SMC

Doc. No. CRB2-OM00001-A

Operation Manual

Rotary Actuator

Vane Type

CRB2BW40

- Thoroughly read and understand this operation manual to install and operate this product.
- Pay particular attention to the safety statements.
- Retain this operation manual to read whenever needed.

SMC CORPORARION

Contents

1. Outline

This operation manual describes Vane Type of Rotary Actuator. Confirm the specifications of this product including load (moment of inertia), rotation time and other operating conditions before the use.

1-1. Model

Model	Internal Volume (cm^2)	Weight (g)	Port Size
CRB2BW40- 90S (E)	25	386.8	M5×0.8
CRB2BW40-180S (E)	31.5	376.2	
CRB2BW40-270S (E)	41	365.3	
CRB2BW40- 90D (E)	33	399.7	
CRB2BW40-100D (E)	33	446.2	

1-2. Specifications

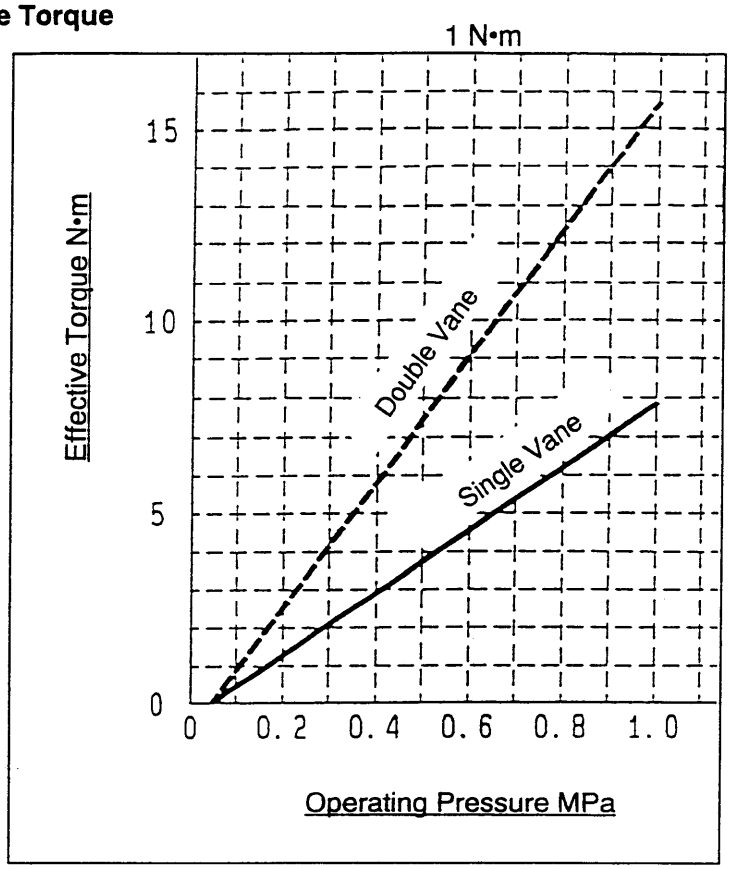
Size	CRB2BW40-※S	CRB2BW40-※D
Vane	Single Vane	Double Vane
Rotation Angle	$90^{\circ}{}^{+4^{\circ}}_{0}$ $180^{\circ}{}^{+4^{\circ}}_{0}$ $270^{\circ}{}^{+4^{\circ}}_{0}$	$90^{\circ}{}^{+4^{\circ}}_{0}$ $100^{\circ}{}^{+4^{\circ}}_{0}$
Fluid	Air (Non-lube)	
Proof Pressure	1.5 MPa	
Max. Operating Pressure	1.0 MPa	
Min. Operating Pressure	0.15 MPa	
Kinetic Energy Note 2	0.04 J	
	0.03 J	
Speed Adjusting Range Note 1	0.07 to 0.5 sec/90°	
Fluid and Ambient Temperature	5 to 60°C	
Shaft Type	Both shafts (Long shaft side: w/Key, Short shaft side: single spanner flat)	

Note 1: Since sticking and/or malfunction may occur with slower speed than 0.5 sec/ 90°, use the product within the speed adjusting range.

Note 2: Value in the upper column shows energy when rubber cushion is used (at rotation end) and that in the lower column shows energy when rubber cushion is not used.

