Calculation of Life Span of Linear Systems 1

Allowable Load

•Basic Dynamic Load Rating (C)
Basic dynamic load rating is a constant load applied in a constant direction that enables each linear system of the same series to travel 50×10^3m under the same conditions, without 90% of the material suffering damage from rolling contact fatigue.

•Basic Static Load Rating (Co)
Basic static load rating is the static load exerted on contacting parts under maximum stress, at which the sum of the permanent deformation in the rolling element and rolling contact surface equals 0.0001 times the diameter of the rolling element.

•Allowable Static Moment (M_P, M_Y, M_R)
Allowable static moment is a critical static moment load that acts upon a system at the loading moment. It is set in accordance with the permanent deformation as in basic static load rating Co.

•Static Safety Factor (fs)
Static safety factors are given in Table-1. When a linear system is still or moving at low speed, basic static load rating Co must be divided by fs in accordance with the conditions of use.

Table-1 Static Safety Factor(Lower Limit of f_s)

Condition of Use	Lower Limit of f_s
Under Normal Operating Conditions	1~2
When Smooth Travel is Required	2~4
When Subjected to Vibrations, Impacts	3~5

Allowable Load (N) $\leq$ Co/fs

Allowable Moment (N·m) $\leq$ (M_P, M_Y, M_R)/fs

f_s:Static Safety Factor Co:Basic Static Load (N)
M_P, M_Y, M_R : Static Allowable Moment (N·m)

Life Span

When a load is applied to a linear system, the system moves back and forth in a linear direction. In the process, repeated stress acts upon rolling elements and rolling contact surfaces, causing damage referred to as flaking from material fatigue.
The life span of a linear system is measured in terms of the total travel distance covered by the system up until initial flaking occurs.
•Rated Life Span (L)
Rated life span is the total travel distance that each linear system of the same series can endure under the same conditions, without the occurrence of flaking in 90% of the system.

Rated life span can be obtained as follows from the basic dynamic load rating and various loads exerted on the linear system.

For Ball Bearings $L=\left(\frac{C}{P}\right)^3 \cdot 50$

For Roller Bearings $L=\left(\frac{C}{P}\right)^{10/3} \cdot 50$

L: Rated Life Span (km)
C: Basic Dynamic Load Rating (N)
P: Acting Load (N)

•When actually using a linear system, the first thing you must do is to calculate the load. It is necessary to consider load also in terms of vibration and impact that occur during operation, as well as its distribution across the entire linear system as it moves back and forth in a linear direction. Calculations are not simple. Operating temperature also significantly influences useful life. When these parameters are taken into consideration, the above formula is transformed as follows:

For Ball Bearings $L=\left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$

For Roller Bearings $L=\left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^{10/3} \cdot 50$

L: Rated Life Span (km)
f_H: Hardness Coefficient (See Fig.1)
C: Basic Dynamic Load Rating (N)
f_T: Temperature Coefficient (See Fig.2)
P: Acting Load (N)
f_C: Contact Coefficient (See Table 3)
f_W: Load Coefficient (See Table 4)

The Life span can be computed as a number of hours by obtaining the travel distance for a unit of time.
It can be obtained by using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$L_h = \frac{L \cdot 10^3}{2 \cdot \ell s \cdot n_1 \cdot 60}$$

L_h: Life Span Hours (hr)
ℓs: Stroke Length (m)
L: Rated Life Span (km)
n_1: Reciprocating Times per Minute (cpm)

Friction Resistance and Required Thrust

Using the following formula, the friction resistance (required thrust) can be obtained from the load and the seal resistance specified by the system.

$$F = \mu \cdot W + f$$

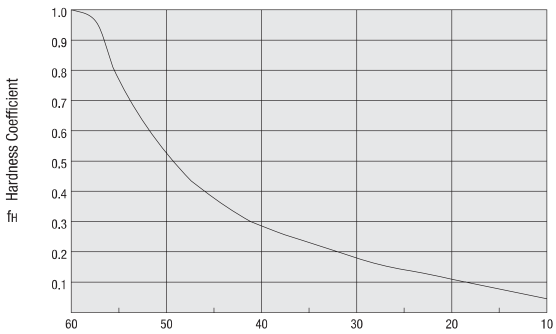
F: Friction Resistance (N)
μ: Dynamic Friction Coefficient
W: Weight Loaded
f: Seal Resistance (2N~5N)

