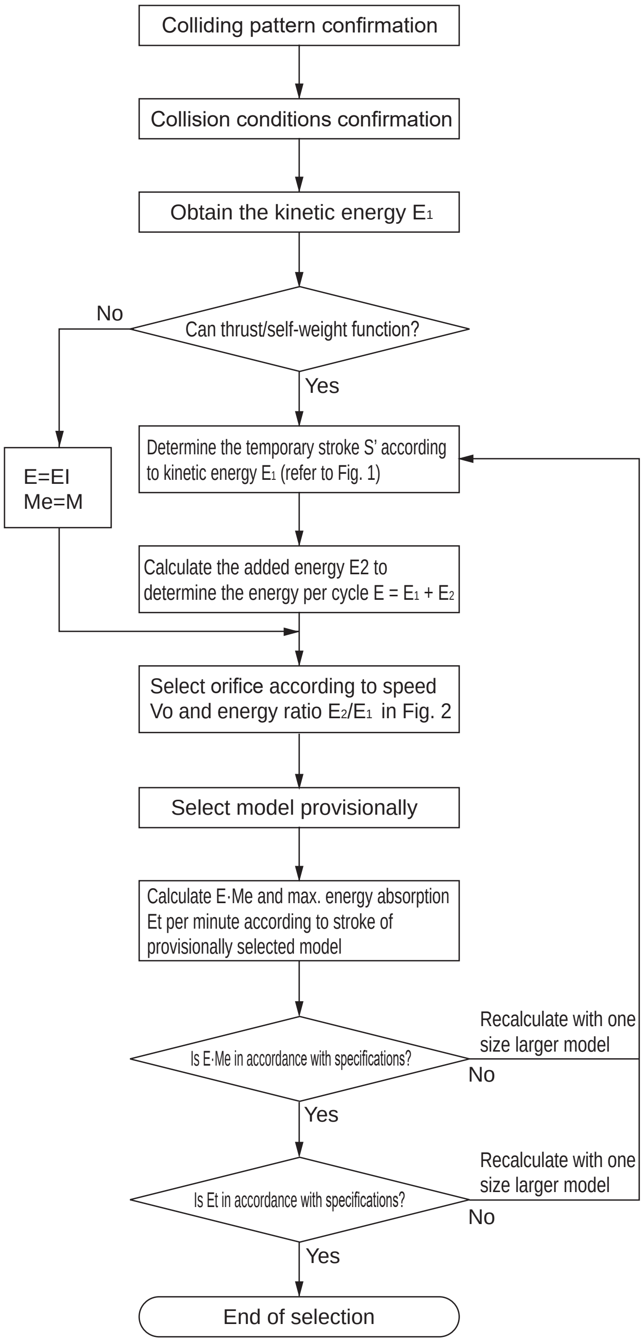
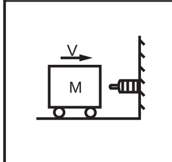
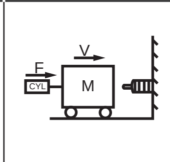
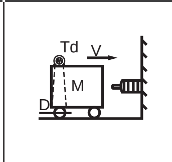
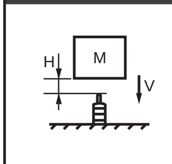
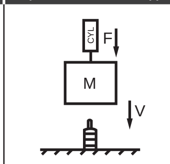
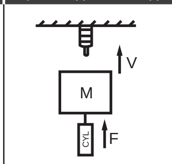
Selection guide flow chart

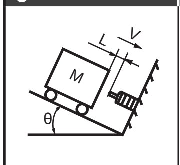
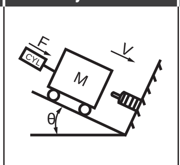
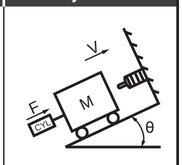


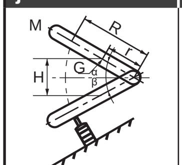
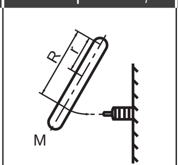
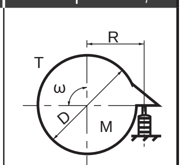
Code	Working conditions	Unit
E	Absorbed energy	J
E_1	Kinetic energy	J
E_2	Thrust/self-weight energy	J
G	Position of center of gravity	
S	FCK stroke	m
g	Gravity acceleration (9.8)	m/s^2
N	Rotation speed	rpm
Me	Equivalent weight	kg
Td	Motor start torque	N·m
K	Reduction ratio	

Example of colliding pattern

	Horizontal colliding		
	a. Simple horizontal colliding	b. With cylinder thrust	c. With motor drive force
Applications			
Kinetic energy E_1(J)	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$
Thrust/self energy E_2(J)	-----	$E_2 = F \cdot S$	$E_2 = 2 \cdot \frac{K}{D} \cdot Td \cdot S$
All absorbed energy E(J)	$E=E_1$	$E=E_1+E_2$	$E=E_1+E_2$
Equivalent weight Me (kg)	Me=M	$Me=\frac{2 \cdot E}{V^2}$	$Me=\frac{2 \cdot E}{V^2}$
Absorbed energy per hour Et(J/h)	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$