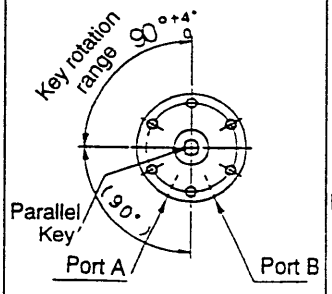
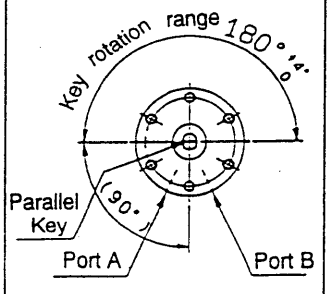
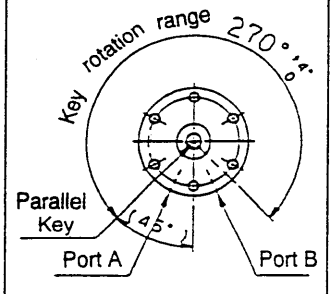
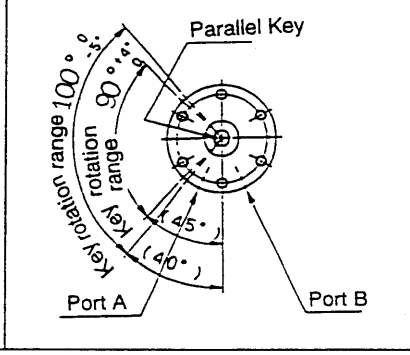
A

1-3. Effective Torque



1-4. Key (Keyway) Position and Rotation Range

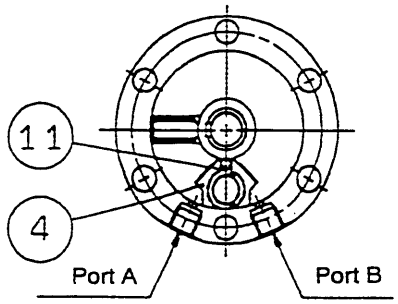
Rotation Range/ View from Long Shaft (Parallel key position in each figure below is when Port B is pressurized).

Series CRB2/ Size:40				
	Single Vane Type			Double Vane Type
	90°	180°	270°	90°, 100°
Standard				

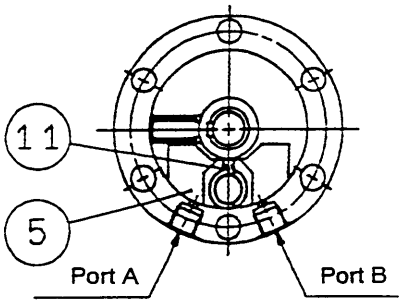
2. Internal Construction and Description of Individual Parts

2-1. Single Vane Type

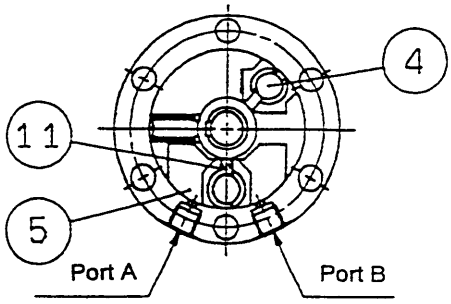
For 270°
(View from Long Shaft)

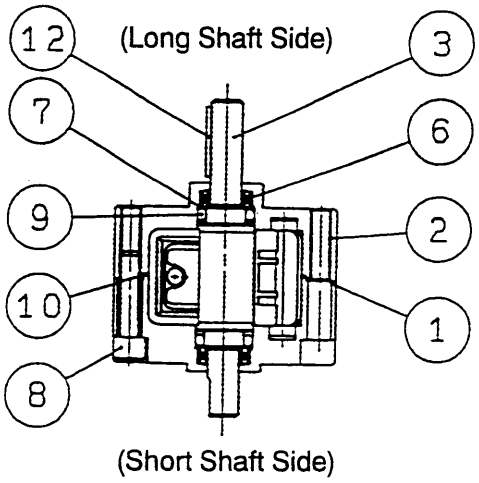


For 180°
(View from Long Shaft)



For 90°
(View from Long Shaft)

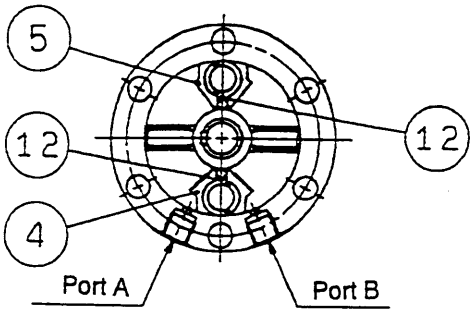




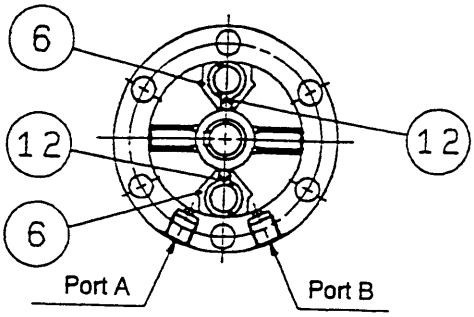
No	Part	Material	Remarks
1	Body (A)	Aluminum Alloy	White
2	Body (B)	Aluminum Alloy	White
3	Vane Shaft	Carbon Steel (NBR)	
4	Stopper	Resin	For 270°
5	Stopper	Resin	For 180°
6	Bearing	Bearing Steel	
7	Backup Ring	Stainless Steel	
8	Hexagon Socket Head Cap Screw	Stainless Steel	Special bolt
9	O-ring	NBR	
10	O-ring	NBR	
11	Stopper Packing	NBR	
12	Parallel Key	Carbon Steel	

