Rexroth
Bosch Group

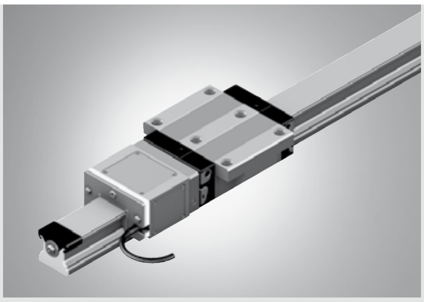
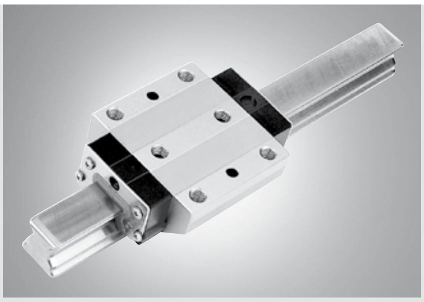
Drive Units with Ball Screw Drives

R310EN 3304 (2007.05)

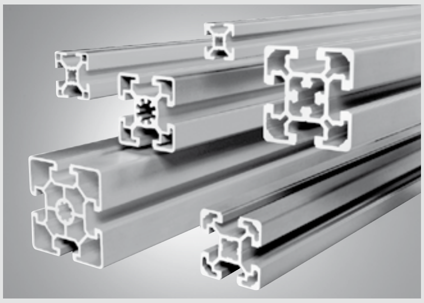
The Drive & Control Company

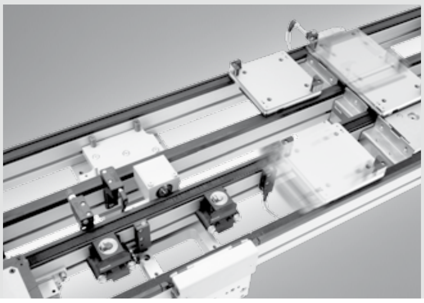
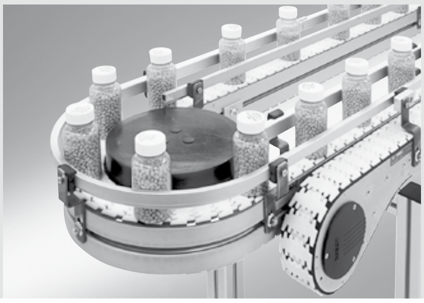
Linear Motion and Assembly Technologies

Ball Rail Systems
Roller Rail Systems
Linear Bushings and Shafts
Precision Ball Screw Assemblies
Linear Motion Systems
Basic Mechanical Elements
Manual Production Systems
Transfer Systems





Catalog Overview

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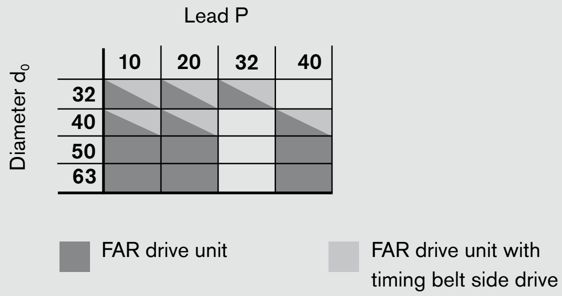

Drive units with driven nut	Page
Precision-rolled screw SN-R Tolerance grades T5, T7, T9	70
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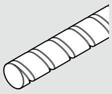
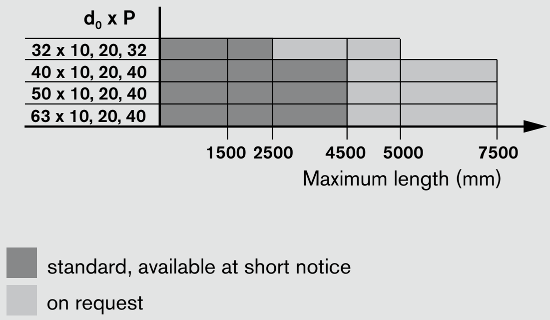




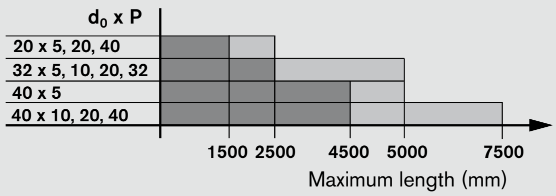
Drive units with driven screw	Page

Lead P (columns) / Diameter d_0 (rows)

Diameter d_0	5	10	20	32	40
20	■		■		■
32	■	■	■	■	
40	■	■	■		■

Lead P (columns) / Diameter d_0 (rows)

Diameter d_0	5	10	20	32	40
20	■		■		■
32	■	■	■	■	
40	■	■	■		■



■ standard, available at short notice

□ on request

Drive units with Driven Nut

Drive Units

For drives using ball screws – including AOK and AGK – the conventional solution today is to have the screw driven by an AC servo motor either directly or via a toothed belt. The driven screw rotates and the nut performs the required linear movement.

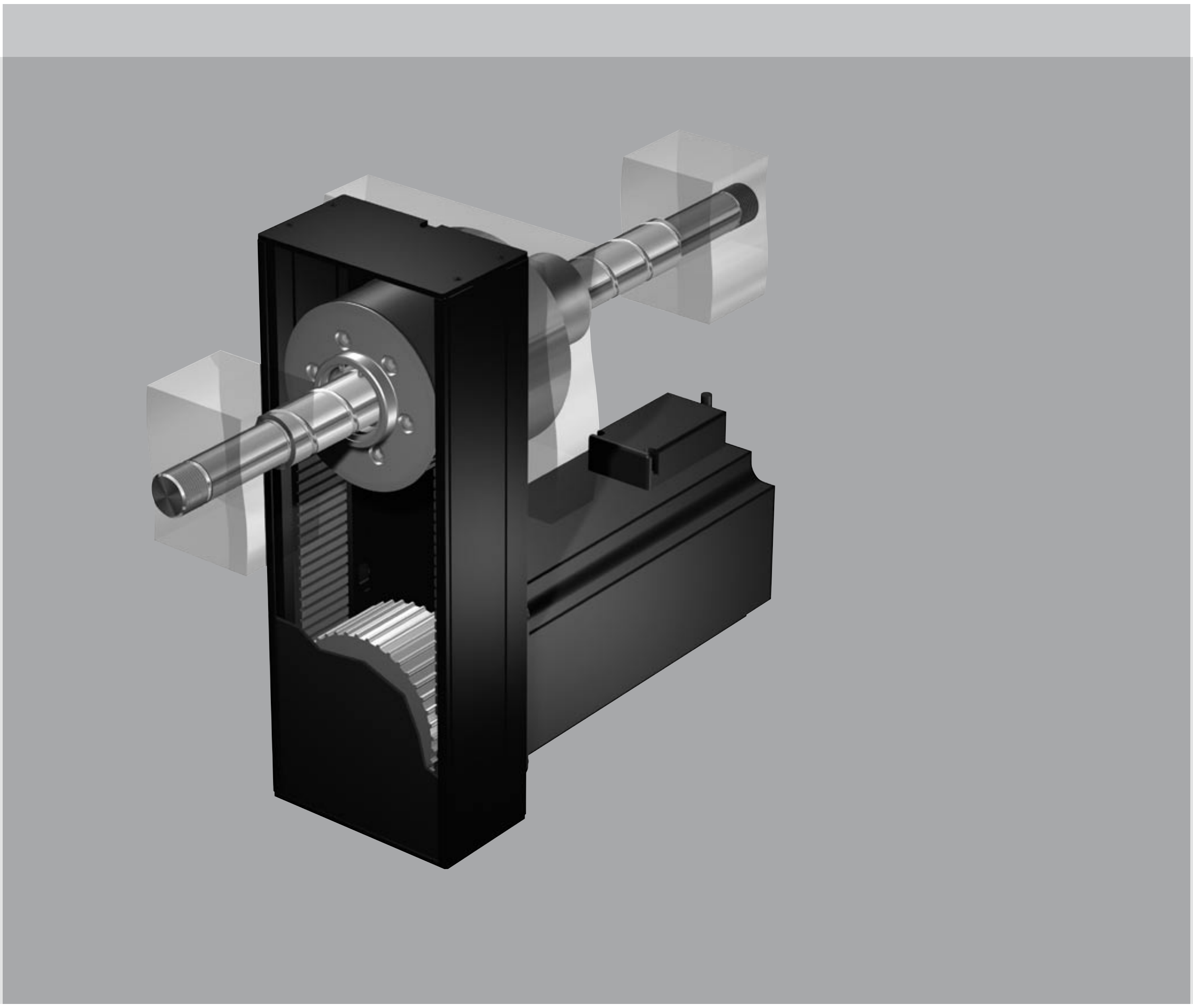
The maximum permissible axial forces (buckling load) and maximum possible linear speeds are frequently limited by the length of the screw and the design of the end bearings. Because of this, the achievable nut speed falls far short of its maximum permissible value (d x n).

Today, a screw's operating speed comes close to its critical speed, especially in high dynamic applications. This, combined with thermal influences, makes it very difficult for physical reasons to implement a high dynamic machine concept. Positioning accuracy may also be limited as a result.

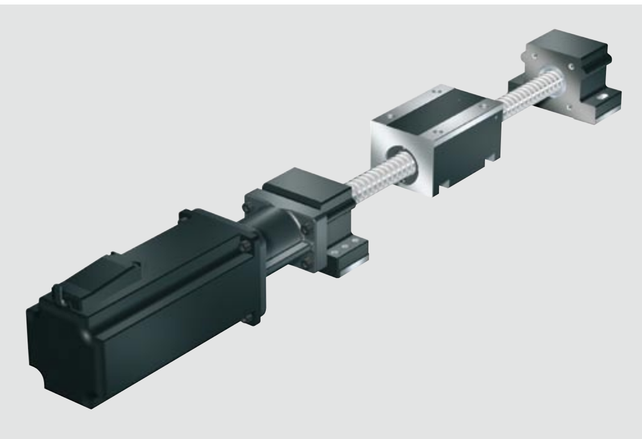
The FAR driven nut takes a different approach.
In this solution, the screw does not rotate, and the ball nut is driven by a toothed belt.

There are no end bearings to limit the speed or rigidity. Undesirable thermal influences can be largely reduced by stretching the screw. Because the screw does not rotate, it is also possible to have a hollow screw and to dissipate the generated heat simply by means of liquid cooling.

If desired, the nut assembly can be delivered as a complete functional unit with timing belt side drive and AC servo motor. With this configuration, even new drive concepts, such as several motors on one screw, can be easily put into practice.



FAR with timing belt side drive



AOK drive unit with motor mount and coupling

AGK drive unit with motor mount and coupling

Drive Units with Driven Nut, FAR Series

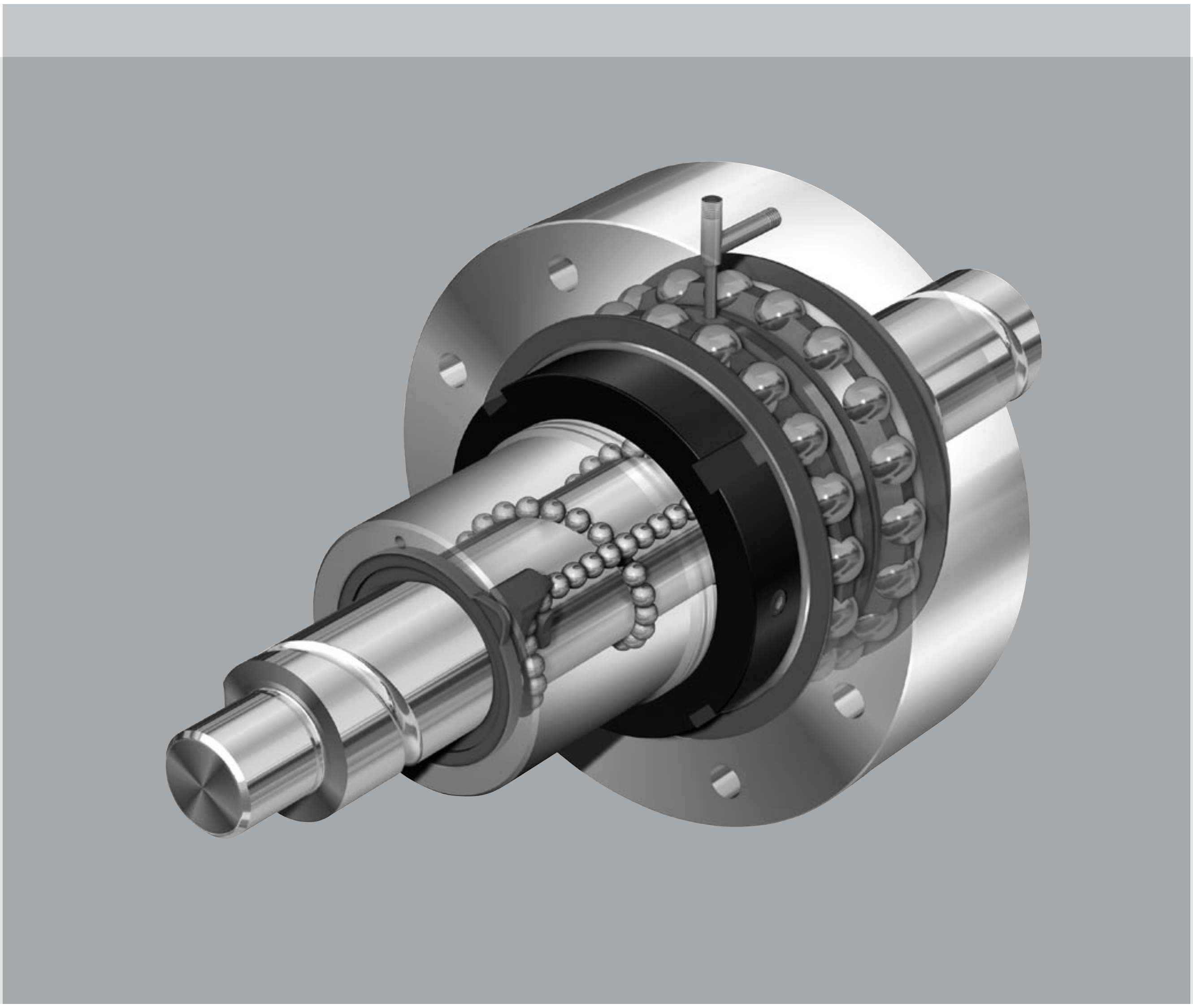
Product Overview, FAR

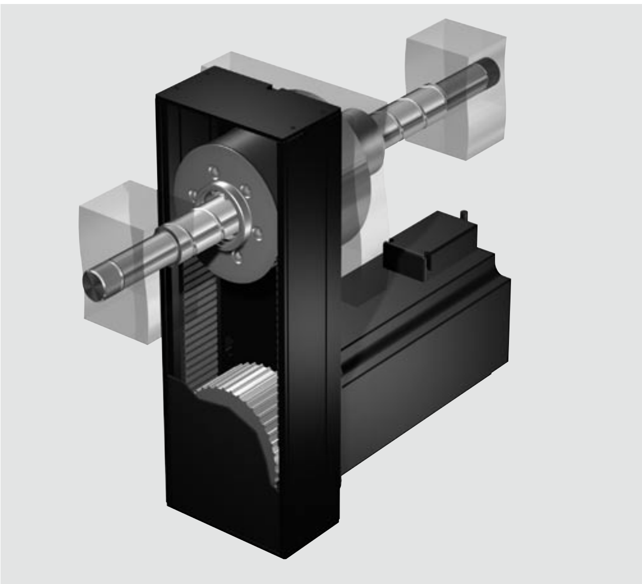
This section contains a complete range of driven nuts.
These products answer customers' wishes for a ready-made solution. The large choice of sizes and screw leads caters for all desired linear speeds and loads. This eliminates the need for complex customer-built constructions.

The driven nut assembly consists of
- a single ball nut
- a two-row angular contact ball bearing with integrated mounting holes and lube port
- a slotted nut

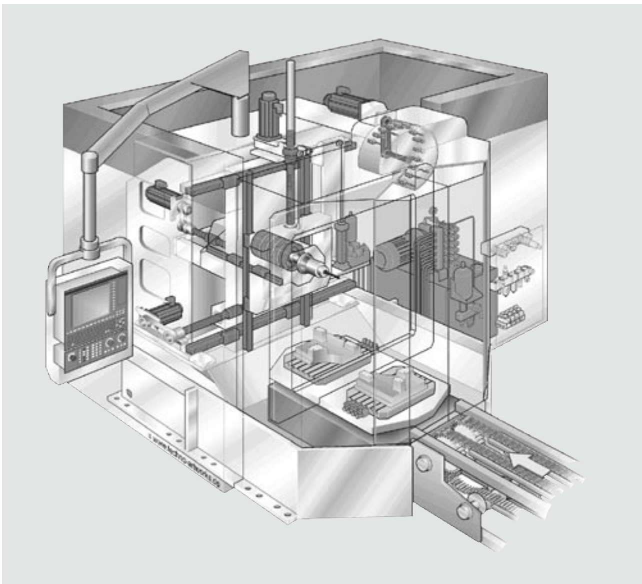
The matching timing belt side drive can be supplied along with the assembly, if required. Suitable AC servo motors and drive controllers are also shown.

User benefits
- Economy through the use of a complete unit consisting of a ball screw, an AC servo motor and a timing belt side drive
- Adaptation to various speeds and loads by means of the screw lead and belt reduction
- Various power classes by using different motor versions
- Low space requirement due to compact design
- Minimal mounting effort by the customer and integral functionality
- Low system costs
- High positioning accuracy
- Can be combined with a rail-integrated measuring system (Catalog R310EN 2350) for direct travel measurement in applications with particularly demanding positioning requirements





FAR drive unit with timing belt side drive and motor



Vertical axis of a machining center: Ball screw drive with driven nut and timing belt side drive

Drive Units with Driven Nut, FAR Series

Sizing of the FAR Drive Unit

Dimensioning

FAR drive units are sized according to the same general criteria as ball screw assemblies:

Service life calculation

The service life of the drive unit is calculated in a similar way as for a classic ball screw drive.
The average speed and average load are calculated for this purpose (see the “Calculations” section).
Because this is a complete unit, the lowest basic load rating of the nut or bearing must be used for the calculation.

Calculation of the permissible drive torque

The maximum permissible drive torque at the motor journal is expressed in formulas and shown in charts, giving a clear indication of the various factors involved. For each ball screw size and length, the classic Euler buckling load of the screw is shown, as well as the respective end fixity and the specific drive journal used along with the load forces.

Permissible speed and critical speed

The permissible speed of the ball screw is influenced by different factors:

– Screw lead
– Maximum permissible nut speed (d x n value)
– Permissible speed of the end bearings
– Length-dependent critical speed of the screw, although this is no longer a genuine restriction in the version with driven nut and fixed-fixed end fixity. The only significant limitations are when the screw is fixed at one end only. The position of the nut is important in this case, as shown in the charts on the following pages.

A **calculation example** that shows the interplay of all chosen components for a typical application can be found in the “Calculations and Examples” section.

Service life calculation

The drive unit size can be determined by performing a service life calculation.

In the “Calculations” section, the dynamic load rating given in the table is compared with the loads occurring in the application.

d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

FAR size	Ball screw size d_0 x P x D_W - i	Part number Nut and bearing assembly	Load ratings dyn. C (N)	stat. C_0 (N)
32	**32 x 10R x 3.969 - 5**	R2532 301 01	31700	58300
	32 x 20R x 3.969 - 3	R2532 301 11	19700	33700
	32 x 32R x 3.969 - 3	R2532 301 21	19500	34000
40	**40 x 10R x 6 - 5**	R2532 401 01	61500	109200
	40 x 20R x 6 - 3	R2532 401 31	37900	62800
	40 x 40R x 6 - 3	R2532 401 41	37000	62300
50	**50 x 10R x 6 - 6**	R2532 501 01	73000	132000
	50 x 20R x 6.5 - 5	R2532 501 31	73000	132000
	50 x 40R x 6.5 - 3	R2532 501 41	46500	85900
63	**63 x 10R x 6 - 6**	R2532 601 01	88800	197000
	63 x 20R x 6.5 - 5	R2532 601 11	83900	190300
	63 x 40R x 6.5 - 3	R2532 601 21	53400	114100

Drive Units with Driven Nut, FAR Series

Length Calculation

The main dimensions can be specified using a simple length calculation.

$$L_{Hmax} = L_{H1} + L_{H2}$$

$$L_C = L_{RV} + L_E$$

for interference contour case 1

$$L_{thr} = L_{Hmax} + L_C + L_N$$

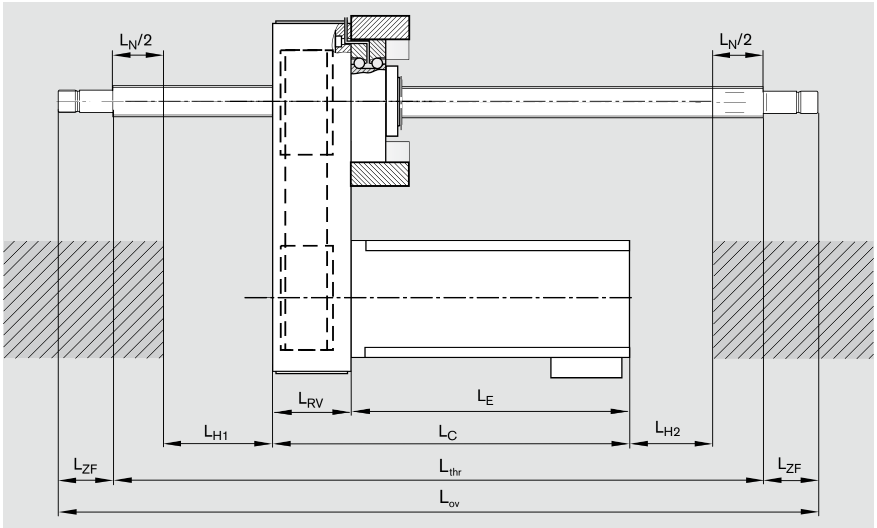
$$L_{ov} = L_{thr} + 2 \times L_{ZF}$$

L_{Hmax} = maximum stroke required by customer
L_C = length of customer attachment or of the motor and timing belt side drive used by Bosch Rexroth
L_{thr} = thread length
L_N = unusable length; includes the necessary excess travel on the screw

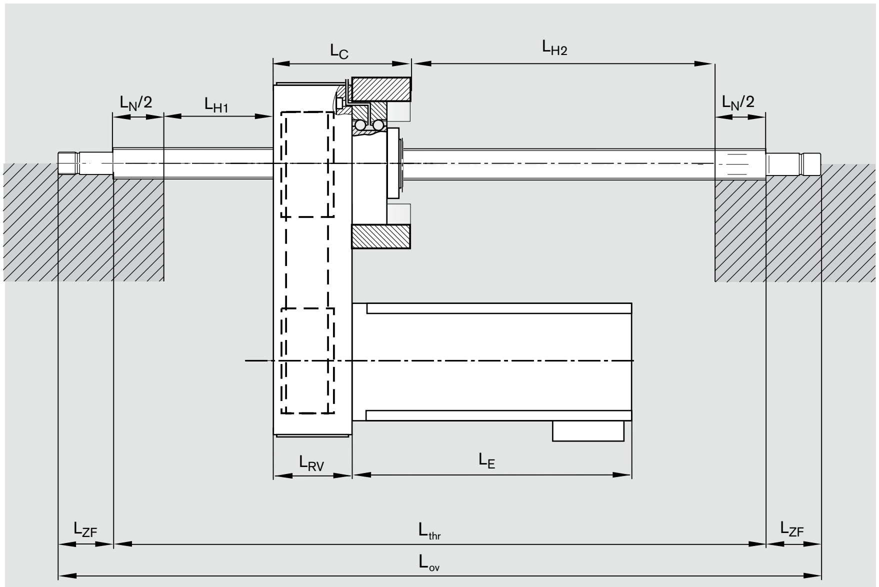
d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

FAR size	Ball screw size d_0 x P x D_W - i	Dimensions (mm) L_N	L_{ZF}	L_3	L_{Rv}	L_E
32	**32 x 10R x 3.969 - 5**	128	108	11	90	313
	32 x 20R x 3.969 - 3					
	32 x 32R x 3.969 - 3					
40	**40 x 10R x 6 - 5**	160	117	12	90	313
	40 x 20R x 6 - 3					
	40 x 40R x 6 - 3					
50	**50 x 10R x 6 - 6**	200	145	13	Customer specific	Customer specific
	50 x 20R x 6.5 - 5					
	50 x 40R x 6.5 - 3					
63	**63 x 10R x 6 - 6**	252	183	20	Customer specific	Customer specific
	63 x 20R x 6.5 - 5					
	63 x 40R x 6,5 - 3					

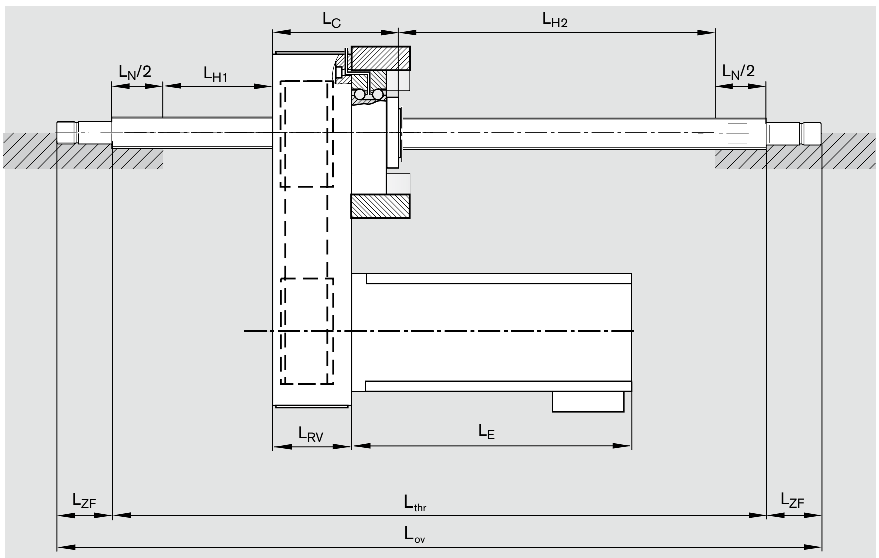
Interference contour case 1
The motor collides with the customer structure on the right and the timing belt side drive does so on the left, thus limiting the stroke.



Interference contour case 2
Customer structure on the right and timing belt side drive on the left limit the stroke of the driven nut.



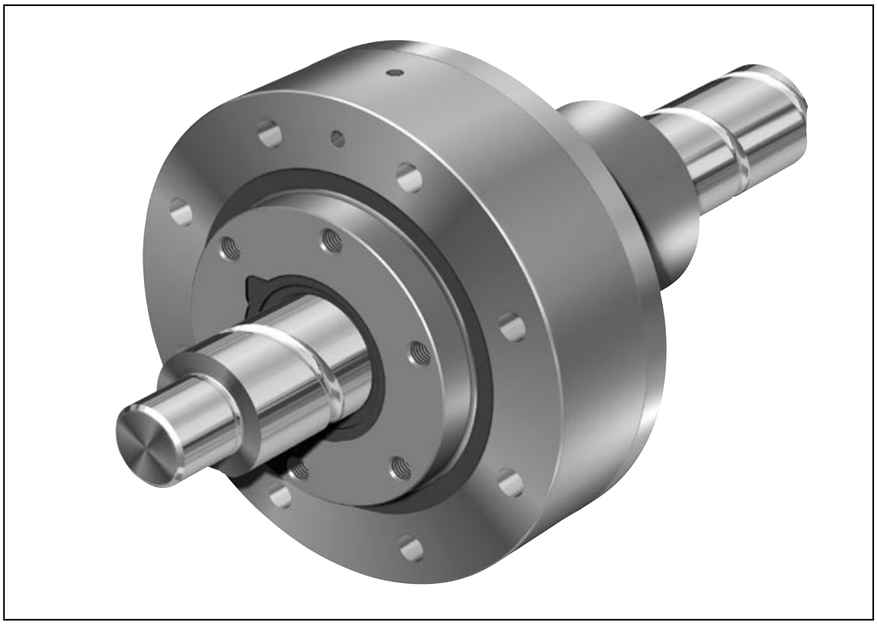
Interference contour case 3
The nut unit and the timing belt side drive limit the stroke.



Drive Units with Driven Nut, FAR Series

Technical Data and Dimensions

Mounting dimensions of the drive unit without timing belt side drive and motor



Sizes 32 - 63
– Can be lubricated with NLGI Class 2 grease at standstill using the lube port on the bearing outer race

Optional
– Liquid-cooled screw
– Lubrication via the screw

For rigidity, please refer to “Technical Notes.”

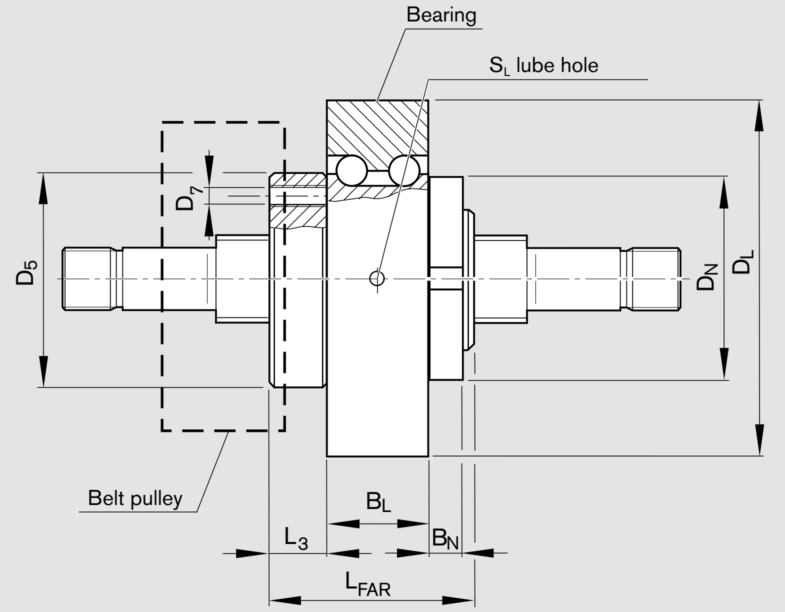
d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

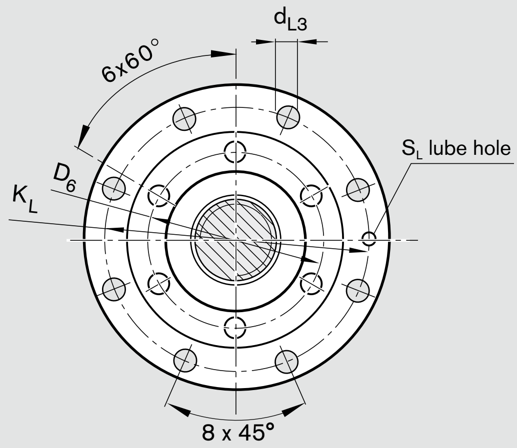
FAR size	Ball screw size d_0 x P x D_W - i	Weight m_{FAR} (kg)	Mass moment of inertia J_{rotFAR} (kgm² · 10^{-4})	Bearing frictional torque M_{RL} (Nm)	Rigidity[1] R_G (N/µm)	Max. rotary speed[2] n_{max} (min⁻¹)
32	32 x 10R x 3.969 - 5	5.8	22.5	1.0	377	3000
	32 x 20R x 3.969 - 3	5.9	22.9		278	
	32 x 32R x 3.969 - 3	6.3	25.1		273	
40	40 x 10R x 6 - 5	7.3	42.7	1.2	448	2800
	40 x 20R x 6 - 3	7.5	43.9		332	
	40 x 40R x 6 - 3	8.4	50.7		323	
50	50 x 10R x 6 - 6	8.3	67.6	1.4	556	2700
	50 x 20R x 6.5 - 5	9.1	76.0		525	
	50 x 40R x 6.5 - 3	9.5	79.8		386	
63	63 x 10R x 6 - 6	12.8	139.0	2.3	627	2300
	63 x 20R x 6.5 - 5	13.5	156.4		599	
	63 x 40R x 6.5 - 3	13.9	161.6		461	

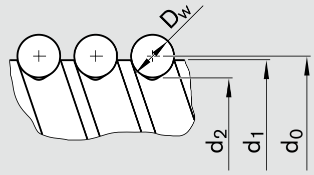
1) Bearing with ball nut at 5% preload

2) Limited by max. rotary speed of bearing. Bearing preloaded without external operating load. Duty cycle 25%; max. steady state temp. +50 °C

FAR size	Screw end type		Ball screw size d_0 x P x D_W - i	Dimensions (mm) B_L	B_N	d_{L3} +0.3/−0.1	d_1	d_2	D_1 h6
32	51	209	32 x 10R x 3.969 - 5	49	16	8.8	31.0	27.9	20
			32 x 20R x 3.969 - 3						
			32 x 32R x 3.969 - 3						
40		309	40 x 10R x 6 - 5	49	18	8.8	38.0	33.8	30
			40 x 20R x 6 - 3						
			40 x 40R x 6 - 3						
50		359	50 x 10R x 6 - 6	49	18	8.8	48.0	43.8	35
			50 x 20R x 6.5 - 5					43.3	
			50 x 40R x 6.5 - 3						
63		409	63 x 10R x 6 - 6	60	20	11.0	61.0	56.8	40
			63 x 20R x 6.5 - 5					56.4	
			63 x 40R x 6.5 - 3						







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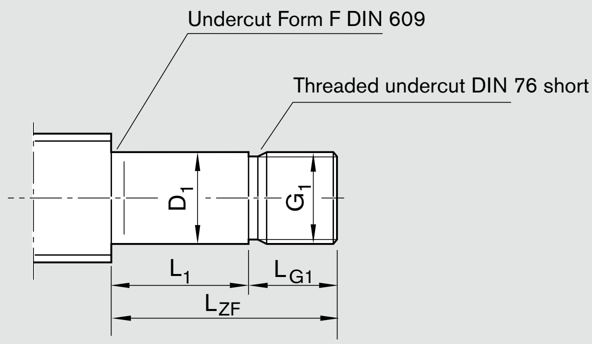
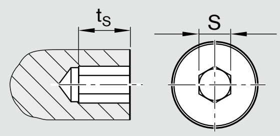
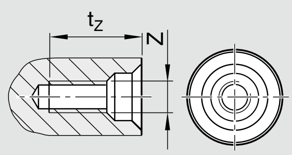


Option (machined end face)

S	
Z	
K	None
F	Liquid cooling of screw on request

FAR size	Screw end type		Dimensions (mm)													Centering hole		Hex socket	
			D_5 h6	D_6	D_7	D_L −0.018	D_N	G_1	K_L	L_{FAR}	L_{G1}	L_{ZF}	L_1	L_3	S_L	Z	t_Z	S	t_S
32	**51**	**209**	80	65	M8	145	75	M20x1	120	77	31	108	77	11	M6	M6	16	8	8
										84									
										120									
40		**309**	93	80	M8	155	92	M30x1.5	130	80	34	117	83	12	M6	M10	22	10	10
										88									
										142									
50		**359**	105	90	M8	165	105	M35x1.5	140	90	36	145	109	13	M6	M12	28	12	12
										132									
										149									
63		**409**	130	110	M10	190	120	M40x1.5	165	100	36	183	147	20	M6	M16	36	17	17
										132									
										149									

Drive Units with Driven Nut, FAR Series

Technical Data and Dimensions

Mounting dimensions of the FAR drive unit with timing belt side drive and AC servo motor with brake

Sizes 32 and 40

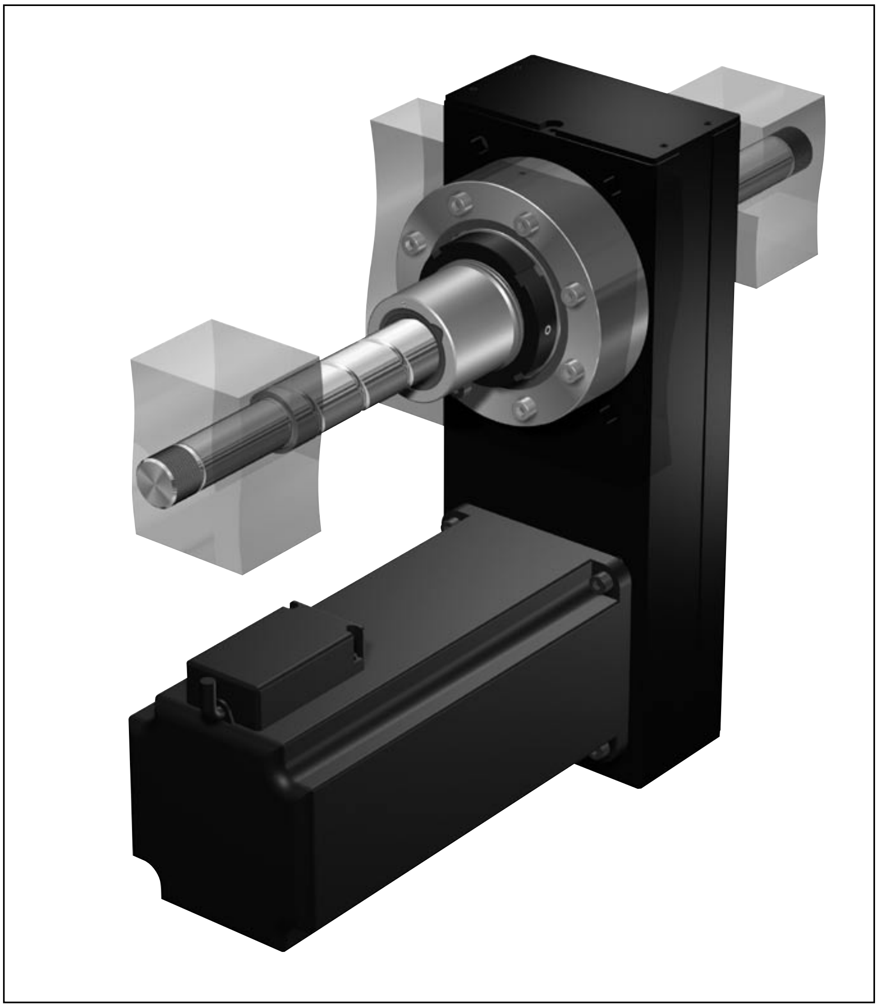
- Can be lubricated with NLGI Class 2 grease at standstill using the lube port on the bearing outer race

Optional

- Liquid-cooled screw
- Lubrication via the screw

More technical data and details of accessories for the servo drive used can be found in the catalogs

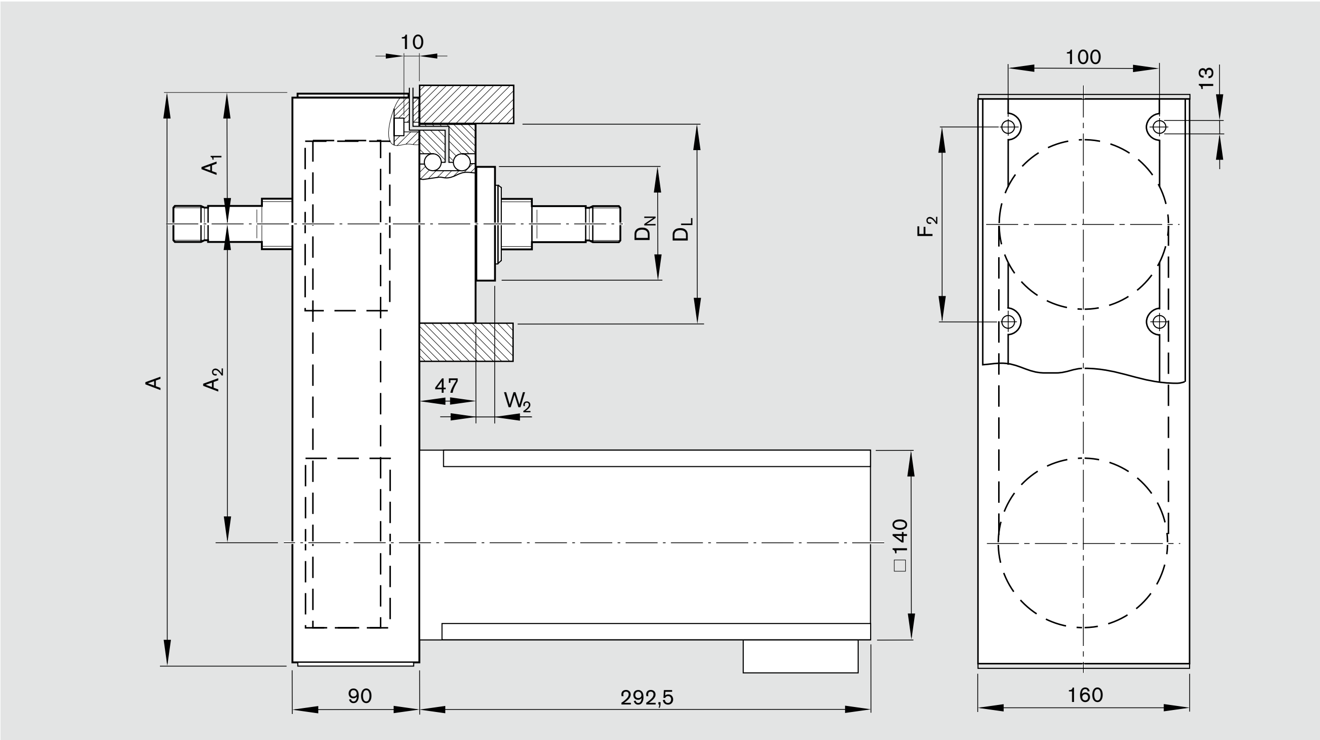
- Controllers, Motors, Electrical Accessories (R310EN 2710)
- Synchronous Motors MSK – Project Planning Manual (R911296288)
- Rexroth IndraDrive and Rexroth IndraDyn (R911311519)



d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

FAR size	Ball screw size	Motor				Mass moment of inertia		Weight (kg)	
		Motor type	Torque (Nm)		Max. rotary speed[2]	(kgm²)10⁻⁴			
			M_{MN}[1]	M_{Mmax}[1]	n_{Mmax}	Motor	Brake	Motor	Brake
	d_0 x P x D_W - i		Rated	Maximum	(min⁻¹)	J_M	J_{BR}	m_M	m_{BR}
32	32 x 10R x 3.969 - 5	MSK 076C	12	43.5	5000	43	3.6	14	1.1
	32 x 20R x 3.969 - 3								
	32 x 32R x 3.969 - 3								
40	40 x 10R x 6 - 5								
	40 x 20R x 6 - 3								
	40 x 40R x 6 - 3								

1) The motor data depend on the control system used.
2) Consider the rotary speed of the ball nut unit.

