C-1-3 Optional Components

MCM Series

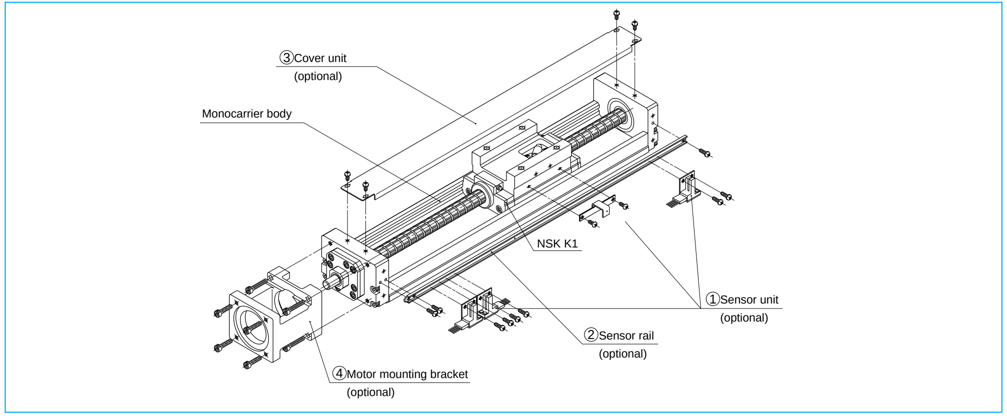

Fig. 3.1 Assembly Optional components for MCM10 (example)

① Sensor unit : Sensors, sensor mounting parts and a sensor dog are available in a set.
∗ When a sensor unit is used, the full cover unit cannot be used.
② Sensor rail : Rail for sensor mounting is available.
③ Cover unit : Top cover or full cover (included top cover and side cover) is available.
④ Motor bracket for motor mounting : Available for a variety of models.
Note: We assemble optional components upon request.

MCH Series

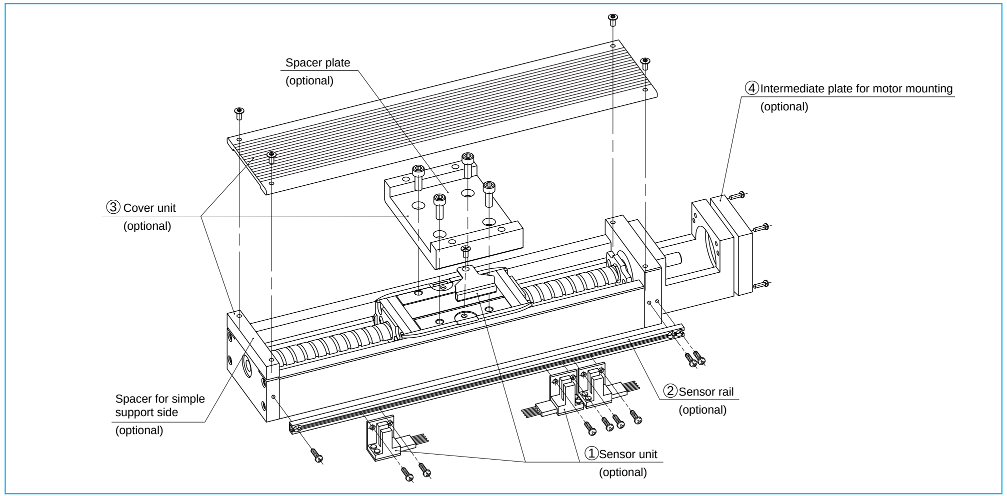

Fig. 3.2 Assembly Optional components for MCH10 (example)

① Sensor unit : Sensors, sensor mounting parts and a sensor dog are available in a set.
② Sensor rail : Rail for sensor mounting is available.
③ Cover unit : Top cover (included spacer plate and spacer for simple support side) is available.
④ Intermediate plate for motor mounting : Available for a variety of models.
Note: We assemble optional components upon request.

C-1-4 Selection of Monocarrier

C-1-4. 1 Procedures for Selecting Monocarrier

Select a reference type of Monocarrier based on stroke and rigidity (Refer to Fig. 4.2, 4.3).

Select a ball screw lead referring to "C-1-4.3 Maximum Speed" so that the rotational speed does not exceed the limit.

Study the loads to be applied to the linear guide and obtain the equivalent load (Fe) substituting them for equation ① or ② on Page C13. Obtain the mean effective load (Fm) substituting them for equation ③ on Page C14, then calculate the life.

Study the loads to be applied to the ball screw and support unit. Obtain the mean effective load (Fm) substituting them for equation ③ on Page C14, then calculate the life.

