SCPD3
SCM
SSD2
MDC2
SMG
LCM
LCR
LCG
LCX
STM
STG
STR2
MRL2
GRC
Cylinder switch
MN3E MN4E
4GA/B
M4GA/B
MN4GA/B
F.R (module unit)
Clean F.R
Precision R
Press gauge Diff. press gauge
Electro-pneumatic R
Speed controller
Auxiliary valve
Fitting/ tube
Clean air unit
Pressure sensor
Flow rate sensor
Valve for air blow
Ending

STEP-1

Calculate the load factor and decide the bore size.

$$\alpha = \frac{F_0}{F} \times 100\ (\%)$$

α : Load factor

F_0 : Force (N) required to move the workpiece

F : Cylinder theoretical thrust (N) (Table 1)

For horizontal operation	For vertical operation
$F_0 = F_W$	$F_0 = W + F_W$
FW: W × 0.2 Note (N)	
W: Load (N)	

Note : coefficient of friction

(Table 1) Theoretical thrust table (Unit: N)

Bore size	Operating direction	Working pressure MPa						
		0.15	0.2	0.3	0.4	0.5	0.6	0.7
ø25 equiv.	PUSH	74	99	148	197	246	296	345
	PULL	57	76	114	152	190	228	266
ø32 equiv.	PUSH	116	155	233	310	388	466	543
	PULL	99	133	199	265	332	398	464

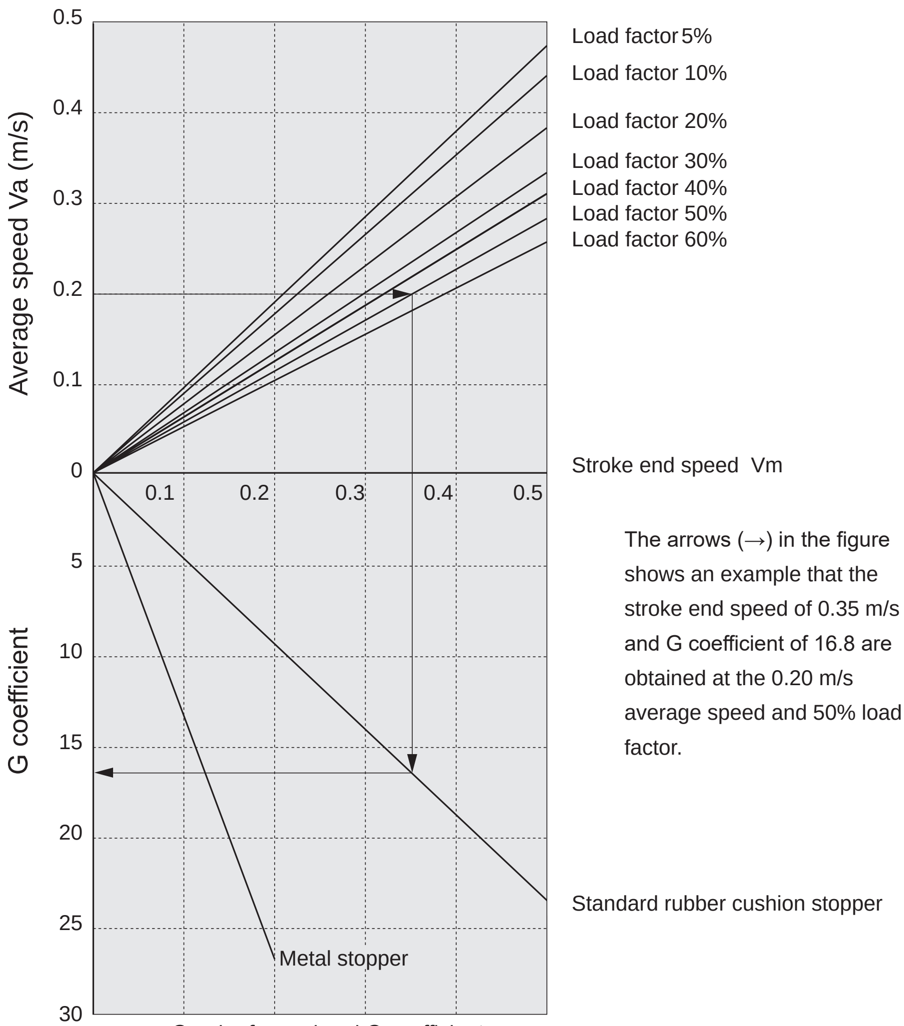
(Table 2) Rough indication of load factor

Working pressure MPa	Load factor (%)
0.2 to 0.3	α ≦ 40
0.3 to 0.6	α ≦ 50
0.6 to 0.7	α ≦ 60

STEP-2

Obtain the stroke end speed (Vm) and G coefficient.

