Operation Manual

Compact Rotary Actuator
CRQ2 Series
Rack Pinion Type

○ Thoroughly read and understand this operation manual to install and operate this product.

○ Pay particular attention to the safety statements.

○ Retain this operation manual to read whenever needed.

SMC CORPORATION

Contents

1. Outline

This operation manual is for rack pinion type compact rotary actuator. Cautions will be given on the load (inertia moment), rotation time and others. Please read through the manual before starting operation.

1-1 Specification

Table 1 Specification-1

Size	10	15	20	30	40
Operating fluid	Air (Non-lube)				
Max. operating pressure	0.7 MPa		1 MPa		
Min. operating pressure	0.15 MPa		0.1 MPa		
Ambient temp. and operating fluid temp.	0～60℃ (No freeze)				
Cushion	Rubber cushion		No. Air cushion		
Angle adjustment	±5°				
Rotation angle	80° ～100° 、170° ～190° 、350° ～370°				
Port size	M5×0.8		Rc 1/8, G 1/8, NPT 1/8, NPTF 1/8		
Supporting style	Basic type				
Output(N·m)	0.3	0.75	1.8	3.1	5.3

Table 2 Specification-2

Size	Allowable kinetic energy			Cushion angle	Safe adjustment range of rotating time
	Allowable kinetic energy (mJ)				
	No air cushion	Rubber cushion	Air cushion		Rotation time (s/90°)
10	—	0.25	—	—	0.2～0.7
15	—	0.39	—	—	0.2～0.7
20	25	—	120	40°	0.2～1
30	48	—	250	40°	0.2～1
40	81	—	400	40°	0.2～1

Allowable kinetic energy of cushion type is the max. adsorbing energy when the cushion needle adjustment is optimum. Operation with the speed lower than adjustment range lead to cause stick clip or termination of operation.

Table 3 Specification-3

Size	Weight (g)			Internal capacity (cm^3)		
	90°	180°	360°	90°	180°	360°
10	120	150	200	1.2	2.2	4.3
15	220	270	380	2.9	5.5	10.7
20	600	700	1000	7.1	13.5	26.3
30	900	1100	1510	12.1	22.9	44.7
40	1400	1600	2280	20.5	39	76

1-2 Effective output

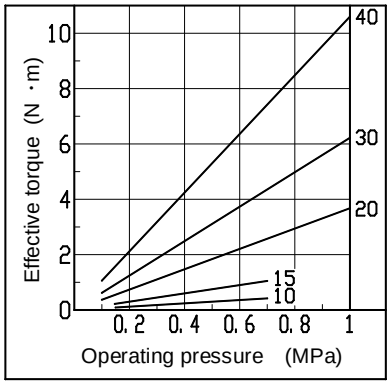
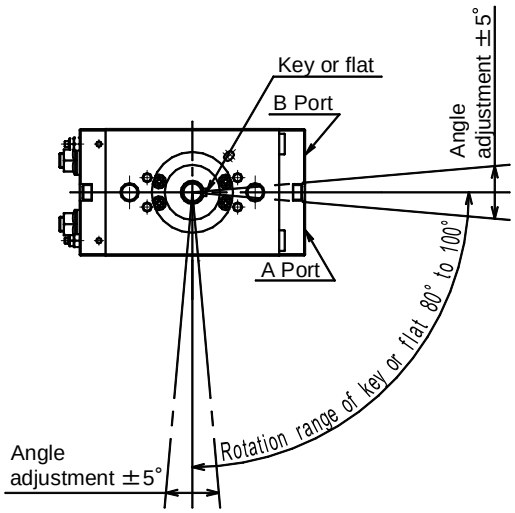


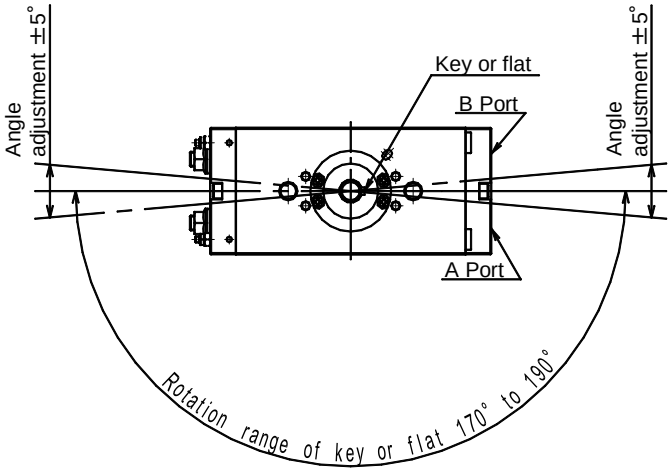
Fig.1 Effective output

1-3 Rotation range

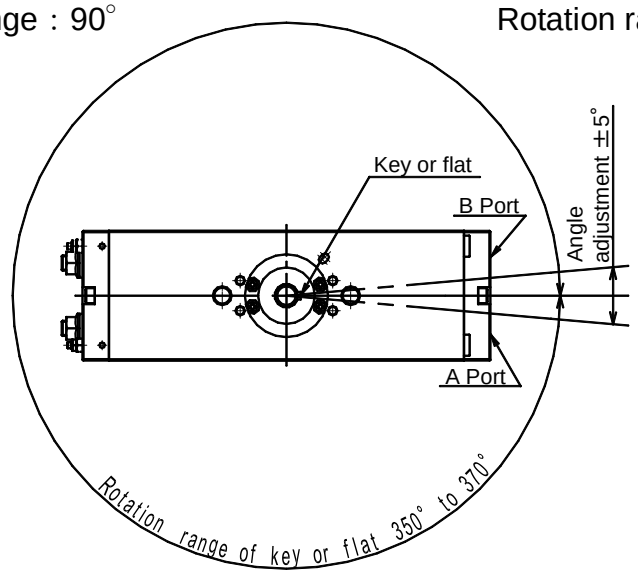
When pressurized from the Port A, the shaft will rotate clockwise.
Flat face and parallel key position indicate B port is pressurized.



