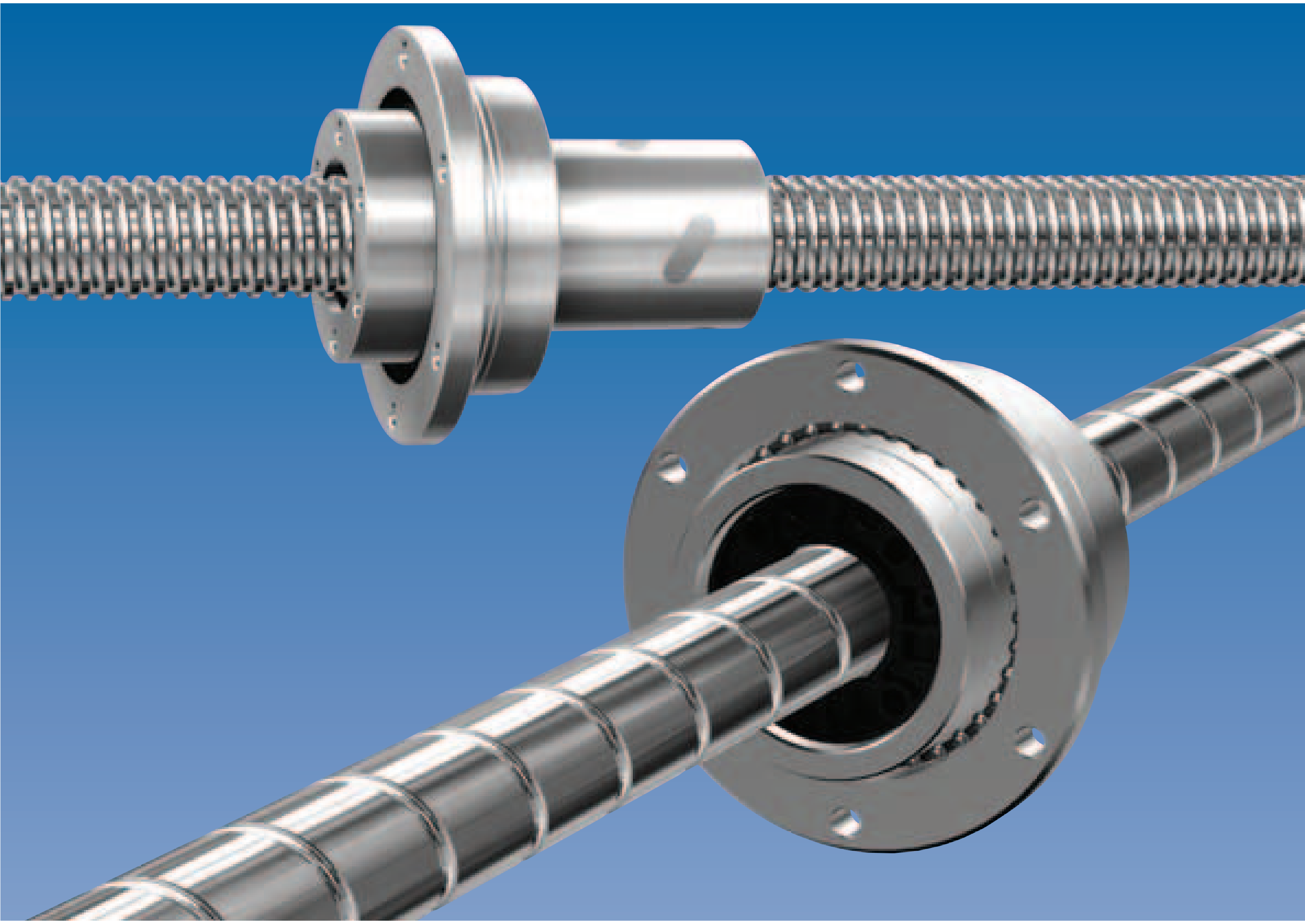
Rotary Ball Screw

Rotary-Nut Series

BLR/DIR



THK CO., LTD.
TOKYO. JAPAN

CATALOG No.326E

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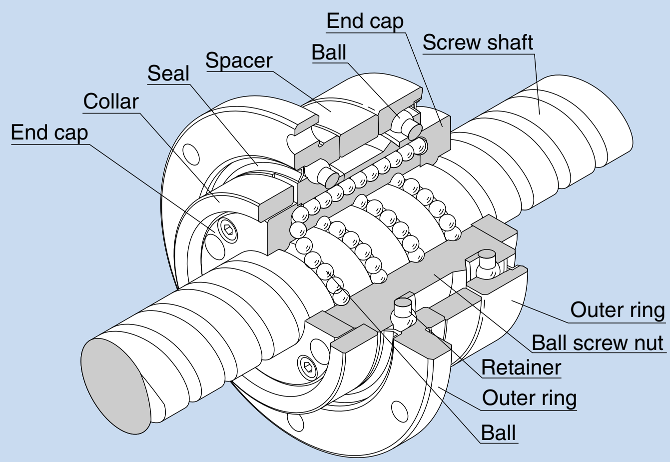
Rotary-Nut Series
Rotary Ball Screw

BLR



Structure of Large-Lead Rotary-Nut Ball Screw Model BLR

Structure and Features

The Rotary Ball Screw is a rotary-nut ball screw unit in which a ball screw nut is integrated with a support bearing. The support bearing is an angular bearing that has a contact angle of 60˚, contains a large number of balls and achieves a large axial rigidity. Model BLR is divided into two types: Precision Ball Screw and Rolled Ball Screw.

