Precision Rolled Ball Screw Drives

SCHAEFFLER GROUP
INDUSTRIAL

Contents

Precision Rolled Ball Screw Drives

Product Description

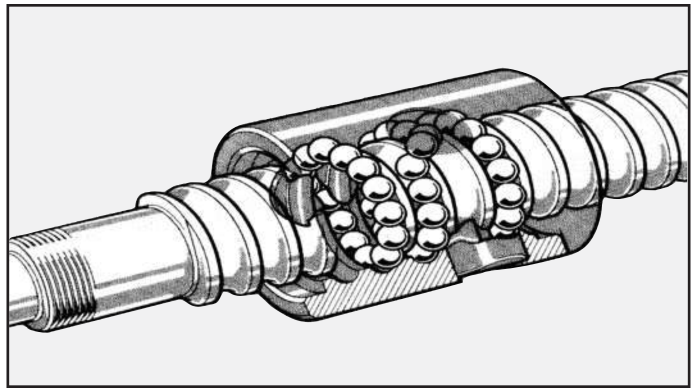


Figure 1 • Ball Return Systems, Guide Pieces

Ball Screw Assembly KGT
A precision rolled ball screw assembly KGT consists of at least one KGF or KGM nut on a screw shaft KGS.

The thread design is a right hand, gothic arch profile. KGT Ball screw assemblies are available in various metric diameter-lead combinations.

Ball Screw Shaft KGS
Series KGS precision rolled metric ball screw shafts are manufactured from high strength steel, Cf53 (SAE 1055). The thread surface is induction hardened to 60 HRC (1.5 mm case depth), min.

Lead accuracies of 23µm/300mm and 50µm/300mm are offered.

Single and multi-start thread designs are used. The number of starts is determined by the diameter-lead combination, and is listed in the dimensional chart for each size.

Standard machined end configurations are offered. Screws can also be machined to customer specifications (drawing required).

Operating Limits
The maximum rotational speed for INA ball screw drives is 4500 rpm. Application specific parameters, such as critical speed may further reduce the speed limit; verification is required.

The permissible operating temperature range is from -30° to +80° C, and up to 110° C for short periods. This assumes proper lubricat-on.

Table 1 • INA Ball Screw Drive Assemblies

Series	Description
KGT..F	Ball screw assembly, KGS screw with single flanged nut KGF
KGT..M	Ball screw assembly, KGS screw with single cylindrical nut KGM
KGT..FM	Ball screw assembly, KGS screw with double preloaded nut unit (1 KGF, 1 KGM)
KGT..MM	Ball screw assembly, KGS screw with double preloaded nut unit (2 KGM)

Table 2 • INA Ball Screw Drive Components

Series	Description
KGS	Ball Screw Shaft
KGF	Flanged Ball Nut
KGM	Cylindrical Ball Nut

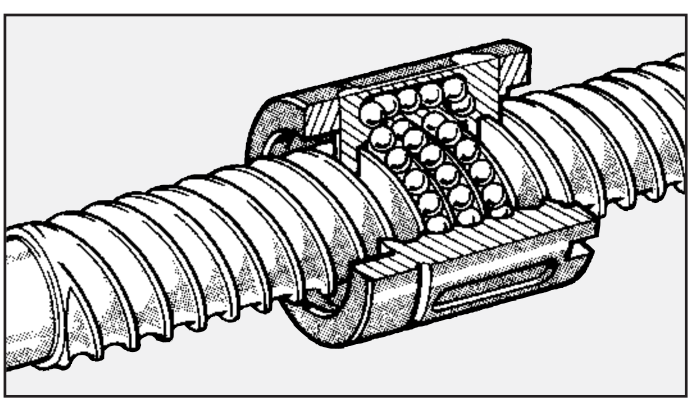


Figure 2 • Ball Return Systems, Return Duct

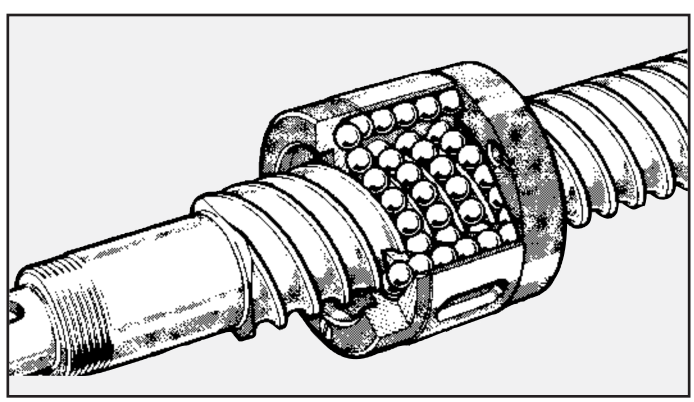


Figure 3 • Ball Return Systems, Multi-Turn Return Duct

Ball Nuts

Flanged Ball Nut KGF
Cylindrical Ball Nut KGM
Series KGF and KGM ball nuts are manufactured from high quality bearing steel, 100Cr6 (SAE 52100). After hardening, the locating surfaces and raceways are precision ground in a single setting to assure accuracy.

INA ball nuts use internal ball return systems. The result is an easy to install compact design.

KGF and KGM ball nuts are offered with Nitrile contact seals on each end face (Suffix EE). The end seals prevent the ingress of contamination and escape of lubrication from the nut.

