# [Technical Data] Selection of Single Axis Actuators 1

Select the nominal SX actuator from the travel and the rating list below. ➡ Determine the ball screw lead so that the operation speed will be within the maximum speed shown in (Table 4). At this stage, the selection is temporary. ➡ Examine the load applied to the rail and put it in formulas (1) and (2) on **page A-058.** Obtain the equivalent load Fe for each process and put it in formula (3) on **page A-058** Obtail the average load Fm and calculate the lifetime. ➡ Examine the load applied to the ball screw and the support bearing. Put it in formula (3) on **page A-058**, obtain the average load Fm and calculate the lifetime.

## ■ Rated load (Table 1)

| Item | | | SX2001 | SX2005 | SX2602 | SX2605 | SX3005 | SX3010 | SX4510 | SX4520 |
|---|---|---|---|---|---|---|---|---|---|---|
| Rail | Dynamic load rating Ca (N) | | 3277 | | 6522 | | 9732 | 6305 | 18450 | 11826 |
| | Static load rating Coa (N) | | 6199 | | 11871 | | 17218 | 9271 | 32441 | 17175 |
| | Radial clearances | | −3~0 | | −4~0 | | −4~0 | | −6~0 | |
| Ball screw | Dynamic load rating Ca (N) | Advanced | 482 | 822 | 1712 | 1600 | 1831 | 1129 | 4167 | 2499 |
| | Static load rating Coa (N) | Advanced | 642 | 1026 | 2251 | 2097 | 2389 | 1386 | 5945 | 3381 |
| | Thread shaft diameter (mm) | | 6 | 6 | 8 | 8 | 10 | 10 | 15 | 15 |
| | Lead (mm) | | 1 | 5 | 2 | 5 | 5 | 10 | 10 | 20 |
| | Core diameter | | 5.3 | 4.918 | 6.4 | 6.46 | 8.2 | | 11.7 | |
| | Ball center diameter | | 6.15 | 6.3 | 8.3 | 8.3 | 10.3 | 10.3 | 15.5 | 15.75 |
| Bearing (fixed side) | Axial load | Dynamic load rating Ca (N) | 730 | | 1637 | | 2702 | | 4335 | |
| | | Static load rating Coa (N) | 461 | | 1205 | | 2197 | | 4106 | |

## ■ Moment equivalent coefficient at rail (Table 2)

| Type | Block | Kp | Ky | Kr |
|---|---|---|---|---|
| SX20_ _ | 1 piece | 0.228 | 0.228 | 0.0667 |
| | Close contact between 2 pcs. | 0.144 | 0.144 | 0.0667 |
| SX26_ _ | 1 piece | 0.17 | 0.17 | 0.0527 |
| | Close contact between 2 pcs. | 0.114 | 0.114 | 0.0527 |
| SX30_ _ | 1 piece | 0.137 | 0.137 | 0.0445 |
| | Close contact between 2 pcs. | 0.0917 | 0.0917 | 0.0445 |
| SX45_ _ | 1 piece | 0.1115 | 0.1115 | 0.0334 |
| | Close contact between 2 pcs. | 0.0840 | 0.0840 | 0.0334 |

## ■ Rail geometrical moment of inertia (Table 3)

| Type | SX ($mm^4$) | Ly ($mm^4$) | Mass (kg/100mm) | Center of Gravity h (mm) |
|---|---|---|---|---|
| SX2001 | $3.2\times10^3$ | $5.2\times10^4$ | 0.22 | 4.4 |
| SX2606 | $1.0\times10^4$ | $1.4\times10^5$ | 0.37 | 6.1 |
| SX30_ _ | $2.5\times10^4$ | $3.1\times10^5$ | 0.6 | 7.8 |
| SX45_ _ | $8.8\times10^4$ | $10.4\times10^5$ | 1.10 | 11.0 |

