B-3-3.10 ∑ Series for Robots

1. Features

∑ Series (NSK's Robotte) is a ball screw with a high-performance spline. It is ideal for various actuators such as the vertical axis of SCALA type robot.

A ball screw groove and a ball spline groove are made in one shaft, combining the ball screw and the ball spline.

Mount housing, nuts, and support bearings are combined into a single unit.

Timing pulley (prepared by the user) is directly secured at the end face of the nut.

● High functions

A single shaft has both feeding mechanism and guide functions. This allows the shaft ends to move back and forth (linear motion), as well as to rotate.

● Compact and lightweight

A ball screw nut and a spline nut are placed on one shaft, and a support bearings are also combined to the unit. This allows compact and high-precision design. Hollow shaft is standard to reduce weight. The hollow can be used for wiring and piping. Other components are also designed to be light in weight.

● Low inertia

Because of return tube type ball nut of which outside diameter is decreased, low inertia design is enabled.

It reduces the inertia by 19% of conventional products.

2. Functions

As shown in **Fig. 1**, the ball screw nut and a spline nut are rotated independently to control rotation value. Thereby the shaft can move in any direction -- linear and rotational. **Table 1** shows the relationship between power input and output.

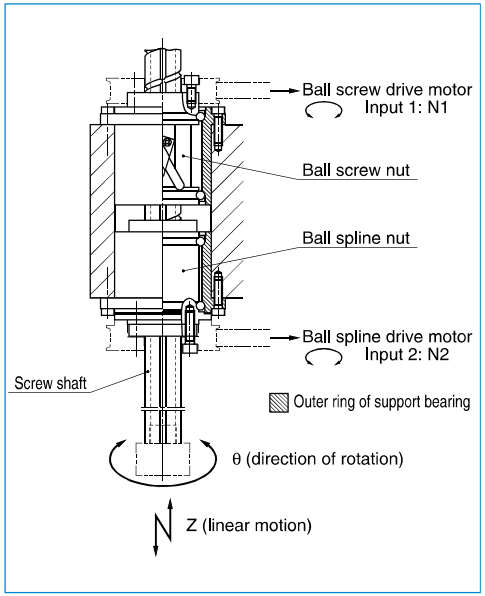


Fig. 1 Example structure of Z axis plus θ axis actuator

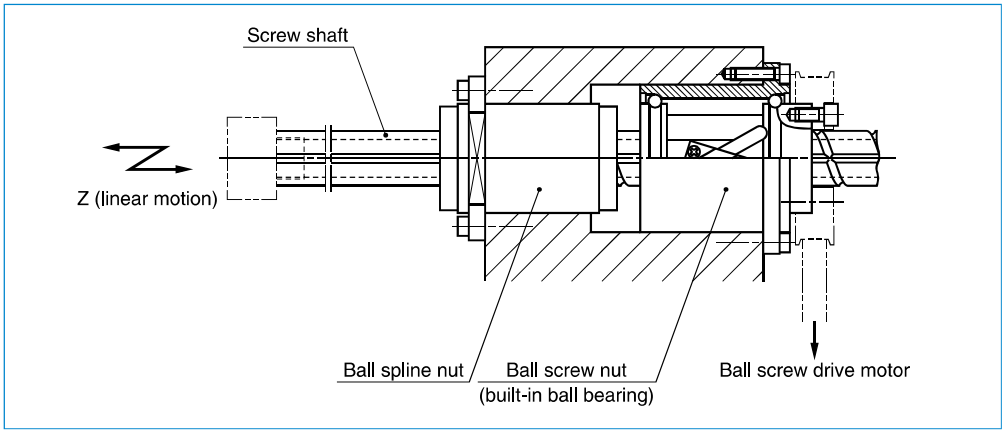


Fig. 2 Example structure of single Z axis unit

Table 1 Power input and output of Σ Series

Shaft movement (output)		Input		
Z (up-down movement) (mm/min)	θ (rotational movement) (min^{-1})	① Ball screw (min^{-1})	② Spline (min^{-1})	Notes
Up, down N1×l	Stop 0	Rotate N1	Stop 0	–
Stop 0	Rotate N2	Rotate N1	Rotate N2	N1 = N2
Up, down N2×l	Rotate N2	Stop 0	Rotate N2	–
Up, down |N1–N2|×l	Rotate N2	Rotate N1	Rotate N2	N1≠N2

3. Specifications

(1) Ball recirculation system

A structure of return tube recirculation system is shown below.