Obtain the stroke end speed (Vm) and G coefficient from the average speed (Va) and load factor obtained in STEP-1.



Graph of speed and G coefficient

G coefficient= [ ]

The arrows (→) in the figure shows an example that the stroke end speed of 0.35 m/s and G coefficient of 16.8 are obtained at the 0.20 m/s average speed and 50% load factor.

STEP-3

Check the allowable absorbed energy.

$$E = \frac{1}{2} \times (m + m_\alpha) \times Vm^2$$

E : Kinetic energy at workpiece end (J)

m : Load weight (kg) $(m \fallingdotseq \frac{W (N)}{9.8})$

m_α : Table weight (from Table 4)

Vm : Stroke end speed (m/s)

E max : Max. allowable value of E_0 (from Table 3)

Confirm E ≤ E max.

(Table 3) LCX allowable absorbed energy value (E_0)

Bore size	Standard (J)	Cushion stopper (J)	Metal stopper (J)
ø25	0.34	0.14	0.07
ø32			

(Table 4) Table weight (Unit: kg)

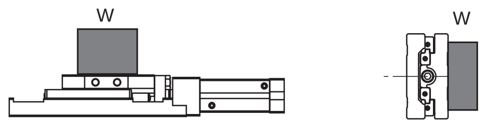
Bore size	Stroke length (mm)								
	10	20	30	40	50	75	100	125	150
ø25	0.030		0.035						
ø32									

STEP-4

Obtain M'T (resultant moment at rest).

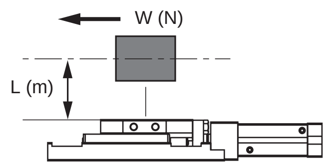
Calculate the load (moment) and the moment of impact occurring at the stroke end and obtain M'T (resultant moment at rest).

● Vertical load: W' (N)



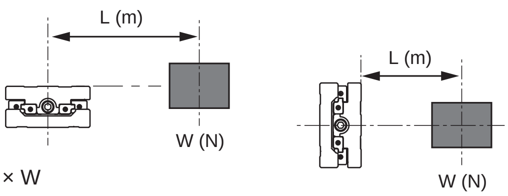
W' = W

● Bending moment: M1' (N·m)



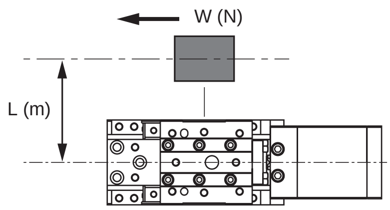
M1'= L × W

● Radial moment: M2' (N·m)



M2'= L × W

● Torsion moment: M3' (N·m)



M3'= L × W

W' = ☐ (N)

M1' × G = ☐ (N·m)

M2' = ☐ (N·m)

M3' × G = ☐ (N·m)

$$M'_T = \frac{W'}{W'max} + \frac{M1' \times G}{M1'max} + \frac{M2'}{M2'max} + \frac{M3' \times G}{M3'max} = \square$$

M'T : Synthesis of moment

G : G coefficient

W'max : Maximum allowable value of W' (from Table 5)

M1'max : Max. allowable value of M1' (from Table 5)

M2'max : Max. allowable value of M2' (from Table 5)

M3'max : Max. allowable value of M3' (from Table 5)

(Table 5) Allowable static load

Bore size	Stroke length	Vertical load W'max (N)	Bending moment M1'max (N·m)	Radial moment M2'max (N·m)	Torsion moment M3'max (N·m)
ø25	10, 20, 30, 40, 50	670	52	110	52
ø32					
ø25	75, 100, 125, 150	970	128	116	128
ø32					

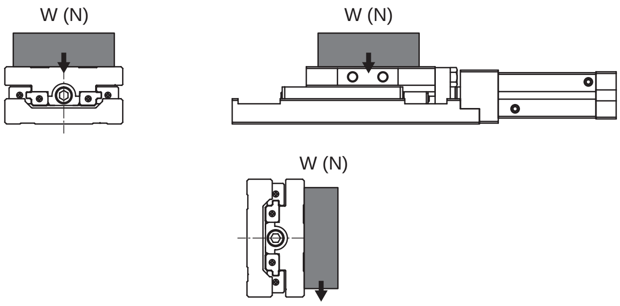
Confirm M'T ≤ 1.