Table-2 Dynamic Friction Coefficient

Type	Dynamic Friction Coefficient (μ)
Miniature Slide Guides	0.004~0.006
Medium Load Slide Guides	0.002~0.003
Slide Ways	0.001~0.003
Slide Tables	0.001~0.003
Linear Bushings	0.002~0.003
Linear Ball Bushings	0.0006~0.0012

•Hardness Coefficient(f_H)
In a linear system, the shaft must be hard enough to withstand contact with the ball bearings. Unless sufficient hardness is provided, the allowable load can decrease, resulting in a short useful life.
Compensate the rated life span with the hardness coefficient.

Fig-1. Hardness Coefficient



•Contact Coefficient (fc)
In general, two or more linear systems are used with each shaft. Depending on the machining precision, the load exerted on each of the respective systems can vary. In this case, the load applied on each linear system changes depending on the machining precision, therefore it cannot be uniformly applied. As a result, allowable load per linear system changes depending on the number of linear systems on one axis.
Compensate the rated life span with the contact coefficient in Table-3.
•Load Coefficient (fw)
When calculating the load that acts on a linear system, it is necessary to work with precise figures for material weight, the force of inertia resulting from operating speed, load moment, various changes that occur over time, and so on. However, it is difficult to have accurate calculation for oscillating movement as beside the normal repetition of start and stop, other factors such as vibration and impact also need to be considered.
Therefore, the life span calculation needs to be simplified using the load coefficient in Table-3.

Linear Bushings

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear bushing.

$$L=\left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$$

L: Rated Life Span (km)
C: Basic Dynamic Load Rating (N)
P: Working Load (N)
fw: Load Coefficient (See Table4)
f_H: Hardness Coefficient (See Fig.1)
f_T: Temperature Coefficient (See Fig.2)
f_C: Contact Coefficient (See Table3)

The Life span can be computed as a number of hours by obtaining the travel distance for a unit of time. It can be obtained using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$L_h=\frac{L \cdot 10^3}{2 \cdot \ell_s \cdot n_1 \cdot 60}$$

L_h: Life Span Hours (hr) ℓs: Stroke Length (m) L: Rated Life Span (km)
n_1: Reciprocating Times per Minute (cpm)

•Temperature Coefficient (f_T)
When temperature in a linear system exceeds 100˚C, the hardness of the system and the shaft become degraded. This decreases the allowable load to a greater extent than when the system is used at ambient temperature, and can shorten the life span.
Compensate the rated life span with the temperature coefficient.

Fig.-2 Temperature Coefficient

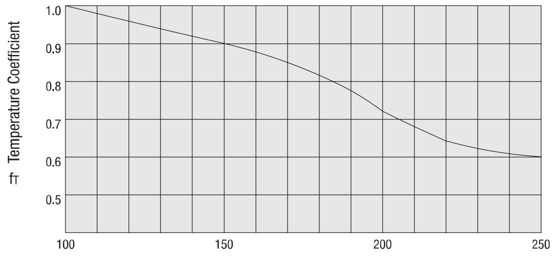


Table-3. Contact Coefficient

Number of Bearings per Shaft	Contact Coefficient fc
1	1.00
2	0.81
3	0.72
4	0.66
5	0.61

Table-4. Load Coefficients

Condition of Use	fw
Low speed with no external vibration or impact (Max. 15m/min)	1.0~1.5
Middle range speed with no exerted vibration or impact of considerable force(Max. 60m/min)	1.5~2.0
High speed with no external vibration or impact (Over 60m/min)	2.0~3.5

Linear Ball Bushings

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear ball bushing.

$$L=\left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P}\right)^3 \cdot 50$$

L: Rated Life Span (km)
C: Basic Dynamic Load Rating (N)
P: Working Load (N)
fw: Load Coefficient (See Table 4)
f_H: Hardness Coefficient (See Fig.1)
f_T: Temperature Coefficient (See Fig.2)
f_C: Contact Coefficient (See Table 3)