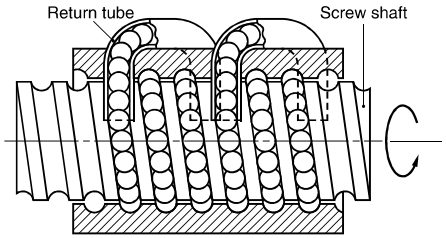


Fig. 3 Structure of return tube recirculation system

(2) Accuracy grade and axial play

The available standard accuracy grade and axial play for ball screw are as follows. The axial play for spline is 0 mm (preloaded product). Please consult NSK for other grades.

Table 2 Accuracy grade and axial play

Accuracy grade	C3, C5, Ct7
Axial play	Z, 0 mm (preloaded) T, 0.005 mm or less; S, 0.020 mm or less

(3) Allowable d•n value and the criterion of maximum rotational speed

Allowable d•n value and the criterion of maximum rotational speed are shown below. Please consult NSK if the rotational speed exceeds the permissible range below.

Permissible d•n value: 70 000 or less

Criterion of maximum rotational speed: 3 000 min^{-1}

Note: Please also review the critical speed.

For details, see "Technical Description: Permissible Rotational Speed" (page B47).

(4) Application

SCALA type and Cartesian type industrial robots, semiconductor manufacturing machines, machines for automobile production facilities, material handling systems, other Z (vertical) axis and Z axis plus θ (rotation) axis actuators.

4. Design precautions

The overall length L can be extended to 25 times of the shaft diameter.

To remove the spline nut from the shaft for assembling, use an arbor as shown in **Fig. 4.** (page B545). Avoid removing ball screw nut as much as possible. Refer to root diameter in the dimension table for arbor diameter. (NSK manufactures the arbors on request.)

For general precautions regarding ball screws, refer to "Precautions in Designing" (page B83) and "Precautions in Handling" (page B103).

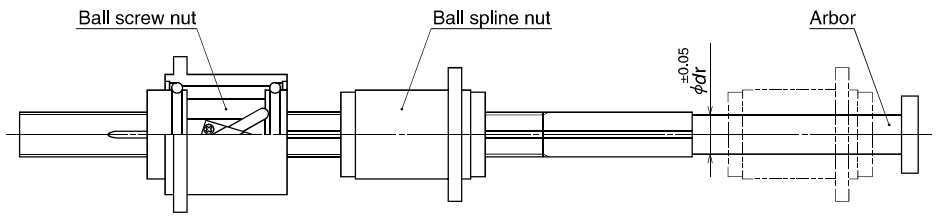
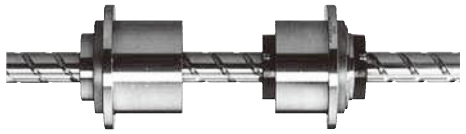


Fig. 4 Removing spline nut

5. Product categories

Σ Series (NSK's Robotte) is four models with different moving functions and performances are available. Select a standard model if rigidity is important. A compact system is recommended for reducing the weight of machine.

Table 3 Σ Series product categories

Model	Appearance	Size	Structure (Movement)
Σ		Standard	Z+θ Unit
ΣZ		Standard	Z Unit
ΣC		Compact	Z+θ Unit
ΣCZ		Compact	Z Unit

6. Load rating and life

The relationship between load rating of the ball spline section and life is the same as in other NSK liner motion products. However, various loads that apply to Robotte must be taken into account. For example, the following factors must be considered in calculating life when the product is used as shown in **Fig. 5.**

Fa : Load that is generated when the shaft moves in up-down direction. (Load is applied to the ball screw nut.)

T : Torque that is generated to the shaft by Fa.

Fr : Load that is generated by moment of inertia of the shaft and the work attached to Robotte as well as by centrifugal force when the arm rotates.

θ : Direction of Fr load that changes by shaft rotation.

NSK has life calculation programs which take these factors into account. Please ask NSK for more details.