	Vertical colliding		
	d. Free fall	e. Cylinder lower limit stopper	f. Cylinder upper limit stopper
Applications			
Kinetic energy E_1(J)	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$
Thrust/self energy E_2(J)	$E_2 = M \cdot g \cdot S$	$E_2 = (M \cdot g + F) \cdot S$	$E_2 = (F - M \cdot g) \cdot S$
All absorbed energy E(J)	$E=E_1+E_2$	$E=E_1+E_2$	$E=E_1+E_2$
Equivalent weight Me (kg)	$Me = \frac{2 \cdot E}{V^2} (V=\sqrt{2/g/H})$	$Me=\frac{2 \cdot E}{V^2}$	$Me=\frac{2 \cdot E}{V^2}$
Absorbed energy per hour Et(J/h)	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$

	Slope colliding		
	g. Free fall	h. With cylinder thrust	i. With cylinder thrust
Applications			
Kinetic energy E_1(J)	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{1}{2} \cdot M \cdot V^2$
Thrust/self energy E_2(J)	$E_2 = M \cdot g \cdot S \cdot \sin\theta$	$E_2 = (M \cdot g \cdot \sin\theta + F) \cdot S$	$E_2 = (F - M \cdot g \cdot \sin\theta) \cdot S$
All absorbed energy E(J)	$E=E_1+E_2$	$E=E_1+E_2$	$E=E_1+E_2$
Equivalent weight Me (kg)	$Me = \frac{2 \cdot E}{V^2} (V=\sqrt{2 \cdot g \cdot L \cdot \sin\theta})$	$Me=\frac{2 \cdot E}{V^2}$	$Me=\frac{2 \cdot E}{V^2}$
Absorbed energy per hour Et(J/h)	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$

	Oscillation colliding		Rotation colliding
	j. Free fall	k. With torque of motor, etc.	l. With torque of motor, etc.
Applications			
Kinetic energy E_1(J)	$E_1 = M \cdot g \cdot H$	$E_1 = \frac{J \cdot \omega^2}{2}$ or $\frac{1}{2} \cdot M \cdot V^2$	$E_1 = \frac{J \cdot \omega^2}{2} = \frac{M \cdot D^2 \cdot \omega^2}{16}$
Thrust/self energy E_2(J)	$E_2 = \frac{r}{R} \cdot M \cdot g \cdot S$	$E_2 = \frac{T}{R} \cdot S$	$E_2 = \frac{T}{R} \cdot S$
All absorbed energy E(J)	$E=E_1+E_2$	$E=E_1+E_2$	$E=E_1+E_2$
Equivalent weight Me (kg)	$Me=\frac{2 \cdot E}{V^2} (V=\frac{R}{r}\sqrt{\frac{3 \cdot g \cdot H}{2}})$	$Me = \frac{2 \cdot E}{V^2} (V=\omega \cdot R)$	$Me = \frac{2 \cdot E}{V^2} (V=\omega \cdot R, \omega=\frac{2\pi \cdot N}{60})$
Absorbed energy per hour Et(J/h)	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$	$E_t = 60 \cdot E \cdot n$

Shock absorber selection guide

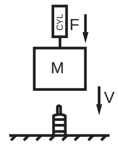
1 Clarify the colliding pattern of the device

- Horizontal motion
  - a. Simple horizontal collision
  - b. Collision with cylinder thrust
  - c. Collision with drive force of motor
- Vertical motion
  - d. Collision due to free fall
  - e. Collision with cylinder thrust (downward)
  - f. Collision with cylinder thrust (upward)
- Slope motion
  - g. Collision due to free sliding
  - h. Collision with cylinder thrust (downward)
  - i. Collision with cylinder thrust (upward)
- Oscillation/rotary motion
  - j. Collision due to free oscillating fall
  - k. Collision with motor torque, etc. (oscillation)
  - l. Collision with motor torque, etc. (rotation)

*1: Refer to “Example of colliding pattern”.

Example of selection

Clarifies colliding pattern of device.

Applications	Vertical colliding e. Cylinder lower limit stopper 
Kinetic energy E_1(J)	$E_1 = \frac{1}{2} \cdot M \cdot V^2$
Thrust/gravity energy E_2(J)	$E_2 = (Mg+F) \cdot S$
All absorbed energy E(J)	$E = E_1 + E_2$
Equivalent weight Me(kg)	$Me = \frac{2 \cdot E}{V^2}$
Absorbed energy per hour Et(J/h)	$E_t = 60 \cdot E \cdot n$

2 Make required conditions/descriptions clear to calculate energy

Horizontal collision

Code	Working conditions	Unit
M	Colliding object weight	kg
V	Colliding speed	m/s
F	Pushing force	N
n	Frequency	Cycle/min.
t	Ambient temperature	°C
Rt	Return time	s

Vertical colliding

Code	Working conditions	Unit
M	Colliding object weight	kg
V	Colliding speed	m/s
F	Pushing force	N
n	Frequency	Cycle/min.
t	Ambient temperature	°C
Rt	Return time	s
H	Drop height	m

Slope colliding

Code	Working conditions	Unit
M	Colliding object weight	kg
V	Colliding speed	m/s
F	Pushing force	N
n	Frequency	Cycle/min.
t	Ambient temperature	°C
Rt	Return time	s
L	Distance moved from collision	m
θ	Slope angle	deg

Vibration/rotation colliding

Code	Working conditions	Unit
M	Colliding object weight	Kg
V	Colliding speed	m/s
T	Torque	N·m
n	Frequency	Cycle/min.
t	Ambient temperature	°C
Rt	Return time	s
ω	Angular speed	rad/s
J	Moment of inertia	kg·m²
R	Distance of rotational axis to colliding point	m
r	Distance of rotational axis to CG	m
α·β	Slope angle	deg
H	Drop height	m
D	Rotor diameter	m

Colliding object weight : M=15 kg
Colliding speed : V=1.42 m/s
Pushing force : F=245.5N
Frequency : n = 10 cycle/min.
Ambient temperature : t=23°C
Return time : Rt = 2s (time up to re-collision)

3 Calculate kinetic energy E_1 according to “Example of colliding pattern”

- Calculate kinetic energy E_1 according to “Example of colliding pattern” (page 1850).

$$E = \frac{1}{2} M \cdot V^2 = \frac{1}{2} \times 15 \times 1.42^2$$
$$= 15.1 \text{ J}$$

4 Select temporary stroke according to temporary selection graph

- From Fig. 1 (page 1853), select the temporary stroke.