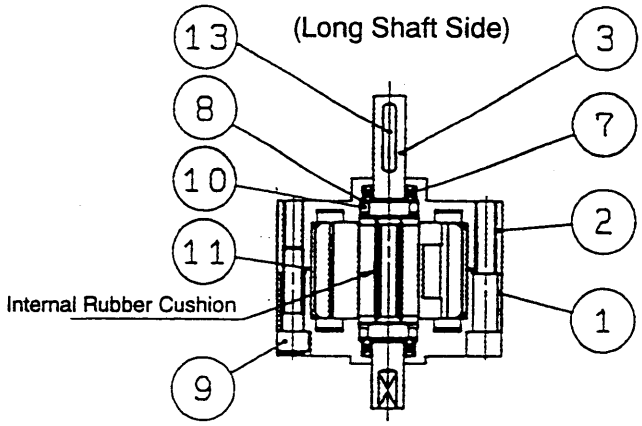
2-2. Double Vane Type

For 90°
(View from Long Shaft)



For 100°
(View from Long Shaft)





(Short Shaft Side)

No	Part	Material	Remarks
1	Body (A)	Aluminum Alloy	White
2	Body (B)	Aluminum Alloy	White
3	Vane Shaft	Carbon Steel (NBR)	
4	Stopper	Aluminum Die Casting	For 90°
5	Stopper	Resin	For 90°
6	Stopper	Aluminum Die Casting	For 100°
7	Bearing	Bearing Steel	
8	Backup Ring	Stainless Steel	
9	Hexagon Socket Head Cap Screw	Stainless Steel	Special bolt
10	O-ring	NBR	
11	O-ring	NBR	
12	Stopper Packing	NBR	
13	Parallel Key	Carbon Steel	

3. Basic Circuit

3-1. Circuit Configuration

Figure 1 shows a basic circuit to activate Rotary Actuator by using Air Filter, Regulator, Solenoid Valve and Speed Controllers.

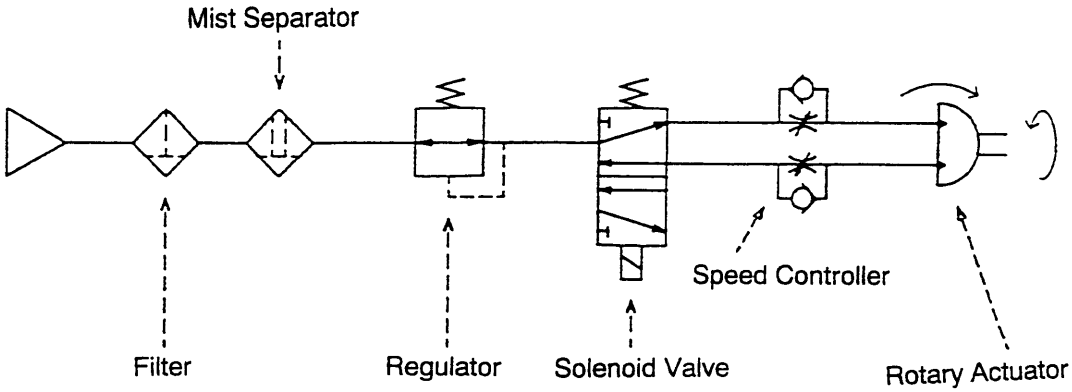


Figure 1

3-2. Preferred Components

Table 1 shows preferred components of solenoid valve, speed controller and tubing used in the basic circuit as Figure 1.

Table 1

Model	Solenoid Valve (Cv)	Speed Controller	Tubing
CRB2BW40	0.1 to 0.2	AS1∗-M5 Note: Make sure to use speed controller in meter-out control.	Ø4 / Ø2.5

4. Installation

4-1. Air Supply

⚠ Caution

① Filter and regulate air supplied to Rotary Actuator by using SMC Air Filter and Regulator (Series AR).

② **Do not apply lubricant since this is non-lube type.**
Internal grease will be flowed out by lubrication so that normal operation will not be obtained.

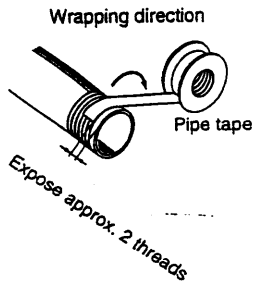
③ Compressed air containing a large quantity of drain may cause malfunction of Rotary Actuator. Install After Cooler, Air Dryer or Drain Catch as a measure.