C-1-4. 2 Rigidity

Rigidity of rail

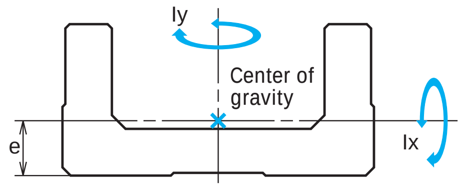

Fig. 4.1

Table 4.1 Rigidity of rail

Nominal size	Geometrical moment of inertia ×10⁴ (mm⁴)		Center of gravity (mm)	Mass (kg/100mm)
	Ix	Iy	e	w
MCM02	0.097	1.32	3.3	0.11
MCM03	0.30	3.3	4.5	0.18
MCM05	0.78	11.4	6.0	0.31
MCM06	2.14	26.1	7.0	0.57
MCM08	5.90	81.0	9.2	0.88
MCM10	15.6	219	12.2	1.52
MCH06	6.5	38.2	10.8	0.67
MCL06	2.58	29.6	7.8	0.56
MCH09	28.7	172	15.5	1.48
MCH10	54.0	307	18	1.93

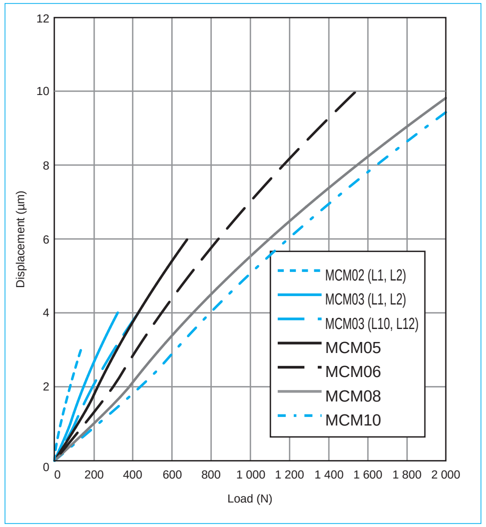

Fig. 4.2 MCM Series Rigidity in radial direction

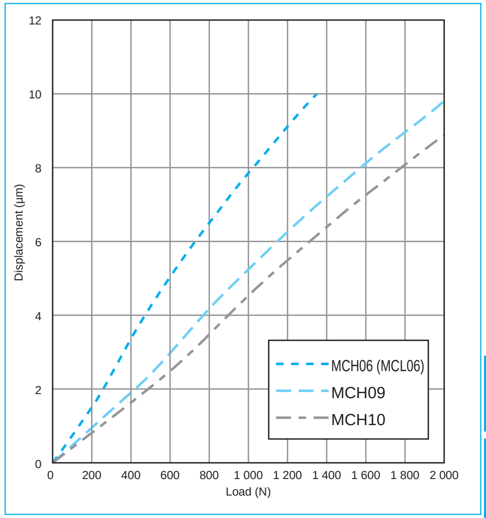

Fig. 4.3 MCH Series Rigidity in radial direction

C-1-4. 3 Maximum Speed

(1) Maximum Speed of MCM Series

Maximum speed of the Monocarrier is determined by the critical speed of the ball screw shaft and the d · n value.
Do not exceed the maximum speeds on the table below.

Table 4.2

	Ball screw lead	stroke (mm)	Rail length L_2 (mm)	Maximum speed (mm/s)
MCM02 Single slider	1	50	100	50
		100	150	
		150	200	
	2	50	100	100
		100	150	
		150	200	
MCM03 Single slider	1	50	115	50
		100	190	
		150	240	
	2	50	115	100
		100	190	
		150	240	
	10	100 – 250	190 – 340	500
	12	100 – 250	190 – 340	600
MCM05 Single slider	5	50 – 200	180 – 330	250
	10	50 – 600	180 – 730	500
	20	300 – 600	430 – 730	1000
MCM05 Double slider	10	60 – 510	280 – 730	500
	20	210 – 510	430 – 730	1000
MCM06 Single slider	5	50 – 500	190 – 640	250
	10	50 – 600	190 – 740	500
		700	840	490
		800	940	390
	20	300 – 600	440 – 740	1000
		700	840	980
		800	940	770
MCM06 Double slider	5	110 – 410	340 – 640	250
	10	110 – 610	340 – 840	500
		710	940	490
	20	210 – 610	440 – 840	1000
		710	940	980

Note: When operating the Monocarriers near the critical speed or exceeding the maximum speed in the table, please consult NSK.

	Ball screw lead	stroke (mm)	Rail length L_2 (mm)	Maximum speed (mm/s)
MCM08 Single slider	5	50 – 200	220 – 370	250
	10	100 – 700	270 – 870	500
		800	970	390
	20	300 – 700	470 – 870	1000
		800	970	780
MCM08 Double slider	10	80 – 680	370 – 970	500
	20	180 – 680	470 – 970	1000
MCM10 Single slider	10	200 – 800	380 – 980	500
		900	1080	440
		1000	1180	360
	20	300 – 800	480 – 980	1000
		900	1080	880
		1000	1180	720
MCM10 Double slider	10	70 – 670	380 – 980	500
		870	1180	440
	20	170 – 670	480 – 980	1000
		870	1180	880

Note: When operating the Monocarriers near the critical speed or exceeding the maximum speed in the table, please consult NSK.

(2) Maximum Speed of MCH Series

Maximum speed of the Monocarrier is determined by the critical speed of the ball screw shaft and the d · n value.
Do not exceed the maximum speeds on the table below.

