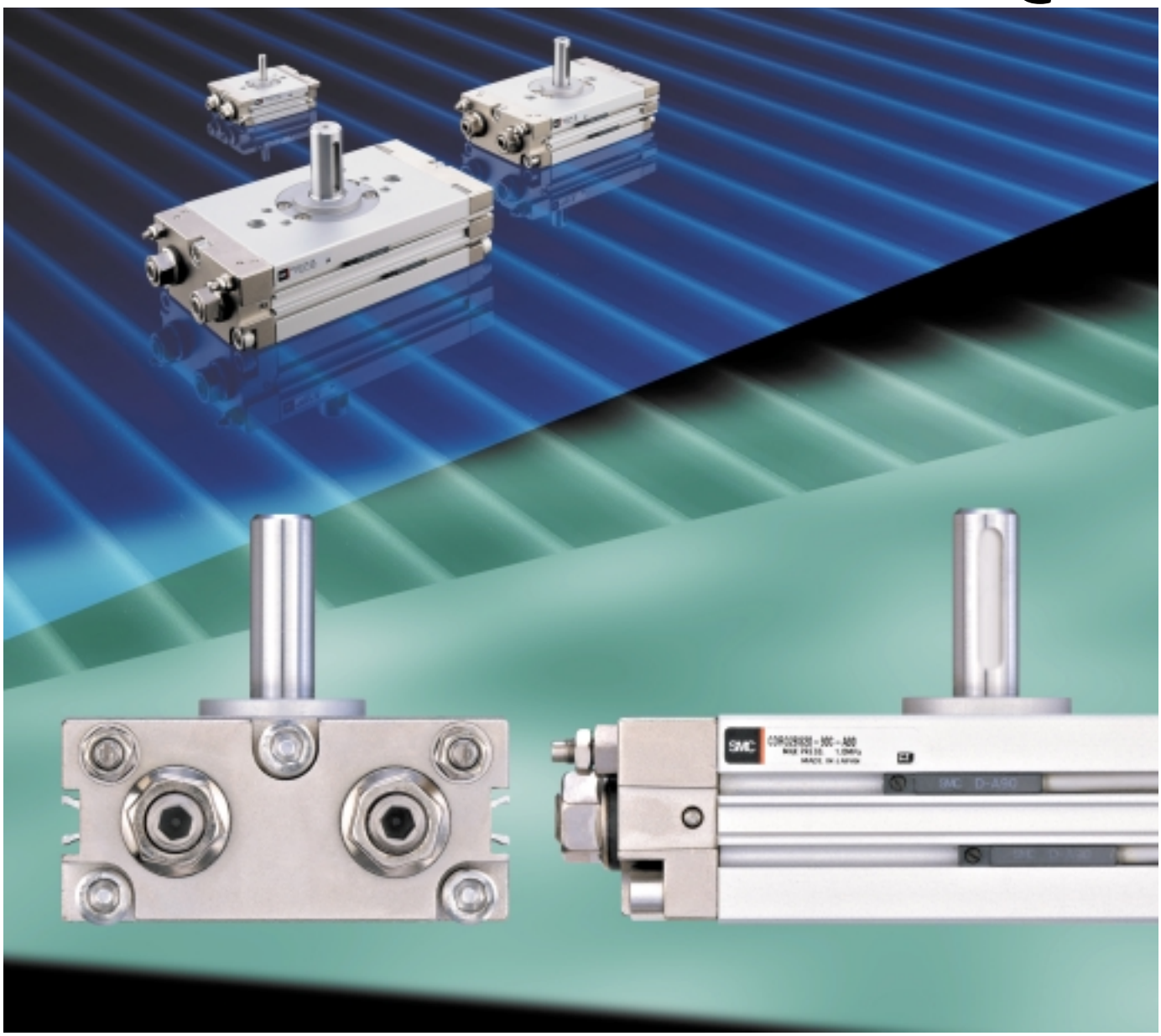
CAT.ES20-147A

SMC

Compact Rotary Actuator
Rack-and-Pinion Type/Sizes: 10, 15, 20, 30, 40

Series CRQ2



Compact Rotary Actuator
Rack-and-Pinion Type/Sizes: 10, 15, 20, 30, 40

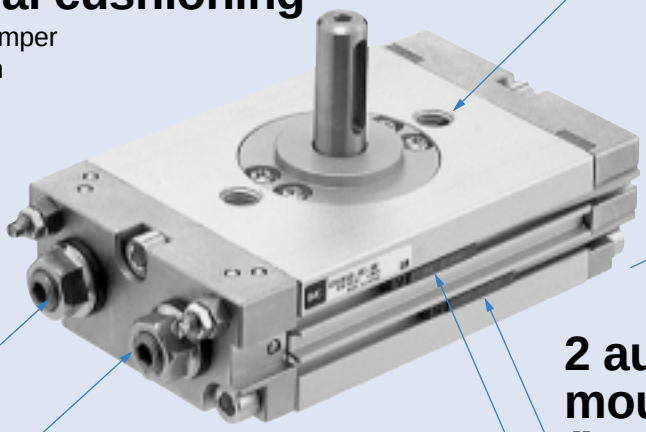
Series CRQ2

Piping can be installed from one end

Body can be used as a flange

Uses internal cushioning

10, 15 : Rubber bumper
20, 30, 40: Air cushion



Compact design saves mounting space

10: 17mm
15: 20mm
20: 29mm
30: 33mm
40: 37mm

2 auto switches can be mounted on same side (both sides)

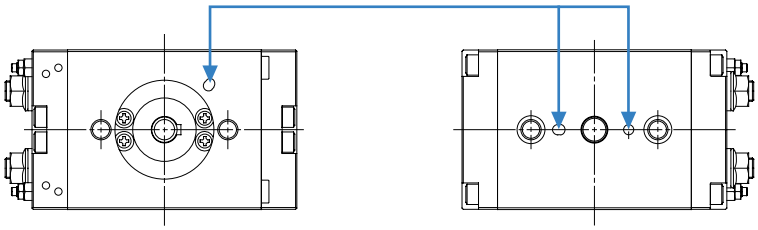
Miniature auto switches do not protrude from the body when installed and require no extra space.

Angle adjustment bolts are standard

Use of double piston eliminates backlash

Easy alignment when mounting body

Body positioning pin holes



Single and double shaft types available in all sizes

Variations

	10	15	20	30	40
Rotation (80° to 100°, 170° to 190°)	●	●	●	●	●
Auto switches	●	●	●	●	●
Air cushion	●	●	●	●	●
Rubber bumper	●	●	●	●	●
Single shaft type (S)	●	●	●	●	●
Double shaft type (W)	●	●	●	●	●

Compact Rotary Actuator
Rack-and-Pinion Type
Series CRQ2

How to Order

Standard type

CRQ2B S 20 – 90 ☐

Shaft type

Single shaft	S
Double shaft	W

Size

10
15
20
30
40

Rotation

90	80° to 100°
180	170° to 190°

Air cushion

Sizes	Air cushion	
10, 15	Without	Nil
20, 30, 40	Without	Nil
	With	C

With auto switch

CDRQ2B S 20 – 90 ☐ – A90 S

Built-in magnet

Shaft type

Single shaft	S
Double shaft	W

Size

10
15
20
30
40

Rotation

90	80° to 100°
180	170° to 190°

Air cushion

Sizes	Air cushion	
10, 15	Without	Nil
20, 30, 40	Without	Nil
	With	C

Auto switch model

Nil	Without auto switch (built-in magnet)

∗ Select applicable auto switch models from the table below.

Number of auto switches

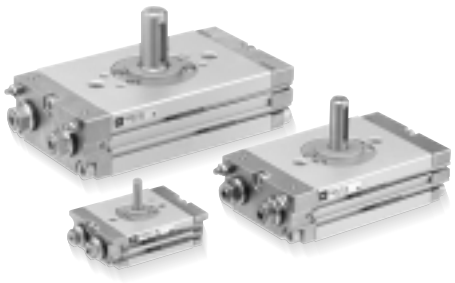
Nil	2 pcs.
S	1 pc.

Applicable auto switches

Type	Special function	Electrical entry	Indicator light	Wiring (output)	Load voltage DC		Load voltage AC	Auto switch part no. Electrical entry direction: Perpendicular	Auto switch part no. Electrical entry direction: In-line	Lead wire length (m)∗ 0.5 (Nil)	3 (L)	5 (Z)	Applicable loads	
Reed switch	——	Grommet	Yes	3 wire (NPN equiv.)	—	5V	—	**A96V**	**A96**	●	—	—	IC circuit	—
								A96VL	**A96L**	—	●	—		
				2 wire	24V	—	100V	**A93V**	**A93**	●	—	—	—	Relay, PLC
								A93VL	**A93L**	—	●	—		
			No			5V, 12V	100V or less	**A90V**	**A90**	●	—	—	IC circuit	
								A90VL	**A90L**	—	●	—		
Solid state switch	——	Grommet	Yes	3 wire (NPN)	24V	5V, 12V	—	**F9NV**	**F9N**	●	—	—	—	Relay, PLC
								F9NVL	**F9NL**	—	●	—		
								F9NVZ	**F9NZ**	—	—	○		
				3 wire (PNP)	—	—		**F9PV**	**F9P**	●	●	—		
								F9PVL	**F9PL**	—	●	—		
								F9PVZ	**F9PZ**	—	—	○		
				2 wire	24V	12V		**F9BV**	**F9B**	●	—	—		
								F9BVL	**F9BL**	—	●	—		
								F9BVZ	**F9BZ**	—	—	○		
	Diagnostic indication (2 color indicator)			3 wire (NPN)		5V, 12V		**F9NWV**	**F9NW**	●	—	—		
								F9NWVL	**F9NWL**	—	●	—		
								F9NWVZ	**F9NWZ**	—	—	○		
				3 wire (PNP)	—	—		**F9PWV**	**F9PW**	●	—	—		
								F9PWVL	**F9PWL**	—	●	—		
								F9PWVZ	**F9PWZ**	—	—	○		
				2 wire	24V	12V		**F9BWV**	**F9BW**	●	—	—		
								F9BWVL	**F9BWL**	—	●	—		
								F9BWVZ	**F9BWZ**	—	—	○		

∗Lead wire length symbols 0.5m … Nil (Example) F9B
3m ..... L (Example) F9BL
5m ..... Z (Example) F9BZ

∗ Solid state auto switches marked with a ○ are produced upon receipt of order.



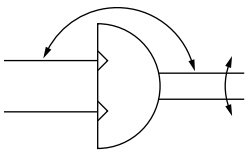
Specifications

Size	10	15	20	30	40
Fluid	Air (unlubricated)				
Maximum operating pressure	0.7MPa		1MPa		
Minimum operating pressure	0.15MPa		0.1MPa		
Ambient and fluid temperature	0 to 60˚C (with no freezing)				
Cushion	Rubber bumper		None, Air cushion		
Angle adjustment	± 5˚				
Rotation	80˚ to 100˚, 170˚ to 190˚				
Port size	M5 x 0.8		Rc1/8		
Mounting brackets	Basic type				
Output Nm*	0.3	0.75	1.8	3.1	5.3

*) Indicates output with operating pressure at 0.5MPa. Refer to Page 14 for details.

Allowable Kinetic Energy and Rotation Time Adjustment Range

JIS symbol



Size	Allowable kinetic energy				Stable operational rotation time adjustment range
	Allowable kinetic energy (J)			Cushion angle	
	Without cushion	Rubber bumper	With air cushion *		Rotation time (s/90˚)
10	—	0.25×10^{-3}	—	—	0.2 to 0.7
15	—	0.39×10^{-3}	—	—	0.2 to 0.7
20	0.025	—	0.12	40˚	0.2 to 1
30	0.048	—	0.25	40˚	0.2 to 1
40	0.081	—	0.40	40˚	0.2 to 1

*) Allowable kinetic energy with cushion
Maximum energy absorption with optimal adjustment of cushion needle

Weight Table

(g)

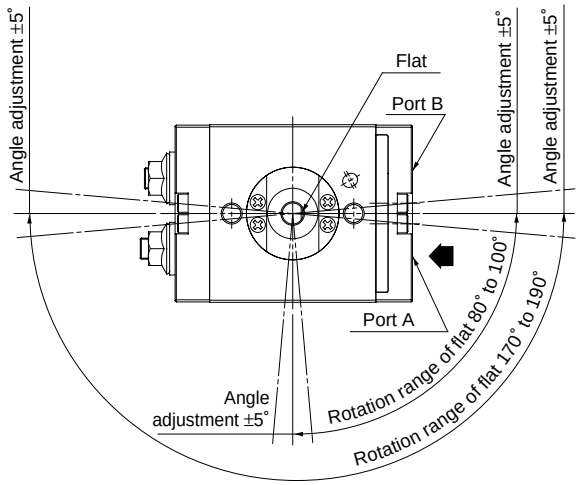
Size	Standard weight*	
	90˚	180˚
10	120	150
15	220	270
20	600	700
30	900	1100
40	1400	1600

*) Value excluding the weight of auto switches.