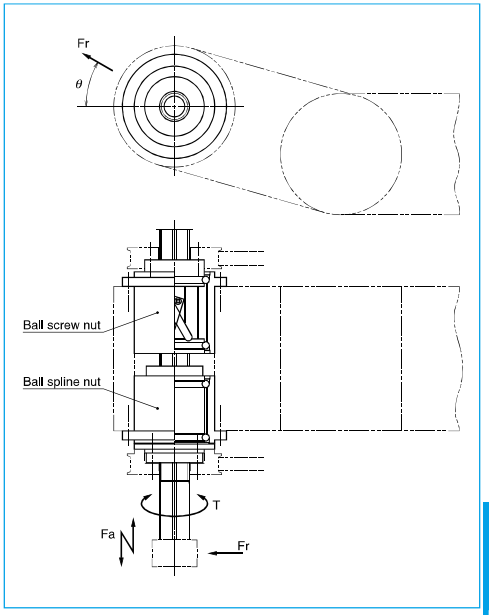


Fig. 5 Example structure of Z axis plus θ axis actuator

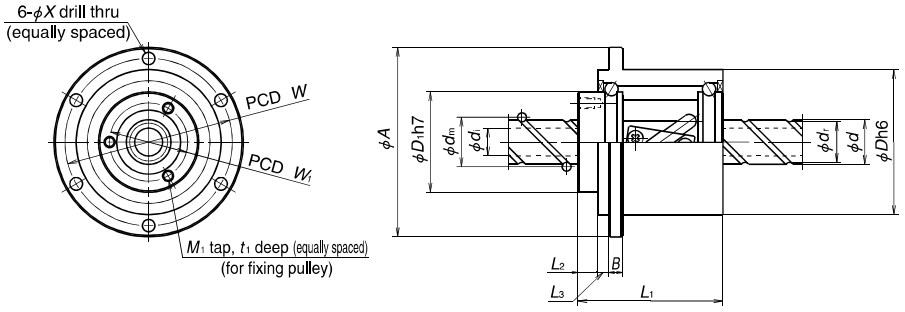
7. Structure of reference number

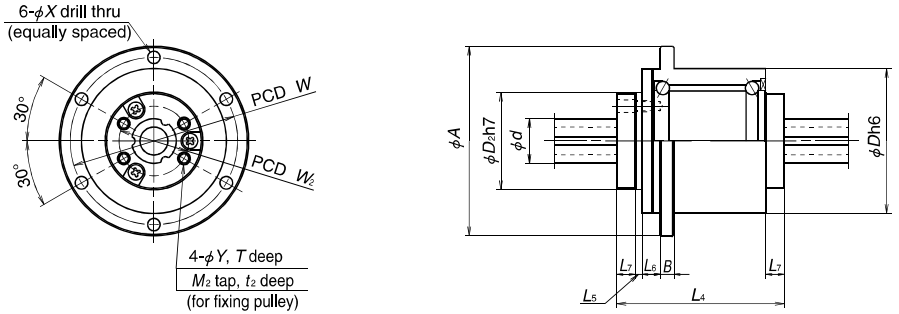
The following describes the structure of "Reference number for ball screw".

◇Reference number for ball screw

PW 25 02 - ** P T U - C5 Z 20

- Product code
- Screw shaft diameter (mm)
- Effective threaded length (in the unit of 100 mm)
- Design serial number
- Preload code: No code, Non-preload; P, P-preload (page B5)
- Hollow shaft ball screw specification
- Use support unit
- Accuracy grade: C3, C5, C7 (Ct7) (page B37 to B42)
- Axial play code: Z, T, S (page B20)
- Lead (mm)

