



# Operation Manual

PRODUCT NAME

*Rotary Actuator*

MODEL / Series / Product Number

CRA1 30~100

**SMC Corporation**

# Contents

<b>Safety Instructions</b>	2
<b>Outline</b>	17
Specification	17
Effective torque	18
Rotation range of Keyway	19
<b>Internal structure and parts description</b>	20
Rotary actuator internal structure	20
<b>Basic circuit for using rotary actuator</b>	21
Circuit configuration	21
Recommended Devices	21
<b>Mounting</b>	22
Restriction of the load	22
Operation of shaft couplings	22
Piping and operating direction	23
Operating air	23
<b>Setting rotation time</b>	24
Moment of inertia	24
Table for calculation of Inertia moment	25
Kinetic energy	26
External stopper	27
<b>Calculation of required torque</b>	28
Load type	28
<b>Maintenance and inspection</b>	29
Periodic inspection	29
Disassembling procedure and assemble procedure	29
Disassembly drawing	30
<b>Trouble shooting</b>	31



# 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.**

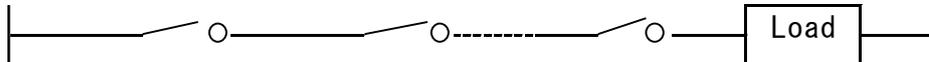
<Reed switch>

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.

Operating current of load (OFF condition) > Leakage current

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

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

**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 (300m/s<sup>2</sup> or more for reed auto switches and 1000m/s<sup>2</sup> 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.



# Rotary Actuator

## How to Use the Air-hydro Type

### • Caution on Design

#### **Warning**

- ① **Do not use a rotary actuator of the air-hydro type near flames, or in equipment or machinery that exceeds an ambient temperatures of 60°C.**  
There is a danger of causing a fire because the rotary actuator of the air-hydro type uses a flammable hydraulic fluid.

#### **Caution**

- ① **Do not use in an environment, equipment, or machine that is not compatible with oil mist.**  
Rotary actuators of the air-hydro types generate an oil mist during operation which may affect the environment.
- ② **Be sure to install an exhaust cleaner on the directional control valve for the rotary actuator of the air-hydro type.**  
A very small amount of hydraulic fluid is discharged from the exhaust port of the rotary actuator of the air-hydro type's directional control valve, which may contaminate the surrounding area.
- ③ **Install a rotary actuator of the air-hydro type in locations where it can be serviced easily.**  
Since the rotary actuator of the air-hydro type requires maintenance, such as refilling of hydraulic fluid and bleeding of air, ensure sufficient space for these activities.
- ④ **Do not use in cases where external leakage of hydraulic oil may adversely affect equipment or machinery.**  
Although it only occurs in minute amounts, a certain amount of sliding leakage from the piston seal is unavoidable with the rotary actuator of the air-hydro type. Because of the construction of the rotary actuator of the air-hydro type, hydraulic oil may leak into the outside due to sliding leakage.

### • Selection

#### **Caution**

- ① **Select the rotary actuator of the air-hydro type based on the combination with the air-hydro unit.**  
Select a proper air-hydro unit that is necessary for good operation of the rotary actuator of the air-hydro type.

## ▪ Piping

### **Caution**

- ① **Use self-align fitting in conjunction with the piping for the rotary actuator of the air-hydro type.**

Do not use a one-touch fitting with the piping for the rotary actuator of the air-hydro type, as this may result in oil leakage.

- ② **For rotary actuator of the air-hydro type piping, use hard nylon tubing or copper piping.**

As in the case of hydraulic circuits, surge pressures greater than the operating pressure may occur in a rotary actuator of the air-hydro type's piping, making it necessary to use safer piping materials.

## ▪ Lubrication

### **Warning**

- ① **Make sure to completely discharge the compressed air in the system before filling the air-hydro unit with hydraulic oil.**

When supplying hydraulic fluid to the air-hydro unit, first confirm that safety measures are implemented to prevent dropping of objects and the release of clamped objects, etc. Then, shut off the air supply and the equipment's electric power and exhaust the compressed air in the system.

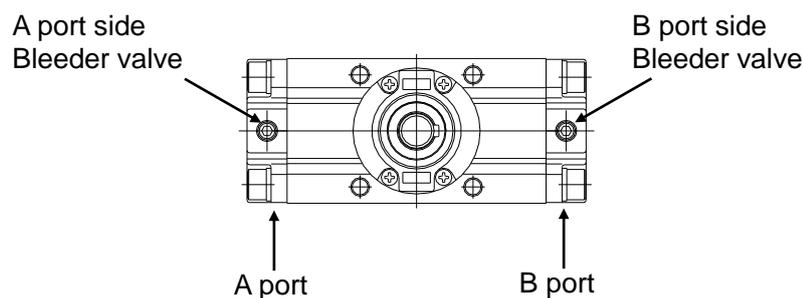
If the air-hydro unit's supply port is opened with compressed air still remaining in the system, there is a danger of hydraulic fluid being blown out.