## ■ Allowable Static Load / Allowable Static Moment (Table 4)

| Type | No. of blocks | Allowable Static Load (kg) | Allowable Static Moment (N·m) | | |
|---|---|---|---|---|---|
| | | Horizontal | Ma | Mb | Mc |
| SX20_ _ | B1 | 6199 | 27 | 27 | 93 |
| | B2 | 12398 | 353 | 353 | 186 |
| SX20_ _C | B1 | 6199 | 27 | 27 | 93 |
| | B2 | 12398 | 353 | 353 | 186 |
| SX26_ _ | B1 | 11871 | 70 | 70 | 225 |
| | B2 | 23742 | 902 | 902 | 450 |
| SX26_ _C | B1 | 11871 | 70 | 70 | 225 |
| | B2 | 23742 | 902 | 902 | 450 |
| SX3005 | B1 | 17218 | 126 | 126 | 387 |
| | B2 | 34436 | 1515 | 1515 | 774 |
| SX3005C | B1 | 17218 | 126 | 126 | 387 |
| | B2 | 34436 | 1515 | 1515 | 774 |
| SX3010 | B1 | 17218 | 126 | 126 | 387 |
| | B2 | 34436 | 1515 | 1515 | 774 |
| SX3010C | B1 | 17218 | 126 | 126 | 387 |
| | B2 | 34436 | 1515 | 1515 | 774 |
| SX4510 | B1 | 32441 | 291 | 291 | 972 |
| | B2 | 64882 | 3945 | 3945 | 1944 |
| SX4520 | B1 | 32441 | 291 | 291 | 972 |
| | B2 | 64882 | 3945 | 3945 | 1944 |

## ■ Allowable Static Load / Allowable Static Moment (Short Block) (Table 5)

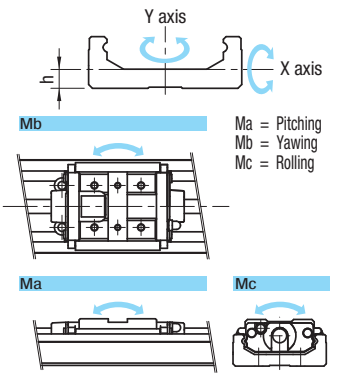
| Type | No. of blocks | Allowable Static Load (kg) | Allowable Static Moment (N·m) | | |
|---|---|---|---|---|---|
| | | Horizontal | Ma | Mb | Mc |
| SX3005 | S1 | 9271 | 63 | 63 | 208 |
| | S2 | 18542 | 579 | 579 | 417 |
| SX3010 | S1 | 9271 | 63 | 63 | 208 |
| | S2 | 18542 | 579 | 579 | 417 |
| SX4510 | S1 | 17175 | 145 | 145 | 515 |
| | S2 | 34350 | 1444 | 1444 | 1029 |
| SX4520 | S1 | 17175 | 145 | 145 | 515 |
| | S2 | 34350 | 1444 | 1444 | 1029 |

## ■ Maximum travel speed (Table 6)

| Type | Lead | L (mm) | Maximum travel speed (mm/s) |
|---|---|---|---|
| | | | Advanced |
| SX20_ _ | 01 | – | 190 |
| | 05 | – | 690 |
| SX26_ _ | 02 | – | 290 |
| | 05 | – | 520 |
| SX30_ _ | 06 | 150 | 410 |
| | | 200 | 410 |
| | | 300 | 410 |
| | | 400 | 410 |
| | | 500 | 370 |
| | | 600 | 250 |
| | 10 | 150 | 830 |
| | | 200 | 830 |
| | | 300 | 830 |
| | | 400 | 830 |
| | | 500 | 740 |
| | | 600 | 500 |
| SX45_ _ | 10 | 340 | 550 |
| | | 390 | 550 |
| | | 440 | 550 |
| | | 490 | 550 |
| | | 540 | 550 |
| | | 590 | 550 |
| | 20 | 340 | 1110 |
| | | 390 | 1110 |
| | | 440 | 1110 |
| | | 490 | 1110 |
| | | 540 | 1110 |
| | | 590 | 1110 |

