



# Operation Manual

PRODUCT NAME

Rotary Actuator with Solenoid valve

MODEL / Series / Product Number

C(D)VRA 1 \* \* \* 3 0 ~ 1 0 0 - \* \* Z



**SMC Corporation**

# Contents

<b>Safety Instructions</b>	2
<b>Outline</b>	15
Specification	15
Effective torque	16
Foot bracket	17
Rotation range of Keyway and How to adjust the rotation speed	17
How to adjust the air cushion	18
<b>Internal structure and parts description</b>	19
Rotary actuator internal structure	19
<b>Basic circuit for using rotary actuator</b>	23
Circuit configuration	23
<b>Mounting</b>	24
Restriction of the load	24
Operation of shaft couplings	24
Piping and operating direction	25
Operating air	25
<b>Setting rotation time</b>	26
Moment of inertia	26
Table for calculation of Inertia moment	27
Kinetic energy	28
External stopper	29
<b>Calculation of required torque</b>	30
Load type	30
<b>Type of auto switch</b>	31
Auto switch specification	31
Auto switch set position and operating range	33
Auto switch working principle	34
<b>Maintenance and inspection</b>	35
Periodic inspection	35
Replacement part	35
Disassembling procedure and assemble procedure	36
<b>Trouble shooting</b>	40



# Rotary Actuator Safety Instructions

These safety instructions are intended to prevent hazardous situations and/or equipment damage. These instructions indicate the level of potential hazard with the labels of "Caution," "Warning" or "Danger." They are all important notes for safety and must be followed in addition to International Standards (ISO/IEC)\*1), and other safety regulations.

\*1) ISO 4414: Pneumatic fluid power -- General rules relating to systems.

ISO 4413: Hydraulic fluid power -- General rules relating to systems.

IEC 60204-1: Safety of machinery -- Electrical equipment of machines .(Part 1: General requirements)

ISO 10218-1992: Manipulating industrial robots -Safety.

etc.



## Caution

**Caution** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.



## Warning

**Warning** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.



## Danger

**Danger** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.

## Warning

### **1. The compatibility of the product is the responsibility of the person who designs the equipment or decides its specifications.**

Since the product specified here is used under various operating conditions, its compatibility with specific equipment must be decided by the person who designs the equipment or decides its specifications based on necessary analysis and test results.

The expected performance and safety assurance of the equipment will be the responsibility of the person who has determined its compatibility with the product.

This person should also continuously review all specifications of the product referring to its latest catalog information, with a view to giving due consideration to any possibility of equipment failure when configuring the equipment.

### **2. Only personnel with appropriate training should operate machinery and equipment.**

The product specified here may become unsafe if handled incorrectly.

The assembly, operation and maintenance of machines or equipment including our products must be performed by an operator who is appropriately trained and experienced.

### **3. Do not service or attempt to remove product and machinery/equipment until safety is confirmed.**

1. The inspection and maintenance of machinery/equipment should only be performed after measures to prevent falling or runaway of the driven objects have been confirmed.

2. When the product is to be removed, confirm that the safety measures as mentioned above are implemented and the power from any appropriate source is cut, and read and understand the specific product precautions of all relevant products carefully.

3. Before machinery/equipment is restarted, take measures to prevent unexpected operation and malfunction.

### **4. Contact SMC beforehand and take special consideration of safety measures if the product is to be used in any of the following conditions.**

1. Conditions and environments outside of the given specifications, or use outdoors or in a place exposed to direct sunlight.

2. Installation on equipment in conjunction with atomic energy, railways, air navigation, space, shipping, vehicles, military, medical treatment, combustion and recreation, or equipment in contact with food and beverages, emergency stop circuits, clutch and brake circuits in press applications, safety equipment or other applications unsuitable for the standard specifications described in the product catalog.

3. An application which could have negative effects on people, property, or animals requiring special safety analysis.

4. Use in an interlock circuit, which requires the provision of double interlock for possible failure by using a mechanical protective function, and periodical checks to confirm proper operation.



# Rotary Actuator Safety Instructions

## Caution

### **1. The product is provided for use in manufacturing industries.**

The product herein described is basically provided for peaceful use in manufacturing industries. If considering using the product in other industries, consult SMC beforehand and exchange specifications or a contract if necessary.  
If anything is unclear, contact your nearest sales branch.

## Limited warranty and Disclaimer/Compliance Requirements

The product used is subject to the following "Limited warranty and Disclaimer" and "Compliance Requirements".

Read and accept them before using the product.

### Limited warranty and Disclaimer

#### **1. The warranty period of the product is 1 year in service or 1.5 years after the product is delivered, whichever is first.\*2)**

Also, the product may have specified durability, running distance or replacement parts. Please consult your nearest sales branch.

#### **2. For any failure or damage reported within the warranty period which is clearly our responsibility, a replacement product or necessary parts will be provided.**

This limited warranty applies only to our product independently, and not to any other damage incurred due to the failure of the product.

#### **3. Prior to using SMC products, please read and understand the warranty terms and disclaimers noted in the specified catalog for the particular products.**

#### **\*2) Vacuum pads are excluded from this 1 year warranty.**

A vacuum pad is a consumable part, so it is warranted for a year after it is delivered.

Also, even within the warranty period, the wear of a product due to the use of the vacuum pad or failure due to the deterioration of rubber material are not covered by the limited warranty.

### Compliance Requirements

#### **1. The use of SMC products with production equipment for the manufacture of weapons of mass destruction (WMD) or any other weapon is strictly prohibited.**

#### **2. The exports of SMC products or technology from one country to another are governed by the relevant security laws and regulations of the countries involved in the transaction. Prior to the shipment of a SMC product to another country, assure that all local rules governing that export are known and followed.**

## Design

### **Warning**

- ① **If the operation involves load fluctuations, ascending/descending movements, or changes in friction resistance, make sure to provide safety measures.**  
Failure to provide such measures could accelerate the movement, which may be hazardous to humans, machinery, and other equipment.
- ② **If there is a chance that the product will pose a hazard to humans, install a protective cover.**  
If the moving portion of the product will pose a hazard to humans or will damage machinery or equipment, provide a construction that prevents direct contact with those areas.
- ③ **Make sure that the secured portions will not loosen.**  
Be sure to adopt a reliable connecting method if the rotary table is used very frequently or if it is used in a location that is exposed to a large amount of vibrations.
- ④ **Consider the possibility of a reduction in the circuit air pressure caused by a power failure.**  
When an actuator is used as clamping mechanism, there is a danger of workpiece dropping if there is a decrease in clamping force, due to a drop in circuit pressure caused by a power failure. Therefore, safety equipment should be installed to prevent damage to machinery and bodily injury.
- ⑤ **Consider the possibility of power source related malfunctions that could occur.**  
For the equipment that rely on power sources such as compressed air, electricity, or hydraulic pressure, adopt a countermeasure to prevent the equipment from causing a hazard to humans or damage to the equipment in the event of malfunction.
- ⑥ **Consider the behavior of the rotary actuator in the event of an emergency stop.**  
Devise a safe system so that if a person engages the emergency stop, or if a safety device is tripped during a system malfunction such as a power failure, the movement of the rotary actuator will not cause a hazard to humans or damage the equipment.
- ⑦ **Consider the action of the rotary actuator when restarting after an emergency stop.**  
Devise a safe design to that the restarting of the rotary actuator will not pose a hazard to humans or damage the equipment. Install manually controlled equipment for safety when the actuator has to be reset to the starting position.
- ⑧ **Do not use the product as a shock absorber.**  
If an abnormal pressure or air leakage occurs, the rotary actuator's speed reduction capability could become severely effected, which could pose a hazard to humans and damage the machinery and equipment.

## Selection

### **Warning**

- ① **Confirm the specifications**  
Rotary actuator is designed only for use in industry compressed air systems.  
Do not operate at pressures or temperatures, etc., beyond the range of specifications, as this can cause damage or malfunction. (Refer to the specifications.)  
Please contact SMC when using a fluid other than compressed air.  
We do not guarantee against any damage if the product is used outside of the specification range.
- ② **Select a speed within the product's allowable energy value.**  
If the product's kinetic energy of the load exceeds the allowable value, it could damage the product, and cause a hazard to humans and damage the machinery and equipment.

**③ Provide a shock absorber if the kinetic energy that is applied to the product exceeds the allowable value.**

If the product's kinetic energy exceeds the allowable value, it could damage the product, and cause a hazard to humans and damage the machinery and equipment.

**④ Do not stop or hold the product at midpoint by keeping air pressure in the product.**

For a product lacking an external stopping mechanism, if the directional control valve is closed to keep the air pressure in the product, in an attempt to stop the product at midpoint, it might not be possible to maintain that stopped position due to an air leakage. As a result, it could pose a hazard to humans and damage the machinery and/or equipment.

**⑤ Do not use two or more rotary actuators with the aim of synchronized movement.**

One of the actuators may bear the load of operation, making synchronized movement impossible, and possibly leading to deformation of the equipment.

**⑥ Do not use in a location where adverse effect could be occurred by the oozing of the lubricant to the exterior.**

The lubricant coating the interior of the product may leak to the outside of the product from the portion of the connection of the rotary shaft, body cover, etc.

## **Caution**

**① Do not use below the speed adjustment range specified for the product.**

If the product is used below the specified speed adjustment range, it could cause the product to stick, slip, or the movement to stop.

**② Do not apply an external torque to the product that exceeds the rated output.**

If an external force that exceeds the product's rated output is applied to the product, it could damage the product.

**③ If it is necessary to provide repeatability of the rotation angle, directly stop the load externally.**

Even with a product that is equipped with an angle adjuster, there are times in which the initial rotation angle could change.

**④ Do not use under hydraulic pressure.**

The product will be damaged if it is used by applying hydraulic pressure.

**⑤ Do not use in places where there are many temperature fluctuations. When using in lower temperature applications, use caution so that frost does not occur inside the cylinder or the piston rod.**

Operation may be unstable.

**⑥ Adjust the speed control in the environment in which it will be used in.**

Speed adjustment may be changed if the environment is different.

## **Mounting**

## **Warning**

**① Ensure sufficient space for maintenance activities.**

When installing the products, allow access for maintenance.

**② Before adjusting the angle by supplying air pressure, take appropriate measures to prevent the equipment from rotating unnecessarily.**

When an adjustment is performed under air pressure, the equipment could rotate and fall during the adjustment, depending on the mounted placement of the equipment. As a result, it could pose a hazard to humans and damage the machinery and equipment.

- ③ Do not loosen the angle adjustment screw beyond the allowable adjustment range.**  
The angle adjustment screw could fall out if it is loosened beyond its allowable adjustment range and cause a hazard to humans and damage to machinery and equipment.
- ④ Do not place a magnetic object near the product.**  
The auto switch is a magnetic sensing type. If a magnetic object is placed close to it, the rotary actuator could operate suddenly, which could pose a hazard to humans and damage the machinery and equipment.
- ⑤ Do not perform additional machining to the product.**  
Additional machining to the product can result in insufficient strength and cause damage to the product. This can lead to possible human injury and damage to the surrounding equipment.
- ⑥ Do not enlarge the fixed throttle by modifying the pipe connectors.**  
If the hole diameter is enlarged, the product's rotation speed will increase, causing the shock force to increase and damage to the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.
- ⑦ If shaft couplings are used, use those with angular freedom.**  
If shaft couplings that lack angular freedom are used, they could scrape due to eccentricity, leading to equipment malfunction and product damage. As a result, it could pose a hazard to humans and damage the machinery and equipment.
- ⑧ Place an external stopper in a position that is away from the rotating shaft.**  
If the stopper is placed near the rotating shaft, the torque that is generated by the product itself will cause the reaction force which is directed to the stopper to be redirected and applied to the rotating shaft. This will lead to the breakage of the rotating shaft and bearing. As a result, it could pose a hazard to humans and damage the machinery and equipment.
- Backlash of the Single Rack Pinion Type CRA1 Series**  
There is a backlash of within 1° at the rotation end of the CRA1 series. It is necessary to decide the position of the external stopper when precise rotation is required.
- ⑨ Do not use springs, etc., to add force in the rotational movement direction.**  
When rotational force from an external spring, etc., acts and generates negative pressure on the product's interior, breakage of the internal seal or acceleration of abrasion may occur.