Preloaded Ball Nuts
Due to low friction and high accuracy, INA ball nuts can be preloaded or assembled to reduce backlash. Two methods are employed to reduce backlash or establish preload:

The most cost-effective method is to reduce or eliminate clearance in the ballnut by ball size selection. This method may result in increased friction in the unloaded state due to four-point ball contact. However, as soon as axial load is applied, normal two-point contact conditions are established and the ballnut operates efficiently, without backlash upon load reversal. The standard preload for this method is 2% of the dynamic load rating [C].

For applications demanding optimum stiffness, INA ball nuts can also be combined to create a preloaded double-nut assembly. The preload is achieved by tensioning the two nuts against each other in conjunction with a ground spacer ring. The total nut length can be enlarged up to 10mm as a consequence of the applied pretensioning ring.

The standard preload for a double-nut assembly is 10% of the dynamic load rating [C]. Other preload values, ranging from 0% to 30% C can be provided upon request.

NOTE: Double-nut preloading is only possible with 5mm and 10mm leads. Leads of 20mm, 25mm, 40mm and 50mm can only be set to low backlash or preloaded by ball selection. Please consult INA Engineering to determine the correct preload for your application.

Preload Variants

KGT-MM
A preloaded nut unit per variation MM consists of two KGM cylindrical nuts and a pretensioning ring.

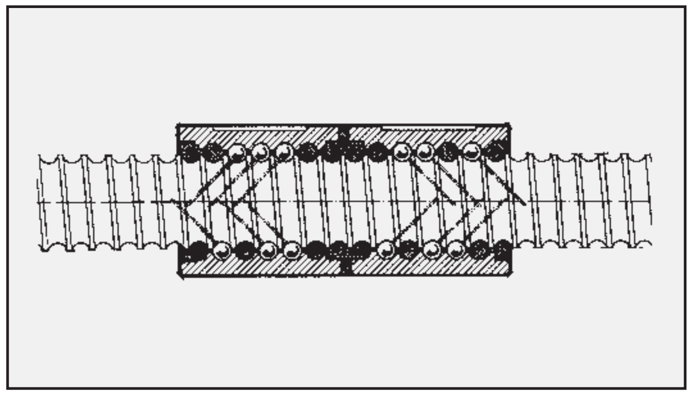


Figure 4

KGT-FM
A preloaded nut unit per variation FM consists of one KGF flanged nut, one KGM cylindrical nut and a pretensioning ring.

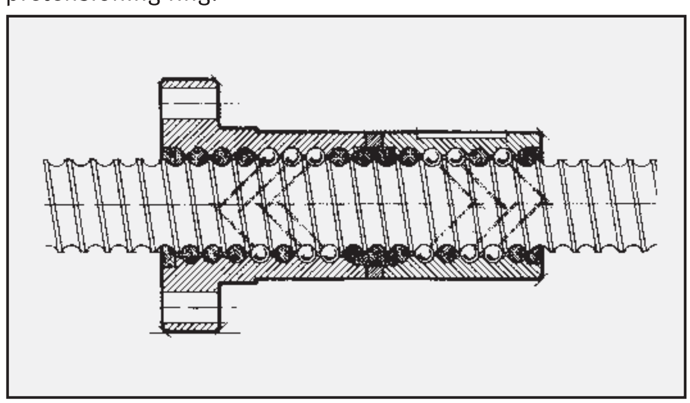


Figure 5

Load Rating And Life

Dynamic Load Rating, C
The dynamic load Rating, C, is the axial load under which 90% of a significantly large group of apparently identical ball screws will reach or exceed 1,000,000 revolutions before the first evidence of material fatigue occurs.

Static Load Rating, Co
The static load rating, Co, is the axial load under which permanent deformation of the raceways or balls occurs in the magnitude of 1/10,000 of the original ball diameter.

Basic Life Rating
The basic life rating can be calculated by using the following equations:

$$L_{10} = \left(\frac{C}{P}\right)^3 \bullet 10^6 \qquad (1)$$

$$L_h = \frac{16,666}{n} \bullet \left(\frac{C}{P}\right)^3 \qquad (2)$$

L10 revolutions
Basic life rating in revolutions

Lh hours
Basic life rating in operating hours

C N
Dynamic load rating

P N
Equivalent axial load

n rpm
Equivalent speed

Equivalent load and equivalent speed
If ball screws are subject to alternating loads and/or alternating speeds, equivalent values must be calculated for use in the basic life calculation.

The equations for equivalent load and equivalent speed are as follows:

$$P_a = \sqrt[3]{\frac{q_1 \bullet n_1 \bullet F_1^3 + q_2 \bullet n_2 \bullet F_2^3 + \ldots + q_z \bullet n_z \bullet F_z^3}{q_1 \bullet n_1 + q_2 \bullet n_2 + \ldots + q_z \bullet n_z}} \qquad (3)$$

$$n = \frac{q_1 \bullet n_1 + q_2 \bullet n_2 + \ldots + q_z \bullet n_z}{100} \qquad (4)$$

P N
Equivalent axial load

$F_{1...z}$ N
Constant operating load within a time interval

$n_{1...z}$ rpm
Constant speed within a time interval

$q_{1...z}$ %
Duration of time interval

N rpm
Equivalent speed

Critical Speed
And Buckling Load

Critical Speed

The critical speed of a shaft is the rotational speed at which the shaft becomes dynamically unstable due to resonance of the rotational imbalances with the natural frequency of the shaft. At the critical speed, the shaft can vibrate and deflect in large magnitudes which could result in damage to the shaft and to the machine of which it is part.