4-2. Piping

⚠ Caution

① Preparation before piping
Flush or wash piping thoroughly to remove chips, cutting oil and dust from inside the pipe.

② When screwing together pipes and fittings, be certain that chips from the pipe threads and sealing material do not get inside the piping. Also, when pipe tape is used, **leave 1.5 to 2 thread ridges exposed** at the end of the pipe.



4-3. Shaft Load Limit

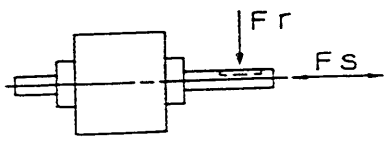
① Although static loads shown in Table 2 are allowable, avoid the use applying direct load to the shaft.

Table 2: Allowable Shaft Load

N

Model	Fr	Fs
CRB2BW40	60	40

Note: Point of application of force Fr is the center to longitudinal dimension of key.



② It is recommended to use the method in Figure 2 to avoid applying direct load to the shaft for better operating conditions.

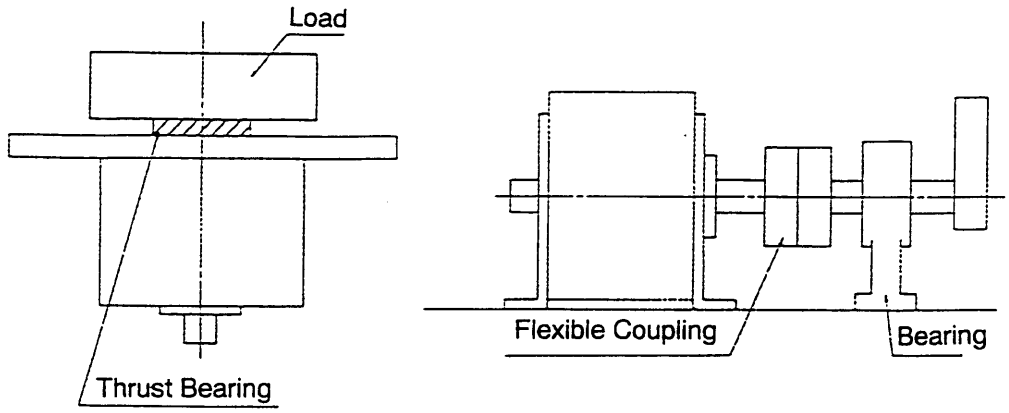


Figure 2

4-4. Coupling

⚠ Warning

As Figure 3 shows, when actuator is used with extended shaft, center the shaft of Rotary Actuator and the counterpart. If they were decentered, load factor partially becomes large and excessive bending moment is applied to the shaft. In such a condition, stable operation cannot be obtained and the shaft may be damaged. In this case, use **Flexible Fitting** (Flexible Joint in JIS).

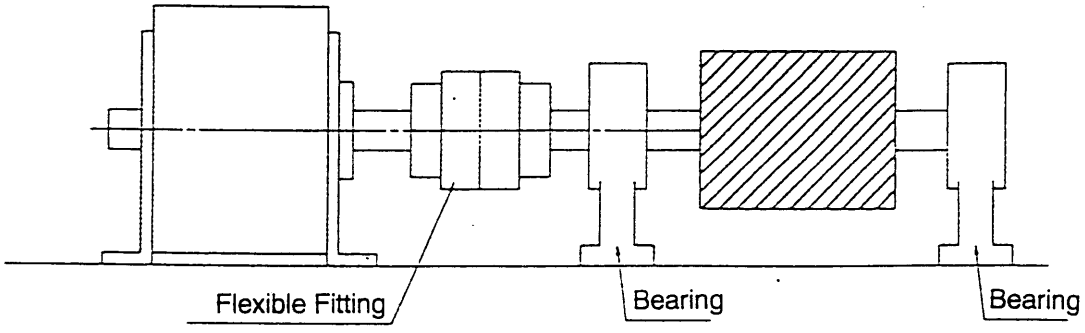


Figure 3

4-5. Operating Environment

⚠ Caution

① **Do not use the product in atmospheres or places where there is a danger of corrosion.**
Refer to "Internal Construction and Description of Individual Parts" (pages 3 & 4) for materials used for Rotary Actuator.

