Coupling data

Size	Rated torque of coupling M_{cN} (Nm)	Mass moment of inertia J_c ($\text{kgm}^2 \cdot 10^{-6}$)	Mass of coupling m_c (kg)
TKK 15-155	19	57	0.26
TKK 20-225	19	57	0.26
	50	200	0.7
TKK 30-325	50	200	0.7
TKK 35-455	98	390	0.9

Specifications of timing belt side drive, floating bearing end, for motor attachment via timing belt side drive

Motor type		MSK 040C, MSM 040B				MSK 050C					
Overall dimensions (mm)		51 x 88				66 x 116					
Frictional torque M_{Rsd} (Nm)		0.4				0.45					
Reduction $i = \dots$		Permissible torque up to length $L = \dots$ at ⁽¹⁾		Reduced mass moment of inertia at		Permissible torque up to length $L = \dots$ at ⁽¹⁾			Reduced mass moment of inertia at		
Belt type		$i = 1$	$i = 1.5$	$i = 1$	$i = 1.5$	$i = 1$	$i = 2$	$i = 1$	$i = 2$	$i = 2$	
Size		M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	
TKK 15-155	Ball screw $d_0 \times P$	L (mm)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	L (mm)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)
	16 x 10	1180	9.6	6.4	260	91					
	16 x 16	1420	9.6	6.4							
	20 x 5	1420	9.6	6.4							
TKK 20-225	20 x 20	2260	9.6	6.4							
	20 x 5	1480	9.6	6.4	270	94	1480	10.0	5.0	1420	230
	20 x 20	2200	9.6	6.4			1600	19.6	9.8		
	25 x 5	2320	9.6	6.4			1960	14.0	7.0		
	25 x 10	2860	9.6	6.4			2320	19.6	9.8		
25 x 25	2860	9.6	6.4			2860	19.6	9.8			

Motor type		MSK 060C				MSK 076C					
Overall dimensions (mm)		66 x 116				90 x 160					
Frictional torque M_{Rsd} (Nm)		0.5				0.6					
Reduction $i = \dots$		Permissible torque up to length $L = \dots$ at ⁽¹⁾		Reduced mass moment of inertia at		Permissible torque up to length $L = \dots$ at ⁽¹⁾			Reduced mass moment of inertia at		
Belt type		$i = 1$	$i = 2$	$i = 1$	$i = 2$	$i = 1$	$i = 2$	$i = 1$	$i = 2$	$i = 2$	
Size		M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	
TKK 30-325	Ball screw $d_0 \times P$	L (mm)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)	L (mm)	M_{sd} (Nm)	M_{sd} (Nm)	J_{sd} (10^{-6} kgm ²)	J_{sd} (10^{-6} kgm ²)
	32 x 5	2860	19.0	9.5	1440	280					
	32 x 10	2860	19.0	13.0							
	32 x 20	2860	19.0	13.0							
TKK 35-455	32 x 32	2860	19.0	13.0							
	40 x 5						2860	26.0	13.0	7860	1280
	40 x 10						2860	52.0	26.0		
	40 x 20						2860	67.0	33.5		
40 x 40						2860	67.0	33.5			

1) Permissible torque for greater lengths available upon request.