S’ = 30

SCP*3
CMK2
CMA2
SCM
SCG
SCA2
SCS2
CKV2
CAV2/COVP/N2
SSD2
SSG
SSD
CAT
MDC2
MVC
SMG
MSD/MSDG
FC*
STK
SRL3
SRG3
SRM3
SRT3
MRL2
MRG2
SM-25
ShkAbs
FJ
FK
Spd Contr
Ending

SCP*3
CMK2
CMA2
SCM
SCG
SCA2
SCS2
CKV2
CAV2/COVP/N2
SSD2
SSG
SSD
CAT
MDC2
MVC
SMG
MSD/MSDG
FC*
STK
SRL3
SRG3
SRM3
SRT3
MRL2
MRG2
SM-25
ShkAbs
FJ
FK
Spd Contr
Ending

5 Calculate absorbed energy E according to “Example of colliding pattern”

- Calculate thrust/self-weight energy E_2 according to “Example of colliding pattern”.
  Calculate S (stroke of FCK) as temporary stroke S’ selected in Step 4.
  Calculate absorbed energy E according to “Example of colliding pattern”.

6 Shock absorber temporary selection

- Select orifice according to energy ratio (thrust/self-weight energy, kinetic energy) and colliding speed on Fig. 2 (page 1853), then select a model provisionally according to calculated absorbed energy E.

*1: Allowable energy absorption may vary depending on colliding speed. Refer to pages 1854 and 1855.

7 Re-calculate absorbed energy E with temporary selected model

- Calculate absorbed energy E_2 according to “Example of collision pattern”. Calculate S (stroke of FCK) as model stroke selected in Step 6.
- Calculate absorbed energy E according to “Example of colliding pattern”.

8 Calculate energy Et per hour

- Calculate energy per hour Et according to “Example of colliding pattern”.

9 Confirm the equivalent weight M

- Calculate equivalent weight M according to “Example of colliding pattern”.

10 Selection confirmation

- If calculated absorbed energy, energy per hour, equivalent weight, frequency of usage, ambient temperature and return time are in accordance with specifications of the selected shock absorber, there is no problem. If exceeding specifications range, select one size larger shock absorber according to model, selected before, then recalculate conditions.

*1: The specified equivalent weight depends on the speed. Refer to pages 1854 and 1855 for details.

Example of selection

(Step 5)

$E_2 = (M \cdot g+F) \cdot S = (15 \times 9.8+245.5) \times 0.03 = 11.8$ J

$E = E_1 + E_2 = 15.1 + 11.8 = 26.9$ J

(Step 6)

$\frac{E_2}{E_1} = \frac{11.8}{15.1} = 0.8$

Provisionally select porous orifice (FCK-H-3) from models of E = 26.9 and higher.

(Step 7)

$E_2 = (15 \times 9.8+245.5) \times 0.016 = 6.28$ J

$E = 15.1 + 6.28 = 21.4$ J

(Step 8)

$Et = 60 \cdot E \cdot n = 60 \times 21.4 \times 10 = 1284$ J/h

(Step 9)

$Me = \frac{2E}{V^2} = \frac{2 \times 21.4}{1.42^2} = 21.2$ kg

(Step 10)

		Calculated value	FCK-H-3 specification values	Judgment
E	J	21.4	29.4 or less	OK
Et	J/h	1284	20580 or less	OK
Me	kg	21.2	29 or less	OK
n	Cycle/min.	10	60 or less	OK
t	°C	23	-5 to 70	OK
Rt	S	2	0.5 or more	OK

[CAUTION]
Use speed just before colliding into shock absorber to select shock absorber by calculation. This speed differs from average speed (cylinder stroke/travel time).
Calculate or measure speed just before collision, or use 1.5 to 2 times the average speed when making calculations for selection.

Fig.1 Temporary selection graph

Obtain temporary stroke S' from kinetic energy E_1.