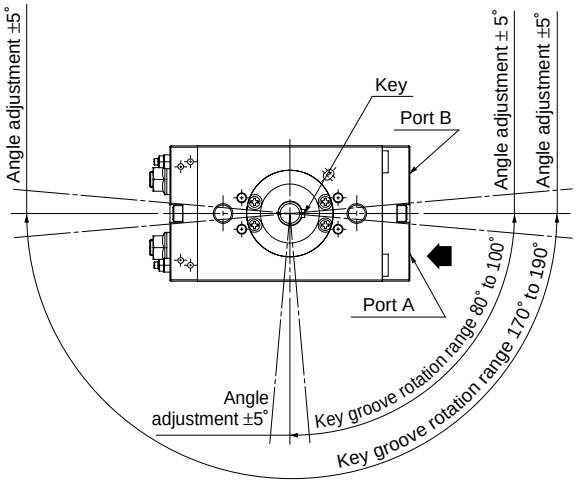
Rotation Range

When pressure is applied to the port on the side with the arrow, the shaft rotates clockwise.

Sizes 10, 15

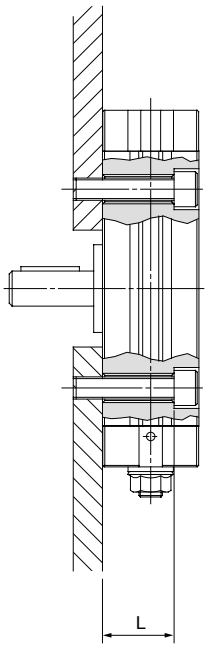


Sizes 20, 30, 40



Using the Body as a Flange

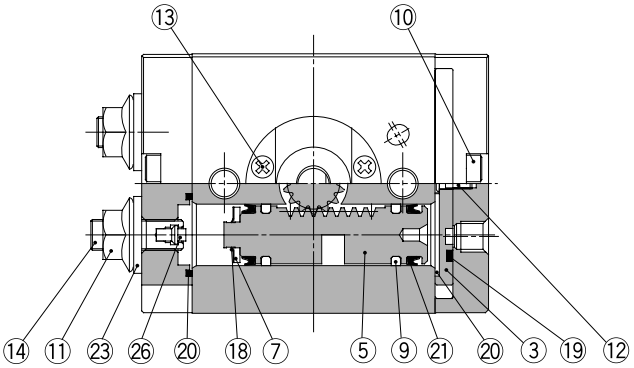
The body's L dimensions are shown in the drawing on the right.
When JIS standard hexagon socket head cap screws are used, the actuator grooves should be used to contain the heads of the screws.

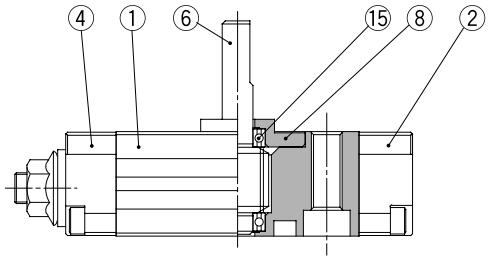


Size	L	Screw
10	13	M4
15	16	M4
20	22.5	M6
30	24.5	M8
40	28.5	M8

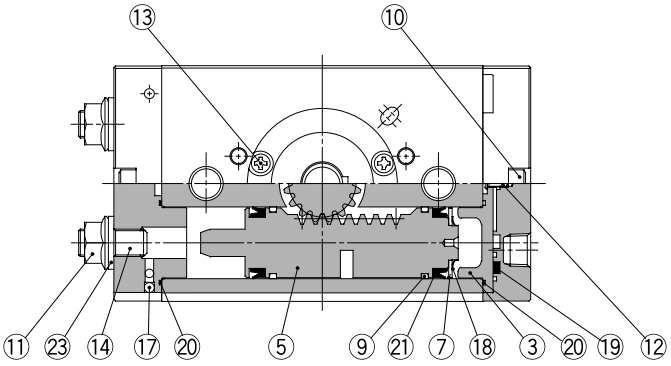
Construction

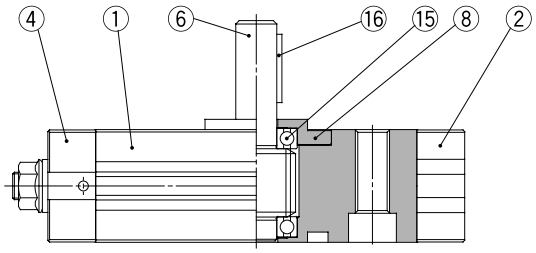
Standard type
Sizes 10, 15





Standard type
Sizes 20, 30, 40





Parts list

No.	Description	Material	Note
1	**Body**	Aluminum alloy	Clear hard anodized
2	**Cover**	Aluminum alloy	Electroless nickel plated
3	**Plate**	Aluminum alloy	
4	**End cover**	Aluminum alloy	Electroless nickel plated
5	**Piston**	Stainless steel	
6	**Shaft**	Stainless steel	Sizes: 10, 15
		Chromium molybdenum steel	Sizes: 20, 30, 40
7	**Seal retainer**	Aluminum alloy	Chromated
8	**Bearing retainer**	Aluminum alloy	Clear hard anodized
9	**Wear ring**	Resin	
10	**Hexagon socket head cap screw**	Stainless steel	
11	**Hexagon nut with flange**	Steel wire	Electroless nickel plated
12	**Round head No. 0 Phillips screw**	Steel wire	Zinc chromated
13	**Round head No. 0 Phillips screw**	Steel wire	10, 15 nickel plated
	Round head Phillips screw		20, 30, 40 nickel plated

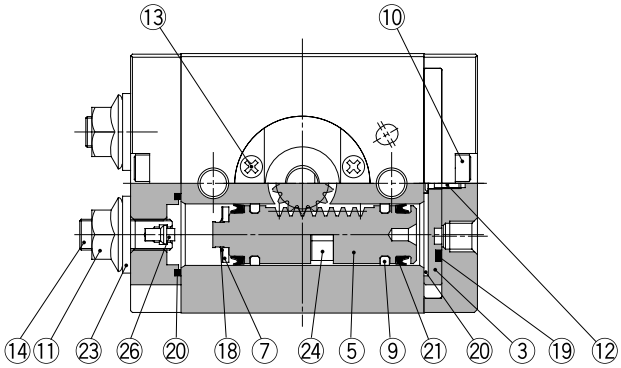
Parts list

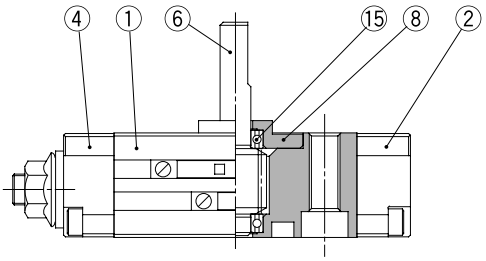
No.	Description	Material	Note
14	**Hexagon socket head set screw**	Chromium molybdenum steel	Electroless nickel plated
15	**Bearing**	Bearing steel	
16	**Parallel key**	Carbon steel	20, 30, 40
17	**Steel balls**	Stainless steel	20, 30, 40
18	**C S type snap ring**	Stainless steel	
19	**Seal**	NBR	
20	**Gasket**		
21	**Piston seal**		
22	**Cushion seal**		20, 30, 40 with cushion
23	**Seal washer**		
24	**Magnet**	Magnetic material	With auto switch
25	**Cushion valve assembly**		20, 30, 40 with cushion
26	**Cushion pad**	Elastic material	10, 15

Replacement parts

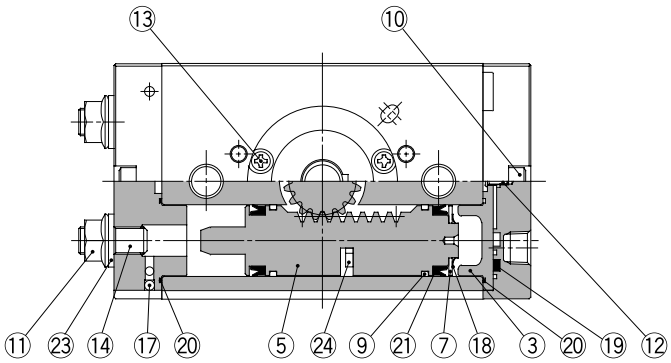
Description	Kit number					Contents
	10	15	20	30	40	
Seal kit	P473010-1	P473020-1	P473030-1	P473040-1	P473050-1	19, 20, 21, 23

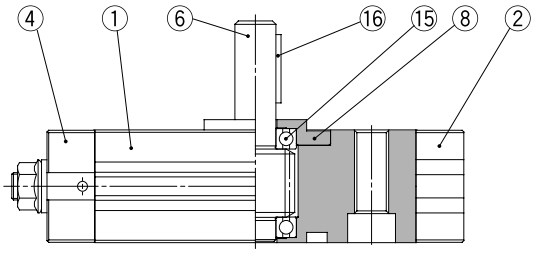
With auto switch
Sizes 10, 15



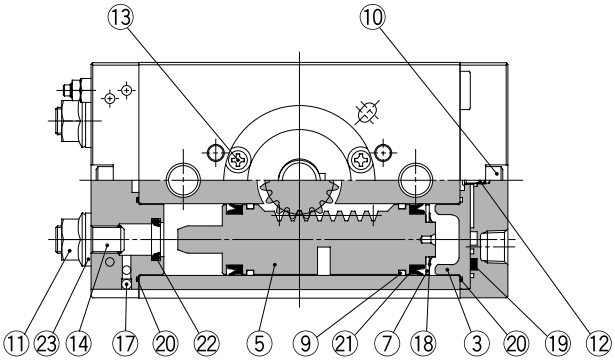


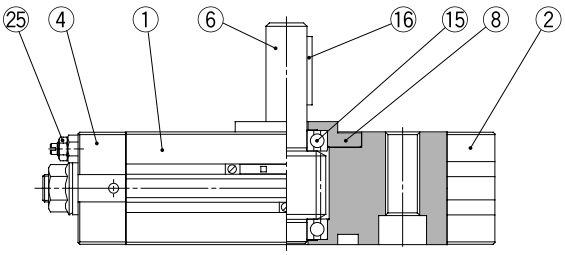
With auto switch
Sizes 20, 30, 40



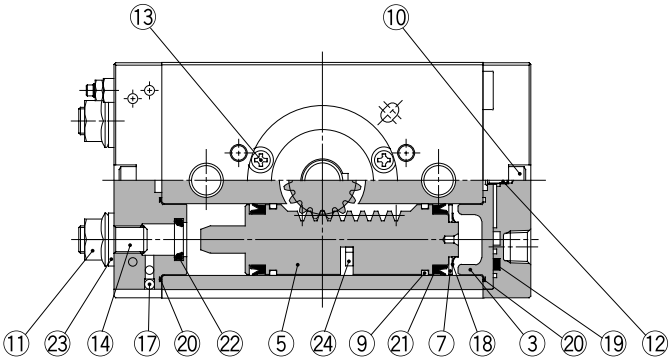


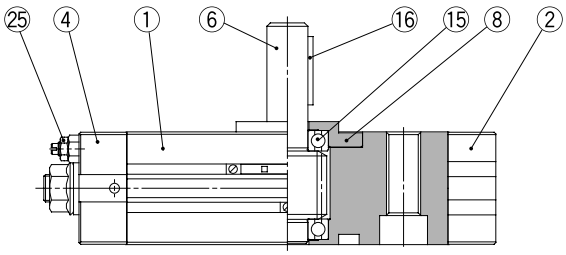
With cushion
Sizes 20, 30, 40





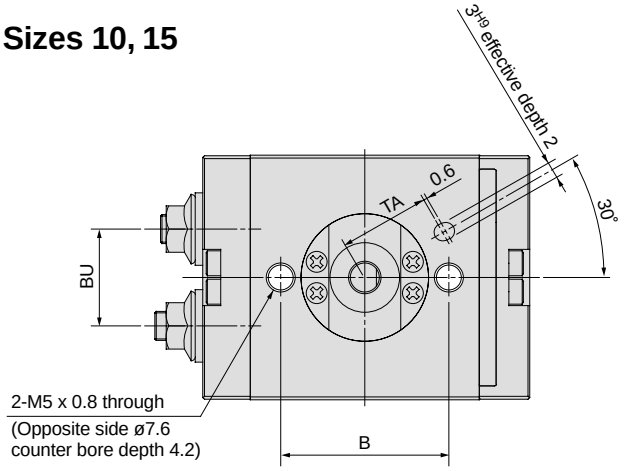
With auto switch and cushion
Sizes 20, 30, 40