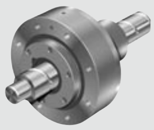


FAR size	Ball screw size d_0 x P x D_W - i	Side drive gear reduction i_{RV}	Weight of timing belt side drive m_{RV} (kg)	Reduced mass moment of inertia at motor journal J_{RV} (kgm²) 10^{-4}	Permissible torque M_{RV} (Nm)	Frictional torque[3)] M_{RRV} (Nm)	Dimensions (mm) A	A_1	A_2	F_2	D_N	D_L	W_2
32	32 x 10R x 3.969 - 5	1	8.6	79	56	0.6	390	89	205	136	75	145	17
	32 x 20R x 3.969 - 3												24
	32 x 32R x 3.969 - 3												60
	32 x 10R x 3.969 - 5	1.25	7.9	42	44				210				17
	32 x 20R x 3.969 - 3												24
	32 x 32R x 3.969 - 3												60
	32 x 10R x 3.969 - 5	2	7.5	14	28				208				17
	32 x 20R x 3.969 - 3												24
	32 x 32R x 3.969 - 3												60
40	40 x 10R x 6 - 5	1	8.7	84	60	0.6	398	99	205	150	92	155	19
	40 x 20R x 6 - 3												27
	40 x 40R x 6 - 3												81
	40 x 10R x 6 - 5	1.25	8.1	45	48				210				19
	40 x 20R x 6 - 3												27
	40 x 40R x 6 - 3												81
	40 x 10R x 6 - 5	2	7.6	15	28				208				19
	40 x 20R x 6 - 3												27
	40 x 40R x 6 - 3												81

3) Frictional torque at motor journal

Drive Units with Driven Nut, FAR Series

Configuration and Ordering Data



Size	Ball screw d_0 x P	Length[1] (mm) (Fig. 1)	Ball nut Sealing type	Preload	Screw Tolerance grade	Screw end, left	Screw end, right	Lubrication
FAR 32	32x10 32x20 32x32	L_{ov} = L_{thr} = L_{Hmax} =	01 Standard seal 00 Without seal	03 2% preload 06 3% preload 02 5% preload	T5 T7	K None F Liquid cooling (on request) Z Centering feature to DIN 332-D S Hex socket	K None F Liquid cooling (on request) Z Centering feature to DIN 332-D S Hex socket	00 Anti-corrosion oil 01 Basic lubrication and anti-corrosion oil
FAR 40	40x10 40x20 40x40							
FAR 50	50x10 50x20 50x40							
FAR 63	63x10 63x20 63x40							

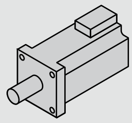
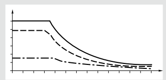
1) Only one length specification necessary

Order example:

Fixed parameters			
Lead direction	right-hand	**No. of ball track turns**	fixed
Nut unit	FAR-B-S	**Screw**	rolled
Screw end, left Screw end type	51	**Screw end, right** Screw end type	51

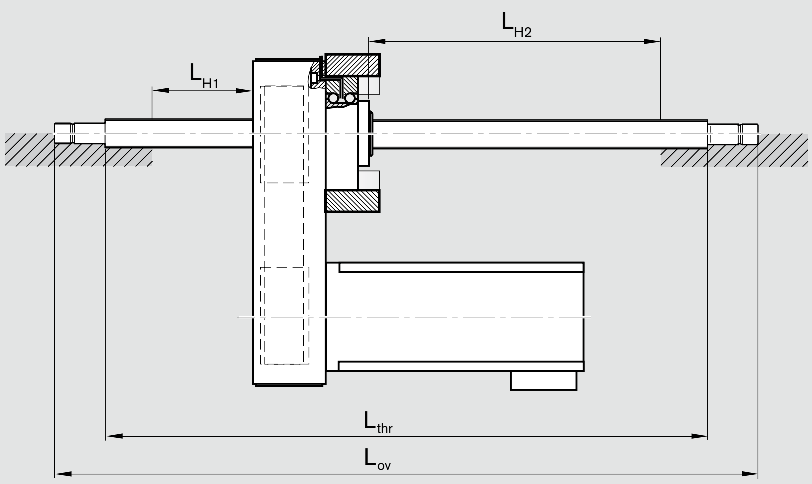
Variable parameters	Selected	Ordering data
FAR size	FAR 40	FAR 40
Ball screw	40 x 20	40 x 20
Length	Overall length 560 mm	$L_{ov} = 560$
Sealing type	Standard seal	01
Preload	5%	02
Tolerance grade	T5	T5
Screw end, left	Hex socket	S
Screw end, right	Hex socket	S
Lubrication	Basic lubrication and anti-corrosion oil	01
Drive type	With timing belt side drive	RV
Attachment kit	For i = 1.25	011
Motor	MSK 076C with brake	093
Documentation	Lead report (incl. standard test report)	001

When ordering:
Please state the option number given in the box as appropriate (e.g. 02).

Motor attachment 				Motor 	Documentation 	
Drive type	**Gear ratio**	**Attachment kit**	**Motor**			**Measurement report**
OF01	–	000		000		
RV	i = 1	010	MSK 076C with brake	093		Lead test report 001
	i = 1.25	011				
	i = 2	012				
OF01	–	000		000		
RV	i = 1	010	MSK 076C with brake	093	Standard (acceptance test report)[2)] 000	Torque test report 002
	i = 1.25	011				
	i = 2	012				
OF01	–	000		000		
OF01	–	000		000		Lead and torque test report 003

2) Is always supplied

Fig. 1



$L_{Hmax} = L_{H1} + L_{H2}$

L_{Hmax} depends on the installation conditions; see length calculation

Drive Units with Driven Screw, AOK Series

Product Overview, AOK

The AOK drive unit is the classic ball screw assembly with pillow blocks and pre-assembled ball nut enclosure.

The drive itself can be supplied along with the unit, if so requested by the customer. These readily available AOK drive units offer users the opportunity to rapidly integrate economical drive solutions with minimal design and manufacturing effort. They combine all the performance characteristics of a classic ball screw drive in one unit. When paired with Rexroth linear guides, they offer machine designers full design freedom for every application.

Advantages

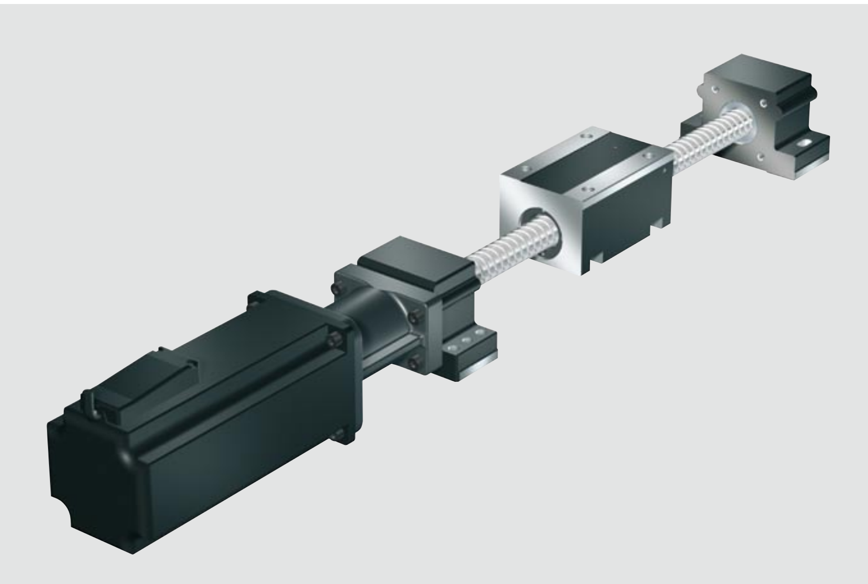
- Freely selectable length (no standard length increments)
- High positioning accuracy and repeatability due to ball screw assembly with zero-backlash nut system
- Easy motor attachment via locating feature and fastening threads on pillow block
- Rapid mounting and easy alignment due to the machined reference edges on the ball nut enclosure and the pillow block units
- High linear speeds thanks to double floating bearing
- Optimal travel performance and high load ratings

Structural design

- Rexroth Precision Ball Screw Assembly with screws of various tolerance grades and cylindrical single nut, also available with zero backlash or preloaded
- Ball nut enclosure made of aluminum finished on all sides with reference edges on both sides
- Pillow block units made of robust extruded aluminum profile with reference edges on both sides and mounting holes as well as locating feature for motor mounting

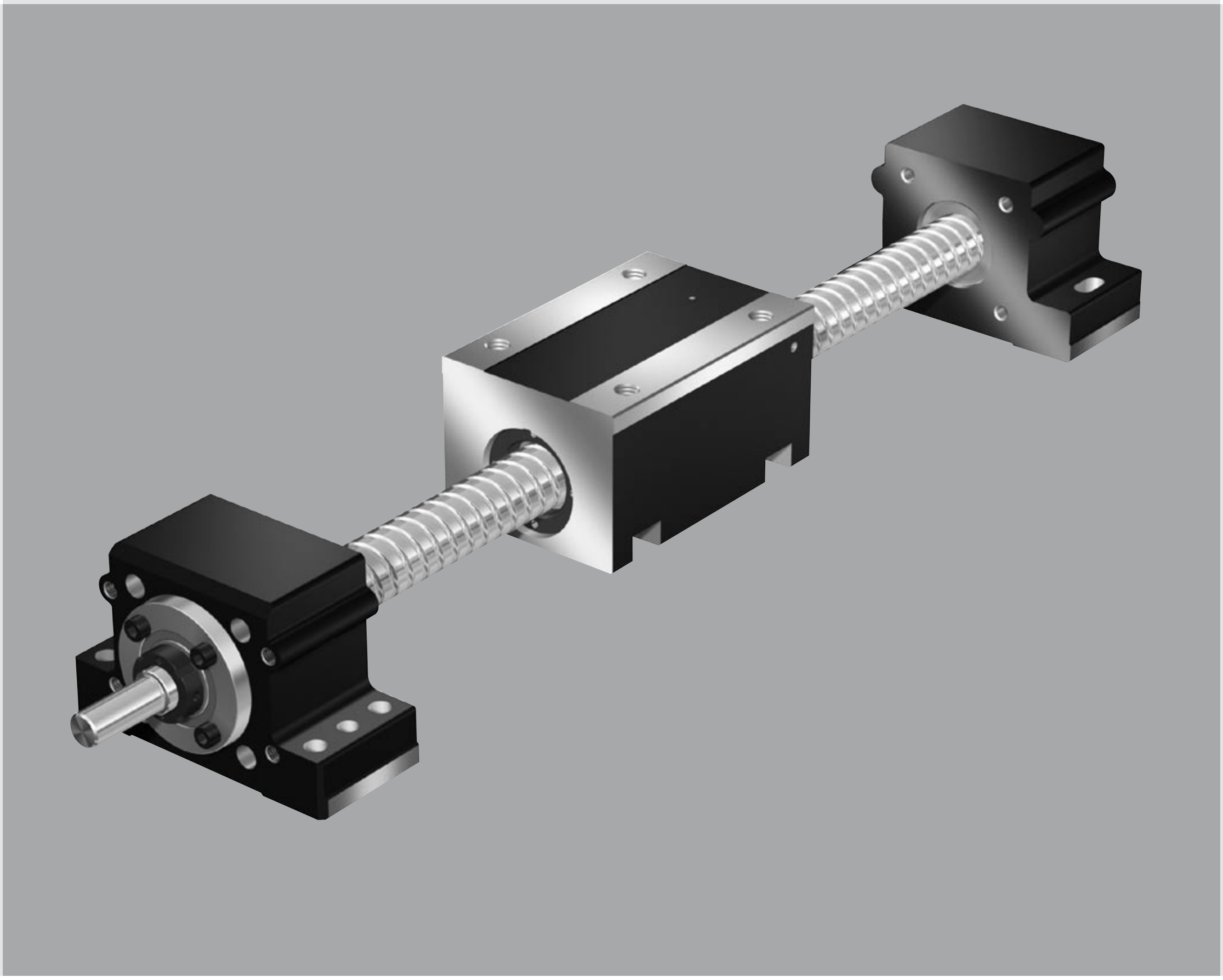
Choice of drive elements

- Motor mount and coupling, pre-assembled with motor attached
- Timing belt side drive with selectable gear ratios, pre-assembled with motor attached
- Maintenance-free digital AC servo drives with integrated brake and attached feedback

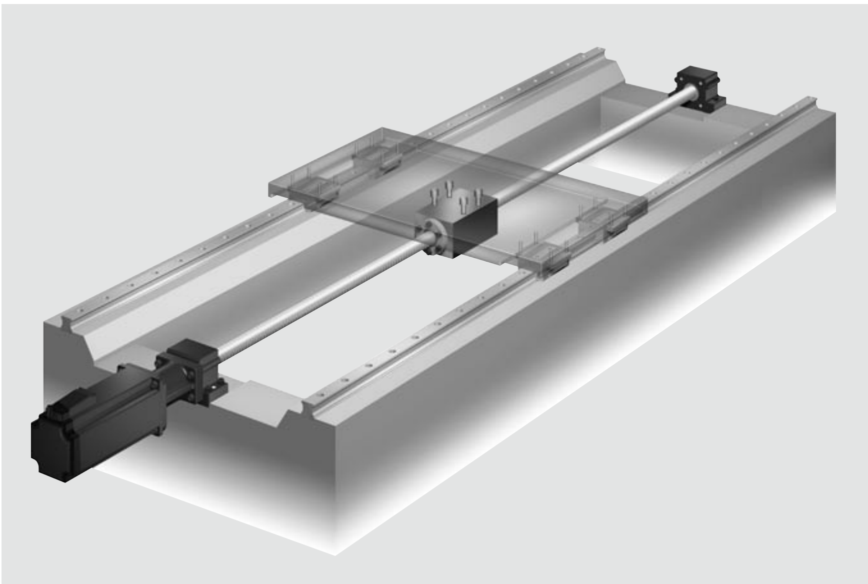


Drive unit with motor mount and coupling

Drive unit with timing belt side drive



Supporting frames can be easily and rapidly built using our proven aluminum profile construction kit. Please refer to catalog “Basic mechanical elements” (MGE 3 842 529 114).



Drive Units with Driven Screw, AOK Series

Sizing

AOK drive units are dimensioned according to the same criteria as for ball screw assemblies:

Service life calculation

The service life of the drive unit is calculated in a similar way as for a classic ball screw drive. The average speed and average load are calculated for this purpose (see the “Calculations” section). Because this is a complete unit, the lowest basic load rating of the nut or bearing must be used for the calculation. The corresponding data is listed in the table opposite (top right).

Permissible linear speed

The permissible speed of the ball screw is influenced by various factors:
- Screw lead
- Maximum permissible nut speed (d x n value)
- Permissible speed of the end bearings
- Length-dependent critical speed of the screw due to screw deflection

The permissible speeds as a function of the drive unit length are shown in charts; see page 40 and following.
These charts make it easy to estimate the attainable speeds.

Permissible drive torque

The maximum permissible drive torque at the motor journal is shown in charts giving a clear indication of the various factors involved; see page 42 and following.

The classic Euler buckling load of the screw is shown for each ball screw size and length, as well as the respective bearing configuration and the specific drive journal used along with the timing belt side drive.

Frictional torques, mass moments of inertia and moved masses

These can be found in the corresponding tables on the following pages.

Calculation example

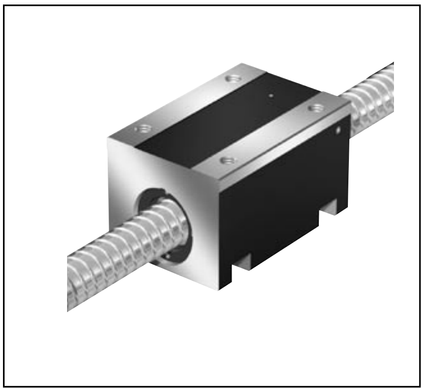
A calculation example showing the interplay of all chosen components for a typical application can be found in the “Calculations and Examples” section.

AOK drive units are delivered with pre-assembled MGA-Z ball nut enclosure and with all attachments; see “Configuration and Ordering Data.”

d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter

i = a x b
“a” – number of load-carrying turns per thread
“b” – number of load-carrying threads on the screw

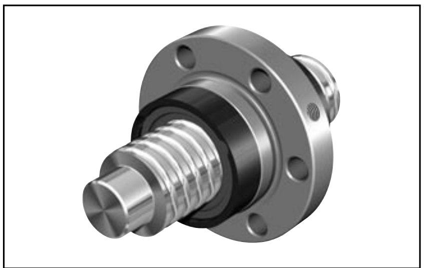
MGA-Z Ball nut enclosure with cylindrical single nut



AOK size d_0 x P x D_W - i	Part number of the ball nut used	AOK load ratings (N) dyn. C	stat. C_0	Weight of ball nut enclosure with nut (kg)
20 x 5R x 3 - 4	R1512 112 43	14300	21500	1.31
20 x 20R x 3.5 - 3	R1512 172 07	13300	18800	1.54
20 x 40R x 3.5 - 1x4	R2522 120 01	14000	26200	1.46
32 x 5R x 3.5 - 4	R1512 310 52	21600	40000	2.69
32 x 10R x 3.969 - 5	R1512 340 52	26000	47000	2.90
32 x 20R x 3.969 - 3	R1512 370 52	19700	33700	2.97
32 x 32R x 3.969 - 3	R1512 390 52	19500	34000	3.28
40 x 5R x 3.5 - 5	R1512 412 21	29000	64000	5.14
40 x 10R x 6 - 4	R1512 440 12	29000	64000	5.20
40 x 20R x 6 - 3	R1512 470 12	29000	62800	5.45
40 x 40R x 6 - 3	R1512 490 52	29000	62300	6.17

Further suitable ball nut types, e.g. flanged single nuts and associated steel nut housings, can be found in the Precision Ball Screw Assemblies catalog.
The many combinations available can also be used in the drive units, but the ball nuts would be delivered unassembled. Please consult us. For calculation purposes, the lowest load rating of the ball nut or bearing must be used in these cases.

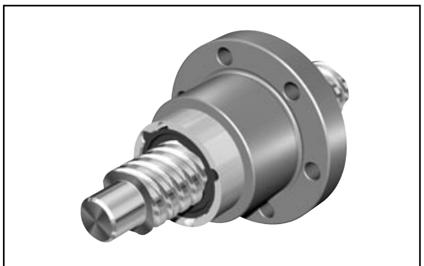
Example: FSZ-E-S Single nut with flange, ECOplus series



Size d_0 x P x D_W - i	Part number Ball nut	Load ratings[1] (N) dyn. C	stat. C_0
20 x 5R x 3 - 4	R1502 110 41	14300	21500
32 x 5R x 3.5 - 4	R1502 310 41	21600	40000
32 x 10R x 3.969 - 5	R1502 340 41	26000	47000
32 x 20R x 3.969 - 2	R1502 370 41	13500	21800
40 x 5R x 3.5 - 5	R1502 410 41	29000	64000
40 x 10R x 6 - 4	R1502 440 41	29000	64000
40 x 20R x 6 - 3	R1502 470 41	29000	62800

1) Load ratings with bearing SEC-F

Example: FEP-E-S Single nut with flange, Speed series



Size d_0 x P x D_W - i	Part number Ball nut	Load ratings[1] (N) dyn. C	stat. C_0
20 x 40R x 3.5 - 1 x 4	R2522 100 11	14000	26200
32 x 32R x 3.969 - 1.2 x 4	R2522 300 01	26000	47000

1) Load ratings with bearing SEC-F

Drive Units with Driven Screw, AOK Series

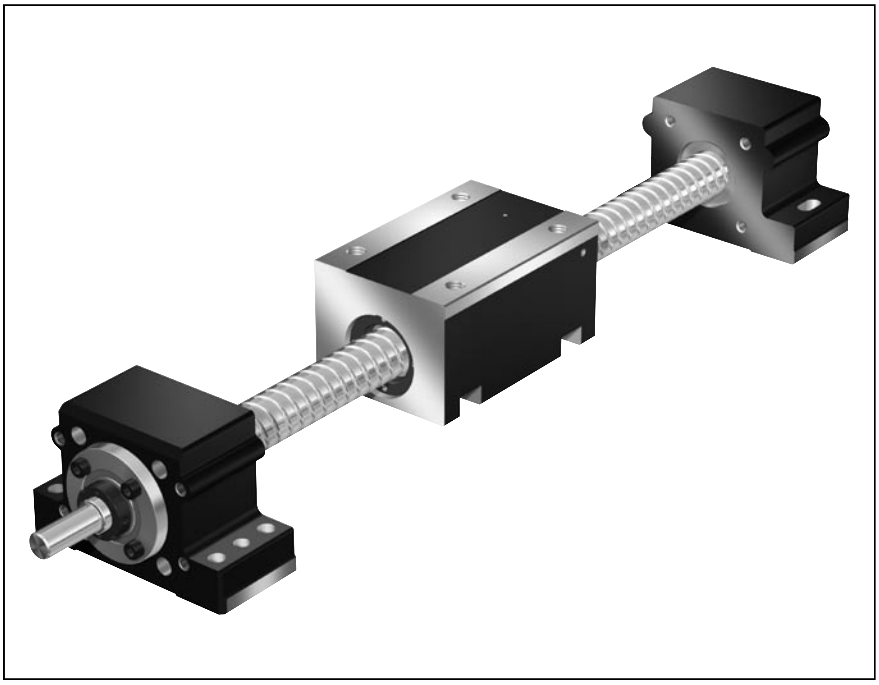
Stroke and Length Calculations

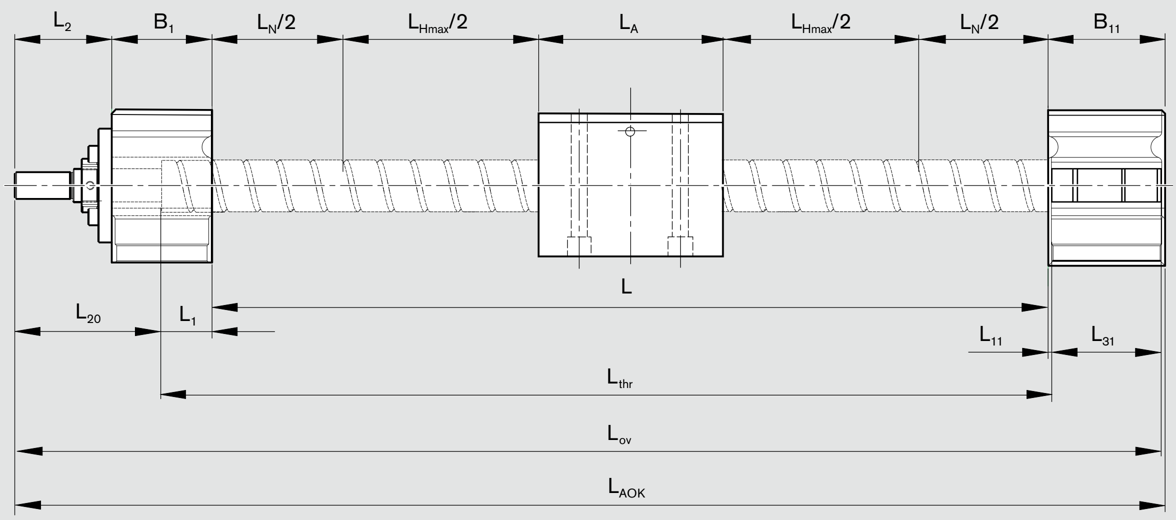
The main dimensions can be specified using a simple length calculation.

$$L = L_{Hmax} + L_A + L_N$$

$$L_{AOK} = L + L_2 + B_1 + B_{11}$$

L_{Hmax} = maximum stroke required by customer
L_A = length of the ball nut enclosure
L_N = unusable length; includes the necessary excess travel on the screw





AOK size	Ball screw size d_0 x P	Dimensions (mm) L_A	L_N	B_1	B_{11}	L_1	L_2	L_{11}	L_{20}	L_{31}
20	20 x 5/20/40	100	80	60	60	42	42	4	60	47
32	32 x 5/10/20/32	150	128	60	70	40	58	4	78	60
40	40 x 5/10/20/40	180	160	65	80	45	73	4	93	68

d_0 = nominal diameter
P = screw lead (right-hand)

Example of a stroke and length calculation for AOK 32x20

The required stroke is 1650 mm.

$L = L_{Hmax} + L_A + L_N$
$L = 1650\ mm + 150\ mm + 128\ mm$
$L = 1928\ mm$

$L_{AOK} = L + L_2 + B_1 + B_{11}$
$L_{AOK} = 1928\ mm + 58\ mm + 60\ mm + 70\ mm$
$L_{AOK} = 2116\ mm$

Drive Units with Driven Screw, AOK Series

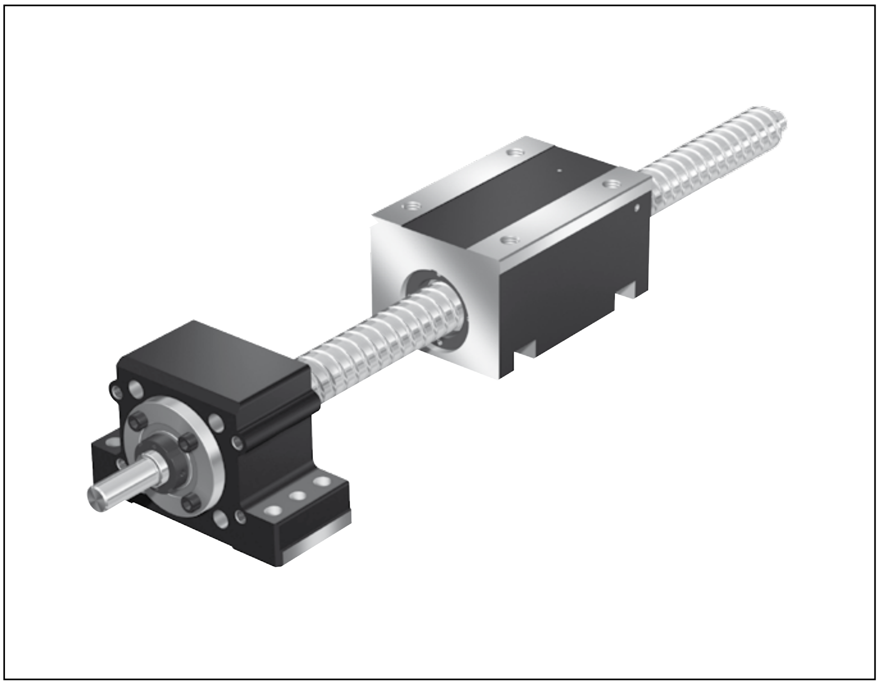
Stroke and Length Calculations

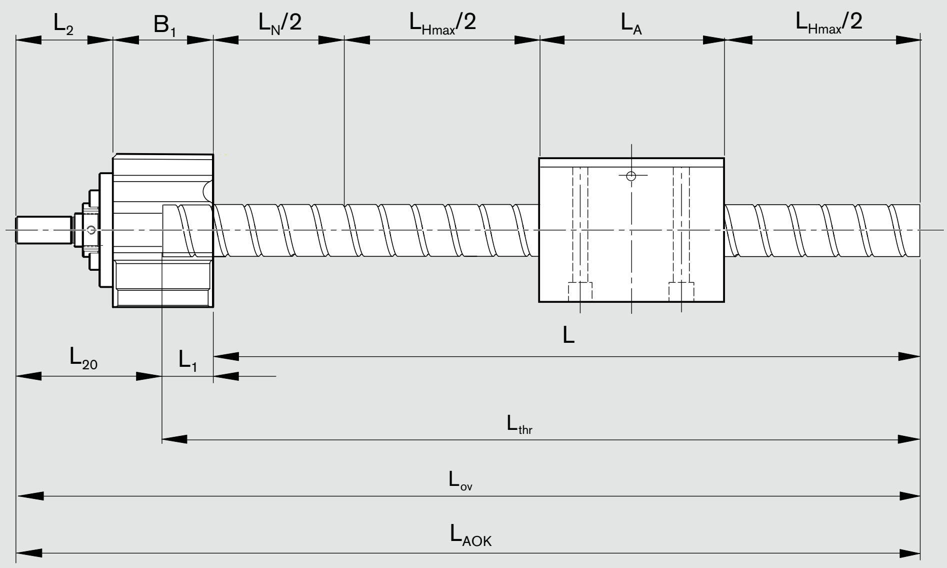
Screw with free shaft end
The main dimensions can be specified using a simple length calculation.

$$L = L_{Hmax} + L_A + L_N/2$$

$$L_{AOK} = L + L_2 + B_1$$

L_{Hmax} = maximum stroke required by customer
L_A = length of the ball nut enclosure
L_N = unusable length; includes the necessary excess travel on the screw





AOK size	Ball screw size d_0 x P	Dimensions (mm)								
		L_A	$L_{thr\ max}$	L_N	B_1	L_1	L_2	L_{11}	L_{20}	L_{31}
20	20 x 5/20/40	100	600	80	60	42	42	4	60	47
32	32 x 5/10/20/32	150	1000	128	60	40	58	4	78	60
40	40 x 5/10/20/40	180	1200	160	65	45	73	4	93	68

d_0 = nominal diameter
P = screw lead (right-hand)
L_N for screw with free shaft end: 1/2 value

Example of a stroke and length calculation for AOK 32x20

The required stroke is 700 mm.

$L = L_{Hmax} + L_A + L_N/2$
$L = 700\ mm + 150\ mm + 128\ mm/2$
$L = 914\ mm$
$L_{AOK} = L + L_2 + B_1$
$L_{AOK} = 914\ mm + 58\ mm + 60\ mm$
$L_{AOK} = 1032\ mm$

Drive Units with Driven Screw, AOK Series

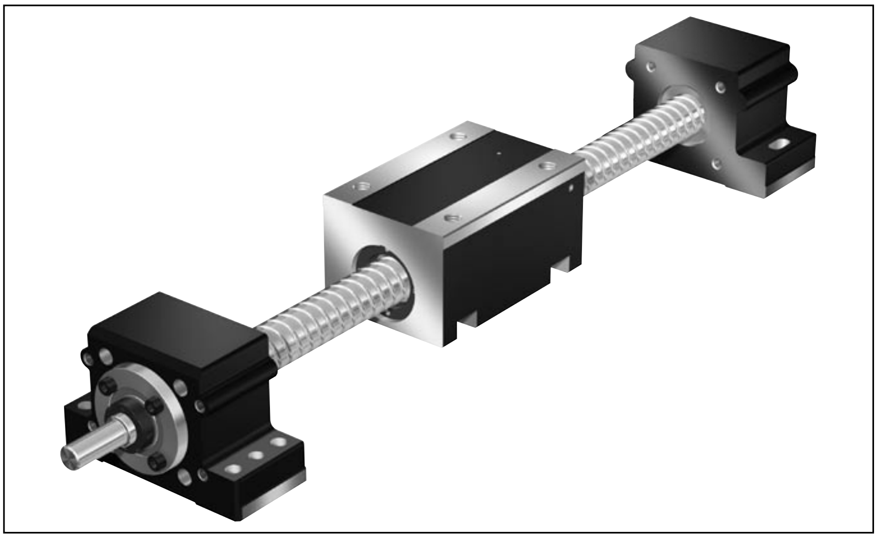
Technical Data and Dimensions

The mounting dimensions for the drive unit and the tolerance specifications for the adjoining structure are given below. For inquiries, there are corresponding CAD files available in AutoCAD format.