SCPD3
SCM
SSD2
MDC2
SMG
LCM
LCR
LCG
LCX
STM
STG
STR2
MRL2
GRC
Cylinder switch
MN3E MN4E
4GA/B
M4GA/B
MN4GA/B
F.R (module unit)
Clean F.R
Precision R
Press gauge Diff. press gauge
Electro-pneumatic R
Speed controller
Auxiliary valve
Fitting/ tube
Clean air unit
Pressure sensor
Flow rate sensor
Valve for air blow
Ending

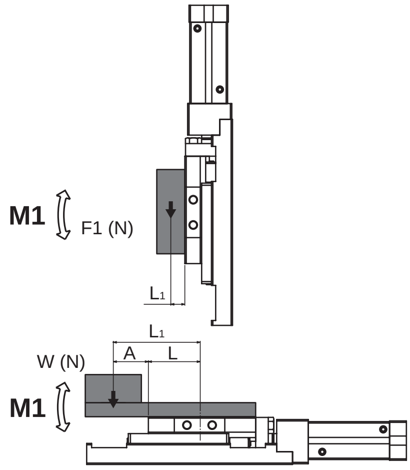
STEP-5

Obtain M_T (resultant moment during movement) (Note that it differs from that obtained in STEP-4.)

● Vertical load: W (N)



● Bending moment: M1 (N·m)



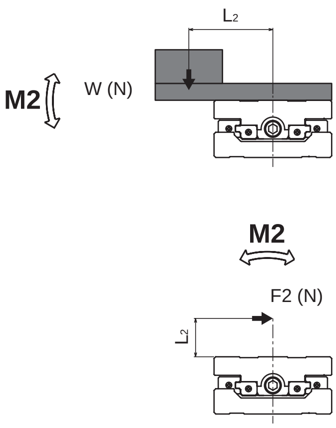
$M1 = F1 \times L_1$

$M1 = W \times L_1$

$L_1 = A + L$

L is a value in the table below.

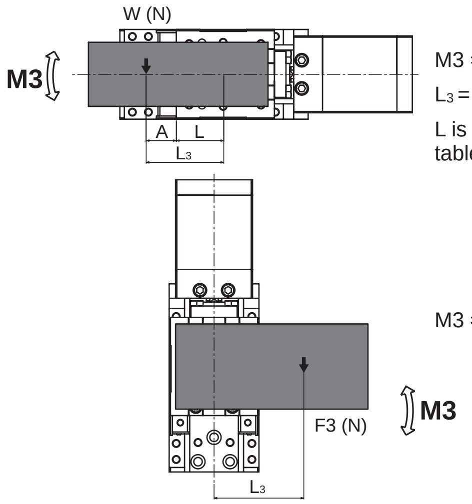
● Radial moment: M2 (N·m)



$M2 = W \times L_2$

$M2 = F2 \times L_2$

● Torsion moment: M3 (N·m)



$M3 = W \times L_3$

$L_3 = A + L$

L is a value in the table below.

$M3 = F3 \times L_3$

L (length from the table end to the center of the bearing) Unit (m)

Bore size	Stroke length								
	10	20	30	40	50	75	100	125	150
ø25	0.037			0.042		0.0535			
ø32									

W = W = ☐ (N)

M1 = M1 = ☐ (N·m)

M2 = M2 = ☐ (N·m)

M3 = M3 = ☐ (N·m)

M_T : Synthesis of moment

Wmax : Maximum allowable value of W (from Table 7)

M1max : Maximum allowable value of M1 (from Table 7)

M2max : Maximum allowable value of M2 (from Table 7)

M3max : Maximum allowable value of M3 (from Table 7)

$$M_T = \frac{W}{Wmax} + \frac{M1}{M1max} + \frac{M2}{M2max} + \frac{M3}{M3max} = \square$$

(Table 7) Allowable moving load

Bore size	Stroke length	Vertical load Wmax (N)	Bending moment M1max (N·m)	Radial moment M2max (N·m)	Twist moment M3max (N·m)
ø25	10, 20, 30, 40, 50	97	7	15	7
ø32					
ø25	75, 100, 125, 150	130	17	16.5	17
ø32					

Can be used when $M_T \leq 1$ is satisfied.