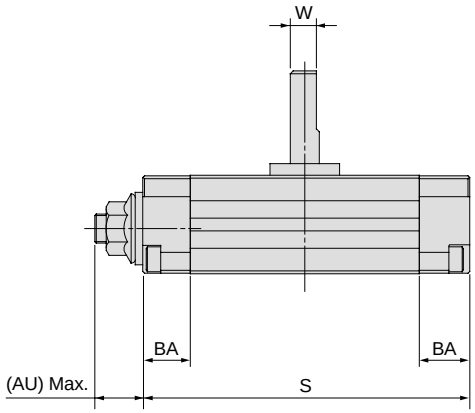


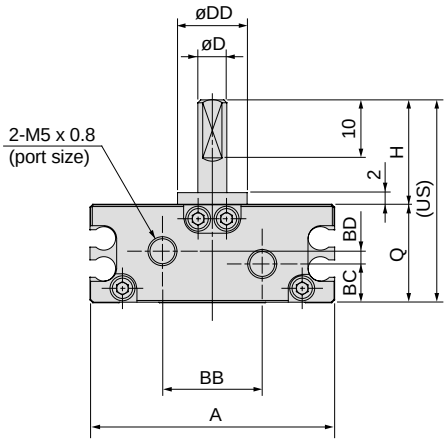


Dimensions

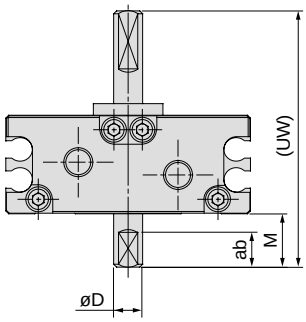
Sizes 10, 15

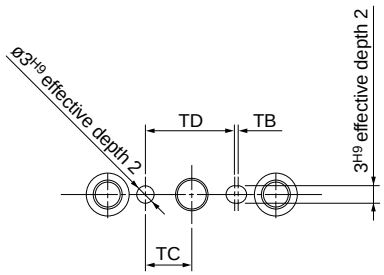






With double shaft



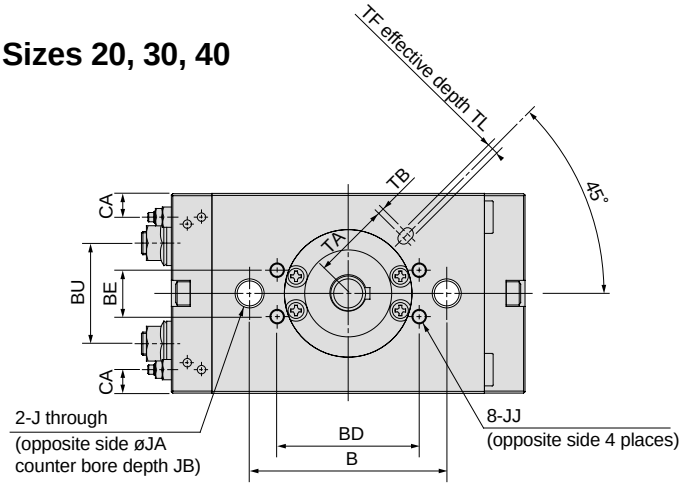


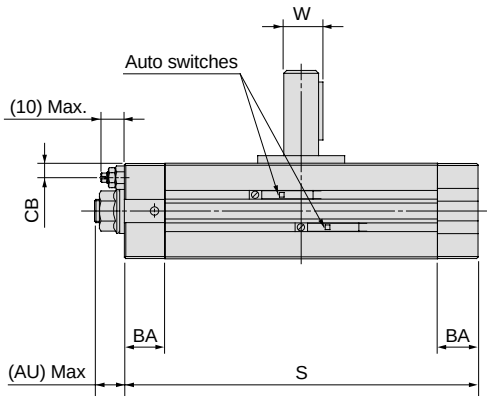
Size	Rotation	A	AU*	B	BA	BB	BC	BD	BU	D (g6)	DD (h9)	H
10	**90°, 180°**	42	(8.5)	29	8.5	17	6.7	2.2	16.7	5	12	18
15	**90°, 180°**	53	(9.5)	31	9	26.4	10.6	–	23.1	6	14	20

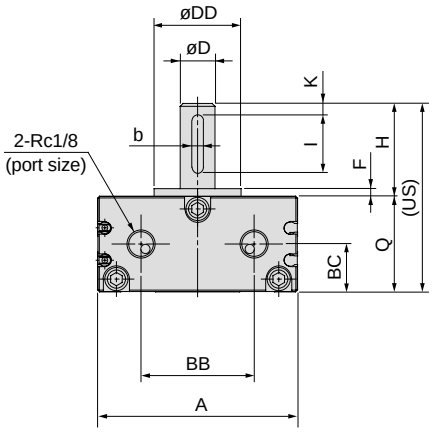
Size	Rotation	W	Q	S	US	UW	ab	M	TA	TC	TD
10	**90°**	4.5	17	56	35	44	6	9	15.5	8	15.4
	180°			69							
15	**90°**	5.5	20	65	40	50	7	10	16	9	17.6
	180°			82							

* Dimension AU does not indicate the dimension when shipped because of the adjustment section. S: Upper space 90°, Lower space 180°

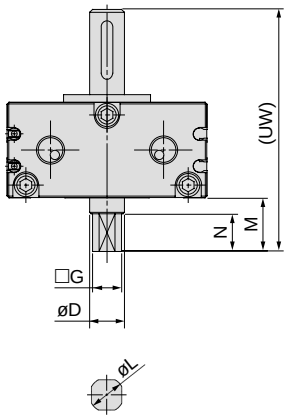
Sizes 20, 30, 40

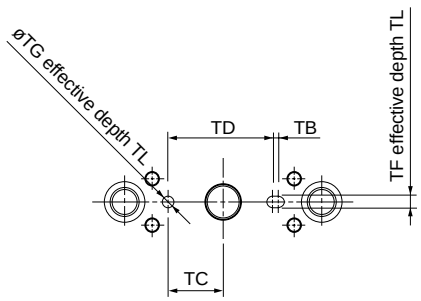






With double shaft





Size	Rotation	A	AU*	B	BA	BB	BC	BD	BE	BU	CA	CB	D (g6)	DD (h9)	F	H	J	JA	JB
20	**90°, 180°**	63	(11)	50	14	34	14.5	–	–	30.4	7	4.7	10	25	2.5	30	M8 x 1.25	11	6.5
30	**90°, 180°**	69	(11)	68	14	39	16.5	49	16	34.7	8.1	4.9	12	30	3	32	M10 x 1.5	14	8.5
40	**90°, 180°**	78	(13)	76	16	47	18.5	55	16	40.4	8.3	5.2	15	32	3	36	M10 x 1.5	14	8.6

Size	Rotation	JJ	K	Q	S	W	Key dimensions b	Key dimensions l	US	TA	TB	TC	TD	TF (H9)	TG (H9)	TL	UW	G	M	N	L
20	**90°**	–	3	29	104	11.5	$4^{0}_{-0.03}$	20	59	24.5	1	13.5	27	4	4	2.5	74	8	15	11	9.6
	180°				130																
30	**90°**	M5 x 0.8 depth 6	4	33	122	13.5	$4^{0}_{-0.03}$	20	65	27	2	19	36	4	4	2.5	83	10	18	13	11.4
	180°				153																
40	**90°**	M6 x 1 depth 7	5	37	139	17	$5^{0}_{-0.03}$	25	73	32.5	2	20	39.5	5	5	3.5	93	11	20	15	14
	180°				177																

∗ Dimension AU does not indicate the dimension when shipped because of the adjustment section.

S: Upper space 90°, Lower space 180°

Series CRQ2
Auto Switch Specifications

Reed Switches

Auto switch part no.	Load voltage	Maximum load current or load current range	Internal voltage drop	Indicator light (lights when ON)	Applications
D-A90 **D-A90V**	AC/DC 24V or less	50mA	0	None	Relay, PLC, IC circuit
	AC/DC 48V or less	40mA			
	AC/DC 100V or less	20mA			
D-A93 **D-A93V**	24VDC	5 to 40mA	2.6V or less	●	Relay, PLC
	100VAC	5 to 20mA			
D-A96 **D-A96V**	4 to 8VDC	20mA	0.8V or less	●	IC circuit

- Lead wires —— D-A90□, A93□ : Oil resistant heavy duty vinyl cord ø2.7
  0.18mm² x 2 wire (Brown, Blue [Red, Black]) 0.5m
  D-A96□: Oil resistant heavy duty vinyl cord ø2.7
  0.15mm² x 3 wire (Brown, Black, Blue [Red, White, Black]) 0.5m
- Insulation resistance —— 50MΩ or more at 500VDC (between lead wire and case)
- Withstand voltage —— 1000VAC for 1 min. (between lead wire and case) • Operation time ——1.2ms
- Ambient temperature —— 10 to 60°C • Impact resistance —— 300m/s² {30.6G} • Leakage current —— 0
- Enclosure —— IEC529 standard IP67 (JIS0920) watertight
- For a lead wire length of 3m, "L" is added to the end of the part number. Example) D-A90L

Solid State Switches

Auto switch part no.	Output type	Power supply voltage	Current con-sumption	Load voltage	Max. load current or load current range	Internal voltage drop	Leakage current	Indicator light	Applications
D-F9N **D-F9NV**	NPN type	24VDC (10 to 28VDC)	8mA or less	28VDC or less	50mA or less	0.4V or less	10μA or less at 24VDC	Lights when ON	Relay, PLC
D-F9NW **D-F9NWV**			12mA or less					2 color indicator	
D-F9P **D-F9PV**	PNP type		10mA or less	—		1.5V or less		Lights when ON	
D-F9PW **D-F9PWV**								2 color indicator	
D-F9B **D-F9BV**	—	—	—	24VDC (10 to 28VDC)	5 to 30mA	4.5V or less	1mA or less at 24VDC	Lights when ON	24VDC Relay, PLC
D-F9BW **D-F9BWV**						5V or less		2 color indicator	

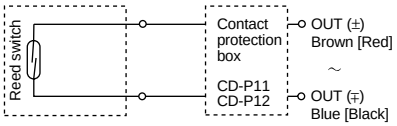
- Lead wires —— Oil resistant heavy duty vinyl cord ø2.7, 0.15mm² x 3 wire (Brown, Black, Blue [Red, White, Black) 0.5m,
  0.18mm² x 2wire (Brown, Blue [Red, Black]) 0.5m
- Insulation resistance —— 50MΩ or more at 500VDC (between lead wire and case)
- Withstand voltage —— 1000VAC for 1 min. (between lead wire and case)
- Ambient temperature —— 10 to 60°C • Operation time —— 1ms or less
- Impact resistance —— 1000m/s² {102G}
- Enclosure —— IEC529 standard IP65 (JIS0920) splash proof
- For a lead wire length of 3m, "L" is added to the end of the part number. Example) D-F90NL

Auto Switch Internal Circuits

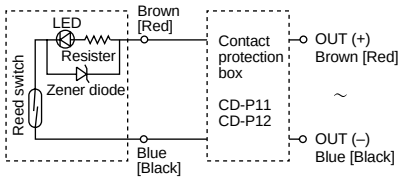
Lead wire colors inside [ ] are those prior to conformity with IEC standards.

Reed switches

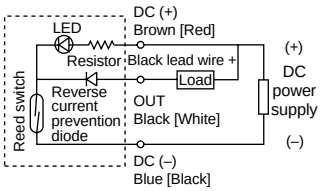
D-A90 (V)



D-A93 (V)

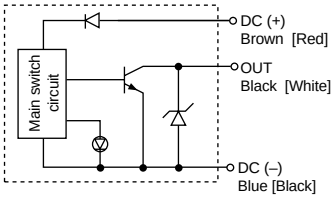


D-A96 (V)

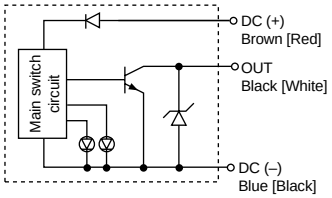


Solid state switches

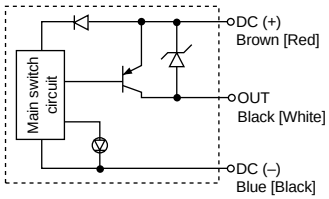
D-F9N (V)



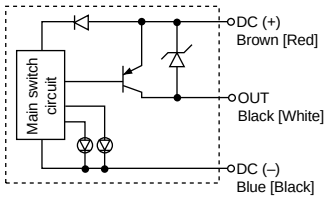
D-F9NW (V)



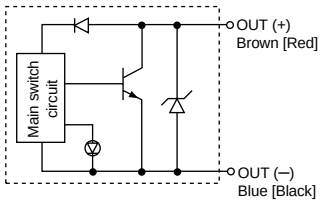
D-F9P (V)



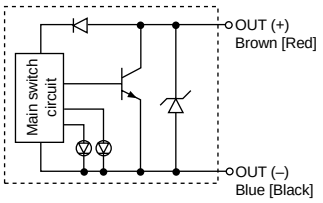
D-F9PW (V)



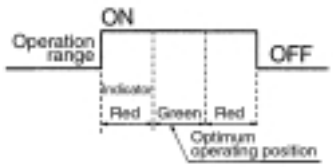
D-F9B (V)



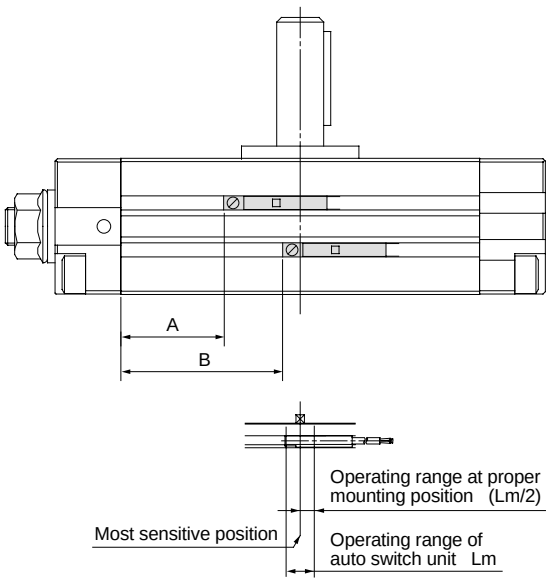
D-F9BW (V)