● Capable of Fast Feed

Since the ball screw nut rotates with the screw shaft being fixed, it can be fed at high speed despite a thin screw shaft. This allows a small driving motor to be used.

● Smooth Motion

It achieves smoother motion than rack-and-pinion based linear motion. In addition, since the screw shaft does not rotate because of the ball screw nut drive, this model does not show skipping, produces low noise and generates little heat.

● Low Noise Level even in High-speed Rotation

Model BLR produces very low noise when its balls are picked up along the end cap. In addition, the balls circulate by passing through the ball screw nut, allowing this model to produce minimum noise even in high-speed operation.

● High Rigidity

The support bearing of this model is larger than that of the rotary screw shaft type. Thus, its axial rigidity is significantly increased.

● Compact

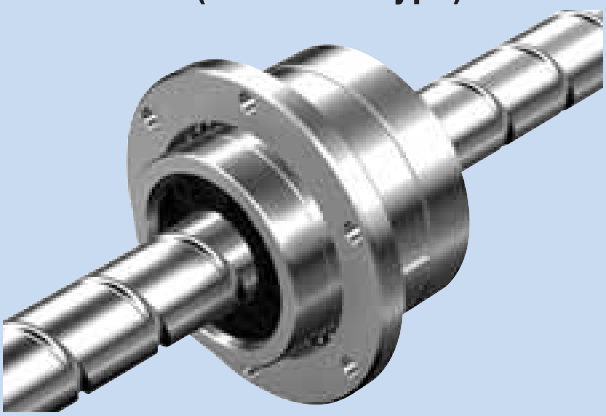
Since the nut and the support bearing are integrated, highly accurate and compact design is achieved.

● Easy Installation

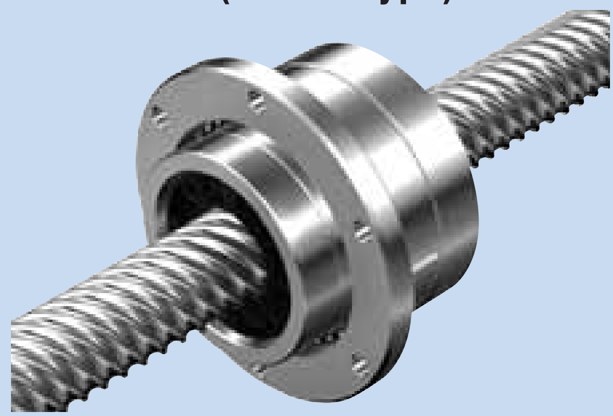
By simply mounting this model to the housing with bolts, a ball nut rotation mechanism is gained (for the housing's inner-diameter tolerance, H7 is recommended).

Types

Model BLR (Precision Type) [Rotary Ball Screw]



Model BLR (Rolled Type) [Rotary Ball Screw]



Static Safety Factor

It is necessary to take into account a static safety factor indicated in Table 1 against the axial load that is applied on the Ball Screw. When studying the static safety factor, a basic static load rating C_0a is required.

[Basic Static Load Rating C_0a]

When a Ball Screw receives an excessive load or a large impact load while it is stationary or in motion, a local permanent deformation occurs between the raceway and the steel ball. If the permanent deformation exceeds a certain limit, it will prevent the Ball Screw from smoothly moving.

It is recognized that in general there will be no operational problem if the amount of permanent deformation is up to approximately 0.0001 of the steel ball diameter. The load present in such cases is called basic static load rating C_0a.

[Static Safety Factor]

$$f_s \leqq \frac{C_0a}{F_a}$$

fs : Static safety factor (see Table 1)

C_0a : Basic static load rating (kN)

(see the dimensional table for model BLR on page 8)

Fa : Axial load (kN)

Table 1 Static Safety Factor

Machine using the Ball Screw	Load conditions	Lower limit of fs
General industrial machinery	Without vibrations or impact	1.0 to 1.3
	With vibrations or impact	2.0 to 3.0
Machine tools	Without vibrations or impact	1.0 to 1.5
	With vibrations or impact	2.5 to 7.0

Rated Life and Service Life Time

[Basic Dynamic Load Rating Ca]

Basic dynamic load rating Ca is used to calculate the service life of a Ball Screw in motion with its ball screw nut being under a load. The basic dynamic load rating Ca is an axial load under which the rated life of 90% of a group of the same Ball Screw units independently operating is 10^6 rev (1 million revolutions).