Life Span Hours
·For revolution and reciprocating motion

$$L_h=\frac{10^6 \cdot L}{60\sqrt{(dm \cdot n)^2+(10 \cdot S \cdot n_1)^2}/dm}$$

·For reciprocating motion

$$L_h=\frac{10^6 \cdot L}{600 \cdot S \cdot n_1/(\pi \cdot dm)}$$

L_h: Life Span Hours(hr) S: Stroke Length(mm) n: Revolutions per Minute(rpm)
n_1: Strokes Per Minute(cpm)
dm: Pitch Diameter of Ball(mm)≈1.15dr
·Revolution and reciprocal motion allowable values

$$DN \geq dm \cdot n+10 \cdot S \cdot n_1$$

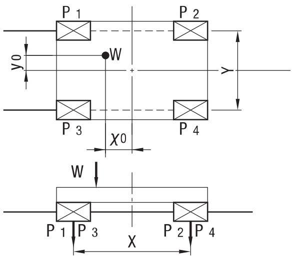
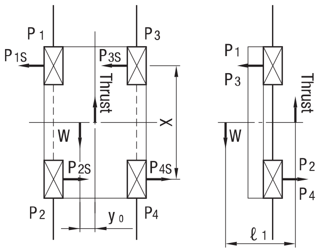
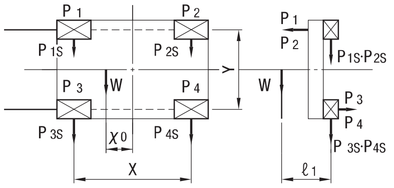
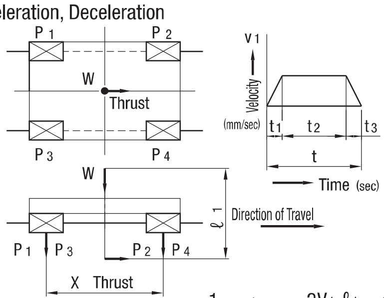
Calculation of Life Span of Linear Systems 2

•Load Calculations

Since a linear system bears the weight of the work while it performs a reciprocating linear motion, the load exerted on the system can vary depending on the work's center of gravity, thrust acting position change, and the speed changes by starting, stopping and acceleration, deceleration.

It is necessary to take these conditions into consideration when selecting a linear system.

Table-5. Use Conditions and Load Calculation Formulas

Type	Condition of Use and Load
1	Horizontal Axis  $P_1=\frac{1}{4}W+\frac{\chi_0}{2X}W+\frac{y_0}{2Y}W$ $P_2=\frac{1}{4}W-\frac{\chi_0}{2X}W+\frac{y_0}{2Y}W$ $P_3=\frac{1}{4}W+\frac{\chi_0}{2X}W-\frac{y_0}{2Y}W$ $P_4=\frac{1}{4}W-\frac{\chi_0}{2X}W-\frac{y_0}{2Y}W$
2	Vertical Axis  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2X}W$ $P_{1S}=P_{2S}=P_{3S}=P_{4S}=\frac{y_0}{2X}W$
3	Perpendicular to Horizontal Axis  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2X}W$ $P_{1S}=P_{3S}=\frac{1}{4}W+\frac{\chi_0}{2X}W$ $P_{2S}=P_{4S}=\frac{1}{4}W-\frac{\chi_0}{2X}W$
4	In Acceleration, Deceleration  •Acceleration at Starting $P_1=P_3=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ •Deceleration at Stopping $P_1=P_3=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ •Constant Speed $P_1=P_2=P_3=P_4=\frac{1}{4}W$ g:Gravitational Acceleration=9.8×10^3mm/sec^2

W :Acting Load(N) P_1,P_2,P_3,P_4:Load applied to the Linear System(N)

X,Y: Linear System Span(mm) V:Moving Speed(mm/sec)

t_1 :Acceleration Time(sec) t_3:Deceleration Time(sec)