## **Caution**

- ① Do not use organic solvent to wipe the area of the name plate that shows the model.**  
It will erase what is indicated on the name plate.
- ② Do not hit the rotating shaft by securing the body or hit the body by securing the rotating shaft.**  
These actions could cause the shaft to bend or damage the bearing. When a load must be coupled to the rotating shaft, secure the rotating shaft.
- ③ Do not place your foot directly on the shaft or on the equipment that is coupled to the shaft.**  
Placing one's weight directly onto the rotating shaft could cause the rotating shaft or the bearing to become damaged.
- ④ If a product is equipped with an angle adjustment function, use it within the specified adjustment range.**  
If the product is used outside the specified adjustment range, it could lead to equipment malfunction or product damage.

## Air Supply

### **Warning**

① **Use clean air.**

Do not use compressed air that contains chemicals, synthetic oils including organic solvents, salt or corrosive gases, etc., as it can cause damage or malfunction.

### **Caution**

① **When extremely dry air is used as the fluid, degradation of the lubrication properties inside the equipment may occur, resulting in reduced reliability(or reduced service life) of the equipment. Please consult with SMC.**

② **Install an air filter.**

Install an air filter upstream near the valve. Select an air filter with a filtration size of 5 µm or smaller.

③ **Take measures to ensure air quality, such as by installing an aftercooler, air dryer, or water separator.**

Compressed air that contains a large amount of drainage can cause malfunction of pneumatic equipment such as rotary actuators. Therefore, take appropriate measures to ensure air quality, such as by providing an aftercooler, air dryer, or water separator.

④ **Ensure that the fluid and ambient temperature are within the specified range.**

If the fluid temperature is 5° or less, the moisture in the circuit could freeze, causing damage to the seals and equipment malfunction. Therefore, take appropriate measures to prevent freezing.

For compressed air quality, refer to Best Pneumatics No. 5.

## Operating Environment

### **Warning**

① **Do not use in an atmosphere having corrosive gases, or where there is direct contact with this.**

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

③ **Do not use in a place subject to heavy vibration and/or shock.**

## Speed Adjustment

### **Warning**

① **To make a speed adjustment, gradually adjust starting from the low speed end.**

If the speed adjustment is performed from the high speed end, it could damage the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.



## Lubrication

### **Warning**

- ① This product should be used without lubrication. Although it will operate even if it is lubricated, it could lead to sticking or slipping.

## Maintenance and Inspection

### **Warning**

- ① During a maintenance inspection, do not disassemble the equipment with electrical power or an air supply applied.
- ② After the product has been disassembled for inspection, make sure to perform the appropriate functionality inspection.  
The product specifications cannot be met unless a functionality inspection is performed.

### **Caution**

- ① For lubrication, use the designated grease for each specific product.  
The use of a non-designated lubricant could damage the seals.

## Attention of auto switch

### 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 specification range for current load, voltage, temperature or impact.

### **Caution**

- ① **Take precautions when multiple actuators are used close together.**  
When multiple auto switch actuators are used close proximity, magnetic field interference may cause the auto switches to malfunction. Maintain a minimum actuator separation of 40mm.  
The auto switches may malfunction due to the interference from the magnetic fields.
- ② **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:

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

**③ 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) Use a contact protection box when the wire length is 5 m or longer.
- 2) Even if an auto switch has a built-in contact protection circuit, when the wiring is more than 30 m 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 consult with SMC in this case.

<Solid state switch>

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

**④ Pay attention to the internal voltage drop of the auto switch.**

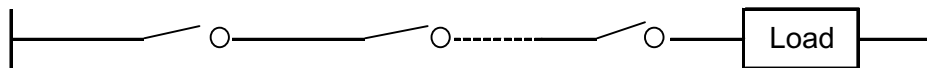
<Reed switch>

- 1) Auto switch 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 the 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.



- 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.

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

- 2) If the internal resistance of a light emitting diode causes a problem, select an auto switch without an indicator for right (MODEL D-A90 , A90V)

<Solid state switch / 2-wire type>

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

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

**⑤ Pay attention to leakage current.**

<Solid state switch / 2-wire type >

Current (leakage current) flows to the load to operate the internal circuit even when in the OFF state.

$$\text{Operating current of load (OFF condition)} > \text{Leakage current}$$

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.

**⑥ Do not use a load that generates surge voltage.**

If driving a load such as a relay that generates a surge voltage,

<Reed switch>

Use an auto switch with built-in contact protection circuit or use a contact protection box.

<Solid state switch>

Use a built-in surge absorbing element type device.

**⑦ 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.

**⑧ Ensure sufficient clearance for maintenance activities.**

When designing an application, be certain to allow sufficient clearance for maintenance.

**⑨ When multiple auto switches are required.**

"n" indicates the number of auto switches which can be physically mounted on the rotary actuators. Detection intervals depends on the auto switch mounting structure and set position, therefore some required interval and set positions may not be available.

**⑩ Use the cylinder and auto switch in proper combination.**

The auto switch is pre-adjusted to activate properly for an auto-switch-capable SMC cylinder/actuator. If the auto switch is mounted improperly, used for another brand of cylinders/actuators or used after the alternation of the machine installation, the auto switch may not activate properly.

## Mounting / Adjustment

### **Caution**

**① Do not drop or bump.**

Do not drop, bump or apply excessive impacts ( $300\text{m/s}^2$  or more for reed auto switches and  $1000\text{m/s}^2$  or more for solid state auto switches) while handling.

Although the body of the auto switch may not be damaged, the inside of the auto switch could be damaged and cause malfunction.

**② Do not carry a cylinder by the auto switch lead wires.**

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

**③ Observe the proper tightening torque for mounting an auto switch.**

When an auto switch is tightened beyond the range of tightening torque, auto switch mounting screws, auto switch mounting brackets or auto switch may be damaged.

On the other hand, tightening below the range of tightening torque may allow the auto 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 position shown in a catalog indicates the optimum, position at stroke end.) If mounted at the end of the operating range (around the borderline of ON and OFF), operation will be unstable.

## Wiring

### **Caution**

**① Avoid repeatedly bending or stretching lead wires.**

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

**② Be certain 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 auto switch will be instantly damaged because of excess current (short circuit).

**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.

## ⑤ Do not allow short-circuit of loads.

<Reed switch>

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

<Solid state switch>

All models of PNP output type auto switches do not have built-in short circuit protection circuits. If a load is short circuited, the auto switch will be instantly damaged as in the case of reed auto switches.

Take special care to avoid reverse wiring with the brown power supply line and the black output line on 3-wire type auto switches.

## ⑥ Avoid incorrect wiring.

<Reed switch>

A 24 VDC auto switch with indicator light has polarity. The brown lead wire or terminal No.1 is (+), and the blue lead wire or terminal No.2 is (—).

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

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

Applicable model : D-A93V

<Solid state switch>

- 1) If connections are reversed on a 2 wire type auto switch, the auto switch will not be damaged if protected by a protection circuit, but the auto switch will always stay in an ON state. However, it is still necessary to avoid reversed connections, since the auto 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 auto switch, the auto switch will be protected by a protection circuit. However, if the power supply line (+) is connected to the blue wire and the power supply line (—) is connected to the black wire, the auto switch will be damaged.

## 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 cylinders/actuators will become demagnetized. (Please consult with SMC if a magnetic field resistant auto switch can be used.)

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

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

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

Please consult with 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.

Please consult with SMC if auto switches are used where there are temperature cycles other than normal temperature changes, as there may be adverse effects inside the auto switches.

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

<Reed switch>

When excessive impact ( $300 \text{ m/s}^2$  or more) is applied to a reed auto switch during operation, the contact point will malfunction and generate or cut off a signal momentarily (1 ms or less). Please consult with SMC if a solid state auto switch can be used according to the environment.

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

<Solid state switch>

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

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

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

**Maintenance and Inspection**

 **Caution**

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

1) Secure and tighten auto 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 auto switches or repair lead wires, etc., if damage is discovered.

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

# Attention of Solenoid Valves

## Design / Selection

### **Warning**

#### ① **Intermediate stops**

For 3-position closed center valve type it is difficult to make a piston stop at the required position accurately due to the compressibility of air.

Furthermore, since valves and cylinders are not guaranteed for zero air leakage, it may not be possible to hold a stopped position for an extended period of time.

### **Caution**

#### ① **Momentary energization**

If a double solenoid valve is operated with momentary energization, it should be energized for at least 0.1 second. However, depending on the condition of the secondary load, it should be energized until the cylinder reaches the stroke end position, since there is a possibility of malfunction.

#### ② **Surge voltage suppressor**

If a surge protection circuit contains nonstandard diodes, such as Zener diodes or ZNR, a residual voltage that is in proportion to the protective circuit and the rated voltage will remain. Therefore, take into consideration the surge voltage protection of the controller.

In the case of diodes, the residual voltage is approximately 1V.

## Mounting

### **Warning**

#### ① **If air leakage increases or equipment does not operate properly, stop operation.**

Check mounting conditions when air and power supplies are connected. Initial function and leakage tests should be performed after installation.

## Piping / Wiring

### **Caution**

#### ① **Connection of fittings**

The connection of fittings to connected port Rc1/4 for the supply, tighten at 12 to 14N.m torque.

#### ② **Polarity**

When connecting power to a solenoid valve with a DC specification and equipped with a light or surge voltage suppressor, check for polarity.

If there is polarity, take note of the following.

##### **No diode to protect polarity:**

If a mistake is made regarding the polarity, damage may occur to the diode in the valve, the switching element in a control device or power supply equipment, etc.

##### **With diode to protect polarity:**

If polarity connection is wrong, the valve does not operate.

#### ③ **Applied voltage**

When electric power is connected to a solenoid valve, be careful to apply the proper voltage. Improper voltage may cause malfunction or coil damage.

## Operating Environment

### **Warning**

- ① Do not use in an atmosphere having corrosive gases, chemicals, sea water, water, water steam, or where there is direct contact with any of these.
- ② Do not use in a place in the explosive atmosphere.
- ③ Do not use in a place subject to heavy vibration and/or shock.
- ④ The valve should not be exposed to prolonged sunlight. Use a protective cover.
- ⑤ Remove any sources of excessive heat.
- ⑥ If it is used in an environment where there is possible contact with oil, weld spatter, etc., exercise preventive measures.

## Maintenance and Inspection

### **Warning**

- ① **Removal of equipment, and supply/exhaust of compressed air**  
When components are removed, first confirm that measures are in place to prevent workpieces from dropping, run-away equipment, etc. Then, cut off the supply pressure and electric power, and exhaust all compressed air from the system using the residual pressure release function.  
For 3-position closed center valve type, exhaust the residual pressure between the valve and the cylinder.  
When the equipment is operated after remounting or replacement, first confirm that measures are in place to prevent lurching of actuators, etc. Then, confirm that the equipment is operating normally.
- ② **Low frequency operation**  
Valves should be operated at least once every 30 days to prevent malfunction. (Use caution regarding the air supply.)
- ③ **Manual override**  
When the manual override is operated, connected equipment will be actuated.  
Operate after safety is confirmed.