[Rated Life]

The service life of a Ball Screw is obtained from the equation below using the basic dynamic load rating and the axial load.

$$L = \left(\frac{Ca}{fw \cdot Fa}\right)^3 \times 10^6$$

L : Rated life (rev)
Ca : Basic dynamic load rating (N) (see the dimensional table for model BLR on page 8)
Fa : Axial load (N)
fw : Load factor (see Table 2)

Table 2 Load Factor

Vibrations/impact	Velocity (V)	fw
Faint	Very low $V \leqq 0.25$ m/s	1.0 to 1.2
Weak	Low $0.25 \leqq V \leqq 1.0$ m/s	1.2 to 1.5
Medium	Moderate $1.0 \leqq V \leqq 2.0$ m/s	1.5 to 2.0
Strong	High 2.0 m/s $< V$	2.0 to 3.5

[Service Life Time]

When the rated life (L) has been determined, the service life time is obtained from the following equation if the stroke length and the number of reciprocations are constant.

$$L_h = \frac{L \times \ell}{2 \times \ell_s \times n_1 \times 60}$$

Lh : Service life time (h)
ℓs : Stroke length (mm)
n_1 : Revolutions per minute (min^{-1})
ℓ : Lead (mm)

(For details, see the General Catalog.)

Axial Clearance of Model BLR

Axial Clearance of Model BLR (Precision Type)

Table 3 shows the axial clearance of model BLR (precision type). If the manufacturing length exceeds the corresponding value indicated in Table 4, the clearance may partially be negative (preloaded state).

Table 3 Axial Clearance of Model BLR (Precision Type)

Unit: mm

Clearance symbol	G0	GT	G1	G2	G3
Axial clearance	0 or below	0 to 0.005	0 to 0.01	0 to 0.02	0 to 0.05

Table 4 Maximum Manufacturing Length of Model BLR (Precision Type) by Axial Clearance

Unit: mm

Model No.	Overall screw length						
	Clearance GT		Clearance G1		Clearance G2		
	C0 to C3	C5	C0 to C3	C5	C0 to C3	C5	C7
BLR1616-3.6	500	400	500	500	700	600	500
BLR2020-3.6 BLR2525-3.6	800	700	800	700	1000	1000	1000
BLR3232-3.6	900	800	1100	900	1400	1200	1200
BLR3636-3.6 BLR4040-3.6	1000	800	1300	1000	2000	1500	1500
BLR5050-3.6	1200	1000	1600	1300	2500	2000	2000

* If the product is to be manufactured with accuracy grade C7 and clearance GT or G1, the clearance will partially be negative.

Axial Clearance of Model BLR (Rolled Type)

Table 5 shows the axial clearance of model BLR (rolled type).

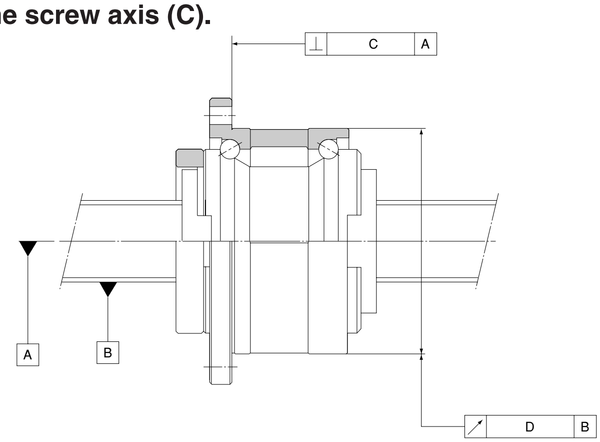
Table 5 Axial Clearance of Model BLR (Rolled Type)

Unit: mm

Model No.	Axial clearance (maximum)
BLR1616-3.6 BLR2020-3.6 BLR2525-3.6	0.1
BLR3232-3.6	0.14
BLR3636-3.6 BLR4040-3.6	0.17
BLR5050-3.6	0.2

Accuracy Standards for Model BLR

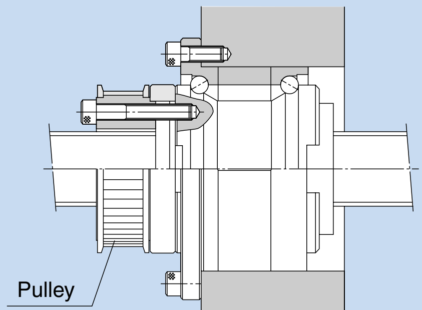
The accuracy of model BLR is compliant with a JIS standard (JIS B 1192) except for the radial run-out of the circumference of the ball screw nut from the screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).