Rotation range：90°



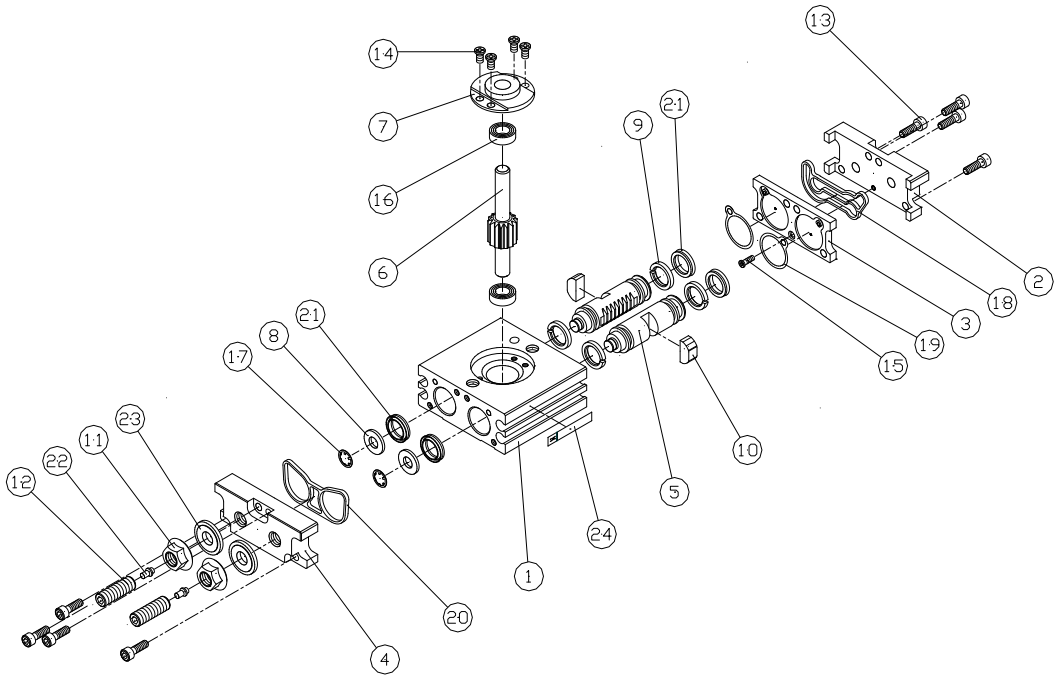
Rotation range：180°



Rotation range：360°

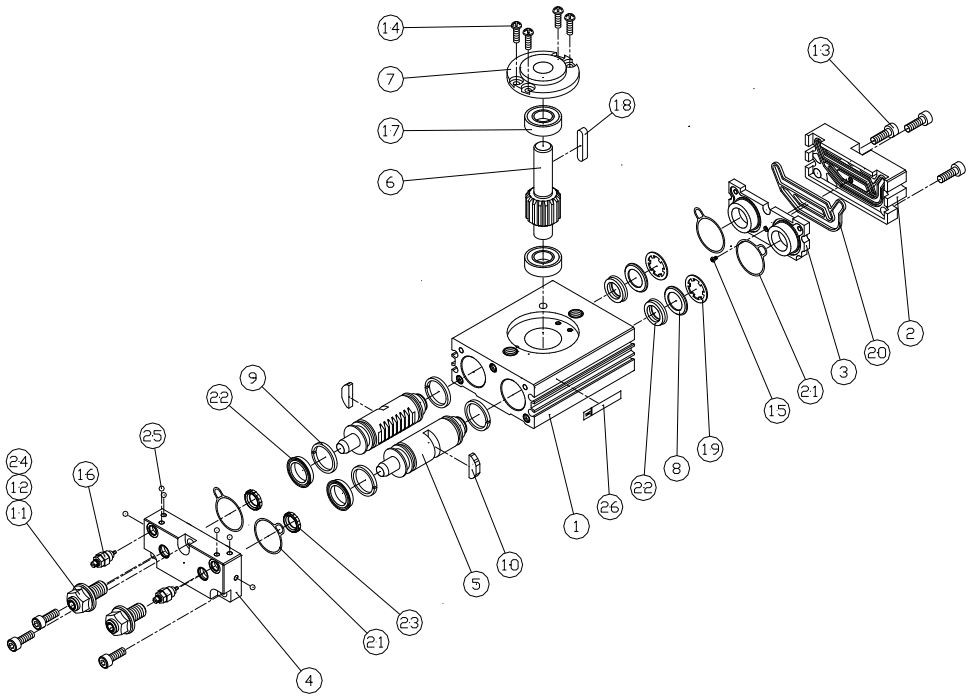
2. Internal structure and parts description

2-1 Size 10,15



No.	Description	Qty.	Note
24	Heat transferred label	1	
23	Seal washer	2	
22	Cushion pad	2	
21	Piston packing	4	
20	End cover gasket	1	
19	Cover gasket	2	
18	Packing	1	
17	Retainer	2	
16	Bearing	2	
15	Cross recessed No.0 screw	1	
14	Cross recessed No.0 screw	4	
13	Hexagon socket head screw	8	
12	Adjust bolt	2	
11	Hexagon nut with flange	2	
10	Magnet	2	Including magnet built-in type
9	Wear ring	4	
8	Packing retainer	2	
7	Bearing retainer	1	
6	Shaft	1	
5	Piston	2	
4	End cover	1	
3	Plate	1	
2	Cover	1	
1	Body	1	

2-2 Size 20,30,40



No.	Description	Qty.	Note
26	Heat transferred label	1	
25	Steel ball		No cushion ：4pcs.， with cushion： 6pcs.
24	Seal washer	2	
23	Cushion packing	2	Only cushion type included
22	Piston packing	4	
21	Gasket	4	
20	Packing	1	
19	Retainer	2	
18	Parallel key	1	
17	Bearing	2	
16	Cushion valve Assy	2	Only cushion type included
15	Cross recessed No.0 screw	1	
14	Cross recessed socket head screw	4	
13	Hexagon socket head bolt	6	
12	Hexagon socket head cap screw	2	
11	Hexagon nut with flange	2	
10	Magnet	2	Only magnet built-in type included
9	Wear ring	4	
8	Packing retainer	2	
7	Bearing retainer	1	
6	Shaft	1	
5	Piston	2	
4	End cover	1	
3	Plate	1	
2	Cover	1	
1	Body	1	

3. Basic circuit of the rotary actuator

3-1 Circuit structure

See below for the circuit to operate the rotary actuator using air filter, regulator, solenoid valve, and speed controller.

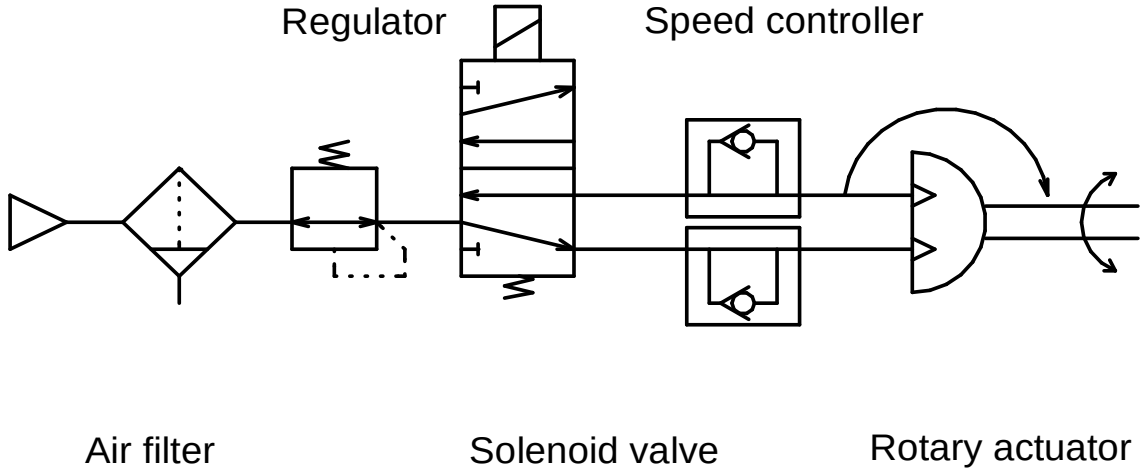


Fig.2 Basic circuit

3-2 Recommended equipment

Table 4 shows recommended solenoid valve, speed controller, tube for the basic circuit in Fig.2.

Table 4 Recommended equipment

Size	Solenoid valve	Speed controller	Tube
10 15	VZ1000 series（M5,Cv=0.05） VJ3000 series（M5,Cv=0.2）	AS1000 series(M5)	φ4／φ2.5
20 30 40	VZ3000 series（Rc1/8,Cv=0.2） VF1000 series（Rc1/8,Cv=0.15）	AS2000 series(Rc1/8)	φ6／φ4

※Solenoid valve is selected by elastic seal method

4. Mounting

4-1 Restriction of the load to axis

Table of load below shows the allowable load when no moving load applied to axis direction. Avoid applying load to the axis directly as much as possible.