Table 4.3

	Ball screw lead	stroke (mm)	Rail length L_2 (mm)	Maximum speed (mm/s)
MCH06 MCL06 Single slider	5	50 – 500	150 – 600	250
	10	50 – 500	150 – 600	500
	20	50 – 500	150 – 600	1000
MCH06 Double slider	5	100 – 400	300 – 600	250
	10	100 – 400	300 – 600	500
	20	100 – 400	300 – 600	1000
MCH09 Single slider	5	200 – 600	340 – 740	250
		800	940	210
	10	200 – 600	340 – 740	500
		800	940	410
	20	200 – 600	340 – 740	1000
		800	940	830
MCH09 Double slider	5	150 – 650	440 – 940	250
	10	150 – 650	440 – 940	500
	20	150 – 650	440 – 940	1000

Note: When operating the Monocarriers near the critical speed or exceeding the maximum speed in the table, please consult NSK.

	Ball screw lead	stroke (mm)	Rail length L_2 (mm)	Maximum speed (mm/s)
MCH10 Single slider	10	400 – 800	580 – 980	500
		900	1080	440
		1000	1180	360
		1100	1280	300
		1200	1380	250
	20	400 – 800	580 – 980	1000
		900	1080	870
		1000	1180	720
		1100	1280	600
		1200	1380	510
MCH10 Double slider	10	250 – 750	580 – 1080	500
		850	1180	480
		950	1280	390
		1050	1380	320
	20	250 – 750	580 – 1080	1000
		850	1180	950
		950	1280	780
		1050	1380	650

Note: When operating the Monocarriers near the critical speed or exceeding the maximum speed in the table, please consult NSK.

C-1-4. 4 Accuracy Grade

The accuracy grade of Monocarrier standard inventories is high grade (H), except for lead 1 and 2 of MCM02, and 03.
When you require strokes longer than 1200 mm, please consult NSK about the accuracy grade.

Table 4.4 (Unit : μm)

Grade	High grade			Precision			
Stroke (mm)	Repeatability	Running Parallelism (vertical)	Backlash	Repeatability	Positioning accuracy	Running Parallelism (vertical)	Backlash
– 200	±10	14	20 or less	±3	20	8	3 or less
– 400		16			25	10	
– 600		20			30	12	
– 700		23			30	15	
– 1000		23			35	15	
– 1200		30			40	20	

C-1-4. 5 Stroke and Ball Screw Lead

(1) MCM Series Standard Combinations of Stroke and Ball Screw Lead

Table 4.5 Single slider

(○mark, Standard inventory; ☆mark, Short-term delivery) (Unit : mm)

Nominal size	MCM02		MCM03				MCM05			MCM06			MCM08			MCM10	
stroke \ lead	1	2	1	2	10	12	5	10	20	5	10	20	5	10	20	10	20
50	○	○	○	○	☆	☆	○	○	☆	○	☆	☆	☆	☆			
100	○	○	○	○	○	○	○	○	☆	○	○	☆	☆	○	☆	☆	☆
150	○	○	☆	☆	☆	☆	☆	○	☆	☆	☆	☆	☆	☆	☆	☆	☆
200					○	☆	○	○	☆	○	○	☆	☆	○	☆	○	☆
250					☆	☆	☆	○	☆	☆	☆	☆	☆	☆	☆	☆	☆
300							☆	○	○	○	○	○	☆	○	○	○	○
400							☆	○	○	○	○	○	☆	○	○	○	○
500							☆	○	○	☆	○	○	☆	○	○	☆	☆
600							☆	○	○	☆	☆	☆	☆	○	☆	○	☆
700										☆	○	○	☆	☆	☆	☆	☆
800										☆	☆	☆	☆	☆	☆	○	☆
900																☆	☆
1000																☆	☆

Table 4.6 Double slider

(☆mark, Short-term delivery) (Unit : mm)

Nominal size	MCM05		MCM06			MCM08		MCM10	
stroke \ lead	10	20	5	10	20	10	20	10	20
60	☆								
70								☆	
80						☆			
110	☆		☆	☆					
160	☆								
170								☆	☆
180						☆	☆		
210	☆	☆	☆	☆	☆				
270								☆	☆
280						☆	☆		
310	☆	☆	☆	☆	☆				
370								☆	☆
380						☆	☆		
410	☆	☆	☆	☆	☆				
470								☆	☆
480						☆	☆		
510	☆	☆		☆	☆				
570								☆	☆
580						☆	☆		
610				☆	☆				
670								☆	☆
680						☆	☆		
710				☆	☆				
870								☆	☆

Note: Please consult NSK about double slider of MCM 02 and 03.