Displacement at point A

[Displacement of table due to M1, M2 and M3 moments]

M1 moment: Displacement at the table end when the load (F1) is applied to the table end
M2 moment: Displacement at the table end (point A) when the load (F2) is applied to the point 100 mm away from the center of the cylinder
M3 moment: Displacement angle of the table when the rotation moment (M3) is applied to the cylinder

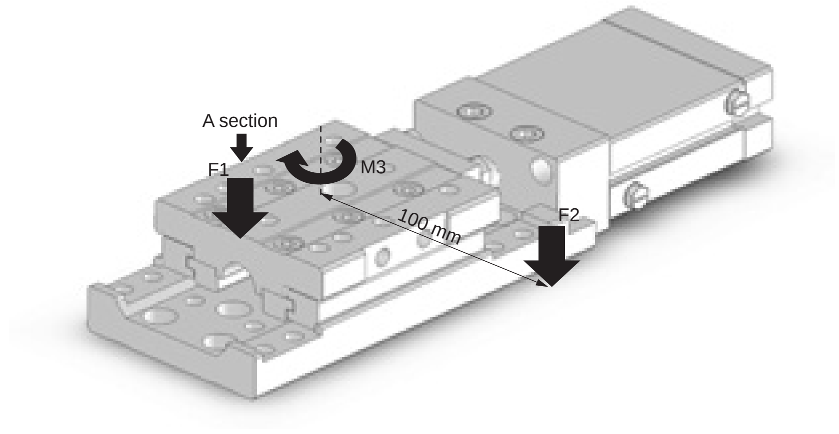


Table deflection of M1 moment

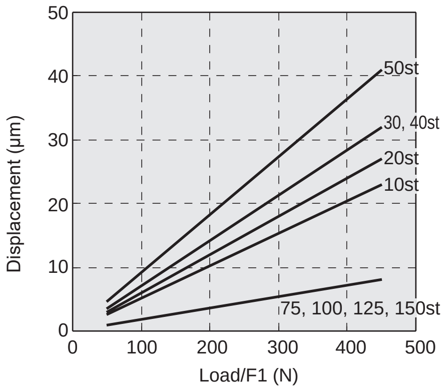


Table deflection of M2 moment

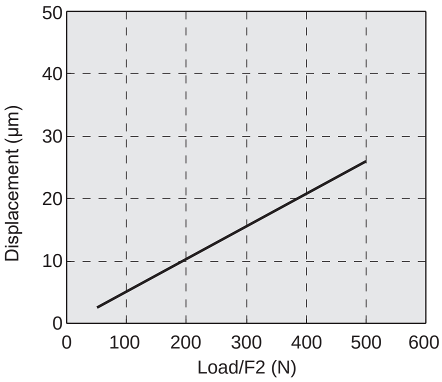
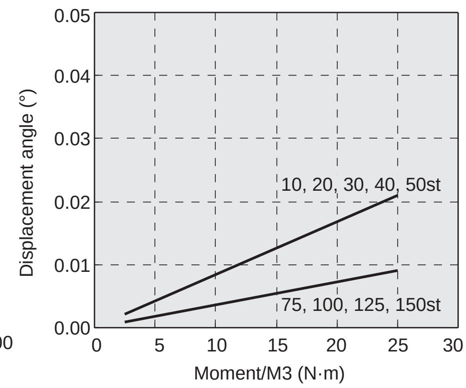
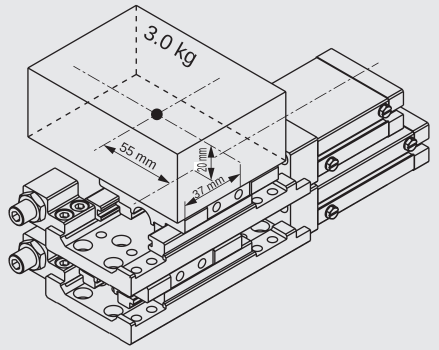


Table deflection of M3 moment



Selection guide: selection example (1)



[Operation condition]

Model used (upper): LCX-25-30-M6 (product weight: 1,270 (g))
(lower): LCX-32-30-S6 (product weight: 1,440 (g))
Pressure: 0.5 (MPa)
Weight of workpiece: 3.0 (kg)
Operating direction: Horizontal
Average speed (upper): 100 (mm/s)
(lower): 230 (mm/s)
Shape of workpiece: As shown on the left

STEP-1 Check of the load factor and decision of the bore size (For details on how to calculate, refer to page 188.)