M_{sd} = maximum permissible torque at motor journal

M_{Rsd} = frictional torque of timing belt side drive at motor journal

J_{sd} = reduced mass moment of inertia of timing belt side drive

i = timing belt side drive reduction

d_0 = nominal diameter

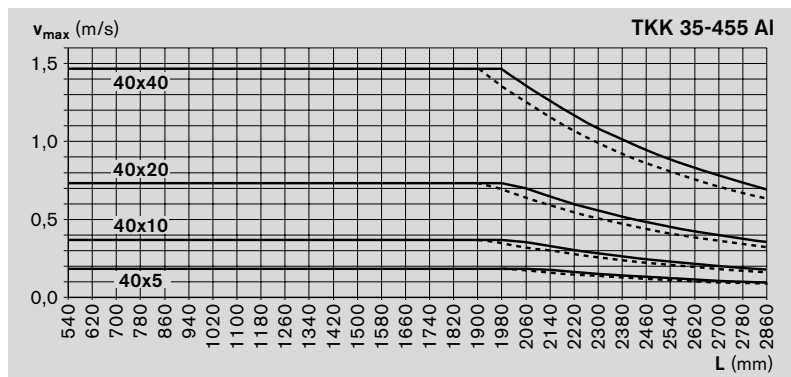
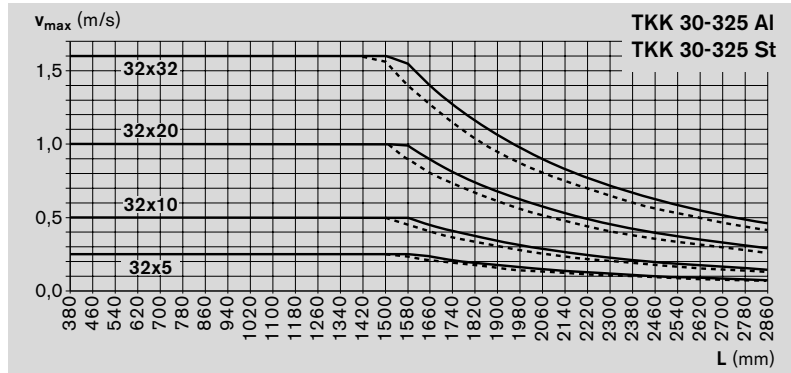
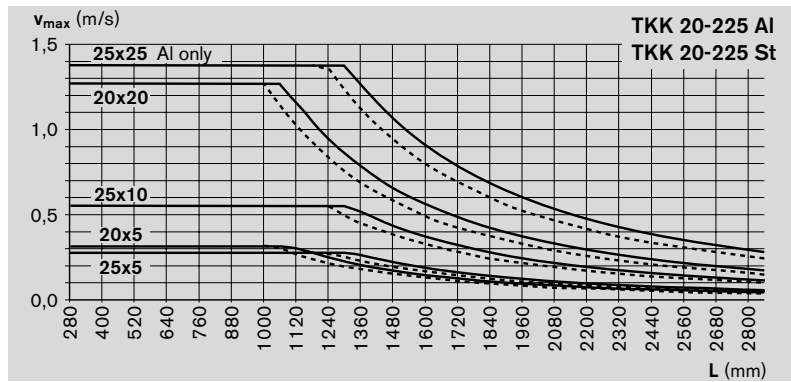
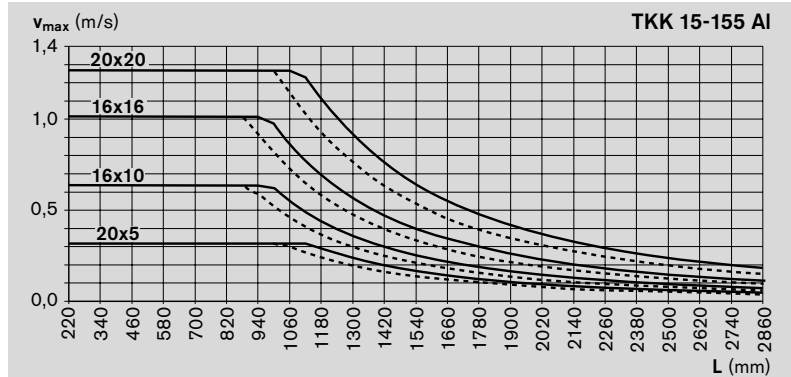
P = lead

Technical Data

Permissible travel speed

Ball Rail Table	Permissible travel speed v_{max} (m/s)
without drive without bellows	5
without drive with bellows	1.66
with drive with bellows	see charts

When selecting the motor, take account of the permissible travel speed of the Ball Rail Table or the selected ball screw drive.



— with bellows
- - - - without bellows

Maximum permissible drive torque, fixed bearing end (at the drive journal)

For motor attachment via motor mount and coupling at the fixed bearing end

For the permissible torque with a motor attached via timing belt drive, see "Timing belt side drive, floating bearing end."

The values shown for M_p apply under the following conditions:

- Horizontal operation
- Ball screw journal without keyway
- No radial load on ball screw shaft end
- Ball Rail Table with polyurethane bellows

Consider the rated torque of the coupling used!