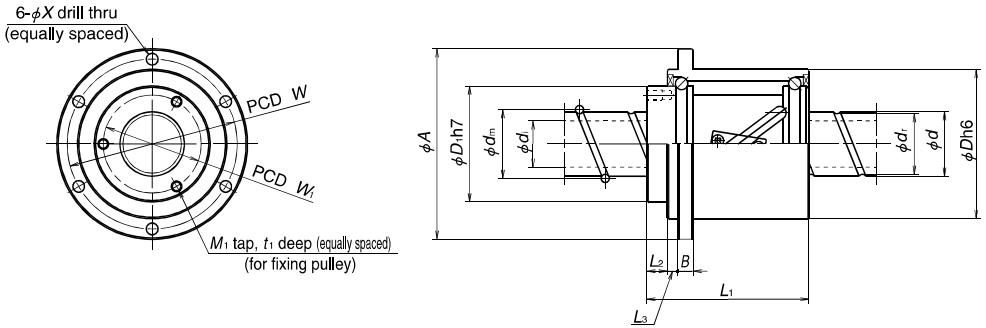


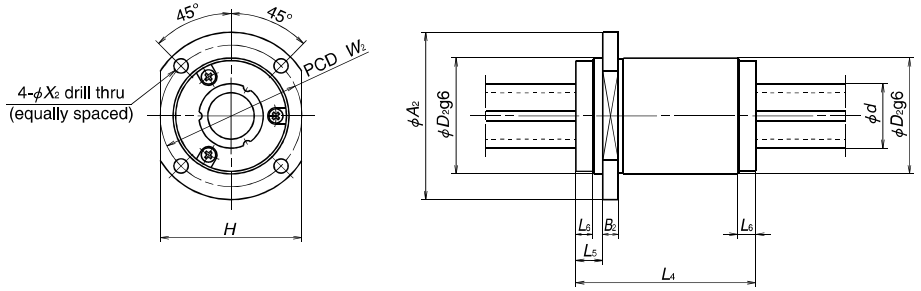


Unit: mm

Model No.	Shaft dia. d	Lead l	Ball dia. D_w	Ball circle dia. d_m	Root dia. d_r	Screw shaft hollow d_i	Ball screw nut: Basic load rating (N) Dynamic C_a	Static C_{0a}	Dimensions D	A	B	L_1	L_2	L_3	M_1	t_1	W_1	D_1	W	X	Moment of inertia (kg·cm²)
Σ1610	16	10	3.175	16.75	13.4	(8)	4 710	8 110	48	64	5	47	7	4	3-M4	6	28	35	56	4.5	0.41
Σ1632		32					2 990	4 870				52									0.44
Σ2010	20	10	3.175	20.75	17.4	(14)	8 210	17 500	54	70	6	57	8	4	3-M4	6	32	40	62	4.5	0.64
Σ2020		20					5 290	10 300				63									0.65
Σ2040		40					3 360	6 170				57									0.64
Σ2510	25	10	3.175	25.75	22.4	(18)	9 110	21 900	58	74	6	57	8	4	3-M4	6	38	45	66	4.5	1.10
Σ2520		20					5 870	13 200				63									1.18
Σ2525		25					5 870	13 200				72									1.30
Σ2550		50					3 730	7 500				64									1.20
Σ3220	32	20	3.175	32.75	29.4	(25)	6 540	16 800	70	95	8	70	10	6	3-M5	10	44	53	82	6.6	2.60
Σ3232		32					6 540	16 800				91									3.15
Σ4020	40	20	3.969	41.0	36.9	(30)	9 770	26 300	85	110	8	73	10	6	4-M5	10	58	67	96	6.6	5.96
Σ4040		40					9 770	26 300				107									7.85
Σ4520	45	20	3.969	46.0	41.9	(35)	10 300	29 700	90	115	8	73	10	6	4-M5	10	63	72	101	6.6	7.73
Σ4540		40					10 300	29 700				107									10.3