## Outline

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

### Specification

Table (1) Specification

Size	50	63	80	100
Fluid	Air(Non-lube)			
Max. operating pressure	1.0 MPa			
Min. operating pressure	0.15 MPa			
Ambient and fluid temperature	0 to 50°C (No freezing)			
Backlash	Within 1°			
Tolerance in rotating angle	0~+4°			
Cushion	Not attached, Air cushion			
Mounting style	Basic style, Foot style			

Table(2) Solenoid Valve Specification

5 Port Pilot Operated Solenoid Valve(Rubber Seal) VF3000				
Electrical entry		Grommet(G),(H) L-type plug connector (L) M-type plug connector (M)	DIN terminal (D) DIN(EN175301-803) terminal(Y) Conduit terminal(T)	
Coil rated voltage V	AC(50/60Hz)	24,100,110,200,220,240		
	DC	24,12		
Allowable voltage change		-10 to +10% of the rated voltage		
Apparent power VA	AC	24V	1.5(With light:1.55)	1.5(With light:1.75)
		100V	1.55(With light:1.65)	1.55(With light:1.7)
		110V [115V]		
		200V		
		220V [230V]		
240V				
Power consumption W	DC	Standard	1.5(With light:1.55)	1.5(With light:1.75)

※It is in common between 110VAC and 115VAC, and between 220VAC and 230VAC.

※Allowable voltage fluctuation is -15% to +5% of the rated voltage for 115VAC or 230VAC.

※Since voltage drops due to the internal circuit in S,Z types, the allowable voltage fluctuation should be within the following range.

24VDC : -7% to +10%    12VDC : -4% to +10%



Table (3) Allowable kinetic energy and safe range of rotation time

Size	Allowable kinetic energy(J)		Adjustable range of rotation time safe in operation (s/90°)
	Without Air cushion	With Air cushion	
50	0.05	0.98	Cushion angle 35°
63	0.12	1.50	
80	0.16	2.00	
100	0.54	2.90	

■ Mass

Mass of product=Table (4)Standard Mass + Table(5)Mass of the solenoid valves + Table(6)Additional mass

Table (4) Standard Mass (Kg)

Size	Standard Type	
	90°	180°
50	1.3	1.5
63	2.2	2.6
80	3.9	4.4
100	7.3	8.3

Table(5) Mass of the solenoid valves (Solenoid valve unit + accessory parts.) (Kg)

Size	Type of actuation				
	single solenoid	single solenoid	closed center	exhaust center	pressure center
50 to 100	0.4	0.5	0.6	0.6	0.6

Table (6) Additional mass (kg)

Size	Additional mass	
	With auto switches( 2 pcs)	Foot bracket
50	0.2	0.3
63	0.4	0.5
80	0.6	0.9
100	0.9	1.2

■ Effective torque

Table (7) Effective torque table (N·m)

Size	Operating pressure (MPa)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
50	1.85	3.71	5.57	7.43	9.27	11.2	13.0	14.9	16.7	18.5
63	3.44	6.88	10.4	13.8	17.2	20.6	24.0	27.5	31.0	34.4
80	6.34	12.7	19.0	25.3	31.7	38.0	44.4	50.7	57.0	63.4
100	14.9	29.7	44.6	59.4	74.3	89.1	104	119	133	149

■ Foot bracket

Table (8) Foot bracket part no.

Size	Foot bracket	Description	Mounting screws included in foot bracket
50	CRA1L50 -Y-1Z	Foot bracket : 2pcs. Mounting thread : 4pcs. Collar : 4pcs.	M8 x1.25x35
63	CRA1L63 -Y-1Z		M10x 1.5x40
80	CRA1L80 -Y-1Z		M12x1.75x50
100	CRA1L100-Y-1Z		M12x1.75x50

After the foot bracket removed the mounting screws of the basic style, mount to the cover with the mounting screws included in foot bracket. Secure the collar with the foot bracket as a spacer of cover spot facing parts.

■ Rotation Range of Keyway and How to adjust the Rotation Speed

**Rotation direction**

When current is applied to SOL1, the shaft rotates clockwise.

**How to adjust the rotation speed:**

Turn the needle valve of the throttle valve clockwise to reduce the exhaust flow volume, thus slowing the rotation speed.

Throttle valve A regulates the clockwise rotation speed of the shaft and throttle valve B regulates the counterclockwise speed to the shaft.

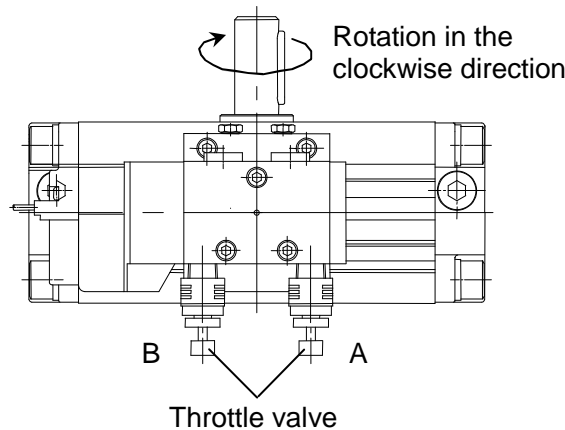


Fig. (1) Rotation direction and How to adjust the rotation speed

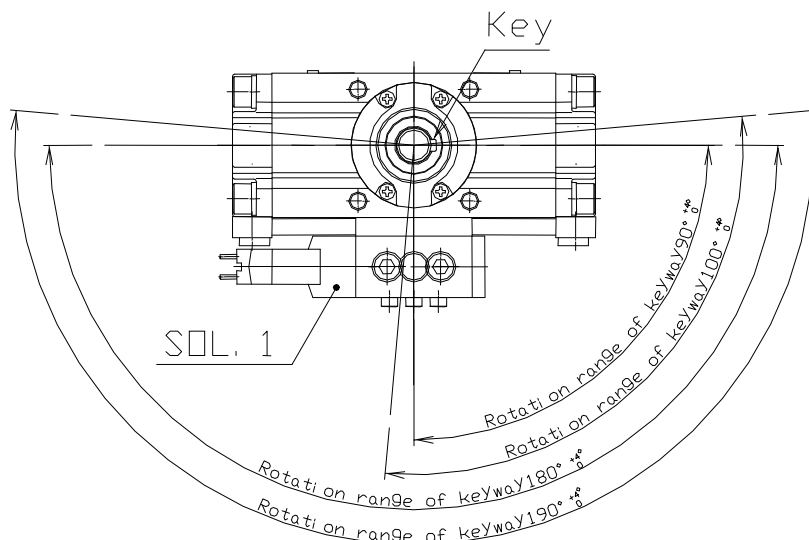


Fig. (2) Rotation Range of shaft Keyway

## How to adjust the air cushion

### How to adjustment

When with air cushion type used, an adjustment must be made in accordance with the operating speed and the moment of inertia of the load.

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

Open the cushion valve gradually from closed condition.

### Caution

- a) 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.
- b) The cushion needle itself is provided with a pull stop. Do not apply an excessive force to loosen the cushion valve.

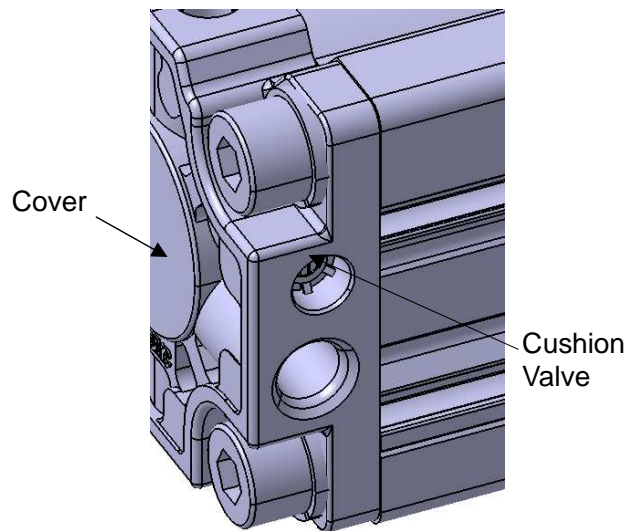
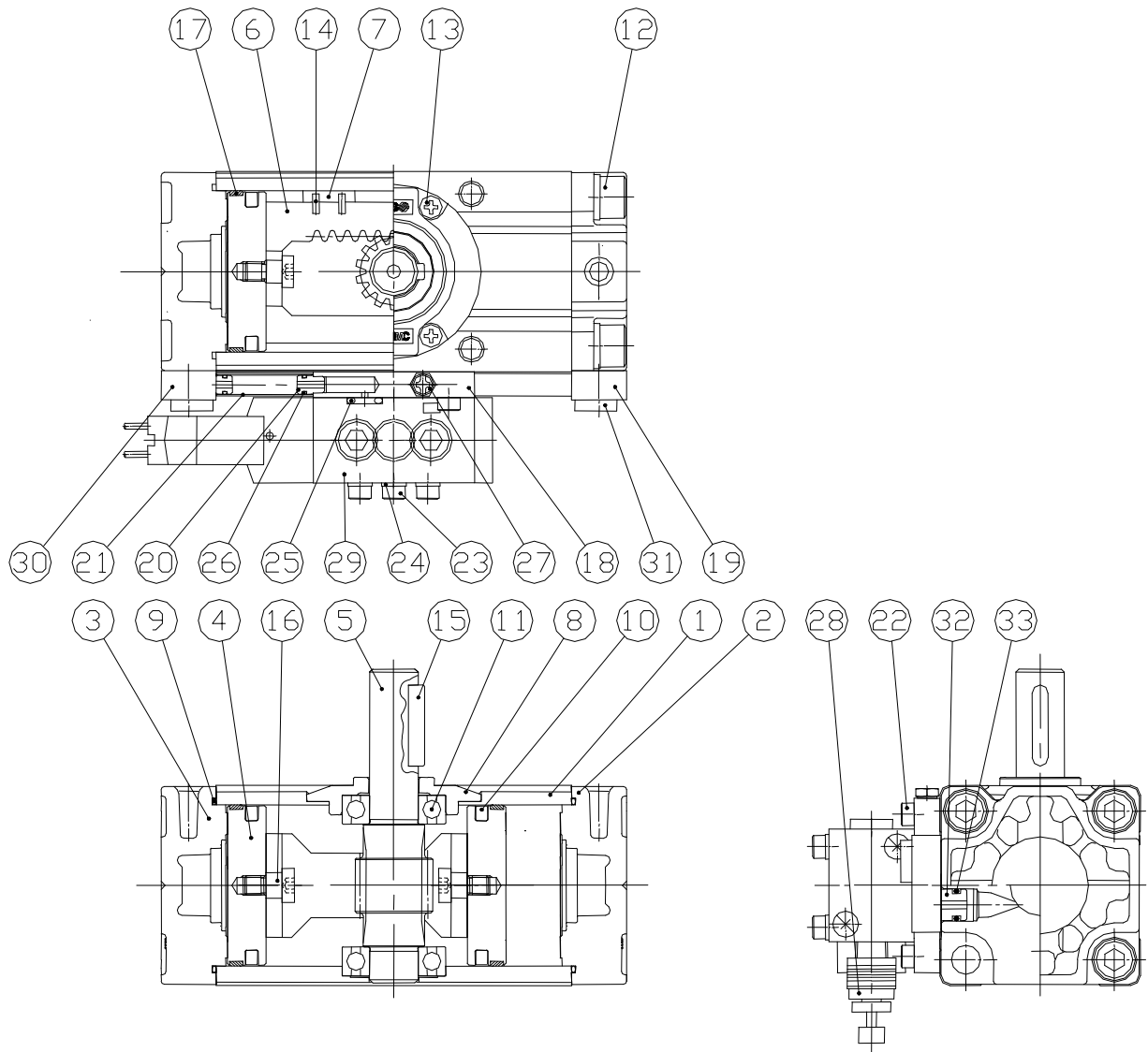