$L_{mtg} = L + B_2 + (B_{11}/2)$

$L_{mtg} = L_{AOK} - L_2 - B_1 + B_2 - (B_{11}/2)$

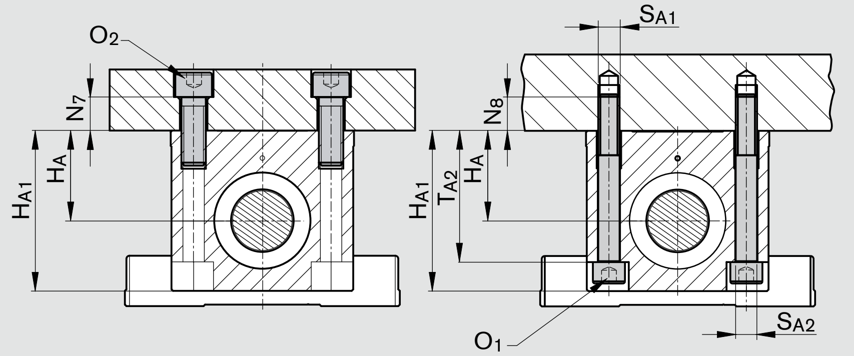
L_{mtg} = mounting length



Connection dimensions for attachments

Top-down fastening of ball nut enclosure

Bottom-up fastening of ball nut enclosure

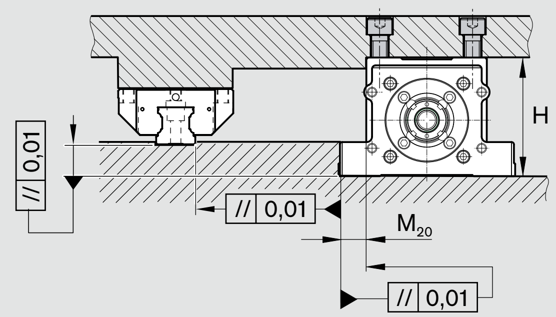


d_0 = nominal diameter
P = screw lead (right-hand)

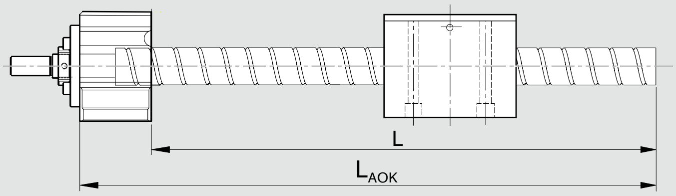
AOK size	Ball screw size d_0 x P	Dimensions (mm) H_A	H_{A1}	N_7	N_8	O_1	O_2	S_{A1}	S_{A2}	T_{A2}
20	**20x5/20/40**	44	75	20	19	M8x75	M10x35	M10	8.5	63
32	**32x5/10/20/32**	49	80	25	22	M10x85	M12x40	M12	10.5	66
40	**40x5/10/20/40**	59	105	30	22	M14x110	M16x45	M16	14.5	86

Parallelism of customer attachment, pillow blocks and rail guides:

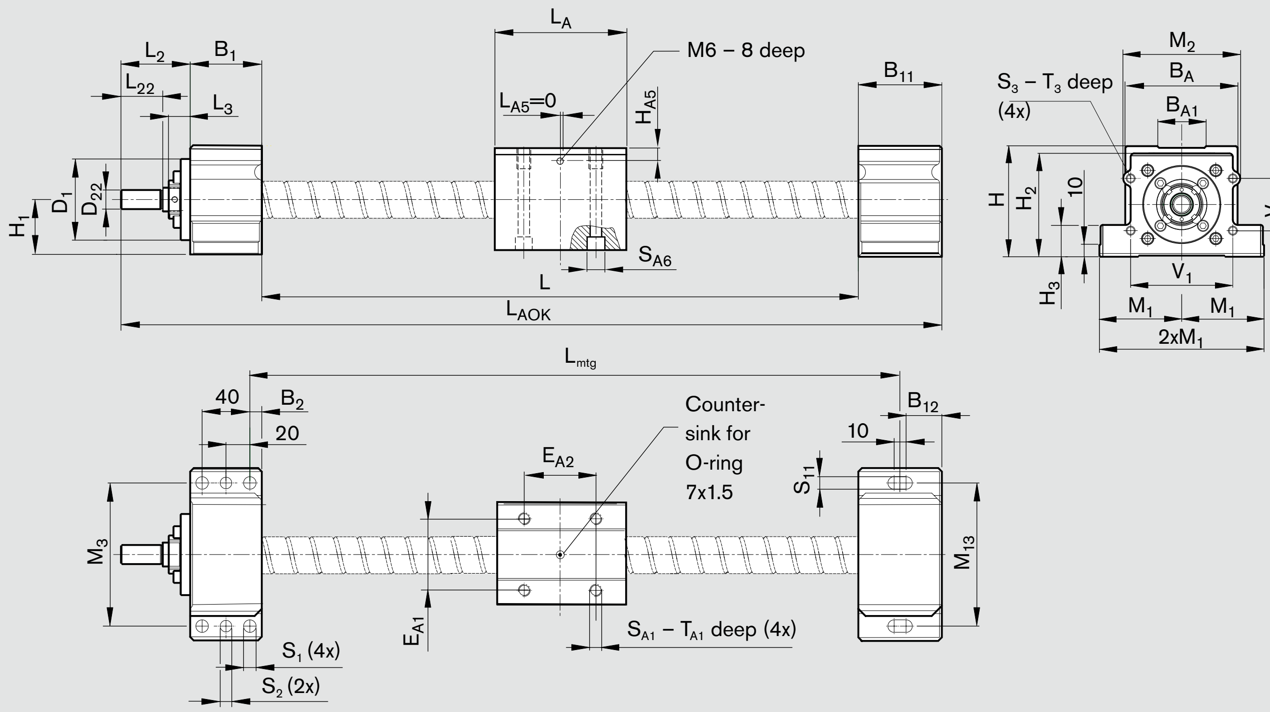
Ball screw size	Dimensions (mm)	
	H	**M_{20}**
d_0 x P	**±0.01**	**±0.01**
20x5/20/40	85	35
32x5/10/20/32	95	22.5
40x5/10/20/40	115	30



Fixed-free end fixity



Fixed-floating end fixity

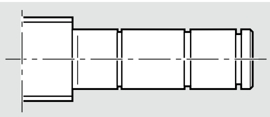


AOK size	Ball screw size d_0 x P	Dimensions (mm) B_1	B_2	B_{11}	B_{12}	B_A ±0.02	B_{A1}	D_1 −0.013	D_{22} h7	E_{A1}	E_{A2}	H_1	H_2 ±0.15	H_3	H_{A5}
20	20x5/20/40	60	10.0	60	25	75	40	55	10	55	60	41	81	28	15
32	32x5/10/20/32	60	10.0	70	30	100	50	68	16	75	100	46	91	28	16
40	40x5/10/20/40	65	12.5	80	35	120	60	80	25	90	120	56	111	33	18

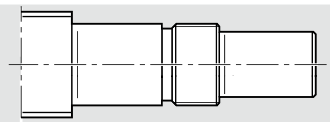
AOK size	Ball screw size d_0 x P	Dimensions (mm) L_2	L_3	L_{22}	L_A	M_1 ±0.015	M_2	M_3	M_{13}	S_1	S_2	S_3	S_{11}	S_{A1}	S_{A6}	T_3	T_{A1}	V_1	V_2
20	20x5/20/40	42	15	25	100	72.5	80	120	120	10.5	9.7	M8	10.5	M10	18	15	20	66	50
32	32x5/10/20/32	58	18	35	150	72.5	103	120	120	10.5	9.7	M8	10.5	M12	20	15	20	90	46
40	40x5/10/20/40	73	20	50	180	90.0	116	150	150	13.0	11.7	M10	13.0	M16	26	20	25	100	65

Screw ends:

Type 31



Type 81

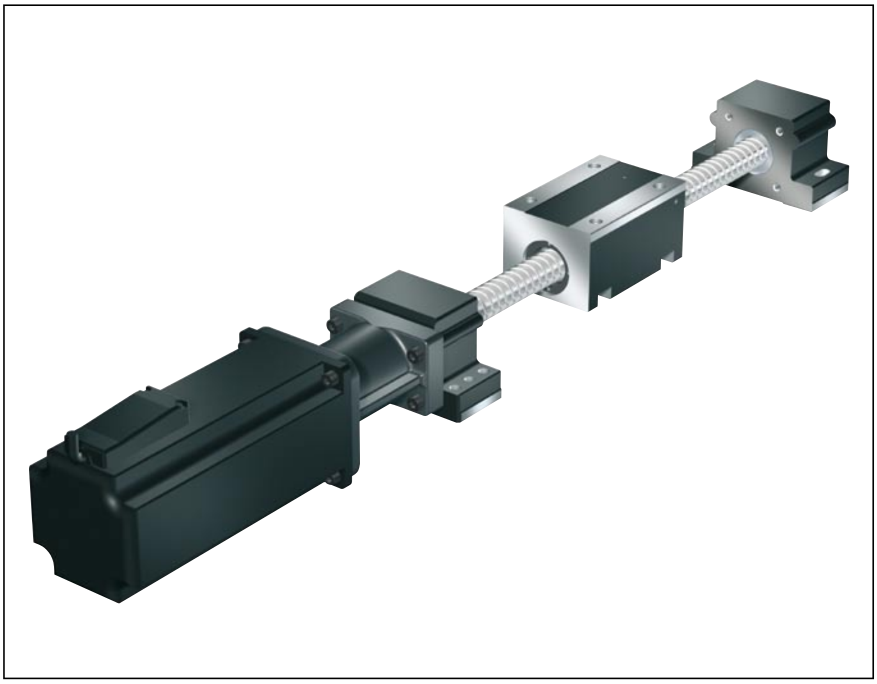


Drive Units with Driven Screw, AOK Series

Technical Data and Dimensions, w/motor mount, coupling and motor

The dimensions for the drive unit version with motor mount, coupling and motor are given below. For inquiries, there are corresponding CAD files available in AutoCAD format.
More technical data and details of accessories for the MSM servo drive used can be found in the catalogs
- ARS, EcoDrive Cs (R310D0 2725)
- EcoDrive Cs – Project Planning Manual (R911295757)
- EcoDrive Cs – Drive Control Units MGP 01 VRS (R911296548)

More technical data and details of accessories for the MSK servo drives used can be found in the catalogs
- Controllers, Motors, Electrical Accessories (R310EN 2710)
- Synchronous Motors MSK – Project Planning Manual (R911296288)
- Rexroth IndraDrive and Rexroth IndraDyn (R911311519)



d_0 = nominal diameter
P = screw lead (right-hand)

Frictional torques at motor journal

AOK size	Ball screw size d_0 x P	Frictional torques at motor journal M_{RS} (Nm)
20	20x5	0.40
	20x20	0.50
	20x40	0.60
32	32x5	0.80
	32x10	0.90
	32x20	0.90
	32x32	1.00
40	40x5	1.20
	40x10	1.50
	40x20	1.30
	40x40	1.60

Technical data of coupling

AOK size	Ball screw size d_0 x P	Motor type	Rated torque M_{KN} (Nm)	Mass moment of inertia J_K (kgm^2 10^{-4})	Weight m_K (kg)
20	20x5/20/40	MSM 040B with/without brake	14.5	0.63	0.265
		MSK 040C with/without brake	19.0	0.60	0.260
		MSK 050C with/without brake	50.0	2.00	0.700
32	32x5/10/20/32	MSK 060C with/without brake	50.0	2.00	0.700
		MSK 076C with brake	98.0	3.90	0.900
40	40x5/10/20/40	MSK 076C with brake	98.0	3.90	0.900

Technical data of motors

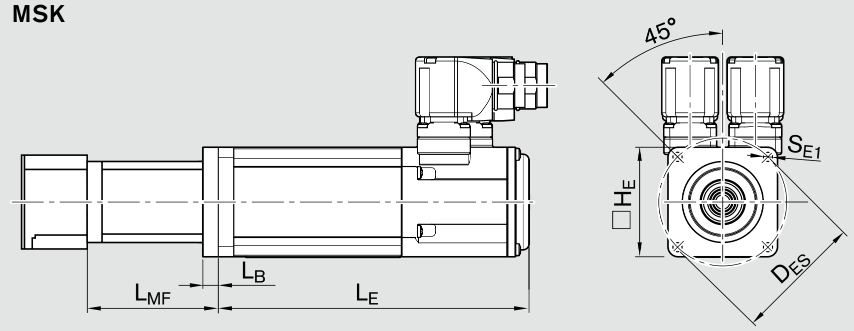
Ambient temperature T_{amb} 0 to +45 °C; protection class IP 65

Motor		MSM 040B	MSK 040C	MSK 050C	MSK 060C	MSK 076C
Part number with brake		R3471 075 03	R3471 087 03	R3471 089 03	R3471 091 03	R3471 093 03
Part number without brake		R3471 074 03	R3471 086 06	R3471 088 03	R3471 090 03	–
Maximum speed n_{max}	(min^{-1})	4500	7500	6000	6000	5000
Rated torque M_{MN}	(Nm)	2.4	2.7	5.0	8.0	12.0
Maximum torque M_{Mmax} [1)]	(Nm)	7.1	8.1	15.0	24.0	43.5
Motor mass moment of inertia J_M	(10^{-4} kgm^2)	0.67	1.4	3.3	8.0	43.0
Brake mass moment of inertia J_{Br}	(10^{-4} kgm^2)	0.08	0.23	1.07	0.59	3.60
Brake holding torque M_{Br}	(Nm)	2.45	4.00	5.00	10.00	11.00
Mass of motor m_M	(kg)	3.1	3.6	5.4	8.4	14.0
Mass of brake m_{Br}	(kg)	0.7	0.3	0.7	0.4	1.1

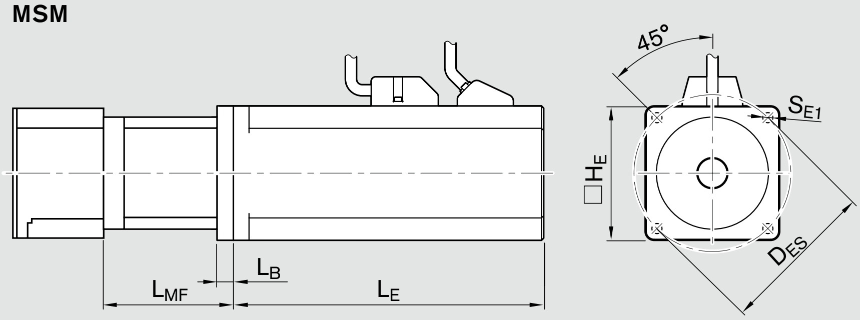
1) Depends on controller used

Motor mount and motor dimensions

MSK



MSM



AOK size	Ball screw size	Motor type	Dimensions (mm)						
			D_{ES}	H_E	L_B	L_E		L_{MF}	S_{E1}
	d_0 x P					without brake	with brake		
20	20x5/20/40	MSM 040B	90	80	17	157.5	191.5	90	6.0
		MSK 040C	95	82	15	185.5	215.5	90	6.6
		MSK 050C	115	98	17	203.0	233.0	115	9.0
32	32x5/10/20/32	MSK 060C	130	116	12	226.0	259.0	125	9.0
		MSK 076C	165	140	17	–	292.5	133	11.0
40	40x5/10/20/40	MSK 076C	165	140	17	–	292.5	140	11.0

Drive Units with Driven Screw, AOK Series

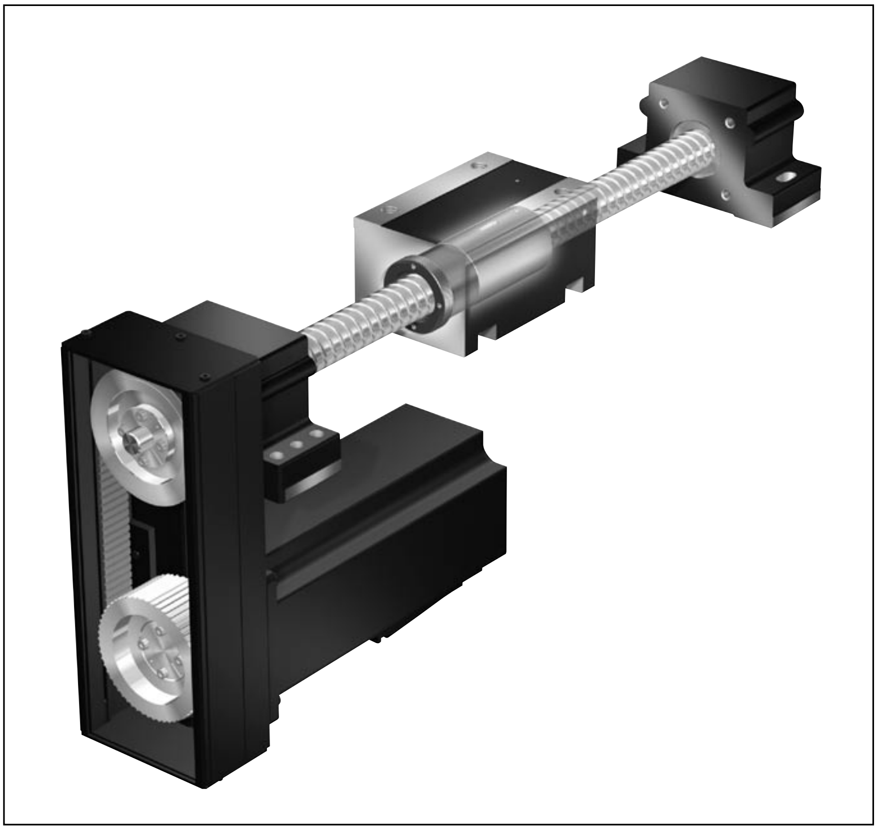
Technical Data and Dimensions, w/timing belt side drive and motor

The dimensions for the drive unit version with timing belt side drive and motor are given below. For inquiries, there are corresponding CAD files available in AutoCAD format.
More technical data and details of accessories for the MSM servo drive used can be found in the catalogs

- ARS, EcoDrive Cs (R310D0 2725)
- EcoDrive Cs – Project Planning Manual (R911295757)
- EcoDrive Cs – Drive Control Units MGP 01 VRS (R911296548)

More technical data and details of accessories for the MSK servo drives used can be found in the catalogs

- Controllers, Motors, Electrical Accessories (R310EN 2710)
- Synchronous Motors MSK – Project Planning Manual (R911296288)
- Rexroth IndraDrive and Rexroth IndraDyn (R911311519)



d_0 = nominal diameter
P = screw lead (right-hand)
i_{RV} = gear reduction of timing belt side drive

Technical data of timing belt side drive

AOK size	Ball screw size d_0 x P	Motor type	Gear ratio i_{RV}	Reduced moment of inertia J_{RV} ($kgm^2 10^{-4}$)	Permissible torque M_{RV} (Nm)	Frictional torque M_{RRV} (Nm)
20	20x5	MSM 040B	1	0.024	2.1	0.4
	20x20				3.6	
	20x40				4.1	
	20x5	MSK 040C		0.024	2.1	
	20x20				3.6	
	20x40				4.1	
	20x5	MSK 050C		0.140	2.3	0.5
	20x20				4.3	
	20x40				5.0	
32	32x5	MSK 060C	1	0.140	12.0	0.5
	32x10/20/32				19.0	
	32x5		2	0.026	6.0	
	32x10				11.0	
	32x20/32				13.0	
40	40x5	MSK 076C	1	0.778	26.0	0.6
	40x10				52.0	
	40x20				67.0	
	40x40				67.0	
	40x5		2	0.126	13.0	
	40x10				26.0	
	40x20				33.5	
	40x40				33.5	

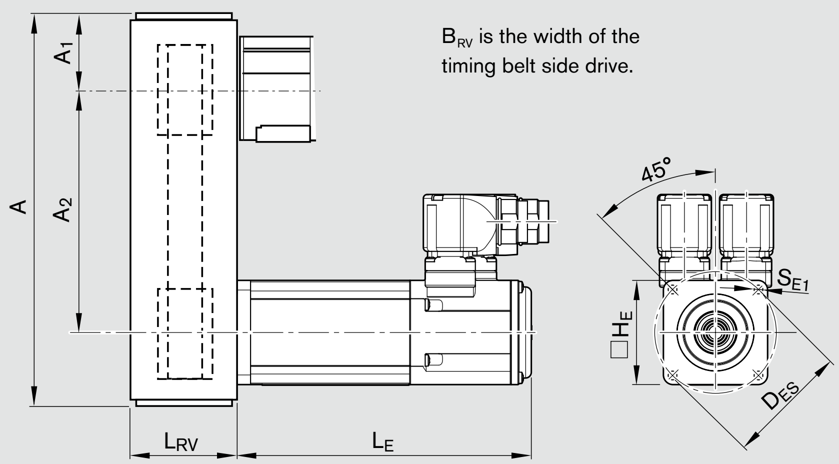
Technical data of motors

Ambient temperature T_{amb} 0 to +45 °C; protection class IP 65

Motor		MSM 040B	MSK 040C	MSK 050C	MSK 060C	MSK 076C
Part number with brake		R3471 075 03	R3471 087 03	R3471 089 03	R3471 091 03	R3471 093 03
Part number without brake		R3471 074 03	R3471 086 06	R3471 088 03	R3471 090 03	–
Maximum speed n_{max}	(min^{-1})	4500	7500	6000	6000	5000
Rated torque M_{MN}	(Nm)	2.4	2.7	5.0	8.0	12.0
Maximum torque M_{Mmax} 1)	(Nm)	7.1	8.1	15.0	24.0	43.5
Motor mass moment of inertia J_M	$(10^{-4}$ $kgm^2)$	0.67	1.4	3.3	8.0	43.0
Brake mass moment of inertia J_{Br}	$(10^{-4}$ $kgm^2)$	0.08	0.23	1.07	0.59	3.60
Brake holding torque M_{Br}	(Nm)	2.45	4.00	5.00	10.00	11.00
Mass of motor m_M	(kg)	3.1	3.6	5.4	8.4	14.0
Mass of brake m_{Br}	(kg)	0.7	0.3	0.7	0.4	1.1

1) depends on controller used

Dimensions of motors and timing belt side drive



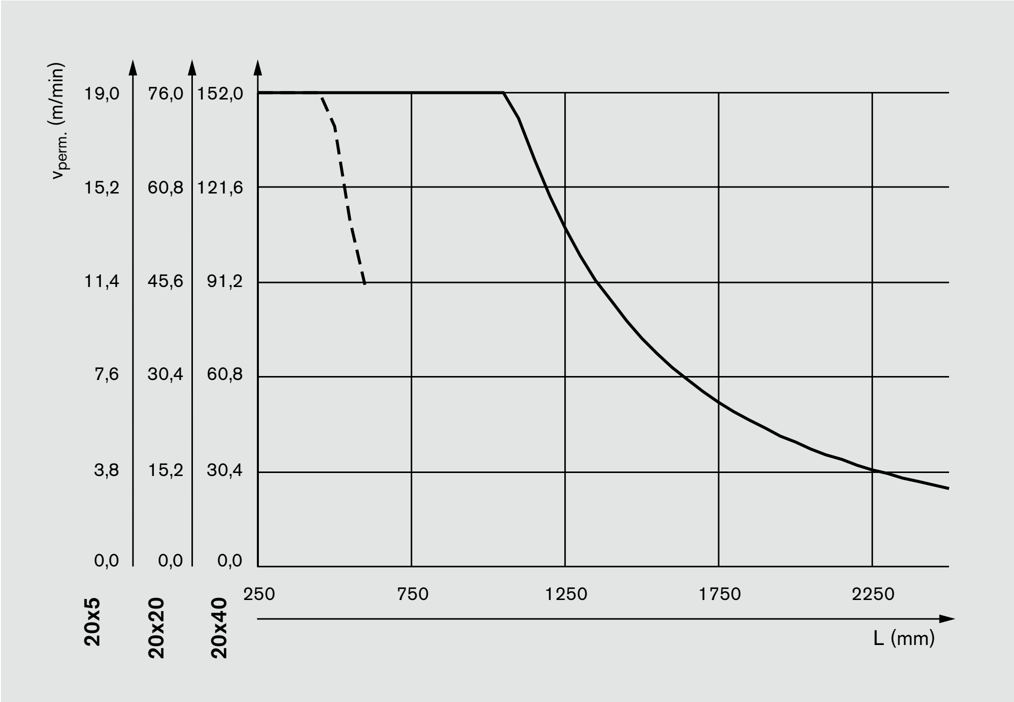
AOK size	Ball screw size	Motor type	Dimensions (mm)											Weight
			A	A_1		A_2	B_{RV}	D_{ES}	H_E	L_E		L_{RV}	S_{E1}	m_{RV}
	d_0 x P				i=1	i=2				without brake	with brake			(kg)
20	20x5/20/40	MSM 040B	231	47.5	122.5	–	88	90	80	157.5	191.5	51	6.0	on req.
		MSK 040C	231	47.5	122.5	–	88	95	82	185.5	215.5	51	6.6	on req.
		MSK 050C	287	66.0	155.0	–	116	115	98	203.0	233.0	56	9.0	on req.
32	32x5/10/20/32	MSK 060C	300	59.0	165.0	162	116	130	116	226.0	259.0	66	9.0	on req.
40	40x5/10/20/40	MSK 076C	409	77.0	240.0	238	160	165	140	–	292.5	90	11.0	on req.

Drive Units with Driven Screw, AOK Series

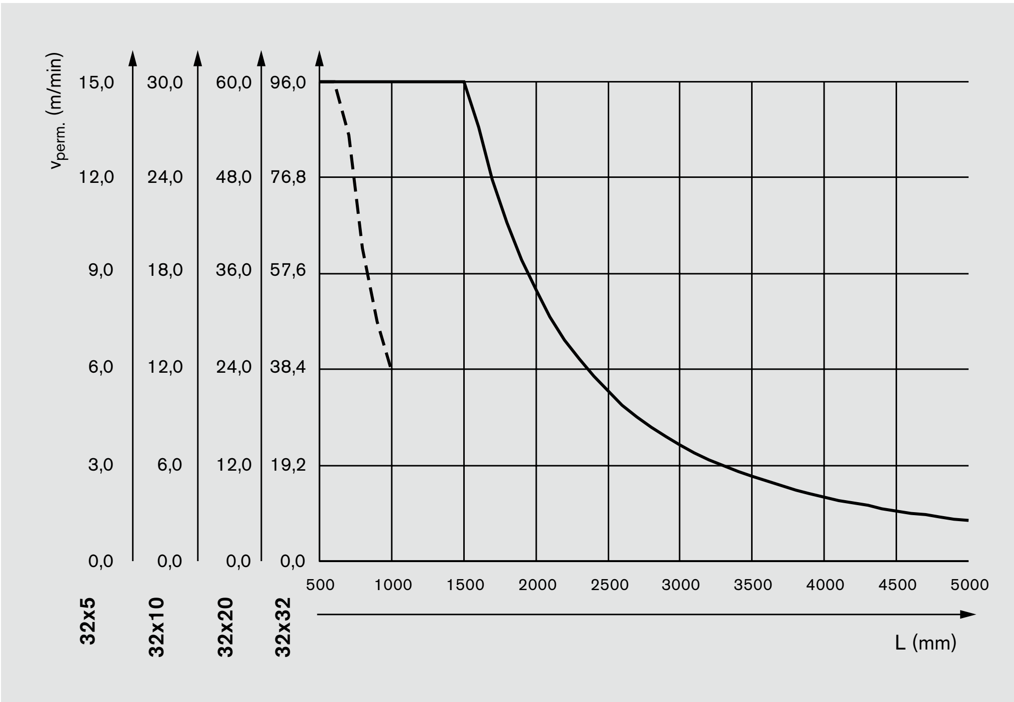
Permissible Linear Speed $v_{perm.}$

AOK 20, AOK 32, AOK 40

AOK size 20



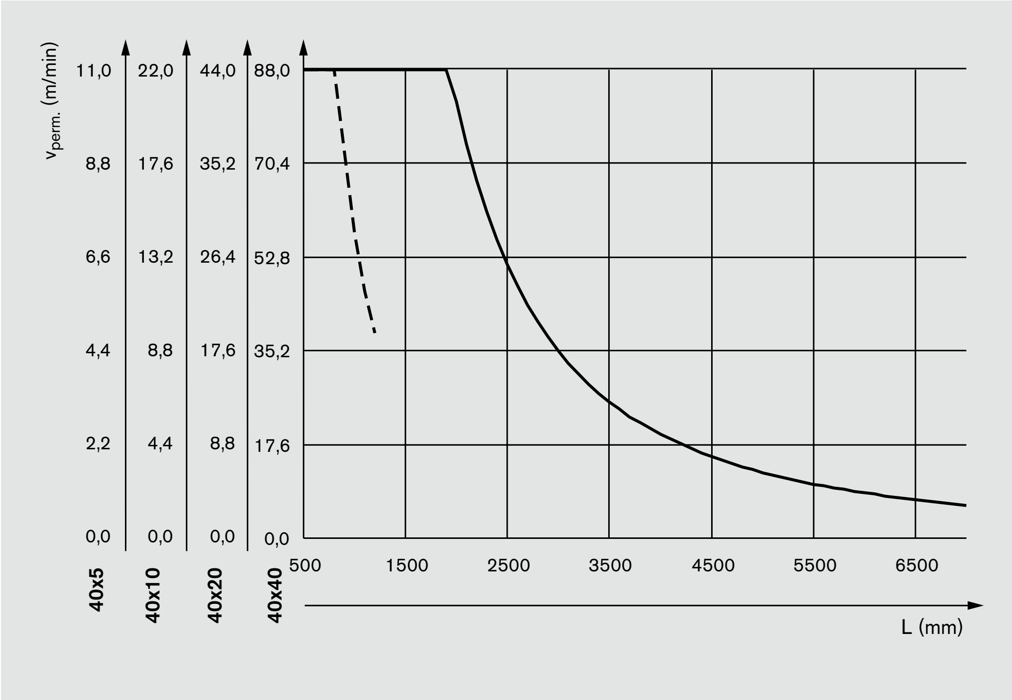
AOK size 32



——— Screw with fixed-floating end fixity

— — — Screw with fixed-free end fixity

AOK size 40



For 40x5, only up to length 5000 mm

——— Screw with fixed-floating end fixity
— — — Screw with fixed-free end fixity

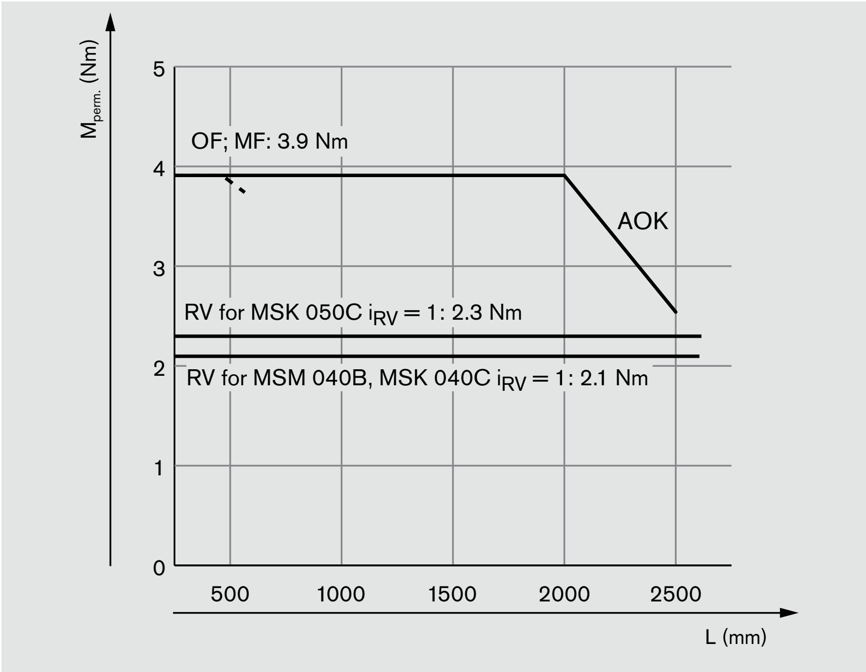
Drive Units with Driven Screw, AOK Series

Permissible drive torque $M_{perm.}$

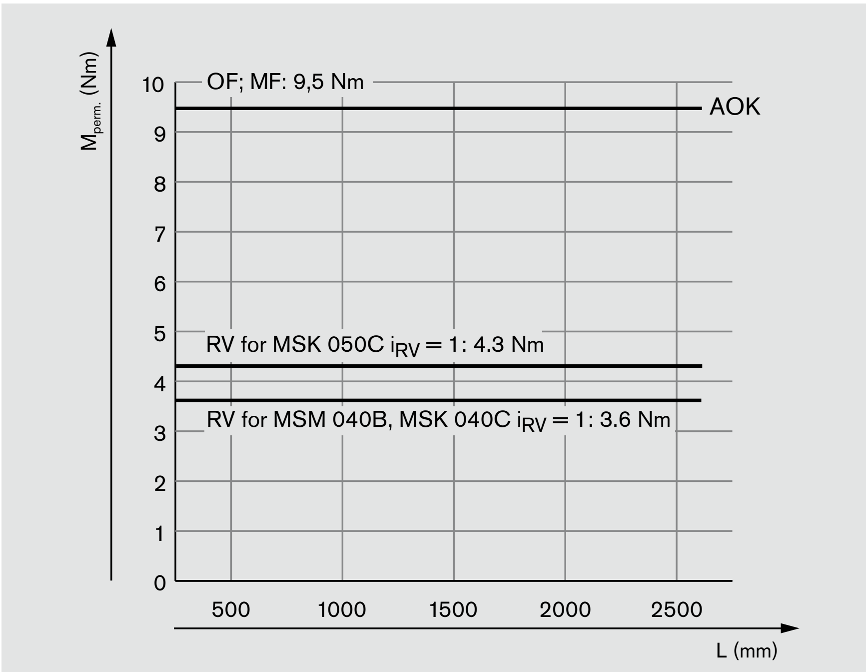
AOK 20

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

Ball screw size 20x5



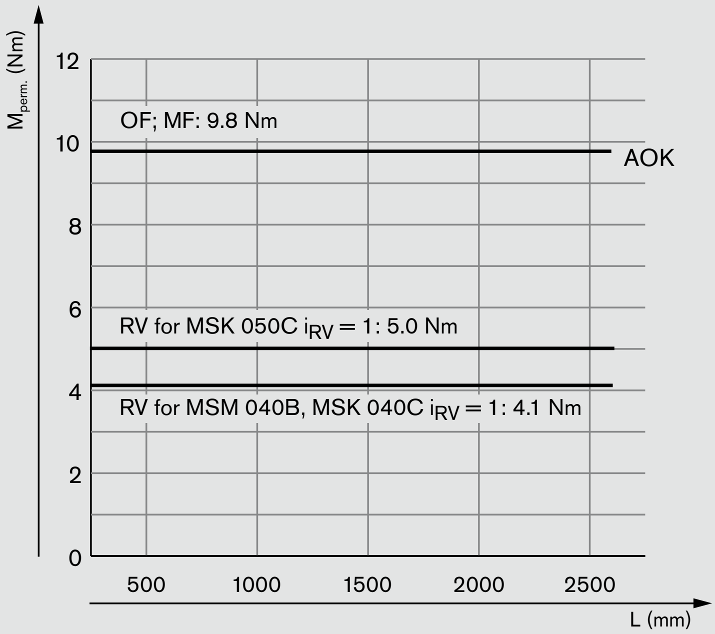
Ball screw size 20x20



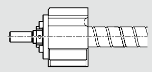
——— Screw with fixed-floating end fixity

— — — Screw with fixed-free end fixity

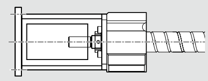
Ball screw size 20x40



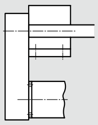
OF



MF



RV



——— Screw with fixed-floating end fixity

— — — Screw with fixed-free end fixity

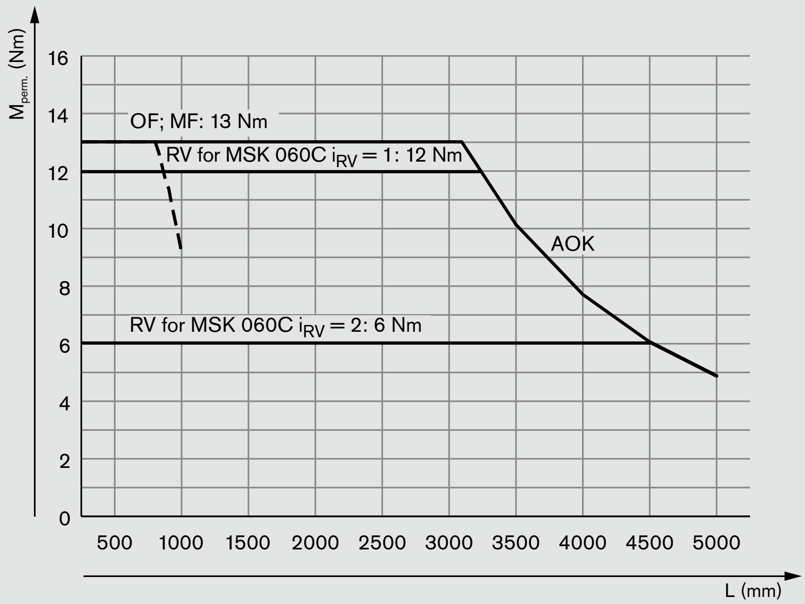
Drive Units with Driven Screw, AOK Series