Mass (kg)	Ball spline nut: Basic load rating (N) Dynamic C_r	Static C_{0r}	Basic torque (N·m) Dynamic C_t	Static C_{0t}	Dimensions D	A	B	L_4	L_5	L_6	L_7	Y	T	M_2	t_2	W_2	D_2	W	X	Moment of inertia (kg·cm²)	Mass (kg)
0.50	5 530	7 270	61.5	91.3	48	64	5	60	2.5	6.5	6.5	4.5	6.5	M4	7	25	35	56	4.5	0.71	0.63
0.55	5 890	8 000	65.5	100																	
0.74	6 260	8 720	86.3	135	54	70	6	65	2.5	6.5	6.5	5.5	6.5	M5	8	30.5	40	62	4.5	1.15	0.87
0.81	6 610	9 450	91.1	145																	
0.74	6 610	9 450	91.1	145																	
0.81	6 630	9 450	115	185	58	74	6	70	2.5	6.5	6.5	5.5	6.5	M5	8	35.5	45	66	4.5	1.88	1.03
0.88	7 290	10 900	125	210																	
1.00	7 290	10 900	125	210																	
0.91	7 290	10 900	125	210																	
1.46	7 630	11 600	165	285	70	95	8	75	2.5	7.5	6.5	5.5	6.5	M5	8	42	50	82	6.6	3.80	1.62
1.83	7 950	12 400	175	305																	
2.02	10 600	14 800	290	455	85	110	8	80	4	7.5	8	5.5	8	M5	8	55	65	96	6.6	9.74	2.38
2.85	11 200	15 900	305	490																	
2.17	11 200	15 900	340	550	90	115	8	85	4	7.5	8	5.5	8	M5	8	60	70	101	6.6	12.5	2.56
3.06	11 700	17 000	360	590																	

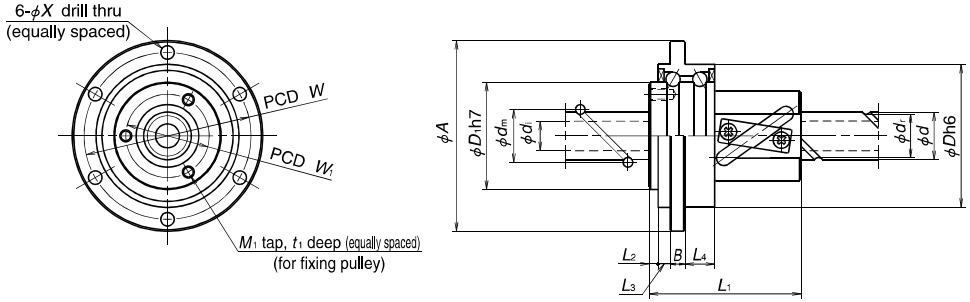


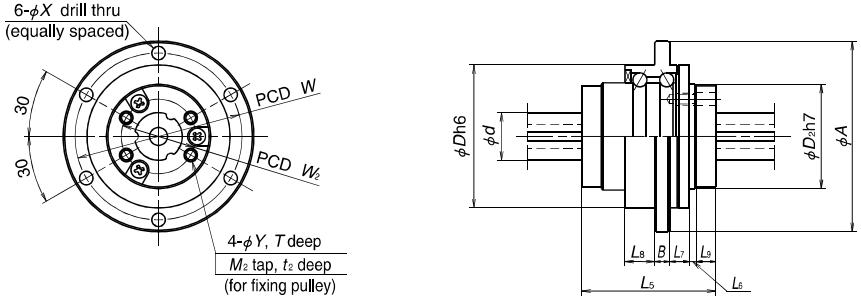


Unit: mm

Model No.	Shaft dia. d	Lead l	Ball dia. D_w	Ball circle dia. d_m	Root dia. d_r	Screw shaft hollow d_1	Ball screw nut: Basic load rating (N) Dynamic C_a	Static C_{0a}	Dimensions D	A	B	L_1	L_2	L_3	M_1	t_1	W_1	D_1	W	X
∑Z1610	16	10	3.175	16.75	13.4	(8)	4 710	8 110	48	64	5	47	7	4	3-M4	6	28	35	56	4.5
∑Z1632		32					2 990	4 870				52								
∑Z2010	20	10	3.175	20.75	17.4	(14)	8 210	17 500	54	70	6	57	8	4	3-M4	6	32	40	62	4.5
∑Z2020		20					5 290	10 300				63								
∑Z2040		40					3 360	6 170				57								
∑Z2510	25	10	3.175	25.75	22.4	(18)	9 110	21 900	58	74	6	57	8	4	3-M4	6	38	45	66	4.5
∑Z2520		20					5 870	13 200				63								
∑Z2525		25					5 870	13 200				72								
∑Z2550		50					3 730	7 500				64								
∑Z3220	32	20	3.175	32.75	29.4	(25)	6 540	16 800	70	95	8	70	10	6	3-M5	10	44	53	82	6.6
∑Z3232		32					6 540	16 800				91								
∑Z4020	40	20	3.969	41.0	36.9	(30)	9 770	26 300	85	110	8	73	10	6	4-M5	10	58	67	96	6.6
∑Z4040		40					9 770	26 300				107								
∑Z4520	45	20	3.969	46.0	41.9	(35)	10 300	29 700	90	115	8	73	10	6	4-M5	10	63	72	101	6.6
∑Z4540		40					10 300	29 700				107								