Fig-3. Stepped Load Fluctuation

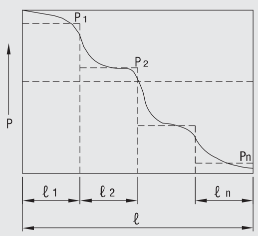


Fig-4. Flat Fluctuation Load

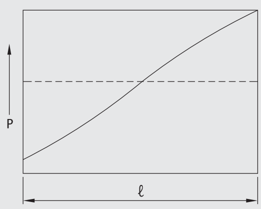
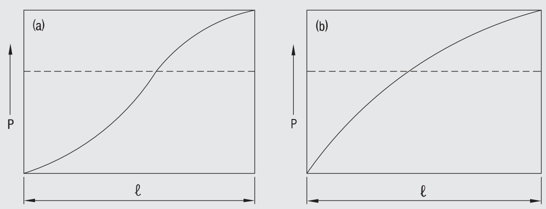


Fig-5. Sinusoidal Load Fluctuation



•Mean Load Derived from Fluctuating Loads

In general, the load acting upon a linear system can change according to how the system is used.This happens for example when the reciprocating motion is started, stopped as compared to constant speed motion, and whether or not work is present during transfer, etc. Therefore, in order to correctly design the life span under various conditions and fluctuating loads, it is necessary to obtain a mean load and apply it to the life span calculations.

(1) When load changes in steps by a travel distance(Fig-3)

Travel distance ℓ_1 subjected to load P_1
Travel distance ℓ_2 subjected to load P_2
⋮ ⋮
Travel distance ℓn subjected to load Pn

Mean load Pm can be obtained by using the following formula:

$$P_m=\sqrt[3]{\frac{1}{\ell}(P_1{}^3\ell_1+P_2{}^3\ell_2\cdots+Pn^3\ell n)}$$

P_m : Mean Load Derived from Fluctuating Loads(N) ℓ : Total Travel Distance(m)

(2) When load changes almost linearly(Fig-4)

Mean load P_m can be approximated by the following formula:

$$P_m\approx\frac{1}{3}(P_{min}+2\cdot P_{max})$$

P_{min} : Min. Fluctuating Load (N)
P_{max}: Max. Fluctuating Load(N)

(3) When the load change resembles a sinusoidal curve as shown in Fig-5 (a), (b), Mean Load Pm can be approximated by the following formula:

Fig-5(a) $P_m\approx0.65P_{max}$
Fig-5(b) $P_m\approx0.75P_{max}$

■ Slide Guides

Rated life span is the total travel distance each linear guide of the same series can endure under the same conditions, without the occurrence of flaking in 90% of the system.

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the slide guide.

$$L=\left(\frac{f_T}{f_W}\cdot\frac{C}{P}\right)^3\cdot50 \quad\text{———————}(1)$$

L : Rated Life Span(km) C : Basic dynamic load rating(N)
f_T : Temperature Coefficient(See Fig-2) P : Acting Load(N)
fw : Load Coefficient(See Fig-4)

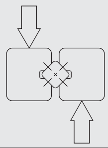
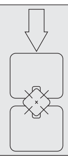
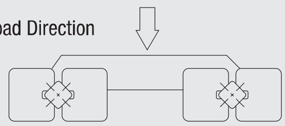
The life span hours can be computed as a number of hours by obtaining the travel distance for a unit of time.It can be obtained by using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$Lh=\frac{L\cdot10^3}{2\cdot\ell s\cdot n_1\cdot60} \quad\text{———————}(2)$$

Lh : Life Span Hours(hr) ℓs : Stroke Length(m)
L : Rated Life Span(km) n_1 : Reciprocating Times per Minute(cpm)

■ Slide Ways

Rated load for slide ways is determined by the rolling elements(numbers of rollers). It can be calculated by using the following formulas:

One shaft is used	Load Direction	
	Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1$
	Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}$
One shaft is used vertically	Load Direction	
	Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1\cdot2^{7/9}$
	Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}\cdot2$
Two shafts are used in parallel	Load Direction	
	Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1\cdot2^{7/9}$
	Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}\cdot2$

C_1 : Basic Dynamic Load Rating per Roller(N)
C_{01} : Basic Static Load Rating per Roller(N)
Z : Number or Rolling Elements

The life span for slide ways is calculated by using the following formula.

$$L=\left(\frac{f_T\cdot C}{fw\cdot P}\right)^{10/3}\cdot50$$

L : Life Span Hours(km) C : Dynamic Load Rating(N)
f_T : Temperature Coefficient(See Fig-2) P : Acting Load(N)
fw : Load Coefficient(See Fig-4)

Life Span Hours

$$L_h=\frac{L\cdot10^3}{2\cdot\ell s\cdot n_1\cdot60}$$

L_h : Life Span Hours(hr) ℓs: Stroke Length(m)
L : Life Span Hours(km) n_1: Reciprocating Times per Minute(cpm)

Selection of Single Axis Actuators 1

Select the nominal LX 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 1906**. Obtain the equivalent load Fe for each process and put it in formula (3) on **page 1906**. Obtain 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 1906**, obtain the average load Fm and calculate the lifetime.

