

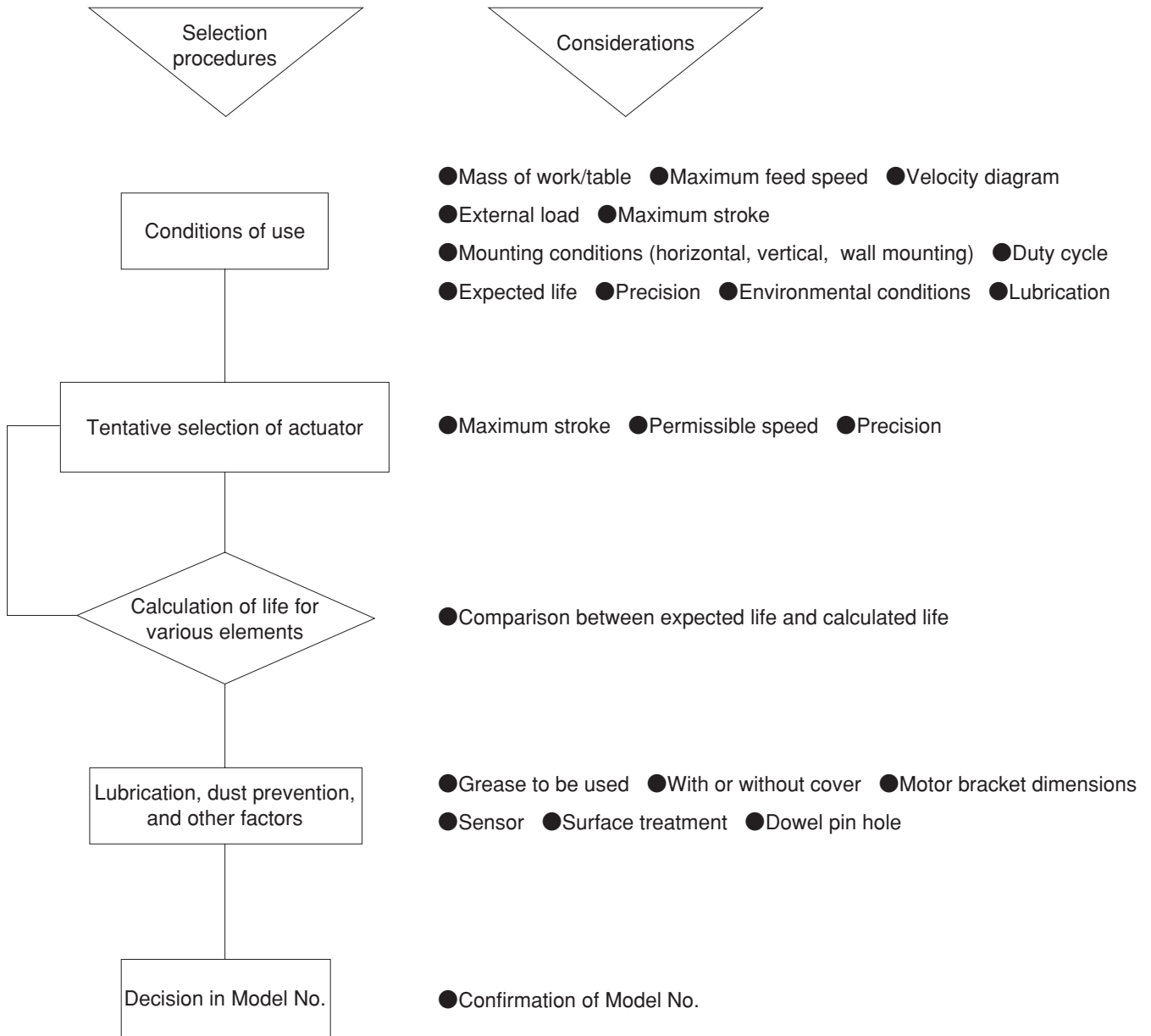
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BALLSCREW ACTUATOR SELECTION GUIDE

Similar to ball screw selections, there is no instant way of selecting appropriate ballscrew actuators for various purposes. The following is an example of general procedures in actuator selection, with some considerations to be made on each step and pages to refer to.