Indicator light/Display method



Proper Auto Switch Mounting Positions



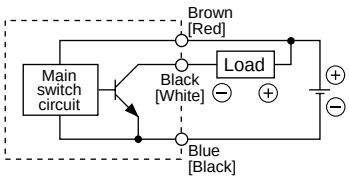
Size	Rotation angle	Reed switches				Solid state switches			
		A	B	Operation range θm	Switch actuation range	A	B	Operation range θm	Switch actuation range
10	90°	6.5	13	63°	12°	10.5	17	75°	3°
	180°	9.5	22.5			13.5	26.5		
15	90°	9.5	18	52°	9°	13.5	22	69°	3°
	180°	13.5	30.5			17.5	34.5		
20	90°	22	34.5	41°	9°	26	38.5	56°	4°
	180°	28	53.5			32	57.5		
30	90°	29	45	32°	7°	33	49	43°	3°
	180°	37	68			41	72		
40	90°	34	53	24°	5°	38	57	36°	4°
	180°	43.5	81.5			47.5	85.5		

Operation range θm: The value of the auto switch operating range Lm converted to the shaft rotation angle
Switch actuation range: The value of the auto switch hysteresis converted to an angle

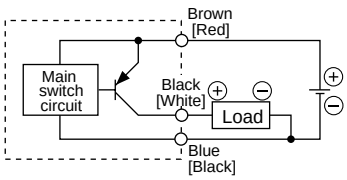
Series CRQ2
Auto Switch Connections and Examples

Basic Wiring

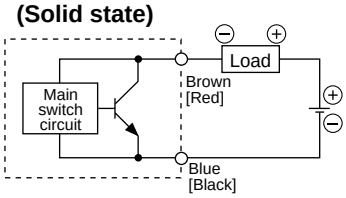
Solid state 3 wire, NPN



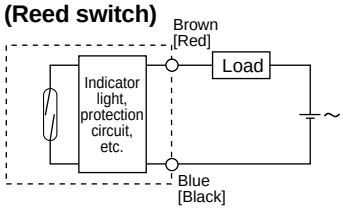
Solid state 3 wire, PNP



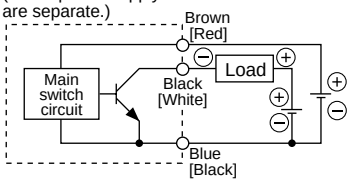
2 wire (Solid state)

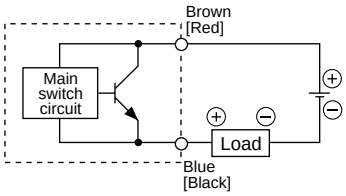


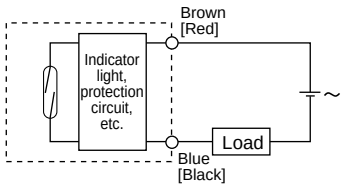
2 wire (Reed switch)



(When power supply for switch and load are separate.)



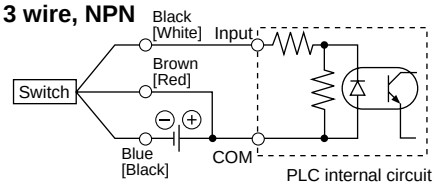




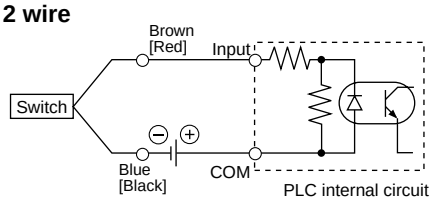
Examples of Connection to PLC

Sink input specifications

3 wire, NPN

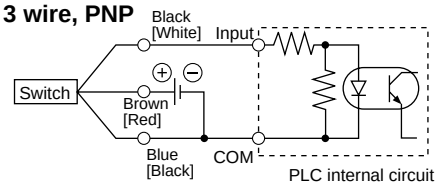


2 wire

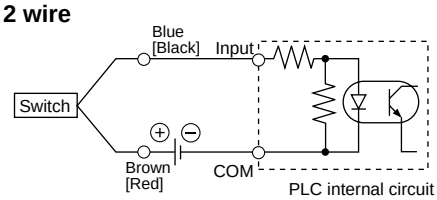


Source input specifications

3 wire, PNP



2 wire

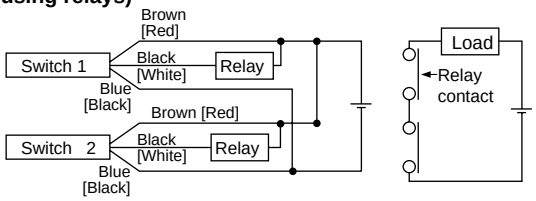


Connect according to the applicable PLC input specifications, as the connection method will vary depending on the PLC input specifications.

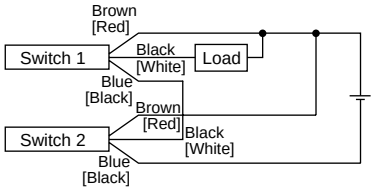
Connection Examples for AND (Series) and OR (Parallel)

3 wire

AND connection for NPN output (using relays)

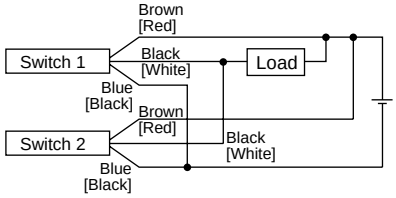


AND connection for NPN output (performed with switches only)

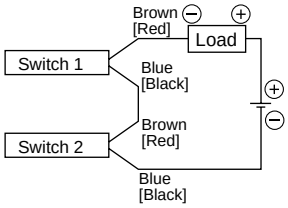


The indicator lights will light up when both switches are turned ON.

OR connection for NPN output



2 wire with 2 switch AND connection



When two switches are connected in series, a load may malfunction because the load voltage will decline when in the ON state.
The indicator lights will light up if both of the switches are in the ON state.

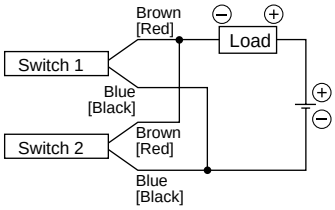
$$\text{Load voltage at ON} = \frac{\text{Power supply voltage}}{} - \frac{\text{Residual voltage}}{} \times 2 \text{ pcs.}$$

$$= 24\text{V} - 4\text{V} \times 2 \text{ pcs.}$$

$$= 16\text{V}$$

Example: Power supply is 24VDC
Voltage decline in switch is 4V

2 wire with 2 switch OR connection



(Solid state)
When two switches are connected in parallel, malfunction may occur because the load voltage will increase when in the OFF state.

$$\text{Load voltage at OFF} = \frac{\text{Leakage current}}{} \times 2 \text{ pcs.} \times \frac{\text{Load impedance}}{}$$

$$= 1\text{mA} \times 2 \text{ pcs.} \times 3\text{k}\Omega$$

$$= 6\text{V}$$

Example: Load impedance is 3kΩ
Leakage current from switch is 1mA

(Reed switch)
Because there is no current leakage, the load voltage will not increase when turned OFF. However, depending on the number of switches in the ON state, the indicator lights may sometimes get dark or not light up, because of dispersion and reduction of the current flowing to the switches.

Series CRQ2
Model Selection

Series CRQ2 Technical Information

Refer to pages 14 through 18 for detailed technical information other than series CRQ2 model selection procedures.
[Data 1] Effective torque [Data 2] Moment of Inertia [Data 3] Air consumption

Step 1

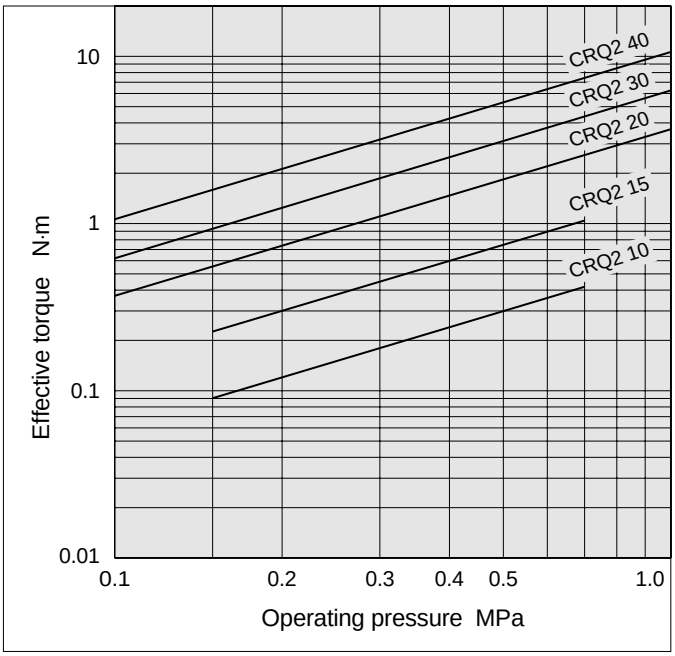
Select the actuator torque.

1. Find the required turning torque for the intended objective.

Work objective	Type of load	Required torque formula N·m*3
Static operation	Static load	Ts
Dynamic*1 operation	Resistance load	(3 to 5) · Tf
	Inertial load*2	S · Ta or more

*1. In the case of dynamic operation, there may be a combination of resistance and inertial loads.
*2. Since it is also necessary to examine inertial load in selection step [2] in calculating the kinetic energy of the work piece, make the selections together.
*3. Refer to load types below for details regarding the terms Ts, Tf, S and Ta in the table.

2. Determine the operating pressure
3. Determine the proper size from the effective torque table.



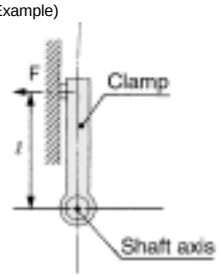
Load Types

● Static load: Ts

The load represented by the clamp which requires pressing force only

(During the course of examination, if it is decided to consider the mass of the clamp itself in the drawing below, it should be regarded as an inertial load.)

(Example)



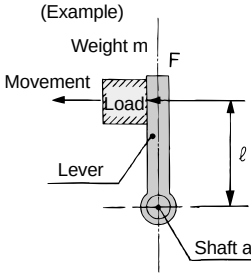
F: Pressing force (N)
Static torque calculation
Ts = F x ℓ (N·m)

● Resistance load: Tf

The load that is affected by external forces such as friction or gravity
Since the object is to move the load, and speed adjustment is necessary, allow an extra margin of 3 to 5 times in the effective torque.
* Actuator effective torque ≥ (3 to 5) Tf

(During the course of examination, if it is decided to consider the mass of the lever itself in the drawing below, it should be regarded as an inertial load.)

(Example)



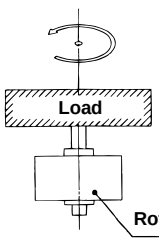
Friction coefficient μ
F = μmg
Static torque calculation
Tf = F x ℓ (N·m)
g = 9.8m/s²

●Inertial load: Ta

The load which must be rotated by the actuator
Since the object is to rotate the load, and speed adjustment is necessary, allow an extra margin of 10 times or more in the effective torque.

*Actuator effective torque ≤ S·Ta
(S is 10 times or more)

Accelerating torque calculation



Ta = I·ώ (N·m)
I : Moment of inertia
Refer to page 11.
ώ : Angular acceleration
$\dot{\omega} = \frac{2\theta}{t^2}$ (rad/s²)
θ : Rotation angle (rad)
t : Rotation time (S)

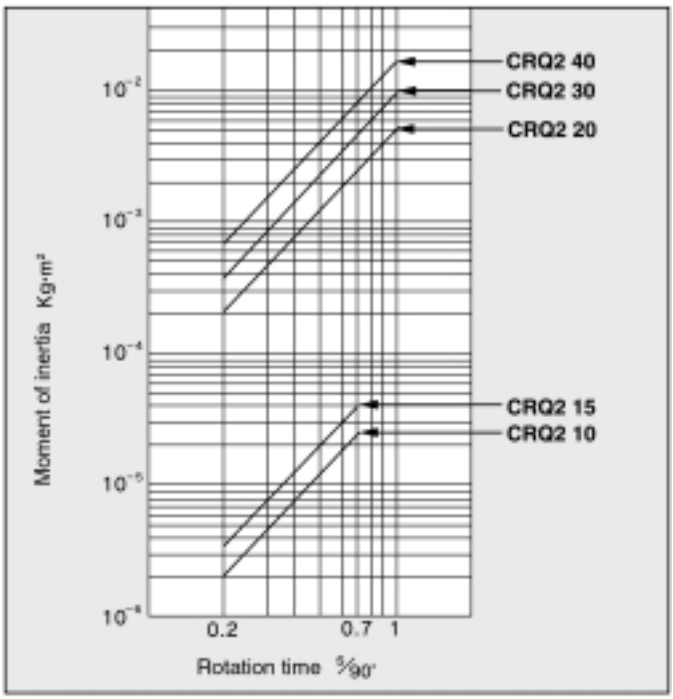
Step **2**

Consider the impact at the end of the rotation.

