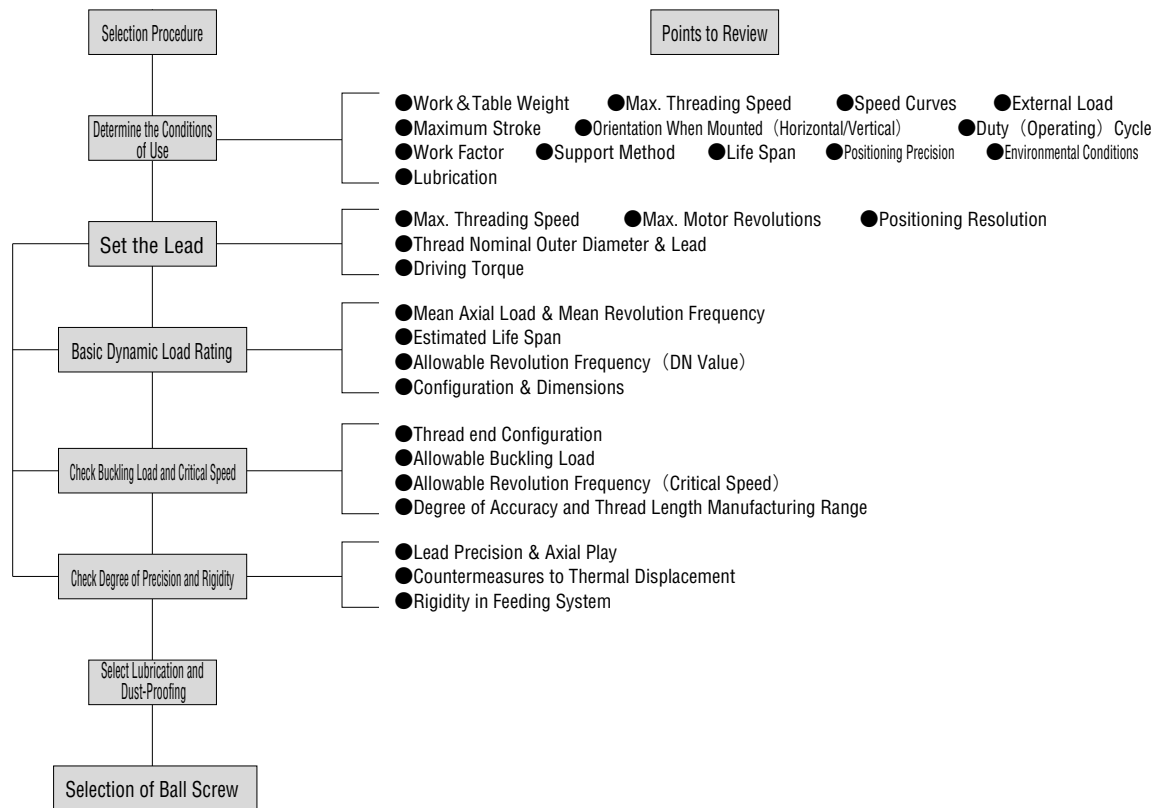


Technical Calculations Selection of Ball Screws 1

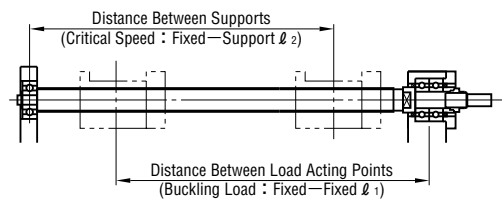
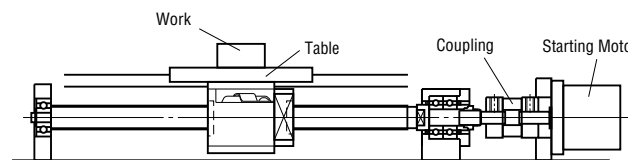
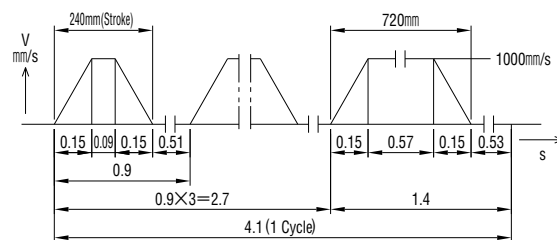
Selection Process



Example of Selection of Ball Screws (For X-Axis of Orthogonal Robot)