Formula

$\alpha = \frac{F_0}{F} \times 100$ (%)

α : Load factor
F_0 : Force (N) required to move the workpiece
F : Cylinder theoretical thrust (N)

Selection example

[Cylinder on upside]

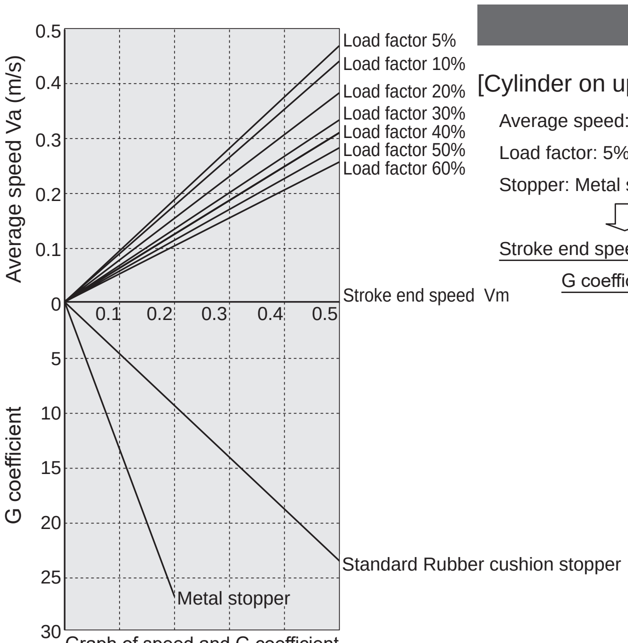
$\alpha 1 = \frac{(3.0 \times 9.8) \times 0.2}{190} \times 100$
$= 3.1\%$

[Cylinder on downside]

$\alpha 2 = \frac{((3.0 + 1.27 + 0.01) \times 9.8) \times 0.2}{332}$
$\times 100 = 2.5\%$

Can be used since the estimated load factor at 0.5 MPa is
Can be used as "α ≦ 50"

STEP-2 Check of the stroke end speed and G factor (For details on how to calculate, refer to page 188.)



Graph of speed and G coefficient
G coefficient =

Selection example

[Cylinder on upside]

Average speed: 100 mm/s
Load factor: 5% or less (3.1%)
Stopper: Metal stopper
⇩
Stroke end speed: 110 mm/s
G coefficient: 14

[Cylinder on downside]

Average speed: 230 mm/s
Load factor: 5% or less (2.5%)
Stopper: Rubber cushion stopper
⇩
Stroke end speed: 240 mm/s
G coefficient: 12

STEP-3 Check of the allowable absorbed energy (For details on how to calculate, refer to page 189.)

Formula

$E = \frac{1}{2} \times (m + m_\alpha) \times Vm^2$

E : Kinetic energy at workpiece end (J)
m : Load weight (kg)
m_α : Table weight (kg)
Vm : Stroke end speed (m/s)

Selection example

[Cylinder on upside]

$E = \frac{1}{2} \times (3.0 + 0.03) \times 0.11^2$
$= 0.02$ (J)

Can be used since the allowable absorbed energy of the metal stopper is "0.07J"

[Cylinder on downside]

$E = \frac{1}{2} \times (3.0 + 1.27 + 0.01 + 0.035)$
$\times 0.24^2 = 0.124$ (J)

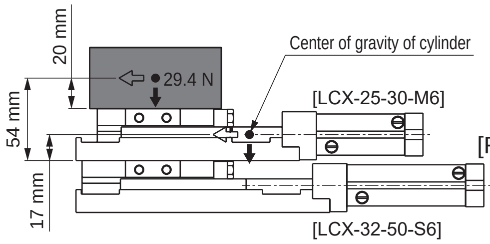
Can be used since the allowable absorbed energy of the rubber cushion stopper is "0.14J"

STEP-4 Check of the allowable static load (For details on how to calculate, refer to page 189.)

Formula

- **Vertical load**
  W' = W
- **Bending moment: M1' (N·m)**
  $M1' = L_1 \times W$
- **Radial moment: M2' (N·m)**
  $M2' = L_2 \times W$
- **Torsion moment: M3' (N·m)**
  $M3' = L_3 \times W$
- ◎ **Synthesis of moment**

$$M'_T = \frac{W'}{W'max} + \frac{M1' \times G}{M1'max} + \frac{M2'}{M2'max} + \frac{M3' \times G}{M3'max}$$



Selection example

[Calculating load and moment]

[Cylinder on upside]

W' = 3.0 × 9.8 = 29.4 (N)
M1' = 0.02 × 29.4 = 0.6 (N·m)
M2' = 0.055 × 29.4 = 1.6 (N·m)
M3' = 0.055 × 29.4 = 1.6 (N·m)

[Cylinder on downside]

W' = 3.0 × 9.8 + 1.27 × 9.8
= 41.8 (N)
M1' = 0.054 × 29.4
<u>+ 0.017 × 1.27 × 9.8</u>
= 1.8 (N·m)
(Omit the underlined part if the cylinder on upside does not work as a moment of impact.)
M2' = 0.055 × 29.4 = 1.6 (N·m)
M3' = 0.055 × 29.4 = 1.6 (N·m)

[Resultant moment when the cylinder on upside operates]