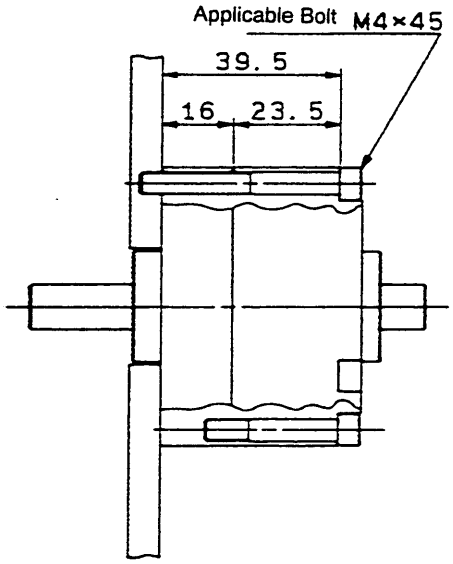
② **Do not use the product in dusty places or where water and oil drops splash on.**

③ **Do not use the product in atmospheres containing ozone.**

④ **Do not use the product in atmospheres containing gases which damage metals, resins and rubbers.**

4-6. Using Body As Flange

Use JIS hexagon socket head cap screw M4×45L since it fits in the groove of Rotary Actuator.



5. How To Set Rotation Time

Due to inertia of the load, even a small torque generated by Rotary Actuator may cause damage to the shaft and internal parts. Therefore, consider the inertia of the load and kinetic energy to set rotation time.

5-1. Moment of Inertia

① Moment of inertia is effort required to turn an object, in other words, effort required to stop it. When an object is moved by Rotary Actuator, the object has inertia force. Large impact (kinetic energy) is applied to Rotary Actuator when Actuator stops at the stroke end. Kinetic energy can be calculated by using the formula below.

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

E: Kinetic energy (J)
I : Moment of inertia (kg•m^2)
ω: Angular speed (rad/s)

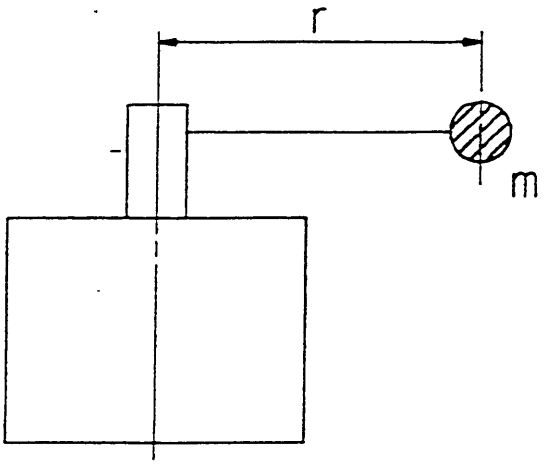
② Since allowable kinetic energy to Rotary Actuator is limited, limit of rotation time can be obtained by finding moment of inertia. How to find moment of inertia is described below.

Moment of inertia can be indicated by the formula below.

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

m: Mass (kg)

This is moment of inertia to rotation axis of an object with mass m in the distance r from the rotation axis.

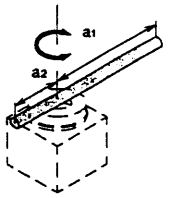


③ How To Calculate Moment of Inertia

Calculation of Moment of Inertia

I: Moment of inertia ($kg \cdot m^2$) m: Load mass (kg)

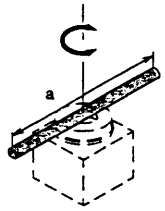
❶Thin rod



Position of pivot :
Passes through one end perpendicular to the rod.

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

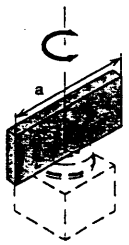
❷Thin rod



Position of pivot :
Passes through the center of gravity perpendicular to the rod.

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

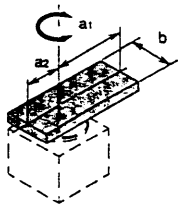
❸Thin rectangular plate (rectangular parallel piped)



Position of pivot :
Passes through the center of gravity, perallel to side b.

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

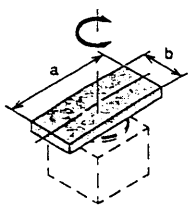
❹Thin rectangular plate (rectangular parallel piped)



Position of pivot :
Passes through one end perpendicular to the plate.

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

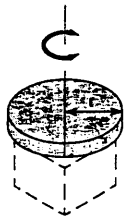
❺Thin rectangular plate (rectangular parallel piped)



Position of pivot :
Passes through the center of gravity perpendicular to the plate.
(Similar to thick rectangular plate)

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

❻Column (inclusive of thin disk)