Fig. (3) How to Adjust the Air cushion

# Internal structure and parts description

Rotary actuator with Solenoid Valve internal structure

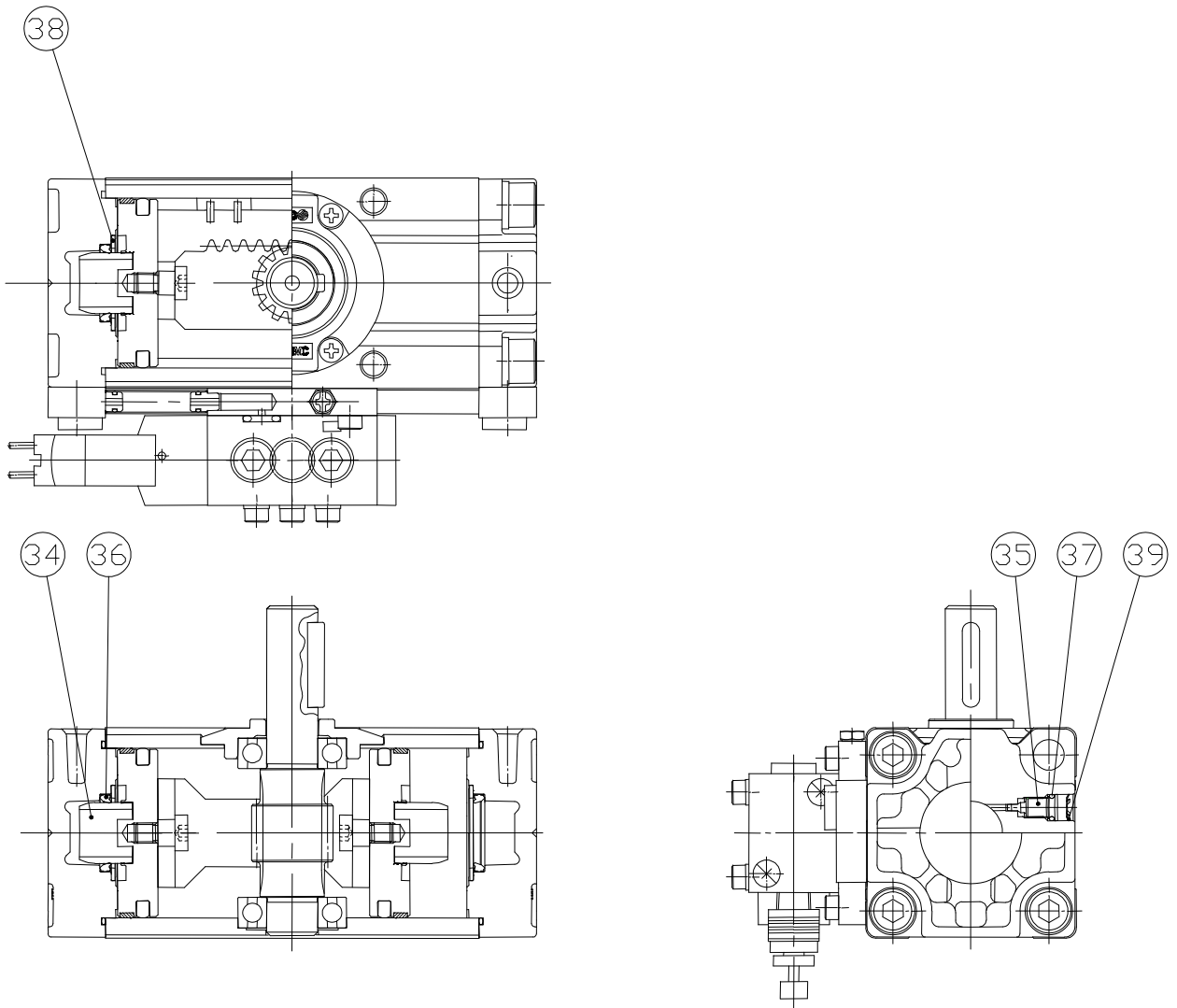
Without air cushion



## Component parts

No.	Description	Material	Note
1	Body	Aluminum alloy	Anodized
2	Right cover	Aluminum alloy	Metallic painting
3	Left cover	Aluminum alloy	Metallic painting
4	Piston	Aluminum alloy	
5	Shaft	Alloy steel	
6	Rack	Carbon steel	Nitriding
7	Slider	Resin	
8	Bearing retainer	Aluminum alloy	Chromated
9	Tube gasket	NBR	
10	Piston seal	NBR	
11	Bearing	High carbon chromium bearing steel	
12	Hexagon socket head cap screw with spring washer	Alloy steel	Zinc Chromated
13	Round head tapping screw	Steel	Zinc Chromated
14	Spring pin	Steel	Zinc Chromated
15	Parallel key	Carbon steel	
16	Connecting screw	Carbon steel	Zinc Chromated
17	Wear ring	Resin	
18	Sub-plate	Aluminum alloy	Chromated
19	Sub-plate(Right cover side)	Aluminum alloy	Chromated
20	Fitting	Aluminum alloy	Chromated
21	Pipe	Stainless steel	
22	Hexagon socket head cap screw	Alloy steel	Zinc Chromated
23	Hexagon socket head cap screw	Alloy steel	Zinc Chromated
24	Spring washer	Alloy steel	Zinc Chromated
25	O-ring	NBR	
26	O-ring	NBR	
27	M5-plug	-	
28	Metering Valve with Silencer	-	
29	Solenoid valve	-	
30	Sub-plate(Left cover side)	Aluminum alloy	Chromated
31	Hexagon socket head cap screw	Alloy steel	Zinc Chromated
32	Fitting(Cover side)	Aluminum alloy	Chromated
33	O-ring	NBR	

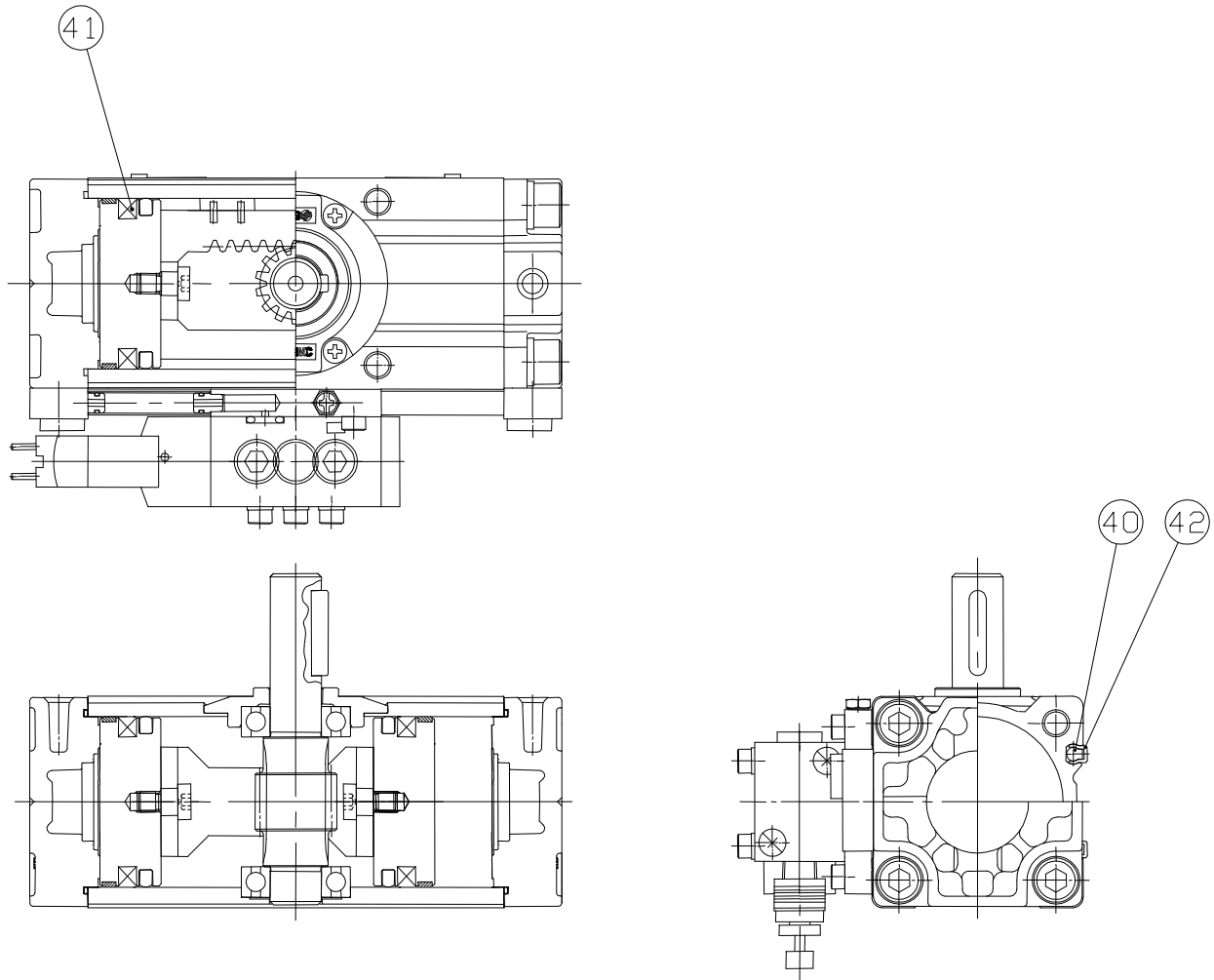
With air cushion



Component parts

No.	Description	Material	Note
34	Cushion ring	Aluminum alloy	Anodized
35	Cushion valve	Steel	Zinc chromated
36	Cushion seal	Urethane	
37	O-ring	NBR	
38	Seal retainer	Steel	
39	Retaining ring	Steel	

With auto switch



Component parts

No.	Description	Material	Note
40	Auto switch	-	
41	Magnet	-	
42	Switch spacer	Resin	

## Basic circuit for using rotary actuator

### Circuit configuration

The basic circuit for operating the rotary actuator using an air filter, regulator, solenoid valve, and speed controller is shown in Fig. (4).

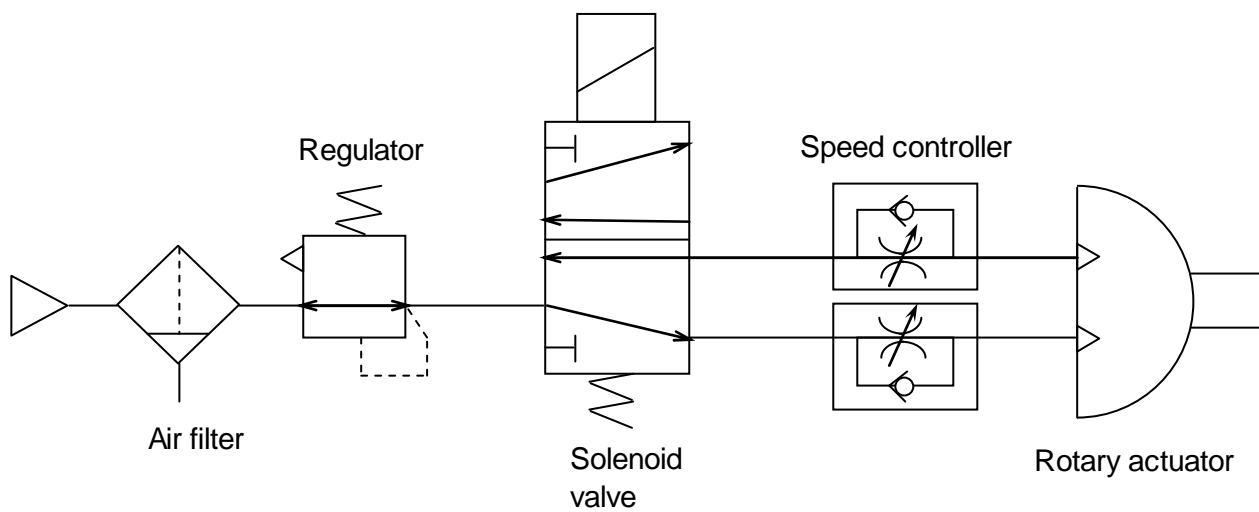


Fig. (4) Basic circuit



# Mounting

## Restriction of the load

Provided that a dynamic load is not generated, a load in the axial direction can be applied up to the value that is indicated in the table (9) below. However, applications in which the load is applied directly to the shaft should be avoided as much as possible.