Ball screw journal with keyway

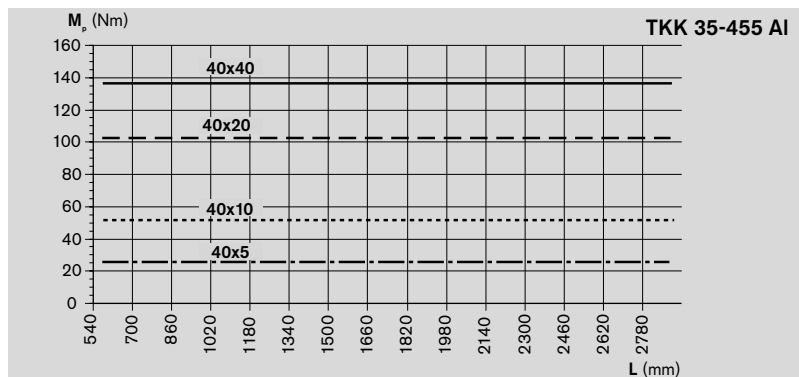
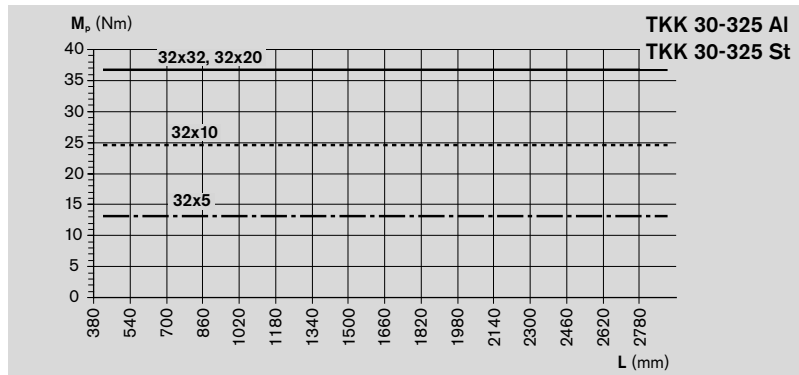
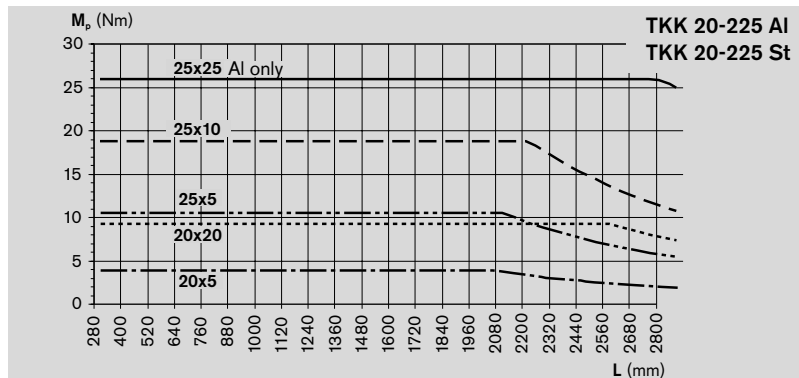
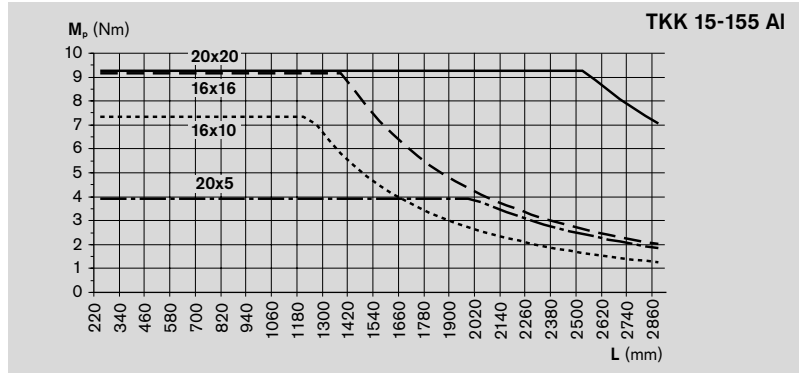
For reasons of stress concentration and a reduction of the effective diameter, do not exceed the following maximum values for drive torque!