## ▪ Maintenance

### **Caution**

- ① **Bleed air from the rotary actuator of the air-hydro type on a regular basis.**

Since air may accumulate inside a rotary actuator of the air-hydro type, bleed air from it, for example before starting work. Bleed air from a bleeder valve provided on the rotary actuator of the air-hydro type or the piping.



- ② **Verify the oil level of the air-hydro system on a regular basis.**

Since a very small amount of hydraulic fluid is discharged from the rotary actuator of the air-hydro type and air-hydro unit circuit, the fluid will gradually decrease. Therefore, check the fluid regularly and refill as necessary.

The oil level can be checked with a level gauge in the air-hydro converter.

## Outline

This operation manual is for rack pinion type Rotary actuator. 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

Type	Pneumatic					Air-hydro			
Size	30	50	63	80	100	50	63	80	100
Fluid	Air(Non-lube)					Hydraulic oil			
Max. operating pressure	1.0 MPa								
Min. operating pressure	0.1 MPa								
Ambient and fluid temperature	0 to 60°C (No freezing)								
Cushion	Not attached, Air cushion					None			
Backlash	None <sup>※</sup>	Within 1°							
Tolerance in rotating angle	—	0~+4°							
Mounting style	Basic style Foot style	Basic style, Foot style, Flange style							

※ Since Size30 has a stopper installed, there is no backlash produced under pressure.

Table (2) 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 <sup>※</sup>	
30	0.01	-	0.2 to 1
50	0.05	0.98	0.2 to 2
63	0.12	1.50	0.2 to 3
80	0.16	2.00	0.2 to 4
100	0.54	2.90	0.2 to 5

※ Allowable kinetic energy of the bumpers equipped model is the maximum absorbed energy under proper adjustment of the cushion valve.

Table (3) Mass

(Kg)

Size	Standard mass		Additional mass			
	90°	180°	With solenoid valves <sup>※2</sup>	With auto switches <sup>※1</sup>	Foot bracket	Flange bracket
30	0.3	0.4	—	0.1	0.1	—
50	1.5	1.7	0.2	0.2	0.3	0.5
63	2.5	3.0	0.2	0.4	0.5	0.9
80	4.3	5.0	0.2	0.6	0.9	1.5
100	8.5	9.5	0.2	0.9	1.2	2.0

※1 With 2 auto switches

※2 The weight of the solenoid valve is not included.

Table (4) Rotary actuator inner volume (cm<sup>3</sup>)

Size	Rotation angle			
	90°	100°	180°	190°
30	7.4	—	14	—
50	32	36	65	68
63	60	67	120	127
80	111	123	221	233
100	259	288	518	547

Effective torque

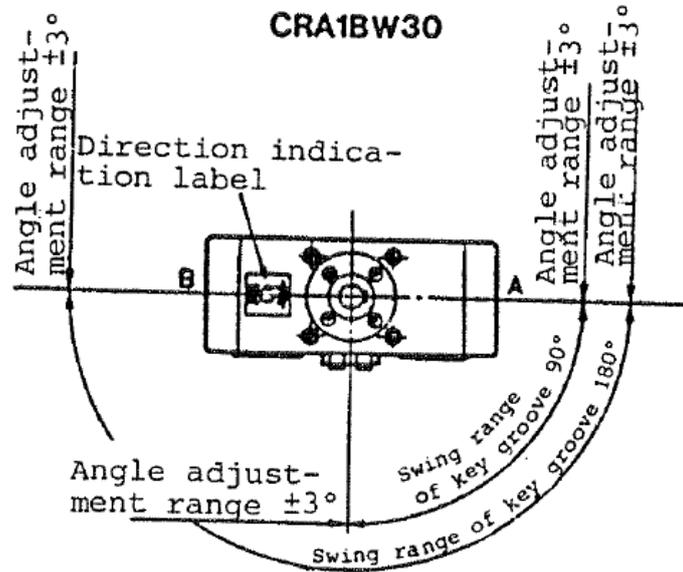
Table (5) Effective torque table (N·m)

Size	Operating pressure (MPa)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
30	0.38	0.76	1.14	1.53	1.91	2.29	2.67	3.05	3.44	3.82
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

**Rotation range of keyway**

If air pressure is applied from the A port side, the shaft rotates clockwise. If air pressure is applied from the B port side, the shaft rotates counterclockwise.