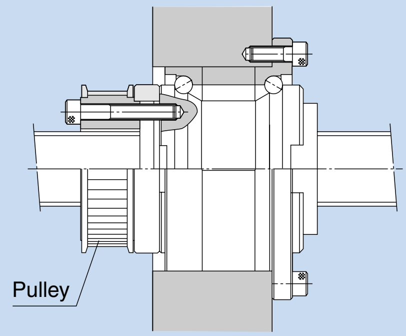
Unit: mm

	Precision Ball Screw						Rolled Ball Screw	
Lead accuracy	C3		C5		C7		C7, C8, C10	
Accuracy grade	C3		C5		C7		C10	
Model No.	C	D	C	D	C	D	C	D
BLR 1616	0.013	0.017	0.016	0.020	0.023	0.035	0.035	0.065
BLR 2020	0.013	0.017	0.016	0.020	0.023	0.035	0.035	0.065
BLR 2525	0.015	0.020	0.018	0.024	0.023	0.035	0.035	0.065
BLR 3232	0.015	0.020	0.018	0.024	0.023	0.035	0.035	0.065
BLR 3636	0.016	0.021	0.019	0.025	0.024	0.036	0.036	0.066
BLR 4040	0.018	0.026	0.021	0.033	0.026	0.046	0.046	0.086
BLR 5050	0.018	0.026	0.021	0.033	0.026	0.046	0.046	0.086

Example of Mounting the Ball Screw Nut for Model BLR



Standard installation



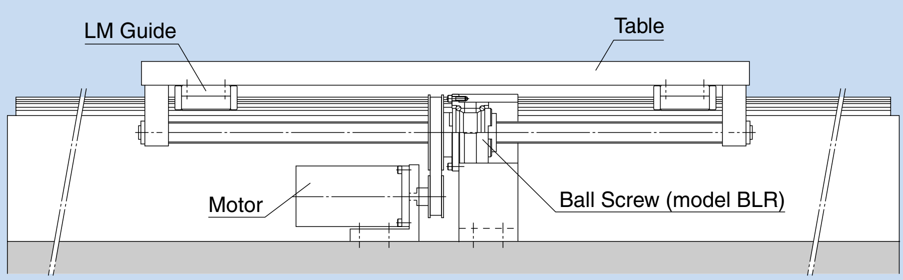
Flange inverted

Note: If the flange is to be inverted, indicate “K” in the model number (applicable only to model BLR)
Example: BLR 2020-3.6 K UU
Symbol for inverted flange
(No symbol for standard flange orientation)

Examples of Mounting Model BLR on the Table

Screw Shaft Free, Ball Screw Nut Fixed

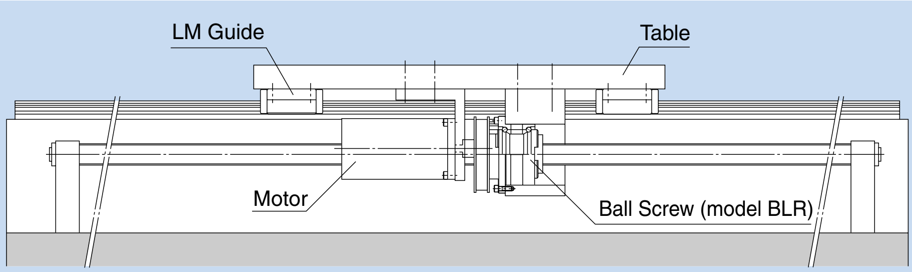
(Suitable for a long table)



Example of Installation on the Table (Ball Screw Nut Fixed)

Ball Screw Nut Free, Screw Shaft Fixed

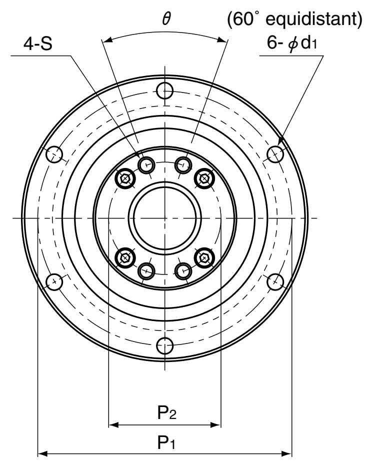
(Suitable for a short table and a long stroke)



Example of Installation on the Table (Screw Shaft Fixed)

BLR TYPE

Dimensional Table for Model BLR
Large-Lead Rotary-Nut Precision Ball Screw
Large-Lead Rotary-Nut Rolled Ball Screw



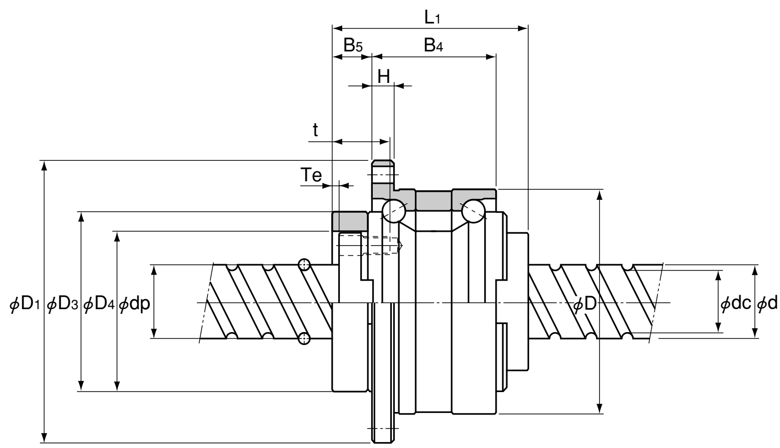
Model No.	Screw shaft outer diameter d	Thread minor diameter dc	Lead Ph	Ball center-to-center diameter dp	Basic load rating Ca kN		Basic load rating C_0a kN		Outer diameter D	Flange diameter D_1	Overall length L_1
					Precision	Rolled	Precision	Rolled			
BLR 1616-3.6	16	13.7	16	16.65	7.1	5.8	14.3	12.9	52 $^{0}_{-0.007}$	68	43.5
BLR 2020-3.6	20	17.5	20	20.75	11.1	7.7	24.7	22.3	62 $^{0}_{-0.007}$	78	54
BLR 2525-3.6	25	22	25	26	16.6	12.1	38.7	35	72 $^{0}_{-0.007}$	92	65
BLR 3232-3.6	32	28.3	32	33.25	23.7	17.3	59.5	53.9	80 $^{0}_{-0.007}$	105	80
BLR 3636-3.6	36	31.7	36	37.4	30.8	22.4	78	70.5	100 $^{0}_{-0.008}$	130	93
BLR 4040-3.6	40	35.2	40	41.75	38.7	28.1	99.2	89.8	110 $^{0}_{-0.008}$	140	98
BLR 5050-3.6	50	44.1	50	52.2	57.8	42.1	155	140.4	120 $^{0}_{-0.008}$	156	126