Table5 Allowable load (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

※Point of application of force of Fr is the center of shaft flat face and longer dimension of the key.

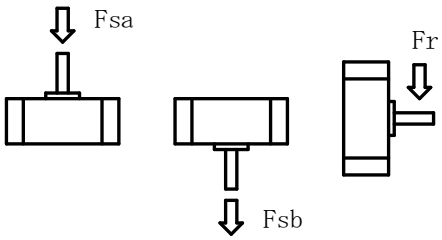


Fig.3 Load direction

Although allowable radial, thrust load can be applied where no moving load exist, direct load to the axis should be avoided as much as possible. Example below is recommended so that the load is not applied to the axis directly.

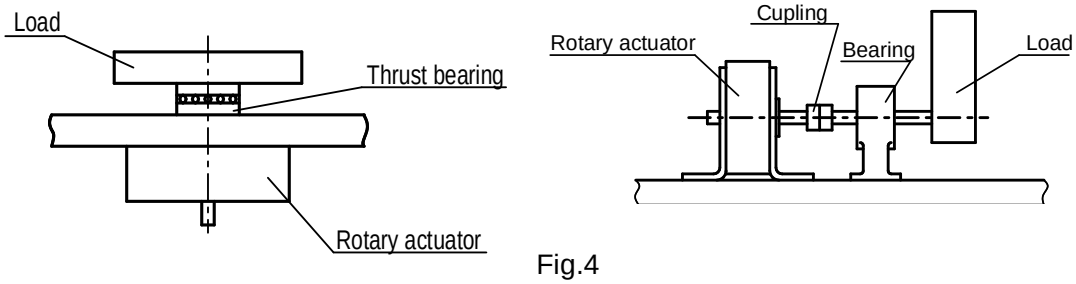


Fig.4

4-2 Operation of axis fitting referring

As in Fig.5, alignment of the rotary actuator and the mating axis is necessary when the rotary actuator is used with its axis lengthened. If misaligned, partial load becomes high and the axis is applied with excessive bend moment. Under this condition, stable operation is not available which lead to cause the damage of axis. In this case, flexible fitting (flexible joint specified by JIS) becomes necessary.

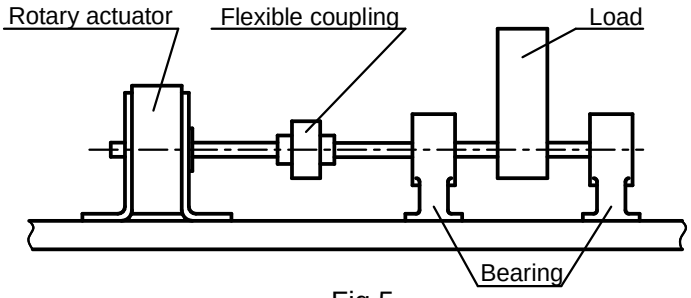


Fig.5

4-3 Flange application

See table 6 for L dimension of the body.
JIS hexagon socket head bolt is neatly placed in the rotary actuator groove.

Table 6

Size	L	Bolt
10	13	M 4
15	16	M 4
20	22.5	M 6
30	24.5	M 8
40	28.5	M 8

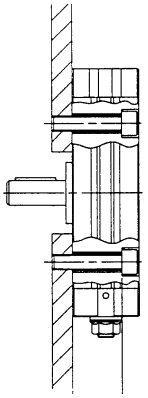


Fig.6

4-4 Piping and operating direction

Fig-7 shows piping ports of the rotary actuator.
Table-7 shows the port size.

Table 7 Port size

Size	Port size
10	M5×0.8
15	
20	Rc 1/8, G 1/8 NPT 1/8, NPTF 1/8
30	
40	

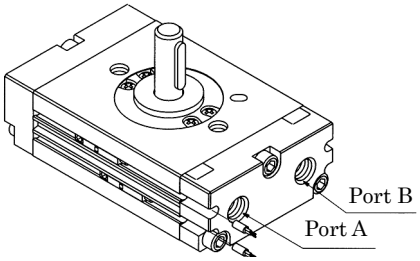


Fig.7 Port location

Fixed orifice is equipped in the rotary actuator port. Don't enlarge the hole. Enlarged hole increases the operation speed of the rotary actuator and the impact which lead to cause the breakage of the rotary actuator.
The axis rotates clockwise when pressurized from A port. Perform followings before piping.

a) Flush or clean the piping to eliminate metal swarf, cutting oil and dust before connecting piping.
b) Mind so that the piping swarf and sealing material do not enter into the piping when screwing in piping and fitting. When using the seal tape, leave 1.5～2 threads.

4-5 Operating air

Air supplied to the rotary actuator shall be cleaned by the filter. CRQ2 series is lubrication free.

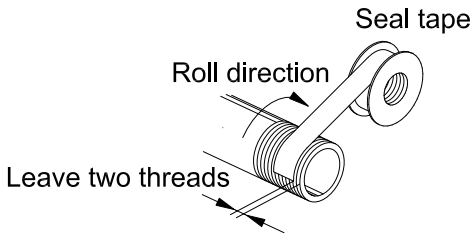


Fig.8 Applying seal tape

5. Setting rotation time

The load inertia lead to cause the damage of the shaft and internal parts even if generated torque of rotary actuator is small. The calculation of load inertia moment and kinetic energy is necessary to set the rotation time for operating the rotary actuator.

5-1 Inertia moment

Inertia moment indicates scales how hard to rotate the object, and also how hard to stop rotating object.

An object started by the rotary actuator is getting to have inertia force. When the rotary actuator stops at the stroke end, the actuator received big impact (kinetic energy) due to inertia force. Please refer below for calculation of kinetic energy

$$E = \frac{1}{2} \times I \times \omega^2$$

E : Kinetic energy J
I : Inertia moment kg・m^2
ω : Angular speed rad／s

Allowable kinetic energy for the rotary actuator is limited. The limit of rotation time is obtained by calculating inertia moment. Please refer following for obtaining inertia moment.

Basic inertia moment

$$I = m \cdot r^2$$

m : Weight of load. kg
r : Load center of gravity and distance of rotation axis. m

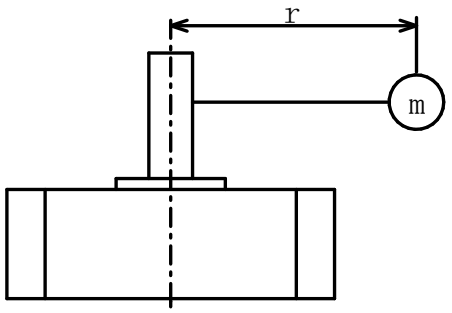


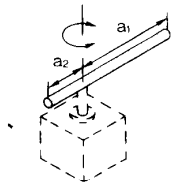
Fig. 9

This shows inertia moment of ñm (weight)òat ñròfrom the rotation axis. Calculation of inertia moment depends on the shape of the object. Please refer the table on the next page for inertia moment calculation.