**Size 30**



Stopper screw A : For end adjustment in clockwise direction  
 Stopper screw B : For end adjustment in counter clockwise direction

Fig. (1) Rotation range of shaft keyway (size 30)

**Size 50 to 100**

**CRA1O50~100**

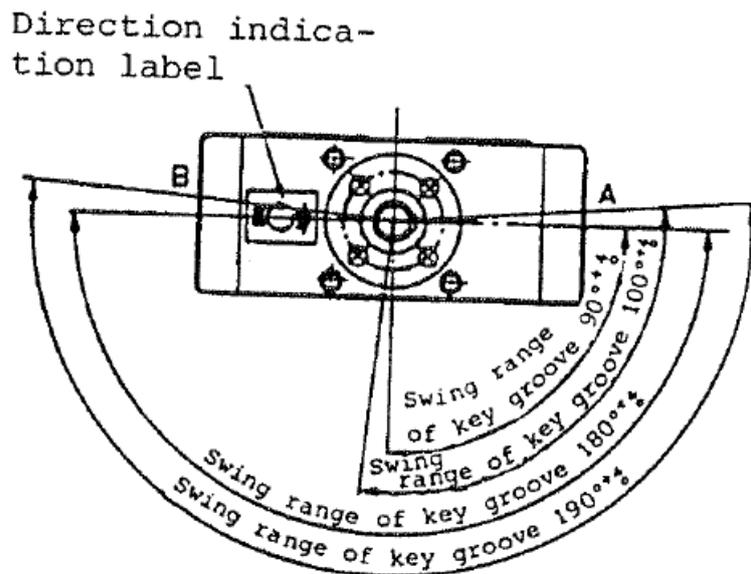
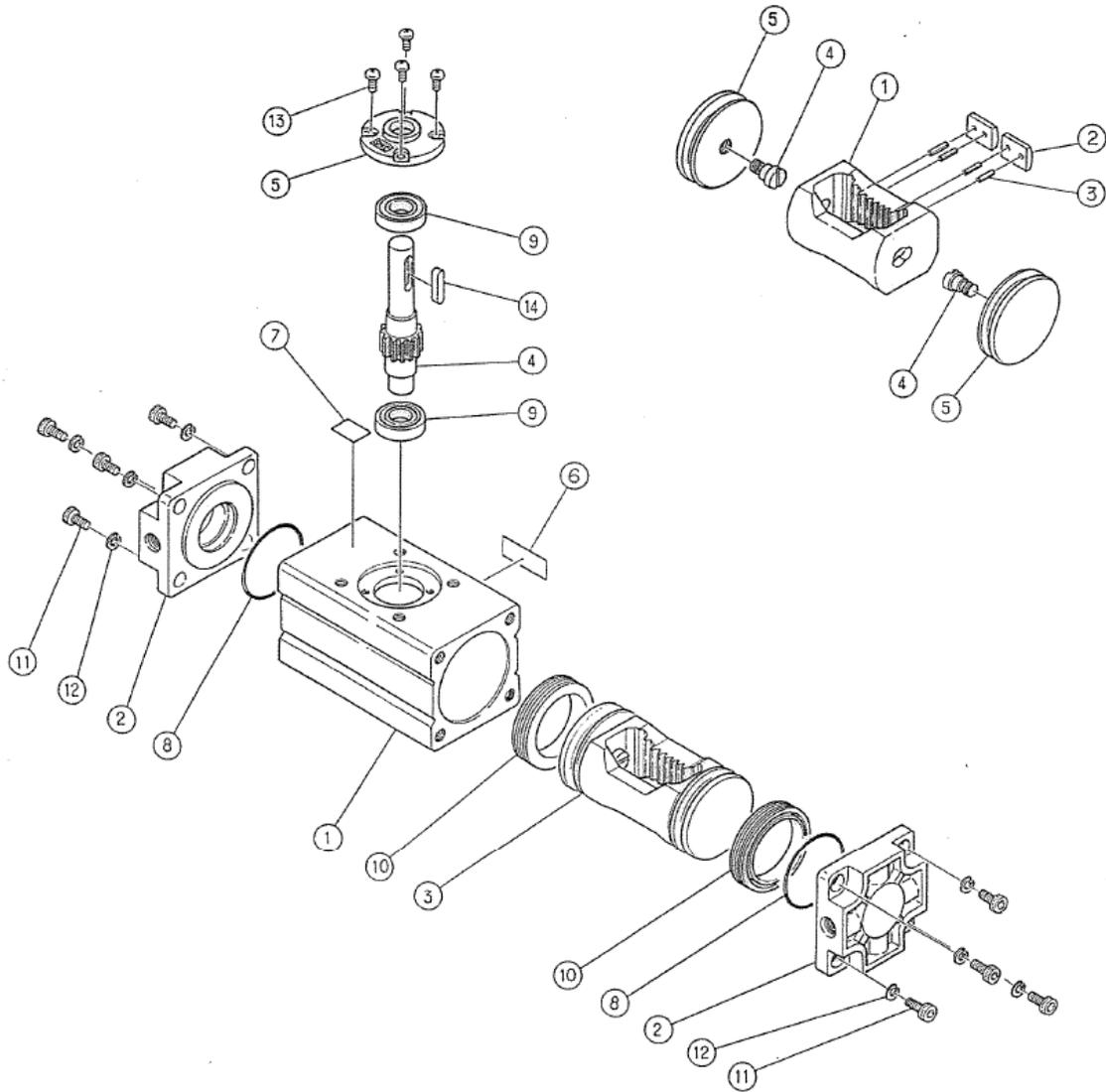