Technical Data

LIFE EXPECTANCY

The shortest life expectancy of among guid-rail, ballscrew and support bearing can be defined as the life expectancy of ballscrew actuators, SE, SG, and SC series.

The following formula is used to calculate the life expectancy.

LIFE EXPECTANCY OF GUIDE

Calculate the life expectancy of guide using the following formula:

$$L_G = \left(\frac{f_c \cdot C}{f_w \cdot P_T} \right)^3 \cdot 50 \quad \text{Formula (1)}$$

L_G : Life expectancy operational length (km)

f_c : Contact factor (see Table 1)

f_w : Load factor (see Table 2)

C : Basic dynamic load rating (N)

P_T : Calculated load per block (N)

Calculation of P_T

To calculate the life expectancy using Formula (1), you need to obtain the calculated load per block (P_T) in consideration of actual moment load.

If the acceleration is high or short-stroke operation is conducted, calculate P_T in consideration of acceleration. This acceleration calculation is made for a mass loaded on SG, SE, and SC.

Obtain the calculated load in uniform motion, accelerated motion, and decelerated motion, and its average figure is used as P_T .

For the calculation of P_T , select a calculation formula according to the installation conditions.

If acceleration needs not to be considered,

$P_T = P_{TC}$ (See Formula (2), (5) and (8)) can be used for calculation. However, you can calculate only the approximate value in this formula, therefore it is recommended that you calculate the life expectancy with an ample margin.

Table 1 Contact factor (f_c)

Number of blocks to be used in contact, when single axis module is used.	Contact factor (f_c)
1	0.1
2	0.81

Table 2 Load factor (f_w)

Operating condition		Load factor (f_w)
Vibration and shock	Speed	
Zero	15m/min or less	1.0~1.5
Small	60m/min or less	1.0~2.0
Large	60m/min or more	2.0~3.5

Table 3 Moment equivalent factor

	$E_p(E2p)$	$E_y(E2p)$	$E_r(E2r)$
SG20**A	2.25×10^{-1}	1.89×10^{-1}	7.84×10^{-2}
SG20**B	3.98×10^{-2}	3.34×10^{-2}	3.92×10^{-2}
SG26**A	1.51×10^{-1}	1.27×10^{-1}	5.88×10^{-2}
SG26**B	2.72×10^{-2}	2.28×10^{-2}	2.94×10^{-2}
SG33**A	1.26×10^{-1}	1.06×10^{-1}	4.55×10^{-2}
SG33**B	2.20×10^{-2}	1.84×10^{-2}	2.27×10^{-2}
SG33**C	2.31×10^{-1}	1.94×10^{-1}	4.55×10^{-2}
SG33**D	3.09×10^{-2}	2.59×10^{-2}	2.27×10^{-2}
SG46**A	8.39×10^{-2}	7.04×10^{-2}	3.17×10^{-2}
SG46**B	1.56×10^{-2}	1.31×10^{-2}	1.59×10^{-2}
SG46**C	1.39×10^{-1}	1.17×10^{-1}	3.17×10^{-2}
SG46**D	2.15×10^{-2}	1.18×10^{-2}	1.59×10^{-2}
SG55**A	6.80×10^{-2}	5.71×10^{-2}	2.74×10^{-2}
SG55**B	1.35×10^{-2}	1.14×10^{-2}	1.37×10^{-2}
SE15**A	2.70×10^{-1}	2.45×10^{-1}	9.64×10^{-2}
SE15**B	4.50×10^{-2}	3.80×10^{-2}	4.82×10^{-2}
SE23**A	1.52×10^{-1}	1.37×10^{-1}	5.22×10^{-2}
SE23**B	2.54×10^{-2}	2.29×10^{-2}	2.61×10^{-2}
SE30**A	1.17×10^{-1}	9.83×10^{-2}	4.54×10^{-2}
SE30**B	1.95×10^{-2}	1.64×10^{-2}	2.27×10^{-2}
SE45**A	8.39×10^{-2}	7.04×10^{-2}	3.17×10^{-2}
SE45**B	1.56×10^{-2}	1.31×10^{-2}	1.59×10^{-2}
SE45**C	1.26×10^{-1}	1.06×10^{-1}	3.17×10^{-2}
SE45**D	2.10×10^{-2}	1.76×10^{-2}	1.59×10^{-2}
SC23**A	1.52×10^{-1}	1.37×10^{-1}	5.22×10^{-2}
SC30**A	1.17×10^{-1}	9.83×10^{-2}	4.54×10^{-2}
SC45**A	8.39×10^{-2}	7.04×10^{-2}	3.17×10^{-2}

(Note) The specifications of a model with two blocks show factors when the two blocks are used in contact.