Table for calculation of Inertia moment

① Thin rod

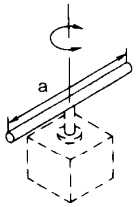
Location of rotation axis: Perpendicular to the rod and passes one end



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

② Thin rod

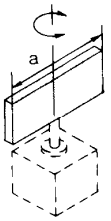
Location of rotation axis: Passes the center of gravity of the rod



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

③ Thin rectangular board (Rectangular parallelopiped)

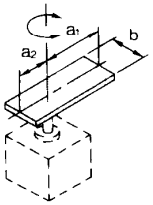
Location of rotation axis: Passes the center of gravity of the board



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

④ Thin rectangular board (Rectangular parallelopiped)

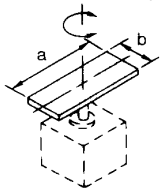
Location of rotation axis: Perpendicular to the board and passes one end (It is the same for the rectangular parallelopiped made with thicker board)



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

⑤ Thin rectangular board (Rectangular parallelopiped)

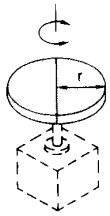
Location of rotation axis: Passes the center of gravity of the board and perpendicular to the board (It is the same for the rectangular parallelopiped made with thicker board)



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

⑥ Column (Including thin round board)

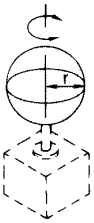
Location of rotation axis: Center axis



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

⑦ Sphere

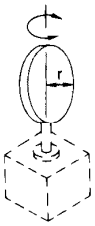
Location of rotation axis: Diameter



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

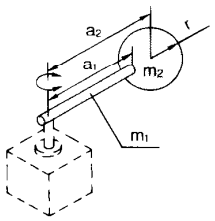
⑧ Thin round board

Location of rotation axis: Diameter



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

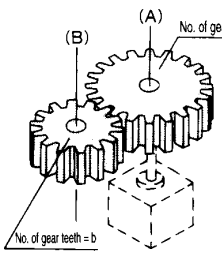
⑨ With a load at the end of the lever



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

Example) $K = m_2 \frac{2r^2}{5}$, referring to the case ⑦ that the state of m_2 is a ball.

⑩ Gear Transmission



1. Calculate moment of inertia I_B around axis (B).
2. Replace moment of inertia I_B around axis (A) with I_A.
   $I_A = (\frac{a}{b})^2 I_B$

5-2 Kinetic energy

Table 8 shows the allowable kinetic energy of the rotary actuator.
The end angular speed ω is obtained by:

Table 8 Allowable kinetic energy

Size	Allowable kinetic energy mJ		Cushion angle
	No cushion	Cushion type	
10	0.25	—	—
15	0.39	—	—
20	25	120	40°
30	48	250	40°
40	81	400	40°

※ Allowable kinetic energy of cushion type is max. adsorption energy when the cushion needle adjustment is optimum.

$$\omega = \frac{2\theta}{t}$$

θ : Rotation angle rad
t : Rotation time s

Kinetic energy E is obtained by:

$$E = \frac{1}{2} \times I \times \omega^2$$

Therefore, the rotary actuator rotation time is:

$$t \geq \sqrt{\frac{2 \times I \times \theta^2}{E}}$$

E : Allowable kinetic energy J
θ : Rotation angle rad
I : Inertia moment kg・m^2

Angular speed ω after t sec. at isometric acceleration is obtained as below

$$\omega = \dot{\omega} \times t \quad \cdots\cdots (1)$$

$\dot{\omega}$: Angular acceleration

$$\theta = \int \dot{\omega} t \, dt = \frac{1}{2} \dot{\omega} t^2 + C \quad \cdots\cdots (2)$$

C : Integral constant

Seconds of arc at $t = 0$ is $\theta = 0$. Therefore $C = 0$.

$$\theta = \frac{1}{2} \dot{\omega} t^2 = \frac{1}{2} \omega t$$

Therefore,

$$\omega = \frac{2\theta}{t}$$

5-3 External stopper

When kinetic energy generating the load exceeds the rotary actuator allowable kinetic energy, the inertia force has to be adsorbed by externally installed cushioning function.

5-3-1 Install position of external stopper

External stopper lead to cause the rotary actuator axis torsion, damage and the breakage of the axis bearing depending on install location of stopper and load shape and the place.

Place an external stopper in apposition that is away from the rotary actuator or the material point.

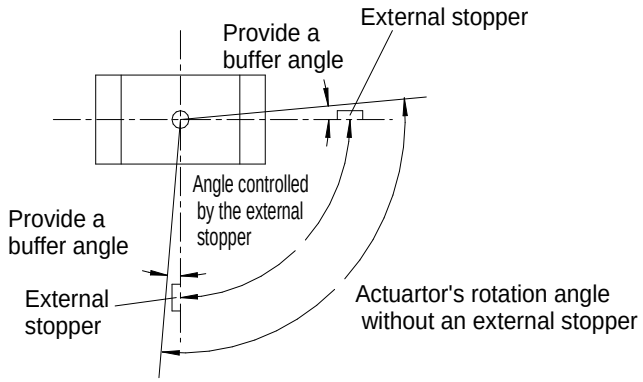
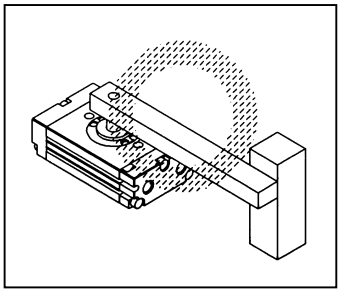
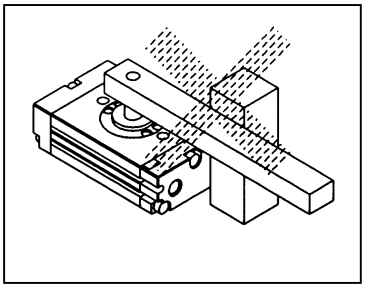
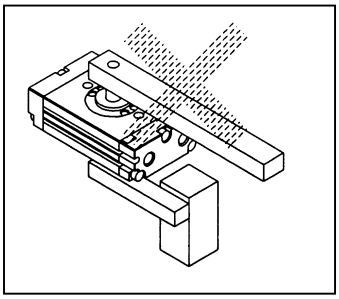


Fig. 10





External stopper acts as fulcrum. Load inertia force is applied to the shaft as bending moment



Inertia force generated by the load is directly applied to the axis if the external stopper on the opposite side of the load.

Fig. 11

5-3-2 Caution on using external stopper

Angle adjustment is available for CRQ2 series rotary actuator. Mind so that the hexagon socket set screw (angle adjusting screw) does not collide into the piston.

6. Rotary actuator with auto switch

The piston of rotary actuator with auto switch is attached with magnet on it, and equipped with auto switch outside to detect the piston position (shaft flat face and key groove position).