(2) MCH Series Standard Combinations of Stroke and Ball Screw Lead

Table 4.7 Single slider

(○mark, Standard inventory; ☆mark, Short-term delivery) (Unit : mm)

Nominal size	MCH06			MCH09			MCH10	
stroke \ lead	5	10	20	5	10	20	10	20
50	○	○	☆					
100	○	○	☆	☆	☆	☆	☆	☆
200	○	○	○	○	○	☆	☆	☆
300	☆	○	○	○	○	☆	☆	☆
400	☆	○	○	○	○	☆	○	○
500	☆	○	○	☆	○	○	○	○
600				☆	○	○	○	○
700				☆	☆	☆	○	○
800				☆	○	○	○	○
900							☆	○
1000							☆	○
1100							☆	☆
1200							☆	☆

Table 4.8 Double slider

(☆mark, Short-term delivery) (Unit : mm)

Nominal size	MCH06			MCH09			MCH10	
stroke \ lead	5	10	20	5	10	20	10	20
100	☆	☆						
150				☆	☆			
200	☆	☆						
250				☆	☆		☆	☆
300	☆	☆						
350				☆	☆		☆	☆
400		☆	☆					
450					☆	☆	☆	☆
550							☆	☆
650					☆	☆	☆	☆
750								☆
850								☆
950								☆
1050								☆

Table 4.9 Limitations

	Nominal size	lead (mm)	slider	stroke (mm)
MCM series	MCM02	1, 2	Single	150
	MCM03	1, 2	Single	150
		10, 12	Single	350
	MCM05	5, 10, 20	Single	900
			Double	810
	MCM06	5, 10, 20	Single	1000
			Double	910
	MCM08	5, 10, 20	Single	1000
			Double	880
	MCM10	10, 20	Single	1800
			Double	1670
MCH series	MCH06	5, 10, 20	Single	600
			Double	500
	MCH09	5, 10, 20	Single	1000
			Double	850
	MCH10	10, 20	Single	1800
			Double	1650
	MCL06	5, 10, 20	Single	500

C-1-4. 6 Basic Load Rating

(1) MCM Series Basic Load Rating

Table 4.10 Basic Load Rating

Nominal size	Lead ℓ (mm)	Shaft dia d (mm)	Basic dynamic load rating (N) Ball screw C_a	Linear guide C	Support unit C_a	Rated running distance L_a (km)	Basic static load rating (N) Ball screw C_{0a}	Linear guide C_0	Support unit Limit load (N)
MCM02	1	ϕ6	340 (High grade) 405 (Precision)	4910	615	1	555 (High grade) 615 (Precision)	2120	490
	2		340 (High grade) 405 (Precision)	3900		2	555 (High grade) 615 (Precision)		
MCM03	1	ϕ6	735	10900	2670	1	1230	4900	1040
	2		735	8650		2			
	10	ϕ8	1230	6250		10	1690	6620	
	12		1230	5880		12			
MCM05	5	ϕ12	3760	15600	4400	5	6310	10900	1450
	10		2260	12400		10	3780		
	20		2260	9850		20	3780		
MCM06	5	ϕ16	7310	25200	6550	5	13500	17000	2730
	10	ϕ15	7060	20000		10	12700		
	20		4560	15900		20	7750		
MCM08	5	ϕ16	7310	30800	7100	5	13500	22800	3040
	10	ϕ15	7060	24400		10	12700		
	20		4560	19400		20	7750		
MCM10	10	ϕ20	10900	33500	7600	10	21700	29400	3380
	20		7060	26600		20	12700		

Notes: ●Basic dynamic and static load ratings indicate the values for one slider. ●Basic dynamic load rating of the linear guide is the load of perpendicular direction to the axis that allows 90% of a group of the same Monocarriers to operate " Rated running distance" in the table, that is equivalent to 1 million revolutions of the ball screw and the support unit, under the same condition without causing flaking by rolling contact fatigue. ●Basic dynamic load rating of the ball screw is a load to axial direction that allows 90% of ball screws of a group of the same Monocarriers to rotate 1 million revolutions under the same condition without causing flaking by rolling contact fatigue. ●Basic dynamic load rating of the support unit is a constant load to axial direction that allows 90% of support units of the same group of Monocarriers to rotate 1 million revolutions under the same condition without causing flaking by rolling contact fatigue. ●Basic static load rating is a load that results in combined permanent deformations at the contact points of balls and ball grooves of respective parts is 0.01% of the diameter.

Table 4.11 Basic static moment load of linear guide

Nominal size	Lead (mm)	Slider	Basic static moment (N · m) Rolling M_{RO}	Pitching M_{PO}	Yawing M_{YO}
MCM02	1, 2	Single	24	8	8
MCM03	1, 2		68	28	28
	10, 12		92	51	51
MCM05	5, 10, 20	Single	229	89	89
		Double	455	765	765
MCM06	5, 10, 20	Single	415	174	174
		Double	825	1220	1220
MCM08	5, 10, 20	Single	770	300	300
		Double	1540	2050	2050
MCM10	10, 20	Single	1170	425	425
		Double	2340	2940	2940

Notes: ● Basic static moment of double slider is a value when two sliders equipped with NSK K1 are butted against each other.
● The basic static moment is the value when a rolling contact pressure of balls exceeds 4000 N/mm^2.
● If you plan to apply extremely heavy load, please consult NSK for estimation of fatigue life.