Table (9) Allowable shaft load (N)

Size	Load direction		
	Fsa	Fsb	Fr*
50	490	196	196
63	588	196	294
80	882	196	392
100	980	196	588

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

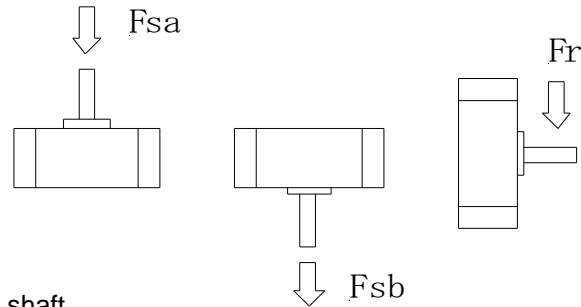


Fig. (5) Load direction

The methods such as those described below are recommended to prevent the load from being applied directly to the shaft in order to ensure a proper operating condition.

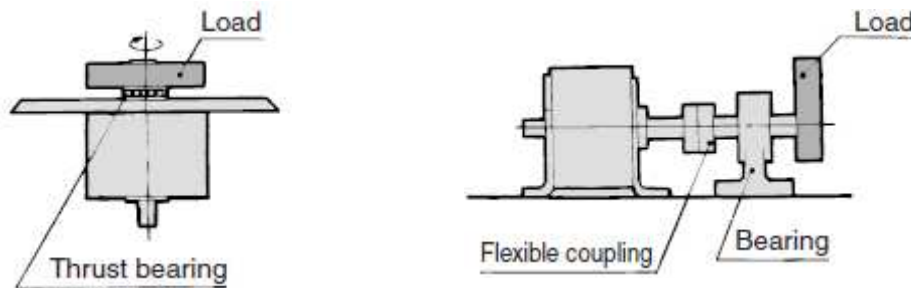


Fig. (6) Bearing

## Operation of shaft couplings

As in Fig. (7), alignment of the rotary actuator and the mating axis is necessary when the rotary actuator is used with its axis lengthened. If misaligned, 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.

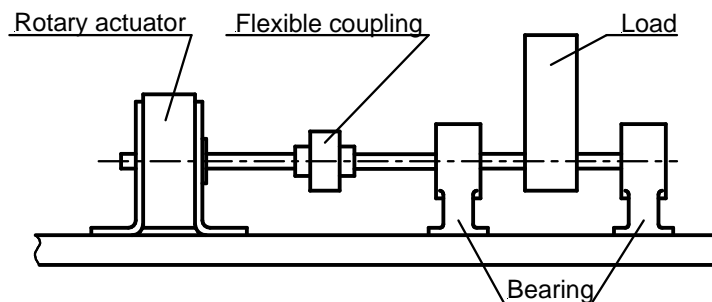


Fig. (7) Flexible coupling

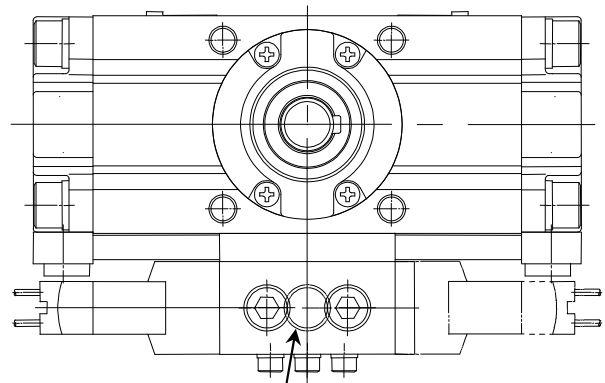
**Piping and operating direction**

Fig. (8) shows piping ports of the rotary actuator.

Table (10) shows the port size.

Table (10) Port size

Size	Port size
50 to 100	Rc1/4



Piping port(Opposite side)

Fig. (8) Port location

Perform followings before piping.

- Before piping is connected, it should be thoroughly blown out with air (flushing) or washed to remove chips, cutting oil and other debris from inside the pipe.
- When screwing piping or fittings into ports, ensure that chips from the pipe threads or sealing material do not enter the piping. Also, if pipe tape is used, as in Fig. (9), leave 1.5 to 2 thread ridges exposed at the end of the threads.

**Operating air**

Air supplied to the rotary actuator shall be cleaned by the filter. CRA1 series is lubrication free.

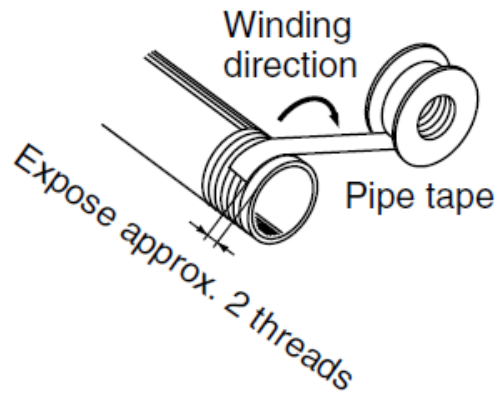


Fig. (9) Wrapping of pipe tape

## Setting rotation time

Even if the torque that is generated by the rotary actuator is small, the parts could become damaged depending on the inertia of the load. Therefore, the rotation time should be determined by calculating the load's inertial moment and kinetic energy.

### Moment of inertia

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<sup>2</sup>  
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)

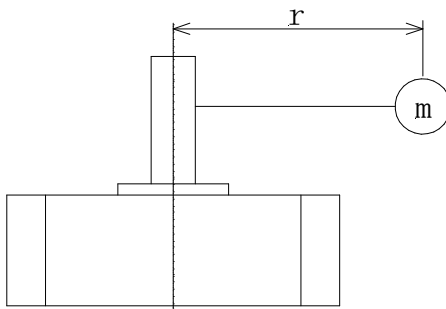
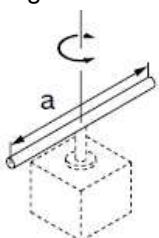
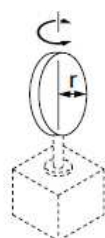
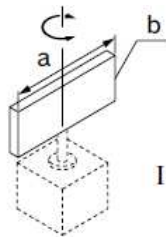
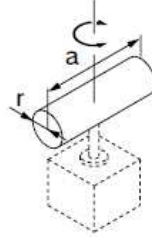
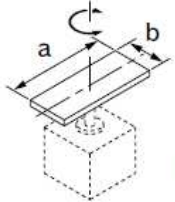
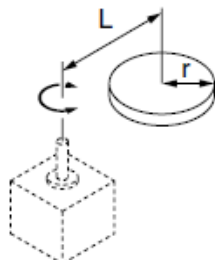
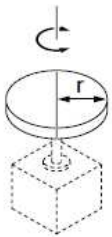
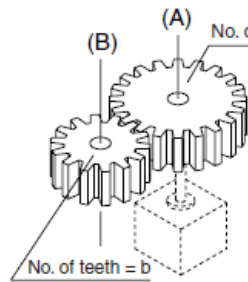
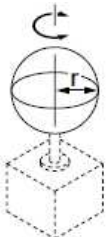


Fig. (10) Inertia moment

This shows inertia moment of “m (weight)” at “r” from 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.

Equation table of moment of inertia

$I$  : Moment of inertia  $\text{kg} \cdot \text{m}^2$      $m$  : Load mass  $\text{kg}$

<p>① Thin shaft Position of rotational axis: Perpendicular to the shaft through the center of gravity.</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑥ Thin round plate Position of rotational axis: Through the center of diameter</p>  $I = m \cdot \frac{r^2}{4}$
<p>② Thin rectangular plate Position of rotational axis: Parallel to side b and through the center of gravity</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑦ Cylinder Position of rotational axis: Through the center of diameter and gravity</p>  $I = m \cdot \frac{3r^2 + a^2}{12}$
<p>③ Thin rectangular plate(Including Rectangular parallelepiped) Position of rotational axis: Perpendicular to the plate through the center of gravity</p>  $I = m \cdot \frac{a^2 + b^2}{12}$	<p>⑧ When the rotational axis and load center of gravity and not consistent</p>  $I = K + m \cdot L^2$ <p><math>K</math>: Moment of inertia around the load center of gravity</p> <p>4. Round plate    <math>K = m \cdot \frac{r^2}{2}</math></p>
<p>④ Round plate(Including column) Position of rotational axis: Through the center axis</p>  $I = m \cdot \frac{r^2}{2}$	<p>⑨ Gear transmission</p>  <ol style="list-style-type: none"> <li>Find the moment of inertia <math>I_B</math> for the rotation of shaft (B).</li> <li><math>I_B</math> is converted to the moment of inertia <math>I_A</math> for the rotation of the shaft (A).</li> </ol> $I_A = \left(\frac{a}{b}\right)^2 \cdot I_B$
<p>⑤ Solid sphere Position of rotational axis: Through the center of diameter</p>  $I = m \cdot \frac{2r^2}{5}$	

## Kinetic energy

Table (11) shows the allowable kinetic energy of the rotary actuator.

The end angular speed  $\omega$  is obtained by:

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

$\theta$  : Rotation angle      rad  
                                     (90°: 1/2  $\pi$  rad)  
                                     (180°:  $\pi$  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:

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

Table (11) Allowable kinetic energy

Size	Allowable kinetic energy (J)	
	Without Air Cushion	With Air Cushion*
30	0.01	—
50	0.05	0.98
63	0.12	1.50
80	0.16	2.00
100	0.54	2.90

\* The allowable kinetic energy of the actuators with a cushion is the maximum absorbed energy when the cushion needle is properly adjusted.

E : Allowable kinetic energy      J

$\theta$  : Rotation angle                      rad

I : Inertia moment                      kg· m<sup>2</sup>

Please refer to Table (3) for the Swing time adjustable range of each size.

For equiangular acceleration, the angular velocity,  $\omega$ , after t seconds are obtained using the following equations.

$$\omega = \dot{\omega} \times t \text{ ----- (1)}$$

$$\theta = \int \dot{\omega} t \, dt = \frac{1}{2} \dot{\omega} t^2 + C \text{ ----- (2)      C : Integration constant}$$

Because the displacement angle in t=0 becomes  $\theta=0$ , it becomes C=0.

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

Hence

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

## External stopper

When the kinetic energy where the load is generated exceeds a permissible kinetic energy of the actuator, it is necessary to install the shock-absorbing mechanism outside and to absorb inertia force.

There is backlash of the gear because the CRA1 series is a single rack type. (It is within  $1^\circ$  at the rotation end.) When there is no backlash, and an accurate positional precision is necessary, an external stopper is needed.

Please use the product of  $100^\circ$  in swing angle and  $190^\circ$  respectively when  $90^\circ$  in swing angle and  $180^\circ$  are set up in an external stopper and used.

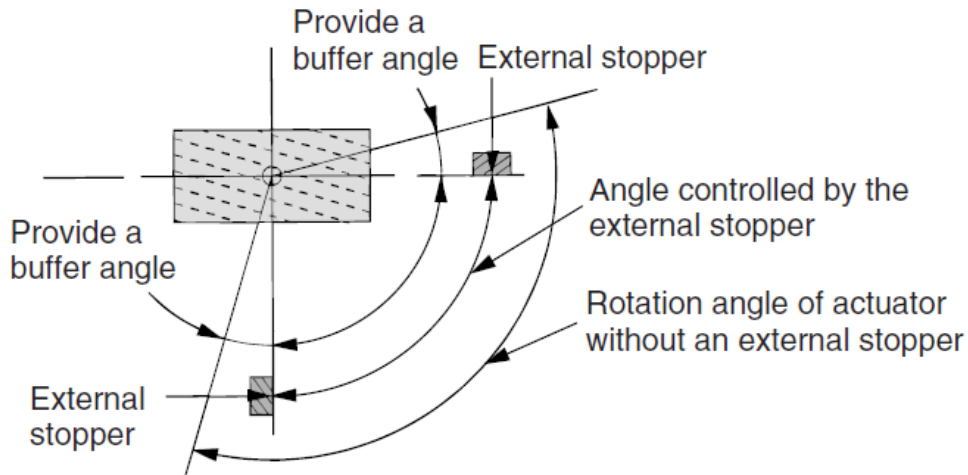
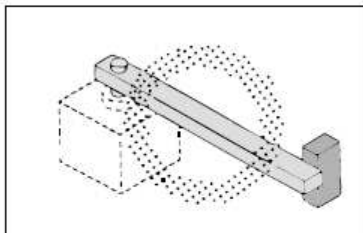
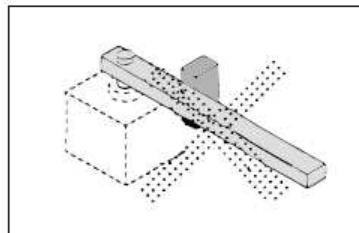


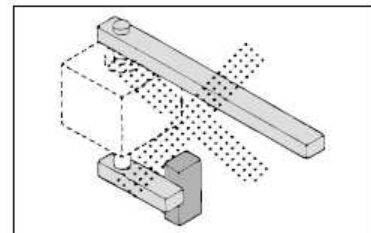
Fig. (11) External stopper



Install the stopper at a sufficient distance from the rotating shaft.