Stroke end speed: 110 mm/s, G factor: 14

[Cylinder on upside]

$$M'_T = \frac{29.4}{670} + \frac{0.6 \times 14}{52} + \frac{1.6}{110} + \frac{1.6 \times 14}{52} = 0.7$$

Can be used since the resultant moment (M'T) is "1 or less"

[Cylinder on downside]

$$M'_T = \frac{41.8}{670} + \frac{1.6 \times 14}{52} + \frac{1.6}{110} + \frac{1.6 \times 14}{52} = 1.0$$

Can be used since the resultant moment (M'T) is "1 or less"

[Resultant moment when the cylinder on downside operates]

Stroke end speed: 240 mm/s, G factor: 12

[Cylinder on upside]

$$M'_T = \frac{29.4}{670} + \frac{0.6 \times 12}{52} + \frac{1.6}{110} + \frac{1.6 \times 12}{52} = 0.6$$

Can be used since the resultant moment (M'T) is "1 or less"

[Cylinder on downside]

$$M'_T = \frac{41.8}{670} + \frac{1.8 \times 12}{52} + \frac{1.6}{110} + \frac{1.6 \times 12}{52} = 0.9$$

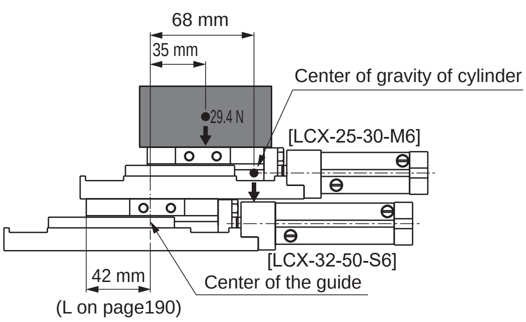
Can be used since the resultant moment (M'T) is "1 or less"

STEP-5 Check of the allowable dynamic load (For details on how to calculate, refer to page 190.)

Formula

- **Vertical load**
  W = W
- **Bending moment: M1 (N·m)**
  $M1 = L_1 \times W$
- **Radial moment: M2 (N·m)**
  $M2 = L_2 \times W$
- **Torsion moment: M3 (N·m)**
  $M3 = L_3 \times W$
- ◎ **Synthesis of moment**

$$M_T = \frac{W}{Wmax} + \frac{M1}{M1max} + \frac{M2}{M2max} + \frac{M3}{M3max}$$



Selection example

[Cylinder on upside]

W = 3.0 × 9.8 = 29.4 (N)
M1 = 0 (N·m)
M2 = 0.055 × 29.4 = 1.6 (N·m)
M3 = 0 (N·m)

$$M_T = \frac{29.4}{97} + \frac{0}{7} + \frac{1.6}{15} + \frac{0}{7} = 0.4$$

Can be used since the resultant moment (M'T) is "1 or less"

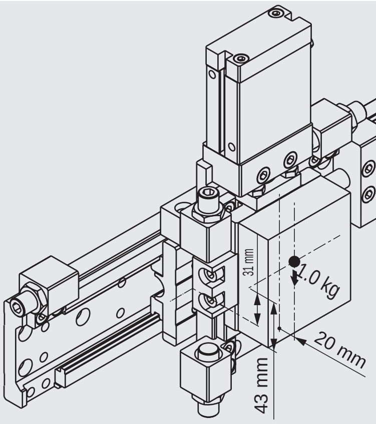
[Cylinder on downside]

W = 3.0 × 9.8 + 1.27 × 9.8
= 41.8 (N)
M1 = 0.035 × 29.4 + 0.068 × 1.27 × 9.8
= 1.9 (N·m)
(Add the value of the cylinder on upside since it works as a moment. Substitute the center of the external dimensions for the center of gravity of the cylinder.)
M2 = 0.055 × 29.4 = 1.6 (N·m)
M3 = 0 (N·m)

$$M_T = \frac{41.8}{97} + \frac{1.9}{7} + \frac{1.6}{15} + \frac{0}{7} = 0.8$$

Can be used since the resultant moment (M'T) is "1 or less"

Selection guide: selection example (2)



[Operation condition]

Model used (X-axis): LCX-32-150-A6 (product weight: 2,450 (g))
(Z-axis): LCX-32-30-S6 (product weight: 1,440 (g))
Pressure: 0.5 (MPa)
Weight of workpiece: 1.0 (kg)
Operating direction: Horizontal + vertical
Average speed (X-axis) : 300 (mm/s)
(Z-axis): 50 (mm/s)
Shape of workpiece: As shown on the left

STEP-1 Check of the load factor and decision of the bore size (For details on how to calculate, refer to page 188.)