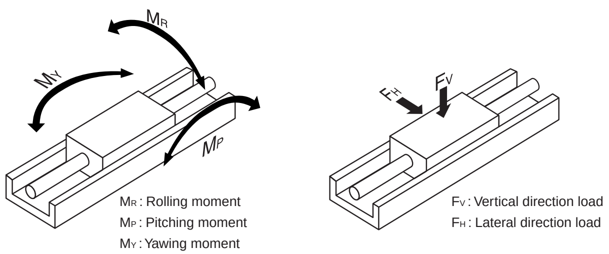

Fig. 4.4

(2) MCH Series Basic Load Rating

Table 4.12 Basic Load Rating

Nominal size	Lead ℓ (mm)	Shaft dia d (mm)	Basic dynamic load rating (N) Ball screw C_a	Linear guide C	Support unit C_a	Rated running distance L_a (km)	Basic static load rating (N) Ball screw C_{0a}	Linear guide C_0	Support unit Limit load (N)
MCH06 (MCL06)	5	ϕ12	3000 (High grade) 3760 (Precision)	22800	4400	5	5410 (High grade) 6310 (Precision)	16300	1450
	10		1930 (High grade) 2260 (Precision)	18100		10	3160 (High grade) 3780 (Precision)		
	20		1930 (High grade) 2260 (Precision)	14400		20	3160 (High grade) 3780 (Precision)		
MCH09	5	ϕ15	6820 (High grade) 7100 (Precision)	40600	7100	5	13200 (High grade) 13000 (Precision)	30500	3040
	10		5110 (High grade) 7060 (Precision)	32200		10	9290 (High grade) 12700 (Precision)		
	20		3290 (High grade) 4560 (Precision)	25500		20	5620 (High grade) 7750 (Precision)		
MCH10	10	ϕ20	8230 (High grade) 10900 (Precision)	44600	7600	10	17100 (High grade) 21700 (Precision)	42000	3380
	20		5300 (High grade) 7060 (Precision)	35400		20	10300 (High grade) 12700 (Precision)		

Notes: ●Basic dynamic and static load ratings indicate the values for one slider. ●Basic dynamic load rating of the linear guide is the load of perpendicular direction to the axis that allows 90% of a group of the same Monocarriers to operate " Rated running distance" in the table, that is equivalent to 1 million revolutions of the ball screw and the support unit, under the same condition without causing flaking by rolling contact fatigue. ●Basic dynamic load rating of the ball screw is a load to axial direction that allows 90% of ball screws of a group of the same Monocarriers to rotate 1 million revolutions under the same condition without causing flaking by rolling contact fatigue. ●Basic dynamic load rating of the support unit is a constant load to axial direction that allows 90% of support units of the same group of Monocarriers to rotate 1 million revolutions under the same condition without causing flaking by rolling contact fatigue. ●Basic static load rating is a load that results in combined permanent deformations at the contact points of balls and ball grooves of respective parts is 0.01% of the diameter.

Table 4.13 Basic static moment load of linear guide

Nominal size	Slider	Basic static moment (N · m) Rolling M_{RO}	Pitching M_{PO}	Yawing M_{YO}
MCH06 (MCL06)	Single	335	133	133
	Double	770	730	730
MCH09	Single	890	385	385
	Double	1780	2070	2070
MCH10	Single	1460	610	610
	Double	2920	3430	3430

Notes: ● Basic static moment of double slider is a value when two sliders equipped with NSK K1 are butted against each other.
● The basic static moment is the value when a rolling contact pressure of balls exceeds 4000 N/mm^2.
● If you plan to apply extremely heavy load, please consult NSK for estimation of fatigue life.

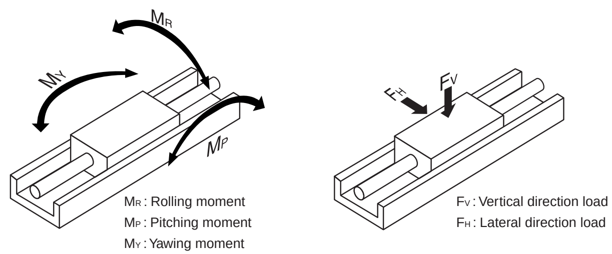

Fig. 4.5

C-1-4. 7 Estimation of Life Expectancy

(1) Life of Linear Guide

Study the load to be applied to the linear guide of Monocarrier (Fig. 4.6). The equivalent load (Fe) is determined by substituting the load for equation ① (Eq.② : in case of the tightly coupled double slider type).

- In case of the single slider

$$Fe = Y_H F_H + Y_V F_V + Y_R \varepsilon_R M_R + Y_P \varepsilon_P M_P + Y_Y \varepsilon_Y M_Y \cdots ①$$

- In case of the double slider

$$Fe = \frac{Y_H F_H}{2} + \frac{Y_V F_V}{2} + Y_R \varepsilon_{Rd} M_R + Y_P \varepsilon_{Pd} M_P + Y_Y \varepsilon_{Yd} M_Y \cdots ②$$

F_H : Lateral direction load acting on the slider (N)
F_V : Vertical direction load acting on the slider (N)
M_R : Rolling moment acting on the slider (N · m)
M_P : Pitching moment acting on the slider (N · m)
M_Y : Yawing moment acting on the slider (N · m)
ε_R, ε_{Rd}
: Dynamic equivalent coefficient to rolling moment
ε_P, ε_{Pd}
: Dynamic equivalent coefficient to pitching moment
ε_Y, ε_{Yd}
: Dynamic equivalent coefficient to yawing moment

Refer to Table 4.14 about Dynamic equivalent coefficient.