● P_T in the case of Horizontal Movement (Horizontal Installation)

① For uniform motion (P_{Tc})

$$P_{Tc} = \frac{1}{n} \cdot W + E_p \cdot M_{pL} + E_y \cdot M_{yL} + E_r \cdot M_{rL} \text{——Formula (2)}$$

② For accelerated motion (P_{Ta})

$$P_{Ta} = \frac{1}{n} \cdot W + E_p (M_{pL} + m \cdot a_a \cdot Z) + E_y (M_{yL} + m \cdot a_a \cdot X) + E_r \cdot M_{rL} \text{——Formula (3)}$$

If item $(M_{pL} + m \cdot a_a \cdot Z)$ or $(M_{yL} + m \cdot a_a \cdot X)$ is a negative value, the value should be set to 0.

③ For decelerated motion (P_{Td})

$$P_{Td} = \frac{1}{n} \cdot W + E_p (M_{pL} + m \cdot a_d \cdot Z) + E_y (M_{yL} + m \cdot a_d \cdot X) + E_r \cdot M_{rL} \text{——Formula (4)}$$

If item $(M_{pL} + m \cdot a_d \cdot Z)$ or $(M_{yL} + m \cdot a_d \cdot X)$ is a negative value, the value should be set to 0.

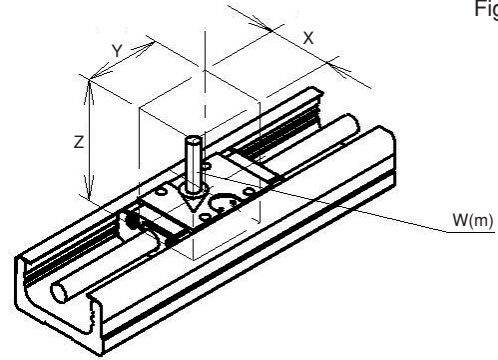


Figure 1

If a load is applied from a different direction other than W (m) in this figure, contact KURODA.

P_{Tc} : Calculated load per block in uniform motion (N)

P_{Ta} : Calculated load per block in accelerated motion (N)

P_{Td} : Calculated load per block in decelerated motion (N)

n : Number of block of SG / SE / SC

W : Load (N)

m : Load mass (kg)

a_a : Acceleration in accelerated motion (m/sec²)

a_d : Acceleration in decelerated motion (m/sec²) (with a minus sign)

X : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Y : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Z : Distance from center of SG / SE / SC ballscrew to center of gravity of loaded mass (mm)

E_p : Moment equivalent factor in pitching direction (see Table 3)

E_y : Moment equivalent factor in yawing direction (see Table 3)

E_r : Moment equivalent factor in rolling direction (see Table 3)

M_{pL} : Load moment in pitching direction (N·mm)

$$M_{pL} = W \cdot Y$$

M_{yL} : Load moment in yawing direction (N·mm)

$$M_{yL} = 0 \text{ (The load moment is zero under this usage.)}$$

M_{rL} : Load moment in rolling direction (N·mm)

$$M_{rL} = W \cdot X$$

(Note) For the moment directions, see Pages 3, 53 and 91.

● P_T in the Case of Horizontal Movement (Wall Installation)

① For uniform motion (P_{Tc})

$$P_{Tc} = \frac{1}{1.19 \cdot n} \cdot W + E_p \cdot M_{pL} + E_y \cdot M_{yL} + E_r \cdot M_{rL} \text{——Formula (5)}$$

② For accelerated motion (P_{Ta})

$$P_{Ta} = \frac{1}{1.19 \cdot n} \cdot W + E_p (M_{pL} + m \cdot a_a \cdot Z) + E_y (M_{yL} + m \cdot a_a \cdot X) + E_r \cdot M_{rL} \text{——Formula (6)}$$