It is recommended that the maximum rotational speed of a ball screw be limited to 80% of the critical speed. The equations to calculate critical speed and maximum speed of INA ball screws are as follows:

$$n_{crit} = \frac{k_n \bullet d_2}{L^2} \bullet 10^7 \qquad (5)$$

$$n_{max} = 0.8 \bullet n_{crit} \qquad (6)$$

n_{crit} rpm
Critical speed of screw shaft

k_n mm/min⁻¹
Factor from Table 1 for the type of support bearing arrangement

d_2 mm
Root diameter of screw shaft listed in dimension table

L mm
Unsupported shaft length according to Table 1

n_{max} rpm
Maximum permissible shaft speed

Buckling Load

A shaft under compressive axial load is subject to potential buckling. It is recommended that the maximum axial load on the ball screw be limited to 50% of the buckling load. Limits due to static and dynamic load ratings must be observed as well.

The equations to calculate buckling load and permissible axial load of INA ball screws are as follows:

$$F_{buckling} = \frac{k_k \bullet d_2^{\,4}}{L^2} \bullet 10^4 \qquad (7)$$

$$F_{perm} = 0.5 \bullet F_{buckling} \qquad (8)$$

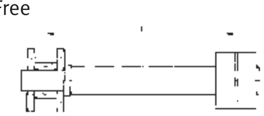
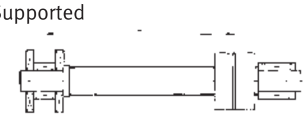
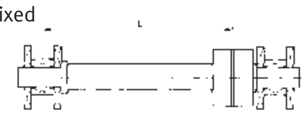
$F_{buckling}$ N
Buckling load of screw shaft

k_k N/mm²
Factor from Table 1 for the type of support bearing arrangement

d_r mm
Root diameter of screw shaft listed in dimension table

L mm
Unsupported shaft length according to Table 1

Table 3 • Coefficients kn and kk

Of Support Bearing Arrangement	Critical Speed Factor k_n	Buckling Load Factor k_k
Fixed-Free 	3.5	0.84
Fixed-Supported 	15.3	7
Fixed-Fixed 	22.3	13.7

Ordering Designations

BALL NUTS

KGF N 20 05 - EE

SERIES
- KGF Flanged Ball Nut
- KGM Cylindrical Ball Nut

DESIGN
- D Per DIN 69051
- N Per INA Standard

NOMINAL PITCH DIA.
In Millimeters

LEAD
In Millimeters

SEALS
- Blank Without End Seals
- EE With End Seals

BALL SCREW SHAFT

KGS 20 05 - 050 - DW / 1250

SERIES
- KGS Ball Screw Shaft

NOMINAL PITCH DIA.
In Millimeters

LEAD
In Millimeters

LEAD ACCURACY
- 023 23 Micron/300 mm
- 050 50 Micron/300mm

END MACHINING OPTIONS
- Blank Form Z & Form Z
- DW Form D & Form W
- DN Form D & Form N
- DZ Form D & Form Z
- CS per customer specification

OVERALL SHAFT LENGTH
In Millimeters

BALL SCREW ASSEMBLY

KGT N 20 05 - 050 FM EE - DW / 1250

SERIES
- KGT Ball Screw Assembly

NUT DESIGN
- D Per DIN 69051
- N Per INA Standard

NOMINAL PITCH DIA.
In Millimeters

LEAD In Millimeters

LEAD ACCURACY
- 023 23 Micron/300 mm
- 050 50 Micron/300mm

NUT CONFIGURATION
- F Single Flanged Nut (1 KGF)
- M Single Cylindrical Nut (1 KGM)
- FM Double Preloaded Nut Unit (1 KGF 1 KGM)
- MM Double Preloaded Nut Unit (2 KGM)

NUT SEAL SUFFIX
- Blank Without End Seals
- EE With End Seals

END MACHINING OPTIONS
- Blank Form Z & Form Z
- DW Form D & Form W
- DN Form D & Form N
- DZ Form D & Form Z
- CS per customer specification