Example of model number coding

Precision Ball Screw

BLR2020-3.6 K UU G1 +1000L C5

- BLR2020-3.6: Model number
- K: Flange orientation symbol (see page 6)
  - K : flange inverted
  - No symbol : standard
- UU: Symbol for support bearing seal
  - UU : seal attached on both sides
  - No symbol : without seal
- G1: Symbol for axial clearance (see page 4)
- +1000L: Overall screw shaft length (in mm)
- C5: Accuracy symbol (see page 5)



Unit: mm

Ball screw dimensions													Support bearing basic load rating		Nut inertial moment
	D_3	D_4	H	B_4	B_5	Te	P_1	P_2	S	t	d_1	θ°	Ca kN	C_0a kN	kg・cm²
	$40^{\ 0}_{-0.025}$	$32^{+0.025}_{\ 0}$	5	27.5	9	2	60	25	M4	12	4.5	40	19.4	19.2	0.48
	$50^{\ 0}_{-0.025}$	$39^{+0.025}_{\ 0}$	6	34	11	2	70	31	M5	16	4.5	40	26.8	29.3	1.44
	$58^{\ 0}_{-0.03}$	$47^{+0.025}_{\ 0}$	8	43	12.5	3	81	38	M6	19	5.5	40	28.2	33.3	3.23
	$66^{\ 0}_{-0.03}$	$58^{+0.03}_{\ 0}$	9	55	14	3	91	48	M6	19	6.6	40	30	39	6.74
	$80^{\ 0}_{-0.03}$	$66^{+0.03}_{\ 0}$	11	62	17	3	113	54	M8	22	9	40	56.4	65.2	16.8
	$90^{\ 0}_{-0.035}$	$73^{+0.03}$	11	68	16.5	3	123	61	M8	22	9	50	59.3	74.1	27.9
	$100^{\ 0}_{-0.035}$	$90^{+0.035}_{\ 0}$	12	80	25	4	136	75	M10	28	11	50	62.2	83	58.2

Example of model number coding

Rolled Ball Screw

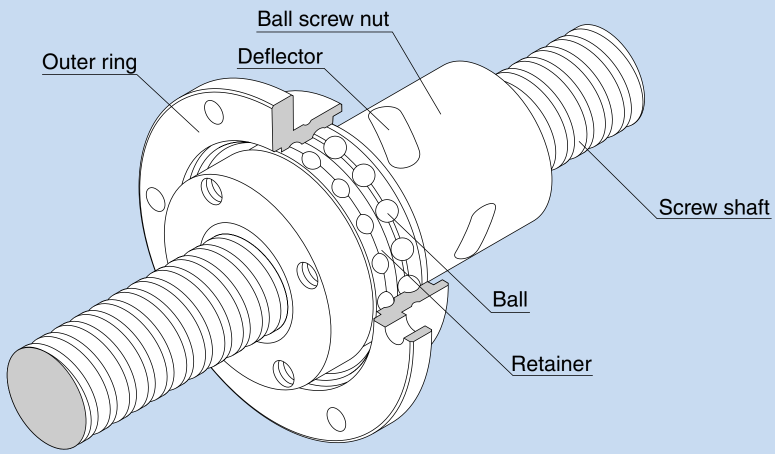
BLR2020-3.6 K UU +1000L C7 T

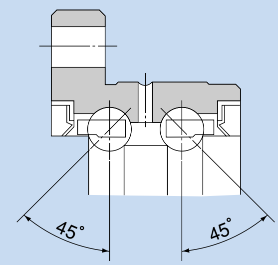
- BLR2020-3.6: Model number
- K: Flange orientation symbol (see page 6)
  - K : flange inverted
  - No symbol : standard
- UU: Symbol for support bearing seal
  - UU : seal attached on both sides
  - No symbol : without seal
- +1000L: Overall screw shaft length (in mm)
- C7: Accuracy symbol (see page 5) (no symbol for grade C10)
- T: Rolled Ball Screw symbol

Note For the axial clearance, see page 4.