Position of pivot :
Axis

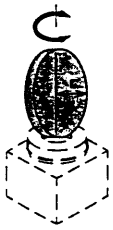
$$I=m \cdot \frac{r^2}{2}$$

❼Solid globe

Position of pivot :
Diameter

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

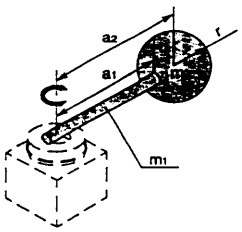
❽Thin disk



Position of pivot :
Diameter

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

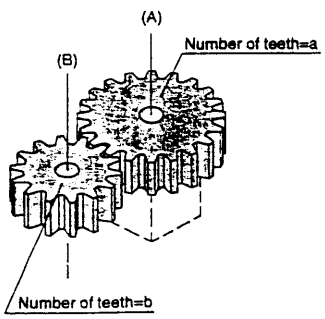
❾If load is in the end of lever



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

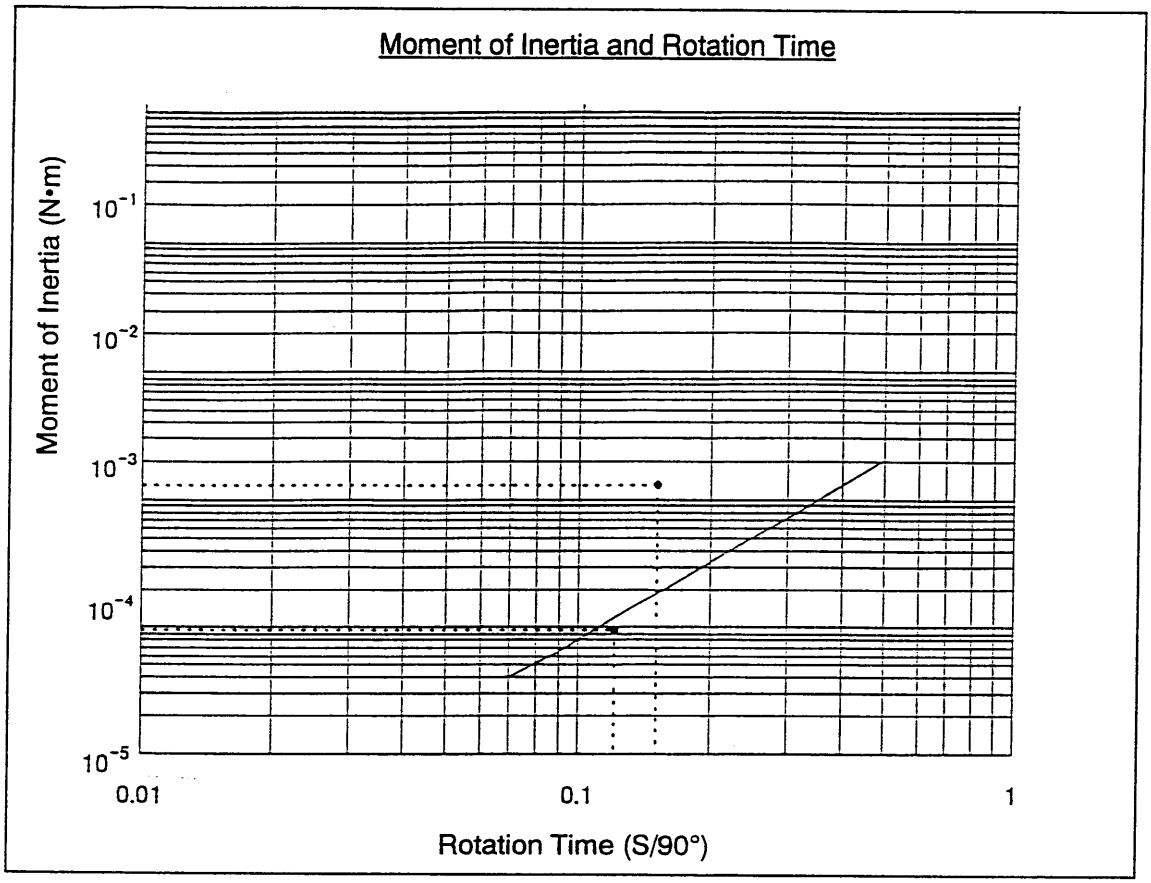
(Example)
When m_2 is spherical,
$K=m_2 \cdot \frac{2r^2}{5}$ according to ❼.

❿Propagation of gear



1. Find the moment of inertia I_B around the shaft (B).
2. Then replace the moment of inertia I_B around the shaft (A) by I_A

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



Graph 1

How To Read Graph 1

Example 1: When CRB2BW40 is used in conditions of moment of inertia of load: 9.5×10^{-5} kg•m^2 and rotation time: 0.12 sec/90°.

Since the intersection of 9.5×10^{-5} kg•m^2 on the vertical axis and 0.12 seconds on the horizontal axis is below the energy curve, CRB2BW40 is applicable.

Example 2: When CRB2BW40 is used in conditions of moment of inertia of load: 1.3×10^{-4} kg•m^2 and rotation time: 0.15 sec/90°.

Since the intersection of 1.3×10^{-4} kg•m^2 on the vertical axis and 0.15 seconds on the horizontal axis is above the energy curve, CRB2BW40 is not applicable. In this case, consider using larger size or external stopper (buffer mechanism) to stop the load itself.