Fig. (2) Rotation range of shaft keyway (size 50 to 100)

# Internal structure and parts description

## Rotary actuator internal structure



### Component parts

No.	Description	Number	Note
1	Body	1	Anodized
2	Cover	2	Black
3	Piston Ass'y	1	
4	Shaft	1	
5	Bearing retainer	1	Black
6	Nameplate	1	
7	Rotation display plate	1	
8	Tube gasket Slider O-ring	2	Zinc Chromated
9	Bearing	2	
11	Piston seal	2	Black dye
12	Hexagon socket set screw	8	Black dye
13	Spring washer	8	Black dye
14	Round head phillips screw	4	

No.	Description	Number	Note
1	Rack	1	Anodized
2	Slider	2	Black
3	Spring pin	4	
4	Connecting screw	2	Zinc Chromated
5	Piston	2	Chromated

# 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. (6).

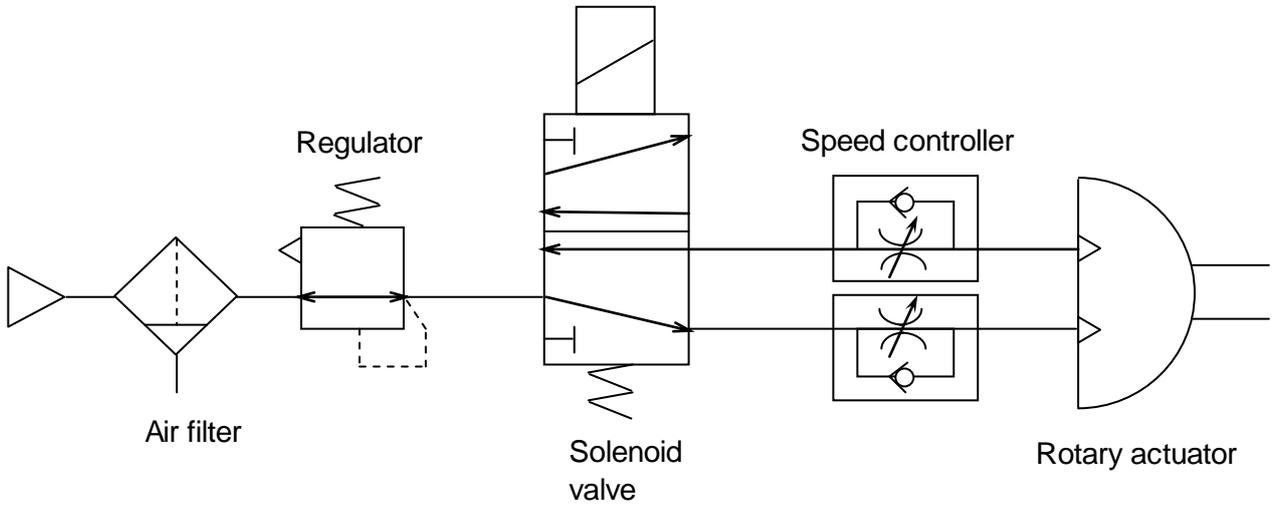


Fig. (3) Basic circuit

## Recommended Devices

Table (6) shows the recommended equipment for the solenoid valve, speed controller, and tube used in the basic circuit shown in Fig. (3).

Table (6) Recommended Devices

Model	Solenoid Valve(CV value) *	Speed Controller	Tube
30	VZ1000 Series VF1000 Series	AS1000 Series	φ4/φ2.5
50	VZ3000 Series VF3000 Series	AS2000 Series	Φ6/φ4
63			
80	VZ5000 Series VF3000 Series	AS3000 Series	φ8/φ6
100	VF3000 Series		φ10/φ7.5

\*The selected solenoid valves are flexible seal types.

# 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 (8) below. However, applications in which the load is applied directly to the shaft should be avoided as much as possible.

Table (7) Allowable shaft load (N)

Size	Load direction		
	Fsa	Fsb	Fr*
30	29.4	29.4	29.4
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.

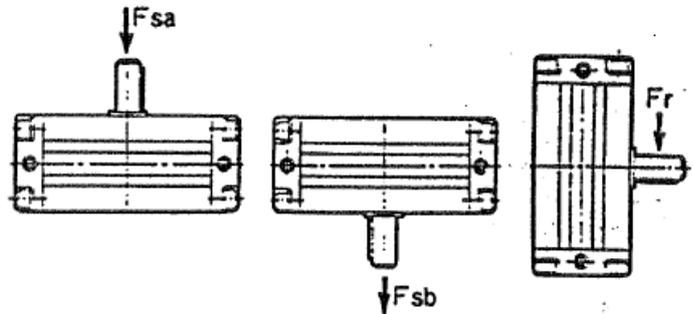


Fig. (4) Load direction

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.