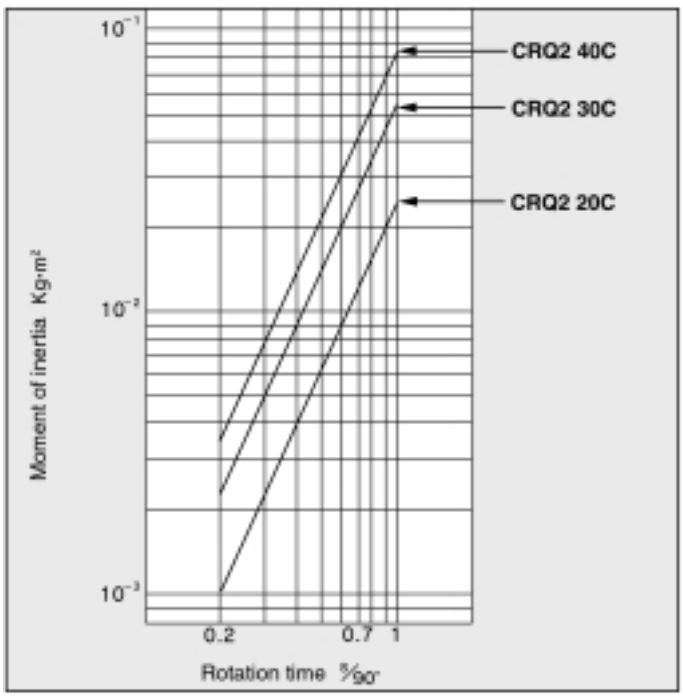
1. When an external stopper (shock absorber) is provided to absorb the impact, be sure to use one which has sufficient absorption capacity.
2. When relying on the actuator's internal cushion without using a stopper, the model selection graphs consider the absorption capacity of the actuator's internal cushion, making it possible to select a model from the rotation time within the speed adjustment range and the moment of inertia of the work piece.

1) Rubber bumper ... Kinetic energy is absorbed by placing an elastic body (rubber) at the end of the rotation.
2) Air cushion ..... The exhaust air is compressed shortly before the end of the rotation, and the load's kinetic energy is absorbed by its repulsive force.

Without cushion



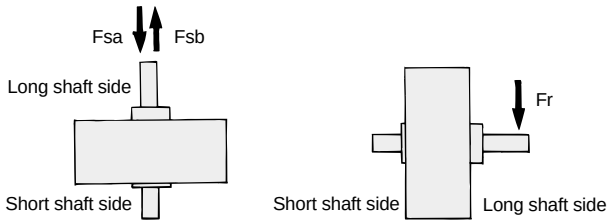
With cushion



Step **3**

Consider the allowable shaft load.

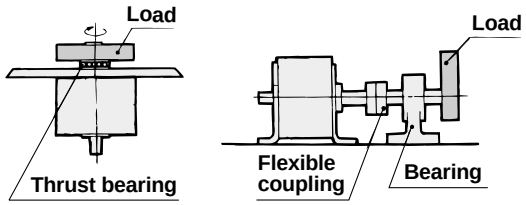
A load can be applied in the axial direction up to the values shown in the table below provided that a dynamic load is not generated. However, applications which apply a load directly to the shaft should be avoided whenever possible.



Rack-and-pinion type (double rack) Unit: N

Size	Load direction		
	Fsa	Fsb	Fr
10	15.7	7.8	14.7
15	19.6	9.8	19.6
20	49	29.4	49
30	98	49	78
40	108	59	98

A load up to the allowable radial/thrust load can be applied provided that a dynamic load is not generated. However, applications which apply a load directly to the shaft should be avoided whenever possible. In order to further improve the operating conditions, a method such as that shown in the drawing below is recommended so that a direct load is not applied to the shaft.



Step **4**

Find the air consumption of the actuator.

Find the air consumption necessary to calculate the running cost of the air supply. Refer to air consumption on page 18.

Rotary Actuator Technical Data 1 and 2
Effective Torque/Moment of Inertia

Effective Torque

Effective torque values are typical values and are not guaranteed.
Use them as guide values in actual applications.

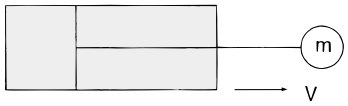
Unit: N·m

Size	Operating pressure (MPa)										
	0.10	0.15	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
10	—	0.09	0.12	0.18	0.24	0.30	0.36	0.42	—	—	—
15	—	0.22	0.30	0.45	0.60	0.75	0.90	1.04	—	—	—
20	0.37	0.55	0.73	1.10	1.47	1.84	2.20	2.57	2.93	3.29	3.66
30	0.62	0.94	1.25	1.87	2.49	3.11	3.74	4.37	4.99	5.60	6.24
40	1.06	1.59	2.11	3.18	4.24	5.30	6.36	7.43	8.48	9.54	10.6

Moment of Inertia

When an object (load) is moved by the actuator, inertial force (kinetic energy) is created in the object. Conversely, in order to stop the moving object, it is necessary to absorb the object's kinetic energy with a stopper or shock absorber, etc. When the load moves in a straight line (air cylinder) or turns (rotary actuator), the kinetic energies can be calculated with the formulas shown in Figures 1 and 2 respectively.

Air cylinder

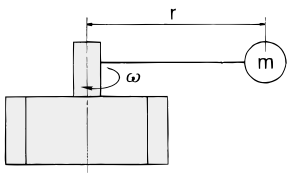


$$E = \frac{1}{2} \cdot m \cdot V^2 \quad \text{..... Formula (1)}$$

E : Kinetic energy
m : Load mass
V : Speed

Figure 1. Linear motion

Rotary actuator



$$E = \frac{1}{2} \cdot I \cdot \omega^2 = \frac{1}{2} \cdot m \cdot r^2 \cdot \omega^2 \quad \text{... Formula (2)}$$

E : Kinetic Energy
I : Moment of Inertia ($=m \cdot r^2$)
ω : Speed

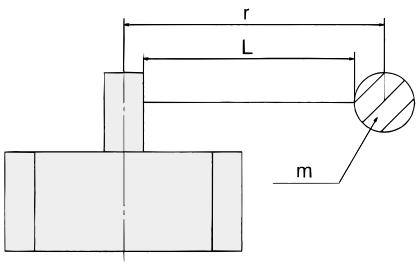
Figure 2. Turning motion

In the case of linear motion, if the speed "V" from Formula (1) is constant, the kinetic energy "E" is readily determined by the mass "m". However, in the case of turning motion it is clear from Formula (2) that the kinetic energy "E" varies in proportion to the square of the turning radius "r", even if the angular speed "ω" and mass "m" are constant. Thus, even if the mass is small, when "r" is large the resulting moment of inertia ($I = m \cdot r^2$) is large, and since the kinetic energy "E" also becomes large, this may lead to damage of the shaft, etc. When a load is moved in this way by a rotary actuator, it is particularly necessary to exercise caution regarding the moment of inertia ($= m \cdot r^2$) of the load.

A Moment of Inertia

The moment of inertia indicates the difficulty of turning an object, or conversely, the difficulty of stopping an object which is turning. Since there is a limit to the kinetic energy allowed in a rotary actuator, the limit value of the rotation time can be found by finding the moment of inertia. How to find the moment of inertia is explained below.

The basic formula for moment of inertia is shown below.



$$I = m \cdot r^2$$ m : Mass (kg)

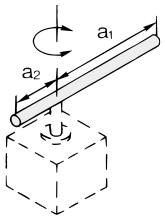
(However, the weight of the L section is ignored)

This indicates the moment of inertia with respect to the rotation axis of a mass "m" which is a distance "r" from the rotational axis. The formula for finding the moment of inertia differs depending on the shape of the object. A reference table of formulas for calculating the moment of inertia is shown on page 15.
Concrete examples of how to calculate the moment of inertia are shown on the following pages.

B Moment of Inertia Formula Table (Calculation of Moment of Inertia) I: Moment of Inertia kg m² m: Load mass kg

1. Thin shaft

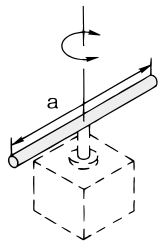
Position of rotational axis: Perpendicular to the shaft through one end



$$I = m_1 \cdot \frac{a_1^2}{3} + m_2 \cdot \frac{a_2^2}{3}$$

2. Thin shaft

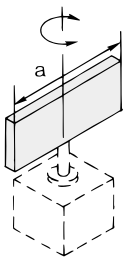
Position of rotational axis: Through the shaft's center of gravity



$$I = m \cdot \frac{a^2}{12}$$

3. Thin rectangular plate (rectangular parallelopiped)

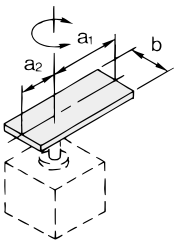
Position of rotational axis: Through the plate's center of gravity



$$I = m \cdot \frac{a^2}{12}$$

4. Thin rectangular plate (rectangular parallelopiped)

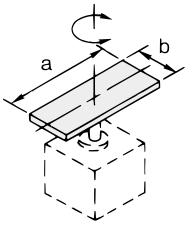
Position of rotational axis: Perpendicular to the shaft through one end (also the same in case of a thicker plate)



$$I = m_1 \cdot \frac{4a_1^2 + b^2}{12} + m_2 \cdot \frac{4a_2^2 + b^2}{12}$$

5. Thin rectangular plate (rectangular parallelopiped)

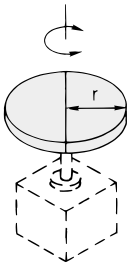
Position of rotational axis: Through the center of gravity and perpendicular to the plate (also the same in case of a thicker plate)



$$I = m \cdot \frac{a^2 + b^2}{12}$$

6. Column (including thin round plate)

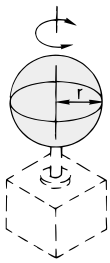
Position of rotational axis: Central axis



$$I = m \cdot \frac{r^2}{2}$$

7. Solid sphere

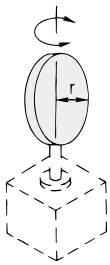
Position of rotational axis: Diameter



$$I = m \cdot \frac{2r^2}{5}$$

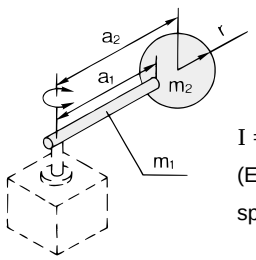
8. Thin round plate

Position of rotational axis: Diameter



$$I = m \cdot \frac{r^2}{4}$$

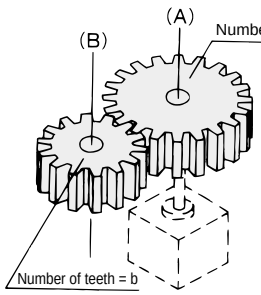
9. Load at end of lever



$$I = m_1 \cdot \frac{a_1^2}{3} + m_2 \cdot a_2^2 + K$$

(Example) When shape of m_2 is a sphere refer to 7 and $K = m_2 \cdot \frac{2r^2}{5}$

10. Gear transmission

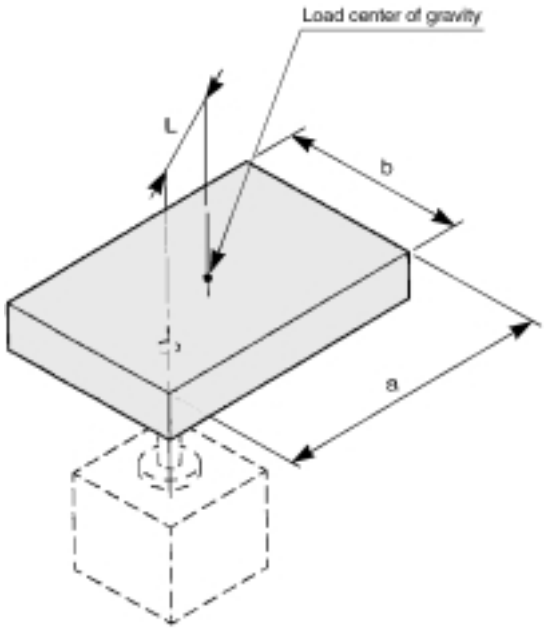


1. Find the moment of inertia I_B for the rotation of shaft (B).
2. Next, I_B is entered to find I_A the moment of inertia for the rotation of shaft (A) as

$$I_A = (\frac{a}{b})^2 \cdot I_B$$

C Moment of Inertia Calculation Examples

1 Rotational Axis at Random Point in Load



Example) When load is a rectangular shape as in technical data 5
Find I_1 with the load center of gravity at the tentative rotational axis.

$$I_1 = m \cdot \frac{a^2 + b^2}{12} \quad kg \cdot m^2$$

Find the moment of inertia I_2 for rotation around the actual rotational axis with the mass of the load concentrated at the load's center of gravity.

$$I_2 = m \cdot L^2 \quad kg \cdot m^2$$

Find the actual moment of inertia I.

$$I \quad I_1 + I_2 \quad kg \cdot m^2$$

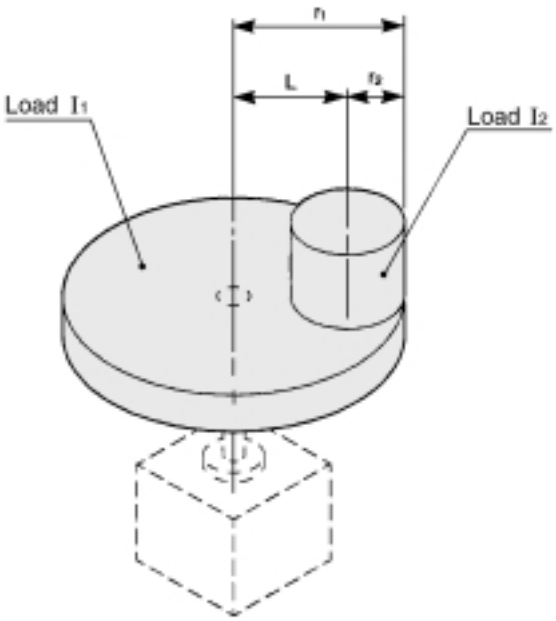
(m: Load mass kg
L : Distance from the rotational axis to the load center of gravity m)