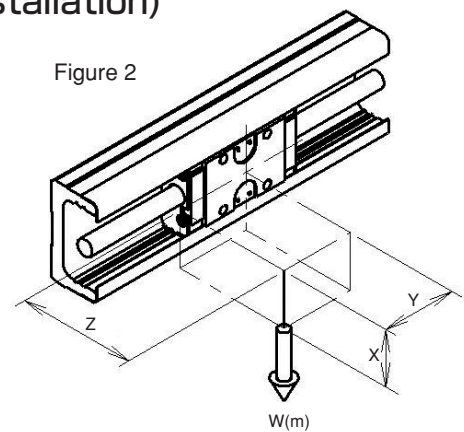
If item $(M_{pL} + m \cdot a_a \cdot Z)$ or $(M_{yL} + m \cdot a_a \cdot X)$ is a negative value, the value should be set to 0.

③ For decelerated motion (P_{Td})

$$P_{Td} = \frac{1}{1.19 \cdot n} \cdot W + E_p (M_{pL} + m \cdot a_d \cdot Z) + E_y (M_{yL} + m \cdot a_d \cdot X) + E_r \cdot M_{rL} \text{——Formula (7)}$$

If item $(M_{pL} + m \cdot a_d \cdot Z)$ or $(M_{yL} + m \cdot a_d \cdot X)$ is a negative value, the value should be set to 0.

Figure 2



If load is applied from a different direction other than W (m), contact KURODA.

P_{Tc} : Calculated load per block in uniform motion (N)

P_{Ta} : Calculated load per block in accelerated motion (N)

P_{Td} : Calculated load per block in decelerated motion (N)

n : Number of block of SG / SE / SC

W : Load (N)

m : Load mass (kg)

a_a : Acceleration in accelerated motion (m/sec²)

a_d : Acceleration in decelerated motion (m/sec²) (with a minus sign)

X : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Y : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Z : Distance from center of SG / SE / SC ballscrew to center of gravity of loaded mass (mm)

E_p : Moment equivalent factor in pitching direction (see Table 3)

E_y : Moment equivalent factor in yawing direction (see Table 3)

E_r : Moment equivalent factor in rolling direction (see Table 3)

M_{pL} : Load moment in pitching direction (N·mm)

$$M_{pL} = 0 \text{ (The load moment is zero under this usage.)}$$

M_{yL} : Load moment in yawing direction (N·mm)

$$M_{yL} = W \cdot Y$$

M_{rL} : Load moment in rolling direction (N·mm)

$$M_{rL} = W \cdot Z$$

(Note) For the moment directions, see Pages 3, 53 and 91.

● P_T in the Case of Vertical Movement

① For uniform motion (P_{TC})

$$P_{TC} = E_p \cdot M_{pL} + E_y \cdot M_{yL} + E_r \cdot M_{rL} \text{ — Formula (8)}$$

② For accelerated motion (P_{Ta})

$$P_{Ta} = E_p (M_{pL} + m \cdot a_a \cdot Z) + E_y (M_{yL} + m \cdot a_a \cdot X) + E_r \cdot M_{rL} \text{ — Formula (9)}$$

If item $(M_{pL} + m \cdot a_a \cdot Z)$ or $(M_{yL} + m \cdot a_a \cdot X)$ is a negative value, the value should be set to 0.

③ For decelerated motion (P_{Td})

$$P_{Td} = E_p (M_{pL} + m \cdot a_d \cdot Z) + E_y (M_{yL} + m \cdot a_d \cdot X) + E_r \cdot M_{rL} \text{ — Formula (10)}$$

If item $(M_{pL} + m \cdot a_d \cdot Z)$ or $(M_{yL} + m \cdot a_d \cdot X)$ is a negative value, the value should be set to 0.