## ■ Load coefficient fw (Table 7)

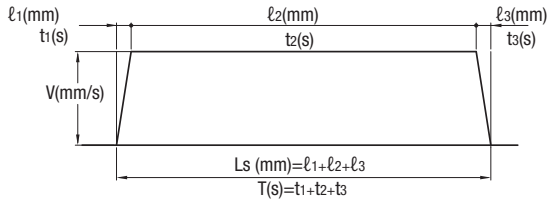
| Vibration/ impact | Speed | fw |
|---|---|---|
| Subtle | Super-low speed V≤ 0.25m/s | 1~1.2 |
| Small | Low speed 0.25m/s<V≤ 1m/s | 1.2~1.5 |
| Medium | Medium speed 1m/s <V≤ 2m/s | 1.5~2 |
| Large | High speed 2m/s<V | 2~3.5 |



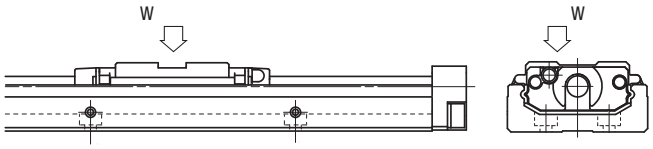
## Life Span

**For the SX actuator, calculate the life span of the rail, ball screw and support bearing. The actuator life span is determined to be the smallest value from among these results.**

Load mass : W kg
Stroke : Ls mm
Acceleration : a mm/s$^2$
Maximum speed : v mm/s
Gravity : g=9.81m/s$^2$
acceleration : Horizontal
Speed diagram : (Fig. 1)
Operating conditions : (Fig. 2)




Speed diagram (Fig. 1)




Status of load applied (Fig. 2)

## Examination Selection

**Select the temporary model number based on the load mass W (kg) and the maximum speed V (mm/s). Then prepare a speed diagram based on the acceleration, maximum speed and travel. The conditions that can develop this speed diagram will serve as the basis for the selection calculation.**

## Calculation Lifetime Calculation Example

**Examine the status of the load applied (Fig. 2) to the rail of the SX actuator. Put each load in the formula below (formula (1) for single nut block specifications and formula (2) for double nut block specifications), and obtain the equivalent load Fe.**

### Equivalent Load

• In the case of single block

$$Fe=Y_HF_H+Y_VF_V+Y_PK_PM_a+Y_YK_YM_b+Y_RK_RM_c \quad -(1)$$

• In the case of double block

$$Fe=Y_HF_H/2+Y_VF_V/2+Y_RK_RM_a+Y_PK_PM_b+Y_YK_YM_c \quad -(2)$$

Fe : Equivalent Load
FH : Horizontal load acting on blocks
Fv : Vertical load applied to the block
Ma : Pitching direction moment applied to the block
Mb : Yawing direction moment applied to the block
Mc : Rolling direction moment applied to the block
Kp : Equivalent coefficient for pitching direction moment
Ky : Equivalent coefficient for yawing direction moment
Kr : Equivalent coefficient for rolling direction moment
YH,Yv,Yp,Yy,YR:1.0 or 0.5

When the actuator is used under moment loads, calculate the load by multiplying the guide moment equivalent coefficient in Table 2. In formulas (1) and (2), in order to obtain the equivalent load Fe, the maximum value among FH, Fv, KpMa, KyMb and KrMc is determined to be 1.0, and the remaining items are set at 0.5.

### Average Load

As Ma and Mb for the SX actuator vary with acceleration and deceleration, obtain the average load Fm from formula (3).