Permissible drive torque $M_{perm.}$

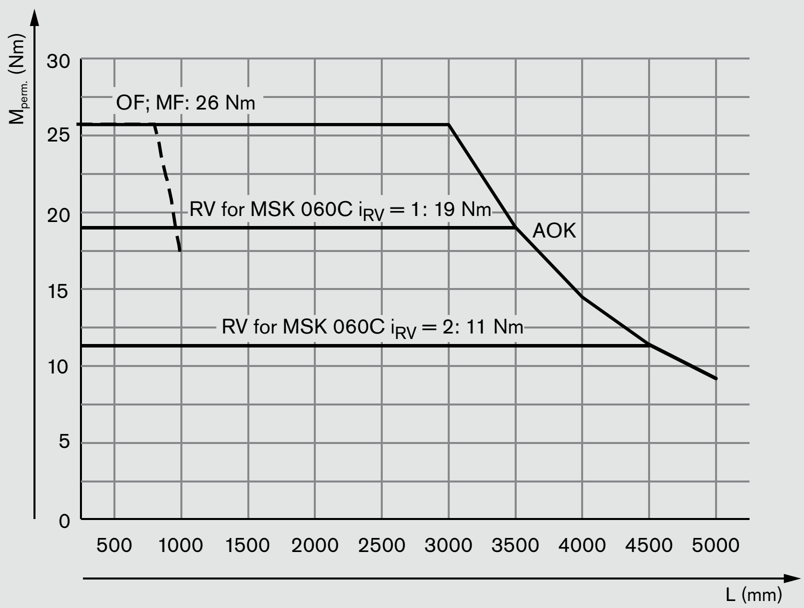
AOK 32

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

Ball screw size 32x5



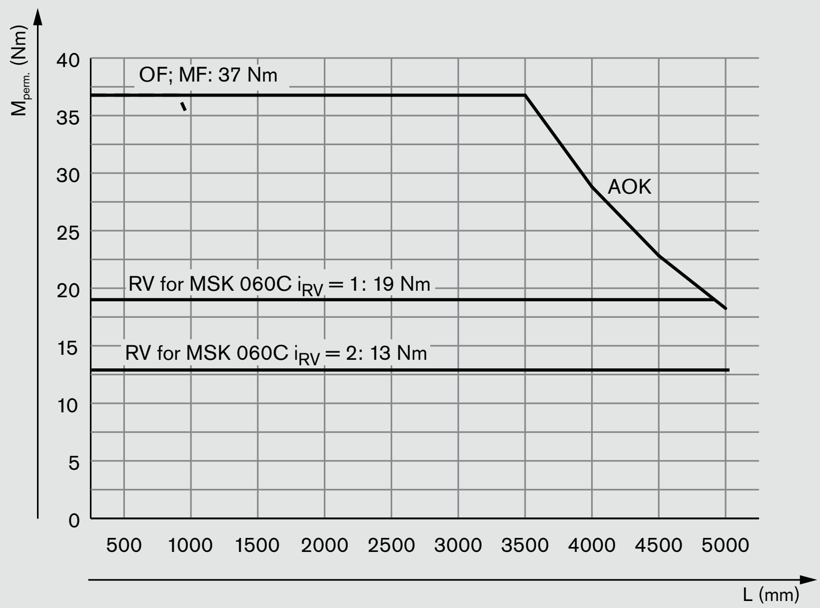
Ball screw size 32x10



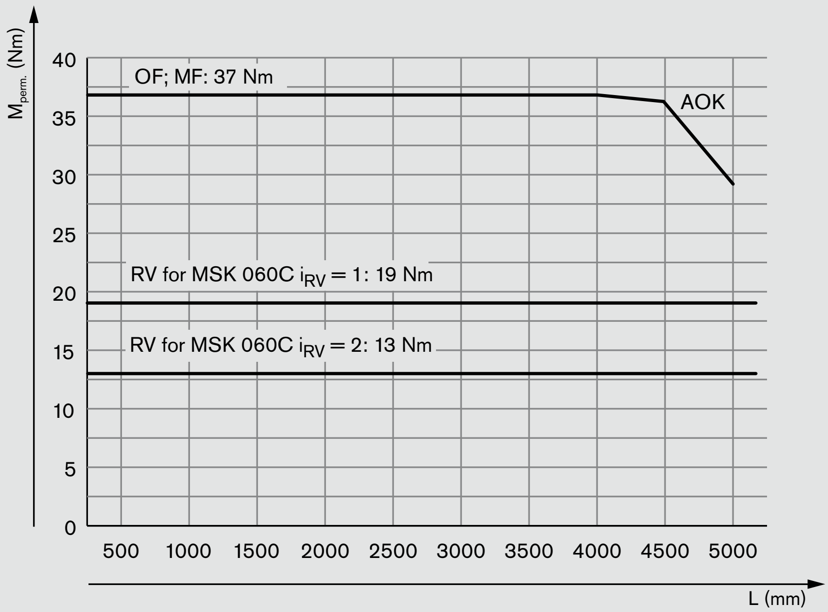
——— Screw with fixed-floating end fixity

— — Screw with fixed-free end fixity

Ball screw size 32x20

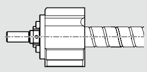


Ball screw size 32x32

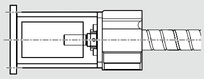


——— Screw with fixed-floating end fixity
— — Screw with fixed-free end fixity

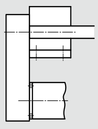
OF



MF



RV



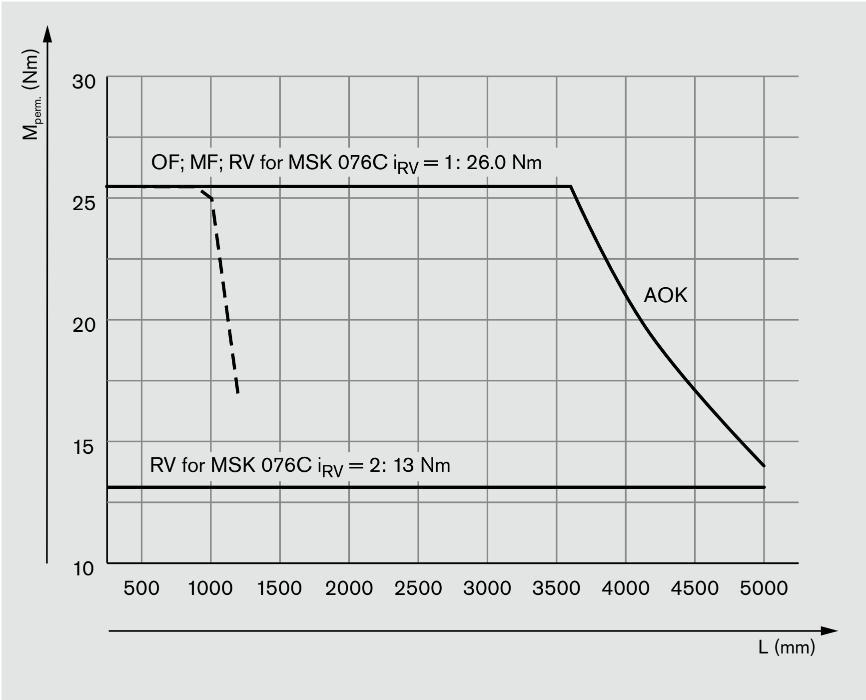
Drive Units with Driven Screw, AOK Series

Permissible drive torque $M_{perm.}$

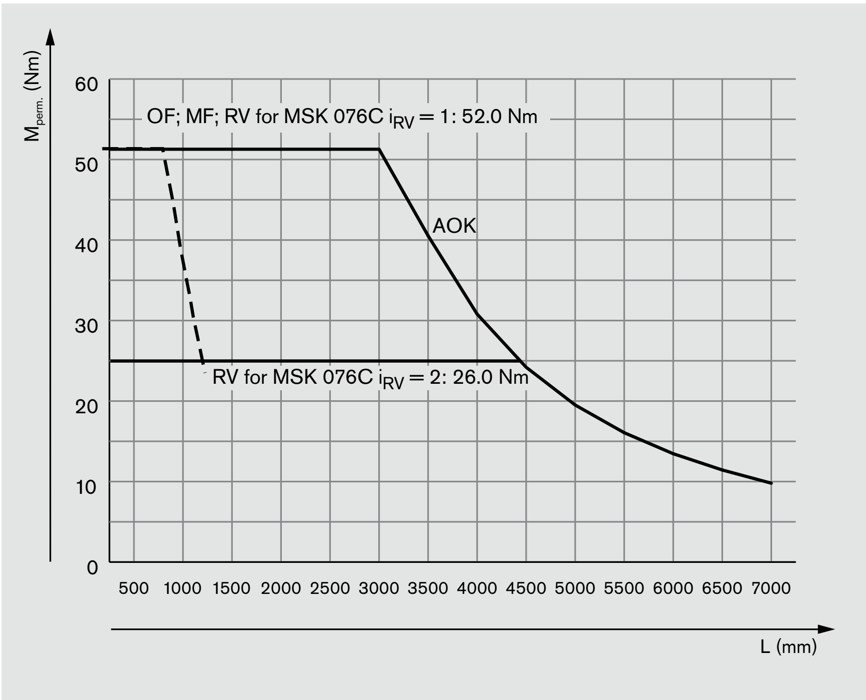
AOK 40

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

Ball screw size 40x5



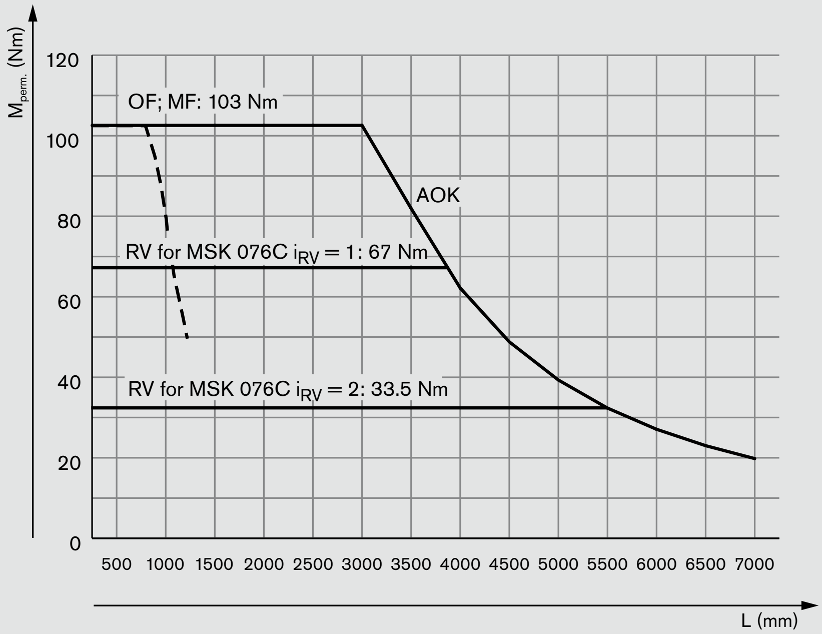
Ball screw size 40x10



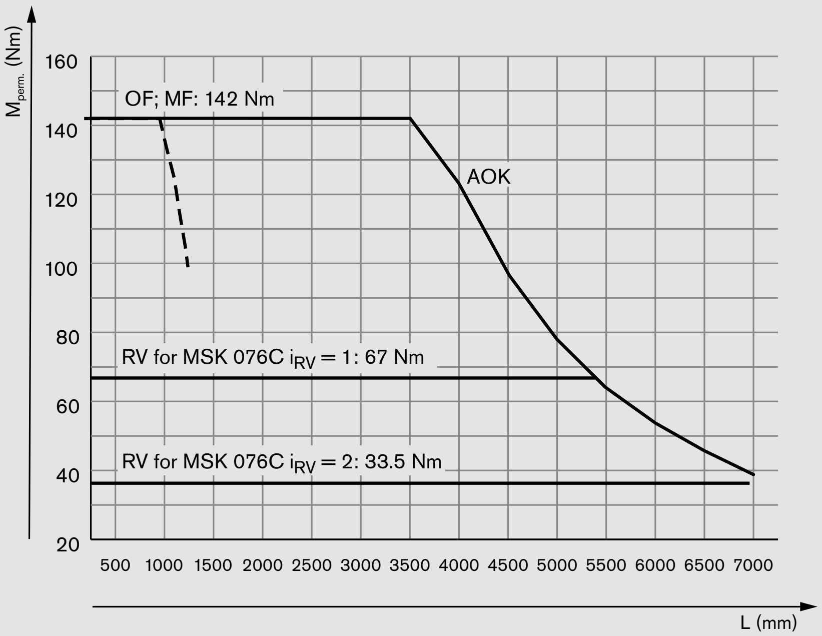
——— Screw with fixed-floating end fixity

— — — Screw with fixed-free end fixity

Ball screw size 40x20



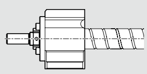
Ball screw size 40x40



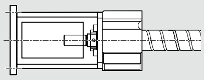
——— Screw with fixed-floating end fixity

— — Screw with fixed-free end fixity

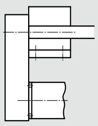
OF



MF

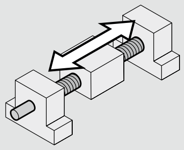


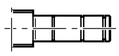
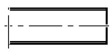
RV



Drive Units with Driven Screw, AOK Series

Configuration and Ordering Data



Size	Ball screw: d_0 x P	Length[1] (mm) (Fig. 1, Fig. 2)	Ball nut: Sealing type	Preload	Screw Tolerance grade	Right side Screw end type	Lubrication
AOK 20	20x5 20x20 20x40	L = L_{AOK} = L_{Hmax} = L_{ov} = L_{thr} =	Standard seal 01 Reinforced seal 02 Low-friction seal[3] 03 Without seal 00	Standard backlash 00 Reduced backlash 01 2% preload 03 3% preload[2] 06 5% preload[2] 02	T5 T7 T9	AOK with fixed-floating end fixity  31 AOK with fixed-free end fixity  00	Basic lubrication and anti-corrosion oil 01 Anti-corrosion oil 00
AOK 32	32x5 32x10 32x20 32x32						
AOK 40	40x5 40x10 40x20 40x40						

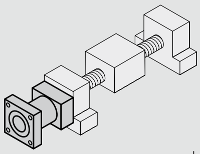
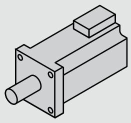
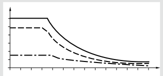
1) Only one length specification necessary 2) Not possible for AOK 20x40 3) Not possible for AOK 20

Order example:

Fixed parameters			
Lead direction	right-hand	**No. of ball track turns**	fixed
Ball nut	ZEM-E-S	**Ball nut enclosure**	MAG-Z
Screw	rolled		
Left-hand bearing Screw end type End face	SEC-F 81 K	**Right-hand bearing** Screw end type End face	SEC-L (for fixed-floating end fixity) 31 K

Variable parameters	Selected	Ordering data
Size	AOK 20	AOK 20
Ball screw	20x20	20x20
Length	Overall length 350 mm	L_{ov} = 350
Sealing type	Standard seal	01
Preload	Reduced backlash	01
Screw tolerance grade	T5	T5
Screw end type, right-hand side	Fixed-floating end fixity	31
Lubrication	Basic lubrication, anti-corrosion oil	01
Drive type	with motor mount	MF01
Attachment kit for motor	MSM 040B with brake	006
Motor	MSM 040B with brake	075
Documentation	Torque test report (incl. standard test report)	002

When ordering:
Please state the option number given in the box as appropriate (e.g. 01).

Motor attachment 				Motor 	Documentation 	
Drive type (Fig. 3, Fig. 4)	Gear ratio	Attachment kit	Motor			Measurement report
OF01		000		000		
MF01		006	MSM 040B oB[5]	074		
			MSM 040B mB[6]	075		
		002	MSK 040C oB	086		
			MSK 040C mB	087		Lead test report 001
		007	MSK 050C oB	088		
			MSK 050C mB	089		
RV01	i =1	032	MSM 040B oB	074		
RV02			MSM 040B mB	075		
RV03		030	MSK 040C oB	086		
RV04			MSK 040C mB	087		
		023	MSK 050C oB	088	Standard (acceptance test report)[4] 000	
			MSK 050C mB	089		
OF01		000		000		
MF01		003	MSK 060C oB	090		Torque test report 002
			MSK 060C mB	091		
		002	MSK 076C mB	093		
RV01 RV02	i =1	023	MSK 060C oB	090		
RV03 RV04			MSK 060C mB	091		
	i =2	024				
OF01		000		000		Lead and torque test report 003
MF01		002	MSK 076C mB	093		
RV01 RV02	i =1	023				
RV03 RV04	i =2	024				

4) Is always supplied
5) oB = without brake
6) mB = with brake

Lengths

Fig. 1

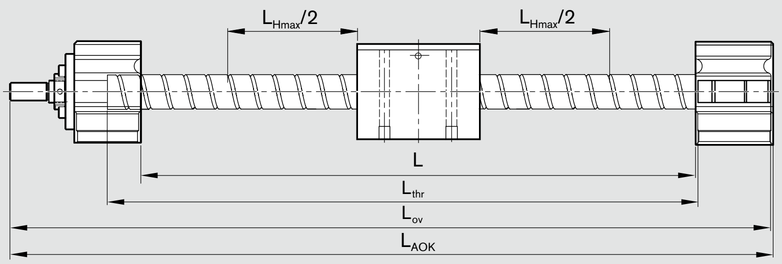
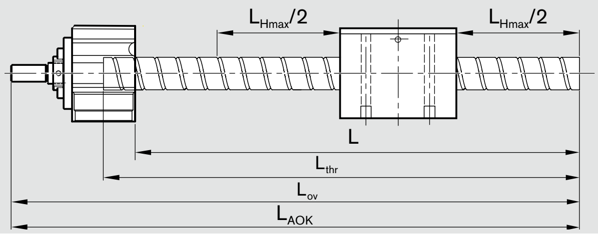


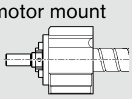
Fig. 2



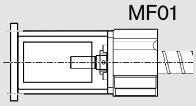
Motor attachment / Attachment kit

Fig. 3

w/o motor mount
OF01



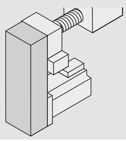
with motor mount
MF01



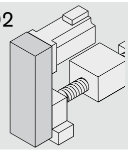
Timing belt side drive

Fig. 4

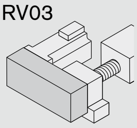
RV01



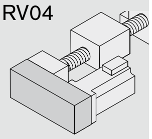
RV02



RV03



RV04



Product Overview, AGK

The AGK drive unit is additionally provided with an enclosure and sealing strip. Optional traveling screw supports allow maximum speeds even over long strokes. These readily available AGK drive units offer users the opportunity to rapidly integrate economical drive solutions with minimal design and manufacturing effort. Maximum linear speed, protection from environmental influences and reliable operation are all optimally combined into one unit.
When paired with Rexroth linear guides, they offer machine designers full design freedom for every application.

Advantages

- Optimal sealing with steel or polyurethane sealing strip
- Traveling screw supports for maximum linear speeds in horizontal operation
- Optimal travel performance, high load ratings, high positioning and repeatability accuracy due to preloaded Rexroth precision ball nuts for demanding positioning applications
- Rapid mounting and easy alignment of the drive unit due to the machined reference edge on the pillow block unit
- High linear speeds thanks to double floating bearing
- Overall length of the AGK drive unit is freely selectable (no fixed length increments)
- Easy motor attachment via locating feature and fastening threads

Structural design

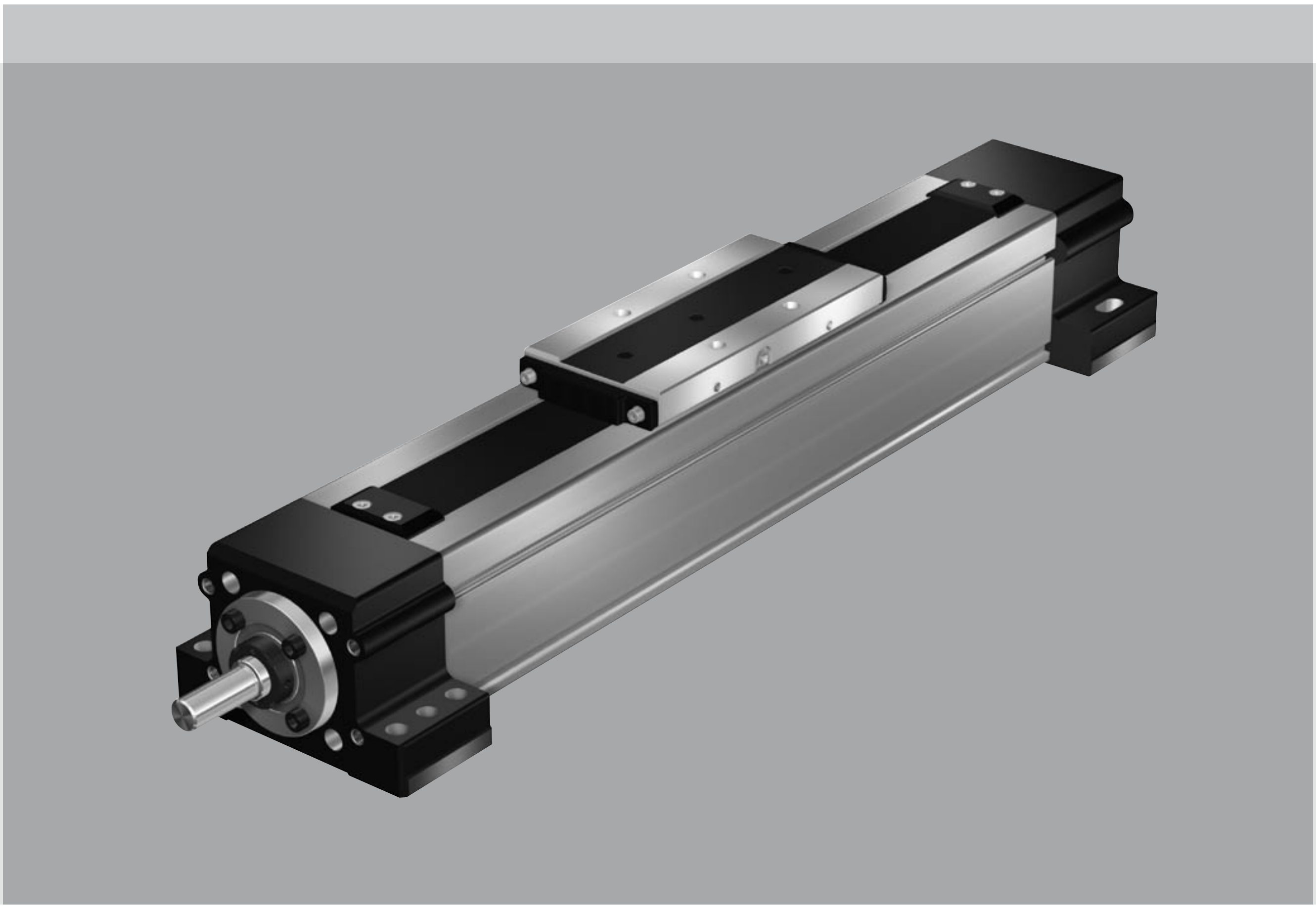
- Rexroth Precision Ball Screw Assembly with screws of various tolerance grades and cylindrical single nut, also available with zero backlash or preloaded
- Variable number of optional screw supports, to increase the maximum linear speed even with long strokes (critical speed)
- Steel or polyurethane sealing strip combined with aluminum extrusion profile encapsulation
- Ball nut enclosure made of aluminum extrusion profile finished on all sides with reference edges on both sides
- Pillow block units made of robust extruded aluminum profile with reference edges on both sides and mounting holes as well as locating feature for motor mounting

Choice of drive elements

- Motor mount and coupling, pre-assembled with motor attached
- Timing belt side drive with selectable gear ratios, pre-assembled with motor attached
- Maintenance-free digital AC servo drives with integrated brake and attached feedback


Drive unit with motor mount and coupling


Drive unit with timing belt side drive



Application examples

The table is supported symmetrically on two rail guides with four runner blocks. The ball nut enclosure is located at the top. The sealing strip ensures extensive protection of the unit. The optional traveling screw supports allow very high linear speeds even over long strokes. Motor attachments can be installed in the desired orientation for optimal functionality or to save space.

Supporting frames can be easily and rapidly built using our proven aluminum profile construction kit. Please refer to catalog “Basic Mechanical Elements” (MGE 3 842 529 114).

Depending on the application requirements, the ball nut enclosure can also be at the side instead of the top. Interesting combinations with the rail guides are also possible.

Drive Units with Driven Screw, AGK Series

Product Overview

Patented screw support

The patented screw support elegantly solves the problem of the critical speed in horizontal ball screw applications.

If the screw is not supported, a longer stroke normally means a reduction in the critical speed and hence the permissible linear speed, corresponding to the square of the added length. Ball screws therefore come up against their physical limitations, which is particularly inconvenient in applications where high speeds could help to achieve shorter machine cycle times.

These limits can be very effectively extended with suitable supports for the rotating screw. Up to now, however, there were no readily available practical solutions, and it was the responsibility of the customer to implement such designs.

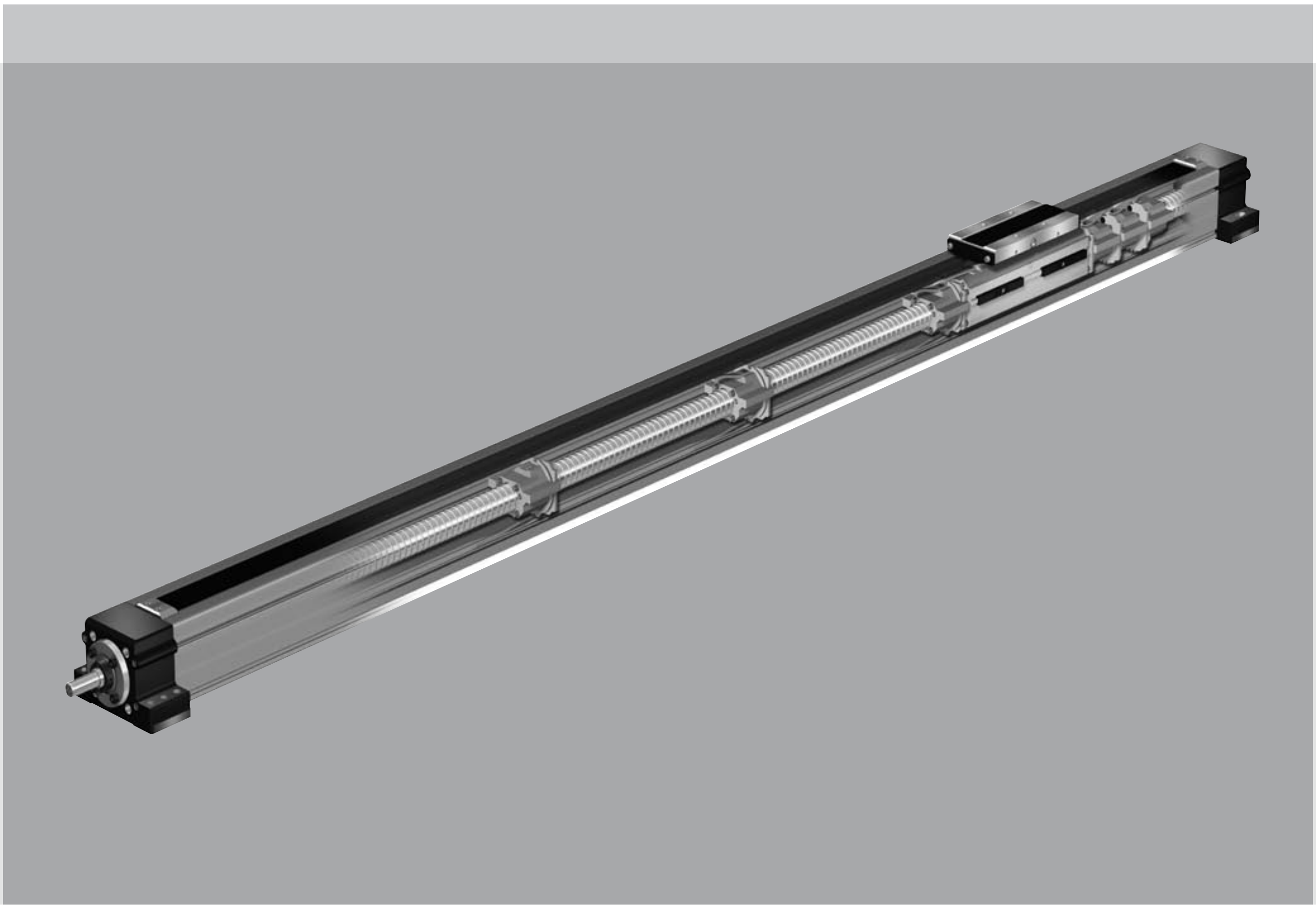
With this product, Rexroth offers a solution that truly deserves the name “drive unit” because all of the design details of this system have been engineered and implemented as elements in a modular structure.

Operating principle of the screw support (SPU) in horizontal operation:

The screw support motion is triggered by the movement of the ball nut along the screw. Screw supports are used in pairs. Depending on the application, one, two or three pairs may be necessary. When the ball nut moves out of the central position, the screw supports are pushed together in the direction of movement, while those behind the nut are positioned at predetermined locations along the travel range. Even when the nut is at the end of its stroke, the screw will be supported radially at several points along its length.

Since the unsupported length between two screw supports is relatively short, the critical speed can be very effectively increased. As a result, real restrictions of the maximum possible linear speed are practically eliminated.

In vertical operation, a further benefit is offered by the pillow blocks. The floating bearings in the pillow blocks contain two deep-groove ball bearings which, in terms of the critical speed, act almost like a fixed bearing, but without exerting any substantial stretching forces on the screw or the machine.



Drive Units with Driven Screw, AGK Series

Sizing

AGK drive units are dimensioned according to the same criteria as for ball screw assemblies:

Service life calculation

The service life of the drive unit is calculated in a similar way as for a classic ball screw drive. The average speed and average load are calculated for this purpose (see the “Calculations” section). Because this is a complete unit, the lowest basic load rating of the nut or bearing must be used for the calculation. The corresponding data is listed in the table opposite.

Permissible linear speed

The permissible speed of the ball screw is influenced by various factors:
- Screw lead
- Maximum permissible nut speed (d x n value)
- Permissible speed of the end bearings
- Length-dependent critical speed of the screw due to screw deflection. By using screw supports (SPU) for longer lengths, it is possible to increase the critical speed because the screw supports function like additional floating bearings.

The permissible speeds as a function of the drive unit length and the number of screw supports are shown in charts on page 64 and following. These charts make it easy to estimate the attainable speeds. It should be noted that screw supports are only used in horizontal applications.

Permissible drive torque

The maximum permissible drive torque at the motor journal is shown in charts giving a clear indication of the various factors involved; see page 66 and following.

The classic Euler buckling load of the screw is shown for each ball screw size and length, as well as the respective bearing configuration and the specific drive journal used along with the timing belt side drive.

Vertical mounting

In vertical applications, screw supports cannot be used because of the system design.

For these applications, the permissible linear speeds and drive torques are those indicated for versions without screw supports.

Frictional torques, mass moments of inertia and moved masses

These can be found in the in the corresponding tables on the following pages.

Calculation example

A calculation example that shows the interplay of all chosen components for a typical application can be found in the “Calculations and Examples” section.

Service life calculation

The size of the drive unit can be specified by performing a service life calculation.
In the "Calculations" section, the dynamic load rating given in the table is compared with the loads occurring in the application.

d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = a x b
"a" – number of load-carrying turns per thread
"b" – number of load-carrying threads on the screw

AGK size	Ball screw size	Part number	Load ratings (N)	
	d_0 x P x D_W - i	of the ball nut used	dyn. C	stat. C_0
20	**20 x 5R x 3 - 4**	R1512 112 43	14300	21500
	20 x 20R x 3.5 - 3	R1512 172 07	13300	18800
	20 x 40R x 3.5 - 1x4	R2522 120 01	14000	26200
32	**32 x 5R x 3.5 - 4**	R1512 310 52	21600	40000
	32 x 10R x 3.969 - 5	R1512 340 52	26000	47000
	32 x 20R x 3.969 - 3	R1512 370 52	19700	33700
	32 x 32R x 3.969 - 3	R1512 390 52	19500	34000
40	**40 x 5R x 3.5 - 5**	R1512 412 21	29000	64000
	40 x 10R x 6 - 4	R1512 440 12	29000	64000
	40 x 20R x 6 - 3	R1512 470 12	29000	62800
	40 x 40R x 6 - 3	R1512 490 52	29000	62300

Drive Units with Driven Screw, AGK Series

Stroke and Length Calculations

The main dimensions can be specified using a simple length calculation.

$L = L_{Hmax} + L_C + L_N$

$L_{AGK} = L + L_2 + B_1 + B_{11}$

L_C = length of the ball nut enclosure
L_{Hmax} = maximum stroke required by customer
L_N = unusable length, resulting from sealing strip fastening, screw supports, and excess travel on the screw

Example of a stroke and length calculation for AGK 32x20 with two screw supports:

The required stroke is 1650 mm.

$L = L_{Hmax} + L_C + L_N$
L = 1650 mm + 204 mm + 454 mm
L = 2308 mm

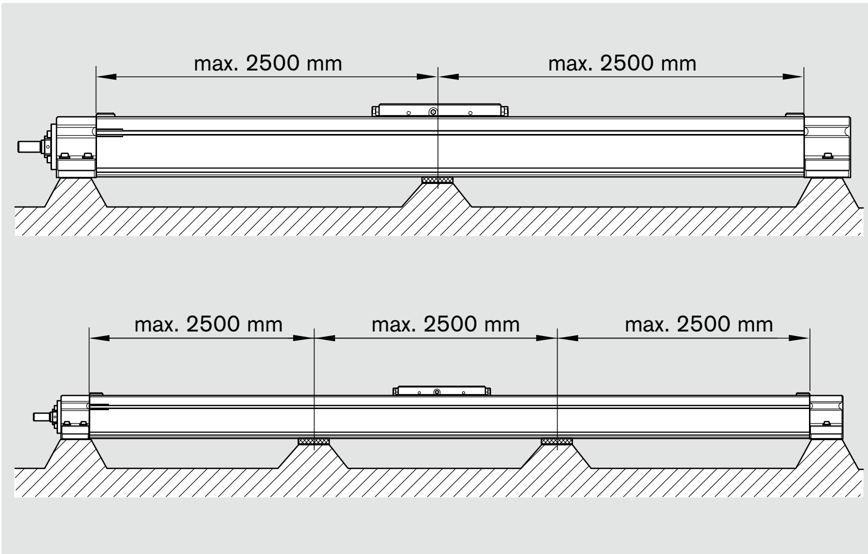
$L_{AGK} = L + L_2 + B_1 + B_{11}$
L_{AGK} = 2308 mm + 58 mm + 60 mm + 70 mm
L_{AGK} = 2496 mm

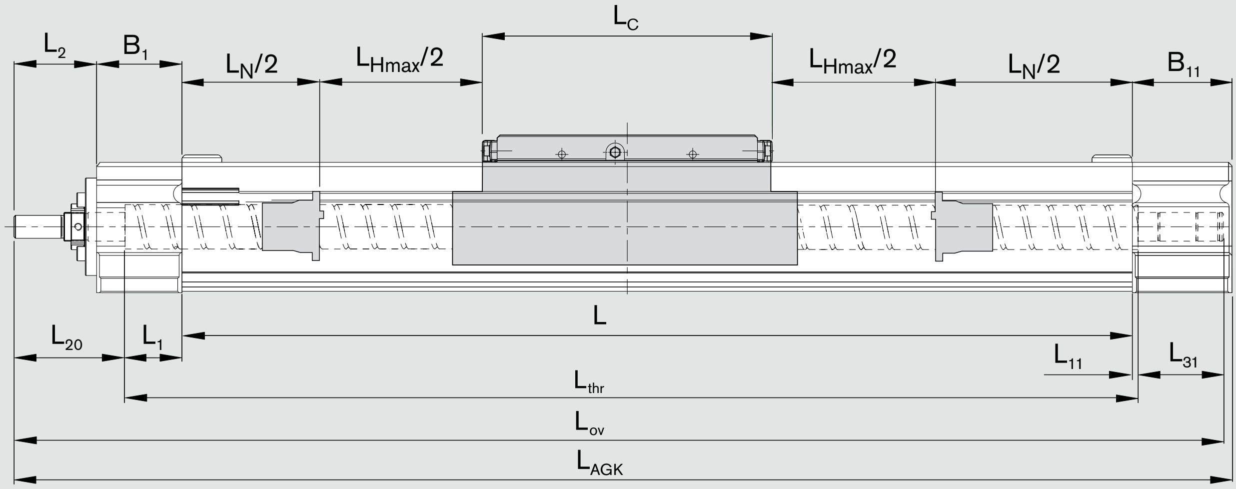
Provide supports for the encapsulation profile
The encapsulation profile may deflect under its own weight.

For a free length L of more than 2500 mm, supports must therefore be provided for the encapsulation profile.
- Spacing between the support points: max. 2500 mm
- The mounting bases for the encapsulation profile supports and the pillow blocks should be on the same level.

When the drive unit is in operation, the encapsulation profile lifts as the drive carriage passes over it, then sinks back down onto the supporting surface.

Provide damping material on the surfaces of the encapsulation profile supports, e.g. foam rubber pads.





AGK size	Ball screw size	Dimensions (mm)											
		L_C	L_N				B_1	B_{11}	L_1	L_2	L_{11}	L_{20}	L_{31}
			w/o SPU	1xSPU	2xSPU	3xSPU							
	d_0 x P			(per side)	(per side)	(per side)							
20	20 x 5/20/40	204	166	281	406	531	60	60	42	42	4	60	47
32	32 x 5/10/20/32	204	214	329	454	579	60	70	40	58	4	78	60
40	40 x 5/10/20/40	264	246	361	486	611	65	80	45	73	4	93	68

d_0 = nominal diameter
P = screw lead (right-hand)

Drive Units with Driven Screw, AGK Series

Technical Data and Dimensions

The mounting dimensions for the drive unit and the tolerance specifications for the adjoining structure are given below. For inquiries, there are corresponding CAD files available in AutoCAD format.