Y_H, Y_V, Y_R, Y_P, Y_Y
: 1.0 or 0.5

At equations ① and ② for obtaining equivalent load Fe, among F_H, F_V, $\varepsilon_P M_P$, $\varepsilon_R M_R$, $\varepsilon_Y M_Y$, the maximum load is assumed to be 1.0, and others are to be 0.5.

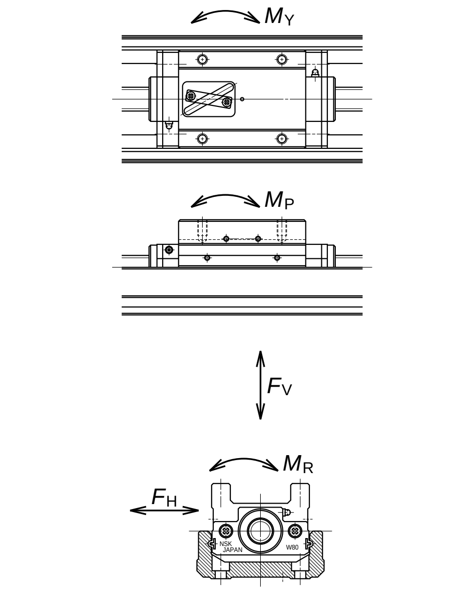

Fig. 4.6 Direction of load

Table 4.14 Dynamic equivalent coefficient

Nominal size	MCM02	MCM03 lead 1, 2	MCM03 lead 10, 12	MCM05	MCM06	MCM08	MCM10	MCH06 MCL06	MCH09	MCH10
ε_R	95.2	79.4	79.4	52.6	45.5	32.5	27.8	48.3	34.5	28.6
ε_P	174	113.9	84.2	81.3	65.1	48.8	45.2	75.1	47.9	41.0
ε_Y	174	113.9	84.2	81.3	65.1	48.8	45.2	75.1	47.9	41.0
ε_{Rd}	–	–	–	26.3	22.7	16.3	13.9	24.2	17.2	14.3
ε_{Pd}	–	–	–	10.4 (12.2)	9.7 (11.5)	7.6 (8.6)	7.1 (8.0)	11.4 (13.2)	8.11 (9.10)	6.98 (7.82)
ε_{Yd}	–	–	–	10.4 (12.2)	9.7 (11.5)	7.6 (8.6)	7.1 (8.0)	11.4 (13.2)	8.11 (9.10)	6.98 (7.82)

Note: Parenthesized figures are Dynamic equivalent coefficient in case of the Monocarrier without NSK K1.

In case when the load acting on the slider may fluctuate (In general, M_P, M_Y may fluctuate with the acceleration/deceleration of slider), the mean effective load is determined by Eq. ③.

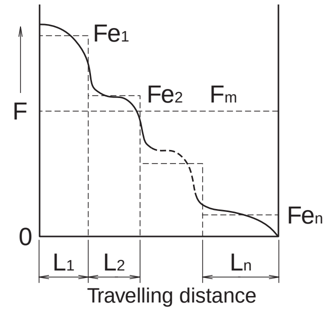

Fig. 4.7 Stepwise Fluctuating Load

Travelling distance under the equivalent load Fe_1 : L_1
Travelling distance under the equivalent load Fe_2 : L_2
. . . .
Travelling distance under the equivalent load Fe_n : L_n

$$Fm = \sqrt[3]{\frac{1}{L}\left(Fe_1^3 L_1 + Fe_2^3 L_2 + \cdots Fe_n^3 L_n\right)} \cdots ③$$

Fm : Mean effective load of fluctuating loads
L : Total travelling distance

The life of linear guide is calculated by Eq. ④

$$L = L_a \times \left(\frac{C}{f_w \cdot Fm}\right)^3 \cdots ④$$

L : Life of linear guide (km)
Fm : Mean effective load acting on the linear guide (N)
C : Basic dynamic load rating of the linear guide (N)
L_a : Travelling distance (km)
f_w : Load factor (Refer to Table 4.15)

When the estimated life does not clear the required life, the life of the linear guide is to be calculated again after the following measures are taken:

1. Change from the single slider type to double slider type.
2. Use a larger size Monocarrier.

(2) Life of Ball Screw (Support unit)

The mean effective load is determined from the axial loads.

For calculation of the mean effective load, use Eq.③.

The life of ball screw is calculated by Eq. ⑤.

$$L = \ell \times \left(\frac{C_a}{f_w \cdot Fm}\right)^3 \times 10^6 \cdots ⑤$$

ℓ : Lead of ball screw (mm)
L : Life of ball screw (mm)
C_a : Basic dynamic load rating of the ball screw (N)
Fm : Mean effective load acting on the ball screw (N)
f_w : Load factor (Refer to Table 4.15)

The life of a support unit is calculated by Eq. ⑤.
If the life of ball screw / support unit does not clear the required life, use a larger size Monocarrier.
After applying the calculations mentioned above, selection of the Monocarrier is completed.