Moment of inertia (kg·cm²)	Mass (kg)	Ball spline nut: Basic load rating (N) Dynamic C_t	Static C_{0t}	Basic torque (N·m) Dynamic C_t	Static C_{0t}	Dimensions D_2	A_2	B_2	L_4	L_5	L_6	H	W_2	X	Mass (kg)
0.41	0.50	5 530	7 270	61.5	91.3	35	55	6	60	10.5	6.5	45	4.5	4.5	0.35
0.44	0.55	5 890	8 000	65.5	100										
0.64	0.74	6 260	8 720	86.5	135	40	60	6	65	10.5	6.5	50	50	5.5	0.46
0.65	0.81	6 610	9 450	91.1	145										
0.64	0.74	6 610	9 450	91.1	145										
1.10	0.81	6 630	9 450	115	185	45	65	6	70	10.5	6.5	55	55	5.5	0.57
1.18	0.88	7 290	10 900	125	210										
1.30	1.00	7 290	10 900	125	210										
1.20	0.91	7 290	10 900	125	210										
2.60	1.46	7 630	11 600	165	285	50	70	6	75	10.5	6.5	60	60	5.5	0.64
3.15	1.83	7 950	12 400	175	305										
5.96	2.02	10 600	14 800	290	455	65	88	8	80	12	8	76	76	6.6	1.20
7.85	2.85	11 200	15 900	305	490										
7.73	2.17	11 200	15 900	340	550	70	93	8	85	12	8	81	81	6.6	1.39
10.3	3.06	11 700	17 000	360	590										

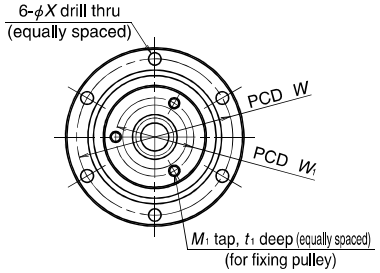


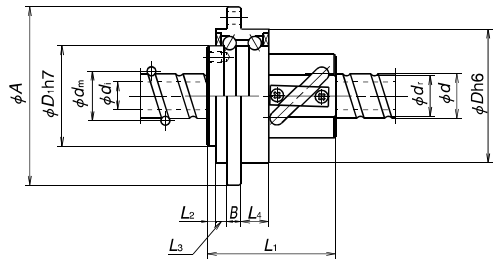


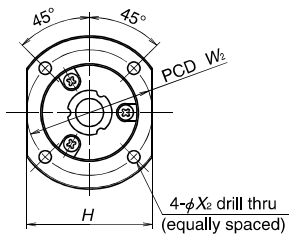
Unit: mm

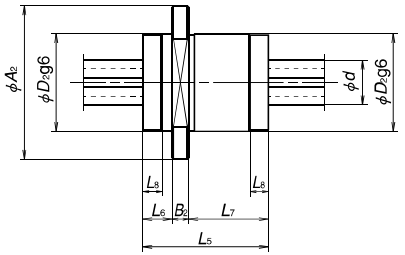
Model No.	Shaft dia.	Lead	Ball dia.	Ball circle dia.	Root dia.	Screw shaft hollow	Ball screw nut															Moment of inertia	Mass
							Basic load rating(N)		Dimensions														
	d	l	D_w	d_m	d_r	d_1	Dynamic C_a	Static C_{0a}	D	A	B	L_1	L_2	L_3	L_4	M_1	t_1	W_1	D_1	W	X	(kg·cm²)	(kg)
∑C1610	16	10	3.175	16.75	13.4	(8)	4 710	8 110	48	64	5	46	3	4	10	3-M4	6	28	35	56	4.5	0.40	
∑C1632		32					2 990	4 870				51										0.43	
∑C2010	20	10	3.175	20.75	17.4	(14)	8 210	17 500	54	70	6	56	4	4	10	3-M4	6	32	40	62	4.5	0.63	
∑C2020		20					5 290	10 300				63										0.65	
∑C2040		40					3 360	6 170				56										0.63	
∑C2510	25	10	3.175	25.75	22.4	(18)	9 110	21 900	58	74	6	56	4	4	10	3-M4	6	38	45	66	4.5	1.04	
∑C2520		20					5 870	13 200				63										1.13	
∑C2525		25					5 870	13 200				71										1.24	
∑C2550		50					3 730	7 500				63										1.13	