1. Conditions of Use

- Work & Table Weight $W=50(\text{kg})$
- Maximum Stroke $S_{\text{max}}=720(\text{mm})$
- Threading Speed $V_{\text{max}}=1000(\text{mm/s})$
- Acceleration Constant $t=0.15(\text{s})$
- Positioning Precision $\pm 0.1/720(\text{mm})$
- Repeat Accuracy $\pm 0.01(\text{mm})$
- Life Span $L_h=30000$ hours
- Direct Acting Guide Coefficient of Friction $\mu=0.02$
- Driving Motor $N_{\text{max}}=3000(\text{r/min})$
- Duty Cycle Model Diagram



2. Setting Lead (L)

Set lead based on maximum motor revolutions and threading speed. Use the following formula :

$$L \geq \frac{V_{\text{max}} \geq 60}{N_{\text{max}}} = 20 (\text{mm})$$

3. Calculating Basic Dynamic Load Rating

Examines the required basic dynamic load rating and the Allowable Revolution Frequency (DN Value)

Calculation of axial load for each operating pattern

① In Acceleration

$$\text{Acceleration } (\alpha) = \frac{V_{\text{max}}}{t} \times 10^{-3} = 6.7 (\text{m/s}^2)$$

$$\text{Axial Load } (P_a) = (W \cdot \alpha + \mu \cdot W \cdot g) \times 10^{-1} = 34.5 (\text{daN})$$

(g : Gravitational Acceleration 9.8m/s²)

② At Constant Speed

$$\text{Axial Load } (P_b) = \mu \cdot W \cdot g \times 10^{-1} = 1 (\text{daN})$$

③ In Deceleration

$$\text{Axial Load } (P_c) = (W \cdot \alpha - \mu \cdot W \cdot g) \times 10^{-1} = 32.5 (\text{daN})$$

Operating Time (s) Per 1 Cycle for Each Operating Pattern (s)

Operating Pattern	A	B	C	Total Operating Time
Operating Time	0.60	0.84	0.60	2.04

Load Conditions for a Lead of 20

Operating Pattern	A	B	C
Axial Load	34.5daN	1daN	32.5daN
Number of Revolutions	1500r/min	3000r/min	1500r/min
Operating Time Ratio	29.4%	41.2%	29.4%

Calculating the mean axial load (P_m) and the mean turns (N_m) by load conditions (P.1569①, ②),

$$P_m = 25 (\text{daN}) \quad N_m = 2118 (\text{r/min})$$

Calculation of the required basic dynamic load rating (C)

The actual life span in running (L_{ho}), which excludes downtime, is as follows:

$$L_{ho} = 30000 \left(\frac{2.04}{4.1} \right) = 14927 (\text{hrs})$$

Insert the work factor (f_w) = 1.2 into the formula of deformation given in ③ on P.1569,

$$C = \left(\frac{60 L_{ho} N_m}{10^6} \right)^{\frac{1}{3}} \times P_m \times f_w = 370 (\text{daN})$$

and select a fitting ball screw from P.1571~.

The result is BSS1520.

Next, look at the DN values (P.1569④) as the Allowable Revolution Frequency.

For a $D_m N \leq 70000$, $D_m N = 15.8 \times 3000 = 47400$

This is within the Allowable range: therefore, proceed to the following investigation using this size of ball screw.

4. Allowable Buckling Load and Critical Speed

Check overall length of thread (L), critical speed (N_c), and buckling load (P_k) as follows.

$$L = \text{Max. Stroke} + \text{Nut length} + \text{Margin} + \text{Dimensions of Both Ends} = 720 + 62 + 60 + 78 = 920 (\text{mm})$$

Check allowable axial load in terms of buckling load.

Assuming the distance between load acting points

$l_1 = 820$, the following is obtained from formulas ⑥ and ⑦ on P.1569.

$$P_k = 722 (\text{daN})$$

This satisfies the conditions of use.

To calculate critical speed, assuming the distance between supports $l_2 = 790$ the following is obtained from the formula ⑤ (Fixed-Support) on P.1569.

$$N_c = 3024 (\text{r/min})$$

This satisfies the conditions of use.

5. Design Precision

Investigate the degree of Precision and axial play According to the tolerance values for lead accuracy (P.271), the class of positioning Precision $\pm 0.1/720\text{mm}$ is C5 (Accumulated typical lead errors = 0.035 fluctuation = 0.025)

Axial play is max. 0.005 based on repeated positioning Precision of ± 0.01

6. Results of the Selection of Ball Screws and Support Units

From the calculations made, the best selection of the ball screw is Catalog No.

BSS1520-950-FC18

The best support unit is Catalog No. BSW12.