The external stopper becomes a fulcrum, resulting in the load's inertia force being applied to the shaft as a bending moment.

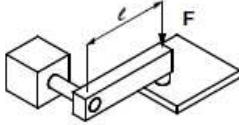
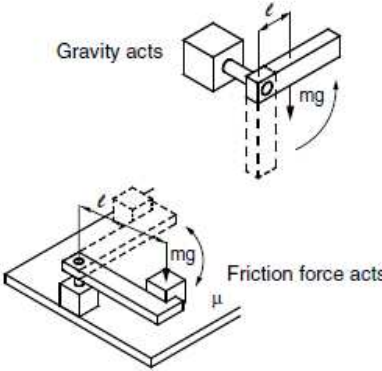
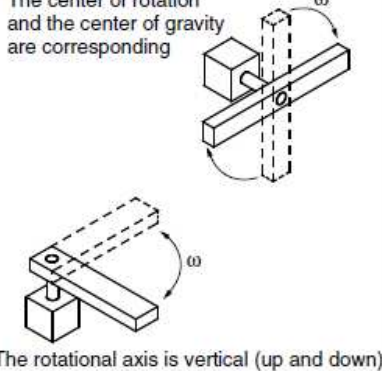


If an external stopper is installed on the shaft side which is opposite of the load, the inertia force generated by the load is applied directly to the shaft.

# Calculation of required torque

## Load type

The calculation method of required torque varies depending on the load type.

Load type		
Static load: $T_s$	Resistance load: $T_f$	Inertial load: $T_a$
When the pressing force is necessary (clamp, etc.)	When friction force or gravity is applied to the rotation direction	When the load with inertia is rotated
		
<p><b><math>T_s = F \cdot l</math></b></p> <p><math>T_s</math>: Static load (N·m)  <math>F</math>: Clamp force (N)  <math>l</math>: Distance from the center of rotation to clamp (m)</p>	<p>When gravity acts to the rotation direction  <b><math>T_f = m \cdot g \cdot l</math></b></p> <p>When friction force acts to the rotation direction  <b><math>T_f = \mu \cdot m \cdot g \cdot l</math></b></p> <p><math>T_f</math>: Resistance load (N·m)  <math>m</math>: Mass of load (kg)  <math>g</math>: Gravitational acceleration 9.8 (m/s<sup>2</sup>)  <math>l</math>: Distance from the center of rotation to the gravity or friction force acting point (m)  <math>\mu</math>: Coefficient of friction</p>	<p><b><math>T_a = I \cdot \ddot{\omega} = I \cdot \frac{2\theta}{t^2}</math></b></p> <p><math>T_a</math>: Inertial load (N·m)  <math>I</math>: Moment of inertia (kg·m<sup>2</sup>)  <math>\ddot{\omega}</math>: Angular acceleration (rad/s<sup>2</sup>)  <math>\theta</math>: Rotating angle (rad)  <math>t</math>: Rotation time (s)</p>
Required torque <b><math>T = T_s</math></b>	Required torque <b><math>T = T_f \times (3 \text{ to } 5)</math></b> <small>Note 1)</small>	Required torque <b><math>T = T_a \times 10</math></b> <small>Note 1)</small>
<p>• Resistance loads → Gravity or friction applies in the rotation direction.            Example 1) The axis of rotation is in a horizontal (lateral) direction, and the center of rotation and center of gravity of the load are not the same.            Example 2) The load slips against the floor while rotating.            *The necessary torque equals the total of the resistance load and inertial load.  <b><math>T = T_f \times (3 \text{ to } 5) + T_a \times 10</math></b></p> <p>• Non-resistance loads → Gravity or friction does not apply in the rotation direction.            Example 1) The axis of rotation is in a perpendicular (vertical) direction.            Example 2) The axis of rotation is in a horizontal (lateral) direction, and the center of rotation and center of gravity of the load are the same.            *The necessary torque equals the inertial load only.  <b><math>T = T_a \times 10</math></b></p> <p style="text-align: right;"><small>Note 1) In order to adjust the velocity, it is necessary to have a margin of adjustment for <math>T_f</math> and <math>T_a</math>.</small></p>		

## Auto switch type for rotary actuator

The rotary actuator with auto switch has a piston with magnet mounted and an auto switch mounted on the body externally to detect the piston (magnet) position.

### Auto switch specification

Table (12) Reed auto switch specification

Auto switch part no.		Load voltage	Applicable load	Indication light (illuminated when ON)	Wiring (Output)	Electrical entry	
Perpendicular	In-line						
D-A96V	D-A96	DC5V	IC circuit	Yes	3-wire (NPN)	Grommet	
D-A93V	D-A93	AC100V	Relay PLC		No		2-wire
		DC12V					
		DC24V					
D-A90V	D-A90	AC100V or less	IC circuit Relay PLC	No	2-wire		
		DC12V					
		DC24V					

- Isolation resistance - 50M $\Omega$  or more at DC500VM (between lead wire and case)
- Withstand voltage - AC1500V for 1 minute (between lead wire and case)
- Operating time - 1.2ms
- Ambient temperature - -10 ~ 60°C
- Shock resistant - 300 m/s<sup>2</sup>
- Current leakage - None
- Enclosure - Standard: IEC60529, watertight: IP67(JISC0920)



Table (13) Solid state auto switch specification

Auto switch part no.		Load voltage	Applicable load	Indication light (illuminated when ON)	Wiring (Output)	Electrical entry
Perpendicular	In-line					
D-M9NV	D-M9N	DC5V,12V	IC circuit Relay PLC	Yes	3-wire (NPN)	Grommet
		DC24V				
D-M9PV	D-M9P	DC5V,12V	IC circuit Relay PLC		3-wire (PNP)	
		DC24V				
D-M9BV	D-M9B	DC12V	Relay PLC		2-wire	
		DC24V				
D-M9NWV	D-M9NW	DC5V,12V	IC circuit Relay PLC		3-wire (NPN)	
		DC24V				
D-M9PWV	D-M9PW	DC5V,12V	IC circuit Relay PLC		3-wire (PNP)	
		DC24V				
D-M9BWV	D-M9BW	DC12V	Relay PLC		2-wire	
		DC24V				
D-M9NAV	D-M9NA	DC5V,12V	IC circuit Relay PLC		3-wire (NPN)	
		DC24V				
D-M9PAV	D-M9PA	DC5V,12V	IC circuit Relay PLC		3-wire (PNP)	
		DC24V				
D-M9BAV	D-M9BA	DC12V	Relay PLC	2-wire		
		DC24V				

- Isolation resistance - 50MΩ or more at DC500VM (between lead wire and case)
- Withstand voltage - AC1000V for 1 minute (between lead wire and case)
- Operating time - 1ms or less
- Ambient temperature - -10 ~ 60°C
- Shock resistant - 1000 m/s<sup>2</sup>
- Enclosure - Standard: IEC60529, watertight: IP67(JISC0920)

■ Proper auto switch mounting position and operating range

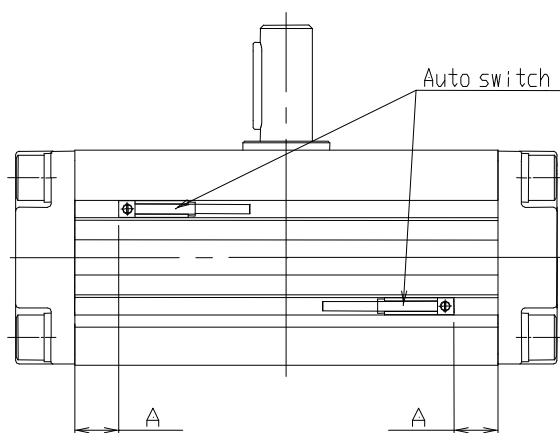


Fig. (12) Proper auto switch mounting position

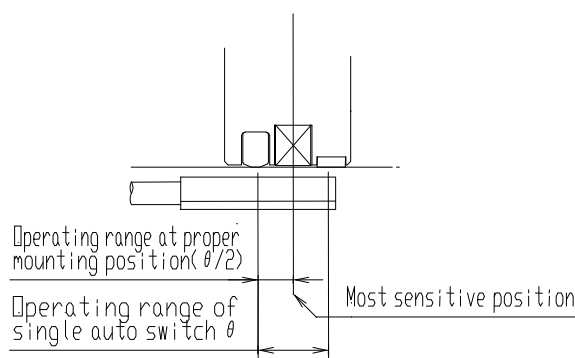


Fig. (13) Operating range of auto switch

Table (14) Operating range of auto switch

Auto switch model	D-A9□/A9□V		D-M9□/M9□V D-M9□W/M9□WV D-M9□A/M9□AV	
	Proper mounting position A(mm)	Operating range θ(°)	Proper mounting position A(mm)	Operating range θ(°)
CDVRA1※50 - 90	18.5	44°	22.5	30°
CDVRA1※50 - 90	35		39	
CDVRA1※63 - 90	21	49°	25	28°
CDVRA1※63 -180	40.5		44.5	
CDVRA1※80 - 90	23.5	41°	27.5	23°
CDVRA1※80 -180	45.5		49.5	
CDVRA1※100 - 90	38.5	29°	42.5	15°
CDVRA1※100 -180	71.5		75.5	

※ Since the operating range is provided as a guideline including hysteresis, it cannot be guaranteed (assuming approximately ±30% dispersion). It may vary substantially depending on an ambient environment. In the actual setting, adjust the value after confirming the auto switch performance.

Table (14) Model of switch spacer

Size	50	63	80	100
Model of Switch spacer	BMY3-016			

※ The above models include 1 piece of switch spacer.

※ Rotary Actuator of built in magnet type attached 2 pieces of switch spacer.

## Auto switch operation principle

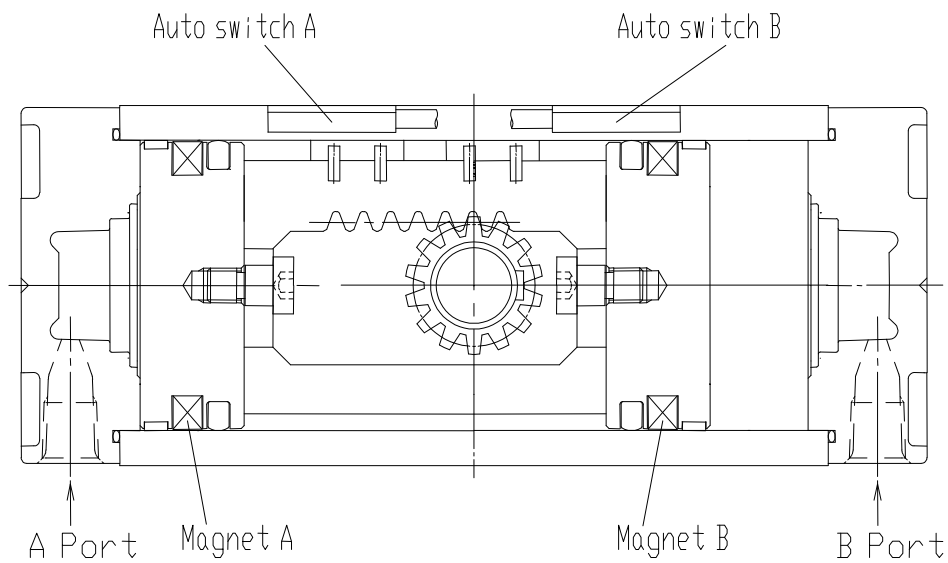


Fig. (14) Auto switch operation principle

In the diagram above, auto switch B is ON. When pressure is applied from A, the piston moves to B, causing the shaft to rotate clockwise. At this time, magnet B goes out of the movement range of auto switch B, causing auto switch B to turn OFF. Furthermore, the piston moves to the right, causing magnet A to enter the movement range of auto switch A. As a result, auto switch A turns ON.