5-2. Kinetic Energy

Allowable kinetic energy of CRB2BW40 is 0.04 (J) when rubber cushion is used, and it is 0.03 (J) when rubber cushion is not used.
Since Rotary Actuator reaches the rotation end during acceleration, terminal acceleration ω can be found by:

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

θ: Rotation angle rad
t : Rotation time s

Since kinetic energy E is:

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

Rotation time t of Rotary Actuator is:

$$t = \sqrt{\frac{2 \cdot I \cdot \theta^2}{E}}$$

E: Allowable kinetic energy (J)
I : Moment of inertia ($kg \cdot m^2$)
θ: Rotation angle (rad) 180°=3.14rad

In uniformly angular accelerated motion, angular speed ω and seconds of arc θ are found as follows.

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

$\theta = \int \dot{\omega} t \, dt = 1/2 \, \dot{\omega} t^2 + C$ ..... (2)

C is integration constant.

Since seconds of arc θ is θ=0 at t=0, integration constant C is C=0.

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

Therefore,

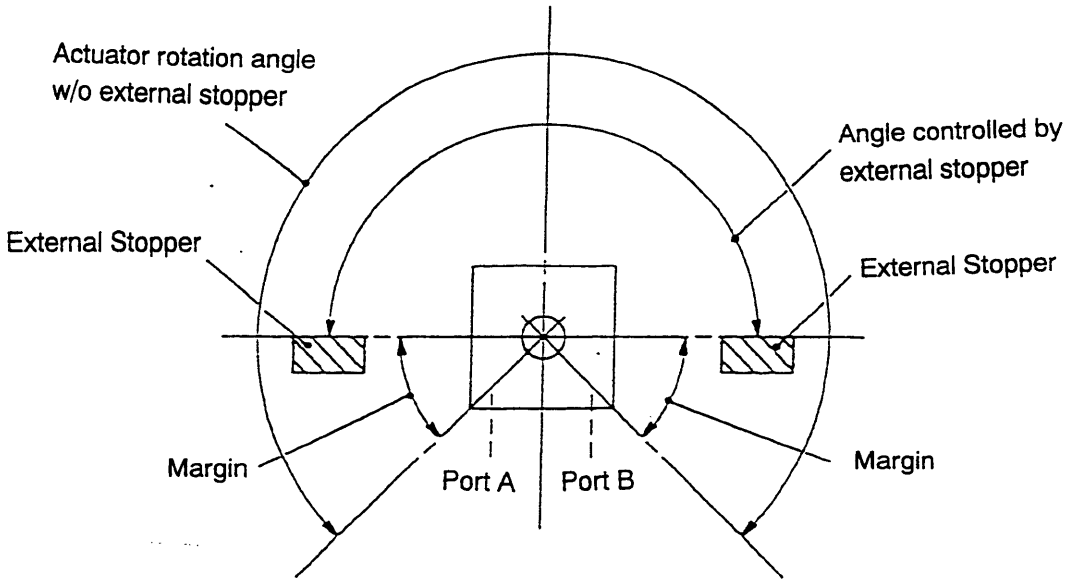
$\omega = 2\theta/t$

5-3. External Stopper

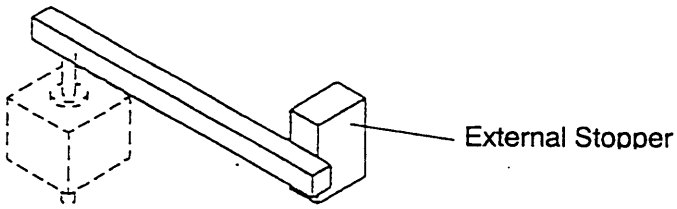
When kinetic energy generated by load exceeds allowable energy of Actuator, use external buffer mechanism to absorb inertia force.

The figure below shows correct installation of external stopper.

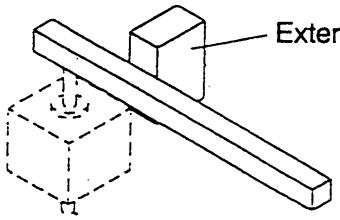
※Rotary Actuator itself has a slight angular error due to the construction, use external stopper when accurate positioning is required.



Proper Location



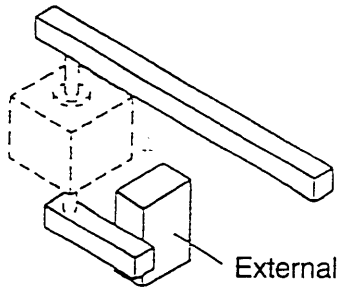
Improper Location



External Stopper becomes fulcrum and inertia of load is applied to shaft as bending moment.