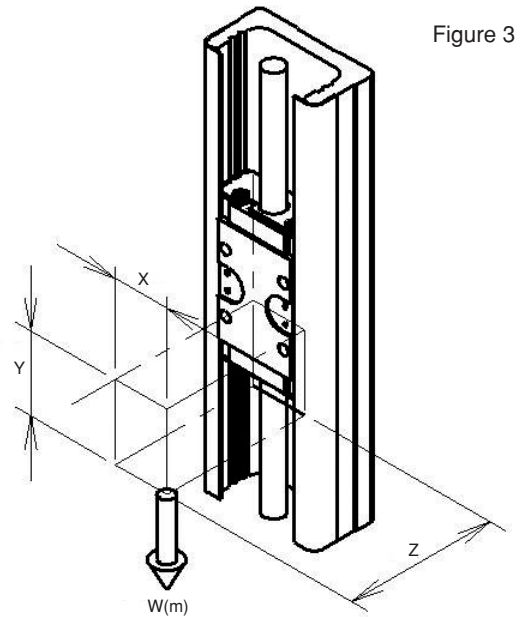


Figure 3

If load is applied from a different direction other than W (m) in this figure, contact KURODA.

P_{TC} : Calculated load per block in uniform motion (N)

P_{Ta} : Calculated load per block in accelerated motion (N)

P_{Td} : Calculated load per block in decelerated motion (N)

n : Number of block of SG / SE / SC

W : Load (N)

m : Load mass (kg)

a_a : Acceleration in accelerated motion (m/sec²)

a_d : Acceleration in decelerated motion (m/sec²) (with a minus sign)

X : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Y : Distance from center of SG / SE / SC to center of gravity of loaded mass (mm)

Z : Distance from center of SG / SE / SC ballscrew to center of gravity of loaded mass (mm)

E_p : Moment equivalent factor in pitching direction (see Table 3)

E_y : Moment equivalent factor in yawing direction (see Table 3)

E_r : Moment equivalent factor in rolling direction (see Table 3)

M_{pL} : Load moment in pitching direction (N·mm)

$$M_{pL} = W \cdot Z$$

M_{yL} : Load moment in yawing direction (N·mm)

$$M_{rL} = W \cdot X$$

M_{rL} : Load moment in rolling direction (N·mm)

$$M_{yL} = 0 \text{ (The load moment is zero under this usage.)}$$

(Note) For the moment directions, see Pages 3, 53 and 91.

● Using one of the above calculation formulas according to your usage, calculate average load in each motion to obtain calculated load per block (P_T).

$$P_T = \sqrt[3]{\frac{1}{(S1+S2+S3)} (P_{Ta}^3 \cdot S1 + P_{TC}^3 \cdot S2 + P_{Td}^3 \cdot S3)} \text{ — Formula (11)}$$

P_T : Calculated load per block (N)

$S1$: Traveling distance in accelerated motion (mm) (see Figure 4)

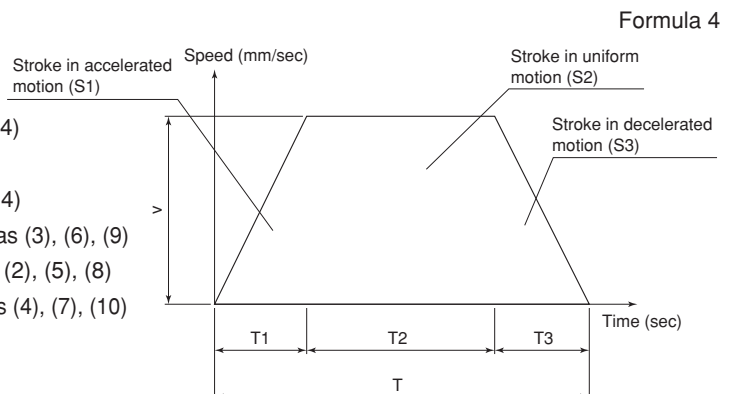
$S2$: Traveling distance in uniform motion (mm) (see Figure 4)

$S3$: Traveling distance in decelerated motion (mm) (see Figure 4)

P_{Ta} : Calculated load per block in accelerated motion (N) - Formulas (3), (6), (9)

P_{TC} : Calculated load per block in uniform motion (N) - Formulas (2), (5), (8)

P_{Td} : Calculated load per block in decelerated motion (N) - Formulas (4), (7), (10)



Formula 4

● LIFE EXPECTANCIES OF BALL SCREW AND SUPPORT BEARING

The life expectancies of the ball screw and the support bearing can be calculated using the following common calculation formula shown as below. Therefore, compare the dynamic load ratings of the ball screw and the support bearing and substitute a smaller value in the formula for calculation.