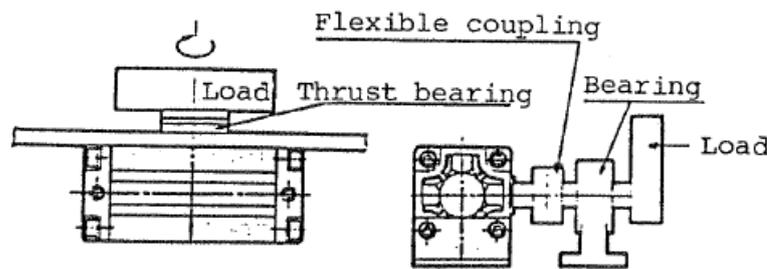


Fig. (5) Bearing

## Operation of shaft couplings

As in Fig. (6), 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.

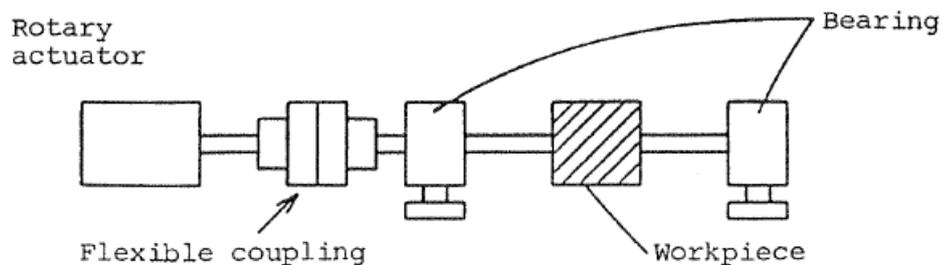


Fig. (6) Flexible coupling

**Piping and operating direction**

Fig. (7) shows piping ports of the rotary actuator.  
Table (8) shows the port size.

Table (8) Port size

Size	Port size
30	M5
50	Rc1/8
63	Rc1/8
80	Rc1/4
100	Rc3/8

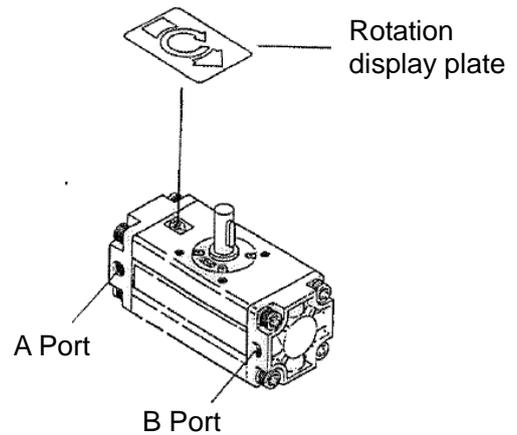


Fig. (7) Port location

A fixed throttle is installed inside the actuator port. Do not increase the size of this hole by re-machining, etc. If you do, the swing velocity of the actuator will increase, causing the shock force to increase, which may damage the actuator.

When pressure is applied from the B side port, the shaft swings in the clockwise direction.

The body of the rotary actuator is equipped with a direction indicator plate to indicate this.

Axis movement direction    Air flow direction

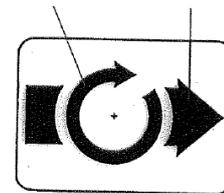


Fig. (8) Direction indicator plate

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. (11), 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.

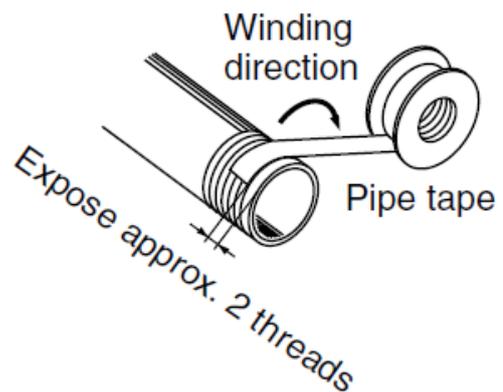


Fig. (9) Wrapping of pipe tape

## 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)

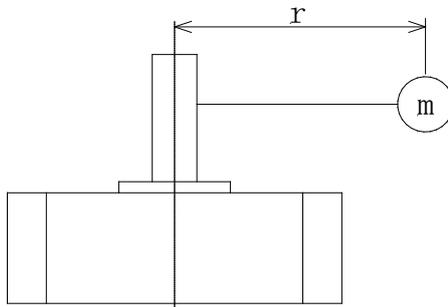
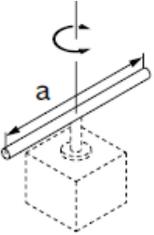
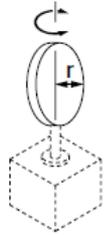
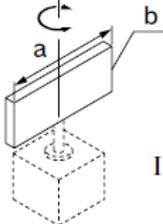
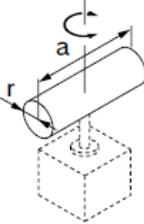
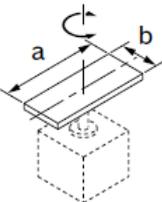
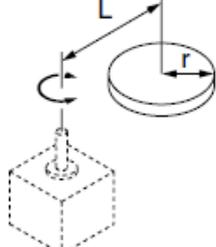
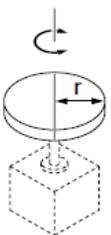
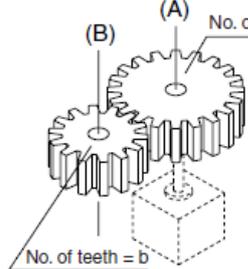
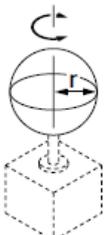