Calculation example

When a = 0.2m, b = 0.1m, L = 0.05m, m = 1.5kg

$I_1 = 1.5 \times \frac{0.2^2 + 0.1^2}{12} = 6.25 \times 10^{-3}$ kg·m²
$I_2 = 1.5 \times 0.05^2 = 3.75 \times 10^{-3}$ kg·m²
$I = (6.25 + 3.75) \times 10^{-3} = 0.01$ kg·m²

2 Load Divided into Multiple Parts



Example) When load is divided into two columns such as shown in technical data 6
{The center of gravity of load I_1 coincides with the rotational axis
The center of gravity of load I_2 is different than the rotational axis}
Find the inertial moment of load I_1

$$I_1 = m_1 \cdot \frac{r_1^2}{2} \quad kg \cdot m^2$$

Find the moment of inertia of load I_2.

$$I_2 = m_2 \cdot \frac{r_1^2}{2} + m_2 \cdot L^2 \quad kg \cdot m^2$$

Find the actual moment of inertia I.

$$I = I_1 + I_2 \quad kg \cdot m^2$$

(m_1, m_2: Mass of loads I_1 and I_2 kg
r_1, r_2: Diameters of loads I_1 and I_2 m
L: Distance from the rotational axis to load I_2 center of gravity m)

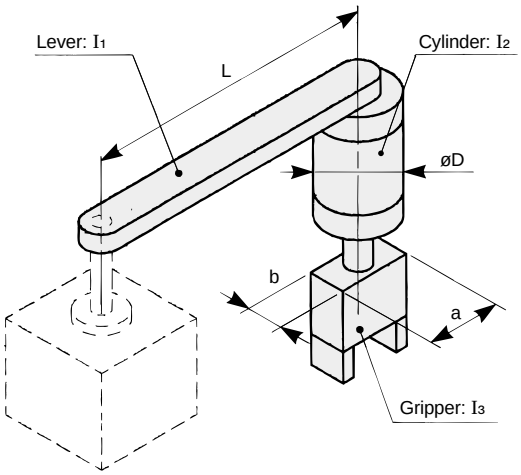
Calculation example

When m_1 2.5kg, m_2 = 0.5kg, r_1 = 0.1m, r_2 = 0.02m, L = 0.08m

$I_1 = 2.5 \times \frac{0.1^2}{2} = 1.25 \times 10^{-2}$ kg·m²
$I_2 = 0.5 \times \frac{0.02^2}{2} + 0.5 \times 0.08^2 = 0.33 \times 10^{-2}$ kg·m²
$I = (1.25 + 0.33) \times 10^{-2} = 1.58 \times 10^{-2}$ kg·m²

Specific Application Example

3 Lever attached to shaft with cylinder and gripper mounted at end of lever



Example) Find the lever's moment of inertia.

$I_1 \quad m1 \quad \cdot \quad \frac{L_2}{3} \qquad kg{\cdot}m^2$

Find the cylinder's moment of inertia.

$I_2 \quad m_2 \quad \cdot \quad \frac{D^2}{8} + m_2{\cdot}L^2 \qquad kg{\cdot}m^2$

Find the gripper's moment of inertia.

$I_3 = m_3 \quad \cdot \frac{a^2+b^2}{12} + m_3{\cdot}L^2 \qquad kg{\cdot}m^2$

Find the actual moment of inertia.

$I = I_1 + I_2 + I_3 \qquad kg{\cdot}m^2$

(m_1: Lever mass kg
m_2: Cylinder mass kg
m_2: Gripper mass kg)

Calculation example

When L = 0.2m, øD = 0.06m, a = 0.06m, b = 0.03m, m_1 = 0.5kg, m_2 = 0.4kg, m_3 = 0.2kg

$I_1 = 0.5 \times \frac{0.2^2}{3} = 0.67 \times 10^{-2}$ kg·m²

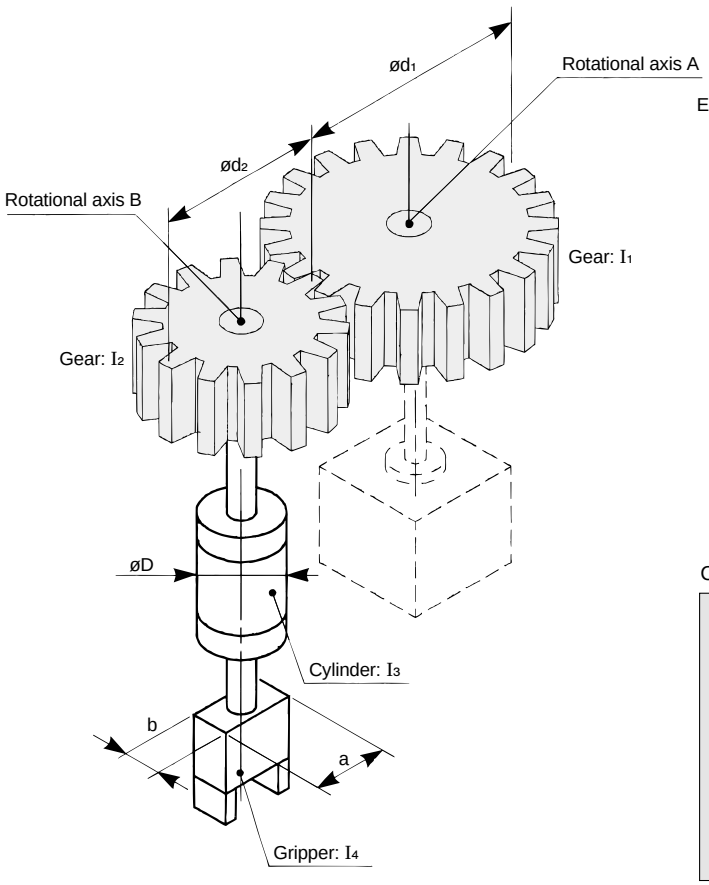
$I_2 = 0.4 \times \frac{0.06^2}{8} + 0.4 \times 0.2^2 = 1.62 \times 10^{-2}$ kg·m²

$I_3 = 0.2 \times \frac{0.06^2 + 0.03^2}{12} + 0.2 \times 0.2^{-2} = 0.81 \times 10^{-2}$ kg·m²

$I = (0.67 + 1.62 + 0.81) \times 10^{-2} = 3.1 \times 10^{-2}$ kg·m²

Specific Application Example

4 Load is rotated via gears



Example) Find the moment of inertial I_1 for rotation around shaft A.

$I_1 \; m_1 \quad \cdot \quad \frac{d_1^2}{8} \qquad kg{\cdot}m^2$

Find the moments of inertial I_2, I_3, I_4 for rotation around shaft B.

$I_2 \; m_2 \quad \cdot \quad \frac{d_2^2}{8} \qquad kg{\cdot}m^2 \qquad I_3 = m_3 \quad \cdot \quad \frac{D^2}{8} \qquad kg{\cdot}m^2$

$I_4 = m_4 \cdot \frac{a^2 + b^2}{12} \qquad kg{\cdot}m^2 \qquad I_B = I_2 + I_3 + I_4 \qquad kg{\cdot}m^2$

Substitute the moment of inertia I_B for rotation around shaft B with the moment of inertia I_A for rotation around shaft A.

$I_A = (A/B)^2 \cdot I_B$ [A/B: Gear tooth ratio]

Find the actual moment of inertia.

$I = I_1 + I_A \qquad kg{\cdot}m^2$

(m_1 to m_4 : Mass of I_1 to I_4 kg)

Calculation example

When d1 = 0.1m, d_2 = 0.05m, D = 0.04m, a = 0.04m, b = 0.02m
m_1 = 1kg, m_2 = 0.4kg, m_3 = 0.5kg, m_4 = 0.2kg, Gear tooth ratio = 2

$I_1 = 1 \quad x \quad \frac{0.1^2}{8} = 1.25 \times 10^{-3}$ kg·m² $\quad I_4 = 0.2 \times \quad \frac{0.04^2+0.02^2}{12} = 0.03 \times 10^{-3}$ kg·m²

$I_2 = 0.4 \times \frac{0.05^2}{8} = 0.13 \times 10^{-3}$ kg·m² $\quad I_B = (0.13 + 0.1 + 0.03) \times 10^{-3} = 0.26 \times 10^{-3}$ kg·m²

$I_3 = 0.5 \times \frac{0.04^2}{8} = 0.1 \quad \times 10^{-3}$ kg·m² $\quad I_A = 2^2 \times 0.26 \qquad \times 10^{-3} = 1.04 \times 10^{-3}$ kg·m²

$I \quad = (1.04 + 1.25) \qquad \times 10^{-3} = 2.29 \times 10^{-3}$ kg·m²

Rotary Actuator Technical Data 3
Air Consumption

Air consumption is the volume of air which is expended by the rotary actuator's reciprocal operation inside the actuator and in the piping between the actuator and the switching valve, etc. This is necessary for selection of a compressor and for calculation of its running cost.

∗ The air consumption (Q_{CR}) required for one reciprocation of the rotary actuator alone is shown in the table below, and can be used to simplify the calculation.

Formulas

Q_{CR}: Since the internal volume is different when the A/B ports are pressurized in vane type sizes 10, 15, 20 and 30, use formula (1). Use formula (2) for vane type sizes 50, 80, 100 and the rack-and-pinion type.

$$Q_{CR} = V \times \left(\frac{P + 0.1013}{0.1013}\right) \times 10^{-3} \quad \text{Formula (1)}$$

$$Q_{CR} = 2V \times \left(\frac{P + 0.1013}{0.1013}\right) \times 10^{-3} \quad \text{Formula (2)}$$

$$Q_{CP} = 2 \times a \times l \times \frac{P}{0.1013} \times 10^{-6} \quad (3)$$

$$Q_C = Q_{CR} + Q_{CP} \quad (4)$$

Q_{CR} = Air consumption of rotary actuator [l (ANR)]

Q_{CP} = Air consumption of tubing or piping [l (ANR)]

V = Internal volume of rotary actuator [cm^3]

P = Operating pressure [MPa]

l = Length of piping [mm]

a = Internal cross section of piping [mm^2]

Q_C = Air consumption required for one reciprocation of rotary actuator [l (ANR)]

When selecting a compressor, it is necessary to choose one which has sufficient reserve for the total air consumption of pneumatic actuators downstream. This is affected by factors such as leakage in piping, consumption by drain valves and pilot valves, etc., and reduction of air volume due to drops in temperature.

Formula

$$Qc_2 = Qc \times n \times \text{Number of actuators} \times \text{Reserve factor}$$

Qc_2 = Compressor discharge flow rate

n = Actuator reciprocations per minute

Internal cross section of tubing and steel piping

Nominal size	O.D. (mm)	I.D. (mm)	Internal cross section a (mm^2)
T□ 0425	4	2.5	4.9
T□ 0604	6	4	12.6
TU 0805	8	5	19.6
T□ 0806	8	6	28.3
1/8B	—	6.5	33.2
T□ 1075	10	7.5	44.2
TU 1208	12	8	50.3
T□ 1209	12	9	63.6
1/4B	—	9.2	66.5
TS 1612	16	12	113
3/8B	—	12.7	127
T□ 1613	16	13	133
1/2B	—	16.1	204
3/4B	—	21.6	366
1B	—	27.6	598

Rack-and-pinion type: Series CRQ2

Air consumption of rotary actuator: Q_{CR} l (ANR)

Size	Rotation angle (°)	Internal volume V (cm^3)	Operating pressure (MPa)										
			0.1	0.15	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	90	1.2	—	0.0060	0.0071	0.0095	0.0119	0.0142	0.0166	0.0190	—	—	—
	180	2.2	—	0.0109	0.0131	0.0174	0.0218	0.0261	0.0305	0.0348	—	—	—
15	90	2.9	—	0.0144	0.0173	0.0230	0.0287	0.0344	0.0402	0.0459	—	—	—
	180	5.5	—	0.0273	0.0327	0.0436	0.0544	0.0653	0.0762	0.0870	—	—	—
20	90	7.8	0.0310	0.0387	0.0464	0.0618	0.0772	0.0926	0.108	0.123	0.139	0.154	0.170
	180	13.4	0.0533	0.0665	0.0797	0.106	0.133	0.159	0.186	0.212	0.233	0.265	0.291
30	90	11.8	0.0469	0.0585	0.0702	0.0935	0.117	0.140	0.163	0.187	0.210	0.233	0.257
	180	22.7	0.0902	0.113	0.135	0.180	0.225	0.269	0.314	0.359	0.404	0.449	0.494
40	90	20	0.0795	0.099	0.119	0.158	0.198	0.237	0.277	0.316	0.356	0.395	0.435
	180	38.5	0.153	0.191	0.229	0.305	0.381	0.457	0.533	0.609	0.685	0.761	0.837

Series CRQ2
Safety Instructions

These safety instructions are intended to prevent a hazardous situation and/or equipment damage. These instructions indicate the level of potential hazard by a label of **"Caution", "Warning" or "Danger"**. To ensure safety, be sure to observe ISO 4414 Note 1), JIS B 8370 Note 2) and other safety practices.