6-1 Auto switch specification

Table 9

Type	Special function	Electrical entry	Indicator	Wiring (Output)	Load voltage DC		Load voltage AC	Autoswitch part no. Electrical entry Vertical	Autoswitch part no. Electrical entry Horizontal	lead wire length (m) 0.5 (Nil)	3 (L)	5 (Z)	Applied load	
Reed auto switch	—	Grommet	Presense	3 wires Equivalent to NPN	—	5V	—	A96V	A96	●	●	—	IC circuit	—
				2 wires	24V	—	100V	A93V	A93	●	●	—	—	Relay PLC
			Nil			5V,12V	00V or les	A90V	A90	●	●	—	IC circuit	
Solid state auto switch	—	Grommet	Presence	3 wires (NPN)	24V	5V,12V	—	M9NV	M9N	●	●	○	—	Relay PLC
				3 wires (PNP)	—	—		M9PV	M9P	●	●	○		
				2 wires	24V	24V		M9BV	M9B	●	●	○		
	Diagnosis display (2 color display)			3 wires (NPN)		5V,12V		F9NWV	F9NW	●	●	○		
				3 wires (PNP)	—	—		F9PWV	F9PW	●	●	○		
				2 wires	24V	12V		F9BWV	F9BW	●	●	○		
	Better water resistance					(10～28V)		—	F9BAL	—	●	○		

Lead switch

- Lead wire-D－A90□、A93□:Oil resisting vinyl cap tire cord φ2.7
  18mm^2×2 core (brown、blue) 0.5m
  D－A96□:Oil resisting vinyl cap tire cord φ2.7
  15mm^2×3 core (brown, black, blue)0.5m
- Insulation resistance-50MΩ or more at DC500Vmega (Between the lead wire and the case)
- Voltage resistance-AC1000V for 1min. (Between the lead wire and the case)
- Operation time-1.2ms
- Ambient temp.-－10～60℃
- Impact resistance-300m/s^2{ 30.6G }
- Leak current-0
- Protection rate-IEC529 standard IP67 (JIS0920) watertight
- When the lead wire length is 3m, the part number is suffixed with ñLò ex)D-A90L

Solid state switch

- Lead wire-Oil resisting vinyl cap tire cord φ2.7
  0.15mm^2×3 core (brown, black, blue)0.5m,18mm^2×2 core(brown, blue)0.5m
- Insulation resistance-50MΩ or more at DC500V (Between lead wire and the case)
- Voltage resistance-AC1000V for 1 min. (between lead wire and the case)
- Operation time-1ms or less
- Ambient temp.-－10～60℃
- Impact resistance-1000m/s^2{ 102G }
- Protection-IEC529 standard IP65 (JIS0920) jet proof
- When the lead wire length is 3m, the part number is suffixed with ñLò ex)D-M90L

6-2 Auto switch installation

Use small driver (5～6mm of grip diameter) to tighten auto switch set screws with 0.1～0.2N・m of tightening torque. Use slotted setscrew (with urethane damper) as setscrew.

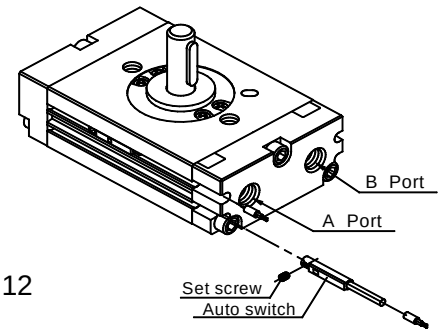
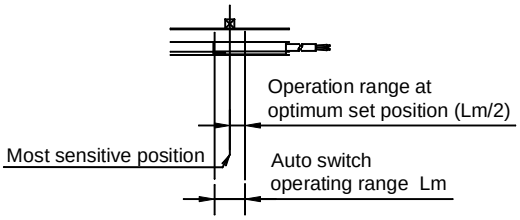


Fig.12

6-3 Auto switch set position



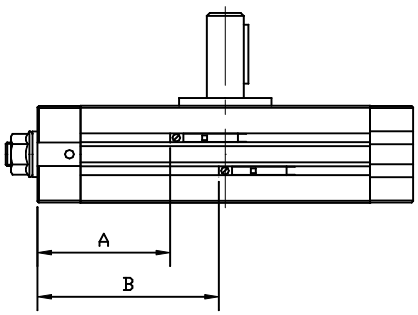


Fig.13

Table 10

Size	Rotation	Reed auto switch				Solid state auto switch			
		A	B	Operation angle θm	Hysteresis angle	A	B	Operation angle θm	Hysteresis angle
10	90°	15	21.5	63°	12°	19	25.5	75°	3°
	180°	18	31			22	35		
	360°	25	52.5			29	56.5		
15	90°	18.5	27	52°	9°	22.5	31	69°	3°
	180°	22.5	39.5			26.5	43.5		
	360°	30.5	64.5			34.5	68.5		
20	90°	36	48.5	41°	9°	40	52.5	56°	4°
	180°	42	67.5			46	71.5		
	360°	55.5	106			59.5	110		
30	90°	43	59	32°	7°	47	63	43°	3°
	180°	51	82			55	86		
	360°	62	125.5			66	129.5		
40	90°	50	69	24°	5°	54	73	36°	4°
	180°	59.5	97.5			63.5	101.5		
	360°	72.5	152			76.5	156		

Operation angle θm： The value in which the auto switch operating range ñLmòis converted to axis rotating value

Hysteresis angle： Value in which the auto switch hysteresis is converted to angle

- If the auto switch is set in dimension ñAò, the magnet is placed around the most sensitive area of the switch when the piston reaching the stroke ends.
  （When rotation angle is 90° and 180° ）

6-4 Internal structure and operation principle

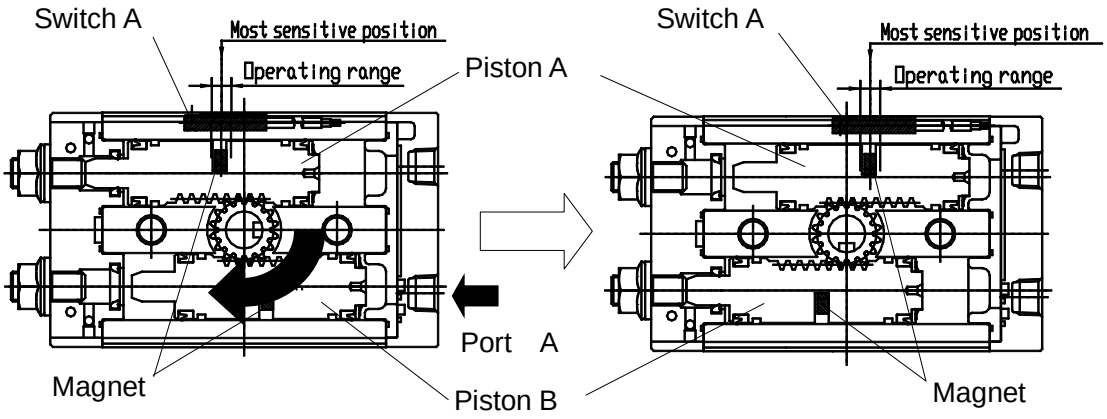


Fig.14

In figure 14, the switch A is turned on. When pressurized from port A, piston B moves to the left and piston A moves to the right, and the shaft rotates clockwise. At this point, magnet goes out of switch A's operation range to turn off switch A. Then, piston A moves right , and the magnet goes into switch B's operation range to turn on switch B.

7. Cushions

a) Rotary actuator is not adjusted so that the cushions work during shipment. Adjust the cushion valve attached to the cover depending on rotation time and load inertia moment. （See Fig 15）

b)Rotating the cushion valve reduces the orifice diameter and increases cushion effect. Counterclockwise increase orifice diameter and reduces cushion effect.

c) Tighten the cushion valve lock nut properly. Loose lock nut lead to cause the cushion valve to rotate and initially set cushion value changes. Re-adjustment is necessary in this case.

d) Cushion packing wears out during long period of operation, and cushion effect becomes weaker. Re-adjustment is necessary.

e) Don't operate the actuator with the cushion valve orifice completely closed. The piston may bumps into the stroke end, not fully travel the stroke, or the pressure exceeds the proof pressure of the cushion packing.

f) Don't start the actuator with the cushion valve orifice completely open. Since this means an actuator without a cushion, the impact is big. If the actuator operate with allowable energy in table 2 with this condition, the rotary actuator may be broken. Open the cushion valve and the speed controller gradually from closed condition.