Rotary-Nut Series
Rotary Ball Screw

DIR





Structure of the Support Bearing

Structure of Standard-Lead Rotary-Nut Ball Screw Model DIR

Structure and Features

Standard-Lead Rotary-Nut Ball Screw model DIR is a rotary-nut Ball Screw that has a structure where a simple-nut Ball Screw is integrated with a support bearing.
Its ball screw nut serves as a ball circulation mechanism using deflectors. Balls travel along the groove of the deflector, mounted in the ball screw nut, to the adjacent raceway, and then circulate back to the loaded area to complete infinite rolling motion. Being a nut under an offset preload, the single ball screw nut provides different phases to the right and left thread in the middle of the nut, thus to set the axial clearance below zero (preloaded state). This allows more compact, smoother motion to be achieved than the conventional double-nut type (a spacer is inserted between two nuts).
The support bearing comprises two rows of DB type angular bearings with a contact angle of 45° to provide a preload. The collar, previously used to mount a pulley, is integrated with the ball screw nut.

● Compact

Because of the internal circulation mechanism using a deflector, the outer diameter is only 70 to 80%, and the overall length is 60 to 80%, of that of the Returned-Pipe Nut, thus reduce the weight and decrease the inertia during acceleration. Since the ball screw nut is integrated with the support bearing, highly accurate and compact design is allowed. In addition, small inertia through the lightweight ball screw nut ensures high responsiveness.

● Capable of High-Speed Rotation

Since the screw shaft is fixed and the ball screw nut is free, the Ball Screw is capable of rotating at high speed even if the shaft diameter is small. It allows a small driving motor to be used.

● Capable of Fine Positioning

Being a Standard-Lead Ball Screw, this model is capable of fine positioning even when the ball screw nut rotates.

● Accuracy Can Easily Be Established

As the support bearing is integrated with the outer ring, the bearing can be assembled with the nut housing on the end face of the outer ring flange. This makes it easy to center the ball screw nut and establish accuracy.

● Well Balanced

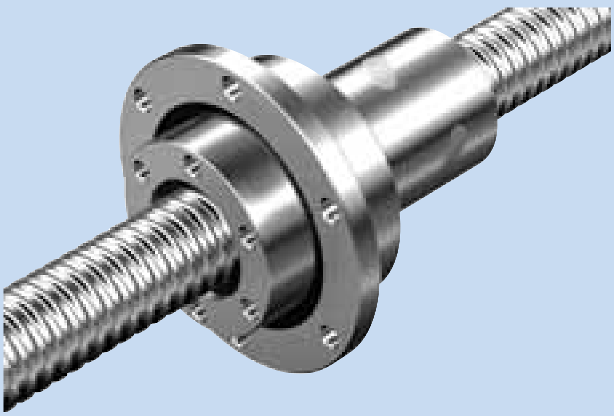
Since the deflectors are evenly placed on the circumference, superb balance is ensured while the ball screw nut is rotating.

● Stable in the Low-speed Range

Traditionally, motors tend to have uneven torque and speed in the low-speed range due to external causes. With model DIR, motors can be connected independently with the screw shaft and the ball screw nut, thus allow fine feed within the motors' stable rotation ranges.

Type

Model DIR [Rotary Ball Screw]



Static Safety Factor

It is necessary to take into account a static safety factor indicated in Table 6 against the axial load that is applied on the Ball Screw. When studying the static safety factor, a basic static load rating C_0a is required.

[Basic Static Load Rating C_0a]

When a Ball Screw receives an excessive load or a large impact load while it is stationary or in motion, a local permanent deformation occurs between the raceway and the steel ball. If the permanent deformation exceeds a certain limit, it will prevent the Ball Screw from smoothly moving.
It is recognized that in general there will be no operational problem if the amount of permanent deformation is up to approximately 0.0001 of the steel ball diameter. The load present in such cases is called basic static load rating C_0a.

[Static Safety Factor]

$$f_s \leqq \frac{C_0a}{F_a}$$

f_s : Static safety factor (see Table 6)
C_0a : Basic static load rating (kN)
(see the dimensional table for model DIR on page 14)
F_a : Axial load (kN)

Table 6 Static Safety Factor

Machine using the Ball Screw	Load conditions	Lower limit of fs
General industrial machinery	Without vibrations or impact	1.0 to 1.3
	With vibrations or impact	2.0 to 3.0
Machine tools	Without vibrations or impact	1.0 to 1.5
	With vibrations or impact	2.5 to 7.0

Rated Life and Service Life Time

[Basic Dynamic Load Rating Ca]

Basic dynamic load rating Ca is used to calculate the service life of a Ball Screw in motion with its ball screw nut being under a load. The basic dynamic load rating Ca is an axial load under which the rated life of 90% of a group of the same Ball Screw units independently operating is 10^6 rev (1 million revolutions).