■Rated load (Table 1)

Item			LX2001	LX2005	LX2602	LX2605	LX3005	LX3010	LX4510	LX4520
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
LX20_ _	1 piece	0.228	0.228	0.0667
	Close contact between 2 pcs.	0.144	0.144	0.0667
LX26_ _	1 piece	0.17	0.17	0.0527
	Close contact between 2 pcs.	0.114	0.114	0.0527
LX30_ _	1 piece	0.137	0.137	0.0445
	Close contact between 2 pcs.	0.0917	0.0917	0.0445
LX45_ _	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	Lx (mm^4)	Ly (mm^4)	Mass (kg/100mm)	Center of Gravity h (mm)
LX2001	3.2×10^3	5.2×10^4	0.22	4.4
LX2606	1.0×10^4	1.4×10^5	0.37	6.1
LX30_ _	2.5×10^4	3.1×10^5	0.6	7.8
LX45_ _	8.8×10^4	10.4×10^5	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
LX20_ _	B1	6199	27	27	93
	B2	12398	353	353	186
LX20_ _C	B1	6199	27	27	93
	B2	12398	353	353	186
LX26_ _	B1	11871	70	70	225
	B2	23742	902	902	450
LX26_ _C	B1	11871	70	70	225
	B2	23742	902	902	450
LX3005	B1	17218	126	126	387
	B2	34436	1515	1515	774
LX3005C	B1	17218	126	126	387
	B2	34436	1515	1515	774
LX3010	B1	17218	126	126	387
	B2	34436	1515	1515	774
LX3010C	B1	17218	126	126	387
	B2	34436	1515	1515	774
LX4510	B1	32441	291	291	972
	B2	64882	3945	3945	1944
LX4520	B1	32441	291	291	972
	B2	64882	3945	3945	1944

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

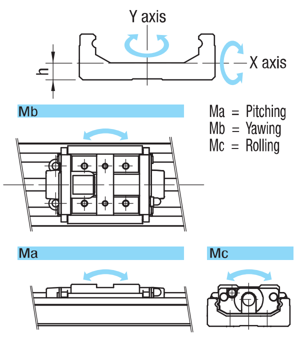
Type	No. of blocks	Allowable Static Load (kg)	Allowable Static Moment (N·m)		
		Horizontal	Ma	Mb	Mc
LX3005	S1	9271	63	63	208
	S2	18542	579	579	417
LX3010	S1	9271	63	63	208
	S2	18542	579	579	417
LX4510	S1	17175	145	145	515
	S2	34350	1444	1444	1029
LX4520	S1	17175	145	145	515
	S2	34350	1444	1444	1029

■Maximum travel speed (Table 6)

Type	Lead	L (mm)	Maximum travel speed (mm/s)
			Advanced
LX20_ _	01	–	190
	05	–	690
LX26_ _	02	–	290
	05	–	520
LX30_ _	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
LX45_ _	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)

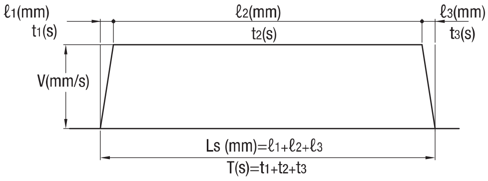
Vibration/impact	Speed	fw
Subtle	Super-low speed V≤ 0.25m/s	1~1.2
Small	Low speed 0.25m/s<V≤ 1m/s	1.2~1.5
Medium	Medium speed 1m/s <V≤ 2m/s	1.5~2
Large	High speed 2m/s<V	2~3.5