## Maintenance and 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.

### Periodic inspection

Check followings for periodic inspection

- (1) If the rotary actuator set screw become loose
- (2) Operating state
- (3) Leakage to outside
- (4) Is not the backlash of the rack-and-pinion abnormally large?

If any items are found by the inspection that require repairing, tighten any loose parts or disassemble the product to repair.

### Replacement parts

When replacement parts are used, be careful about the following items.

- (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) Clean each part sufficiently before assembly to make sure no dust is stuck to it.
- (5) Apply the grease provided in the replacement parts to each part. As a guideline, apply enough grease to make the surface shiny.
- (6) Do not scratch the seal when mounting it to the piston.
- (7) Be careful with the direction of the piston seal.
- (8) Please consult with us when you have any question on disassembling and inspection.

Table (16) Basic style replacement parts

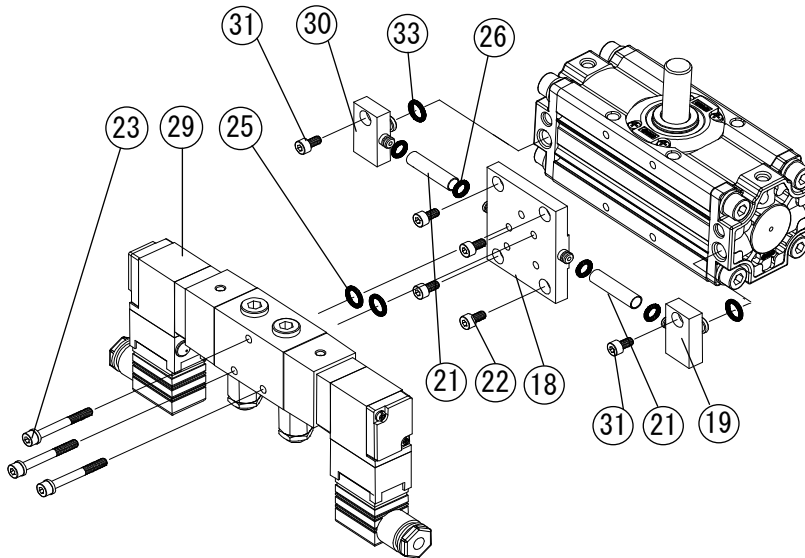
Model	Product no.		Description	
	Without Air cushion	With Air cushion	Parts name	Amount
C□VRA1□□50	P694020-49	P694020-50	⑦ Slider ⑨ Tube gasket	2pcs 2pcs
C□VRA1□□63	P694030-49	P694030-50	⑩ Piston seal ⑭ Spring pin ⑮ O-ring	2pcs 4pcs 2pcs
C□VRA1□□80	P694040-49	P694040-50	⑯ O-ring ⑳ O-ring ㉓ O-ring	4pcs 2pcs 2pcs
C□VRA1□□100	P694050-49	P694050-50	㉖ Cushion seal* (Grease pack)	2pcs (10g)

※ For with Air cushion refer to page 21 for detailed Product structure.

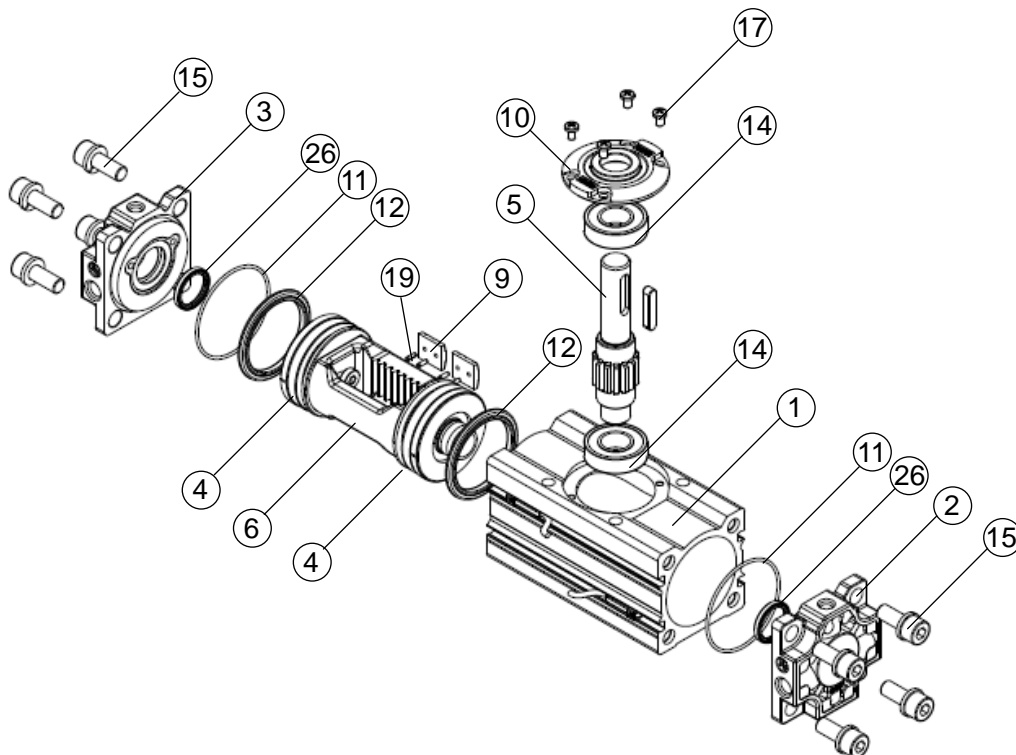
## Disassembly procedure and assembly procedure

### Disassembly procedure

1. Loosen the hexagon socket head cap screws (23) to remove O-ring (25) with the Solenoid valve (29)
2. Loosen the hexagon socket head cap screws (22)(31) to remove the sub-plate (18)(19)(30) and the pipe (20).  
(At this stage, O-rings (23) and (24) are attached to the groove.)



3. Loosen the cross recessed round head tapping screw (13) to remove the bearing retainer (8) with the shaft (5) from the body (1). Remove the lower bearing (11) from the body housing at this time.
4. Loosen the hexagon socket head cap screw with washers (12) to remove the cover (2) and (3) from the body. (Remove the cover from the right and left sides.)
5. Remove the piston (4) with the rack (6) from the body.  
(The rack has a specified mounting direction, so this should be checked when removing it from the body.)