OVERALL SHAFT LENGTH
In Millimeters

Rolled Ball Screws

Series KGS

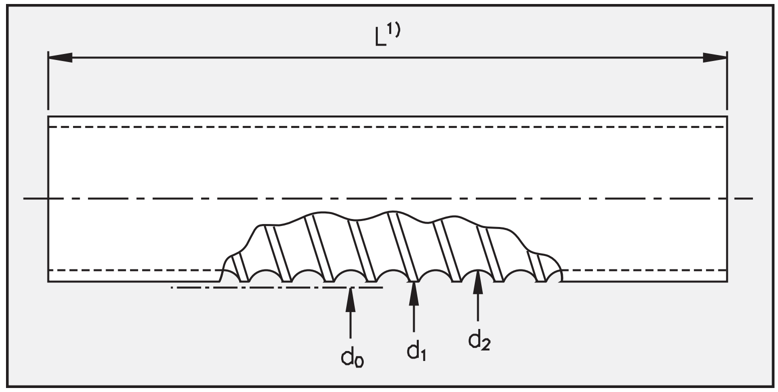


Figure 6 • KGS Rolled Ball Screw

Nominal Pitch Diameter d_o	Designation	Accuracy Class (µm/300 mm)	Dimensions in (mm)						Mass (kg/m)
			d_o	Lead P	d_1 (h11)	d_2	Number Of Starts	L_{max}1)	
16	KGS 1605	23 / 50	16	5	15.5	12.9	1	5600	1.26
	KGS 1610	23 / 50	16	10	15.4	13.0	2	5600	1.26
20	KGS 2005	23 / 50	20	5	19.5	16.9	1	5600	2.04
	KGS 2020	23 / 50	20	20	19.5	16.9	4	5600	2.07
	KGS 2050	23 / 50	20	20	19.1	16.5	5	5600	2.04
25	KGS 2505	23 / 50	25	5	24.5	21.9	1	5600	3.33
	KGS 2510	23 / 50	25	10	24.5	21.9	1	5600	3.33
	KGS 2520	23 / 50	25	20	24.6	22.0	4	5600	3.33
	KGS 2525	23 / 50	25	25	24.5	22.0	5	5600	3.33
	KGS 2550	23 / 50	25	50	24.5	21.5	5	5600	3.33
32	KGS 3205	23 / 50	32	5	31.5	28.9	1	5600	5.61
	KGS 3210	23 / 50	32	10	32.7	27.3	1	5600	5.60
	KGS 3220	23 / 50	32	20	31.7	27.9	2	5600	5.61
	KGS 3240	23 / 50	32	40	30.9	28.3	4	5600	5.61
40	KGS 4005	23 / 50	40	5	39.5	36.9	1	5600	9.03
	KGS 4010	23 / 50	40	10	39.5	34.1	2	5600	8.33
	KGS 4020	23 / 50	40	20	39.7	35.9	2	5600	9.01
	KGS 4040	23 / 50	40	40	38.9	36.3	4	5600	9.01
50	KGS 5010	50	50	10	49.5	44.1	1	5600	13.48
	KGS 5020	50	50	20	49.5	44.1	2	5600	13.50
63	KGS 6310	50	63	10	62.5	57.1	1	5600	22.04

Notes

1) For 5600mm, delivered length is 6000 mm with both ends soft-annealed over a length of 200 mm.

Flanged Ball Nuts

Series KGF

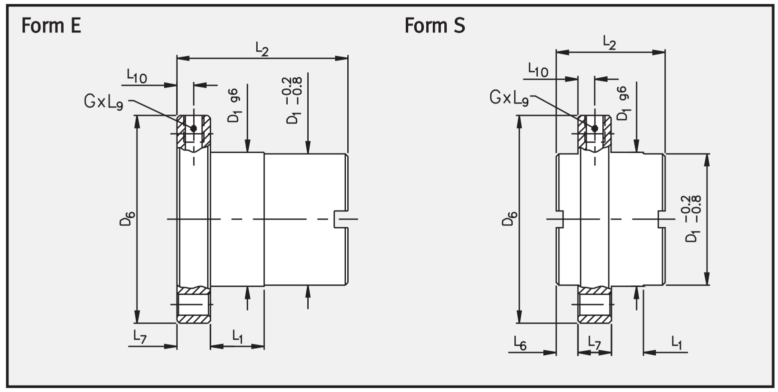


Figure 7 • KGF Flanged Ball Nuts

Nomina Pitch Diameter d_0	Designation d_0 Lead	Seal Suffix	Form	Hole Pattern	D_1	D_4	D_5	D_6	L_1	L_2	L_6	L_7	L_8	L_9	L_{10}	Lube Hole G	Axial Backlash Max	Load Rating Dyn C (kN)	Load Rating Stat C_0 (kN)
16	KGF D 16 05	EE	E	1	28	38	5.5	48	10	42	-	10	40	10	5	M6	0.08	12.0	12.7
	KGF D 16 10	EE	E	1	28	38	5.5	48	10	55	-	10	40	10	5	M6	0.08	23.0	26.0
20	KGF N 20 05	EE	E	3	32	45	7	55	8	44	-	12	-	8	6	M6	0.08	14.0	17.0
	KGF N 20 20	EE	S	3	35	50	7	62	4	30	8	10	-	8	5	M6	0.08	12.0	19.2
	KGF N 20 50	EE	S	3	35	50	7	62	10	56	9	10	-	8	5	M6	0.15	18.0	22.0
25	KGF D 25 05	EE	E	1	40	51	6.6	62	10	42	-	10	48	10	5	M6	0.08	15.0	22.4
	KGF D 25 10	EE	E	1	40	51	6.6	62	16	55	-	10	48	10	5	M6	0.08	17.5	25.0
	KGF D 25 20	EE	S	1	40	51	6.6	62	4	35	10.5	10	48	8	5	M6	0.15	19.0	23.5
	KGF D 25 25	EE	S	1	40	51	6.6	62	9	35	8	10	-[1)]	8	5	M6	0.08	21.0	31.0
	KGF D 25 50	EE	S	1	40	51	6.6	62	10	58	10.5	10	48	8	5	M6	0.15	22.5	29.0
32	KGF N 32 05	EE	E	3	45	58	7	70	10	59	-	16	-	8	8	M6	0.08	24.0	49.0
	KGF N 32 10	EE	E	3	53	68	7	80	10	73	-	16	-	8	8	M8x1	0.08	44.0	53.0
	KGF D 32 20	EE	E	1	53	65	9	80	16	80	-	12	62	10	6	M6	0.08	42.5	61.0
	KGF N 32 40	EE	S	3	53	68	7	80	14	45	7.5	16	-	10	8	M6	0.08	17.0	32.0
40	KGF D 40 05	EE	E	2	63	78	9	93	10	57	-	14	70	10	7	M6	0.08	26.0	63.5
	KGF D 40 10	EE	E	2	63	78	9	95	16	71	-	14	70	10	7	M8x1	0.08	50.0	70.0
	KGF D 40 20	EE	E	2	63	78	9	93	16	80	-	14	70	10	7	M8x1	0.08	44.5	77.0
	KGF D 40 40	EE	S	2	63	78	9	93	16	85	7.5	14	-[1)]	10	7	M8x1	0.08	42.0	93.0
50	KGF D 50 10	EE	E	2	75	93	11	110	16	95	-	16	85	10	8	M8x1	0.08	78.0	153.0
	KGF D 50 20	EE	E	2	85	103	11	125	22	95	-	18	95	10	9	M8x1	0.08	82.0	137.0
63	KGF N 63 10	EE	E	3	85	105	11	125	10	99	-	20	-	8	10	M8x1	0.08	60.0	200.0

Notes
1) Round flange.