$L_{mtg} = L + B_2 + (B_{11}/2)$

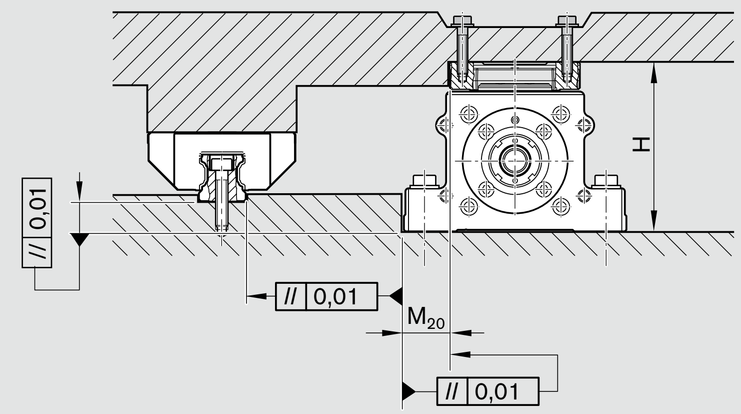
$L_{mtg} = L_{AGK} - L_2 - B_1 + B_2 - (B_{11}/2)$

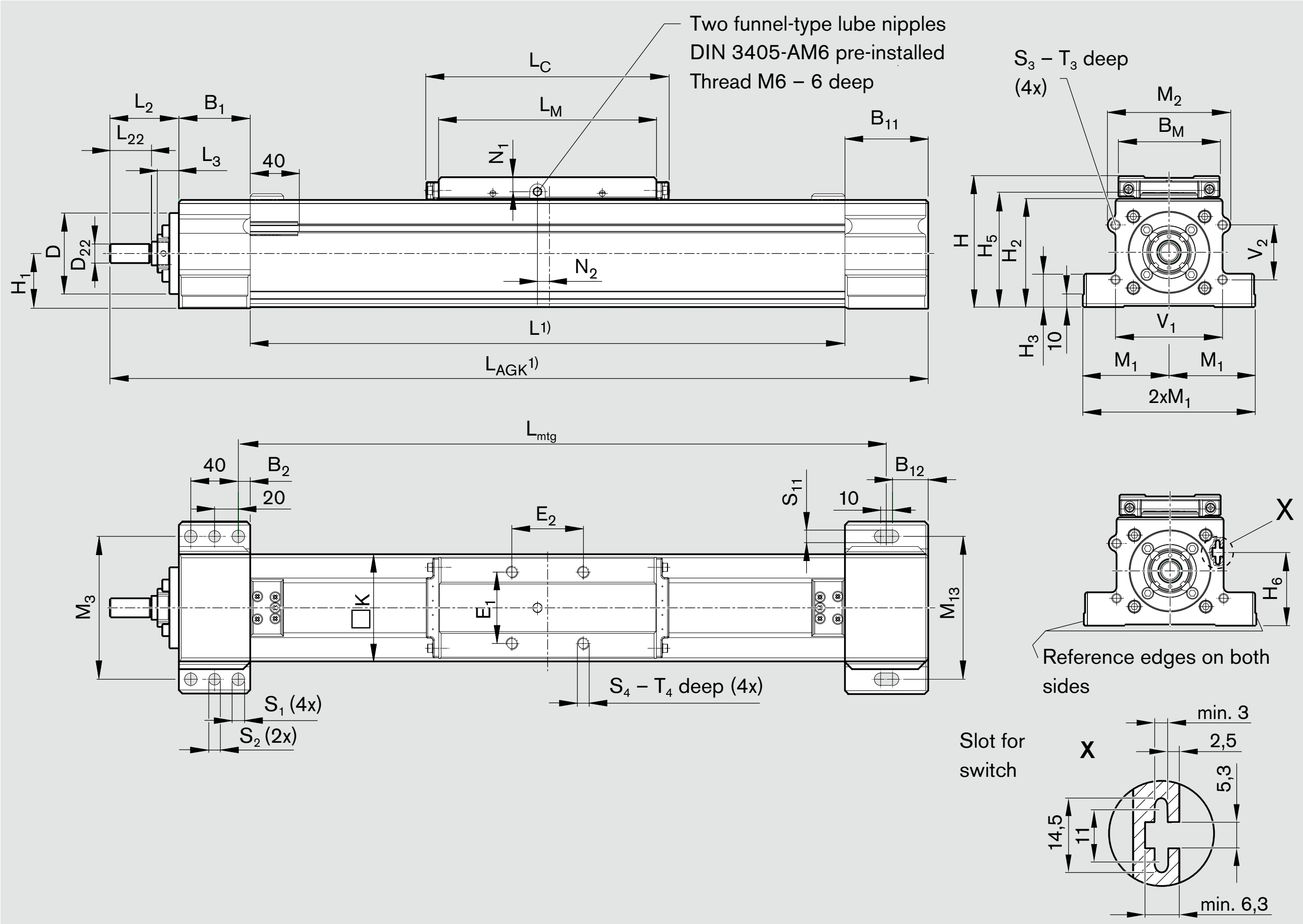
L_{mtg} = mounting length

d_0 = nominal diameter
P = screw lead (right-hand)

Parallelism of customer attachment, pillow blocks and rail guides:

Ball screw size	Dimensions (mm)	
	H	M_{20}
d_0 x P	±0.01	±0.01
20x5/20/40	100	35.0
32x5/10/20/32	110	30.0
40x5/10/20/40	135	37.5





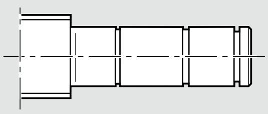
1) as calculated

AGK size	Ball screw size d_0 x P	Dimensions (mm) B_1	B_2	B_{11}	B_{12}	B_M	D_1 −0.013	D_{22} h7	E_1	E_2	H_1	H_2 ±0.15	H_3	H_5	H_6	K	L_2	L_3
20	20x5/20/40	60	10.0	60	25	75	55	10	60	60	41	81	28	86	31	80	42	15
32	32x5/10/20/32	60	10.0	70	30	85	68	16	60	60	46	91	28	96	67	90	58	18
40	40x5/10/20/40	65	12.5	80	35	105	80	25	80	80	56	111	33	116	82	110	73	20

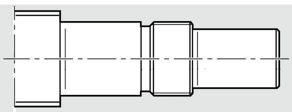
AGK size	Ball screw size d_0 x P	Dimensions (mm) L_{22}	L_M	M_1 ±0.015	M_2	M_2	M_{13}	N_1	N_2	S_1	S_2	S_3	S_4	S_{11}	T_3	T_4	V_1	V_2
20	20x5/20/40	25	183	72.5	80	120	120	12	20.0	10.5	9.7	M8	M10	10.5	15	15	66	50
32	32x5/10/20/32	35	183	72.5	103	120	120	12	8.5	10.5	9.7	M8	M10	10.5	15	15	90	46
40	40x5/10/20/40	50	243	90.0	116	150	150	17	19.0	13.0	11.7	M10	M12	13.0	20	16	100	65

Screw ends:

Type 31



Type 81

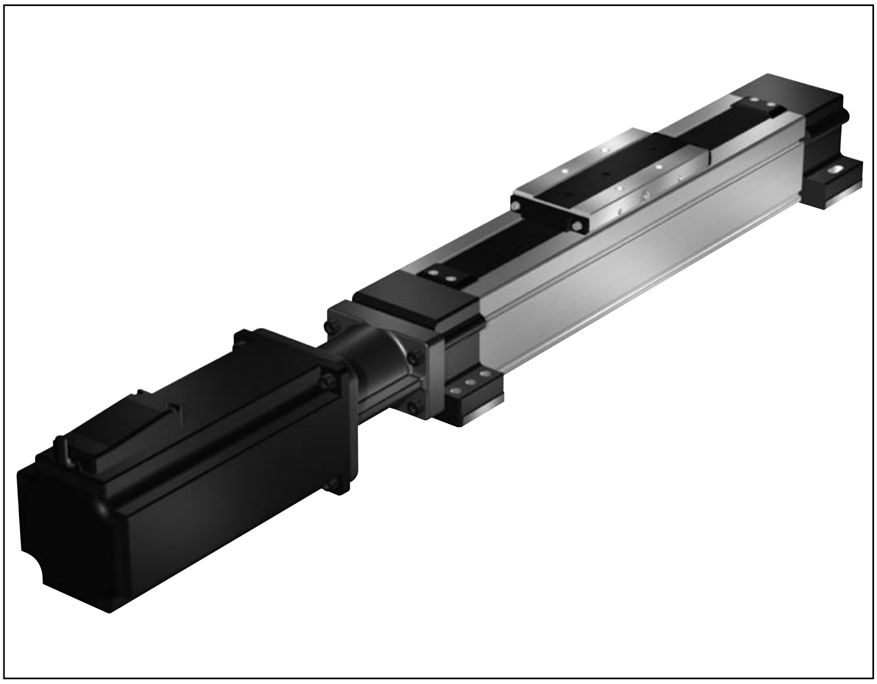


Drive Units with Driven Screw, AGK Series

Technical Data and Dimensions, with motor mount, coupling and motor

The dimensions for the drive unit version with motor mount, coupling and motor are given below. For inquiries, there are corresponding CAD files available in AutoCAD format.
More technical data and details of accessories for the MSM servo drive used can be found in the catalogs
- ARS, EcoDrive Cs (R310D0 2725)
- EcoDrive Cs – Project Planning Manual (R911295757)
- EcoDrive Cs – Drive Control Units MGP 01 VRS (R911296548)

More technical data and details of accessories for the MSK servo drives used can be found in the catalogs
- Controllers, Motors, Electrical Accessories (R310EN 2710)
- Synchronous Motors MSK – Project Planning Manual (R911296288)
- Rexroth IndraDrive and Rexroth IndraDyn (R911311519)



d_0 = nominal diameter
P = screw lead (right-hand)

Frictional torques at motor journal

AGK size	Ball screw size	Frictional torques at motor journal M_{RS} (Nm)			
	d_0 x P	w/o SPU	1 pair SPU	2 pairs SPU	3 pairs SPU
20	20x 5	0.40	0.40	0.50	0.50
	20x20	0.50	0.60	0.70	0.80
	20x40	0.60	0.80	1.00	1.20
32	32x5	0.80	0.80	0.90	0.90
	32x10	0.90	1.00	1.00	1.10
	32x20	0.90	1.00	1.10	1.30
	32x32	1.00	1.20	1.40	1.60
40	40x5	1.20	1.20	1.30	1.30
	40x10	1.50	1.60	1.70	1.80
	40x20	1.30	1.50	1.60	1.80
	40x40	1.60	1.90	2.30	2.60

Technical data of coupling

AGK size	Ball screw size d_0 x P	Motor type	Rated torque M_{KN} (Nm)	Mass moment of inertia J_K (kgm² 10^{-4})	Weight m_K (kg)
20	20x5/20/40	MSM 040B with/without brake	14.5	0.63	0.265
		MSK 040C with/without brake	19.0	0.60	0.260
		MSK 050C with/without brake	50.0	2.00	0.700
32	32x5/10/20/32	MSK 060C with/without brake	50.0	2.00	0.700
		MSK 076C with brake	98.0	3.90	0.900
40	40x5/10/20/40	MSK 076C with brake	98.0	3.90	0.900

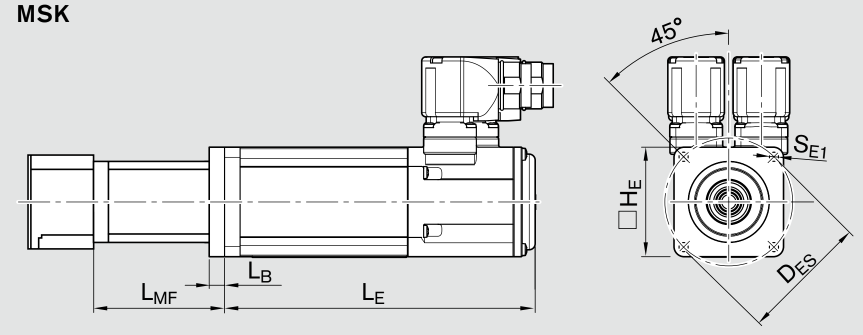
Technical data of motors

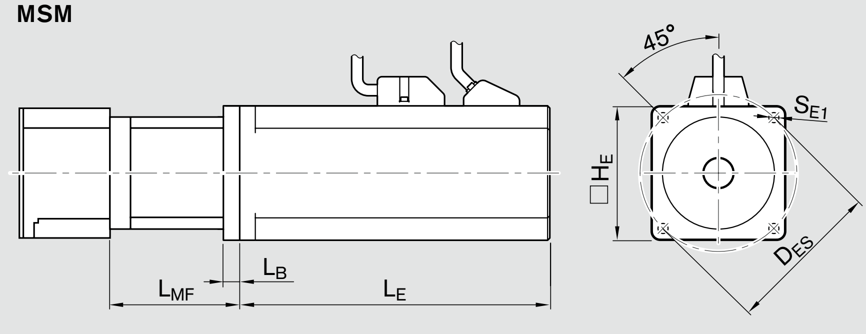
Ambient temperature T_{amb} 0 to +45 °C; protection class IP 65

Motor		MSM 040B	MSK 040C	MSK 050C	MSK 060C	MSK 076C
Part number with brake		R3471 075 03	R3471 087 03	R3471 089 03	R3471 091 03	R3471 093 03
Part number without brake		R3471 074 03	R3471 086 06	R3471 088 03	R3471 090 03	–
Maximum speed n_{max}	(min^{-1})	4500	7500	6000	6000	5000
Rated torque M_{MN}	(Nm)	2.4	2.7	5.0	8.0	12.0
Maximum torque M_{Mmax} 1)	(Nm)	7.1	8.1	15.0	24.0	43.5
Motor mass moment of inertia J_M	(10^{-4} kgm^2)	0.67	1.4	3.3	8.0	43.0
Brake mass moment of inertia J_{Br}	(10^{-4} kgm^2)	0.08	0.23	1.07	0.59	3.60
Brake holding torque M_{Br}	(Nm)	2.45	4.00	5.00	10.00	11.00
Mass of motor m_M	(kg)	3.1	3.6	5.4	8.4	14.0
Mass of brake m_{Br}	(kg)	0.7	0.3	0.7	0.4	1.1

1) depends on controller used

Motor mount and motor dimensions





AGK size	Ball screw size d_0 x P	Motor type	Dimensions (mm) D_{ES}	H_E	L_B	L_E w/o brake	L_E with brake	L_{MF}	S_{E1}
20	20x5/20/40	MSM 040B	90	80	17	157.5	191.5	90	6.0
		MSK 040C	95	82	15	185.5	215.5	90	6.6
		MSK 050C	115	98	17	203.0	233.0	115	9.0
32	32x5/10/20/32	MSK 060C	130	116	12	226.0	259.0	125	9.0
		MSK 076C	165	140	17	–	292.5	133	11.0
40	40x5/10/20/40	MSK 076C	165	140	17	–	292.5	140	11.0

Drive Units with Driven Screw, AGK Series

Technical Data and Dimensions, with timing belt side drive and motor

For inquiries, there are corresponding CAD files available in AutoCAD format. More technical data and details of accessories for the MSM servo drive used can be found in the catalogs
- ARS, EcoDrive Cs (R310D0 2725)
- EcoDrive Cs – Project Planning Manual (R911295757)
- EcoDrive Cs – Drive Control Units MGP 01 VRS (R911296548)

More technical data and details of accessories for the MSK servo drives used can be found in the catalogs
- Controllers, Motors, Electrical Accessories (R310EN 2710)
- Synchronous Motors MSK – Project Planning Manual (R911296288)
- Rexroth IndraDrive and Rexroth IndraDyn (R911311519)

d_0 = nominal diameter
P = screw lead (right-hand)
i_{RV} = gear reduction of timing belt side drive

Technical data of timing belt side drive

AGK size	Ball screw size d_0 x P	Motor type	Gear ratio i_{RV}	Reduced moment of inertia J_{RV} ($kgm^2 10^{-4}$)	Permissible torque M_{RV} (Nm)	Frictional torque M_{RRV} (Nm)
20	20x5	MSM 040B	1	0.024	2.1	0.4
	20x20				3.6	
	20x40				4.1	
	20x5	MSK 040C		0.024	2.1	
	20x20				3.6	
	20x40				4.1	
	20x5	MSK 050C		0.140	2.3	0.5
	20x20				4.3	
	20x40				5.0	
32	32x5	MSK 060C	1	0.140	12.0	0.5
	32x10/20/32				19.0	
	32x5		2	0.026	6.0	
	32x10				11.0	
	32x20/32				13.0	
40	40x5	MSK 076C	1	0.778	26.0	0.6
	40x10				52.0	
	40x20				67.0	
	40x40				67.0	
	40x5		2	0.126	13.0	
	40x10				26.0	
	40x20				33.5	
	40x40				33.5	

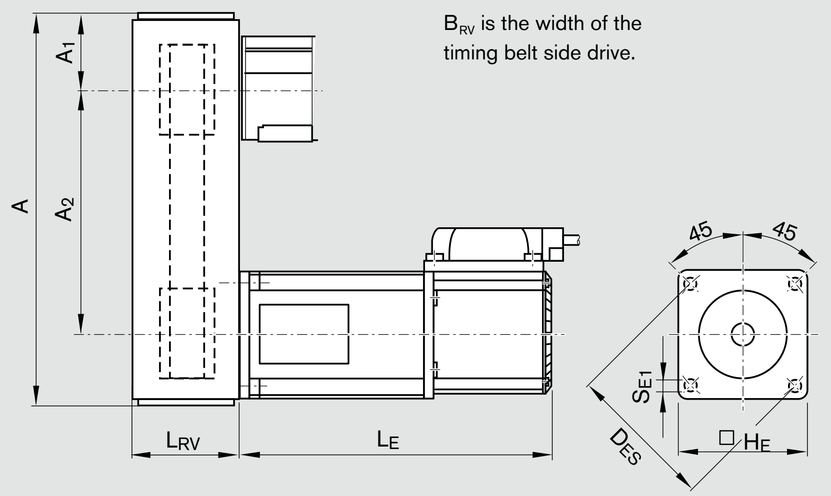
Technical data of motors

Ambient temperature T_{amb} 0 to +45 °C; protection class IP 65

Motor		MSM 040B	MSK 040C	MSK 050C	MSK 060C	MSK 076C
Part number with brake		R3471 075 03	R3471 087 03	R3471 089 03	R3471 091 03	R3471 093 03
Part number without brake		R3471 074 03	R3471 086 06	R3471 088 03	R3471 090 03	–
Maximum speed n_{max}	(min^{-1})	4500	7500	6000	6000	5000
Rated torque M_{MN}	(Nm)	2.4	2.7	5.0	8.0	12.0
Maximum torque M_{Mmax} 1)	(Nm)	7.1	8.1	15.0	24.0	43.5
Motor mass moment of inertia J_M	(10^{-4} kgm²)	0.67	1.4	3.3	8.0	43.0
Brake mass moment of inertia J_{Br}	(10^{-4} kgm²)	0.08	0.23	1.07	0.59	3.60
Brake holding torque M_{Br}	(Nm)	2.45	4.00	5.00	10.00	11.00
Mass of motor m_M	(kg)	3.1	3.6	5.4	8.4	14.0
Mass of brake m_{Br}	(kg)	0.7	0.3	0.7	0.4	1.1

1) depends on controller used

Dimensions of motors and timing belt side drive



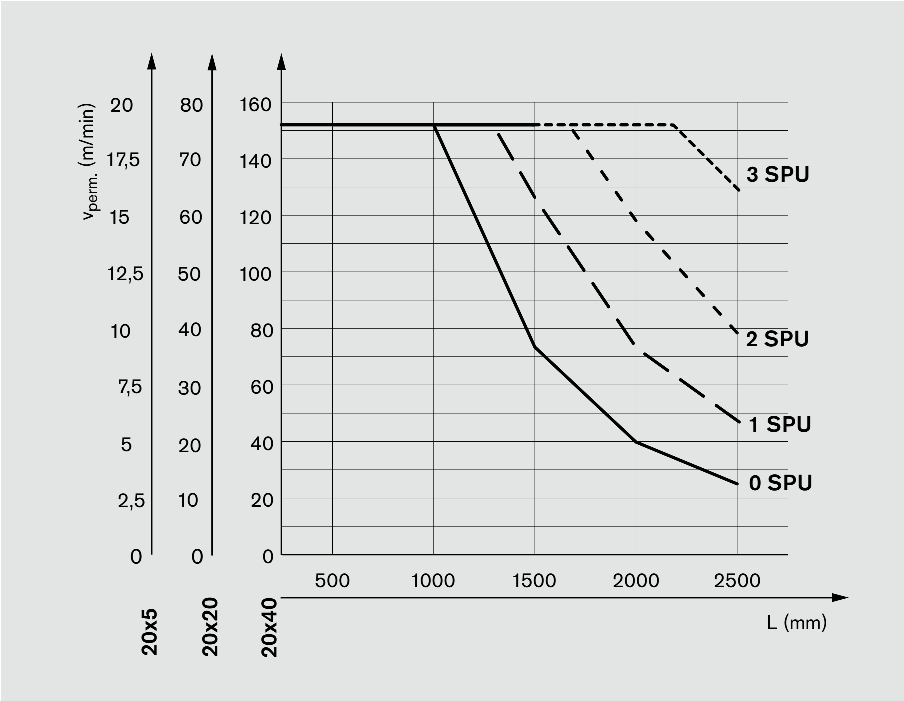
AGK size	Ball screw size d_0 x P	Motor type	Dimensions (mm) A	A_1	A_2 i=1	A_2 i=2	B_{RV}	D_{ES}	H_E	L_E without brake	L_E with brake	L_{RV}	S_{E1}	Weight M_{RV} (kg)
20	20x5/20/40	MSM 040B	231	47.5	122.5	–	88	90	80	157.5	191.5	51	6.0	on req.
		MSK 040C	231	47.5	122.5	–	88	95	82	185.5	215.5	51	6.6	on req.
		MSK 050C	287	66.0	155.0	–	116	115	98	203.0	233.0	56	9.0	on req.
32	32x5/10/20/32	MSK 060C	300	59.0	165.0	162	116	130	116	226.0	259.0	66	9.0	on req.
40	40x5/10/20/40	MSK 076C	409	77.0	240.0	238	160	165	140	–	292.5	90	11.0	on req.

Drive Units with Driven Screw, AGK Series

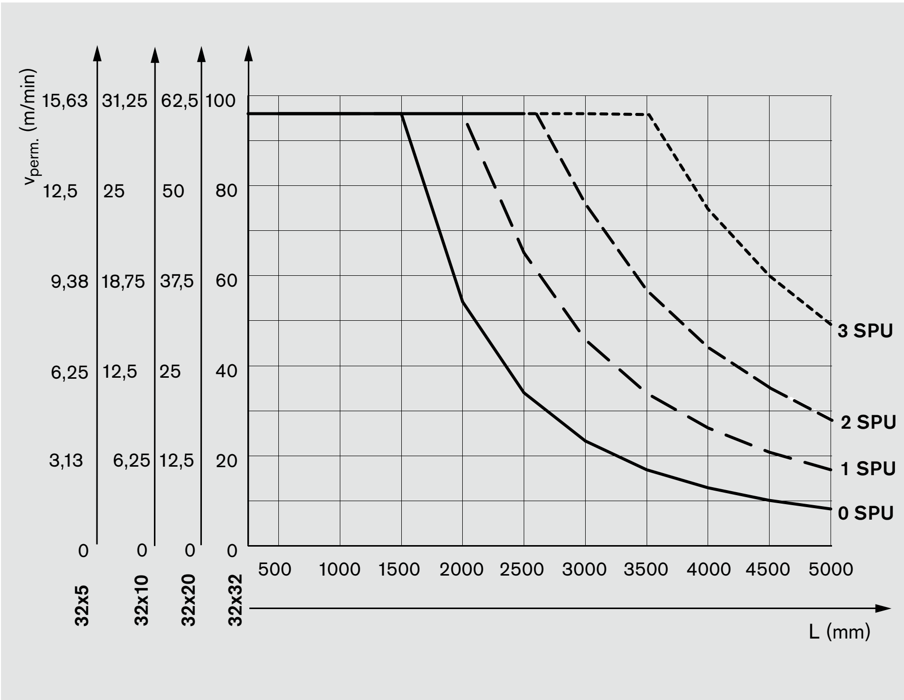
Permissible Linear Speed $v_{perm.}$

AGK 20, AGK 32, AGK 40

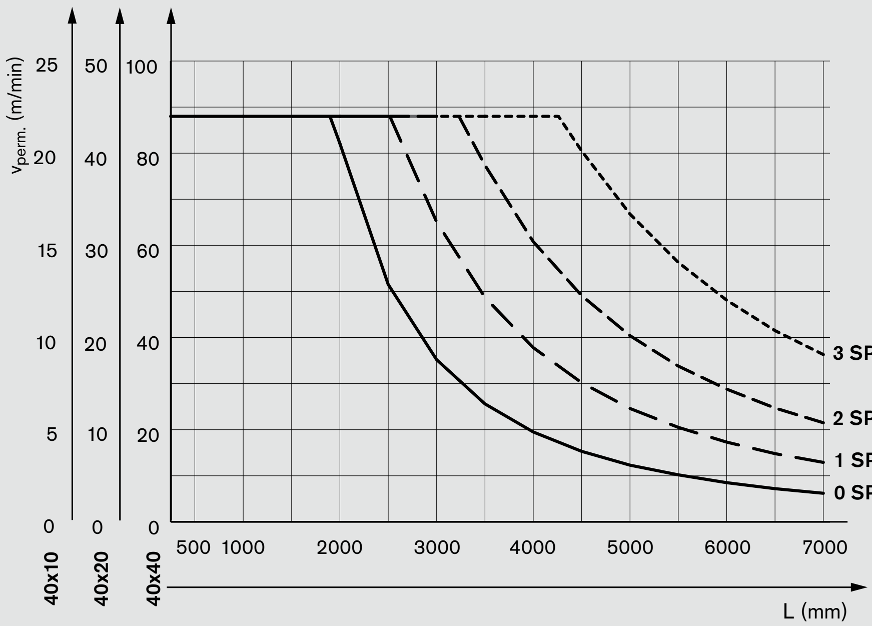
AGK size 20



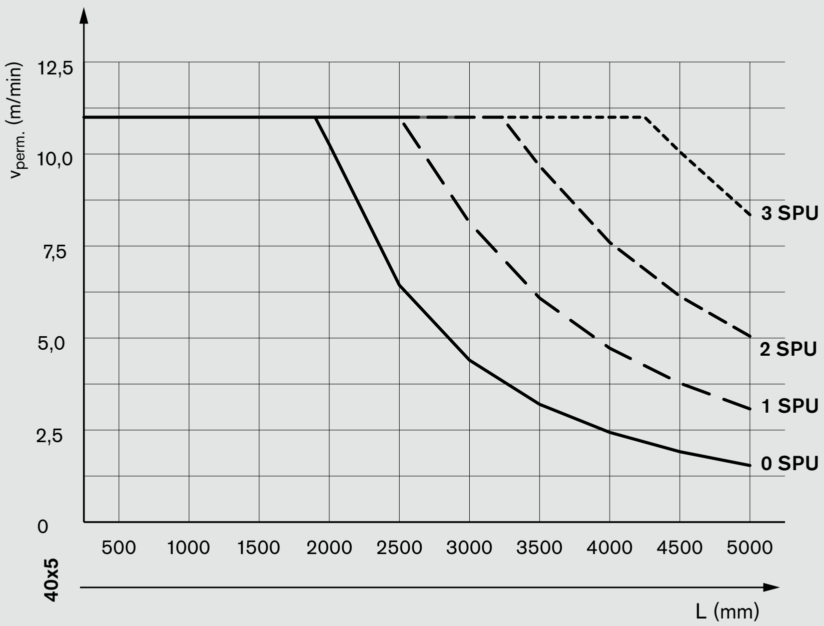
AGK size 32



AGK size 40



vperm. (m/min)
25
20
15
10
5
0
50
40
30
20
10
0
100
80
60
40
20
0
40x10
40x20
40x40
500 1000 2000 3000 4000 5000 6000 7000
L (mm)
3 SPU
2 SPU
1 SPU
0 SPU



vperm. (m/min)
12,5
10,0
7,5
5,0
2,5
0
40x5
500 1000 1500 2000 2500 3000 3500 4000 4500 5000
L (mm)
3 SPU
2 SPU
1 SPU
0 SPU

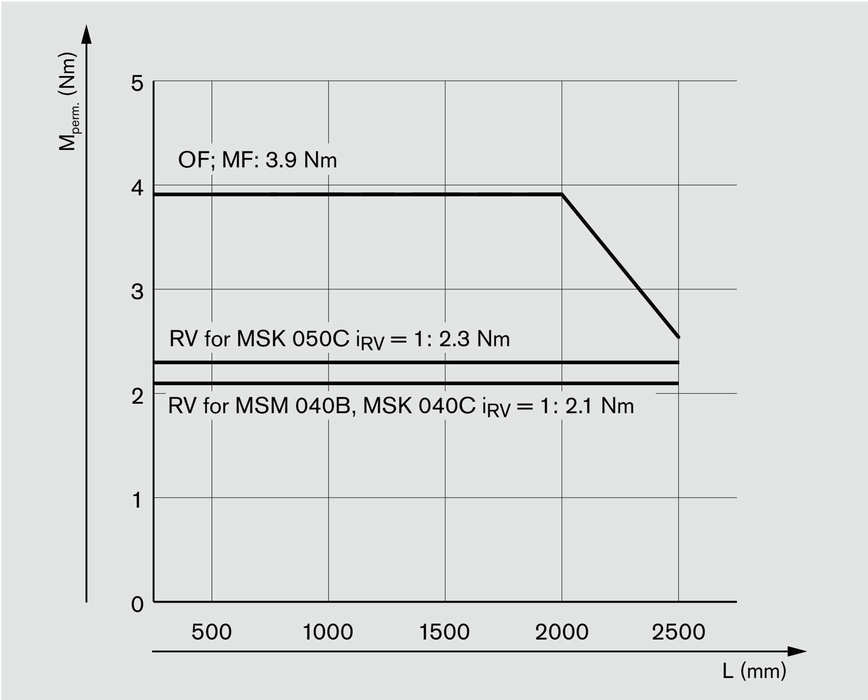
Drive Units with Driven Screw, AGK Series

Permissible drive torque $M_{perm.}$

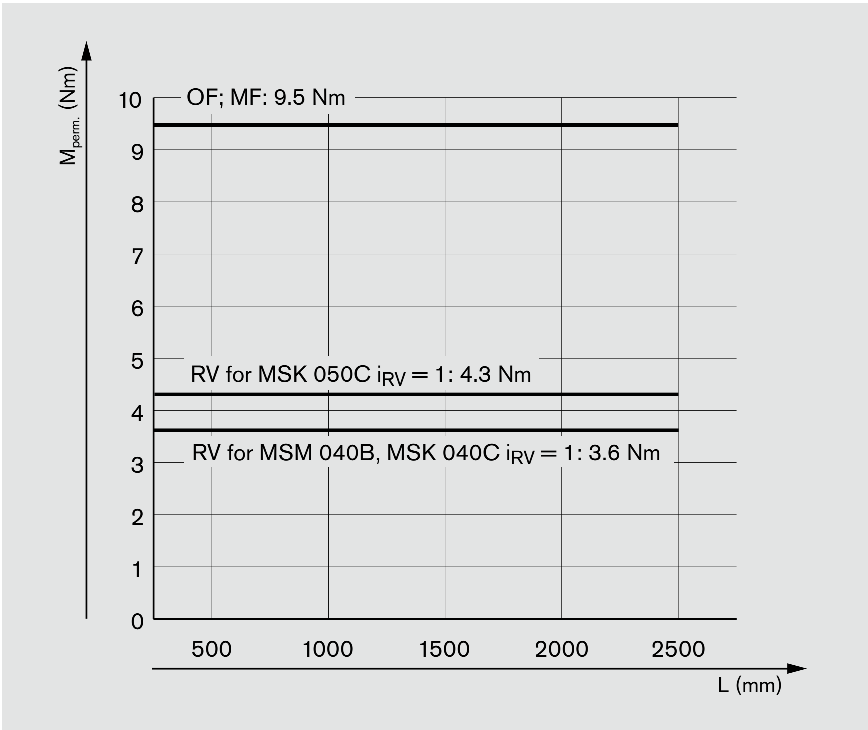
AGK 20

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

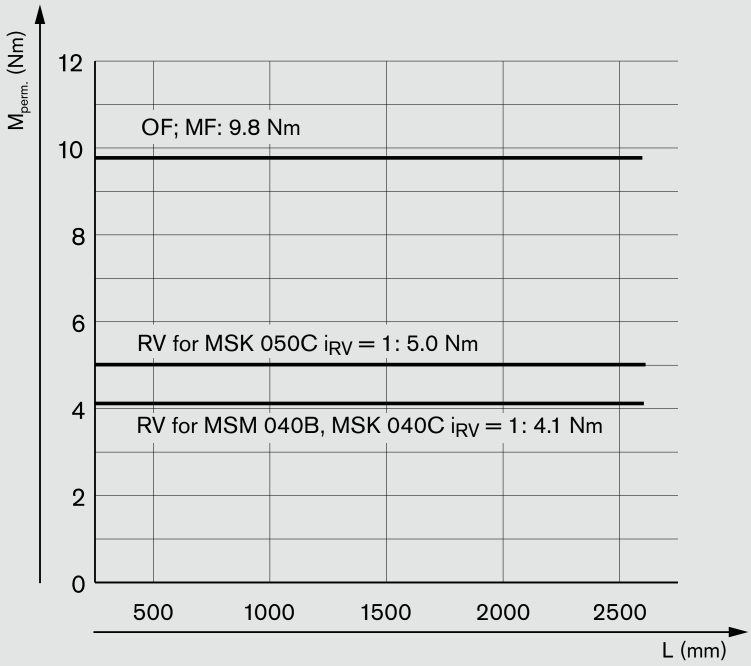
Ball screw size 20x5



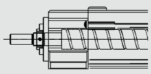
Ball screw size 20x20



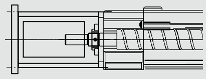
Ball screw size 20x40



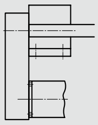
OF



MF



RV



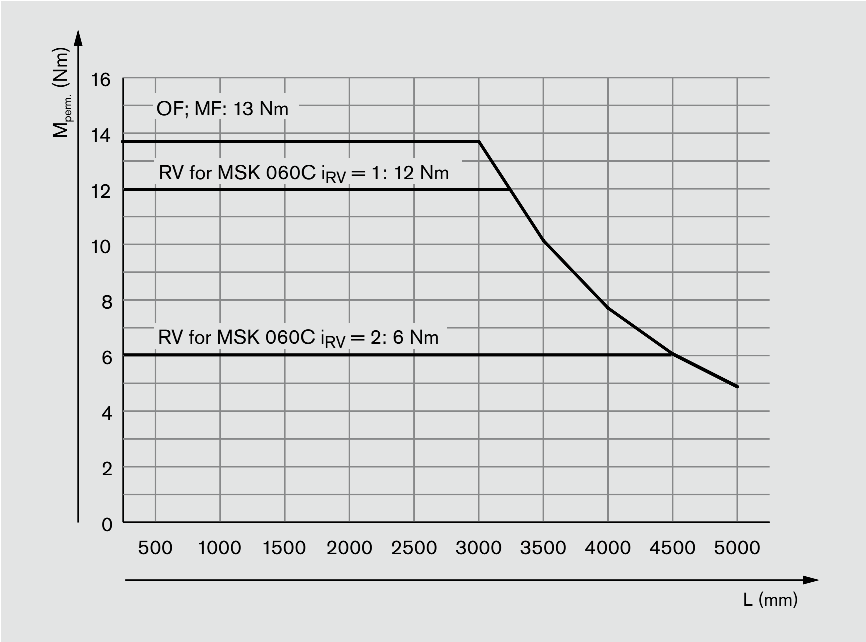
Drive Units with Driven Screw, AGK Series