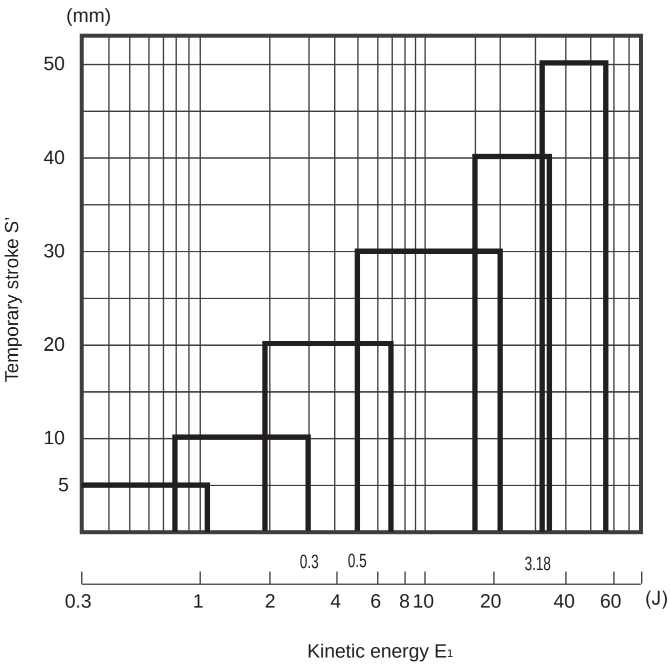
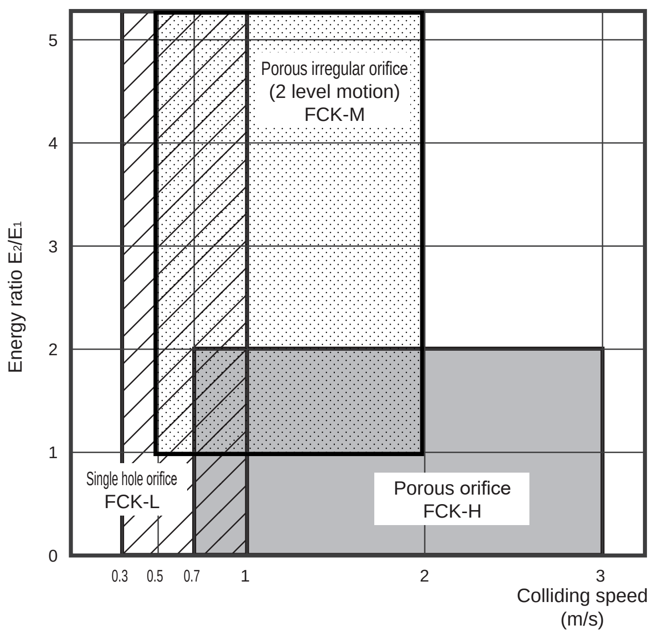
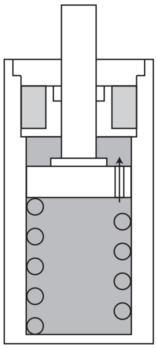
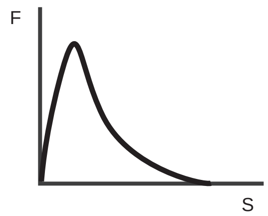
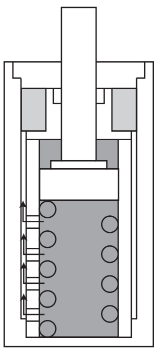
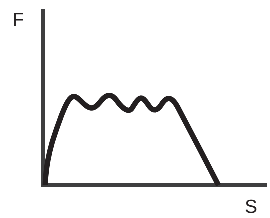
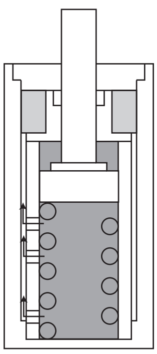
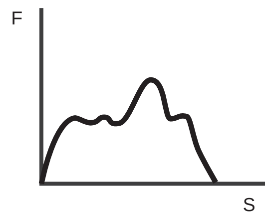


Fig. 2. Energy ratio (thrust/self-weight energy E_2, inertia energy E_1)

Refer to the following figure to select the orifice.



Absorbing characteristics structure

Constant orifice	Single hole orifice structure	FCK-L		Single hole orifice structure includes a dash pot structure that uses the clearance between the piston and cylinder tube, a single tube structure with an orifice on the piston, and a double tube single hole orifice structure (adjustable). Each type has similar resistance characteristics. The common single tube structure is explained here. The piston, which has a single hole orifice, slides in the cylinder tube filled with oil. Since the orifice area is constant throughout the full stroke, resistance increases immediately after collision, and decreases as the stroke advances and speed declines.	
Displacement dependent orifice	Porous orifice structure	FCK-H		This orifice has a double structure consisting of an outer and inner tube. The piston slides along the inner wall of the inner tube. This inner tube has several orifices set in the direction of the stroke. The orifice area gradually decreases as the stroke advances and speed drops. Resistance thus fluctuates in a wave, but max. resistance is suppressed at a low level. Based on orifice design, absorption characteristics are matched to individual collision conditions.	
	Porous irregular orifice structure	FCK-M		Structurally, this type is basically the same as the multiple orifice above, but by changing the orifice, energy is absorbed based on the purpose instead of with constant attenuation force. For example, the orifice in the FCK-M Series absorbs kinetic energy with the first half of the stroke and controls speed with the second half. Energy is absorbed ideally for cylinder thrust.	

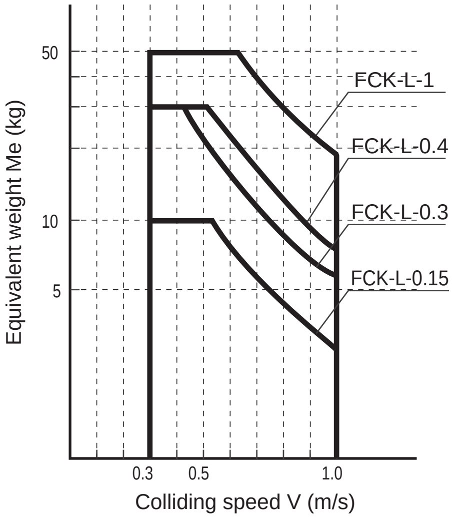
Equivalent weight/colliding speed characteristics graph

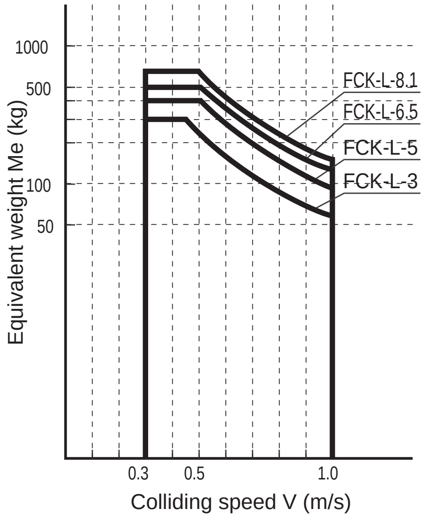
Equivalent weight:
Weight obtained by calculating all cylinder thrust and weight mass as inertial energy.