Size	M_p (Nm)
TKK 15-155	4.5
TKK 20-225	4.5 (BS $\varnothing 20$) 11.0 (BS $\varnothing 25$)
TKK 30-325	18.0
TKK 35-455	76.0

When comparing the chart and table, the lower of the two values will always apply!

Example:

TKK 15-155, ball screw 20x5, length 1060 mm
 Drive torque $M_p \approx 3.9$ Nm from chart
 Maximum permissible drive torque as per table: 4.5 Nm
 Drive torque for sizing: 3.9 Nm



Calculations

Calculation principles

Combined equivalent load on bearing of the linear guide

$$F_{comb} = |F_y| + |F_z| + C \cdot \frac{|M_x|}{M_t} + C \cdot \frac{|M_y|}{M_L} + C \cdot \frac{|M_z|}{M_L}$$

Size	Dimension (mm)
	Z_1
TKK 15-155	23.7
TKK 20-225	36.6
TKK 30-325	48.5
TKK 35-455	65.5

- C = dynamic load capacity (N)
- F_{comb} = combined equivalent load on bearing (N)
- F_y = force in y-direction (N)
- F_z = force in z-direction (N)
- i = timing belt side drive reduction
- J_s = mass moment of inertia of linear motion system (without external load) (10^6 kgm^2)
- $k_{J \text{ fix}}$ = constant for fixed-length portion of mass moment of inertia (10^6 kgm^2)
- $k_{J \text{ var}}$ = constant for variable-length portion of mass moment of inertia (10^6 kgm^2)
- L = nominal life in meters (m)
- L_h = nominal life in hours (h)
- M_L = dynamic longitudinal moment load capacity (Nm)
- M_R = frictional torque at motor journal (Nm)
- M_{Rs} = frictional torque of the system (Nm)
- M_{Rsd} = frictional torque of timing belt side drive at motor journal (Nm)
- M_t = dynamic torsional moment load capacity (Nm)
- M_x = torsional moment about the X-axis (Nm)
- M_y = torsional moment about the Y-axis (Nm)
- M_z = torsional moment about the Z-axis (Nm)
- v_m = average travel speed (m/s)
- Z_1 = application point of the effective force (mm)

Life expectancy

Nominal life of the guideway in meters:

$$L = \left(\frac{C}{F_{comb}} \right)^3 \cdot 10^5$$

Nominal life of the guideway in hours:

$$L_h = \frac{L}{3600 \cdot v_m}$$

Frictional torque

for motor attachment via motor mount and coupling:

$$M_R = M_{Rs}$$

for motor attachment via timing belt side drive:

$$M_R = \frac{M_{Rs}}{i} + M_{Rsd}$$

Mass moment of inertia of the linear motion system J_s referred to the drive journal

$$J_s = (k_{J \text{ fix}} + k_{J \text{ var}} \cdot L) \cdot 10^{-6}$$

Mass moment of inertia of the mechanical system referred to the motor journal

Motor attachment via motor mount and coupling:

$$J_{ex} = J_s + J_t + J_c$$

Motor attachment via timing belt side drive:

$$J_{ex} = \frac{J_s + J_t}{i^2} + J_{sd}$$

Translatory mass moment of inertia of external load referred to the drive journal