Formula

$\alpha = \frac{F_0}{F} \times 100$ (%)

α : Load factor
F_0 : Force (N) required to move the workpiece
F : Cylinder theoretical thrust (N)

Selection example

[X-axis cylinder]

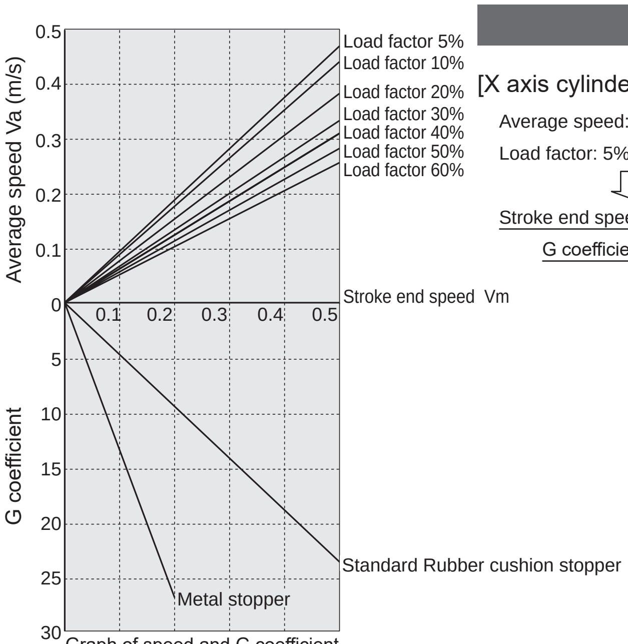
$\alpha 1 = \frac{((1.0 + 1.29 + 0.01) \times 9.8) \times 0.2}{332} \times 100 = 1.4\%$

[Z axis cylinder]

$\alpha 2 = \frac{(1.0 \times 9.8) + 0.2 \times (1.0 \times 9.8)}{332} \times 100 = 3.5\%$

Can be used since the estimated load factor at 0.5 MPa is
Can be used as "α≦50"

STEP-2 Check of the stroke end speed and G factor (For details on how to calculate, refer to page 188.)



Graph of speed and G coefficient
G coefficient = ☐

Selection example

[X axis cylinder]

Average speed: 300 mm/s
Load factor: 5% or less (1.4%)
⇩
Stroke end speed: 310 mm/s
G coefficient: 4

[Z axis cylinder]

Average speed: 50 mm/s
Load factor: 5% or less (3.5%)
Stopper: Rubber cushion stopper
⇩
Stroke end speed: 55 mm/s
G coefficient: 3

STEP-3 Check of the allowable absorbed energy (For details on how to calculate, refer to page 189.)

Formula

$E = \frac{1}{2} \times (m + m_\alpha) \times Vm^2$

E : Kinetic energy at workpiece end (J)
m : Load weight (kg)
m_α : Table weight (kg)
Vm : Stroke end speed (m/s)

Selection example

[X axis cylinder]

$E = \frac{1}{2} \times (1.0 + 1.29 + 0.01 + 0.035) \times 0.31^2 = 0.11$ (J)

Can be used since the allowable absorbed energy of the shock absorber stopper is "1.3J"

[Z axis cylinder]

$E = \frac{1}{2} \times (1.0 + 0.035) \times 0.055^2 = 0.002$ (J)

Can be used since the allowable absorbed energy of the rubber cushion stopper is "0.14J"

STEP-4 Check of the allowable static load (For details on how to calculate, refer to page 189.)

Formula

- Vertical load

  $W' = W$
- Bending moment: M1' (N·m)

  $M1' = L_1 \times W$
- Radial moment: M2' (N·m)

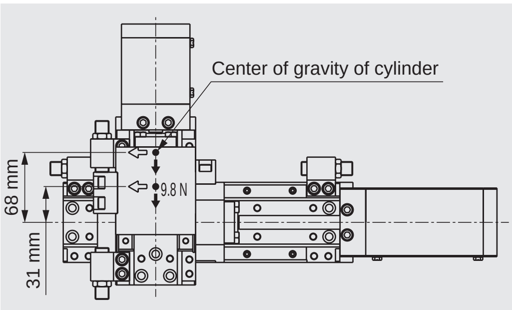
  $M2' = L_2 \times W$
- Torsion moment: M3' (N·m)

  $M3' = L_3 \times W$

◎ Synthesis of moment

$$M'_T = \frac{W'}{W'max} + \frac{M1' \times G}{M1'max} + \frac{M2'}{M2'max} + \frac{M3' \times G}{M3'max}$$

Note) In the crossed unit, a moment of impact may occur in the M2 direction. Multiply the G coefficient with the M2' value as necessary.