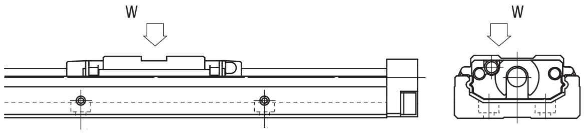
Life Span

For the LX 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/s²
Maximum speed : v mm/s
Gravity : g=9.81m/s²
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 LX 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

$$Fe=Y_HF_H+Y_VF_V+YpKpMa+YyKyMb+YrKrMc \quad \text{—(1)}$$

•In the case of double block

$$Fe=Y_HF_H/2+Y_VF_V/2+Y_RK_RMa+Y_PK_PMb+Y_YK_YMc \quad \text{—(2)}$$

Fe : Equivalent Load
F_H : 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
Y_H, Y_V, Y_P, Y_Y, Y_R: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 LX actuator vary with acceleration and deceleration, obtain the average load Fm from formula (3).

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

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

Rail Life Span

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

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

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).

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

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).

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

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)

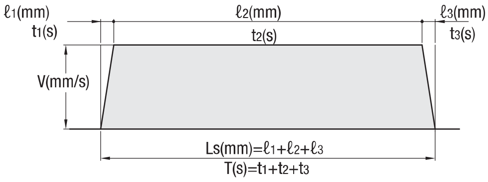
[Technical Data]
Selection of Single Axis Actuators 2

Rated lifetime calculation example

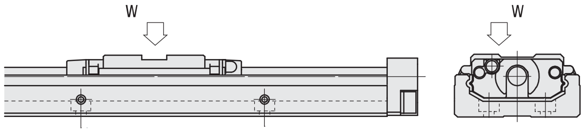
1 Model number for examination

Operating conditions : LX26
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/s²
Stroke : 200mm
Gravity : g=9.81m/s²
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/s² and a maximum speed of 250 mm/s. Based on these conditions, assume that the LX26 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

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

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
ℓa : 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

$$I=\frac{\pi\cdot d_1^4}{64}=85.49(mm^4)$$

d_1 : 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)
δ : Allowable tension/compression stress 147(N/mm²)
d_1 : Root diameter of screw shaft 6.46(mm)

Critical speed

$$N_1=\frac{60\cdot\lambda^2}{2\pi\cdot\ell b^2}\cdot\sqrt{\frac{E\times10^3\cdot I}{\gamma\cdot A}}\times0.8=12485(min^{-1})$$

N_1 : Critical speed
ℓb : Distance between mounting points
E : Young's modules $2.06\times10^5(N/mm^2)$
λ : Coefficient according to mounting method (Fixed-Support 3.927)
γ : 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 average load

$$F_m=\sqrt[3]{\frac{1}{L_s}}(F_{e1}^3\cdot L_1+F_{e2}^3\cdot L_2+F_{e3}^3\cdot L_3\cdot\cdot F_{en}^3\cdot L_n)=6.096(N)$$

Rated life span

$$L=\left(\frac{C_a}{f_w\cdot F_m}\right)^3\cdot\ell\times10^6=25.64\times10^6(km)$$

fw : Load coefficient 1.2
ℓ : Ball screw lead 2 (mm)

3–3 Examination of support bearing

Axial load

$F_{e1}=0.981(N)$
$F_{e2}=9.311(N)$
$F_{e3}=7.352(N)$

Static safety coefficient

$$f_s=\frac{P_{oa}}{F_{emax}}=\frac{P_{oa}}{F_{e2}}=129.42$$

Equivalent load

Axial average load

$$F_m=\sqrt[3]{\frac{1}{L_s}}(F_{e1}^3\cdot L_1+F_{e2}^3\cdot L_2+F_{e3}^3\cdot L_3\cdot\cdot F_{en}^3\cdot L_n)=6.096(N)$$

Rated lifetime

$$L=\left(\frac{C_a}{f_w\cdot F_m}\right)^3\cdot\ell\times10^6=22.41\times10^6(km)$$

fw : Load coefficient 1.2
ℓ : Ball screw lead 2 (mm)

LX2602	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)	11.89×10^6	22.31×10^6	19.505×10^6
Maximum axial load (N)	–	9.311	–
Maximum number of operating revolutions	–	7500	–