Permissible drive torque $M_{perm.}$

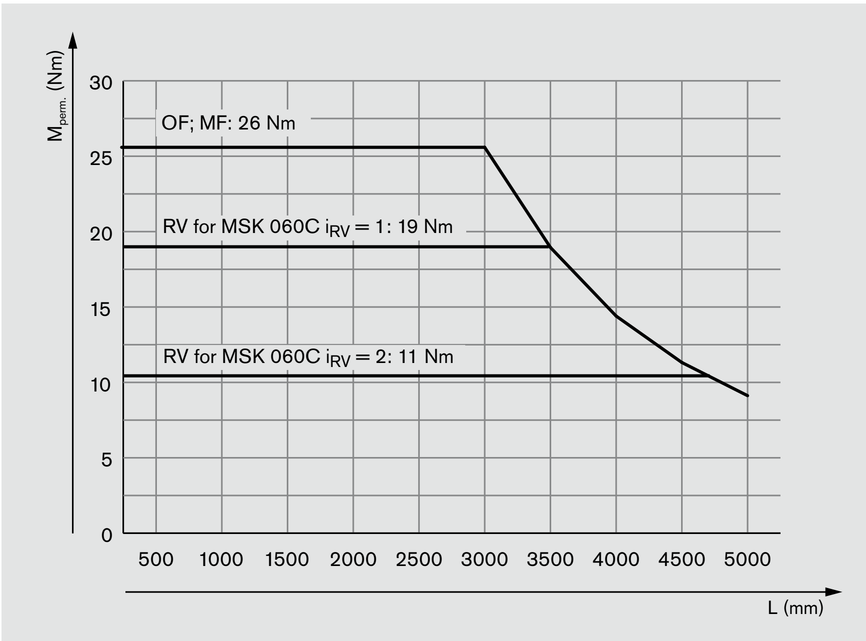
AGK 32

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

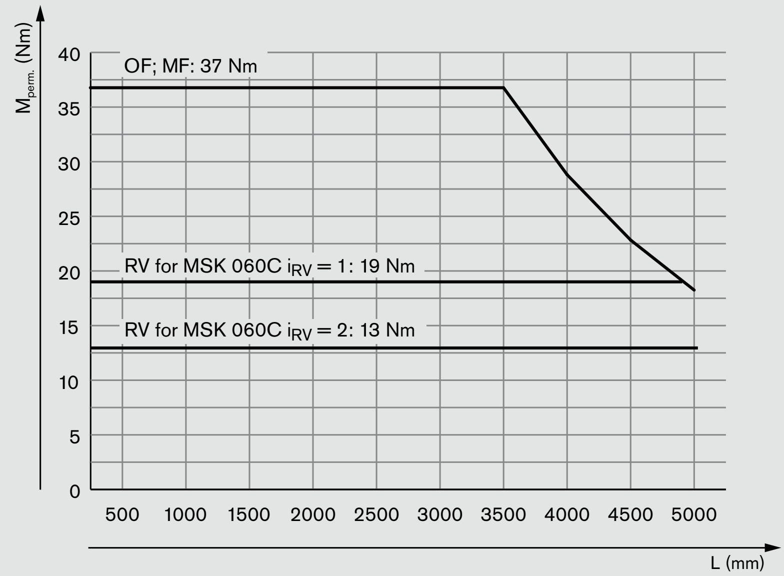
Ball screw size



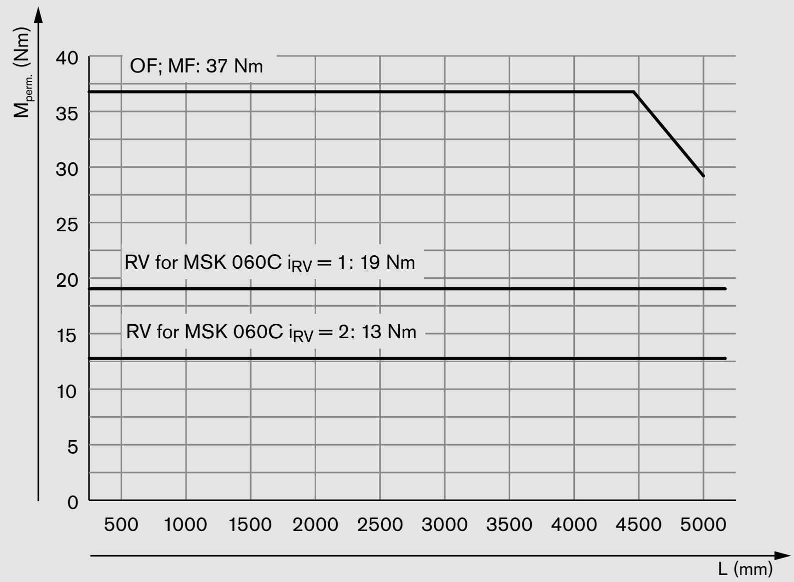
Ball screw size 32x10



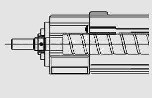
Ball screw size 32x20



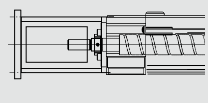
Ball screw size 32x32



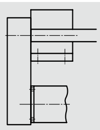
OF



MF



RV



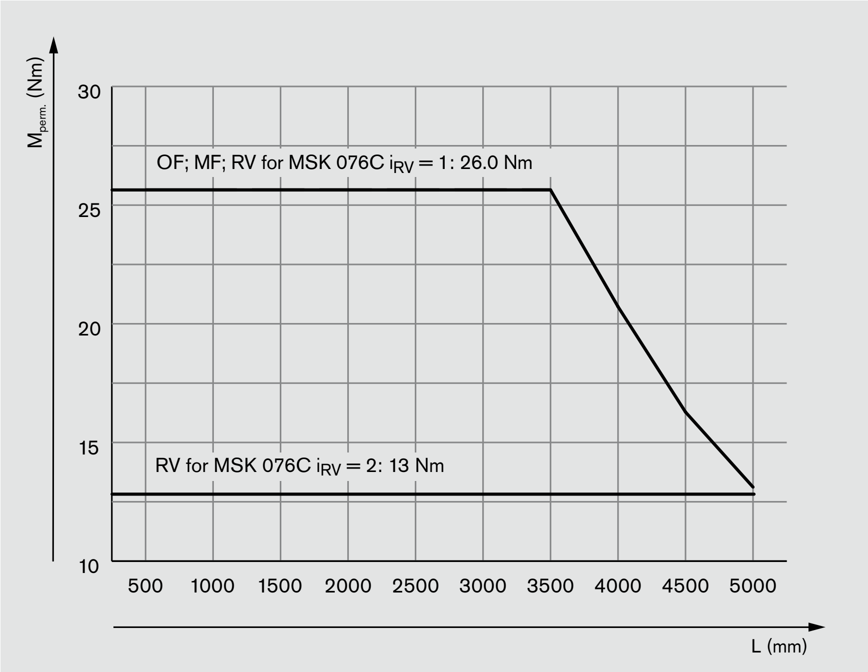
Drive Units with Driven Screw, AGK Series

Permissible drive torque $M_{perm.}$

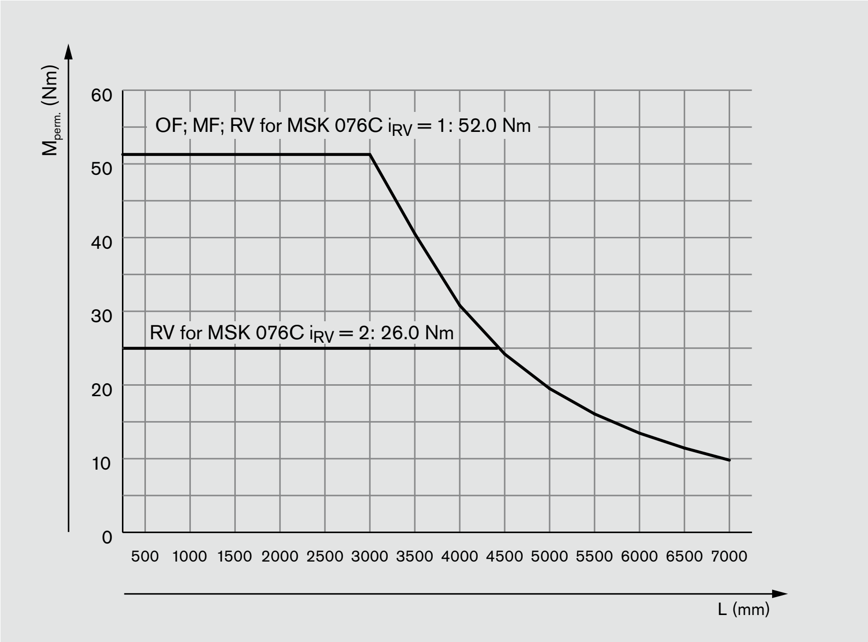
AGK 40

The torque must be read off from the curve for the specific drive type, OF (w/o motor mount), MF (with motor mount), or RV (timing belt side drive).

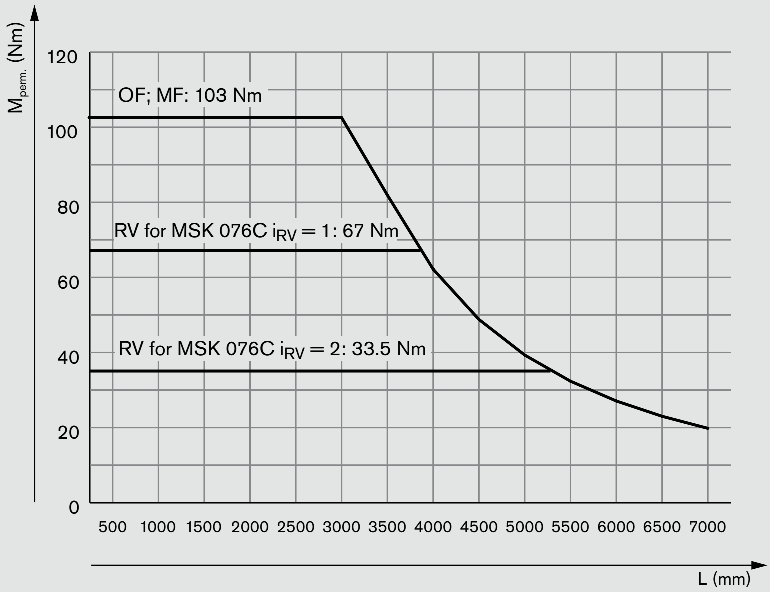
Ball screw size 40x5



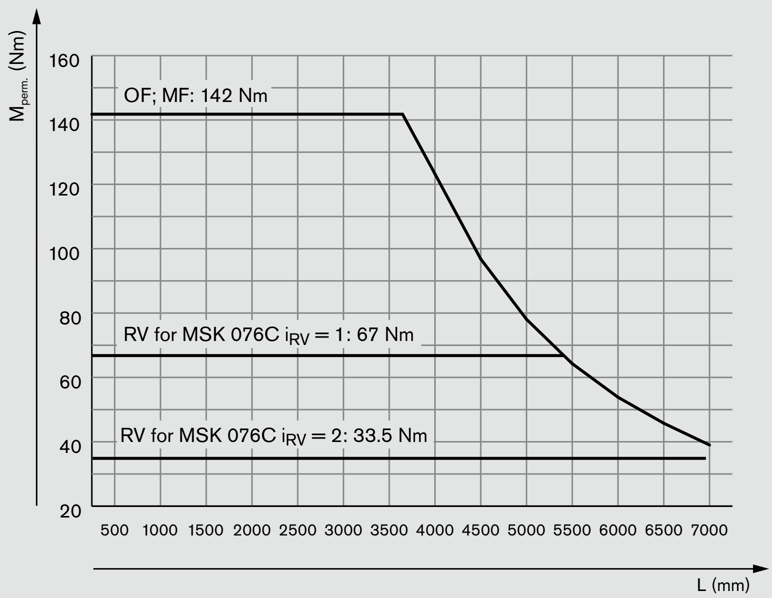
Ball screw size 40x10



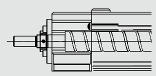
Ball screw size 40x20



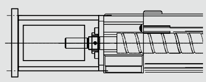
Ball screw size 40x40



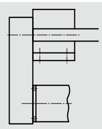
OF



MF

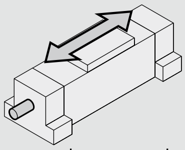


RV



Drive Units with Driven Screw, AGK Series

Configuration and Ordering Data



Size	Ball screw d₀ x P	Length[1] (mm) (Fig. 1)	Ball nut Sealing type	Preload	Screw Tolerance grade	Lubrication	Ball nut enclosure (Fig. 2)	Sealing strip	Screw support
AGK 20	20x5 20x20 20x40	L = L_{AGK} = L_{Hmax} = L_{ov} = L_{thr} =	Standard seal 01 Low-friction seal 03 Without seal 00	Standard backlash 00 Reduced backlash 01 2% preload 03 3% preload 06	T5 T7 T9	Basic lubrication and anti-corrosion oil 01 Anti-corrosion oil 00	MA01 MA02 MA01	Steel[2] 01 Polyurethane 02	0SPU 00 1SPU 01 2SPU 02 3SPU 03
AGK 32	32x5 32x10 32x20 32x32								
AGK 40	40x5 40x10 40x20 40x40								

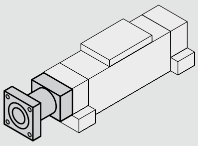
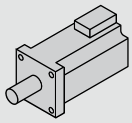
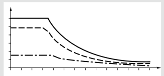
1) Only one length specification necessary
2) Up to L = 3500 mm only

Order example:

Fixed parameters			
Lead direction	right-hand	**Number of ball track turns**	fixed
Ball nut enclosure	MAG-Z	**Screw**	rolled
Ball nut	ZEM-E-S		
Left-hand bearing	SEC-F	**Right-hand bearing**	SEC-L
Screw end type	81	Screw end type	31
End face	K	End face	K

Variable parameters	**Selected**	**Ordering data**
Size	AGK 20	AGK 20
Ball screw	20x20	20x20
Length	Overall length 1350 mm	L_{ov} = 1350
Sealing type	Standard seal	01
Preload	Reduced backlash	01
Screw tolerance grade	T5	T5
Lubrication	Basic lubrication, anti-corrosion oil	01
Ball nut enclosure	MA02	MA02
Sealing strip	Steel	01
Screw support	2SPU	02
Drive type	with motor mount	MF01
Gear ratio	–	–
Attachment kit for motor	MSM 040B with brake	006
Motor	MSM 040B with brake	075
Documentation	Torque test report (incl. standard test report)	002

When ordering:
Please state the option number given in the box as appropriate (e.g. 01).

Motor attachment 				Motor 	Documentation 	
Drive type (Fig. 3, Fig. 4)	Gear ratio	Attachment kit	Motor			Measurement report
OF01	–	000		000		
MF01	–	006	MSM 040B oB[4]	074		
			MSM 040B mB[5]	075		
		002	MSK 040C oB	086		
			MSK 040C mB	087		Lead test report 001
		007	MSK 050C oB	088		
			MSK 050C mB	089		
RV01 RV02 RV03 RV04	i =1	032	MSM 040B oB	074		
			MSM 040B mB	075		
		030	MSK 040C oB	086		
			MSK 040C mB	087		
		023	MSK 050C oB	088		
			MSK 050C mB	089	Standard (acceptance test report)[3] 000	
OF01		000		000		
MF01		003	MSK 060C oB	090		Torque test report 002
			MSK 060C mB	091		
		002	MSK 076C mB	093		
RV01 RV02 RV03 RV04	i =1	023	MSK 060C oB	090		
			MSK 060C mB	091		
	i =2	024				
OF01		000		000		Lead and torque test report 003
MF01		002	MSK 076C mB	093		
RV01 RV02	i =1	023				
RV03 RV04	i =2	024				

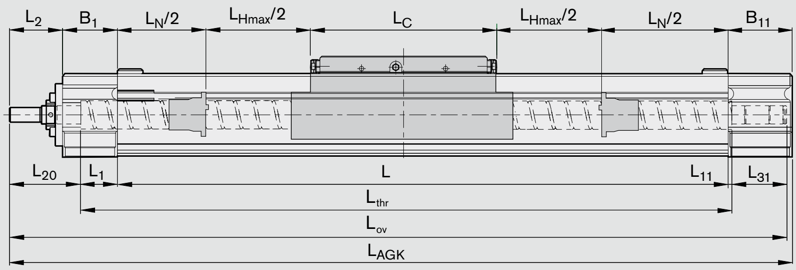
3) Is always supplied

4) oB = without motor

5) mB = with motor

Selection aids
Lengths

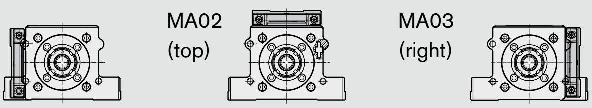
Fig. 1



Ball nut enclosure

Fig. 2

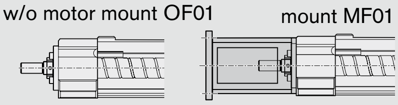
MA01 (left) MA02 (top) MA03 (right)



Motor attachment / Attachment kit

Fig. 3

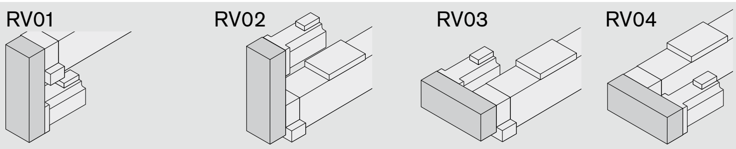
w/o motor mount OF01 with motor mount MF01



Timing belt side drive

Fig. 4

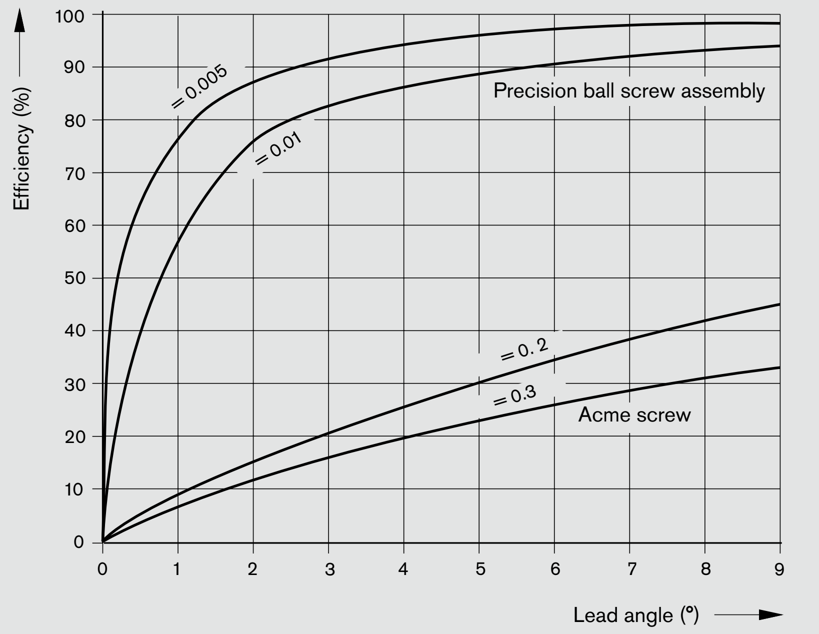
RV01 RV02 RV03 RV04



Technical Notes

DIN 69051, Part 1 defines a ball screw as follows:

An assembly comprising a ball screw shaft and a ball nut and which is capable of converting rotary motion into linear motion and vice versa. The rolling elements of the assembly are balls.



Advantages over the Acme screw drive

- The mechanical efficiency of an Acme screw drive is a maximum 50%, whereas a ball screw can reach a mechanical efficiency of up to 98%.
- Higher life expectancy due to negligible wear during operation
- Low drive power required
- No stick-slip effect
- More precise positioning
- Higher travel speed
- Less heat-up

Due to their higher mechanical efficiency, ball screws are in principle not self-locking.

⚠ **Safety information**
We recommend that a safety nut be installed for particularly critical applications in vertical set-ups.
Please consult us.

Selection criteria for ball screws

The following factors should be considered when selecting the ball screw for a given application:
- degree of accuracy required (lead deviation)
- in-service load conditions
- service life
- critical speed
- buckling load
- rigidity/permissible clearance or desired preload
- characteristic speed (max. permissible linear speed)

For best results in terms of design and cost-efficiency, the following points should be taken into consideration:
- The lead is a decisive factor for the load-carrying capacity (depending on the maximum possible ball diameter) and the drive torque.
- The calculation of the service life should be based on average loads and average speeds, not on maximum values.
- In order for us to provide you with a customized solution, installation drawings or sketches of the ball nut environment should be enclosed with your inquiry.

⚠ **Note**
Radial and eccentric forces relative to the screw must be avoided, as they can affect the ball screw's performance and shorten its life.

Where special conditions of use are involved, please consult us.

Load-carrying capacities and service life
We calculate load ratings and service life in accordance with DIN 69051, Part 4 and ISO 3408-4, Part 5.

Basic static load rating C_0
The static load rating is an axial, concentrically acting force that induces a permanent deformation of 0.0001 x the ball diameter between the ball and the ball raceway.

Dynamic load rating C
The dynamic load rating is an axial, concentrically acting force of constant magnitude and direction under which 90% of a sufficiently large number of identical ball screws can achieve a nominal service life of one million revolutions.

Service life
The nominal life is expressed by the number of revolutions (or number of operating hours at constant speed) that will be attained or exceeded by 90% of a representative sample of identical ball screws before the first signs of material fatigue become evident. The nominal life is designated as L or L_h, depending on whether it is specified in revolutions or hours.

Short stroke
During a short stroke, the ball does not make a real turn. It is therefore impossible for an adequate lubricating film to form. This may result in premature wear. In the chart, the minimum required stroke (travel) for a 10% lower load rating is shown as a function of the number of turns and lead of the nut. Hence the most favorable range lies above each curve. It may help to have occasional longer strokes, which are performed with simultaneous relubrication as “lubricating strokes.” If in doubt, please ask.

Critical speed and buckling load
The critical speed and buckling load can be checked using the corresponding charts.
For precise calculations:
See the “Design Calculations” section in the main Precision Ball Screw Assemblies catalog R310EN 3301.

Characteristic speed $d_0 \cdot n$
Rexroth ball screws can be operated at very high speeds due to their internal ball recirculation system. Characteristic speeds of up to 150,000 are possible depending on the nut type.

$d_0 \cdot n$	$\leq$	**150,000**	
d_0	=	**nominal diameter**	**(mm)**
n	=	**speed**	**(min^{-1})**

The theoretically possible maximum linear speed v_{max} (m/min) is specified on the page featuring the relevant nut. Actually attainable speeds are heavily dependent among other factors on preload and duty cycle. They are generally restricted by the critical speed. (See “Design Calculations” section.)

Material, hardness
Our standard ball screw assemblies are made of high-quality, heat-treatable steel, carbon chrome alloy steels or case-hardened steels. The screw and nut raceways have a minimum Rockwell hardness of HRC 60. Ball screw assemblies made of corrosion-resistant steel (DIN 17230, EN 10088) are available on request. Normally, the screw ends remain unhardened.

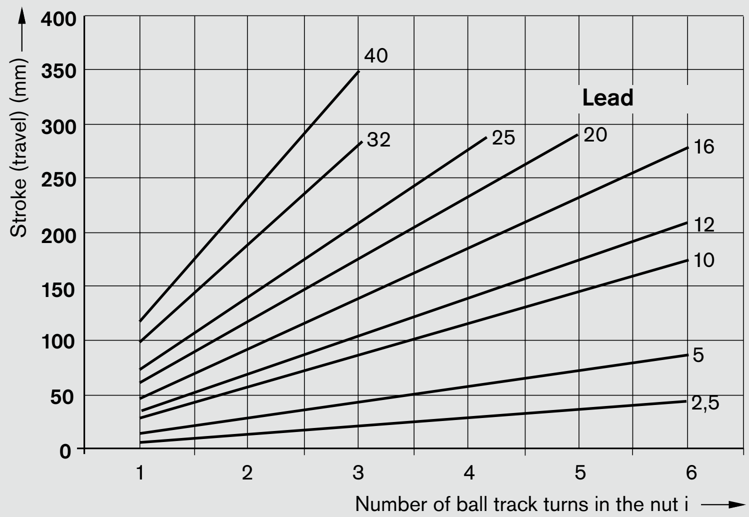
Sealing
Ball screws are precision assemblies that require protection against contamination. Flat protective covers and bellows type dust boots or the drive unit AGK are particularly suitable for this purpose. As there are many applications in which these methods do not provide sufficient protection, we have developed a gapless lip-type seal which ensures an optimal sealing effect and maintains high efficiency due to the low friction level. Our ball screws are therefore supplied with seals in their standard versions.
At the customer’s request, these seals can be omitted or special seals used in their place. A reinforced version of the standard seal has been developed for those applications where heavy contamination of the screw appears inevitable. The sealing effect has been improved further by increasing the preload. What must be borne in mind is the significantly higher friction torque in comparison with the standard friction torque (see Technical Data) and the associated increased heat build-up. The reinforced seal can be easily recognized by its dark green color.

Permissible operating temperatures
Ball screws are suitable for continuous operation at temperatures up to 80°C with temporary peaks of 100°C (measurements taken on the outer shell of the nut).

Permissible operating temperatures:
$-10\ °C \leq T_{operating} \leq 80\ °C$

Permissible bearing temperature:
$-15\ °C \leq T_{bearing} \leq 80\ °C$

Short stroke limit (load rating reduced by less than 10%)



Technical Notes

Acceptance Conditions and Tolerance Grades

Permissible travel deviation

in accordance with DIN 69051, Part 3 and ISO 3408-3

Many values are significantly more accurate than those defined in DIN 69051, Part 3 and ISO 3408-3.

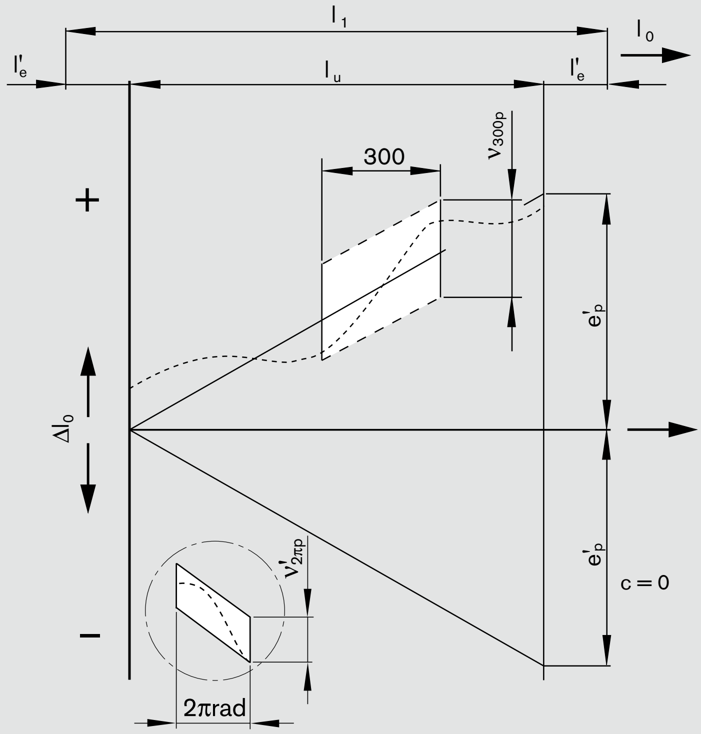
Symbol definitions: (excerpt)

- l_0 = nominal travel
- l_1 = thread length
- Δl_0 = travel deviation
- l_u = useful travel
- l'_e = excess travel (the closer tolerances for travel and hardness do not apply here)
- c = travel compensation for useful travel, defined by user (standard: c = 0)
- e'_p = tolerance for mean actual travel deviation
- ν_{up} = permissible travel variation within useful travel l_u
- ν_{300p} = permissible travel deviation within 300 mm travel
- $\nu'_{2\pi p}$ = permissible travel deviation within 1 revolution

Subindices:

- p = permissible
- a = actual

T **Ball screw with precision-rolled screw SN-R**



Improved values
compared with DIN 69051, Part 3 and ISO 3408-3 (tolerance reduced by half).

l_u		e'_p (µm) Tolerance grade		
>	≤	5	7	9
0	**100**	18	44	110
100	**200**	20	48	130
200	**315**	23	52	150
315		$e'_p = \frac{l_u}{300} \cdot \nu_{300p}$		

For precision screws SN-R the following values apply in all cases:

ν_{300p} (µm) Tolerance grade		
5	7	9
23	52	130

$\nu'_{2\pi p}$ (µm) Tolerance grade		
5	7	9
8	10	10

Non-usable length l'_e
(excess travel)

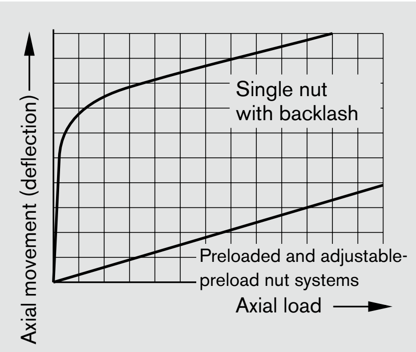
d_0 (mm)	l'_e (mm)
8	15
12, 16	20
20, 25, 32, 40	40
50, 63, 80	50

Technical Notes

Preload and Rigidity

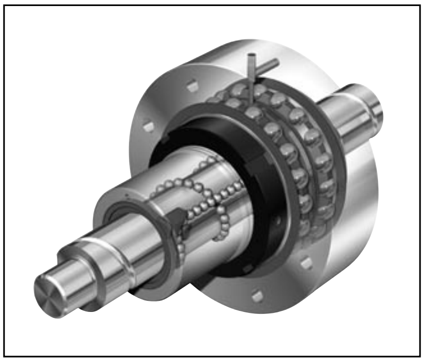
Nut system preload

In addition to single nuts with reduced backlash, Rexroth supplies nut systems preloaded by means of optimized ball size selection.



Driven nut for FAR units

Like any single nut, the driven nut can be preloaded to 2%, 3% or 5% of the basic dynamic load rating by means of ball size selection.



Rigidity of drive units

The rigidity of a drive unit is influenced by all adjoining parts such as bearings, housing bores, ball nut enclosures etc.
The tables opposite show pre-calculated values. In addition, the rigidity of the screw must be taken into account.

Overall axial rigidity R_{tot} of a single ball screw

The overall axial rigidity R_{tot} is comprised of the component rigidity of the screw R_S and the nut unit R_G.

$$\frac{1}{R_{tot}} = \frac{1}{R_s} + \frac{1}{R_G}$$

Please note that in most cases, the rigidity R_S of the screw will be significantly lower than the rigidity R_G of the nut unit.

- i = number of ball track turns
- d_0 = nominal diameter
- D_W = ball diameter
- P = lead
- R_{tot} = overall rigidity (complete system)
- R_S = rigidity of the screw
- R_G = rigidity of the ball nut enclosure with nut for a driven screw; rigidity of the nut and bearing for a driven nut

Rigidity in the area of the nut unit R_G

The rigidity in the area of the preloaded nut unit is calculated according to DIN 69051, Part 5. In drive units, R_G includes the additional rigidity of the nut bearing in versions with a driven nut. See the corresponding tables for rigidity values.

Rigidity values for FAR

FAR size	Ball screw size	Rigidity		Overall rigidity of the nut unit (N/µm)	
		Screw	Bearing	5% preload	2% preload
		R_S	R_{aL}	R_G	R_G
	d_0 x P x D_W - i	(Nm/µm)	(N/µm)		
32	32x10Rx3.969-5	141	860	377	316
	32x20Rx3.969-3	141	860	278	222
	32x32Rx3.969-3	141	860	273	222
40	40x10Rx6-5	211	950	448	379
	40x20Rx6-3	211	950	332	271
	40x40Rx6-3	211	950	323	266
50	50x10Rx6-6	345	1050	556	482
	50x20Rx6.5-5	345	1050	525	448
	50x40Rx6.5-3	340	1050	386	315
63	63x10Rx6-3	569	1150	627	549
	63x20Rx6.5-5	563	1150	599	514
	63x40Rx6.5-3	563	1150	461	381

Dynamic drag torque

d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

Size	Dynamic drag torque without seals T_{pr0} (Nm) Screws with preloaded single nuts						
	2%	3%		5%			
	Tolerance grade 5; 7	Tolerance grade 5; 7		Tolerance grade 5		Tolerance grade 7	
D_0 x P x D_W - i	max.	min.	max.	min.	max.	min.	max.
20 x 5R x 3 - 4	0.060	0.030	0.14	0.07	0.21	0.06	0.23
20 x 20R x 3.5 - 3	0.050	0.030	0.13	0.07	0.20	0.05	0.21
20 x 40R x 3.5 - 1x4	0.060	–	–	–	–	–	–
32 x 5R x 3.5 - 4	0.140	0.100	0.31	0.24	0.45	0.21	0.48
32 x 10R x 3.969 - 5	0.200	0.150	0.46	0.36	0.66	0.30	0.71
32 x 20R x 3.969 - 3	0.130	0.070	0.31	0.22	0.41	0.19	0.44
32 x 32R x 3.969 - 3	0.120	0.070	0.31	0.22	0.41	0.19	0.44
40 x 5R x 3.5 - 5	0.230	0.170	0.52	0.41	0.76	0.35	0.81
40 x 10R x 6 - 4	0.400	0.360	0.84	0.75	1.25	0.70	1.30
40 x 10R x 6 - 5	0.490	0.440	1.03	0.92	1.53	0.86	1.59
40 x 20R x 6 - 3	0.300	0.230	0.68	0.57	0.95	0.53	0.99
40 x 40R x 6 - 3	0.300	0.220	0.67	0.56	0.93	0.52	0.96
50 x 10R x 6 - 6	0.800	0.720	1.67	1.49	2.49	1.39	2.59
50 x 20R x 6.5 - 5	0.760	0.680	1.59	1.42	2.37	1.32	2.46
50 x 40R x 6.5 - 3	0.470	0.420	0.98	0.87	1.45	0.81	1.51
63 x 10R x 6 - 6	1.120	1.010	2.35	2.24	3.36	2.10	3.50
63 x 20R x 6.5 - 5	1.060	0.950	2.22	2.11	3.17	1.98	3.30
63 x 40R x 6.5 - 3	0.670	0.610	1.41	1.26	2.10	1.18	2.19

The values given for dynamic drag torque are proven practical indicators for the nut preloading.

Technical Notes

Seals and Mounting

In addition to standard seals, reinforced seals and low-friction seals are also available as an option. Reinforced seals are identified by their opal-green color and their part number.

Low friction seals are gap seals without frictional drag. The seals are identified by their red-brown color and their part number.

Fig. 1
Single seal

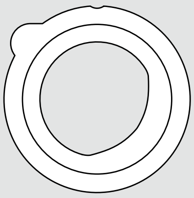


Fig. 2
Seal for double precision-rolled screw SN-R with average lead

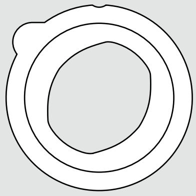
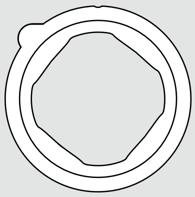


Fig. 3
Seal for quadruple precision rolled screw SN-R with high lead



Seal torque for single nuts

The dynamic drag torque of seals has already been taken into account in the drive units. Reinforced seals will increase this torque.

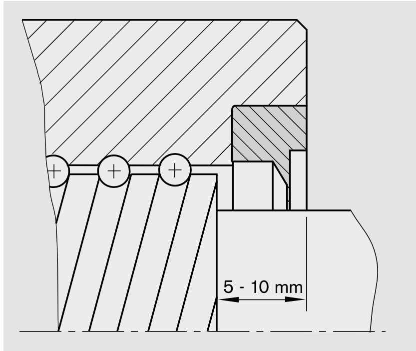
Size	Dynamic drag torque of the 2 seals T_{RD} (Nm) approx.		
	Standard seals	**Reinforced seals**	**Low-friction seals**
d_0 x P x D_W - i			$T_{RD} = 0$ Nm
20 x 5R x 3	0.10	–	x
20 x 20R x 3.5	0.12	–	✓
20 x 40R x 3.5	0.04	–	✓
32 x 5R x 3.5	0.25	0.51	x
32 x 10R x 3.969	0.25	0.46	x
32 x 20R x 3.969	0.25	0.49	x
32 x 32R x 3.969	0.25	0.45	x
40 x 5R x 3.5	0.40	0.85	x
40 x 10R x 6	0.40	0.91	x
40 x 20R x 6	0.40	0.54	x
40 x 40R x 6	0.40	–	✓
50 x 10R x 6	0.60	0.95	–
50 x 20R x 6.5	0.60	–	–
50 x 40R x 6.5	0.70	–	–
63 x 10R x 6	1.20	–	–
63 x 20R x 6.5	1.20	1.0	–
63 x 40R x 6.5	1.20	1.4	–

✓ Seal available
x Seal in preparation

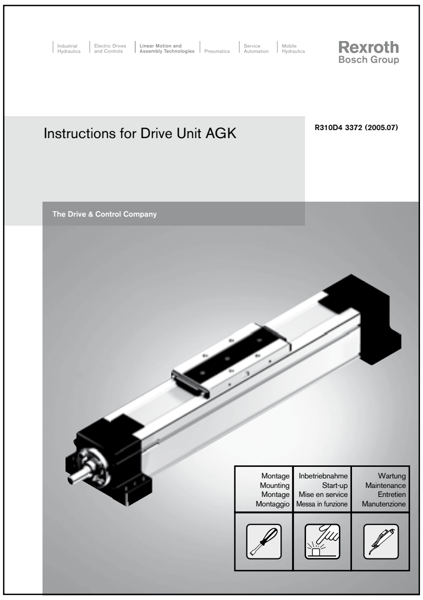
T_{RD} = dynamic drag torque of the 2 seals
d_0 = nominal diameter
P = screw lead (R = right-hand)
D_W = ball diameter
i = number of ball track turns

Inserting the seal

Position the nut on the screw as illustrated in the diagram. Insert the seal so that its projection is in the recess and press it in until it snaps into the groove. While turning the nut on the screw, watch the sealing lip carefully and straighten it if necessary by applying pressure to the exposed face. Ensure that the lip is not damaged. Detailed mounting instructions are delivered along with the parts.