$$L_a = \left(\frac{1}{f_w} \cdot \frac{C_a \text{ or } C_b}{P_a} \right)^3 \cdot \ell \text{ ————— Formula (12)}$$

L_a : Life expectancy operational length (km)
 f_w : Load factor (see Table 2)
 C_a : Basic dynamic load rating of ball screw (N)
 C_b : Basic dynamic load rating of support bearing (N)
 P_a : Axial load (N)
 ℓ : Ball screw lead (mm)

● Calculation of P_a

To calculate the life expectancy using Formula (6), calculate P_a in consideration of acceleration. Calculate the axial load in uniform, accelerated, and decelerated motions and its average figure is used as P_a .

● In the Case of Horizontal Movement

① For uniform motion (P_{ac})

$$P_{ac} = m \cdot W + F + F_b \cdot n \text{ ————— Formula (13)}$$

② For accelerated motion (P_{aa})

$$P_{aa} = m \cdot W + F + f_b \cdot n + (m + m_b \cdot n) \alpha_a \text{ ————— Formula (14)}$$

③ For decelerated motion (P_{ad})

$$P_{ad} = m \cdot W + F + f_b \cdot n - (m + m_b \cdot n) \alpha_d \text{ ————— Formula (15)}$$

P_{ac} : Axial load rating in uniform motion (N)
 P_{aa} : Axial load rating in accelerated motion (N)
 P_{ad} : Axial load rating in decelerated motion (N)
 μ : Friction factor (0.006)
 W : Load on block (N)
 F : External force (load) in axial direction (N)
 f_b : Slide resistance per block (N) (see Table 4)
 n : Number of blocks of SG / SE
 m : Load mass (kg)
 m_b : Block mass of SG / SE (kg)
 g : Gravitational acceleration (9.8 m / sec²)
 α_a : Acceleration in accelerated motion (m / sec²)
 α_d : Acceleration in decelerated motion (m / sec²)

● In the Case of Vertical Movement

① For uniform motion (P_{ac})

$$P_{ac} = (m + m_b \cdot n) g + F + f_b \cdot n \text{ ————— Formula (16)}$$

② For accelerated motion (P_{aa})

$$P_{aa} = (m + m_b \cdot n) \cdot (g + \alpha_a) + F + f_b \cdot n_a \text{ ————— Formula (17)}$$

③ For decelerated motion (P_{ad})

$$P_{ad} = (m + m_b \cdot n) \cdot (g - \alpha_d) + F + f_b \cdot n_d \text{ ————— Formula (18)}$$

● Using one of the above calculation formulas according to your usage, calculate an average axial load (P_a).

$$P_a = \sqrt[3]{\frac{1}{(S1+S2+S3)} (P_{aa}^3 \cdot S1 + P_{ac}^3 \cdot S2 + P_{ad}^3 \cdot S3)} \text{ ————— Formula (19)}$$

P_a : Average axial load (N)

$S1$: Traveling distance in accelerated motion (mm) (see Figure 4)

$S2$: Traveling distance in uniform motion (mm) (see Figure 4)

$S3$: Traveling distance in decelerated motion (mm) (see Figure 4)

P_{aa} : Axial load in accelerated motion (N) - Formulas (14), (17)

P_{ac} : Axial load in uniform motion (N) - Formulas (13), (16)

P_{ad} : Axial load in decelerated motion (N) - Formulas (15), (18)

Table 4 Slide resistance per block (f_b) (seal resistance)
(Unit: N)

Model No.	Accuracy grade	
	H	P
SG20	2.3	4.9
SG26	5.4	9.8
SG33	4.4	10.2
SG46	7.4	13.3
SG55	9	16

(Unit: N)

Model No.	Accuracy grade
	U/W
SE15	2.0
SE23, SC23	2.5
SE30, SC30	2.5
SE45, SC45	7.5