Selection example

[Calculating load and moment]

[X axis cylinder]

$W' = 1.0 \times 9.8 + 1.44 \times 9.8 = 23.9$ (N)

$M1' = 0.054 \times 9.8 + 0.017 \times 1.44 \times 9.8$

$= 0.8$ (N·m)

(Add the value of the Z-axis cylinder since it works as a moment.)

$M2' = 0.054 \times 9.8 + 0.017 \times 1.44 \times 9.8$

$= 0.8$ (N·m)

$M3' = 0.031 \times 9.8 + 0.068 \times 1.44 \times 9.8$

$= 1.3$ (N·m)

[Z axis cylinder]

$W' = 0$ (N)

$M1' = 0.02 \times 9.8 = 0.2$ (N·m)

$M2' = 0.02 \times 9.8 = 0.2$ (N·m)

$M3' = 0.001 \times 9.8 = 0.01$ (N·m)

[Resultant moment when the X-axis cylinder operates]

Stroke end speed: 310 mm/s, G factor: 4

[X axis cylinder]

$$M'_T = \frac{23.9}{970} + \frac{0.8 \times 4}{128} + \frac{0.8}{116} + \frac{1.3 \times 4}{128} = 0.1$$

Can be used since the resultant moment (M'T) is "1 or less"

[Z axis cylinder]

$$M'_T = \frac{0}{670} + \frac{0.2}{52} + \frac{0.2 \times 4}{110} + \frac{0.01 \times 4}{52} = 0.01$$

(Multiply the G factor if a moment of impact in M2 direction is caused in the Z-axis cylinder by operation of the X-axis cylinder.)

Can be used since the resultant moment (M'T) is "1 or less"

[Resultant moment when the Z-axis cylinder operates]

Stroke end speed: 55 mm/s, G factor: 3

[X axis cylinder]

$$M'_T = \frac{23.9}{970} + \frac{0}{128} + \frac{0.5 \times 3 + 0.2}{116} + \frac{0}{128} = 0.04$$

(Multiply the G factor if a moment of impact in M2 direction is caused in the X-axis cylinder by operation of the Z-axis cylinder.)

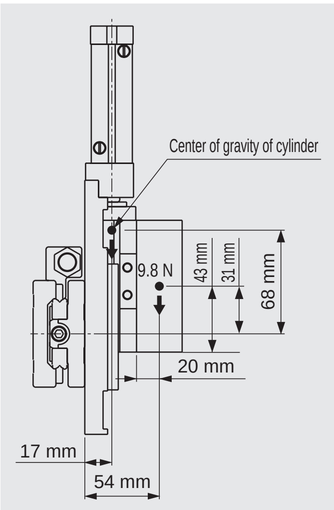
Can be used since the resultant moment (M'T) is "1 or less"

[Z axis cylinder]

$$M'_T = \frac{0}{670} + \frac{0.2 \times 3}{52} + \frac{0}{110} + \frac{0}{52} = 0.01$$

Can be used since the resultant moment (M'T) is "1 or less"

STEP-5 Check of the allowable dynamic load (For details on how to calculate, refer to page 190.)



Formula

- Vertical load

  $W = W$
- Bending moment: M1 (N·m)

  $M1 = L_1 \times W$
- Radial moment: M2 (N·m)

  $M2 = L_2 \times W$
- Torsion moment: M3 (N·m)

  $M3 = L_3 \times W$

◎ Synthesis of moment

$$M_T = \frac{W}{Wmax} + \frac{M1}{M1max} + \frac{M2}{M2max} + \frac{M3}{M3max}$$

Selection example

[X axis cylinder]

$W = 1.0 \times 9.8 + 1.44 \times 9.8$

$= 23.9$ (N)

$M1 = 0$ (N·m)

$M2 = 0.054 \times 9.8 + 0.017 \times 1.44 \times 9.8$

$= 0.8$ (N·m)

$M3 = 0$ (N·m)

$$M_T = \frac{23.9}{130} + \frac{0}{17} + \frac{0.8}{16.5} + \frac{0}{17} = 0.2$$

Can be used since the resultant moment (M'T) is "1 or less"

[Z axis cylinder]

$W = 0$ (N)

$M1 = 0.02 \times 9.8 = 0.2$ (N·m)

$M2 = 0$ (N·m)

$M3 = 0$ (N·m)

$$M_T = \frac{0}{97} + \frac{0.2}{7} + \frac{0}{15} + \frac{0}{7} = 0.03$$

Can be used since the resultant moment (M'T) is "1 or less"