Mounting



R310D4 3372 (2005-11)

Coming soon:

Instructions for Drive Unit AOK (R310D4 3374)

Instructions for Drive Unit FAR (R310D4 3373)

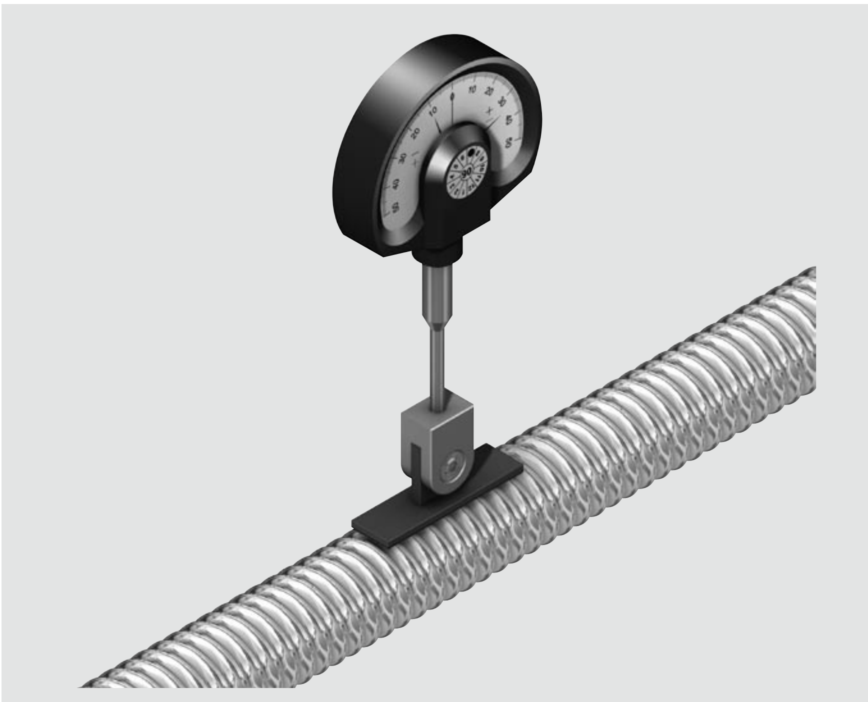
Alignment of the precision ball screw assembly in the machine

A gauge with a self-aligning contact pad is available from Rexroth for easy alignment of the ball screw assembly.

Two pads of different lengths are available for use with different screw leads.

- Part number R3305 131 19, length 33 mm for leads < 20
- Part number R3305 131 21, length 50 mm for leads > 20

These pads can be ordered separately (without the gauge).



Technical Notes

Lubrication

Standard lubrication practices for ball bearings also apply to ball screws. Lubricant loss is, however, greater than that from conventional ball bearings, for instance, due to the axial motion between the screw and the nut.

Oil lubrication

The influence of the temperature on the performance of the ball screw is very significant, as the thermal expansion of the ball screw interferes with the positioning accuracy of the assembly.
One of the advantages of oil lubrication over grease lubrication is therefore the minimized heat build-up of the ball screw, particularly at high speeds.
As a rule, commercially available mineral base oils used for ball bearings are suitable.

The necessary viscosity depends on the speed, temperature and load conditions of the respective application (see DIN 51501, 51517, 51519 and GfT Worksheet 3).
Oils ranging from ISO VG 68 to approx. ISO VG 460 are used in practice. The high viscosity grades (e.g. ISO VG 460) should be preferred in general and particularly for slow running screws.
A maximum relubrication interval of up to 10 operating hours can be attained with small quantities from the table below.
Please ask for details for driven nuts.

Relubrication quantity and intervals for oil

d_0	Lubricating quantity		Lubricating interval[1]						
	Initial lubrication	Relubrication	Time	Revolutions (mill.)	Travel (km) with lead P =				
(mm)	V_e (ml)	V_n (ml/10h)	(h)		5	10	20	32	40
20	0.600	0.060	10	1.0	5.0		20.0		40.0
32	0.600	0.060	10	1.0	5.0	10.0	20.0	32.0	
40	2.000	0.400	10	1.0	5.0	10.0	20.0		40.0
50	4.000	0.800	10	1.0	5.0	10.0	20.0		40.0
63	4.000	0.800	10	1.0		10.0	20.0		40.0

1) The value first reached defines the lubricating interval.

d_0 = nominal diameter

Limit conditions:

Load	≤	0.2 C
n_{min}	=	100 min^{-1}
$Temp_{max. nut}$	=	80 °C
$Temp_{continuous nut}$	=	60 °C

Orientation: – any

Operating mode: – driven screw
– no short stroking or hypercritical operation

Sealing: – standard

Grease lubrication

The advantage of grease lubrication is that the ball screw can run long distances on one supply of grease. As a result, a lubricating system is not required in many cases. The amount of grease used should fill the nuts to approximately half of their capacity. All commercially available high-quality ball bearing lubricating greases may be used. Read the lubricant manufacturer's specifications carefully! Never use greases with solid lubricant components (e.g. graphite or MoS_2).

For relubrication, grease cartridges containing Dynalub 510 and 520 are available from Rexroth. Greases in accordance with DIN 51825-K2K and, for higher loads, KP2K of NLGI Class 2 in accordance with DIN 51818 are recommended for the longest possible lubrication intervals. Tests have shown that greases of NLGI Class 00 achieve only about 50% of the running performance of Class 2 at higher loads. The relubrication interval depends on many factors such as the degree of contamination, operating temperature, load, etc. The following values can thus serve only as a guide.

Relubrication intervals for NLGI 2 greases

d_0	Lubricating quantity Relubrication V_e (ml)	Lubricating interval Revolutions (mill.)	Travel (km) with lead P = 5	10	20	32	40
≤ **40**	See table for	50	250	500	1000	1600	2000
> **40**	NLGI 2 greases	10	50	100	200		400

d_0 = nominal diameter

Relubrication quantities for AOK, AGK

For NLGI 2 greases:

The nut has to be lubricated with lubricant via the lube port before the ball screw is started.

Twice the relubrication quantity of grease is to be used when lubricating for the first time.

Ball screw size d_0 x P x D_w - i	Relubrication quantity of grease (g) AOK, AGK
20 x 5R x 3 - 4	0.90
20 x 20R x 3.5 - 3	2.20
20 x 40R x 3.5 - 1x4	1.30
32 x 5R x 3.5 - 4	2.00
32 x 10R x 3.969 - 5	2.80
32 x 20R x 3.969 - 3	3.20
32 x 32R x 3.969 - 3	4.90
40 x 5R x 3.5 - 5	2.70
40 x 10R x 6 - 4	6.00
40 x 20R x 6 - 3	7.80
40 x 40R x 6 - 2	9.40
40 x 40R x 6 - 3	12.90

Lubrication of the end bearings (for AOK, AGK)

As a rule, the initial grease quantity will last for the entire service life of a ball screw assembly.

Technical Notes

Lubrication

Relubrication quantities for driven nut FAR

For NLGI 2 greases

The driven nut can be relubricated with grease via the outer race of the angular contact thrust ball bearing. The nut can be at any position along the screw. The only precaution required is to make sure that the nut is at a standstill when applying the lubricant. This effectively solves the problem of a rotating lube port on the nut itself.

Two lube ports (M6) with radial or axial access points are provided. These ports are closed by set screws for shipment. The selected lube port can be opened simply by removing the set screw.

FAR size	Ball screw size d_0 x P x D_w - i	Relubrication quantity (g)
32	32 x 10R x 3.969 - 5	3.2
	32 x 20R x 3.969 - 3	3.7
	32 x 32R x 3.969 - 3	5.6
40	40 x 10R x 6 - 5	7.7
	40 x 20R x 6 - 3	9.0
	40 x 40R x 6 - 3	14.8
50	50 x 10R x 6 - 6	11.2
	50 x 20R x 6.5 - 5	17.9
	50 x 40R x 6.5 - 3	21.4
63	63 x 10R x 6 - 6	12.7
	63 x 20R x 6.5 - 5	22.1
	63 x 40R x 6.5 - 3	26.4

Calculations and Examples

Service Life Calculation

Average speed and average load

Where the speed and load fluctuate, the service life must be calculated using the averages F_m and n_m.

- Where the speed fluctuates, the average speed n_m is calculated as follows

$$n_m = \frac{q_1}{100} \cdot n_1 + \frac{q_2}{100} \cdot n_2 + \ldots + \frac{q_n}{100} \cdot n_n$$

- Where the load fluctuates and the speed is constant, the average load F_m is calculated as follows

$$F_m = \sqrt[3]{F_1^3 \cdot \frac{q_1}{100} + F_2^3 \cdot \frac{q_2}{100} + \ldots + F_n^3 \cdot \frac{q_n}{100}}$$

- Where both the load and the speed fluctuate, the average load F_m is calculated as follows

$$F_m = \sqrt[3]{F_1^3 \cdot \frac{n_1}{n_m} \cdot \frac{q_1}{100} + F_2^3 \cdot \frac{n_2}{n_m} \cdot \frac{q_2}{100} + \ldots + F_n^3 \cdot \frac{n_n}{n_m} \cdot \frac{q_n}{100}}$$

Service life in revolutions L

$$L = \left(\frac{C}{F_m}\right)^3 \cdot 10^6 \qquad \Rightarrow C = F_m \cdot \sqrt[3]{\frac{L}{10^6}} \qquad \Rightarrow F_m = \frac{C}{\sqrt[3]{\frac{L}{10^6}}}$$

Nominal life

Service life in hours L_h

$$L_h = \frac{L}{n_m \cdot 60}$$

$$\text{Machine operating hours} = L_h \cdot \frac{\text{Machine duty cycle}}{\text{Screw duty cycle}}$$

C	=	dynamic load rating	(N)	L_h	=	service life	(h)
F_m	=	average load	(N)	n_m	=	average speed	(min^{-1})
L	=	service life	(revolutions)	q	=	discrete time step	(%)

Drive torque and drive power

Drive torque M_{ta}

The dynamic drag torque must be taken into account for preloaded nuts.

$$M_{ta} = \frac{F \cdot P}{2000 \cdot \pi \cdot \eta}$$

Drive power P_a

$$P_a = \frac{M_{ta} \cdot n}{9550}$$

F	=	operating load	(N)
M_{ta}	=	drive torque	(Nm)
n	=	rotary speed	(min^{-1})
P	=	lead	(mm)
P_a	=	drive power	(kW)
η	=	mechanical efficiency (approx. 0.9)	

Calculations and Examples

Sizing of the FAR Drive Unit

Basic benefits of systems with driven nuts

Mass moment of inertia

In long screws, only the nut has to be set into rotation during the acceleration phase, and not the screw. The mass moment of inertia is therefore not a determining factor.
The ball nut's mass moment of inertia is relatively small and no longer depends on the specified stroke.

Dynamics

Complex end bearing designs, e.g. fixed bearings with angular contact thrust ball bearings at both ends, are no longer required to achieve high dynamics.

Stretching

Since screw is stationary, it can be stretched with relatively little effort.
- Higher permissible axial load (buckling load); not limited by end bearings
- Compensation of thermal effects
- Higher total rigidity

Liquid cooling

Improved cooling can be easily accomplished by selecting a hollow screw. Since the screw is stationary, it can be cooled with relatively little design effort. With a controlled cooling system, length variations due to temperature fluctuations can be virtually eliminated.

Design and manufacturing tolerances

The use of nuts with high parallelism and radial runout accuracy reduces whipping of the screw to a minimum. All functional elements come from a single source, so there is no need for customer-built designs.

Critical speed

$$n_k = f_{nk} \cdot \frac{d_2}{l_n^2} \cdot 10^7 \,(\text{min}^{-1})$$

$$n_{kperm.} = 0.8 \cdot n_k \,(\text{min}^{-1})$$

n_k = critical speed (min^{-1})
$n_{kperm.}$ = permissible operating speed (min^{-1})
f_{nk} = corrector value determined by bearing
d_2 = core diameter, see Dimension Tables (mm)
l_n = critical screw length for preloaded nut systems (mm)

Critical speed for driven screw:

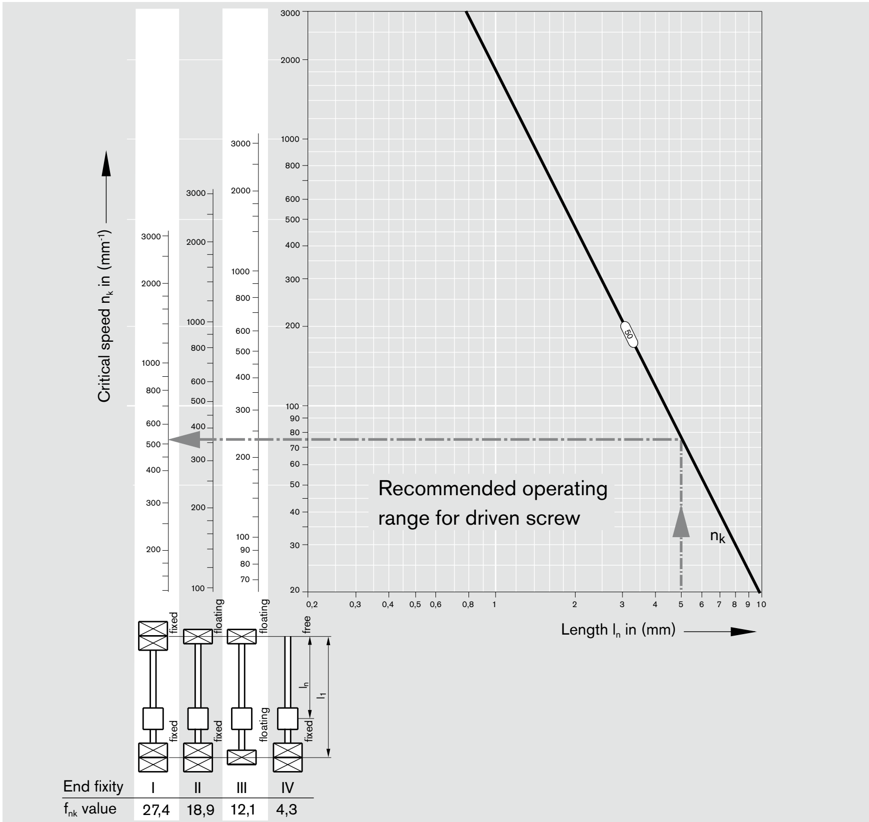
For the driven, rotating screw, the critical speed depends on the type of end fixity:

I fixed-fixed
II fixed-floating
III floating-floating
IV fixed-free

For systems with a driven screw the critical speed often restricts the achievable linear speed.

When horizontally mounted, the rotating screw itself can generate oscillations in the system as a result of its deflection or any imbalances. Depending on the free screw length and the speed, the oscillations can reach resonance level or very high amplitudes (whipping), which destroy the system.

For this reason, the screw is generally sized so that its maximum operating speed will be 20% below the critical speed.



Critical speed for driven nut:

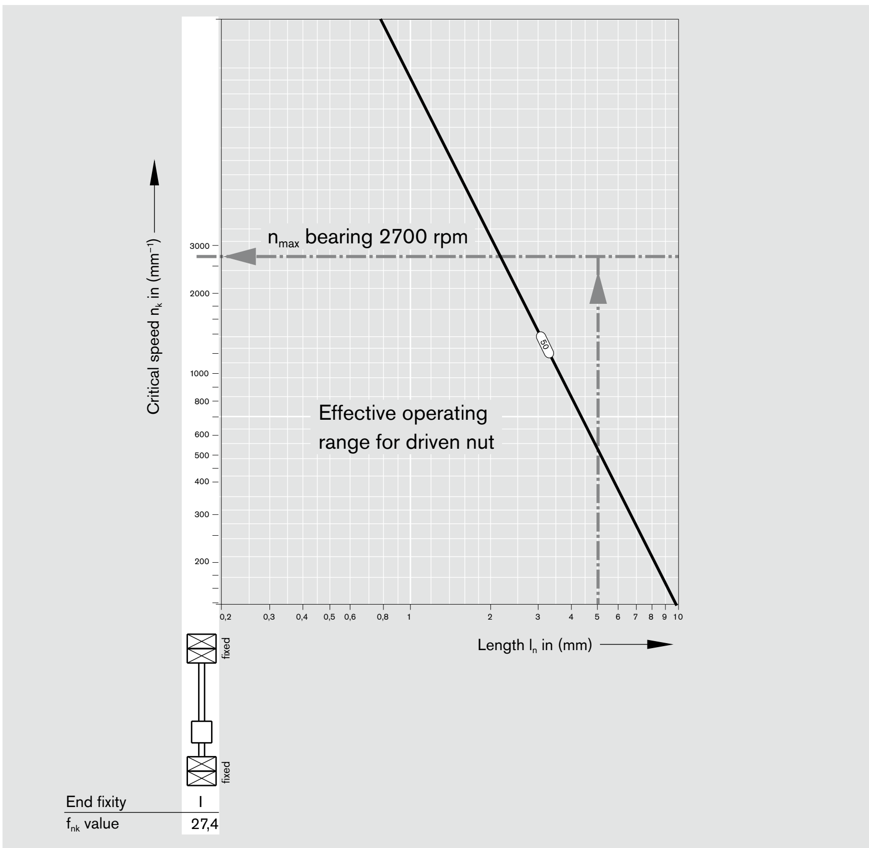
For systems with a driven nut and stationary screw, auto-excitation of screw can be completely eliminated by appropriate constructions.

The only remaining factors that can cause oscillation are the manufacturing accuracy of the rotating nut and the machine configuration.

Since the FAR drive units use only ball nuts with highly accurate parallelism and radial runout, any negative influence on the total system emanating from the ball nut can therefore be ruled out.

The critical speed is no longer a restriction. The maximum linear speed is only limited by the maximum rotary speed of the bearings used and, in rarer cases, the high maximum permissible speed (d x n value) of the ball nut.

Note:
Applies only to fixed-fixed end fixity type



Calculations and Examples

Sizing of the FAR Drive Unit

Permissible linear speed as a function of ball nut position

Permissible linear speed of driven ball nut
Fixity I fixed-fixed
Fixity II fixed-floating

Parameters:
- Screw length
- Screw diameter
- Lead
- End fixity
- Stretching force, negligible
- Max. rotary speed of bearing
- d x n value of ball nut

The charts shown here clearly illustrate the benefits of the driven nut over a conventional ball screw with a driven screw for a size 50x40Rx6.5 unit.

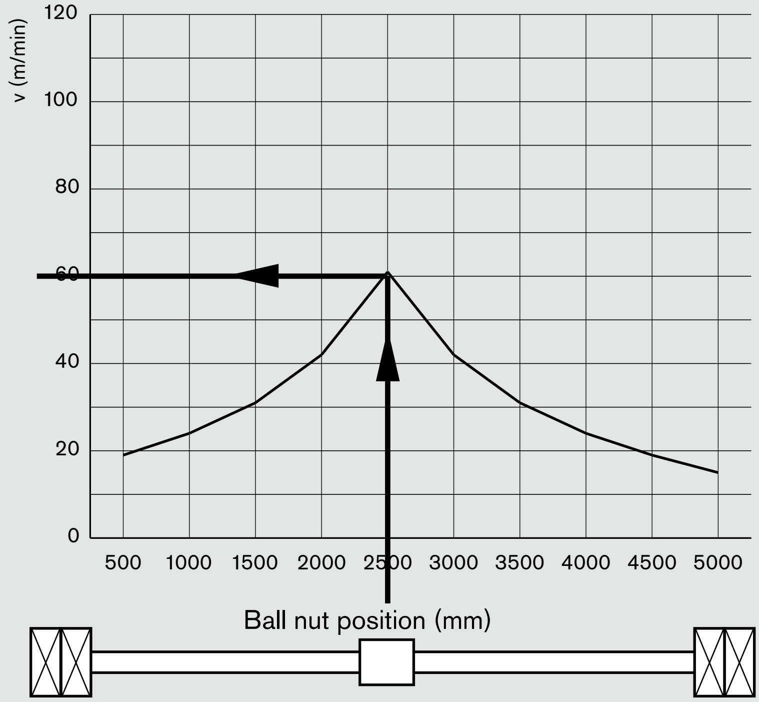
For the driven screw (top chart), the maximum linear speed for a ball nut favorably positioned in the middle of the screw is approx. 60 m/min. However, this speed is only achieved at one point in the stroke. When the nut is positioned anywhere else along the screw, only approx. 20 m/min can be achieved. To achieve a higher speed, the screw would have to be supported. As a result, the high rotary speed (d x n value) of the ball nut cannot be fully exploited in practice.

Driven nut
With a driven nut (bottom chart, fixity I fixed-fixed), on the other hand, the maximum linear speed of the drive unit is 108 m/min and is permissible at any position of the ball nut along the entire stroke.

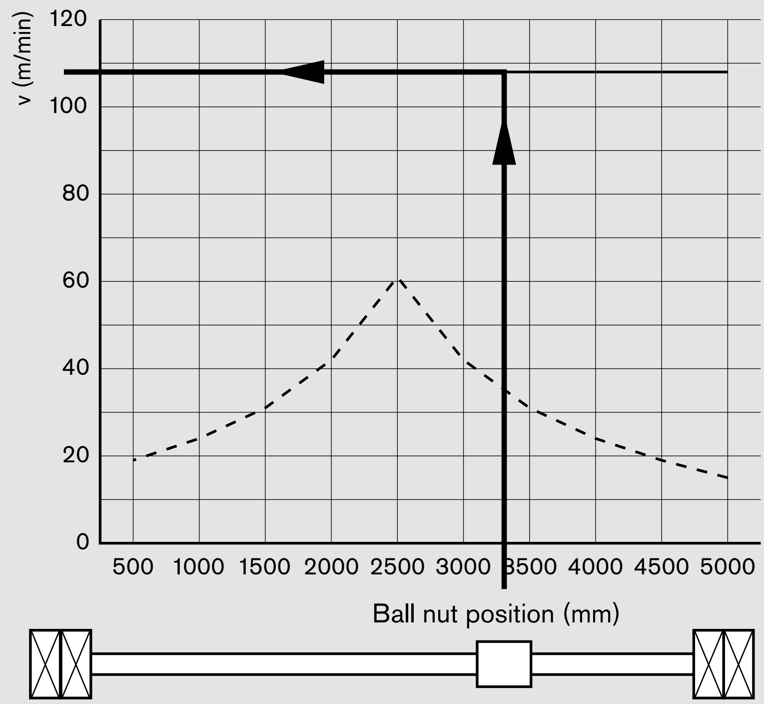
For fixity II fixed-floating, the floating bearing (allowing axial displacement) can be designed so that the deflection line is tangential (deflection angle at the bearing point = 0).

When this is done, a floating bearing can be considered as a fixed bearing in the calculation.

For comparison: Driven screw:
Max. permissible linear speed as a function of ball nut position
Size 50x40Rx6.5 with fixed-fixed fixity and driven screw



Driven nut
Max. permissible linear speed
Size 50x40Rx6.5 with fixed-fixed fixity and driven ball nut



The permissible rotary and linear speeds of the FAR drive units are listed in the following table:
Fixity I fixed-fixed, and
Fixity II fixed-floating

FAR size d_0 x P x D_W - i	Rotary speed n_{Max} (min^{-1})	Linear speed v_{maxFAR} (m/min)
32 x 10R x 3.969 - 5	3000	30
32 x 20R x 3.969 - 3	3000	60
32 x 32R x 3.969 - 3	3000	96
40 x 10R x 6 - 5	2800	28
40 x 20R x 6 - 3	2800	56
40 x 40R x 6 - 3	2800	112
50 x 10R x 6 - 6	2700	27
50 x 20R x 6.5 - 5	2700	54
50 x 40R x 6.5 - 3	2700	108
63 x 10R x 6 - 6	2300	23
63 x 20R x 6.5 - 5	2300	46
63 x 40R x 6.5 - 3	2300	92

Conversion of rotary speed to linear speed

$$v_{max} = \frac{n_{max} \cdot P}{1000}$$

v_{max} = linear speed (m/min)
P = lead (mm)
n_{max} = rotary speed (rpm)

Fixity III floating-floating

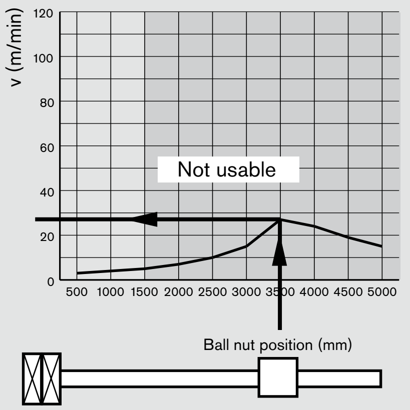
This type of end fixity is practically never used.

Critical speed for a rotating ball nut and screw fixity IV fixed-free
For systems with a driven nut and fixity fixed-free, the screw can only be sized for short strokes in practice. To give an extreme example, in a horizontal set-up the dead weight of a 54x40 screw with a length of 5000 mm would cause an extreme deflection in the static state of approx. 180 mm. Even much smaller deflections and the resulting forces on the ball nut have to be reliably avoided by appropriate design measures.

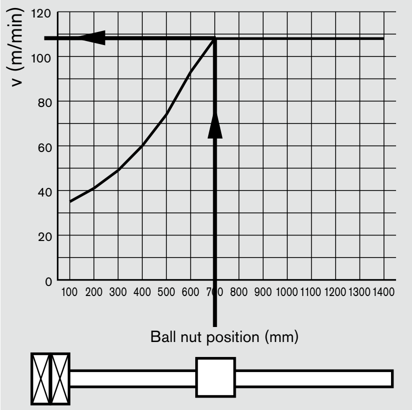
In this case, even in the FAR models the critical speed can be taken as the limit when the ball nut is in an unfavorable position at the end fixity (see chart at right). According to the chart, the maximum theoretical value is 28 m/min, but this cannot be used because of the deflection.

For practical applications, the screw length must therefore be limited.

Driven nut
Max. permissible linear speed
Size 50x40Rx6.5 with fixity fixed-free



Driven nut
Max. permissible linear speed
Size 50x40Rx6.5 with fixity fixed-free



At the recommended maximum screw length $L_{thr\ max}$ the linear speed for a ball nut position of 700 mm is 108 m/min, as can be seen in the example shown in the chart on the far right.

Ball screw size	Recommended maximum length (mm) $L_{thr\ max}$
32	1000
40	1200
50	1400
63	1600

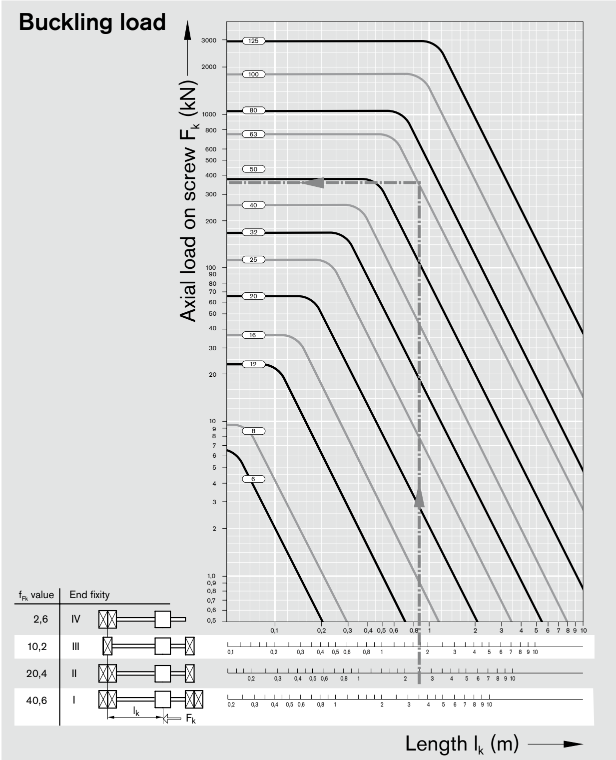
Calculations and Examples

Sizing of the FAR Drive Unit

Permissible torque as a function of ball nut position

With the driven nut, the permissible drive torque is restricted by the following parameters:

- Screw length
- Screw diameter
- End fixity
- Stretching force
- Screw end geometry
- Load direction; in the worst case, an axial load on the longer portion of the screw (buckling)



The screw length, diameter and end fixity are taken into account in the Euler buckling equation. This gives the permissible axial screw load (see chart above). In practice, the formulas shown at right are used.

$$F_k = f_{Fk} \cdot \frac{d_2^4}{l_k^2} \cdot 10^4 \text{ (N)}$$

$$F_{kperm.} = \frac{F_k}{2} \text{ (N)}$$

$$F \leq F_{kperm.}$$

For a stretched screw, the following applies:

$$F_{kperm.} = \frac{F_k}{2} + F_R$$

F_k	=	theoretically permissible axial load on screw	(N)
$F_{kperm.}$	=	permissible axial load on the screw during operation	(N)
f_{Fk}	=	corrector value determined by bearing	
d_2	=	core diameter, see Dimension Tables	(mm)
l_k	=	unsupported threaded length	(mm)
F	=	operating load at customer	(N)
F_R	=	stretching force on screw	(N)

The stretching force may decrease due to a rise in temperature during operation. This effect must be taken into account when calculating $F_{kperm.}$.

The drive torque required for the operating load can be calculated using the following formula:

$$M_{ta} = \frac{F \cdot P}{2000 \cdot \pi \cdot \eta}$$

The dynamic drag torque must be taken into account for preloaded nuts.

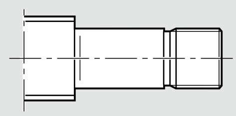
M_{ta}	=	drive torque at the ball nut	(Nm)
F	=	operating load	(N)
P	=	lead	(mm)
η	=	mechanical efficiency (approx. 0.9)	

$$M_{ta} < M_{scr\ perm.}$$

$M_{scr\ perm.}$ = permissible torque at the screw shaft end (Nm)

Recommended maximum torques for screw end geometry 51

51

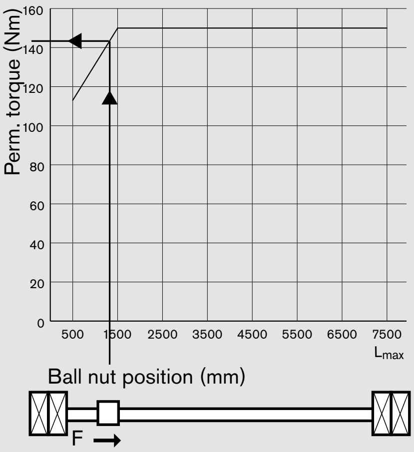


Ball screw size	$M_{scr\ perm.}$ (Nm)
32	< 40
40	< 150
50	< 180
63	< 190

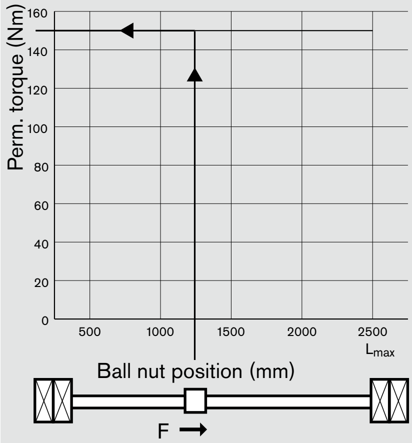
Typical application cases

Fixity I fixed-fixed
Parameters:
- Screw length; two different cases considered
- Screw diameter
- End fixity, in this case fixed-fixed
- Stretching force, not taken into account here (see next page)
- Screw end geometry, Type 51 at both ends
- Load direction; in the worst case, an axial load on the longer portion of the screw (buckling)

Example: With a long screw axis, as in water jet cutting, a high drive torque can be achieved, but this is dependent on the position of the ball nut.



Example: A short screw in a machine tool axis allows a high drive torque irrespective of the ball nut position.



Fixity II fixed-floating

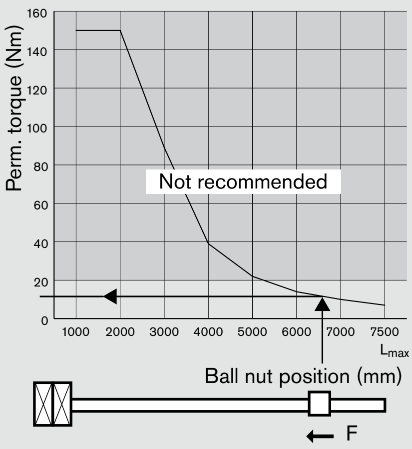
Stretching not possible

Fixity III floating-floating

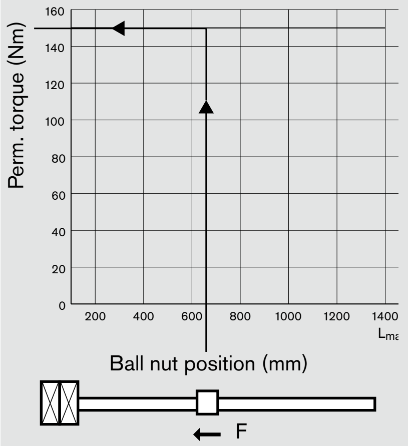
This type of end fixity is practically never used.

Fixity IV fixed-free
Parameters:
- Screw length; two different cases considered
- Screw diameter
- End fixity, in this case fixed-free
- Stretching force, none
- Screw end geometry, Type 51 at one end
- Axial load in the direction of the fixed bearing

A long screw is not advisable in set-ups with fixity fixed-free.



Example: A short screw, as in a press application, allows high torques.



Calculations and Examples

Sizing of the FAR Drive Unit

Stretching of screws

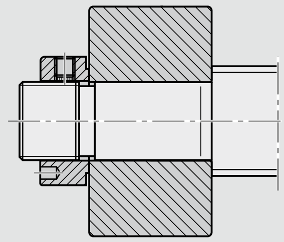
Basic principles

To utilize the full performance capability of a system with a driven nut, the screw should be fixed at both ends (end fixity: fixed-fixed).

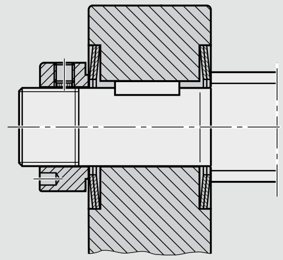
Stretching the screw has the following positive effect on the overall system:
- Compensation of thermal influences to avoid axial loads in the screw, thus reducing the danger of buckling

The change in length and tensioning of the screw resulting from the stretching must be kept within a limit that is acceptable for the overall system. Otherwise, elastic deformation could result in excessive lead deviations between the ball nut and the screw, having a negative effect on the service life.
If the screw is cooled by convection, a temperature difference of max. 10 °C can be compensated for by stretching. For long, composite screws, the temperature difference should not be more than 5 °C. For higher temperature differences, water cooling is necessary.

Fixed clamping



Clamping with leaf spring



Thermal expansion

Calculation of the thermal expansion of a screw as a result of a rise in temperature during operation.

$$\Delta L = L_{thr} \cdot \alpha_L \cdot (\vartheta_{scr} - \vartheta_R)$$

where $\alpha_L = 0{,}0000115$

ΔL	=	thermal expansion	(mm)
L_{thr}	=	thread length	(mm)
α_L	=	coefficient of thermal expansion	(1/K)
ϑ_{scr}	=	screw temperature in operation	(K)
ϑ_R	=	room temperature	(K)

Stretching force

Calculation of the necessary stretching force to counteract thermal expansion.

$$F_R = \frac{\Delta L \cdot E \cdot \frac{\pi}{4} \cdot d_N^2}{L_{thr}}$$

F_R	=	stretching force	(N)
d_N	=	approximate diameter	(mm)

$$d_N = \frac{d_0 + d_2}{2}$$

d_0	=	nominal diameter	(mm)
d_2	=	screw core diameter	(mm)

Compressive stress

The compressive stresses arising in a screw with fixed-fixed end fixity as a result of temperature variations is calculated as shown opposite.

$$\sigma_D = E \cdot (\vartheta_{scr} - \vartheta_R) \cdot \alpha_L$$

where $E = 210{,}000\ N/mm^2$

σ_D	=	compressive stress due to temperature rise	(N/mm^2)
E	=	modulus of elasticity	(N/mm^2)

Tensile stress

For practical applications, the screw must be stretched so that resulting tensile stress is higher than the temperature-induced compressive stress. At the same time, the permissible tensile stress must not be exceeded.

Tensile stress generated in the screw by stretching

$$\sigma_Z = \frac{F_R}{\frac{\pi}{4} \cdot d_N^2}$$

σ_Z = tensile stress (N/mm²)

$$\sigma_Z < \sigma_{perm.}$$

Maximum permissible stress
$\sigma_{perm.}$ = 70 N/mm²

Permissible elongation

Stretching causes the screw to elongate, which changes the screw and thread geometry. The extent of elongation must be checked to avoid any negative effects on the service life of the ball screw.

$$\Delta L_{perm.} = \frac{L_{thr}}{P} \cdot 0.002$$

$$\Delta L \leq \Delta L_{perm.}$$

$\Delta L_{perm.}$ = permissible elongation (mm)
P = lead (mm)
L_{thr} = thread length (mm)

Calculations and Examples

Rough Sizing of the FAR Drive Unit

The following calculation formulas are provided to help users pre-select an appropriate drive motor for the FAR drive unit. Accurate layout information is essential, as the motor choice is dependent on the mounting orientation, the applied loads and the guides used. For precise calculation of the drive motor, see R310EN 2710 and R310D0 2725.