$\frac{1}{2}MV^2+F{\cdot}S=E=MeV^2$

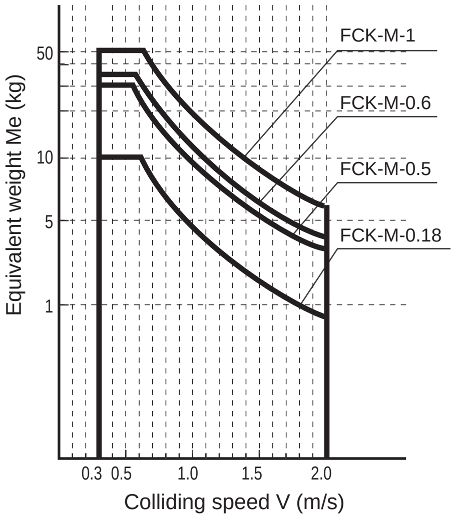
M: Colliding object weight
F: Self weight of cylinder thrust or weight
Me: Equivalent weight

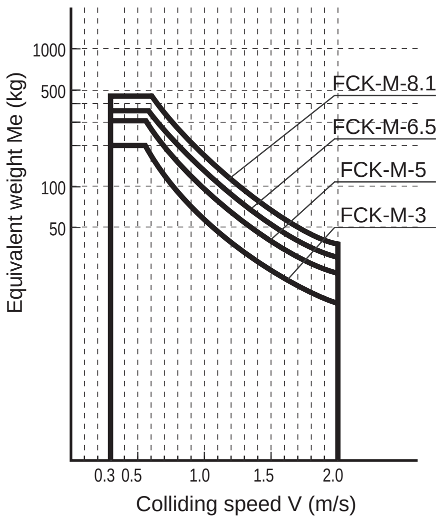
Single hole orifice (FCK-L)

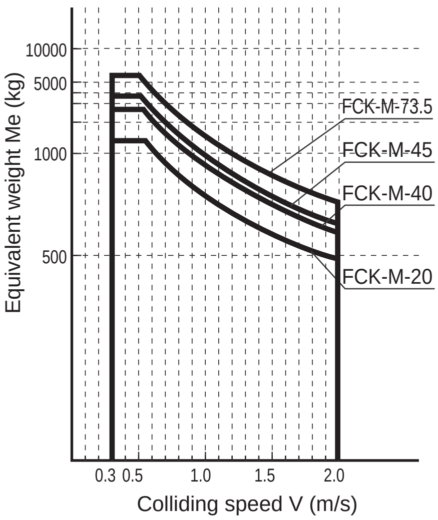




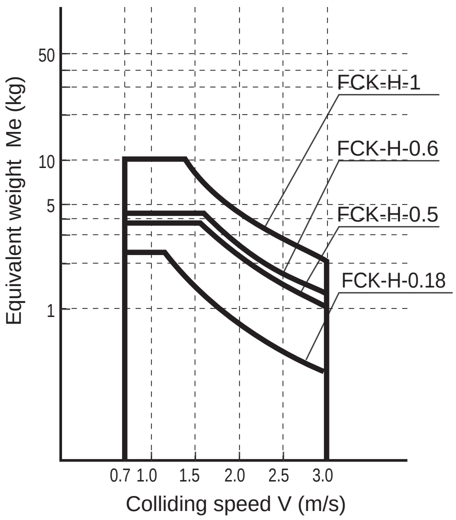
Porous irregular orifice (FCK-M)

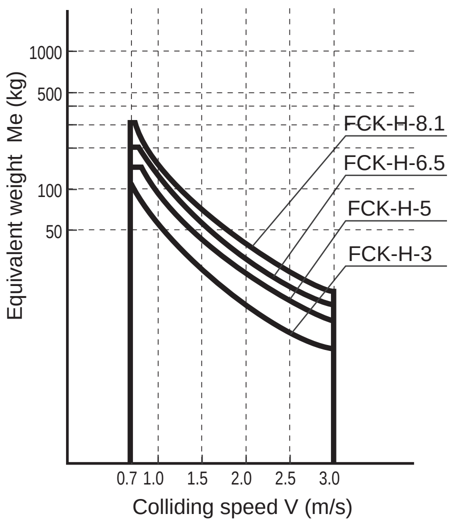


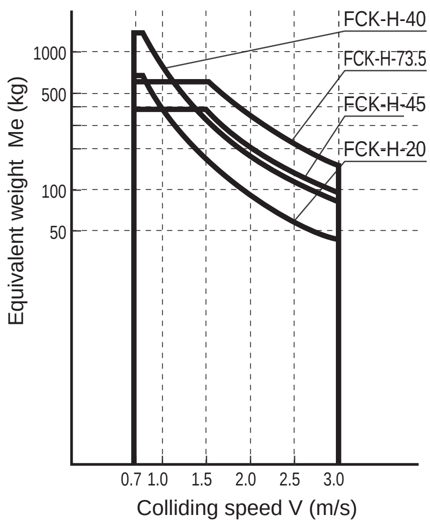




Porous orifice (FCK-H)