[Rated Life]

The service life of a Ball Screw is obtained from the equation below using the basic dynamic load rating and the axial load.

$$L = \left(\frac{Ca}{fw \cdot Fa}\right)^3 \times 10^6$$

L : Rated life (rev)
Ca : Basic dynamic load rating (N) (see the dimensional table for model DIR on page 14)
Fa : Axial load (N)
fw : Load factor (see Table 7)

Table 7 Load Factor

Vibrations/impact	Velocity (V)	fw
Faint	Very low V≦0.25 m/s	1.0 to 1.2
Weak	Low 0.25≦V≦1.0 m/s	1.2 to 1.5
Medium	Moderate 1.0≦V≦2.0 m/s	1.5 to 2.0
Strong	High 2.0 m/s<V	2.0 to 3.5

[Service Life Time]

When the rated life (L) has been determined, the service life time is obtained from the following equation if the stroke length and the number of reciprocations are constant.

$$L_h = \frac{L \times \ell}{2 \times \ell_s \times n_1 \times 60}$$

Lh : Service life time (h)
ℓs : Stroke length (mm)
n_1 : Revolutions per minute (min^{-1})
ℓ : Lead (mm)

(For details, see the General Catalog.)

Axial Clearance of Model DIR

Table 8 shows the axial clearance of model DIR (precision type). If the manufacturing length exceeds the corresponding value indicated in Table 9, the clearance may partially be negative (preloaded state).

Table 8 Axial Clearance of Model DIR

Unit: mm

Clearance symbol	G0	GT	G1	G2	G3
Axial clearance	0 or below	0 to 0.005	0 to 0.01	0 to 0.02	0 to 0.05

Table 9 Maximum Manufacturing Length of Model DIR by Axial Clearance

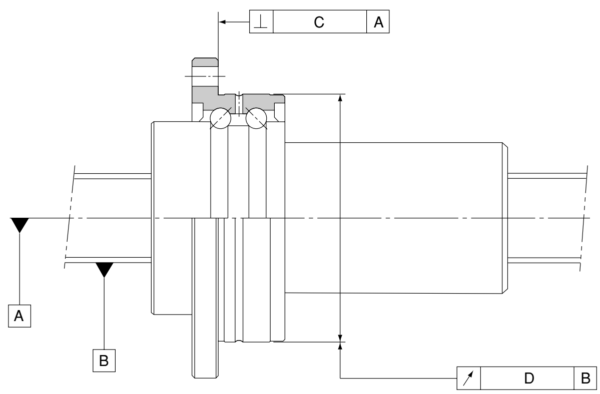
Unit: mm

Model No.	Overall screw length						
	Clearance GT		Clearance G1		Clearance G2		
	C0 to C3	C5	C0 to C3	C5	C0 to C3	C5	C7
DIR16□□	500	400	500	500	700	600	500
DIR20□□ DIR25□□	800	700	800	700	1000	1000	1000
DIR32□□	900	800	1100	900	1400	1200	1200
DIR36□□ DIR40□□	1000	800	1300	1000	2000	1500	1500

* If the product is to be manufactured with accuracy grade C7 and clearance GT or G1, the clearance will partially be negative.

Accuracy Standards for Model DIR

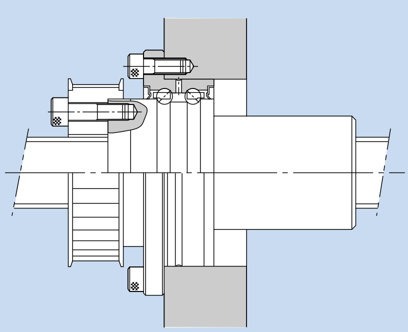
The accuracy of model DIR is compliant with a JIS standard (JIS B 1192) except for the radial run-out of the circumference of the ball screw nut from the screw axis (D) and the perpendicularity of the flange-mounting surface against the screw axis (C).

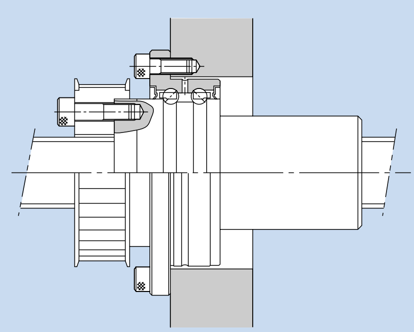


Unit: mm

Accuracy grade	C3		C5		C7	
Model No.	C	D	C	D	C	D
DIR 16□□	0.013	0.017	0.016	0.020	0.023	0.035
DIR 20□□	0.013	0.017	0.016	0.020	0.023	0.035
DIR 25□□	0.015	0.020	0.018	0.024	0.023	0.035
DIR 32□□	0.015	0.020	0.018	0.024	0.023	0.035
DIR 36□□	0.016	0.021	0.019	0.025	0.024	0.036
DIR 40□□	0.018	0.026	0.021	0.033	0.026	0.036

Example of Mounting the Ball Screw Nut for Model DIR

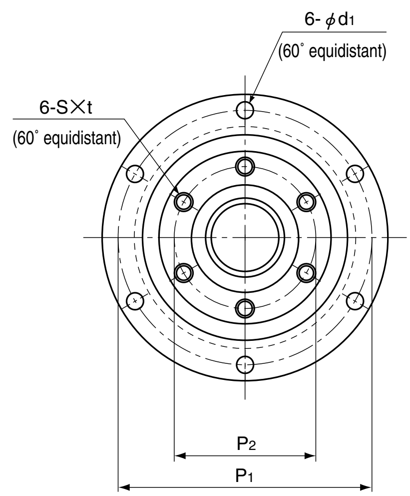




Installation to the housing can be performed on the end face of the outer ring flange.