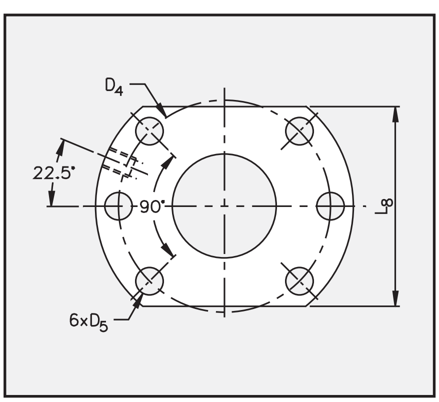


Figure 8 • Hole Pattern 1

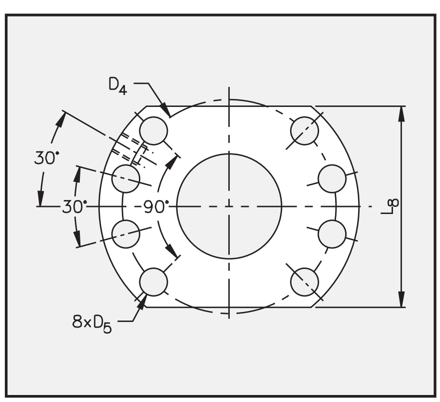


Figure 9 • Hole Pattern 2

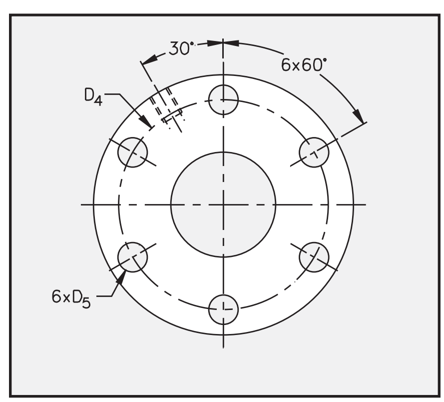


Figure 10 • Hole Pattern 3

Cylindrical Ball Nuts

Series KGM

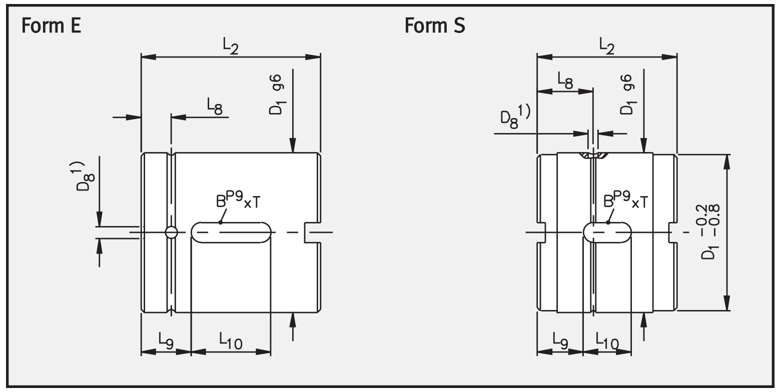


Figure 11 • KGM Cylindrical Ball Nuts

Nominal Pitch Diameter d_0	Designation	d_0 Lead	Seal Suffix	Form	Dimensions in (mm) D_1	D_8 1)	L_2	L_8	L_9	L_{10}	BxT	Axial Backlash Max	Dyn C (kN)	Stat C_0 (kN)
16	KGM D	16 05	EE	E	28	3	34	7	7	20	5x2	0.08	12.5	12.7
	KGM D	16 10	EE	E	28	3	50	7	15	20	5x2	0.08	23.0	26.0
20	KGM N	20 05	EE	E	32	3	34	7	7	20	5x2	0.08	14.0	17.0
	KGM N	20 20	EE	S	35	1.5	30	11.5	9	12	5x3	0.08	12.0	19.2
	KGM N	20 50	EE	S	35	1.5	56	16	18	20	5x3	0.15	18.0	22.0
25	KGM D	25 05	EE	E	40	3	34	7	7	20	5x2	0.08	15.0	22.4
	KGM D	25 10	EE	E	40	3	45	7.5	12.5	20	5x2	0.08	17.5	25.0
	KGM D	25 20	EE	S	40	1.5	35	14	11.5	12	5x3	0.15	19.0	23.5
	KGM D	25 25	EE	S	40	1.5	35	11.5	11	13	5x3	0.08	21.0	31.0
	KGM D	25 50	EE	S	40	1.5	58	17	19	20	5x3	0.15	22.5	29.0
32	KGM N	32 05	EE	E	45	3	45	7.5	8	30	6x2.5	0.08	24.0	49.0
	KGM N	32 10	EE	E	53	4	60	10	15	30	6x2.5	0.08	44.0	53.0
	KGM N	32 20	EE	E	53	3	70	7.5	20	30	6x2.5	0.08	42.5	61.0
	KGM N	32 40	EE	S	53 2)	1.5	45	13	10	25	6x4	0.08	17.0	32.0
40	KGM D	40 05	EE	E	63	3	45	7.5	8	30	6x2.5	0.08	26.0	63.5
	KGM D	40 10	EE	E	63	4	60	10	15	30	6x2.5	0.08	50.0	70.0
	KGM D	40 20	EE	E	63	3	70	7.5	20	30	6x2.5	0.08	44.5	77.0
	KGM D	40 40	EE	S	63	1.5	85	15	27.5	30	6x3.5	0.08	42.0	93.0
50	KGM D	50 10	EE	E	75	4	82	11	23	36	6x2.5	0.08	78.0	153.0
	KGM N	50 20	EE	E	85	4	82	10	23	36	6x2.5	0.08	82.0	137.0
63	KGM N	63 10	EE	E	85	4	82	11	23	36	6x2.5	0.08	60.0	200.0