$$J_t = m_{ex} \cdot k_{jm} \cdot 10^{-6}$$

Mass moment of inertia of the drive train referred to the motor journal

$$J_{dc} = J_{ex} \cdot J_{br}$$

Mass moment of inertia ratio

$$V = \frac{J_{dc}}{J_m}$$

Application area	V
Handling	≤ 6.0
Processing	≤ 1.5

Total mass moment of inertia referred to the motor journal

$$J_{tot} = J_{dc} + J_m$$

Maximum permissible rotary speed for mechanical system

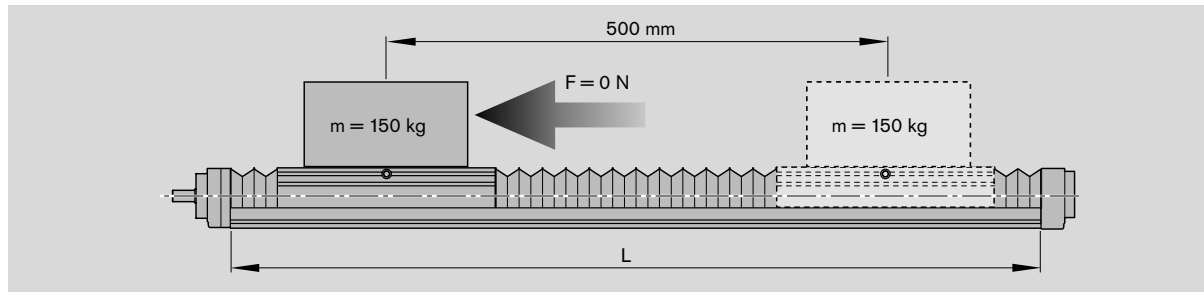
$$n_{mech} = \frac{v_{mech} \cdot i \cdot 1000 \cdot 60}{P}$$

$$n_{mech} < n_{m \max}$$

- J_{br} = mass moment of inertia, motor brake (kgm²)
- J_c = mass moment of inertia, coupling (kgm²)
- J_{dc} = mass moment of inertia, drive train (kgm²)
- J_{ex} = mass moment of inertia of mechanical system (kgm²)
- J_m = mass moment of inertia, motor (kgm²)
- J_s = mass moment of inertia of linear motion system (without external load) (kgm²)
- J_{sd} = mass moment of inertia of timing belt side drive at motor journal (kgm²)
- J_t = translatory mass moment of inertia of external load referred to the drive journal (kgm²)
- J_{tot} = total mass moment of inertia (kgm²)
- i = gear ratio of timing belt side drive (-)
- k_{jm} = constant for mass-specific portion of mass moment of inertia (10⁶ m²)
- m_{ex} = moved external load (kgm)
- $n_{m \max}$ = maximum permissible rotary speed of motor with controller (min⁻¹)
- n_{mech} = maximum permissible rotary speed of mechanical system (min⁻¹)
- P = screw lead (mm)
- V = ratio of mass moments of inertia of drive train and motor (-)
- v_{mech} = maximum permissible linear speed of mechanical system (m/s)

Calculation example

When sizing the drive, the motor-controller combination must always be considered, as the motor type and performance data (e.g. maximum useful speed and maximum torque) will depend on the controller or control system used. (See also Product Overview, "Motor selection based on drive controllers and control system.")



Given data

A mass of 150 kg is to be moved 500 mm at a maximum travel speed of 0.66 m/s. The following was selected based on the technical data and the connection dimensions:

Ball Rail Table TKK 30-325 AI

- $L_{ca} = 320$ mm
- 2% preload
- With protective bellows
- With motor MSK 060C attached via motor mount and coupling

Estimation of the Ball Rail Table length L

Excess travel	=	$2 \cdot P = 2 \cdot 32 \text{ mm} = 64 \text{ mm}$
Max. travel	=	$\text{stroke}_{\text{eff}} + 2 \cdot \text{excess travel}$
	=	$500 \text{ mm} + 2 \cdot 64 \text{ mm}$
	=	628 mm
Length L:		for max. travel = 628 mm
		from data sheet TKK 30-325 AI
L	=	1100 mm

Selection of ball screw

See charts in "Technical Data" section.

General recommendation:

Always select the lowest lead (resolution, braking distance, length).

Permissible ball screws according to the "Permissible travel speed" chart at $v = 0.66$ m/s and $L = 1100$ mm:
Ball screw 32 x 20 and ball screw 32 x 32
 Ball screw selected (lower lead)
Ball screw 32 x 20
 with a maximum permissible drive torque of 36.5 Nm as per "Permissible drive torque" chart for $L = 1100$ mm

Calculation of the Ball Rail Table length L

Excess travel	=	$2 \cdot P = 2 \cdot 20 \text{ mm} = 40 \text{ mm}$
Max. travel	=	$\text{stroke}_{\text{eff}} + 2 \cdot \text{excess travel}$
	=	$500 \text{ mm} + 2 \cdot 40 \text{ mm}$
	=	580 mm
L	=	1020 mm for max. travel = 580 mm
		(582 mm) from data sheet TKK 30-325 AI