DIR TYPE

Dimensional Table for Model DIR Standard-Lead Rotary-Nut Ball Screw

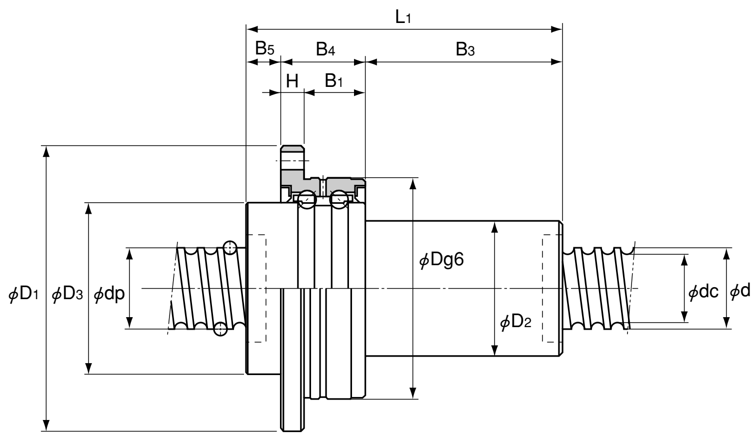


Model No.	Screw shaft outer diameter d	Thread minor diameter dc	Lead Ph	Ball center-to-center diameter dp	Basic load rating Ca kN	Basic load rating C_0a kN	Rigidity K N/μm	Outer diameter D	Flange diameter D_1	Overall length L_1	D_3 h7
DIR 1605-6	16	13.2	5	16.75	7.4	13	310	48	64	79	36
DIR 2005-6	20	17.2	5	20.75	8.5	17.3	310	56	72	80	43.5
DIR 2505-6	25	22.2	5	25.75	9.7	22.6	490	66	86	88	52
DIR 2510-4		21.6	10	26	9	18	330	66	86	106	52
DIR 3205-6	32	29.2	5	32.75	11.1	30.2	620	78	103	86	63
DIR 3206-6		28.4	6	33	14.9	37.1	630	78	103	97	63
DIR 3210-6		26.4	10	33.75	25.7	52.2	600	78	103	131	63
DIR 3610-6	36	30.5	10	37.75	28.8	63.8	710	92	122	151	72
DIR 4010-6	40	34.7	10	41.75	29.8	69.3	750	100	130	142	79.5
DIR 4012-6		34.4	12	41.75	30.6	72.3	790	100	130	167	79.5

Example of model number coding

DIR2005-6 RR G0 +520L C1

- DIR2005-6: Model number
- RR: Seal symbol (RR: labyrinth seal attached on both ends of the ball screw nut)
- G0: Symbol for axial clearance (see page 11)
- +520L: Overall screw shaft length (in mm)
- C1: Accuracy symbol (see page 12)



Unit: mm

Ball screw dimensions												Support bearing basic load rating		Nut inertial moment
	D_2	B_5	B_4	B_3	P_1	P_2	H	B_1	S	t	d_1	Ca kN	C_0a kN	kg・cm²
	30	8	21	50	56	30	6	15	M4	6	4.5	8.7	10.5	0.61
	34	9	21	50	64	36	6	15	M5	8	4.5	9.7	13.4	1.18
	40	13	25	50	75	43	7	18	M6	10	5.5	12.7	18.2	2.65
	40	11	25	70	75	43	7	18	M6	10	5.5	12.7	18.2	2.84
	46	11	25	50	89	53	8	17	M6	10	6.6	13.6	22.3	5.1
	48	11	25	61	89	53	8	17	M6	10	6.6	13.6	22.3	5.68
	54	11	25	95	89	53	8	17	M6	10	6.6	13.6	22.3	8.13
	58	14	33	104	105	61	10	23	M8	12	9	20.4	32.3	14.7
	62	14	33	95	113	67	10	23	M8	12	9	21.5	36.8	20.6
	62	14	33	120	113	67	10	23	M8	12	9	21.5	36.8	22.5

Note The rigidity values in the table represent spring constants each obtained from the load and the elastic displacement when providing a preload 10% of the basic dynamic load rating (Ca) and applying an axial load three times greater than the preload.
These values do not include the rigidity of the components related to mounting the ball screw nut. Therefore, it is normally appropriate to assume roughly 80% of the value in the table to be the actual value.
If the applied preload (Fa_0) is not equal to 0.1 Ca, the rigidity value (K_N) is obtained from the following equation.

$$K_N = K\left(\frac{Fa_0}{0.1Ca}\right)^{\frac{1}{3}}$$

K: rigidity value in the dimensional table