Notes

1) Position of lubrication hole not defined on circumference.

2) D_1 -0.2/-0.8 is D_1 -1/-1.5

Standard Screw Ends

Form D

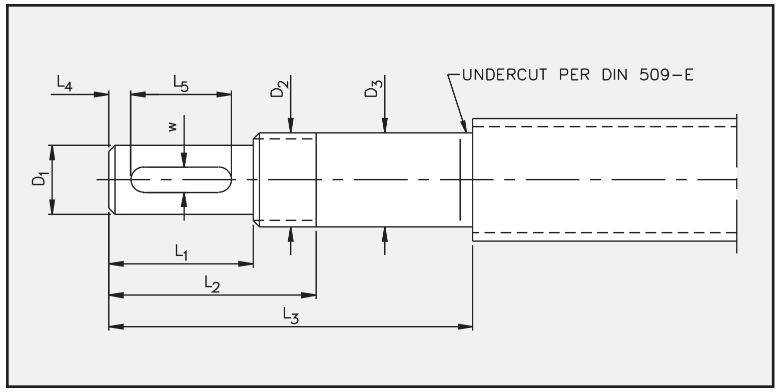


Figure 12 • Standard Screw End - Form D

Nominal Pitch Diameter d_0	Dimensions in (mm)							Keyway to DIN 6885
	D_1^{h6}	D_2	D_3^{h6}	L_1	L_2	L_3	L_4	w x depth x L_6
16	9	M12x1	12	20	30	55	2.5	3 x 1.8 x 16
20	11	M15x1	15	23	33	58	3.5	4 x 2.5 x 16
25	14	M20x1	20	30	42	70	4	5 x 3 x 22
32	19	M25x1.5	25	40	54	82	6	6 x 3.5 x 28
40	24	M30x1.5	30	50	64	92	7	8 x 4 x 36

Nominal Pitch Diameter d_0	Dimensions in (mm)							Bearing		Locknut	Max Axial Load (kN)
	D_4	D_5	D_6	D_7	L_6	L_7	N x S				
16	55	42	22	42	8	25	3 x M6	ZKLF 1255-2RS-PE	ZKLN 1242-2RS-PE	ZM12	12
20	60	46	25	45	8	25	3 x M6	ZKLF 1560-2RS-PE	ZKLN 1545-2RS-PE	ZM15	14
25	68	53	32	52	10	28	4 x M6	ZKLF 2068-2RS-PE	ZKLN 2052-2RS-PE	ZM20	16
32	75	58	38	57	12	28	4 x M6	ZKLF 2575-2RS-PE	ZKLN 2557-2RS-PE	ZM25	20
40	80	63	45	62	12	28	6 x M6	ZKLF 3080-2RS-PE	ZKLN 3062-2RS-PE	ZM30	22

Notes

Bearings and locknut must be ordered separately. For more information, see INA publication ZAE.