Frictional torque M_R

M_R	=	M_{RS} (see "Technical Data")
M_R	=	1.21 Nm

Mass moment of inertia of the mechanical system

$$\begin{aligned}
 J_{\text{ex}} &= J_{\text{S}} + J_{\text{t}} + J_{\text{C}} \\
 J_{\text{S}} &= (k_{\text{J fix}} + k_{\text{J var}} \cdot L) \cdot 10^{-6} \text{ kgm}^2 \\
 &= (265.3 + 0.667 \cdot 1020 \text{ mm}) \cdot 10^{-6} \text{ kgm}^2 \\
 &= 945.64 \cdot 10^{-6} \text{ kgm}^2 \quad (\text{see "Technical Data"}) \\
 J_{\text{t}} &= m_{\text{ex}} \cdot k_{\text{J m}} \cdot 10^{-6} \text{ kgm}^2 \\
 &= 150 \cdot 10.13 \cdot 10^{-6} \text{ kgm}^2 \\
 &= 1519.5 \cdot 10^{-6} \text{ kgm}^2 \quad (\text{see "Technical Data"}) \\
 J_{\text{C}} &= 200 \cdot 10^{-6} \text{ kgm}^2 \quad (\text{see "Technical Data"}) \\
 J_{\text{ex}} &= (945.64 + 1519.5 + 200) \cdot 10^{-6} \text{ kgm}^2 \\
 &= 2665 \cdot 10^{-6} \text{ kgm}^2 \\
 J_{\text{dc}} &= J_{\text{ex}} + J_{\text{br}} \\
 J_{\text{br}} &= 55 \cdot 10^{-6} \text{ kgm}^2 \quad (\text{see "Motors"}) \\
 J_{\text{dc}} &= (2665 + 55) \cdot 10^{-6} \text{ kgm}^2 \\
 &= 2720 \cdot 10^{-6} \text{ kgm}^2
 \end{aligned}$$

Mass moment of inertia for handling ($V \leq 6$)

$$\begin{aligned}
 V &= \frac{J_{\text{dc}}}{J_{\text{m}}} \leq 6 \\
 &= \frac{2720 \cdot 10^{-6} \text{ kgm}^2}{800 \cdot 10^{-6} \text{ kgm}^2} \\
 &= 3.4 \leq 6
 \end{aligned}$$

The selected motor (MSK 060C) is therefore suitable.

Rotary speed n
at $v = 0.66 \text{ m/s}$

$$n_{\text{mech}} = \frac{v_{\text{mech}} \cdot i \cdot 1000 \cdot 60}{P} = \frac{0,66 \text{ m/s} \cdot 1 \cdot 1000 \cdot 60}{20 \text{ mm}} = 1980 \text{ min}^{-1}$$

$v_{\text{mech}} = 0.66 \text{ m/s}$ If the permissible travel speed of 0.66 m/s is not sufficient, switch to size 32 x 32 and repeat the calculation.

Result

Ball Rail Table TKK 30-325 Al
 Length L = 1020 mm
 Ball screw:
 Diameter 32 mm;
 Lead 20 mm;
 Carriage length: $L_{\text{ca}} = 320 \text{ mm}$;
 Preload: 2%

Motor attachment via motor mount and coupling

Motor with: – maximum useful speed $n_{\text{m max}} > 2000 \text{ min}^{-1}$
 – mass moment of inertia $J_{\text{m}} > 450 \cdot 10^{-6} \text{ kgm}^2$
 – maximum permissible drive torque $M_{\text{max}} < 36.5 \text{ Nm}$
 Consider the rated coupling torque M_{cN} and the frictional torque M_{R} ($M_{\text{cN}} = 50 \text{ Nm}$; $M_{\text{R}} = 1.21 \text{ Nm}$)

These requirements are fulfilled by all AC servo motors approved for TKK 30-325 Al in the "Components and Ordering Data" table.

The specific motor is selected:

- according to criteria in the "Motors" section
- and by recalculating the drive unit with performance data from the "ECODRIVE Cs" and "IndraDrive for Linear Motion Systems" catalogs.