Mass	Ball spline nut																							Moment of inertia	Mass
	Basic load rating(N)		Basic torque(N·m)		Dimensions																				
(kg)	Dynamic C_r	Static C_{0r}	Dynamic C_t	Static C_{0t}	D	A	B	L_5	L_6	L_7	L_8	L_9	Y	T	M_2	t_3	W_2	D_2	W	X	(kg·cm²)	(kg)
0.41	4 300	5 090	47.9	63.9	48	64	5	45	2.5	6.5	10	6.5	4.5	6.5	M4	7	25	35	56	4.5	0.52	0.42	
0.43																							
0.53	4 730	5 820	65.1	90.5	54	70	6	50	2.5	6.5	10	6.5	5.5	6.5	M5	8	30.5	40	62	4.5	0.86	0.56	
0.56	5 110	6 540	70.5	100																			
0.53	5 110	6 540	70.5	100																			
0.60	5 130	6 540	87.8	125	58	74	6	55	2.5	6.5	10	6.5	5.5	6.5	M5	8	35.5	45	66	4.5	1.44	0.67	
0.64	5 870	8 000	100	155																			
0.69	5 870	8 000	100	155																			
0.64	5 870	8 000	100	155																			









Unit: mm

Model No.	Shaft dia. d	Lead l	Ball dia. D_w	Ball circle dia. d_m	Root dia. d_r	Screw shaft hollow d_1	Ball screw nut: Basic load rating(N) Dynamic C_a	Ball screw nut: Basic load rating(N) Static C_{0a}	Dimensions D	A	B	L_1	L_2	L_3	L_4	M_1	t_1	W_1	D_1	W	X
∑CZ1610	16	10	3.175	16.75	13.4	(8)	4 710	8 110	48	64	5	46	3	4	10	3-M4	6	28	35	56	4.5
∑CZ1632		32					2 990	4 870				51									
∑CZ2010	20	10	3.175	20.75	17.4	(14)	8 210	17 500	54	70	6	56	4	4	10	3-M4	6	32	40	62	4.5
∑CZ2020		20					5 290	10 300				63									
∑CZ2040		40					3 360	6 170				56									
∑CZ2510	25	10	3.175	25.75	22.4	(18)	9 110	21 900	58	74	6	56	4	4	10	3-M4	6	38	45	66	4.5
∑CZ2520		20					5 870	13 200				63									
∑CZ2525		25					5 870	13 200				71									
∑CZ2550		50					3 730	7 500				63									

Moment of inertia (kg·cm²)	Mass (kg)	Ball spline nut: Basic load rating(N) Dynamic C_t	Basic load rating(N) Static C_{0r}	Basic torque(N·m) Dynamic C_t	Basic torque(N·m) Static C_{0t}	Dimensions D_2	A_2	B_2	L_5	L_6	L_7	L_8	H	W_2	X_2	Mass (kg)
0.40	0.41	4 300	5 090	47.9	63.9	35	55	6	45	10.5	28.5	6.5	45	45	4.5	0.26
0.43	0.43															
0.63	0.53	4 730	5 820	65.1	90.5	40	60	6	50	10.5	33.5	6.5	50	50	5.5	0.35
0.65	0.56	5 110	6 540	70.5	100											
0.63	0.53	5 110	6 540	70.5	100											
1.04	0.60	5 130	6 540	87.8	125	45	65	6	55	10.5	38.5	6.5	55	55	5.5	0.44
1.13	0.64	5 870	8 000	100	155											
1.24	0.69	5 870	8 000	100	155											
1.13	0.64	5 870	8 000	100	155											