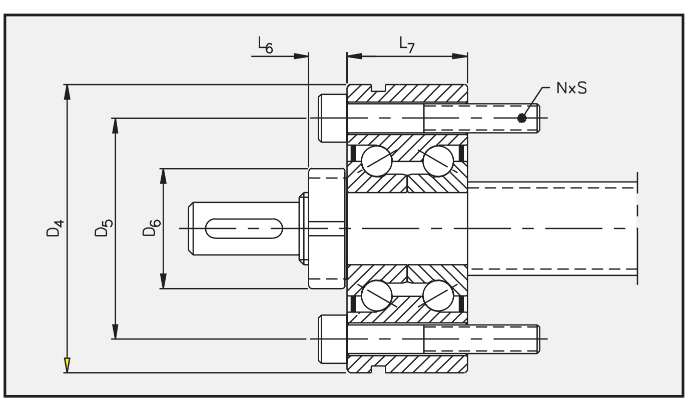


Figure 13 • Standard Screw End - Form D With ZKLF & ZM

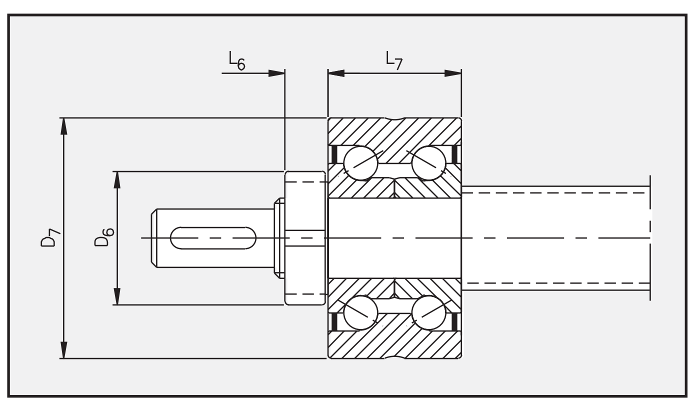


Figure 14 • Standard Screw End - Form D With ZKLN & ZM

Standard Screw Ends

Forms W, N and Z

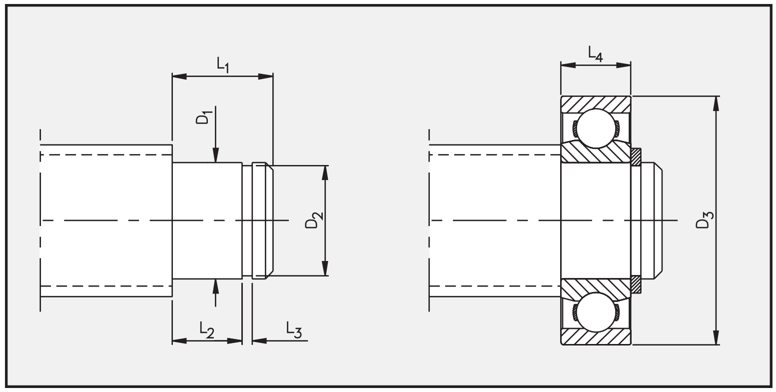


Figure 15 • Standard Screw End - Form W

Form W

Nominal Pitch Diameter d_0	Dimensions in (mm)							Bearing	Shaft Ring Per DIN 471
	D_1^{j6}	D_2	D_3	L_1	L_2	L_3	L_4		
16	12	11.5	28	12	8	1.1	8	6001-2RSR	12x1
20	15	14.2	32	13	9	1.3	9	6002-2RSR	15x1
25	20	18.8	42	16	12	1.3	12	6004-2RSR	20x1.2
32	25	23.7	52	20	15	1.3	15	6205-2RSR	25x1.2
40	30	28.6	62	21	16	1.6	16	6206-2RSR	30x1.5
50	40	38.5	80	25	18	1.85	18	6208-2RSR	40x1.75
63	55	52	100	29	21	2.15	21	6211-2RSR	55x2

Notes
Bearings must be ordered separately. For more information, see INA publication 517.
Shaft rings not included.

Form N

Nominal Pitch Diameter d_0	Dimensions in (mm)							INA Needle Roller Bearing	INA Snap Ring
	D_1^{j6}	D_2	D_3	L_1	L_2	L_3	L_4		
16	12	11.5	24	18	14	1.1	13	NA 4901-2RSR	WR 12
20	15	14.4	28	18	14	1.3	13	NA 4902-2RSR	WR 15
25	20	19.2	37	22	18	1.3	17	NA 4904-2RSR	WR 20
32	25	24	42	23	18	1.3	17	NA 4905-2RSR	WR 25
40	30	29	47	23	18	1.6	17	NA 4906-2RSR	WR 30
50	40	38.5	62	30	23	1.6	22	NA 4908-2RSR	WR 40
63	50	48.5	62	30.5	23	1.6	22	NA 4910-2RSR	WR 50

Notes
Bearings must be ordered separately. For more information, see INA publication 517.
Shaft rings not included.

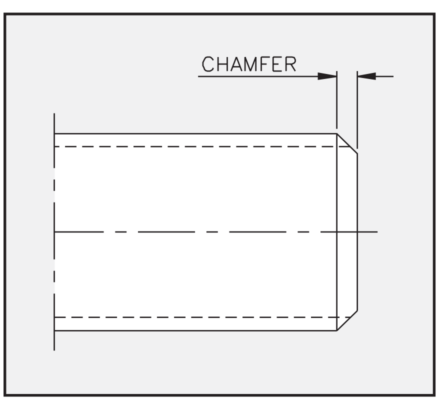


Figure 16 • Standard Screw End - Form Z

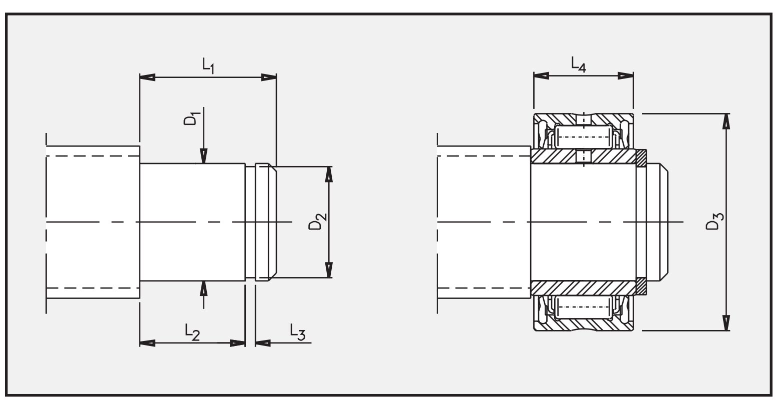
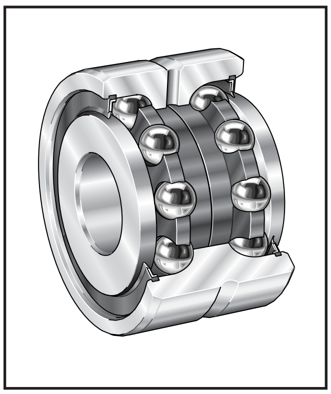


Figure 17 • Standard Screw End - Form N

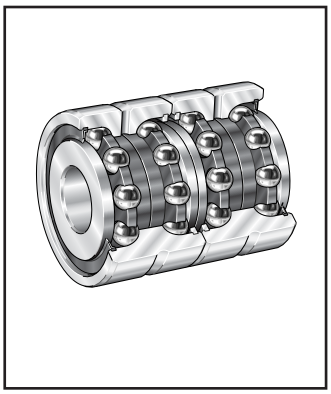
Bearing Components For Screw Drives

INA manufactures a complete line of ball screw support bearings and precision lock nuts.
INA ball screws can be machined to accommodate numerous bearing arrangements.