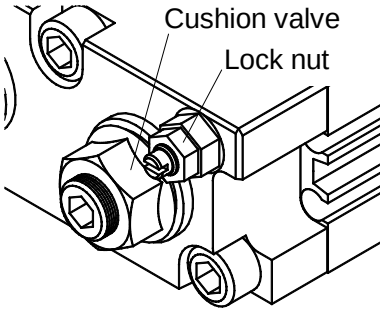


Fig.15

8. Maintenance・Inspection

Periodic inspection is necessary for optimum use. Generally, annual inspection is recommended for the rotary actuator. Even if no problem is found, seal parts replacement is recommended every three years. It is highly possible that the actuator is operated out of specification when the components like shaft, pinion, rack, bearing are broken. Please revise the operating condition. In this case, please return the broken actuator to SMC to repair.

8-1 Periodic inspection

Check followings for periodic inspection

(1) If the rotary actuator set screw become loose
(2) If the rotary actuator set frame become loose
(3) Smooth operation
(4) External leak

If problem found, tighten additionally or disassemble to repair.

8-2 Disassemble and reassemble

8-2-1 Caution on disassemble

(1) Disassemble where clean and spacious place.
(2) Cover the rotary actuator pipe inlet and the end of rubber hose after removing the rotary actuator.
(3) Mind not to damage internal sliding surface of the rotary actuator when disassembling it.
(4) Please consult with us when you have any question on disassembling and inspection.

8-2-2 Disassembling procedure

(1) Loosen cross recessed no.0 screw（size 10,15）or roundhead screw（size 20,30,40）.
(2) Pull out the bearing retainer and the shaft from the body. Remove the bearing from the housing at this time.
(3) Loosen hexagon socket head bolt to remove the cover Assŷ and the end cover Assŷ.
(4) Push piston Assŷ from one side to pull out two piston Assŷs from the body.
(5) Take out the bearing from the body.

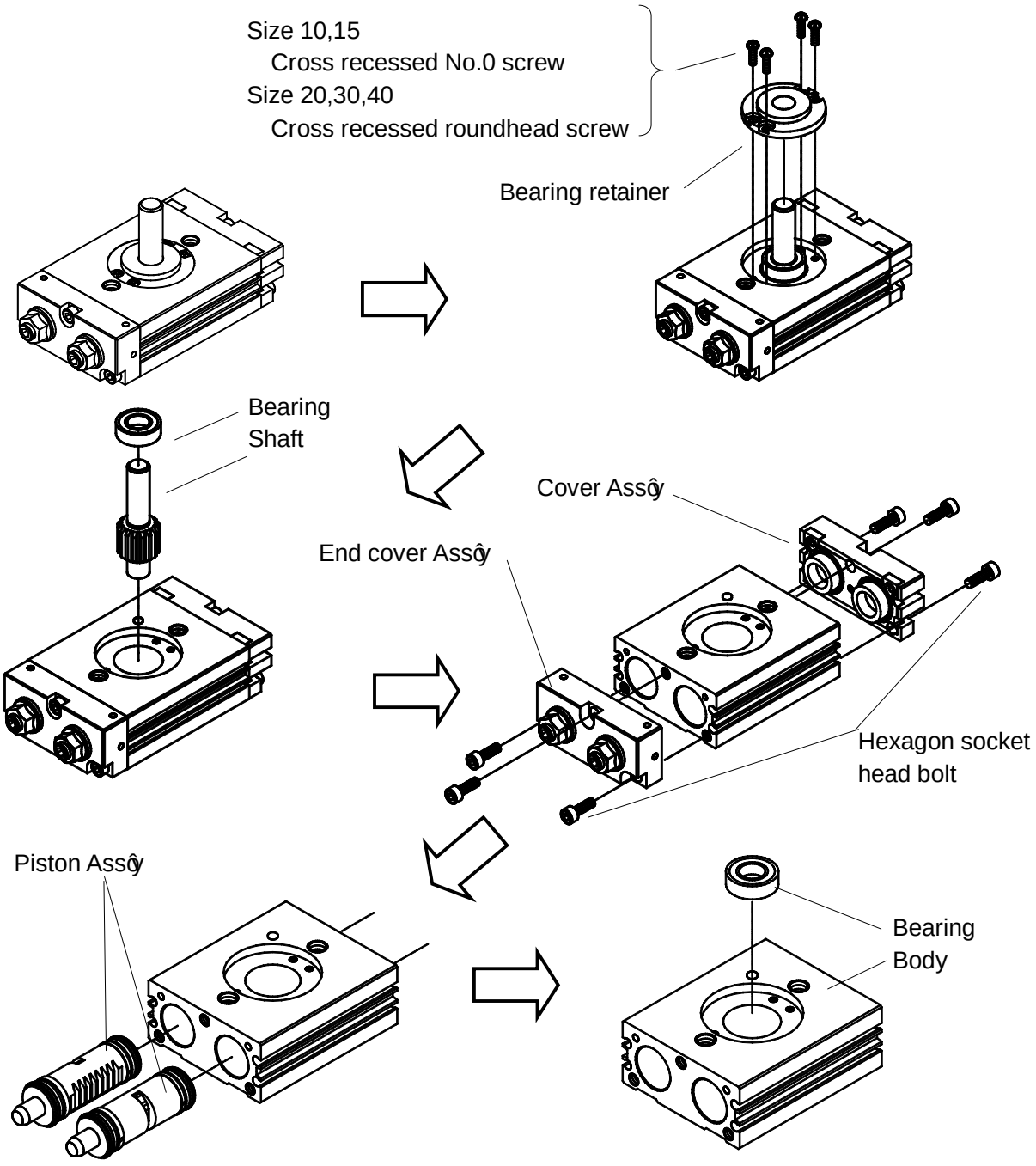


Fig.16

8-2-3 Assemble procedure

(1) Clean parts thoroughly before assembling to remove dust.

Apply grease to parts where specified in table 11 so that the surface become glossy (Not too much!). Donôt damage the packing when attaching the piston packing to the piston.

Table 11 Parts applied with grease

Grease applied parts	Grease
Cylinder internal surface	GR-S-010 (Lithium mineral oil grease No.2)
Piston packing groove	
Piston packing	
Cover gasket	
End cover gasket	
Gasket	
Cushion packing	
Pinion gear	Dow coring Molykote BR2-Plus