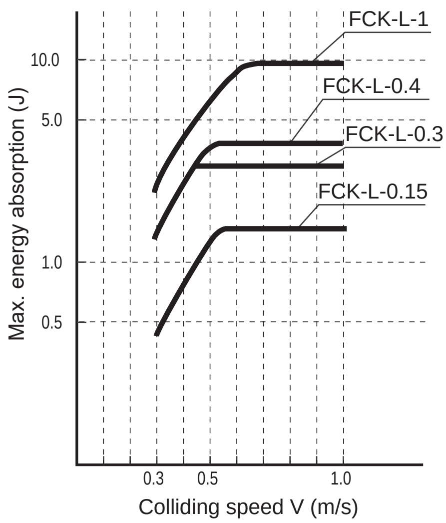


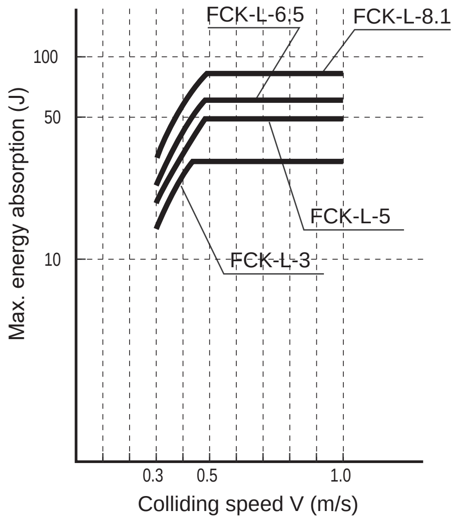




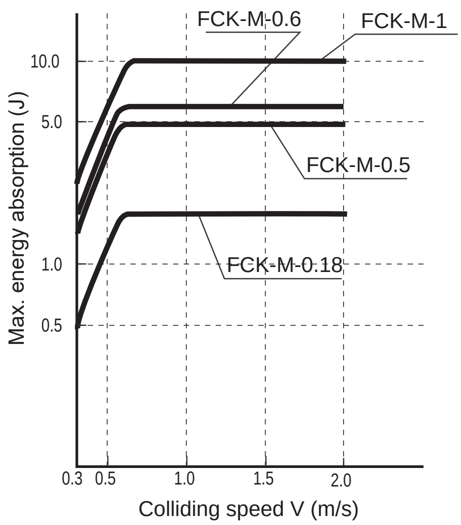
Absorbed energy/colliding speed characteristics graph

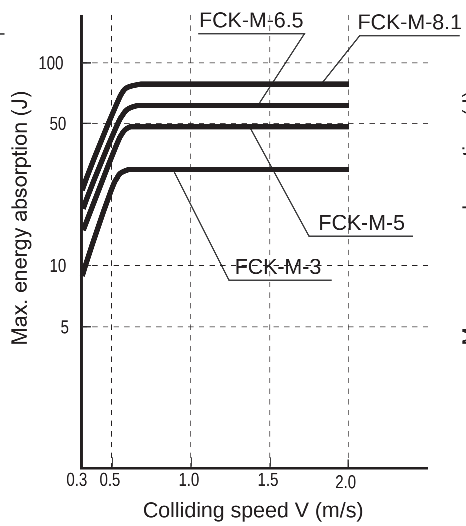
Single hole orifice (FCK-L)

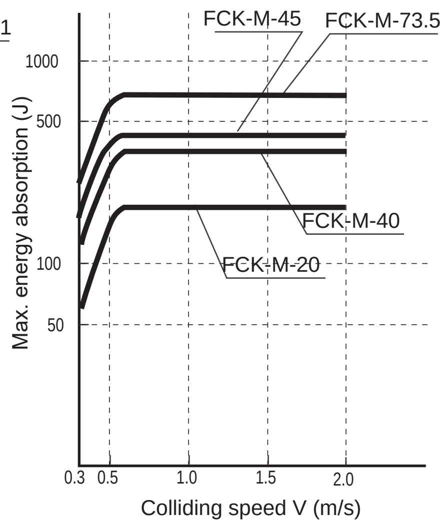




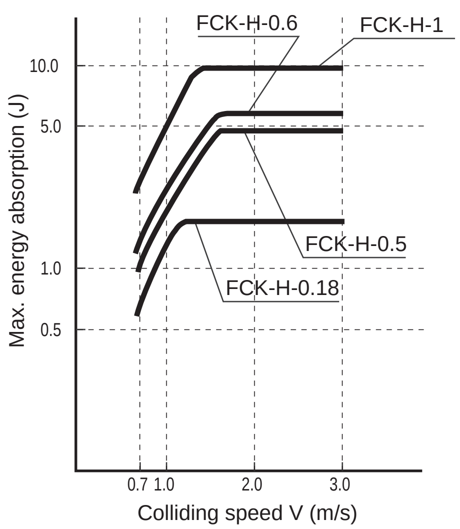
Porous irregular orifice (FCK-M)