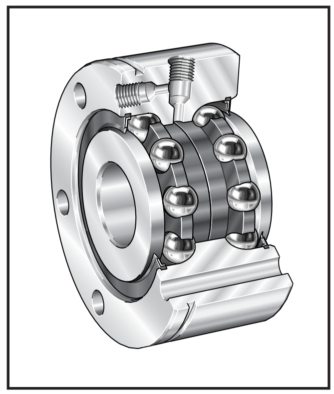
For more information see publication TPI123, Bearings For Screw Drives



ZKLN



ZKLN..2AP



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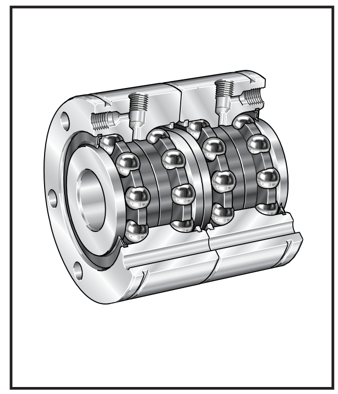

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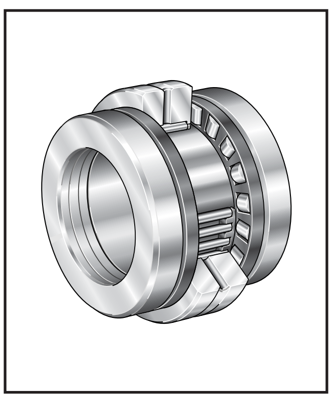
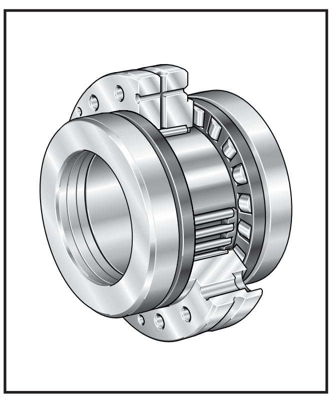
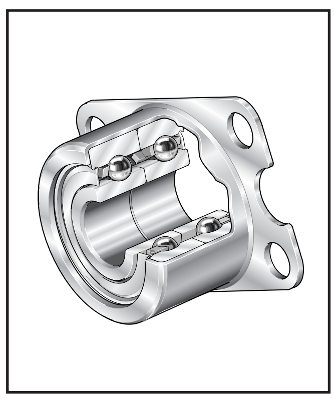


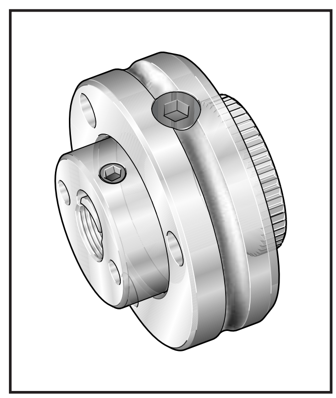
ZARN



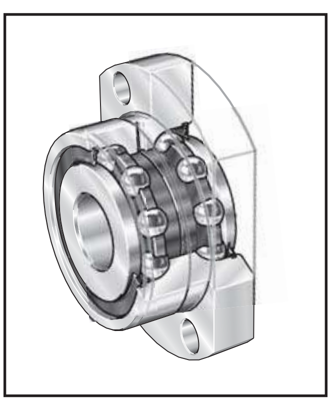
ZARF



ZKLR



ZAXFM



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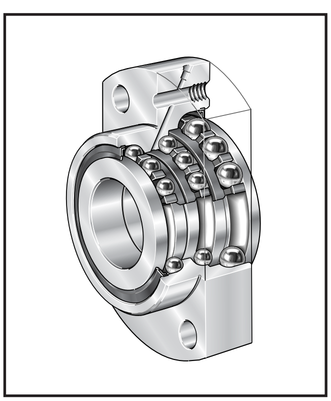
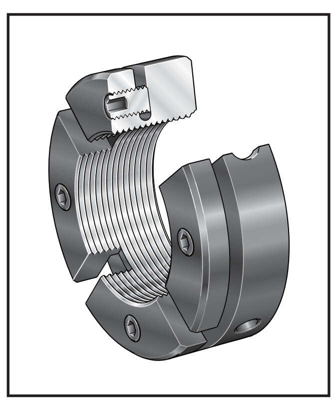
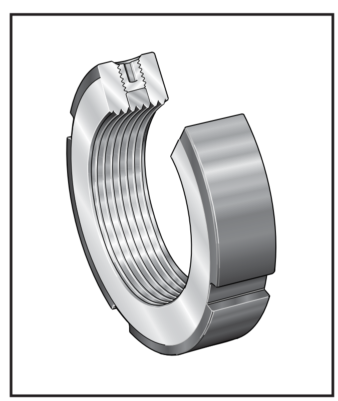


DKLFA



AM



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