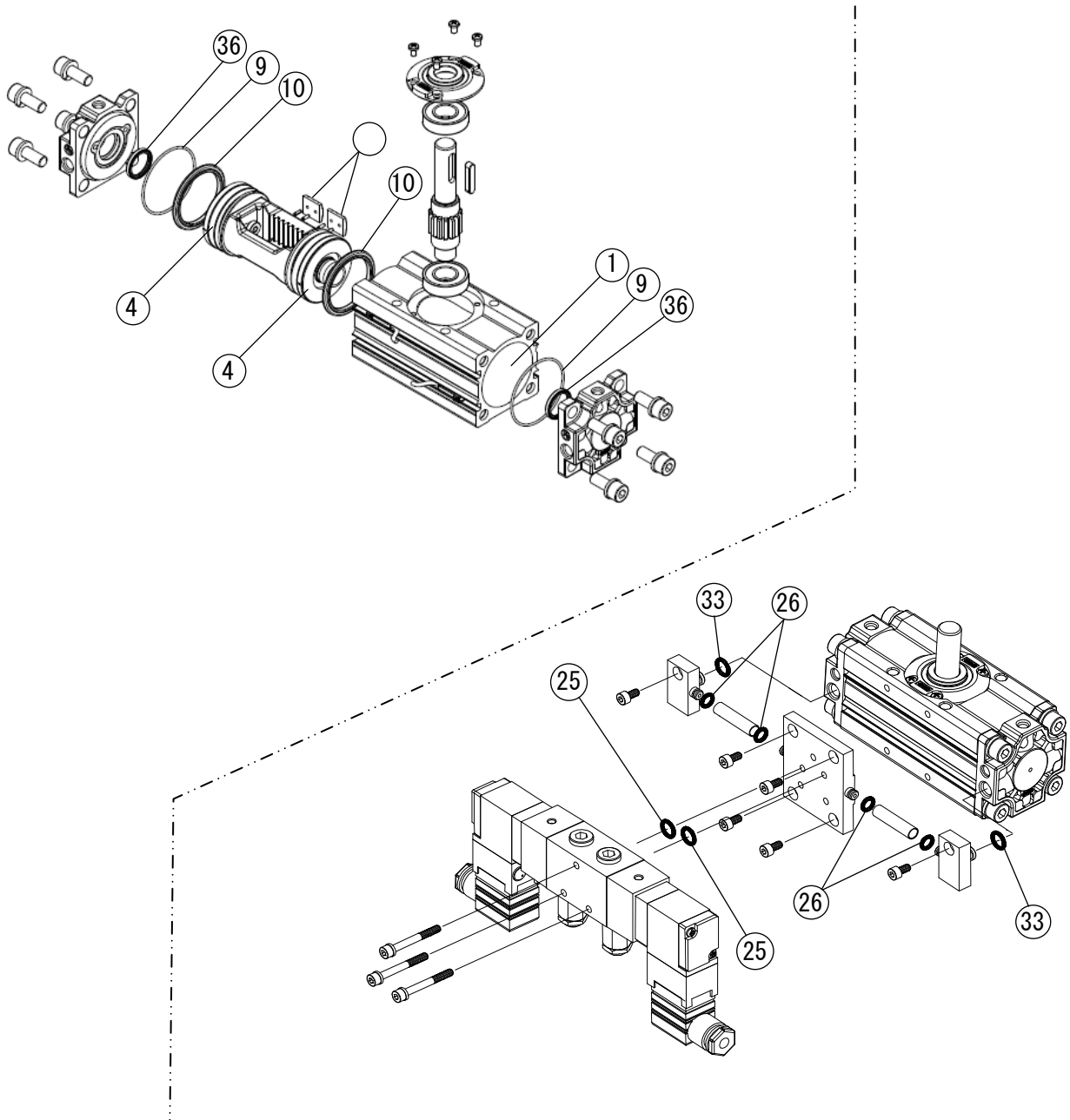


■ Assembly procedure

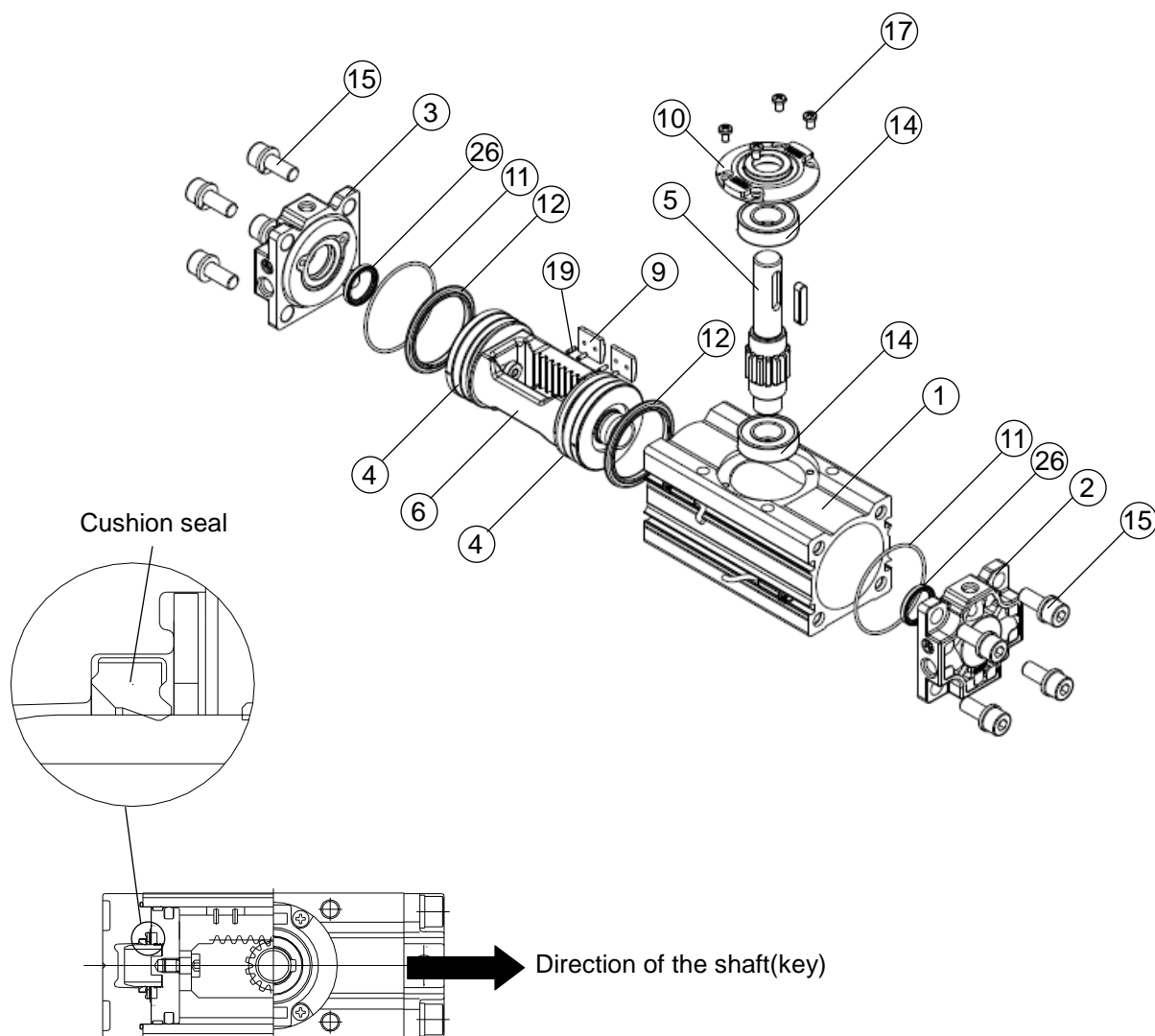
1. Apply the grease provided in the seal kit to parts shown in Table (17).

Table (17) Parts where grease is to be applied

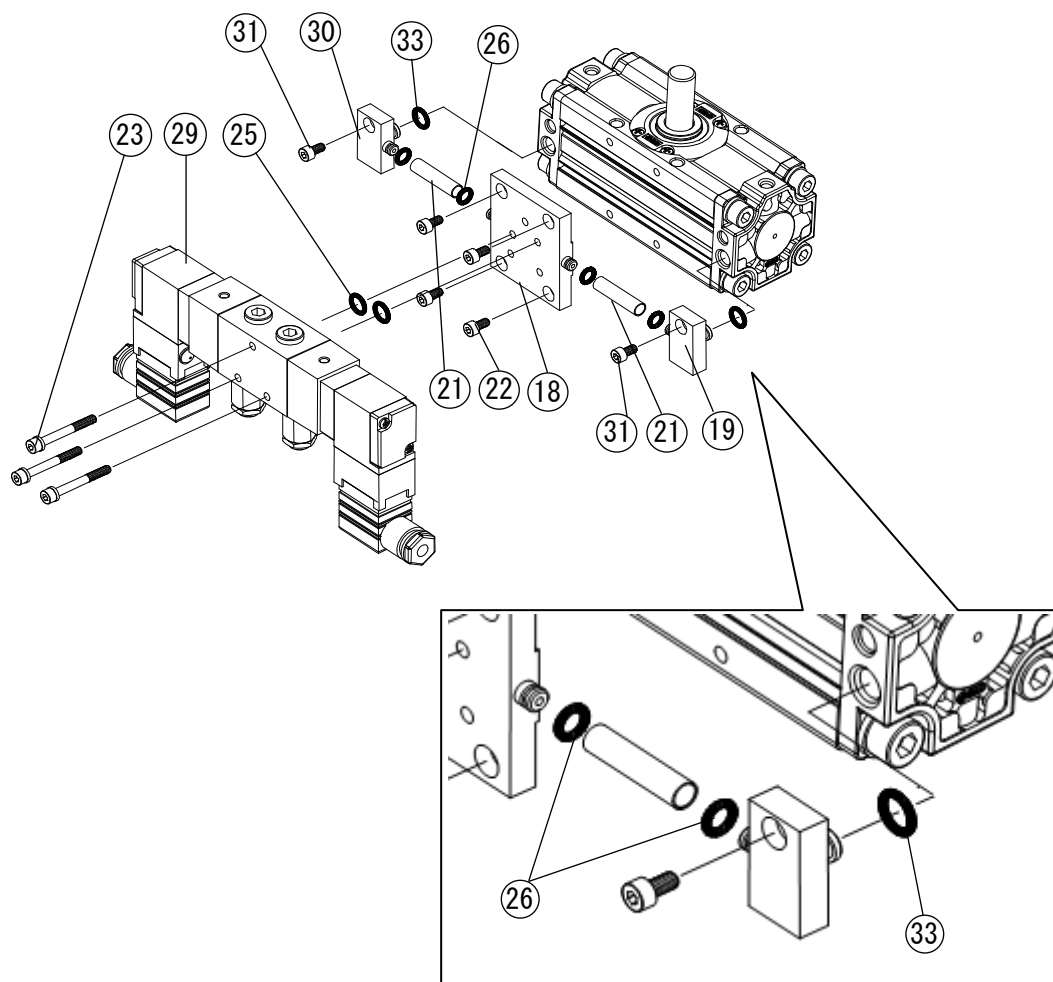
Application of grease	Grease
① Body (inner sliding surface)	GR-S-010
④ Piston (Seal groove)	
⑦ Slider (Sliding surface)	
⑨ Tube gasket	
⑩ Piston seal	
③⑥ Cushion seal ( For with air cushion )	
②⑤ ②⑥ ③③ O-ring	



2. Mount the tube gasket (9) to the left cover (3) to mount to the body (1). Tighten them with the hexagon socket head cap screw with washers (12).
3. Insert the rack (6) and the piston (4) into the body. Set the lower bearing (11) to the housing in the body. At this time, the piston assembly should be inserted carefully so as not to damage the piston seal (10) through which the housing for the bearing of the body will pass.
4. Push the rack and the piston until it touches the left cover (3). Mount the shaft (5) to the body. Refer to Fig.(15) for the direction of the keyway (facing to the right cover (2)).
5. Mount the upper bearing (11) and the bearing retainer (8) to the shaft and the body. Tighten them with the cross recessed round head tapping screw (13).
6. Mount the tube gasket (9) to the right cover (2) to mount to the body (1). Tighten them with the hexagon socket head cap screw with washers (12).



7. Mount the pipe (21) to the sub-plate (18) (19) and (30) and fix with hexagon socket head cap screws (22) (31) to the body (1).
8. Mount the O-ring (25) to the solenoid valve (29) and fix with hexagon socket head cap screws (23) to the sub-plate (18).



9. After assembly is completed, perform an operation test and check that there is no air leakage.



## Troubleshooting

Problem	Possible cause	Solution	Reference page
Rotary actuator doesn't move	Supply pressure isn't applied correctly.	Correctly set the regulator at the supply pressure side.	15
	The directional switching valve (such as a solenoid valve) doesn't switch.	Correctly apply a signal to the directional switching valve (such as a solenoid valve).	15
	Air leakage from piping.	Inspect the piping and stop the leakage.	25
	The restrictor in the port is clogged.	Clean the restrictor. Take the following countermeasures: (1) Blow air through the piping again. (2) Inspect the air filter.	25
Operation is not smooth. (stick-slip)	A load has some friction.	Reduce the friction resistance.	24
	Actuator axis and mating axis not aligned.	Align the two centers or use a flexible fitting.	24
	Insufficient output due to a low supply pressure.	To obtain stable operation, adjust the supply pressure so that the load rate becomes 50% or less.	30
	Throttle valve is restricted too much.	Adjust the throttle valve so that the rotating marks will be in the adjusting range.	17
Extreme rotating angle changes.	Internal parts are broken.	<p>Replace with a new actuator. Please do the following treatment on that.</p> <p>(1) Calculate the kinetic energy applied to the rotary actuator, and adjust the load and rotating speed so that the kinetic energy will be within the allowable range.</p> <p>(2) Please install the stopper or the shock absorber outside and absorb the impact power. In this case, please provide a buffer angle to the stroke of the actuator ( Use 100° actuator in the case of 90° stroke and use 190° actuator in the case of 180° stroke. ) and touch it to an external stopper or the shock absorber surely.</p>	26 29

Problem	Possible cause	Solution	Reference page
Air leakage from the shaft.	Piston packing is worn out.	<p>Please confirm the presence of the wound in the cylinder inner wall after cleaning the inside of the cylinder. Please do the following treatment on that.</p> <p>(1) Please exchange packing when there is no wound in the cylinder.</p> <p>(2) Please exchange it for a new actuator when there is a wound in the cylinder.</p> <p>(3) Please when very dirty in the cylinder inspect the air filter, do blow air through the piping</p>	25 35
The pinion gear is broken.	Excessive kinetic energy was applied to the rotary actuator.	<p>Replace with a new actuator. Please do the following treatment on that.</p> <p>(1) Calculate the kinetic energy applied to the rotary actuator, and adjust the load and rotating speed so that the kinetic energy will be within the allowable range.</p> <p>(2) Please install the stopper or the shock absorber outside and absorb the impact power. In this case, please provide a buffer angle to the stroke of the actuator ( Use 100° actuator in the case of 90° stroke and use 190° actuator in the case of 180° stroke. ) and touch it to an external stopper or the shock absorber surely.</p>	26
	(With the air cushion) It doesn't become the best the adjustment of the cushion valve, and the kinetic energy is unabsorbed in the cushion.	<p>Replace with a new actuator. Please do the following treatment on that.</p> <p>(1) Please adjust the cushion valve best.</p> <p>(2) Please the kinetic energy where the load is generated is cushion absorption energy or less or check.</p>	18 26

Problem	Possible cause	Solution	Reference page
Insufficient rotating Angle.	There is no margin on swing angle of actuator, hence swing range of actuator is unsymmetrical with respect to external stopper.	External stopper remove, and please confirm the range of all swings of the actuator, and install external stopper in correct position. In this case, please provide a buffer angle to the stroke of the actuator ( Use 100°actuator in the case of 90°stroke and use 190°actuator in the case of 180°stroke. ) and touch it to an external stopper or the shock absorber surely.	29
	(With the air cushion) The cushion valve is in the state of totally enclosed.	Please adjust the cushion valve.	18
The auto switch will not operate or operates incorrectly.	The auto switch is mounted in an inappropriate position.	Mount the auto switch in the correct position.	33
	Influence from an external magnetic field	Check that there is no strong magnetic field present.	11
	Trouble with the electrical circuit	Check that there is no trouble with the electrical circuit.	8
	Trouble with the electrical specification	Check there is no trouble with the electrical specification.	31
Solenoid valve doesn't operate.	Faulty wiring	Try to connect wires correctly.	13
	Decreased pilot pressure	Please adjust the setting of the supply pressure side decompression valve correctly.	15
	Decreased power-supply voltage	Please confirm the problem is not in the specifications such as the voltages and the currents.	15

Revision history
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Note: Specifications are subject to change without prior notice and any obligation on the part of the manufacturer.  
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