Table 4.15 Values of load factor f_w

Operating conditions	Load factor f_w
At smooth operation with no mechanical shock	1.0 – 1.2
At normal operation	1.2 – 1.5
At operation with mechanical shock and vibrations	1.5 – 3.0

C-1-4. 8 Example of Life Estimation

This section offers an example how to estimate the life of Monocarrier based on the life of each component.

<<Example of calculation-1>>

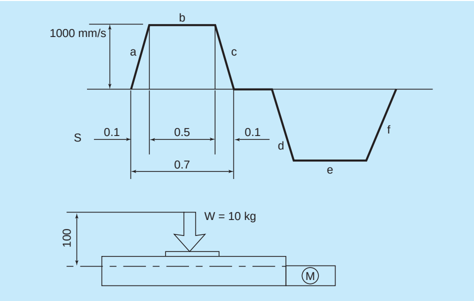

Fig. 4.8

1. Use condition

Stroke	: 600 mm
Maximum Speed	: 1000 mm/s
Load Mass	: W = 10 kg
Acceleration	: g = 9.8 m/s²
Setting Position	: Horizontal
Operating Profile	: See above figure

2. Selection of Nominal size (Interim Selection)

Firstly, select a greater ball screw lead as the maximum speed is 1000 mm/s. The interim selection is MCM06060H20K00, a single slider specification MCM06 that has 600 mm stroke, as the stroke is 600 mm.

3. Calculation

3-1. Linear guide

3-1-1. Fatigue life

Multiply the result of the Eq. ① by the dynamic equivalent coefficient (Table 4.14 single slider) to convert the load volume. From above operation profile,

i) Constant speed $Fe_1 = Y_V F_V = Y_V W_g = 1 \cdot 10 \cdot 9.8 = 98$ N

ii) Accelerating $Fe_2 = Y_V F_V + Y_P \varepsilon_P M_P = 0.5 \cdot 10 \cdot 9.8 + 1 \cdot 65.1 \cdot 0.1 \cdot 100 = 700$ N

iii) Decelerating $Fe_3 = Y_V F_V + Y_P \varepsilon_P M_P = 0.5 \cdot 10 \cdot 9.8 + 1 \cdot 65.1 \cdot 0.1 \cdot 100 = 700$ N

Mean effective load Fm

$$Fm = \sqrt[3]{\frac{1}{L}\left(Fe_1^3 \cdot L_1 + Fe_2^3 \cdot L_2 + Fe_3^3 \cdot L_3\right)}$$

$$= \sqrt[3]{\frac{1}{600}\left(98^3 \cdot 500 + 700^3 \cdot 50 + 700^3 \cdot 50\right)}$$

$= 387$ N

$$L = \left(\frac{C}{f_w \cdot F_m}\right)^3 \times L_a$$

$$= \left(\frac{15900}{1.2 \cdot 387}\right)^3 \times 20$$

$= 8.02 \times 10^5$ km

3-1-2. Static safety factor; Divide the basic static load rating by the maximum load.

$$F_S = \frac{C_0}{Fe} = \frac{C_0}{Fe_2} = \frac{17000}{700} = 24.2$$

3-2. Ball screw

3-2-1. Fatigue life; Obtain the axial load of each stage of operation referring to the operation profile, then calculate the mean load.

By the process above,

i) Constant speed

$Fe_1 = \mu \cdot W \cdot g = 0.01 \cdot 10 \cdot 9.8 = 0.98$

ii) Accelerating

$Fe_2 = Fe_1 + W\alpha = 101$ N

iii) Decelerating

$Fe_3 = Fe_1 - W\alpha = 99$ N

Axial mean effective load Fm

$$Fm = \sqrt[3]{\frac{1}{L}\left(Fe_1^3 \cdot L_1 + Fe_2^3 \cdot L_2 + Fe_3^3 \cdot L_3\right)}$$

$$= \sqrt[3]{\frac{1}{600}\left(0.98^3 \cdot 500 + 101^3 \cdot 50 + 99^3 \cdot 50\right)}$$

$= 55$ N

$$L = \left(\frac{C_a}{f_w \cdot F_m}\right)^3 \times \ell \times 10^6$$

$$= \left(\frac{4560}{1.2 \cdot 55}\right)^3 \times 20 \times 10^6 \text{ (mm)}$$

$= 6.5 \times 10^6$ km

3-2-2. Static safety factor; Divide the basic static load rating by the maximum axial load.

$$F_S = \frac{C_{0a}}{Fe} = \frac{C_{0a}}{Fe_2} = \frac{7750}{101} = 76.7$$

3-2-3. Maximum rotational speed; According to the table of maximum speed on page C7, MCM06 with 20 mm lead and 600 mm stroke, is possible to operate under the maximum speed of 1000 mm/s.