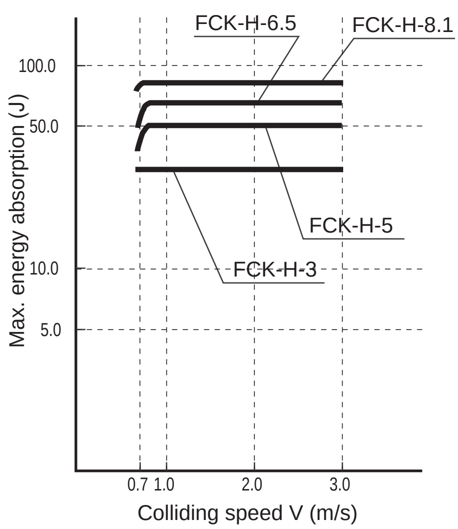


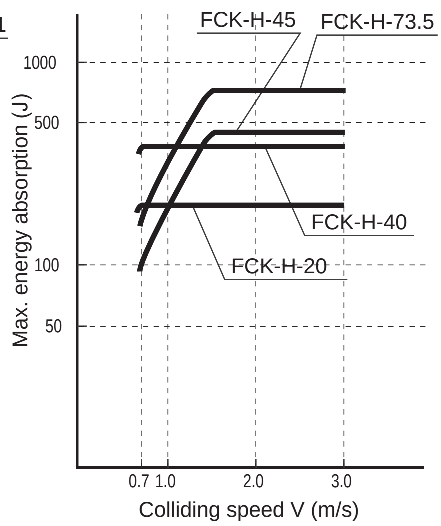




Porous orifice (FCK-H)

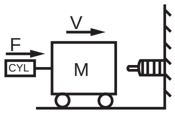
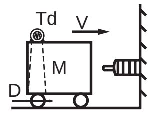


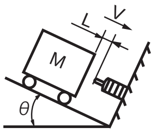
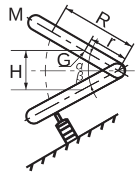


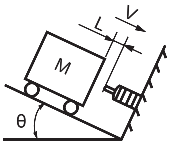
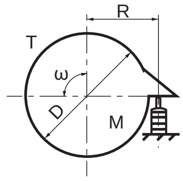


SCP*3
CMK2
CMA2
SCM
SCG
SCA2
SCS2
CKV2
CAV2/COVP/N2
SSD2
SSG
SSD
CAT
MDC2
MVC
SMG
MSD/MSDG
FC*
STK
SRL3
SRG3
SRM3
SRT3
MRL2
MRG2
SM-25
ShkAbs
FJ
FK
Spd Contr
Ending

Selection calculation example

	Selection example 1	Selection example 2
1. Applications	Horizontal collision with cylinder thrust  Cylinder bore size = ø40 Pressure = 0.5 MPa	Horizontal collision with motor drive force  Motor start torque Td = 0.196 N·m Wheel diameter of carriage D = 50 mm Reduction ratio of carriage K = 10
2. Collision conditions	M = 30 kg V = 0.6 m/s F = 628.3 N $(F = \frac{\pi}{4} \times 40^2 \times 0.5 = 628.4\ N)$ n = 20 cycle/min. t = 23°C Rt = 3S	M = 150 kg V = 0.785 m/s F = 78.4 N $(F = 2 \cdot \frac{K}{D} \cdot Td = 2 \times \frac{10}{0.05} \times 0.196 = 78.4\ N)$ n = 5 cycle/min. t = 23°C Rt = 2S
3. Kinetic energy E_1	$E_1 = \frac{1}{2}MV^2 = \frac{1}{2} \times 30 \times 0.6^2 = 5.4\ J$	$E_1 = \frac{1}{2}MV^2 = \frac{1}{2} \times 150 \times 0.785^2 = 46.2\ J$
4. Temporary stroke S'	S' = 20mm from Fig.1	S' = 50mm from Fig.1
5. Thrust/self-weight energy E_2 Absorbed energy E	$E_2 = F \cdot S = 628.3 \times 0.02 = 12.57J$ $E = E_1 + E_2 = 5.4 + 12.57 = 17.97\ J$	$E_2 = 2 \cdot \frac{K}{D} \cdot TdS = 2 \times \frac{10}{0.05} \times 0.196 \times 0.05$ $= 3.92\ J$ $E = E_1 + E_2 = 46.2 + 3.92 = 50.12\ J$
6. Temporary selection	$\frac{E_2}{E_1} = \frac{12.57}{5.4} = 2.3$ Select porous irregular orifice (FCK-M-3) temporarily	$\frac{E_2}{E_1} = \frac{3.92}{46.2} = 0.08$ Select porous orifice (FCK-H-6.5) temporarily
7. Absorbed energy recalculation	$E_2 = F \cdot S = 628.3 \times 0.016 = 10.05J$ $E = E_1 + E_2 = 15.45\ J$	$E_2 = 2 \cdot \frac{K}{D} \cdot TdS = 2 \times \frac{10}{0.05} \times 0.196 \times 0.04$ $= 3.14\ J$ $E = E_1 + E_2 = 49.34\ J$
8. Energy per hour Et	$Et = 60 \cdot E \cdot n = 60 \times 15.45 \times 20 = 18540\ J/h$	$Et = 60 \times E \cdot n = 60 \times 49.34 \times 5 = 14802J/h$
9. Equivalent weight Me	$Me = \frac{2E}{V^2} = 85.8\ kg$	$Me = \frac{2E}{V^2} = \frac{2 \times 49.34}{0.785^2} = 160\ kg$
10. Confirmation	E, Et, Me, n, t and Rt are all OK Determined at FCK-M-3	E, Et, Me, n, t and Rt are all OK Determined at FCK-H-6.5