Fig. (10) Inertia moment

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 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>K: 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 (9) 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 (9) 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       $\text{kg} \cdot \text{m}^2$

Please refer to Table (2) 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.

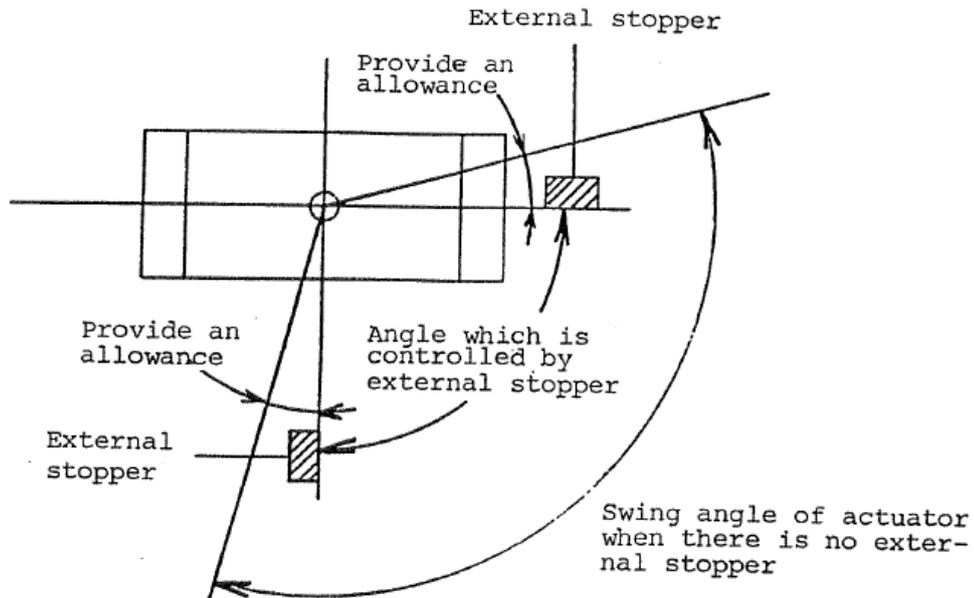
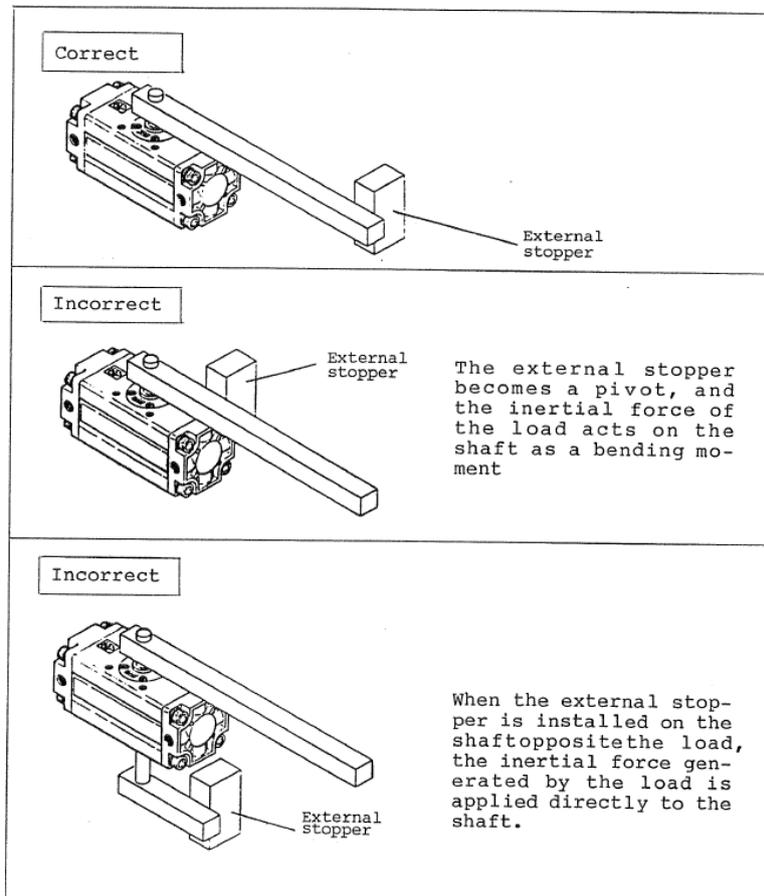