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3+\cdots+Fe_n^3\cdot L_n\right)} \quad -(3)$$

Fm: Average load for fluctuating loads (N) L: Total travel distance (km)

### Rail Life Span

Obtain the rail life span for the SX actuator from formula (4).

$$L=La\times\left(\frac{C}{fw\cdot Fm}\right)^3 \quad -(4)$$

L: Rail lifetime (km) La: Travel distance (km) fw: Load coefficient
C: Basic dynamic load rating (N)

When the travel length and the number of reciprocal motions per minute are constant, the number of life span hours can be calculated from formula (5).

$$Lh=\frac{L\times10^6}{2\cdot\ell s\cdot n1\times60} \quad -(5)$$

Lh: Life span hours (h) ℓs: Travel (mm) n1: Reciprocal motions per minute

### Life span of ball screw and support areas

Obtain the average load from the load applied in the axial direction. Calculate life span for both ball screws and bearings from formula (6). Obtain the average load from formula (3).

$$Lr=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times10^6 \quad -(6)$$

Lr: Life span of ball screw (km) ℓ: Ball screw lead (mm)
fw: Load coefficient Ca: Basic dynamic load rating of screw and support (N)

# [Technical Data] Selection of Single Axis Actuators 2

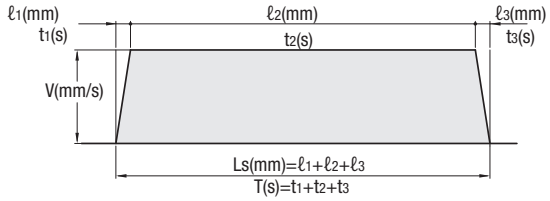


## Rated lifetime calculation example

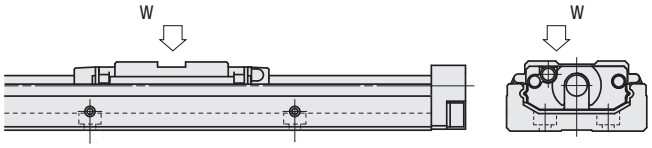
### 1 Model number for examination

Operating conditions : SX26
Rail : C (Basic dynamic load rating)=6522N Co (Basic static load rating)=11871N
Ball screw : Ca (Basic dynamic load rating)=1712N Coa (Basic static load rating)=2251N
Support bearings : Ca (Basic dynamic load rating)=1637N Poa (Basic static load rating)=1205N

Load mass : 10kg
Maximum speed : 250mm/s
Acceleration : 833mm/s$^2$
Stroke : 200mm
Gravity : g=9.81m/s$^2$
Position : Horizontal
Speed diagram : (Fig. 1)
Operating Conditions : (Fig. 2)




Speed diagram (Fig. 1)




Status of load applied (Fig. 2)

### 2 Examination

**Temporary selection**

Use a travel distance of 200 mm with an acceleration of 833 mm/s$^2$ and a maximum speed of 250 mm/s. Based on these conditions, assume that the SX26 series is used. (The selection software can be used on the Misumi website after customer registration has been completed.)

### 3 Calculation

#### 3–1 Examination of rail

Multiply the moment equivalent coefficient in the table with the load according to the condition in which one nut block is used.

**Load for nut block**

1) At constant speed

$Fe_1=Yv\ \ Fv=Yv\cdot W\cdot g=1\cdot 10\cdot 9.81=98.1(N)$

2) At acceleration

$Fe_2=YvFv+Yp\ \ Kp\ \ Ma=0.5\cdot 98.1+1\cdot 0.17\cdot 70\cdot 0=60.95(N)$

3) At deceleration

$Fe_3=Yv\ \ Fv+Yp\ \ Kp\ \ Ma=0.5\cdot 98.1+1\cdot 0.17\times 70\cdot 0=60.95(N)$

Static safety coefficient

$$fs=\frac{Co}{Femax}=\frac{Co}{W\cdot g}=\frac{11871}{98.1}=121.1$$

**Rated life span**

Axial average load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3+\cdots+Fen^3\cdot Ln\right)}=87.72(N)$$

Rated life span

$$L=\left(\frac{C}{fw\cdot Fm}\right)^3\times 50=11.89\times 10^6$$

fw: Load coefficient 1.2
La: Travel distance

#### 3–2 Examination of ball screw

Obtain the axial loads for the parts and the average load from the speed diagram.