Piston Ass'y

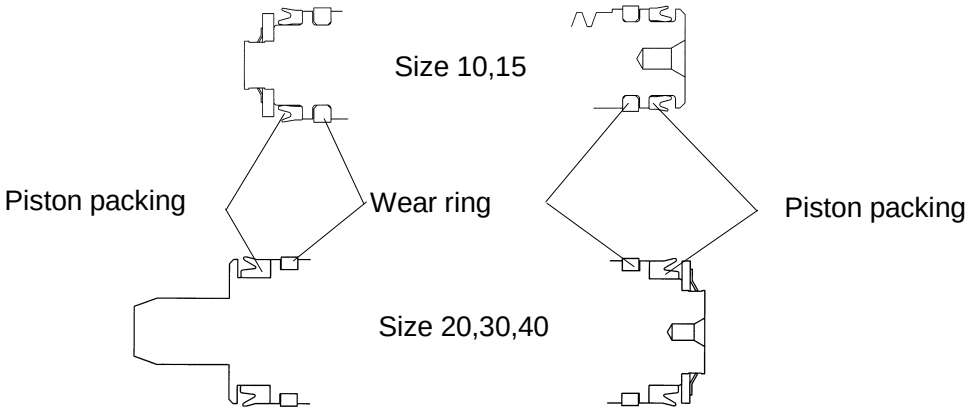


Fig.17

Cover Ass'y

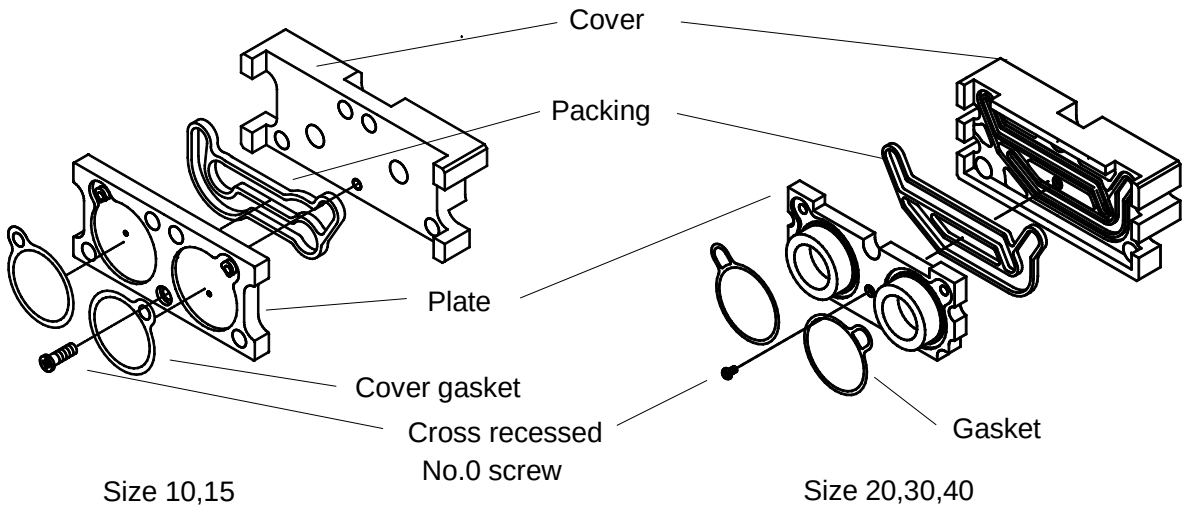


Fig.18

End cover Ass'y

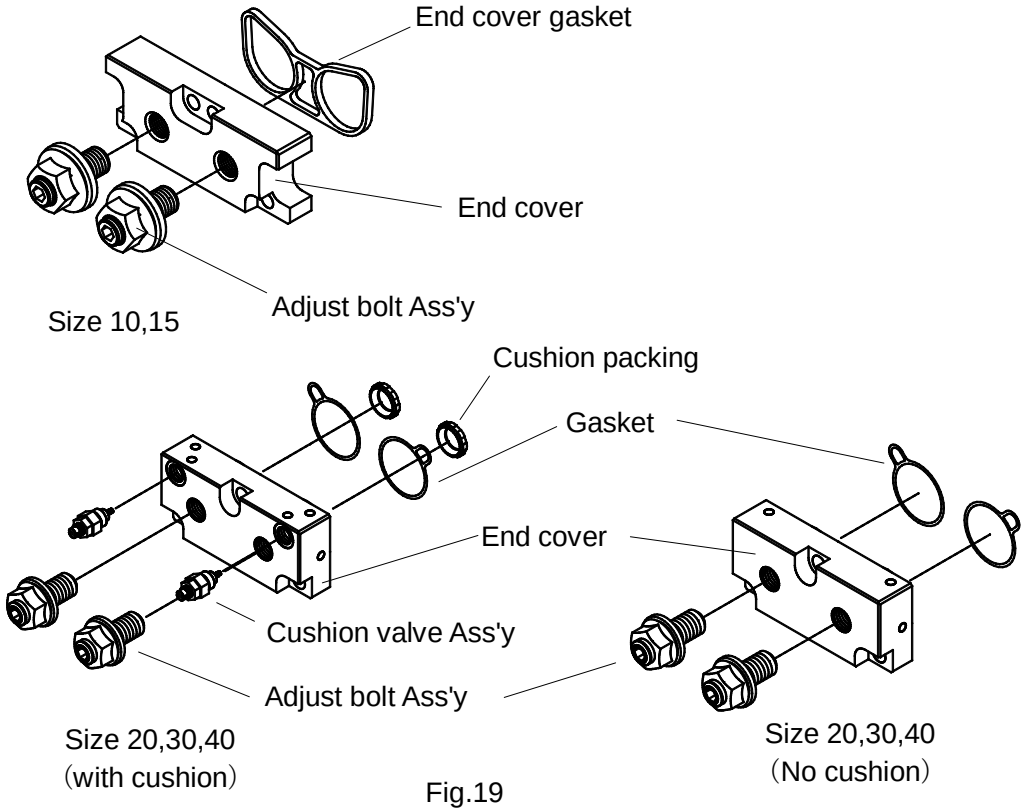


Fig.19

Insert and attach the cushion packing and the packing with the direction in the drawing below.

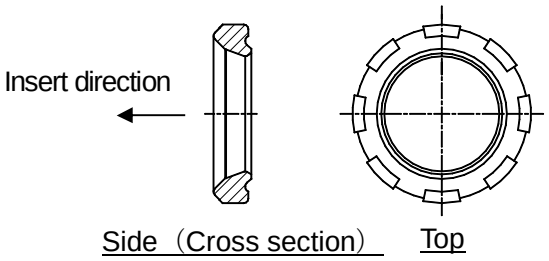


Fig.20

Adjust bolt Ass'y

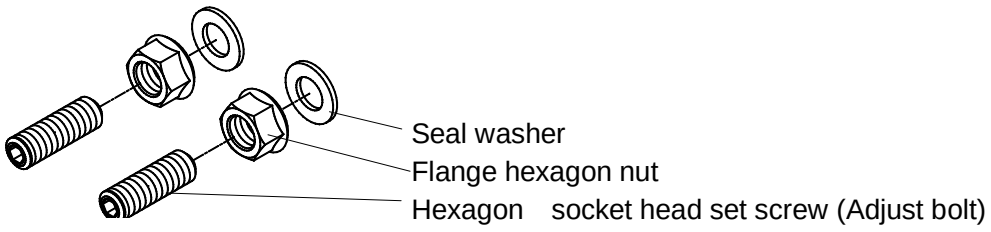


Fig.21

Shaft

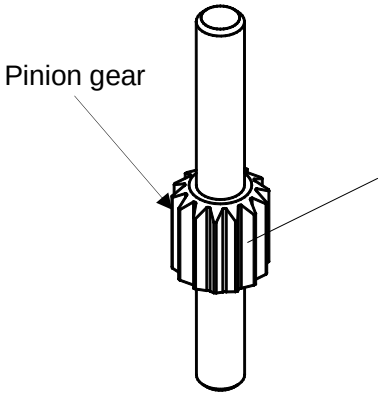


Fig.22

(2) Set the bearing to the housing of the body, and insert the piston Assŷ to the body. Since the piston packing goes through the bearing housing, insert the piston Assŷ slowly pressing the packing inside so that packing is not gouged.
Pay attention to the direction when you insert the piston.（See fig. 23）