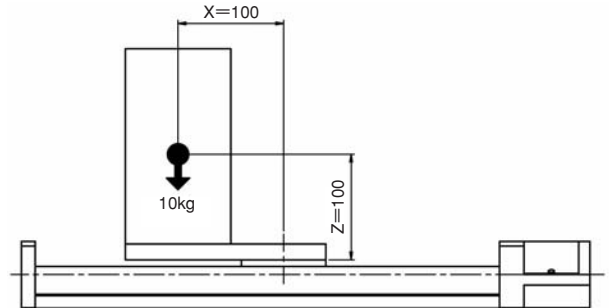
EXAMPLE OF BALLSCREW ACTUATOR SELECTION

● Linear motion robot - X-axis

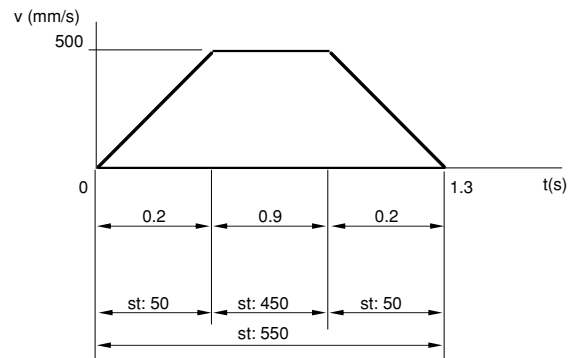
<Specifications>

Mass of work and table: M	10kg
Load distribution	See right side diagram.
Maximum stroke: st	550mm
Fast-feed speed: v	500mm/s
Acceleration/deceleration time constant: t	0.2 s
Maximum motor speed	6000min ⁻¹
Orientating orientation	Horizontal
Repeated positioning accuracy	±0.01 mm or less
Expected life	30,000h

Load distribution diagram



Duty cycle model diagram



① Tentatively select SE4510A-740W-A1NN-NN in SE series, based on the conditions such as stroke and speed.

② Calculation of life expectancy

②-1. Calculating life expectancy of guide

Considering the usage with moment being loaded, average load and life expectancy were calculated in accordance with "LIFE EXPECTANCY OF GUIDE" on page 111, and they resulted in 1,274 N and 39,030 hours, respectively. The load coefficient for the above calculation was determined to be 2, based on the conditions of use.

②-2. Calculating expected life of ball screw and support bearings

Average axial load and life expectancy were calculated in accordance with "LIFE EXPECTANCIES OF BALL SCREW AND SUPPORT BEARING" on page 114, and the axial load resulted in 14.9 N and expected life of both ball screw and support bearing in over a million hours. The load coefficient for the above calculation was determined to be 2, based on the conditions of use.

③ Results of the selection

The above calculation results of life expectancies confirmed that the tentatively selected model would satisfy the required specifications. Since there is no other particular specification to be further considered, the model is selected officially.

Selected model of ballscrew actuator: SE4510A-740W-A1NN-NN

If longer life expectancy than the calculated life is preferred, make re-calculation after changing specifications, such as upgrading model size or adding extra slide block.

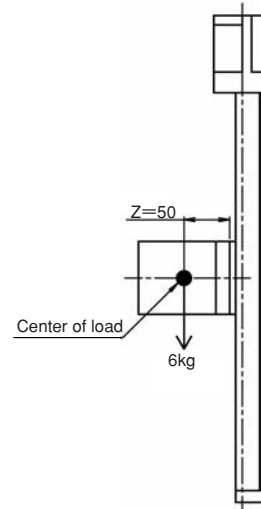
EXAMPLE OF BALLSCREW ACTUATOR SELECTION

● Lift - Z-axis

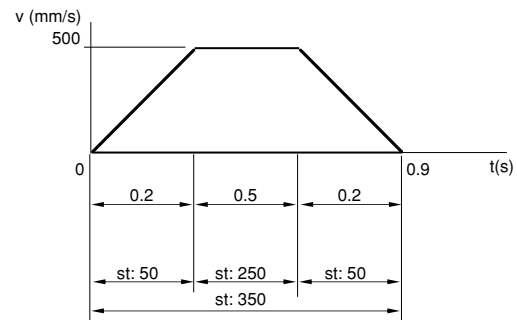
<Specifications>

Mass of work and table: M	6kg
Load distribution	See right side diagram.
Maximum stroke: st	350mm
Fast-feed speed: v	500mm/s
Acceleration/deceleration time constant: t	0.2 s
Maximum motor speed	6000min ⁻¹
Orientating orientation	Vertical
Repeated positioning accuracy	±0.003 mm or less
Life expectancy	40,000h

Load distribution diagram



Duty cycle model diagram



① Tentative selection of ballscrew actuator

Tentatively select SG3310A-500H-A0NN-NN in SG series, based on the conditions such as strokes and speed.