⚠ Caution : Operator error could result in injury or equipment damage.

⚠ Warning : Operator error could result in serious injury or loss of life.

⚠ Danger : In extreme conditions, there is a possible result of serious injury or loss of life.

Note 1) ISO 4414: Pneumatic fluid power – Recommendations for the application of equipment to transmission and control systems.

Note 2) JIS B 8370: General Rules for Pneumatic Equipment

⚠ Warning

1. The compatibility of pneumatic equipment is the responsibility of the person who designs the pneumatic system or decides its specifications.

Since the products specified here are used in various operating conditions, their compatibility for the specific pneumatic system must be based on specifications or after analysis and/or tests to meet your specific requirements.

2. Only trained personnel should operate pneumatically operated machinery and equipment.

Compressed air can be dangerous if an operator is unfamiliar with it. Assembly, handling or repair of pneumatic systems should be performed by trained and experienced operators.

3. Do not service machinery/equipment or attempt to remove components until safety is confirmed.

1. Inspection and maintenance of machinery/equipment should only be performed after confirmation of safe locked-out control positions.
2. When equipment is to be removed, confirm the safety process as mentioned above. Cut the supply pressure for this equipment and exhaust all residual compressed air in the system.
3. Before machinery/equipment is restarted, take measures to prevent shooting-out of cylinder piston rod, etc. (Bleed air into the system gradually to create back pressure.)

4. Contact SMC if the product is to be used in any of the following conditions:

1. Conditions and environments beyond the given specifications, or if product is used outdoors.
2. Installation on equipment in conjunction with atomic energy, railway, air navigation, vehicles, medical equipment, food and beverages, recreation equipment, emergency stop circuits, press applications, or safety equipment.
3. An application which has the possibility of having negative effects on people, property, or animals, requiring special safety analysis.

Series CRQ2
Rotary Actuator Precautions 1

Be sure to read before handling.

Precautions on design

⚠ Warning

1. In cases of load variations, lifting/lowering operations or changes in frictional resistance, employ a safety design which allows for these factors.

Increases in operating speed can cause human injury as well as damage to equipment and machinery.

2. A protective cover is recommended to minimize the risk of human injury.

If a stationary object and moving parts of a cylinder are in close proximity, human injury may occur. Design the structure to avoid contact with the human body.

3. Make secure connections so that stationary parts and connecting parts do not become loose.

Particularly when operation frequency is high or a rotary actuator is used in a location with excessive vibration, employ a secure method of connection.

4. A deceleration circuit or shock absorber, etc., may be required.

When a driven object is operated at high speed or the load is heavy, a cylinder's cushion will not be sufficient to absorb the impact. Install a deceleration circuit to reduce the speed before cushioning, or install an external shock absorber to relieve the impact. In this case, the rigidity of the machinery should also be examined.

5. Consider a possible drop in operating pressure due to a power outage, etc.

When a cylinder is used in a clamping mechanism, there is a danger of work pieces dropping if there is a decrease in clamping force due to a drop in circuit pressure caused by a power outage, etc. Therefore, safety equipment should be installed to prevent damage to machinery and/or human injury.

6. Consider a possible loss of power source.

Measures should be taken to protect against human injury and equipment damage in the event that there is a loss of power to equipment controlled by air pressure, electricity or hydraulics, etc.

7. When a speed controller is mounted on an exhaust throttle, employ a safety design which considers residual pressure.

If the air supply side is pressurized when there is no residual pressure on the exhaust side, operation will be abnormally fast and this can cause human injury as well as damage to equipment and machinery.

8. Consider emergency stops.

Design so that human injury and/or damage to machinery and equipment will not be caused by operation of a rotary actuator when machinery is stopped by a manual emergency stop or by a safety device under abnormal conditions, such as a power outage.

9. Consider the action when operation is restarted after an emergency stop or abnormal stop.

Design the machinery so that human injury or equipment damage will not occur upon restart of operation. When the rotary actuator has to be reset at the starting position, install manual safety equipment.

Precautions on design

⚠ Warning

10. Do not use the product as a shock absorbing mechanism.

If abnormal pressure or leakage occurs, there may be a drastic loss of deceleration effectiveness, leading to a danger of human injury as well as damage to equipment and machinery.

Selection

⚠ Warning

1. Keep the speed setting within the product's allowable energy value.

If operated with the kinetic energy of the load exceeding the allowable value, this can cause damage to the product, leading to human injury as well as damage to equipment and machinery.

2. Provide a shock absorbing mechanism when kinetic energy applied to the product exceeds the allowable value.

Operation exceeding the allowable kinetic energy can cause damage to the product and lead to human injury and damage to equipment and machinery.

3. Do not perform stops or holding operations by containing air pressure inside the product.

If intermediate stops are performed by containing air with a directional control valve when the product does not have an external stopping mechanism, the stopping position may not be held due to leakage, etc., and this can cause human injury and damage to equipment and machinery.

⚠ Caution

1. Do not operate the product at low speeds which are below the prescribed speed adjustment range.

If operated at low speeds below the speed adjustment range, this may cause sticking and slipping or stopping of operation.

2. Do not apply external torque which exceeds the product's rated output.

If external force is applied which exceeds the product's rated output, the product can be damaged.

3. Holding torque at end of rotation for double piston type

In double piston type products, where the internal piston is stopped by contact with an angle adjustment screw or cover, the holding torque at the rotation end is one half the value of the effective output.

4. When repeatability of the rotation angle is required, the load should be directly stopped externally.

The initial rotation angle may vary even in products equipped with angle adjustment.

5. Avoid operation with oil hydraulics.

Operation with oil hydraulics can cause damage to the product.

Series CRQ2
Rotary Actuator Precautions 2

Be sure to read before handling.

Mounting

⚠ Warning

1. When angle adjustment is performed while applying pressure, make advance preparations to keep equipment from rotating any more than necessary.

When adjustment is performed with pressure applied, there is a possibility of rotation and dropping during adjustment depending on the mounting position of the equipment, etc. This can cause human injury and damage to equipment and machinery.

2. Do not loosen the angle adjustment screw above the adjustment range.

If the angle adjustment screw is loosened above the adjustment range, it may come out causing human injury and damage to equipment and machinery.

3. Do not allow external magnetism close to the product.

Since the auto switches used are types sensitive to magnetism, external magnetism in close proximity to the product can cause malfunction leading to human injury and damage to equipment and machinery.

4. Do not perform additional machining on the product.

Additional machining of the product can result in insufficient strength and cause damage leading to human injury and damage to equipment and machinery.

5. Do not enlarge the fixed throttle on the piping port by reworking, etc.

If the bore is enlarged, rotation speed and impact force will increase, which can cause damage to the product leading to human injury and damage to equipment and machinery.

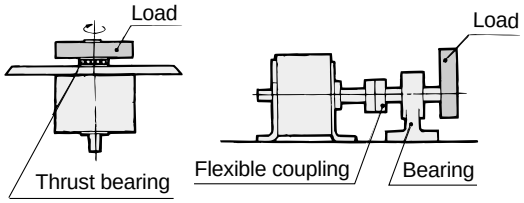
6. When using a shaft coupling, use one with a sufficient degree of freedom.

If a shaft coupling is used which does not have a sufficient degree of freedom, twisting will occur due to eccentricity, and this can cause malfunction and product damage leading to human injury and damage to equipment and machinery.

7. Do not apply loads to the shaft exceeding the values shown on page 13.

If loads exceeding the allowable values are applied to the product, this can cause malfunction and product damage leading to human injury and damage to equipment and machinery.

A load up to the allowable radial/thrust load can be applied provided that a dynamic load is not generated. However, applications which apply a load directly to the shaft should be avoided whenever possible. In order to further improve the operating conditions, a method such as that shown in the drawing below is recommended so that a direct load is not applied to the shaft.



8. Attach external stoppers away from the axis of rotation.

If the stopper is installed close to the axis of rotation, the reactive force operating on the stopper due to torque generated by the product itself will be applied to the shaft. This can cause damage to the shaft and bearing, leading to human injury and damage to equipment and machinery.

Precautions when using external stoppers

When the kinetic energy generated by the load exceeds the limit value of the actuator, an external shock absorbing mechanism must be provided to absorb the energy. The correct method for mounting external stoppers is explained in the figure below.

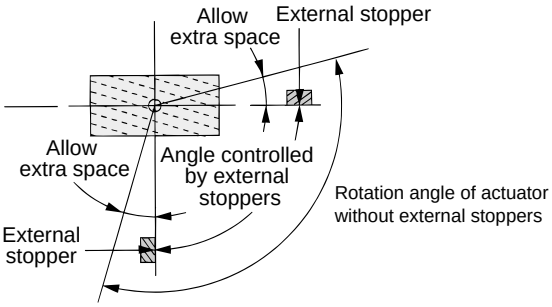
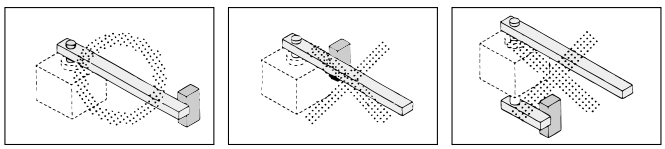


Figure 10.



External stopper becomes a fulcrum, and load's inertial force is applied to shaft as bending moment.

If external stopper is installed on shaft side opposite to load, inertial force generated by load is applied directly to shaft.

⚠ Caution

1. Do not wipe the model indications on labels, etc., with solutions such as organic solvents.

This will remove the indications.

2. Do not secure the body and strike the shaft, or secure the shaft and strike the body, etc.

This can bend the shaft and cause damage to the bearing. When installing a load, etc., on the shaft, secure the shaft.

3. Do not step directly on the shaft or the equipment installed on the shaft.

Stepping directly on the shaft can cause damage to the shaft and bearing, etc.

4. Operate products equipped with the angle adjustment function within the prescribed adjustment range.

Operation outside the adjustment range can cause malfunction and product damage. Refer to product specifications for the adjustment range of each product.

Series CRQ2
Rotary Actuator Precautions 3

Be sure to read before handling.

Air Supply

⚠ Warning

1. Use clean air.

If compressed air includes chemicals, synthetic oils containing organic solvents, salt or corrosive gases, etc., it can cause damage or malfunction.

⚠ Caution

1. Install air filters.

Install air filters at the upstream side of valves. The filtration degree should be 5µm or finer.

2. Install an after cooler, air dryer or Drain Catch, etc.

Air that includes excessive drainage may cause malfunction of rotary actuators and other pneumatic equipment. To prevent this, install an after cooler air dryer or Drain Catch, etc.

3. Use the product within the specified range of fluid and ambient temperature.

Take measures to prevent freezing, since moisture in circuits may be frozen under 5°C, and this can cause damage to seals and lead to malfunction.

Refer to SMC's "Air Cleaning Equipment" catalog for further details on compressed air quality.

Operating Environment

⚠ Warning

1. Do not use in environments where there is a danger of corrosion.

Refer to the construction drawings regarding rotary actuator materials.

2. Do not use in dusty locations or where water and oil, etc., splash on the equipment.

Speed and Cushion Adjustment

⚠ Warning

1. Perform speed adjustment gradually from the low speed side.

Speed adjustment from the high speed side can cause product damage leading to human injury and damage to equipment and machinery.

2. Since the cushion needle is not adjusted before shipment, perform adjustment for the applicable operation speed and load moment of inertia.

Absorption of kinetic energy by the cushion is accomplished by adjustment of the needle, and improper adjustment can cause product damage leading to human injury and damage to equipment and machinery.

3. Do not operate with the cushion needle fully closed.

This can cause seal damage leading to human injury and damage to equipment and machinery.

4. Do not loosen the cushion needle with excessive force.

The needle unit is provided with a stop to prevent it from coming out. Loosening it with excessive force can cause damage leading to human injury and damage to equipment and machinery.

Lubrication

⚠ Caution

1. Use this product without lubrication. It can be used with lubrication also, but this can cause problems such as sticking and slipping.

Maintenance

⚠ Warning

1. Maintenance should be performed according to the procedure indicated in the instruction manual. Improper handling can cause damage and malfunction of equipment and machinery.

2. During maintenance, do not disassemble while the electric power and supply air are turned ON.

3. Conduct suitable function tests after the product has been disassembled for maintenance.

Failure to test functions can result in inability to satisfy the product specifications.

⚠ Caution

1. For lubrication use the grease specified for each product.

Use of a lubricant other than that specified can cause damage to seals, etc.

Series CRQ2
Auto Switch Precautions 1
Be sure to read before handling.

Design & Selection

⚠ Warning

1. Confirm the specifications.

Read the specifications carefully and use this product appropriately. The product may be damaged or malfunction if it is used outside the range of specifications of current load, voltage, temperature or impact.

2. Take precautions when actuators are used close together.

When multiple auto switch actuators are used in close proximity, magnetic field interference may cause the switches to malfunction. Maintain a minimum actuator separation of 40mm. (When the allowable separation is indicated for each actuator series, use the specified value.)