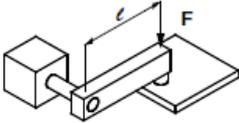
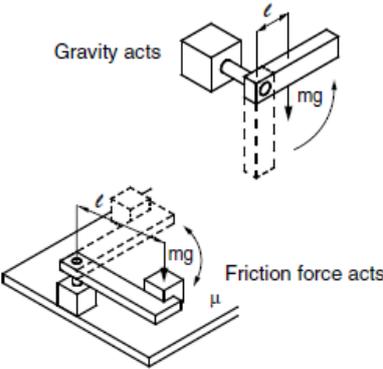
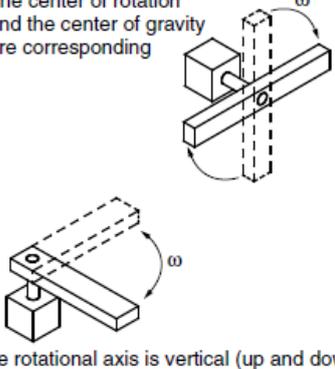
Fig. (11) External stopper



# 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
		
$T_s = F \cdot l$ $T_s$ : Static load (N·m) $F$ : Clamp force (N) $l$ : Distance from the center of rotation to clamp (m)	When gravity acts to the rotation direction $T_f = m \cdot g \cdot l$ When friction force acts to the rotation direction $T_f = \mu \cdot m \cdot g \cdot l$ $T_f$ : Resistance load (N·m) $m$ : Mass of load (kg) $g$ : Gravitational acceleration 9.8 (m/s <sup>2</sup> ) $l$ : Distance from the center of rotation to the gravity or friction force acting point (m) $\mu$ : Coefficient of friction	$T_a = I \cdot \omega \cdot \dot{\omega} = I \cdot \frac{2\theta}{t^2}$ $T_a$ : Inertial load (N·m) $I$ : Moment of inertia (kg·m <sup>2</sup> ) $\dot{\omega}$ : Angular acceleration (rad/s <sup>2</sup> ) $\theta$ : Rotating angle (rad) $t$ : Rotation time (s)
Required torque $T = T_s$	Required torque $T = T_f \times (3 \text{ to } 5)$ <small>Note 1)</small>	Required torque $T = T_a \times 10$ <small>Note 1)</small>
<ul style="list-style-type: none"> <li>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.  <math>T = T_f \times (3 \text{ to } 5) + T_a \times 10</math> </li> <li>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.  <math>T = T_a \times 10</math> </li> </ul>		

Note 1) In order to adjust the velocity, it is necessary to have a margin of adjustment for  $T_f$  and  $T_a$ .

# 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.

## Disassembly procedure and assembly procedure

### Disassembly procedure

1. Loosen small pan-head screw (13) and remove the shaft from the main unit.  
Also, remove bearing (9) from the housing.
2. Loosen the hexagon socket head cap screw (11) and remove covers (2). (Remove both the left and right covers.)
3. The piston will be visible inside main unit (1). Push the piston from one side and remove piston assembly (3) from the main unit. The rack has a specified mounting direction, so this should be checked when removing it from the main unit. (If you install the rack in reverse when reassembling the rotary actuator, the engagement between the gears will be imperfect, resulting in an error in the swing range of the key groove.)

### Assembly procedure

1. Before assembling the rotary actuator, thoroughly wash each part to ensure that no dirt adheres to it.
2. Coat each part with grease.  
When installing the piston packing in the piston, be careful not to damage the packing.
3. The letters R and L, which represent left and right, respectively, are marked on the inside of covers (2). First, install the left cover(L).
4. Insert piston assembly (3) into the main unit, then push the piston until it strikes left cover(L) (2). At this time, the piston packing will pass through the bearing housing. Be sure, therefore, not to damage the packing.
5. Install bearing (9) in the housing of the main unit, and assemble the shaft so that the direction of the key groove is the same as the direction of the right cover. If the key groove does not face the right side, this means that rack is assembled in reverse. In this case, correctly assemble the rack.
6. Install cover(R) (2).
7. After assembling the rotary actuator, perform an operating test and also check the actuator to ensure that there is no air leakage.

Tightening torque for the cover(2)(L)(R) and hexagon socket head cap screw(11).

Size	Tightening torque	Additional tightening torque
30	5.1N·m	4.7~5.7N·m
50	21.6N·m	17.6~26.4N·m
63	43.1N·m	35.2~50.8N·m
80	75.5N·m	61.6~92.4N·m
100		

Tightening torque for bearing retainer(5) and pan head machine screw(13).