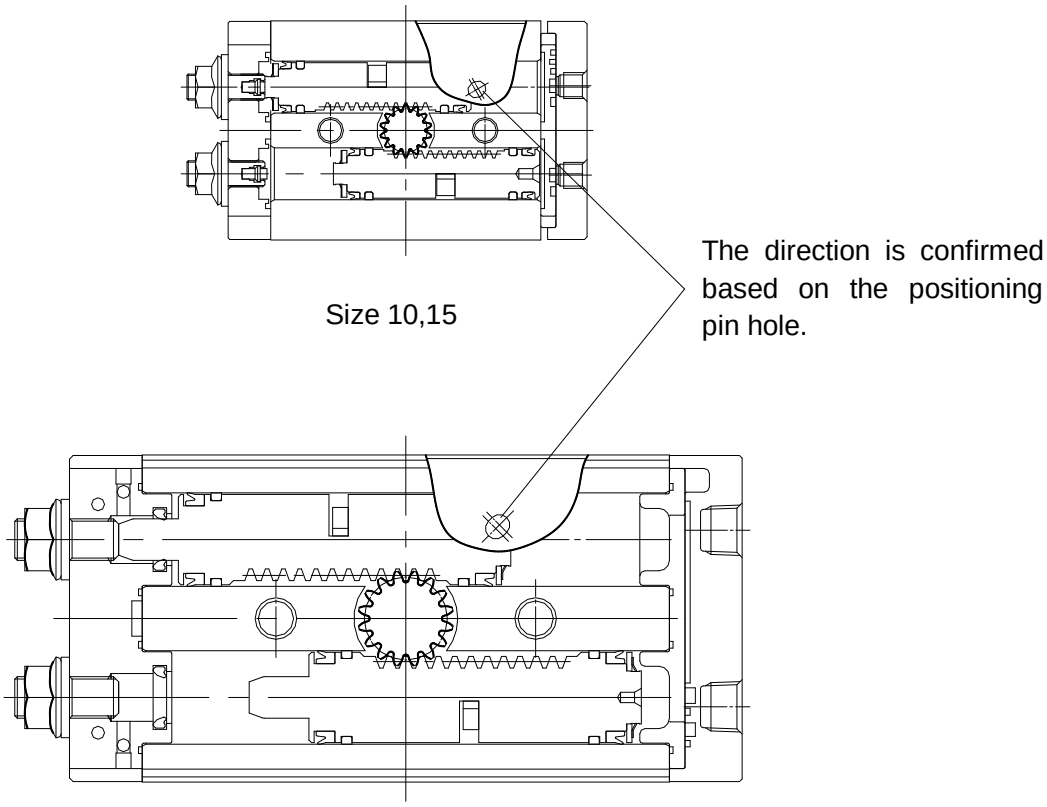


Fig.23

(3) Mount the cover and the end cover, and push the piston Assŷ and the cover until they touch the end cover as in Fig.24 Adjust the hexagon socket head set screw (adjust bolt) so that the screw does not contact with the piston Assŷ.

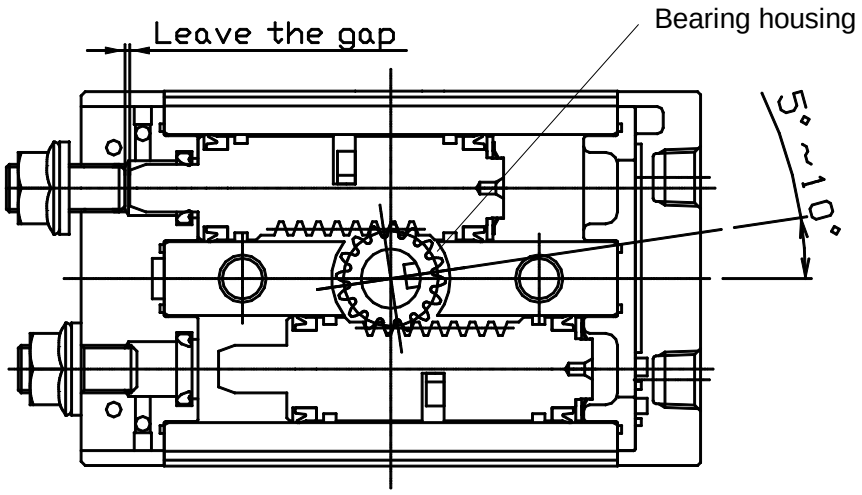


Fig.24

(4)Mount the shaft. Key groove or flat direction is the same as the cover direction, and mount the shaft so that the shaft is on the right turning upward by 5～10° to horizontal line(see above). If the key groove rotation range is inadequate or displaced, correct the piston Assŷ to the right position and assemble as specified in clause (4).

(5)Mount the bearing retainer and tighten cross recessed No.0 screw or cross recessed round head screw.

(6)Perform operation test after assembling and check external leakage.

8-3 Trouble shoot

Phenomenon	Possible cause	Remedy
Actuator not operate	Correct supply pressure is not applied	Adjust the setting of the regulator at pressure supply side
	Directional valve(solenoid valve) is not switched	Apply correct signal to directional valve(solenoid valve)
	Air leakage from the piping	Check piping to stop leakage
	Orifice clogging in the cover port	Remove the cover and clean the orifice. 1.Flush piping 2.Check the air filter
Operation is not smooth	Partial friction of the load	Reduce the friction resistance
	Actuator axis and mating axis not aligned	Use flexible fitting for the joint
	Output shortage due to inadequate supply pressure	Adjust the supply pressure so that load rate is less than 50% for stable operation
	Speed controller works too much	Each size has its actuator speed adjusting rage. Readjust the speed controller
Rotation angle changes dramatically	Internal parts damage	Replace by a new actuator, and do followings. 1. Calculate the kinetic energy applied to the actuator, and adjust the speed controller so that the rotation time is appropriate. 2. Adsorb the load kinetic energy by applying the external stopper and shock absorber. Adjust the adjust bolt so that it does not contact with the piston, and determine the rotation end by external stopper.

Phenomenon	Possible cause	Remedy
Air leaks from the shaft	Piston packing wears out	Replace with new piston packing
Pinion gear breakage	Pinion gear broken by excess kinetic energy applied to the actuator	Replace by new actuator, and do followings 1. Calculate the kinetic energy applied to the actuator, and adjust the speed controller so that the rotation time is appropriate. 2. Adsorb the load kinetic energy by applying the external stopper and shock absorber. Adjust the adjust bolt so that it does not contact with the piston, and determine the rotation end by external stopper.
	（when cushion equipped） Cushion needle adjustment is not optimum. Kinetic energy is not adsorbed by the cushion.	Replace by new actuator, and do followings. 1. Adjust the cushion needle at optimum condition 2. Confirmation if kinetic energy generated by the load is less than cushion absorbable energy
Rotation angle inadequate	The adjust bolt is set lower than necessary rotation angle	Adjust the adjust bolt to the correct position
	No allowance in actuator rotation angle. Actuator rotation angle deviated to the external stopper.	Remove the external stopper to check the all rotation range of actuator to set the external stopper to the correct place.
	（When cushion equipped） Cushion needle is closed	Adjust the cushion needle
Auto switch not turn ON/OFF	Auto switch set position is not correct	Set the auto switch at correct position

Revision history
A : Grease name change

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