② Calculation of life expectancy

②-1. Calculating life expectancy of guide

Considering the usage with moment being loaded, average load and life expectancy were calculated in accordance with "LIFE EXPECTANCY OF GUIDE" on page 111, and they resulted in 805 N and 17,166 hours, respectively. The load coefficient for the above calculation was determined to be 2, based on the conditions of use.

②-2. Calculating expected life of ball screw and support bearing

Average axial load and life expectancy were calculated in accordance with "LIFE EXPECTANCIES OF BALL SCREW AND SUPPORT BEARING" on page 114, and the axial load resulted in 60N and expected life of ball screw and support bearing in 44,202 and 353,620 hours, respectively. The load coefficient for the above calculation was determined to be 2, based on the conditions of use.

③ Results of the selection

According to the above results of life expectancies, the life of the guide does not satisfy the life expectancy requirement. Since the ball screw and support bearing have satisfactory life expectancies, make re-calculation after changing the block on the guide. Leaving the guide rail length and required stroke as they are, change the model to SG3310D-500H-A0NN-NN.

④ Re-calculation of life

As in the previous step, average load and life expectancy were calculated in accordance with "LIFE EXPECTANCY OF GUIDE" on page 111, and they resulted in 198 N (load per block) and 146,740 hours, respectively.

⑤ Results of the re-selection

The results of re-calculation of life expectancy of the guide confirmed that the selected model would satisfy required hours of life expectancy.

Purchase Source: GROUP SIX (USA)
info@grp6.com 978-752-2255

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info@grp6.com 978-752-2255

BALLSCREW ACTUATOR SPECIFICATION DATA SHEET

Company Name		Date	
Department		Contact personnel	
Address		Tel • Fax	
Name of equipment/machine used		Location of use	
Drawing/conceptual drawing attached?	<input type="checkbox"/> Yes	pieces of pages	<input type="checkbox"/> No

Conditions of Use (Either unit system may be used.)

Mass of work and table				
Operating orientation	<input type="checkbox"/> Horizontal	<input type="checkbox"/> Vertical	<input type="checkbox"/> Wall installation	<input type="checkbox"/> Other
Maximum table speed	1000 mm/s	Maximum table stroke		
Mount/support method	<input type="checkbox"/> Fixed - support (standard)	<input type="checkbox"/> Fixed - fixed (semi-fixed)	<input type="checkbox"/> Fixed - free	<input type="checkbox"/> Support - support
Moving conditions	Oscillation	<input type="checkbox"/> Yes	<input type="checkbox"/> No	Range of oscillation m m
Vibration impact level				
Expected life				

Operating conditions (Select either Case A or B below and describe the operating conditions)

Case A (when axial load and revolving speed can be classified into several patterns) - Please attach a separate document if your descriptions do not fit in the following table.

No. of patterns	Axial load	Revolving speed	Hours or ratio of use
1			
2			
3			

Case B (when largely impacted by inertial force) - Please attach a separate document if your descriptions do not fit in the following table.

No. of patterns	Strokes	Table speed	Acceleration time	Constant-speed time	Deceleration time
1					
2					
3					

Load distribution (see below) X = Y = Z =

Horizontal		Vertical		Wall installation	
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Lubrication	Grease (brand)	Unless otherwise specified, Multemp PS No.2 Grease (KYODO YUSHI CO., LTD.) will be used as lubricant.						
Environmental conditions	Temp.	Dust	Humidity	Gas	Liquid	Clean room	Vacuum	Others
Name of motor					Parallel motor mounting	<input type="checkbox"/> Required	<input type="checkbox"/> Not required	
Actuator quantity per a machine					Quantity for prototype			
Quantity for mass production					Change control	<input type="checkbox"/> Yes	<input type="checkbox"/> No	

Ball screw actuator specifications

Size	Lead	Slide block	Guide rail length	Precision grade
Dust-preventive cover	Sensor	Surface treatment		

Additional description/request

KURODA office		Contact personnel
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Technical Data