Frictional torque

for motor attachment via timing belt side drive

$$M_R = \frac{M_{RS}}{i_{Rv}} + M_{RRv}$$

$$M_{RS} = M_{RL} + T_{pr0} + T_{RD}$$

i_{Rv} = gear reduction of timing belt side drive
M_R = frictional torque at motor journal (Nm)
M_{RS} = frictional torque of system (Nm)
M_{RRv} = frictional torque of timing belt side drive at motor journal (Nm)
M_{RL} = frictional torque of bearing (Nm)
T_{pr0} = dynamic drag torque of ball screw without seals (Nm)
T_{RD} = dynamic drag torque of the two seals (Nm)

Mass moment of inertia

$$m_{FAR\text{-}B\text{-}R} = m_{FAR} + m_{Rv} + m_M + m_{Br}$$

$$J_s = J_{rotFAR} + (m_{FAR\text{-}B\text{-}R} + m_{fr}) \cdot \left(\frac{P}{20 \cdot \pi}\right)^2 \cdot 10^{-4}$$

$$J_{fr} = \frac{J_s}{i_{Rv}^{\,2}} + J_{Rv} + J_{Br}$$

$$J_{tot} = J_{fr} + J_M$$

$$J_{tot} = \frac{J_S}{i^2_{Rv}} + J_{Rv} + J_{Br} + J_M$$

The ratio of the mass moment of inertia of the payload to the motor mass moment of inertia is therefore as follows:

For handling:

$$6 \cdot J_M \geq J_{fr}$$

For processing:

$$1.5 \cdot J_M \geq J_{fr}$$

i_{Rv} = gear reduction of timing belt side drive
J_{fr} = mass moment of inertia of external load (kgm²)
J_{rotFAR} = rotating mass moment of inertia of FAR (kgm²)
J_{tot} = total mass moment of inertia (kgm²)
J_s = mass moment of inertia of system with external load (kgm²)
J_M = mass moment of inertia of motor (kgm²)
J_{Br} = mass moment of inertia of motor brake (kgm²)
J_{Rv} = reduced mass moment of inertia of timing belt side drive at motor journal (kgm²)
m_{FAR} = mass of FAR (kg)
m_{fr} = mass of external load (kg)
m_{Rv} = mass of timing belt side drive (kg)
m_M = mass of motor (kg)
m_{Br} = mass of brake (kg)
$m_{FAR\text{-}B\text{-}R}$ = mass of drive unit with timing belt side drive and brake (kg)
P = lead (mm)
π = 3.1416

Rotary speed

When attaching a gear motor, the gear mass moment of inertia and the gear ratio must also be included in the calculation.

$$n_1 = \frac{i_{RV} \cdot v \cdot 1000}{P}$$

$$n_1 < n_{Mmax}$$

$$n_2 = \frac{v \cdot 1000}{P} = \frac{n_1}{i}$$

$$n_2 < n_{max}$$

i_{RV}	=	gear reduction of timing belt side drive	
n_1	=	rotary speed (motor)	(min^{-1})
n_{Mmax}	=	maximum usable motor speed	(min^{-1})
n_{max}	=	maximum usable speed of the nut unit	(min^{-1})
n_2	=	rotary speed of ball nut	(min^{-1})
P	=	lead	(mm)
v	=	permissible linear speed	(m/min)

Calculations and Examples

Rough Sizing of the AOK Drive Unit

The following calculation formulas are provided to help users pre-select an appropriate drive motor for the AOK drive unit. Accurate layout information is essential, as the motor choice is dependent on the mounting orientation, the applied loads and the guides used. For precise calculation of the drive motor, see R310EN 2710 and R310D0 2725.

Frictional torque

for motor attachment via motor mount and coupling

$$M_R = M_{RS}$$

for motor attachment via timing belt side drive

$$M_R = \frac{M_{RS}}{i_{Rv}} + M_{RRv}$$

i_{Rv} = gear reduction of timing belt side drive
M_R = frictional torque at motor journal (Nm)
M_{RS} = frictional torque of system (Nm)
M_{RRv} = frictional torque of timing belt side drive at motor journal (Nm)

Mass moment of inertia

for motor attachment via motor mount and coupling

$$J_S = (k_1 + k_2 \cdot L + k_3 \cdot m_{fr}) \cdot 10^{-6}$$

$$J_{fr} = J_S + J_K + J_{Br}$$

$$J_{tot} = J_{fr} + J_M = J_S + J_K + J_{Br} + J_M$$

for motor attachment via timing belt side drive

$$J_S = (k_1 + k_2 \cdot L + k_3 \cdot m_{fr}) \cdot 10^{-6}$$

$$J_{fr} = \frac{J_S}{i_{RV}^2} + J_{Rv} + J_{Fr}$$

$$J_{tot} = J_{fr} + J_M = \frac{J_S}{i_{RV}^2} + J_{RV} + J_{Br} + J_M$$

i_{RV} = gear reduction of timing belt side drive
J_{tot} = total mass moment of inertia (kgm²)
J_{fr} = mass moment of inertia of external load (kgm²)
J_S = mass moment of inertia of system with external load (kgm²)
J_K = mass moment of inertia of coupling (kgm²)
J_{Br} = mass moment of inertia of motor brake (kgm²)
J_M = mass moment of inertia of motor (kgm²)
J_{RV} = reduced mass moment of inertia of timing belt side drive at motor journal (kgm²)
k_1, k_2, k_3 = constants, see table
L = reference length (mm)
m_{fr} = mass of external load (kg)

The ratio of the mass moment of inertia of the payload to the motor mass moment of inertia is therefore as follows:

For handling:

$$6 \cdot J_M \geq J_{fr}$$

For processing:

$$1.5 \cdot J_M \geq J_{fr}$$

Rotary speed

$$n_1 = \frac{i_{RV} \cdot v \cdot 1000}{P}$$

$$n_1 < n_{Mmax}$$

v = permissible linear speed as read off from chart

i_{RV} = gear reduction of timing belt side drive (–)
n_1 = rotary speed (motor) (min⁻¹)
n_{Mmax} = maximum usable motor speed (min⁻¹)
P = screw lead (mm)
v = permissible linear speed (m/min)

Technical data for AOK

Constants for calculation of frictional torques and mass moments of inertia

AOK size	Ball screw size d_0 x P	Constants k_1	k_2	k_3	Frictional torque at motor journal M_R (Nm)
20	20x 5	16.9480	0.1004	0.6330	0.40
	20x20	40.6951	0.1004	10.1320	0.50
	20x40	116.6860	0.1004	40.5285	0.60
32	32x5	131.7373	0.7117	0.6330	0.80
	32x10	138.3865	0.7117	2.5330	0.90
	32x20	164.9833	0.6668	10.1320	0.90
	32x32	220.3047	0.6668	25.9380	1.00
40	40x5	378.5481	1.7830	0.6330	1.20
	40x10	354.1415	1.6070	2.5330	1.50
	40x20	404.2955	1.6070	10.1320	1.30
	40x40	604.9115	1.6070	40.5280	1.60

Technical data for couplings

AOK size	Ball screw size d_0 x P	Motor type	Rated torque M_{KN} (Nm)	Mass moment of inertia J_K (kgm² 10^{-4})	Weight m_K (kg)
20	20x5/20/40	MSM 040B with/without brake	14.5	0.63	0.265
		MSK 040C with/without brake	19.0	0.60	0.260
		MSK 050C with/without brake	50.0	2.00	0.700
32	32x5/10/20/32	MSK 060C with/without brake	50.0	2.00	0.700
		MSK 076C with brake	98.0	3.90	0.900
40	40x5/10/20/40	MSK 076C with brake	98.0	3.90	0.900

Calculations and Examples

Rough Sizing of the AGK Drive Unit

The following calculation formulas are provided to help users pre-select an appropriate drive motor for the AGK drive unit. Accurate layout information is essential, as the motor choice is dependent on the mounting orientation, the applied loads and the guides used. For precise calculation of the drive motor, see R310EN 2710 and R310D0 2725.

Frictional torque

for motor attachment via motor mount and coupling

$$M_R = M_{RS}$$

for motor attachment via timing belt side drive

$$M_R = \frac{M_{RS}}{i_{Rv}} + M_{RRv}$$

i_{Rv} = gear reduction of timing belt side drive
M_R = frictional torque at motor journal (Nm)
M_{RS} = frictional torque of system (Nm)
M_{RRv} = frictional torque of timing belt side drive at motor journal (Nm)

Mass moment of inertia

for motor attachment via motor mount and coupling

$$J_S = (k_1 + k_2 \cdot L + k_3 \cdot m_{fr}) \cdot 10^{-6}$$

$$J_{fr} = J_S + J_K + J_{Br}$$

$$J_{tot} = J_{fr} + J_M = J_S + J_K + J_{Br} + J_M$$

for motor attachment via timing belt side drive

$$J_S = (k_1 + k_2 \cdot L + k_3 \cdot m_{fr}) \cdot 10^{-6}$$

$$J_{fr} = \frac{J_S}{i_{RV}^2} + J_{Rv} + J_{Br}$$

$$J_{tot} = J_{fr} + J_M = \frac{J_S}{i_{RV}^2} + J_{RV} + J_{Br} + J_M$$

i_{RV} = gear reduction of timing belt side drive
J_{tot} = total mass moment of inertia (kgm^2)
J_{fr} = mass moment of inertia of external load (kgm^2)
J_S = mass moment of inertia of system with external load (kgm^2)
J_K = mass moment of inertia of coupling (kgm^2)
J_{Br} = mass moment of inertia of motor brake (kgm^2)
J_M = mass moment of inertia of motor (kgm^2)
J_{RV} = reduced mass moment of inertia of timing belt side drive at motor journal (kgm^2)
k_1, k_2, k_3 = constants, see table
L = reference length (mm)
m_{fr} = mass of external load (kg)

The ratio of the mass moment of inertia of the payload to the motor mass moment of inertia is therefore as follows:

For handling:

$$6 \cdot J_M \geq J_{fr}$$

For processing:

$$1.5 \cdot J_M \geq J_{fr}$$

Rotary speed

$$n_1 = \frac{i_{RV} \cdot v \cdot 1000}{P}$$

$$n_1 < n_{Mmax}$$

v = permissible linear speed as read off from chart

i_{RV} = gear reduction of timing belt side drive (–)
n_1 = rotary speed (motor) (min^{-1})
n_{Mmax} = maximum usable motor speed (min^{-1})
P = screw lead (mm)
v = permissible linear speed (m/min)

Technical data for AGK

Constants for calculation of frictional torques and mass moments of inertia

AGK size	Ball screw size	Constants			Frictional torque at motor journal M_R (Nm)			
	d_0 x P	k_1	k_2	k_3	without SPU	1 pair SPU	2 pairs SPU	3 pairs SPU
20	20x 5	16.9480	0.1004	0.6330	0.40	0.40	0.50	0.50
	20x20	40.6951	0.1004	10.1320	0.50	0.60	0.70	0.80
	20x40	116.6860	0.1004	40.5285	0.60	0.80	1.00	1.20
32	32x5	131.7373	0.7117	0.6330	0.80	0.80	0.90	0.90
	32x10	138.3865	0.7117	2.5330	0.90	1.00	1.00	1.10
	32x20	164.9833	0.6668	10.1320	0.90	1.00	1.10	1.30
	32x32	220.3047	0.6668	25.9380	1.00	1.20	1.40	1.60
40	40x5	378.5481	1.7830	0.6330	1.20	1.20	1.30	1.30
	40x10	354.1415	1.6070	2.5330	1.50	1.60	1.70	1.80
	40x20	404.2955	1.6070	10.1320	1.30	1.50	1.60	1.80
	40x40	604.9115	1.6070	40.5280	1.60	1.90	2.30	2.60

Technical data for couplings

AGK size	Ball screw size d_0 x P	Motor type	Rated torque M_{KN} (Nm)	Mass moment of inertia J_K (kgm² 10^{-4})	Weight m_K (kg)
20	20x5/20/40	MSM 040B with/without brake	14.5	0.63	0.265
		MSK 040C with/without brake	19.0	0.60	0.260
		MSK 050C with/without brake	50.0	2.00	0.700
32	32x5/10/20/32	MSK 060C with/without brake	50.0	2.00	0.700
		MSK 076C with brake	98.0	3.90	0.900
40	40x5/10/20/40	MSK 076C with brake	98.0	3.90	0.900

Calculations and Examples

Calculation Example, FAR Drive Unit

Given data

A drive unit is to be selected and calculated for the table drive of a handling system. The table and the payload weigh 200 kg. The frictional drag of the guides has already been factored into the forces involved.

Operating conditions

The maximum linear speed in rapid approach mode is specified as 108 m/min. The service life of the system should be 40,000 operating hours with the ball screw operating 60% of the time.

The end fixity is specified as fixed-fixed. The loads, rotary speeds and discrete time steps are given in the table at right.

F_1 = 17000 N at n_1 = 20 min^{-1} for q_1 = 10% of the duty cycle
F_2 = 7000 N at n_2 = 100 min^{-1} for q_2 = 22% of the duty cycle
F_3 = 3000 N at n_3 = 500 min^{-1} for q_3 = 47% of the duty cycle
F_4 = 2000 N at n_4 = 2700 min^{-1} for q_4 = 21% of the duty cycle
100%

Length calculation

Example of a stroke and length calculation for FAR 40x40:

The required stroke is L_{Hmax} = 2500 mm.
The length L_C of the customer-built attachment (= interference contour) is 403 mm.
Because of the installation conditions, the thread length is specified as 3063 mm.

$$L_{thr} = L_{Hmax} + L_C + L_N$$
$$L_{thr} = 2500\ \text{mm} + 403\ \text{mm} + 160\ \text{mm}$$
$$L_{thr} = 3063\ \text{mm}$$

Checking the linear speed

The rapid approach speed of 108 m/min can be attained by the drive unit FAR 40x40Rx6-3. The maximum permissible linear speed of 112 m/mm will not be exceeded (see table on page 83).
Since the end fixity is fixed-fixed, no further limitation of the linear speed is necessary. The chosen drive unit meets the requirements and the calculation can be continued.

Service life calculation

Average rotary speed n_m

$$n_m = \frac{10}{100}\cdot 20 + \frac{22}{100}\cdot 100 + \frac{47}{100}\cdot 500 + \frac{21}{100}\cdot 2700$$
$$n_m = 826\ \text{min}^{-1}$$

Average load F_m for variable load and variable speed

$$F_m = \sqrt[3]{17000^3\cdot\frac{20}{824}\cdot\frac{10}{100} + 7000^3\cdot\frac{100}{824}\cdot\frac{22}{100} + 3000^3\cdot\frac{500}{824}\cdot\frac{47}{100} + 2000^3\cdot\frac{2700}{824}\cdot\frac{21}{100}}$$
$$F_m = 3246\ \text{N}$$

Required service life L (revolutions)
The life L can be calculated by transposing the formulas:

$$L = L_h \cdot n_m \cdot 60$$
$$L_h = \text{Machine operating hours} \cdot \frac{\text{Screw duty cycle}}{\text{Machine duty cycle}}$$
$$L_h = 40000 \cdot \frac{60}{100} = 24000\ \text{hours}$$
$$L = 24000 \cdot 826 \cdot 60 \qquad L = 1189 \cdot 10^6\ \text{revolutions}$$

Required basic dynamic load rating C_{req}

$$C_{req} = 3246 \cdot \sqrt[3]{\frac{1189000000}{10^6}} \qquad C_{req} \approx 34388\ \text{N}$$

Result and selection

At 34,388 N, the calculated required load rating of the drive unit is smaller than the given load rating C = 37,000 N for the size 40x40. The dimensioning of the drive unit therefore meets the service life requirement.

Cross check
Service life of the selected ball screw in revolutions

$$L = \left(\frac{37000}{3246}\right)^3 \cdot 10^6$$

$$L \approx 1481 \cdot 10^6 \text{ revolutions}$$

Service life in hours L_h
The life of the selected ball screw is thus greater than the required service life of 24,000 hours (including the duty cycle).

$$L_h = \frac{1481 \cdot 10^6}{826 \cdot 60}$$

$$L_h \approx 29883 \text{ hours}$$

Cross check of maximum permissible load

$$F_k = f_{Fk} \cdot \frac{d_2^4}{l_k^2} \cdot 10^4 = 40.6 \cdot \frac{33.8^4}{3063^2} \cdot 10^4 = 56481 \text{ N}$$

$$F_{kperm.} = \frac{F_k}{2} = \frac{56481}{2} = 28241 \text{ N}$$

$$F_{max} = 17000 \text{ N}$$

$$F_{max} \leq F_{kperm.} \checkmark$$

For a stretched screw, the following applies:

$$F_{kperm.} = \frac{F_k}{2} + F_R$$

Frictional torque for motor attachment via timing belt side drive
Calculation of the required drive torque under maximum axial load.

Comparison of the calculated drive torque with the permissible torque of the screw shaft end:

Recommended maximum torques for the geometry of screw end 51

$$M_R = \frac{M_{RS}}{i_{RV}} + M_{RRV}$$

$$M_{RS} = M_{RL} + T_{pr0} + T_{RD}$$

$$M_R = \frac{M_{RL} + T_{pr0} + T_{RD}}{i_{RV}} + M_{RRV}$$

$$= \frac{1.2 + 0.3 + 0.4}{1} + 0.6$$

$$= 2.5 \text{ Nm}$$

$$M_{ta} = \frac{F \cdot P}{2000 \cdot \pi \cdot \eta} + M_R$$

$$= \frac{17000 \cdot 40}{2000 \cdot \pi \cdot 0.9} + 2.5$$

$$= 122.7 \text{ Nm}$$

$$M_{ta} < M_{scr\ perm.} = 150 \text{ Nm} \checkmark$$

M_R	= frictional torque at motor journal	(Nm)
M_{RS}	= frictional torque of system	(Nm)
M_{RRV}	= frictional torque of timing belt side drive	(Nm)
i_{RV}	= gear reduction of timing belt side drive	(Nm)
M_{RL}	= frictional torque of bearing	(Nm)
T_{pr0}	= dynamic drag torque of ball screw without seals	(Nm)
T_{RD}	= dynamic drag torque of the two seals	(Nm)
M_{ta}	= drive torque (from axial screw)	(Nm)
η	= mechanical efficiency (approx. 0.9)	

Calculations and Examples

Calculation Example, FAR Drive Unit

Mass moment of inertia for motor attachment via timing belt side drive

$$m_{FAR\text{-}B\text{-}R} = m_{FAR} + m_{RV} + m_M + m_{Br} = 8.4 + 8.7 + 14 + 1.1 = 32.2 \text{ kg}$$

$m_{FAR\text{-}B\text{-}R}$ = mass of system (kg)
m_{FAR} = mass of FAR (kg)
m_{RV} = mass of timing belt side drive (kg)
m_M = mass of motor (kg)
m_{Br} = mass of motor brake (kg)

$$J_s = J_{rotFAR} + (m_{FAR\text{-}B\text{-}R} + m_{fr}) \cdot \left(\frac{P}{20 \cdot \pi}\right)^2 \cdot 10^{-4}$$
$$= 50.7 \cdot 10^{-4} + (32.2 + 200) \cdot \left(\frac{40}{20 \cdot \pi}\right)^2 \cdot 10^{-4}$$
$$= 144.8 \cdot 10^{-4} \text{ kgm}^2$$

J_S = mass moment of inertia of system with external load (kgm^2)
J_{rotFAR} = rotating mass moment of inertia of FAR (kgm^2)
m_{fr} = mass of external load (kg)

$$J_{fr} = \frac{J_S}{i_{RV}^2} + J_{RV} + J_{Br} = \frac{144.8}{1^2} + 84 + 3.6 = 232.4 \cdot 10^{-4} \text{ kgm}^2$$

$$J_{tot} = J_{fr} + J_M = 232.4 + 43 = 275.4 \cdot 10^{-4} \text{ kgm}^2$$

J_{fr} = mass moment of inertia of external load (kgm^2)
J_{RV} = reduced mass moment of inertia of timing belt side drive at motor journal (kgm^2)
J_{Br} = mass moment of inertia of motor brake (kgm^2)
J_{tot} = mass moment of inertia of the system (kgm^2)
J_M = mass moment of inertia of motor (kgm^2)

$$6 \cdot J_M \geq J_{fr}$$
$$6 \cdot 43 \cdot 10^{-4} \geq 232.4 \cdot 10^{-4}$$
$$258 \cdot 10^{-4} \geq 232.4 \cdot 10^{-4} \ \checkmark$$

Rotary speed

$$n_1 = \frac{i_{RV} \cdot v \cdot 1000}{P} = \frac{1 \cdot 108 \cdot 1000}{40} = 2700 \frac{1}{min}$$
$$n_1 < n_{Mmax}$$
$$2700 \frac{1}{min} < 5000 \frac{1}{min} \ \checkmark$$

i_{RV} = gear reduction of timing belt side drive (–)
n_1 = rotary speed (motor) (min^{-1})
n_{Mmax} = maximum usable motor speed (min^{-1})
P = screw lead (mm)
v = permissible linear speed (m/min)

$$n_2 = \frac{v \cdot 1000}{P} = \frac{n_1}{i_{RV}} = \frac{108 \cdot 1000}{40} = 2700 \frac{1}{min}$$
$$n_2 < n_{max}$$
$$2700 \frac{1}{min} < 2800 \frac{1}{min} \ \checkmark$$

n_2 = rotary speed (ball nut) (min^{-1})
n_{max} = maximum usable speed of the nut unit (min^{-1})

Calculation Example, AGK Drive Unit **(and similarly for AOK)**

Given data

The application example is a handling axis. The table mass is 100 kg. The frictional drag of the guides has already been factored into the forces involved. The rapid approach speed is v = 60 m/min.

Operating conditions

The service life of the system should be 40,000 operating hours with the ball screw operating 50% of the time.

F_1 =	2000 N	at n_1 =	200 min^{-1}	for q_1 =	15%	of the duty cycle
F_2 =	2000 N	at n_2 =	500 min^{-1}	for q_2 =	30%	of the duty cycle
F_3 =	1800 N	at n_3 =	1500 min^{-1}	for q_3 =	30%	of the duty cycle
F_4 =	800 N	at n_4 =	3000 min^{-1}	for q_4 =	25%	of the duty cycle
					100%	

Length calculation

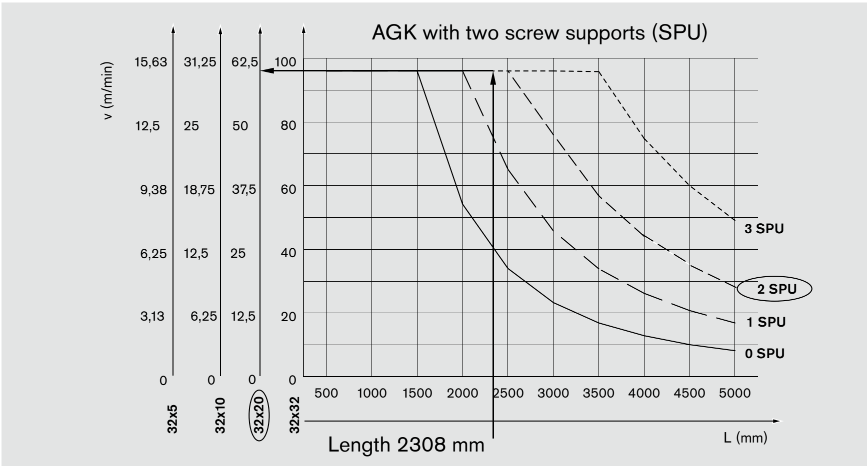
Example of a stroke and length calculation for AGK 32x20 with two screw supports:

The required stroke is 1650 mm. By using 2 screw supports, the maximum linear speed can be achieved over the entire stroke (see relevant charts).

$$L = L_{Hmax} + L_C + L_N$$
$$L = 1650\ mm + 204\ mm + 454\ mm$$
$$L = 2308\ mm$$
$$L_{AGK} = L + L_2 + B_1 + B_{11}$$
$$L_{AGK} = 2308\ mm + 58\ mm + 60\ mm + 70\ mm$$
$$L_{AGK} = 2496\ mm$$

Checking the linear speed

The desired speed of 60 m/min is equal to the permissible speed of 60 m/min:



For comparison: Without screw supports, the maximum linear speed would be limited to 25 m/min.

Service life calculation

Average rotary speed n_m

$$n_m = \frac{15}{100} \cdot 200 + \frac{30}{100} \cdot 500 + \frac{30}{100} \cdot 1500 + \frac{25}{100} \cdot 3000 \qquad n_m = 1380\ min^{-1}$$

Average load F_m for variable load and variable speed

$$F_m = \sqrt[3]{2000^3 \cdot \frac{200}{1380} \cdot \frac{15}{100} + 2000^3 \cdot \frac{500}{1380} \cdot \frac{30}{100} + 1800^3 \cdot \frac{1500}{1380} \cdot \frac{30}{100} + 800^3 \cdot \frac{3000}{1380} \cdot \frac{25}{100}}$$

$$F_m = 1477\ N$$

Required service life L
(revolutions)
The life L can be calculated by transposing the formulas:

$$L = L_h \cdot n_m \cdot 60$$
$$L_h = \text{Machine operating hours} \cdot \frac{\text{Screw duty cycle}}{\text{Machine duty cycle}}$$
$$L_h = 40000 \cdot \frac{50}{100} = 20000\ h$$
$$L = 20000 \cdot 1380 \cdot 60 = 1656 \cdot 10^6 \text{ revolutions}$$

Required basic dynamic load rating C_{req}

$$C_{req} = 1477 \cdot \sqrt[3]{\frac{1656000000}{10^6}} \qquad C_{req} \approx 17474\ N$$

Calculations and Examples

Calculation Example, AGK Drive Unit

Result and selection

At 17,474 N, the calculated required load rating of the drive unit is smaller than the given load rating C = 19,700 N for the size 32x20. The dimensioning of the drive unit therefore meets the service life requirement.

Cross check
Service life of the selected ball screw in revolutions

$$L = \left(\frac{19700}{1477}\right)^3 \cdot 10^6 \qquad L \approx 2373 \cdot 10^6 \text{ revolutions}$$

Service life in hours L_h
The life of the selected ball screw is thus greater than the required service life of 20,000 hours (including the duty cycle).

$$L_h = \frac{2373 \cdot 10^6}{1380 \cdot 60}$$

$$L_h \approx 28659 \text{ hours}$$

Checking the drive torque
Calculation of the required drive torque under maximum axial load. Two pairs of SPUs were used.

$$M_R = M_{RS}$$

$$M_R = 1.1 \text{ Nm}$$

$$M_{ta} = \frac{F \cdot P}{2000 \cdot \pi \cdot \eta} + M_R$$

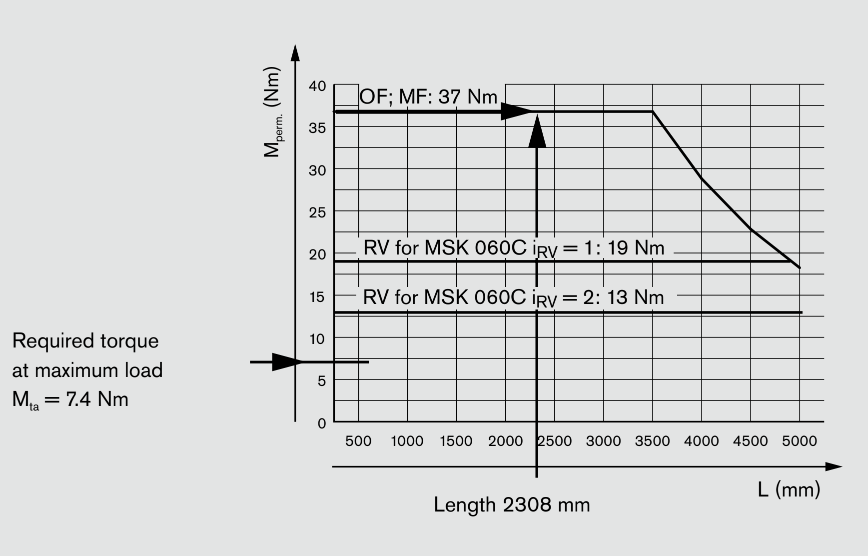
$$= \frac{2100 \cdot 20}{2000 \cdot \pi \; 0.9} + 1.1$$

$$= 8.5 \text{ Nm}$$

M_R = frictional torque with 2 pairs SPU (Nm)
M_{RS} = frictional torque of system (Nm)
P = lead (mm)
η = mechanical efficiency (approx. 0.9)

The required torque lies below the permissible drive torque according to the chart.

Permissible torque



Even at maximum loading, the required torque is well below the permissible value.

Rough sizing of the drive unit

A motor MSK 060C with brake is specified for the drive. Motor attachment is via motor mount and coupling.

$$J_S = (k_1 + k_2 \cdot L + k_3 \cdot m_{fr}) \cdot 10^{-6}$$
$$= (164.9833 + 0.6668 \cdot 2308 + 10.1320 \cdot 100) \cdot 10^{-6}$$
$$= 2717 \cdot 10^{-6}\ kgm^2$$

$$J_{fr} = J_s + J_k + J_{Br}$$
$$= 2717 \cdot 10^{-6} + 2 \cdot 10^{-4} + 0.59 \cdot 10^{-4}$$
$$= 2976 \cdot 10^{-6}\ kgm^2$$

$$J_{tot} = J_{fr} + J_M$$
$$= 2976 \cdot 10^{-6} + 8.0 \cdot 10^{-4}$$
$$= 3776 \cdot 10^{-6}\ kgm^2$$

$$6 \cdot J_M \geq J_{fr}$$
$$6 \cdot 8 \cdot 10^{-4} \geq 2976 \cdot 10^{-6}$$
$$4800 \cdot 10^{-6} \geq 2976 \cdot 10^{-6} \checkmark$$

Rotary speed

$$n_1 = \frac{i_{RV} \cdot v \cdot 1000}{P}$$
$$= \frac{1 \cdot 60 \cdot 1000}{20}$$
$$= 3000 \frac{1}{min}$$
$$n_1 < n_{Mmax}$$
$$3000 \frac{1}{min} < 6000 \frac{1}{min} \checkmark$$

i_{RV} = gear reduction of timing belt side drive (–)
n_1 = rotary speed (motor) (min^{-1})
$n_{m\ max}$ = maximum usable motor speed (min^{-1})
P = screw lead (mm)
v = permissible linear speed (m/min)

Design Calculation Service Form

Bosch Rexroth AG
Linear Motion and Assembly Technologies
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97424 Schweinfurt, Germany
Fax +49 9721 937-288

Sender

Customers can also perform the technical calculations themselves using our WINKGT software.

Application: **New design** ☐ **Redesign** ☐

Operating conditions

Loads (N)	**Rotary speeds (min-1)**	**Discrete time steps (%)**
F_1 = ______	at n_1 = ______	for q_1 = ______
F_2 = ______	at n_2 = ______	for q_2 = ______
F_3 = ______	at n_3 = ______	for q_3 = ______
F_4 = ______	at n_4 = ______	for q_4 = ______
F_5 = ______	at n_5 = ______	for q_5 = ______
F_6 = ______	at n_6 = ______	for q_6 = ______
Average load	**Average rotary speed**	**Sum of discrete time steps**
F_m = ______	n_m = ______	Q = 100%

Maximum static load: ______ N

Required service life: ______ operating hours or ______ x 10^6 revolutions of ball screw

Orientation of screw

horizontal ☐ vertical ☐

FAR ☐

AOK ☐

AGK ☐

Application details:

Layout: Please attach all available drawings/sketches!

Drawing enclosed ☐

Lubrication method: ______

Operating temperature: ______ °C – min/max. ______/______ °C

Exceptional operating conditions: ______

From

OEM ☐ User ☐ Distributor ☐

Company: ______

Address: ______

______

Name: ______
Department: ______
Telephone: ______
Telefax: ______
e-mail: ______

Inquiry and Order Forms

Inquiry and Order Form, FAR

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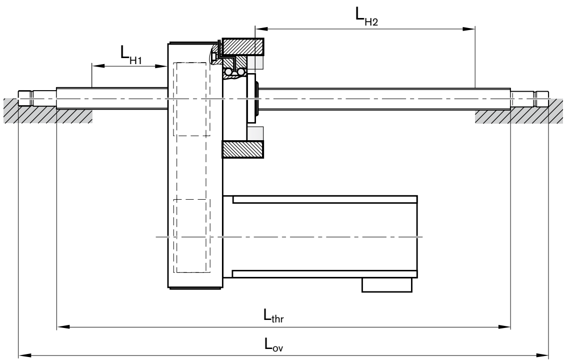
For explanations of the ordering parameters, see page 18/19, "Configuration and Ordering Data."

Order example: Drive unit FAR 40

Ordering data		Explanation
Size	= FAR 40	
Ball screw	= 40x20	d_0 x P
Length	= L_{ov} = 560 mm	Only one length specification necessary
Ball nut sealing type	= 01	Standard seal
Preload	= 02	5%
Screw tolerance grade	= T5	
Screw end, left	= S	Hex socket
Screw end, right	= S	Hex socket
Lubrication	= 01	Basic lubrication and anti-corrosion oil
Motor attachment	= RV	With timing belt side drive
Attachment kit	= 011	For i = 1.25
Motor	= 093	MSK 076C with brake
Documentation	= 001	Lead report (incl. standard test report)

Length specification options – Only one length specification necessary



To be completed by customer: Inquiry ☐ / Order ☐

FAR drive unit

Size = ________
Ball screw = ________
Length = ________
Ball nut sealing type = ________
Preload = ________
Screw tolerance grade = ________
Screw end, left = ________
Screw end, right = ________
Lubrication = ________
Motor attachment = ________
Attachment kit = ________
Motor = ________
Documentation = ________

Quantity Order of: ________ pcs, ________ per month, ________ per year, per order, or ________

Comments:

From

Company: ________ Name: ________
Address: ________ Department: ________
________ Telephone: ________
________ Telefax: ________

Inquiry and Order Form, AOK

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Linear Motion and Assembly Technologies
Ernst-Sachs-Straße 100
97424 Schweinfurt, Germany

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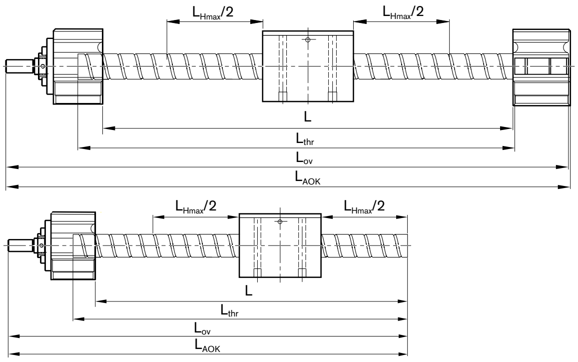
Sender

For explanations of the ordering parameters, see page 42/43, “Configuration and Ordering Data.”

Order example: Drive unit AOK 20

Ordering data		Explanation
Size	= AOK 20	
Ball screw	= 20x20	d_0 x P
Length	= L = 350 mm	Only one length specification necessary
Ball nut sealing type	= 01	Standard seal
Preload	= 01	Reduced backlash
Screw tolerance grade	= T7	
Screw end type, right-hand side	= 31	Fixed-floating end fixity
Lubrication	= 01	Basic lubrication and anti-corrosion oil
Motor attachment	= MF01	With motor mount
Attachment kit	= 006	For motor MSM 040B w/o brake
Motor	= 074	MSM 040B w/o brake
Documentation	= 001	Lead test report

Length specification options – Only one length specification necessary



To be completed by customer: Inquiry ☐ / Order ☐

AOK drive unit

Size = __________
Ball screw = __________
Length = __________
Ball nut sealing type = __________
Preload = __________
Screw tolerance grade = __________
Screw end type, right-hand side = __________
Lubrication = __________
Motor attachment = __________
Attachment kit = __________
Motor = __________
Documentation = __________

Quantity Order of: __________ pcs, _________ per month, __________ per year, per order, or ______________
Comments:

From
Company: ______________________ Name: ______________________
Address: ______________________ Department: ______________________
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Inquiry and Order Form, AGK

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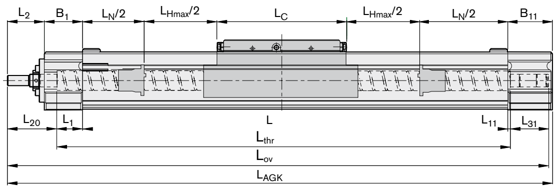
For explanations of the ordering parameters, see page 66/67, "Configuration and Ordering Data."

Order example: Drive unit AGK 20

Ordering data		Explanation
Size	= AGK 20	
Ball screw	= 20x20	d_0 x P
Length	= L = 1350 mm	Only one length specification necessary
Ball nut sealing type	= 01	Standard seal
Preload	= 01	Reduced backlash
Screw tolerance grade	= T7	
Lubrication	= 01	Basic lubrication and anti-corrosion oil
Ball nut enclosure	= MA02	
Sealing strip	= 01	Steel
Screw support	= 02	2 pairs SPU
Motor attachment	= MF01	With motor mount
Attachment kit	= 006	For motor MSM 040B with brake
Motor	= 075	MSM 040B with brake
Documentation	= 002	Torque test report (incl. standard test report)

Length specification options – Only one length specification necessary



To be completed by customer: Inquiry ☐ / Order ☐

AGK drive unit

Size = __________
Ball screw = __________
Length = __________
Ball nut sealing type = __________
Preload = __________
Screw tolerance grade = __________
Lubrication = __________
Ball nut enclosure = __________
Sealing strip = __________
Screw support = __________
Motor attachment = __________
Attachment kit = __________
Motor = __________
Documentation = __________

Quantity Order of: __________ pcs, _________ per month, __________ per year, per order, or ______________
Comments:

From
Company: ____________________ Name: ____________________
Address: ____________________ Department: ____________________
____________________ Telephone: ____________________
____________________ Telefax: ____________________

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