3. Pay attention to the length of time that a switch is ON at an intermediate stroke position.

When an auto switch is placed at an intermediate position of the stroke and a load is driven at the time the piston passes, the auto switch will operate, but if the speed is too great the operating time will be shortened and the load may not operate properly. The maximum detectable piston speed is:

$$V(mm/s) = \frac{\text{Auto switch operating range (mm)}}{\text{Time load applied (ms)}} \times 1000$$

4. Keep wiring as short as possible.

<Reed switch>

As the length of the wiring to a load gets longer, the rush current at switching ON becomes greater, and this may shorten the product's life. (The switch will stay ON all the time.)

1) For an auto switch without a contact protection circuit, use a contact protection box when the wire length is 5m or longer.

2) Even if an auto switch has a built-in contact protection circuit, when the wiring is more than 30m long, it is not able to adequately absorb the rush current and its life may be reduced. It is again necessary to connect a contact protection box in order to extend its life. Please contact SMC in this case.

<Solid state switch>

3) Although wire length should not affect switch function, use wiring 100m or shorter.

5. Take precautions for the internal voltage drop of the switch.

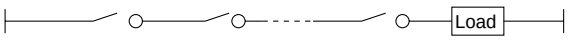
<Reed switch>

1) Switches with an indicator light (Except D-A96/A96V)

• If auto switches are connected in series as shown below, take note that there will be a large voltage drop because of internal resistance in the light emitting diodes. (Refer to internal voltage drop in the auto switch specifications.)

[The voltage drop will be "n" times larger when "n" auto switches are connected.]

Even though an auto switch operates normally, the load may not operate.



⚠ Warning

• In the same way, when operating under a specified voltage, although an auto switch may operate normally, the load may not operate. Therefore, the formula below should be satisfied after confirming the minimum operating voltage of the load.

$$\text{Supply voltage} - \text{Internal voltage drop of switch} > \text{Minimum operating voltage of load}$$

2) If the internal resistance of a light emitting diode causes a problem, select a switch without an indicator light (Model D-A90/A90V).

<Solid state switch>

3) Generally, the internal voltage drop will be greater with a 2 wire solid state auto switch than with a reed switch. Take the same precautions as in 1).

Also, note that a 12VDC relay is not applicable.

6. Pay attention to leakage current.

<Solid state switch>

With a 2 wire solid state auto switch, current (leakage current) flows to the load to operate the internal circuit even when in the OFF state.

Operating current of load (OFF condition) > Leakage current

If the criteria given in the above formula are not met, it will not reset correctly (stays ON). Use a 3 wire switch if this specification will not be satisfied.

Moreover, leakage current flow to the load will be "n" times larger when "n" auto switches are connected in parallel.

7. Do not use a load that generates surge voltage.

<Reed switch>

If driving a load such as a relay that generates a surge voltage, use a switch with a built-in contact protection circuit or use a contact protection box.

<Solid state switch>

Although a zener diode for surge protection is connected at the output side of a solid state auto switch, damage may still occur if the surge is applied repeatedly. When a load, such as a relay or solenoid, which generates surge is directly driven, use a type of switch with a built-in surge absorbing element.

8. Cautions for use in an interlock circuit

When an auto switch is used for an interlock signal requiring high reliability, devise a double interlock system to avoid trouble by providing a mechanical protection function, or by also using another switch (sensor) together with the auto switch. Also perform periodic maintenance and confirm proper operation.

9. Ensure sufficient clearance for maintenance activities.

When designing an application, be sure to allow sufficient clearance for maintenance and inspections.

Series CRQ2
Auto Switch Precautions 2

Be sure to read before handling.

Mounting & Adjustment

⚠ Warning

1. Do not drop or bump.

Do not drop, bump or apply excessive impacts (300m/s² or more for reed switches and 1000m/s² or more for solid state switches) while handling. Although the body of the switch may not be damaged, the inside of the switch could be damaged and cause a malfunction.

2. Do not carry a rotary actuator by the auto switch lead wires.

Never carry a rotary actuator by its lead wires, as this may not only cause broken lead wires, but it may cause internal elements of the switch to be damaged by the stress.

3. Mount switches using the proper tightening torque.

When a switch is tightened beyond the range of tightening torque, the mounting screws, mounting bracket or switch may be damaged. On the other hand, tightening below the range of tightening torque may allow the switch to slip out of position.

4. Mount a switch at the center of the operating range.

Adjust the mounting position of an auto switch so that the piston stops at the center of the operating range (the range in which a switch is ON). (The mounting positions shown in the catalog indicate the optimum positions at stroke end.) If mounted at the end of the operating range (around the borderline of ON and OFF), operation may be unstable.

Wiring

⚠ Warning

1. Avoid repeatedly bending or stretching lead wires.

Broken lead wires will result from repeatedly applying bending stress or stretching force to the lead wires.

2. Be sure to connect the load before power is applied.

<2 wire type>

If the power is turned ON when an auto switch is not connected to a load, the switch will be instantly damaged because of excess current.

3. Confirm proper insulation of wiring.

Be certain that there is no faulty wiring insulation (contact with other circuits, ground fault, improper insulation between terminals, etc.). Damage may occur due to excess current flow into a switch.

4. Do not wire with power lines or high voltage lines.

Wire separately from power lines or high voltage lines, avoiding parallel wiring or wiring in the same conduit with these lines. Control circuits containing auto switches may malfunction due to noise from these other lines.

Wiring

⚠ Warning

5. Do not allow short circuit of loads.

<Reed switch>

If the power is turned ON with a load in a short circuit condition, the switch will be instantly damaged because of excess current flow into the switch.

<Solid state switch>

Model D-F9□(V), D-F9□W(V) and all models of PNP output type switches do not have built-in short circuit protection circuits. As in the case of reed switches, if loads are short circuited, the switches will be instantly damaged.

Take special care to avoid reverse wiring with the brown (red) power supply line and the black (white) output line on 3 wire type switches.

6. Avoid incorrect wiring.

<Reed switch>

A 24VDC switch with indicator light has polarity. The brown (red) lead wire or terminal 1 is (+), and the blue (black) lead wire or terminal 2 is (–).

1) If connections are reversed, a switch will operate, however, the light emitting diode will not light up.

Also note that a current greater than that specified will damage a light emitting diode and it will no longer operate.

Applicable models: D-A93/A93V

<Solid state switch>

1) If connections are reversed on a 2 wire type switch, the switch will not be damaged if protected by a protection circuit, but the switch will be in a normally ON state. However, it is still necessary to avoid reversed connections, since the switch could be damaged by a load short circuit in this condition.

2) If connections are reversed (power supply line + and power supply line –) on a 3 wire type switch, the switch will be protected by a protection circuit. However, if the power supply line (+) is connected to the blue (black) wire and the power supply line (–) is connected to the black (white) wire, the switch will be damaged.

∗ Lead wire color changes

Lead wire colors of SMC switches and related products have been changed in order to meet NECA (Nippon Electric Control Equipment Industries Association) Standard 0402 for production beginning September, 1996 and thereafter. Please refer to the tables provided.

Special care should be taken regarding wire polarity during the time that the old colors still coexist with the new colors.

2 wire

	Old	New
Output (+)	Red	Brown
Output (–)	Black	Blue

3 wire

	Old	New
Power supply	Red	Brown
GND	Black	Blue
Output	White	Black

Solid state with diagnostic output

	Old	New
Power supply	Red	Brown
GND	Black	Blue
Output	White	Black
Diagnostic output	Yellow	Orange

Solid state with latch type diagnostic output

	Old	New
Power supply	Red	Brown
GND	Black	Blue
Output	White	Black
Latch type diagnostic output	Yellow	Orange

Series CRQ2
Auto Switch Precautions 3

Be sure to read before handling.

Operating Environment

⚠ Warning

1. Never use in an atmosphere of explosive gases.

The structure of auto switches is not intended to prevent explosion. Never use in an atmosphere with an explosive gas since this may cause a serious explosion.

2. Do not use in an area where a magnetic field is generated.

Auto switches will malfunction or magnets inside actuators will become demagnetized. (Consult SMC regarding the availability of a magnetic field resistant auto switch.)

3. Do not use in an environment where the auto switch will be continually exposed to water.

Although switches, except some models, satisfy IEC standard IP67 construction (JIS C 0920: water tight structure), do not use switches in applications where continually exposed to water splash or spray. Poor insulation or swelling of the potting resin inside switches may cause malfunction.

4. Do not use in an environment with oil or chemicals.

Consult SMC if auto switches will be used in an environment with coolant, cleaning solvent, various oils or chemicals. If auto switches are used under these conditions for even a short time, they may be adversely affected by improper insulation, malfunction due to swelling of the potting resin, or hardening of the lead wires.

5. Do not use in an environment with temperature cycles.

Consult SMC if switches are used where there are temperature cycles other than normal temperature changes, as they may be adversely affected internally.

6. Do not use in an environment where there is excessive impact shock.

<Reed switch>

When excessive impact (300m/s² or more) is applied to a reed switch during operation, the contact point will malfunction and generate or cut off a signal momentarily (1ms or less). Consult SMC regarding the need to use a solid state switch depending upon the environment.

7. Do not use in an area where surges are generated.

<Solid state switch>

When there are units (solenoid type lifter, high frequency induction furnace, motor, etc.) which generate a large amount of surge in the area around actuators with solid state auto switches, this may cause deterioration or damage to the internal circuit elements of the switches. Avoid sources of surge generation and disorganized lines.

8. Avoid accumulation of iron debris or close contact with magnetic substances.

When a large amount of ferrous debris such as machining chips or welding spatter is accumulated, or a magnetic substance (something attracted by a magnet) is brought into close proximity to actuators with auto switches, it may cause the auto switches to malfunction due to a loss of the magnetic force inside the actuator.

Maintenance

⚠ Warning

1. Perform the following maintenance periodically in order to prevent possible danger due to unexpected auto switch malfunction.

1) Secure and tighten switch mounting screws.

If screws become loose or the mounting position is dislocated, retighten them after readjusting the mounting position.

2) Confirm that there is no damage to lead wires.

To prevent faulty insulation, replace switches or repair lead wires, etc., if damage is discovered.

3) Confirm the lighting of the green light on the 2 color indicator type switch.

Confirm that the green LED is on when stopped at the established position. If the red LED is on, the mounting position is not appropriate. Readjust the mounting position until the green LED lights up.

Other

⚠ Warning

1. Consult SMC concerning water resistance, elasticity of lead wires and usage at welding sites, etc.

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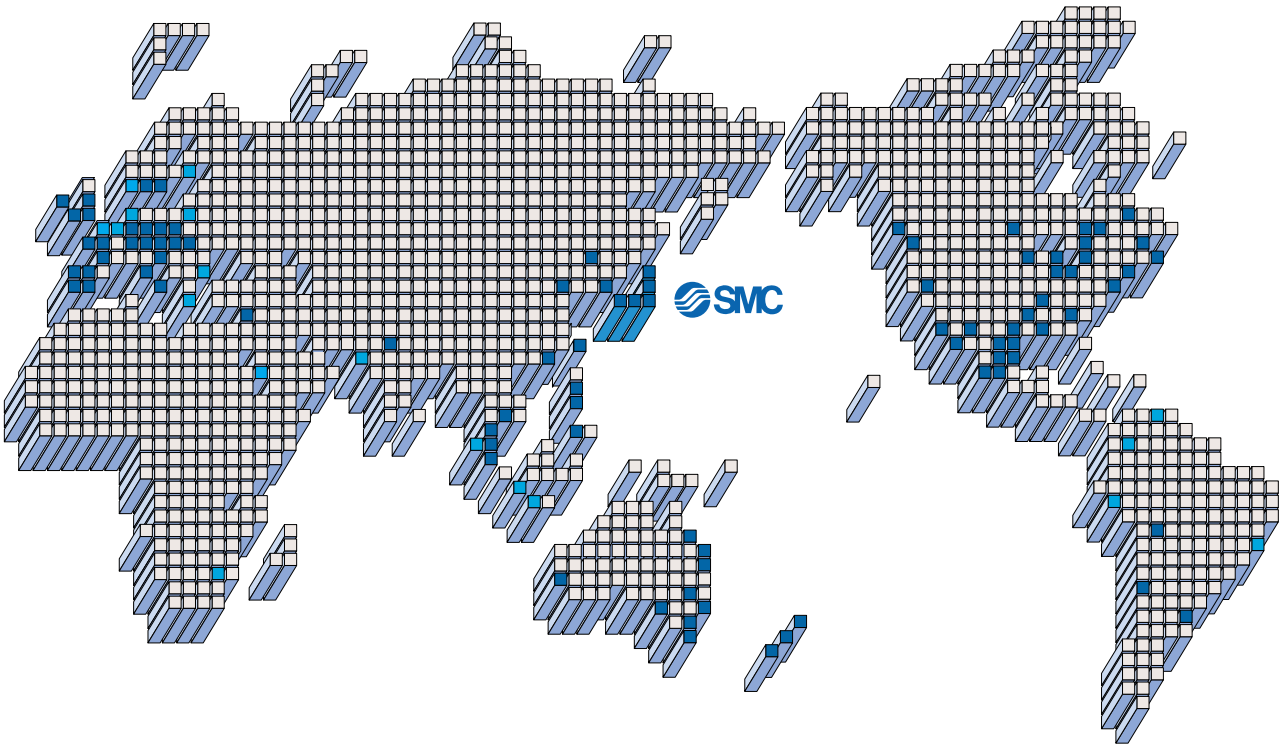

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