Selection example 3	Selection example 4
Carriage falling down slope  L=1 m θ=2°	Object performing rotational free fall  α = 15° β = 5°
M = 100 kg V = 0.83 m/s ($V = \sqrt{2\cdot g\cdot L\cdot \sin\theta} = \sqrt{2 \times 9.8 \times 1 \times \sin 2°} = 0.83$ m/s) n = 10 cycle/min. t = 23°C Rt = 5 S	M = 2 kg R = 0.5 m H = 0.1 m r = 0.3 m ($V = \frac{R}{r}\sqrt{\frac{3\cdot g\cdot H}{2}} = \frac{0.5}{0.3}\sqrt{\frac{3 \times 9.8 \times 0.1}{2}} = 2.02$ m/s) n = 50 cycle/min. t = 20°C Rt = 0.6S
$E_1 = \frac{1}{2}\cdot M\cdot V^2 = \frac{1}{2} \times 100 \times 0.83^2 = 34.4$J	$E_1 = M\cdot g\cdot H = 2 \times 9.8 \times 0.1 = 1.96$J
S' = 50mm from Fig.1	S' = 10 mm from Fig.1
$E_2 = M\cdot g\cdot S\cdot \sin\theta = 100 \times 9.8 \times 0.05 \times \sin 2° = 1.71$J $E = E_1 + E_2 = 34.4 + 1.71 = 36.1$ J	$E_2 = \frac{r}{R}\cdot M\cdot g\cdot S\cdot \cos\beta = \frac{r}{R} \times 2 \times 9.8 \times 0.01 \times \cos 5°C = 0.11$J $E = E_1 + E_2 = 1.96 + 0.11 = 2.07$ J
$\frac{E_2}{E_1} = \frac{1.71}{34.4} = 0.05$ Select porous orifice (FCK-H-5) temporarily	$\frac{E_2}{E_1} = \frac{0.11}{1.96} = 0.06$ Select porous orifice (FCK-H-0.5) temporarily
$E_2 = M\cdot g\cdot S\cdot \sin\theta = 100 \times 9.8 \times 0.03 \times \sin 2° = 1.03$J $E = E_1 + E_2 = 35.4$ J	$E_2 = \frac{r}{R}\cdot M\cdot g\cdot S\cdot \cos\beta = 0.11$J $E = E_1 + E_2 = 1.96 + 0.11 = 2.07$ J
$Et = 60\cdot E\cdot n = 60 \times 35.4 \times 10 = 21240$J/h	$Et = 60\cdot E\cdot n = 60 \times 2.07 \times 50 = 6210$J/h
$Me = \frac{2E}{V^2} = \frac{2 \times 35.4}{0.83^2} = 102.7$ kg	$Me = \frac{2E}{V^2} = \frac{2 \times 2.07}{2.02^2} = 1.0$ kg
E, Et, Me, n, t and Rt are all OK Determined at FCK-H-5	E, Me, n, t and Rt are OK. However, recalculate with one size larger FCK-H-0.6, since Et is too high.

Selection example 5	Selection example 6
Object falling down slope  L = 0.45 m θ = 5°	Horizontal rotational collision with torque 
M = 1.0 kg V = 0.88 m/s (V = $\sqrt{2 \cdot g \cdot L \cdot \sin\theta} = \sqrt{2 \times 9.8 \times 0.45 \times \sin 5°}$ = 0.88 m/s) n = 15 cycle/min. t = 23°C Rt = 2S	J = 204.1 kgm^2 ω = 0.6 rad/s R = 1.25 m n = 10 cycle/min. T = 68.6 N·m t = 20°C Rt = 3s
$E_1 = \frac{1}{2} \cdot M \cdot V^2 = \frac{1}{2} \times 1.0 \times 0.88^2 = 0.387J$	$E_1 = \frac{J \cdot \omega^2}{2} = \frac{204.1 \times 0.6^2}{2} = 36.7\ J$
S' = 5mm from Fig.1	S' = 50mm from Fig.1
$E_2 = M \cdot g \cdot S \cdot \sin\theta = 1 \times 9.8 \times 0.005 \times \sin 5° = 0.004J$ $E = E_1 + E_2 = 0.387 + 0.004 = 0.391\ J$	$E_2 = \frac{T}{R} \cdot S = \frac{68.6}{1.25} \times 0.05 = 2.74J$ $E = E_1 + E_2 = 36.7 + 2.74 = 39.44\ J$
$\frac{E_2}{E_1} = \frac{0.004}{0.387} = 0.01$ Select single hole orifice (FCK-L-0.15) temporarily	$\frac{E_2}{E_1} = \frac{2.74}{36.7} = 0.07$ $V = \omega \cdot R = 0.6 \times 1.25 = 0.75$ m/s Select porous orifice (FCK-H-5) temporarily
$E_2 = M \cdot g \cdot S \cdot \sin\theta = 1 \times 9.8 \times 0.008 \times \sin 5° = 0.007J$ $E = E_1 + E_2 = 0.394\ J$	$E_2 = \frac{T}{R} \cdot S = \frac{68.6}{1.25} \times 0.03 = 1.65J$ $E = E_1 + E_2 = 38.6\ J$
$Et = 60 \cdot E \cdot n = 60 \times 0.394 \times 15 = 354.6J/h$	$Et = 60 \cdot E \cdot n = 60 \times 38.6 \times 10 = 23160J/h$
$Me = \frac{2E}{V^2} = \frac{2 \times 0.394}{0.88^2} = 1.02$ kg	$Me = \frac{2E}{V^2} = \frac{2 \times 38.6}{0.75^2} = 137.2$ kg
E, Et, Me, n, t and Rt are all OK Determined at FCK-L-0.15	E, Et, Me, n, t and Rt are OK. Determined at FCK-H-5.