Size	Tightening torque
30	0.68N·m
50	1.4~1.8N·m
63	
80	
100	

Disassembly drawing

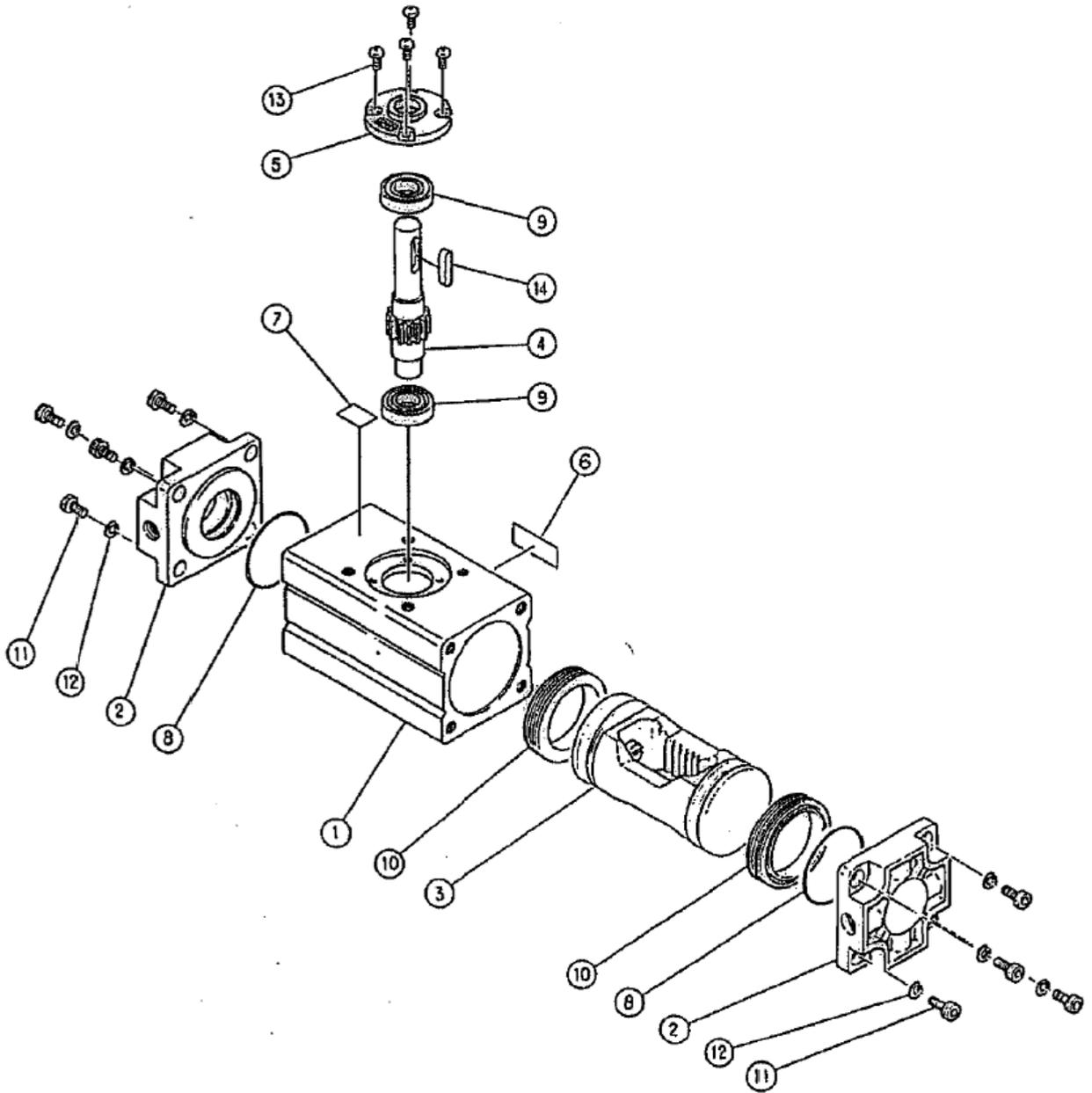


Table (10) Parts where grease is to be applied

Application of grease	Grease
Body (inner sliding surface)	GR-S-10
Piston (Seal groove)	
Slider (Sliding surface)	
Tube gasket	
Piston seal	
Pinion gear	BR2-Plus
Rack	

## 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.	17
	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).	21
	Air leakage from piping.	Inspect the piping and stop the leakage.	21
	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.	23
Operation is not smooth. (stick-slip)	A load has some friction.	Reduce the friction resistance.	22
	Actuator axis and mating axis not aligned.	Align the two centers or use a flexible fitting.	22
	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.	18
Extreme rotating angle changes.	Internal parts are broken.	Replace with a new actuator. Please do the following treatment on that.  (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. (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.	24 25 26 27

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>	23 29 30
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>	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.	27
	(With the air cushion) The cushion valve is in the state of totally enclosed.	Please adjust the cushion valve.	27

Revision history
A: Change from non-SI unit to SI unit
B: Fix unclear areas
C: Fix unclear areas
D: Grease name changed
E: Format change , Additional tightening torque

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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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