3-3. Support unit

3-3-1. Fatigue life; Use the axial load Fm = 55 N, that is the result of above calculation 3-2-1.

$$L = \left(\frac{C_a}{fw \cdot Fm}\right)^3 \times \ell \times 10^6 = \left(\frac{6550}{1.2 \times 55}\right)^3 \times 20 \times 10^6 \text{ (mm)}$$

$= 1.95 \times 10^7$ km

3-3-2. Static safety factor; Divide the limit load by the maximum axial load.

$$F_S = \frac{C_{0a}}{Fe} = \frac{C_{0a}}{Fe_2} = \frac{2730}{101} = 27.0$$

3-4. Result

MCM06060H20K00	Linear guide	Ball screw	Support unit
Fatigue life	8.02×10^5 km	6.5×10^6 km	1.95×10^7 km
Static safety factor	24.2	76.7	27.0

In this case, the linear guide has the shortest fatigue life of the components. Therefore, the linear guide fatigue life is used as the life of the Monocarrier. The interim selection of MCM06060H20K00, that is chosen based on the use conditions, satisfies the required life.

<<Example of calculation-2>>

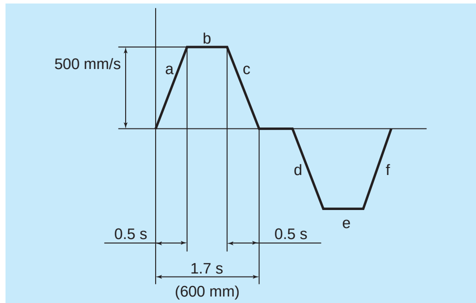

Fig. 4.9

1. Use condition

Stroke	: 600 mm
Maximum Speed	: 500 mm/s
Load Mass	: W = 20 kg
Acceleration	: 9.8 m/s²
Setting Position	: Vertical
Operating Profile	: See above figure

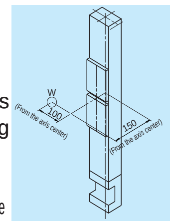

Fig. 4.10

2. Selection of Nominal size (Interim Selection)

Select a 10 mm lead ball screw as the maximum speed is 500 mm/s.

The interim selection is MCM08068H10D00 as a double slider specification of MCM08 has 680 mm stroke, and the setting position is vertical.

3. Calculation

3-1. Linear guide

3-1-1. Fatigue life; Multiply the result of the Eq. ② by the dynamic equivalent coefficient (Table 4.14. double slider) to convert the load volume. From operation profile (Fig. 4.9), the acceleration is 1 m/s².

i) Constant speed $Fe_1 = Y_P \times \varepsilon_{Pd} \times M_P + Y_Y \times \varepsilon_{Yd} \times M_Y = 1 \cdot 7.6 \cdot 20 \cdot 9.8 \cdot 0.15 + 0.5 \cdot 7.6 \cdot 20 \cdot 9.8 \cdot 0.1 = 298$ N

ii) Accelerating $Fe_2 = Y_P \times \varepsilon_{Pd} \times M_P + Y_Y \times \varepsilon_{Yd} \times M_Y = 1 \cdot 7.6 \cdot 20 \cdot (9.8 + 0.15) \cdot 0.15 + 0.5 \cdot 7.6 \cdot 20 \cdot (9.8 + 1.0) \cdot 0.1 = 329$ N

iii) Decelerating $Fe_3 = Y_P \times \varepsilon_{Pd} \times M_P + Y_Y \times \varepsilon_{Yd} \times M_Y = 1 \cdot 7.6 \cdot 20 \cdot (9.8 - 1.0) \cdot 0.15 + 0.5 \cdot 7.6 \cdot 20 \cdot (9.8 - 1.0) \cdot 0.1 = 268$ N

Mean effective load Fm

$$Fm = \sqrt[3]{\frac{1}{L}\left(Fe_1^3 \cdot L_1 + Fe_2^3 \cdot L_2 + Fe_3^3 \cdot L_3\right)}$$

$$= \sqrt[3]{\frac{1}{600}\left(298^3 \cdot 350 + 329^3 \cdot 125 + 268^3 \cdot 125\right)}$$

$= 300$ N

$$L = L_a \times \left(\frac{C}{f_w \cdot F_m}\right)^3$$

$$= 10 \times \left(\frac{24400}{1.2 \cdot 300}\right)^3$$

$= 3.11 \times 10^6$ km

3-1-2. Static safety factor; Divide the basic static load rating by the maximum load.

$$F_S = \frac{C_0}{Fe} = \frac{C_0}{Fe_2} = \frac{22800}{329} = 69.3$$

3-2. Ball screw

3-2-1. Fatigue life; Obtain the axial load of each stage of operation referring to the operation profile, then calculate the mean load.

i) Constant speed

$Fe_1 = W \cdot g = 20 \cdot 9.8 = 196$ N

ii) Accelerating

$Fe_2 = Fe_1 + W \cdot \alpha = 196 + 20 \cdot 1 = 216$ N

iii) Decelerating

$Fe_3 = Fe_1 - W \cdot \alpha = 196 - 20 \cdot 1 = 176$ N