**Lifetime of ball screw**

Axial load

1) At constant speed

$Fe_1=\mu\cdot W\cdot g=0.01\times 10\times 9.81=0.981(N)$

2) At acceleration

$Fe_2=Fe_1+W\cdot a\times 10^{-3}=0.981+10\cdot 0.833=9.311(N)$

3) At deceleration

$Fe_3=Fe_1-W\cdot a\times 10^{-3}=7.352(N)$

Static safety coefficient

$$fs=\frac{Coa}{Femax}=\frac{Coa}{Fe_2}=\frac{2251}{9.311}=241.76$$

### Buckling load

$$P_1=\frac{n\cdot\pi^2\cdot E\cdot I}{\ell a^2}\times 0.5=5562.02(N)$$

$P_1$ : Buckling load
$\ell a$ : Distance between mounting points 250(mm)
E : Young's modules $2.06\times10^5$ (N/mm$^2$)
n : Coefficient according to mounting method
0.5: Safety factor
I : Minimum geometrical moment of inertia of screw shaft

$$I=\frac{\pi\cdot d1^4}{64}=85.49(mm^4)$$

d1 : Root diameter of screw shaft 6.46(mm)

### Allowable tension/compression load

$$P_2=\frac{\delta\cdot\pi\cdot d_1{}^2}{4}=4818.06$$

$P_2$ : Allowable tension/compression load (N)
$\delta$ : Allowable tension/compression stress 147(N/mm$^2$)
$d_1$ : Root diameter of screw shaft 6.46(mm)

### Critical speed

$$N1=\frac{60\cdot\lambda^2}{2\pi\cdot\ell b^2}\cdot\sqrt{\frac{E\times10^3\cdot I}{\gamma\cdot A}}\times0.8=12485(min^{-1})$$

N1 : Critical speed
$\ell b$ : Distance between mounting points
E : Young's modules $2.06\times10^5$ (N/mm$^2$)
$\lambda$ : Coefficient according to mounting method (Fixed-Support 3.927)
$\gamma$ : Density ($7.85\times10^{-6}$kg/mm$^3$)
0.8: Safety factor

### DN value

DN=62250(≤70000)

D : Ball center to center diameter (8.3mm)
N : Maximum number of operating revolutions (min$^{-1}$)

### Rated life span

Axial avera ge load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe1^3\cdot L1+Fe2^3\cdot L2+Fe3^3\cdot L3+\cdots+Fen^3\cdot Ln\right)}=6.096(N)$$

Rated life span

$$L=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times10^6=25.64\times10^6(km)$$

fw : Load coefficient 1.2
$\ell$ : Ball screw lead 2 (mm)

## 3–3 Examination of support bearing

Axial load

Fe1=0.981(N)
Fe2=9.311(N)
Fe3=7.352(N)

Static safety coefficient

$$fs=\frac{Poa}{Femax}=\frac{Poa}{Fe2}=129.42$$

### Equivalent load

Axial average load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe1^3\cdot L1+Fe2^3\cdot L2+Fe3^3\cdot L3+\cdots+Fen^3\cdot Ln\right)}=6.096(N)$$

Rated lifetime

$$L=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times10^6=22.41\times10^6(km)$$

fw : Load coefficient 1.2
$\ell$ : Ball screw lead 2 (mm)

| SX2602 | Rail | Ball screw | Support bearing |
|---|---|---|---|
| Static safety factor | 121.1 | 241.76 | 129.42 |
| Buckling load (N) | – | 5562.02 | – |
| Allowable tension/compression load (N) | – | 4818.06 | – |
| Critical speed (min$^{-1}$) | – | 12485 | – |
| DN value | – | 62250 | – |
| Rated lifetime (km) | $11.89\times10^6$ | $22.31\times10^6$ | $19.505\times10^6$ |
| Maximum axial load (N) | – | 9.311 | – |
| Maximum number of operating revolutions | – | 7500 | – |