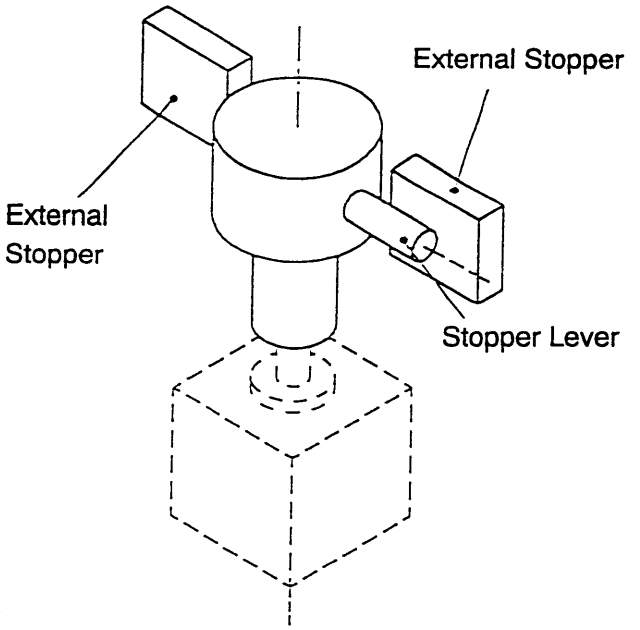
Improper Location

When buffer such as Shock Absorber is used, or when load is within allowable energy range, single rod can be used.

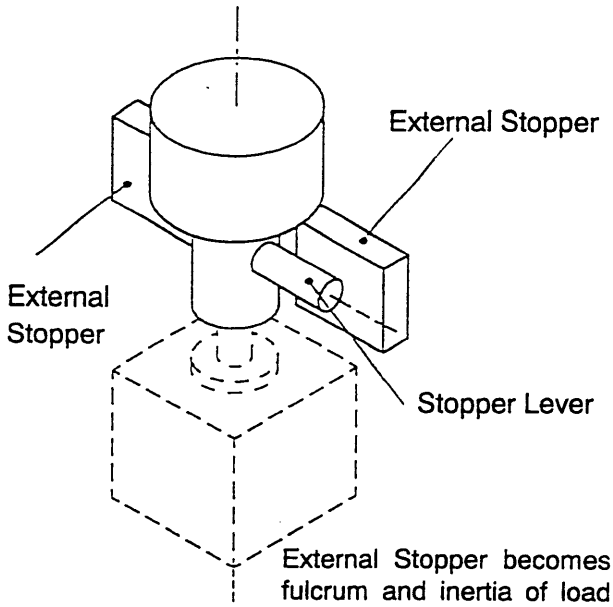


When external stopper is mounted to the other side of the rod where load is attached, inertia generated by the load is directly applied to the rod.

Proper Mounting



Improper Mounting



External Stopper becomes fulcrum and inertia of load is applied to shaft as bending moment.

Even when external stopper cannot be used, kinetic energy of load may be decreased by changing rotation speed, load mass and load shape to use the product. Figure 4 shows an example of lightening.

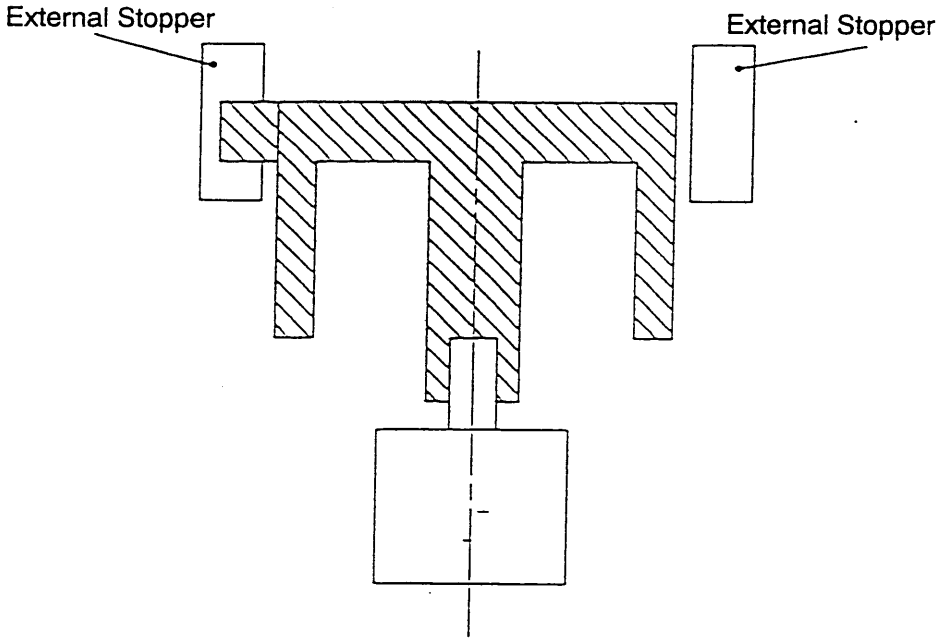
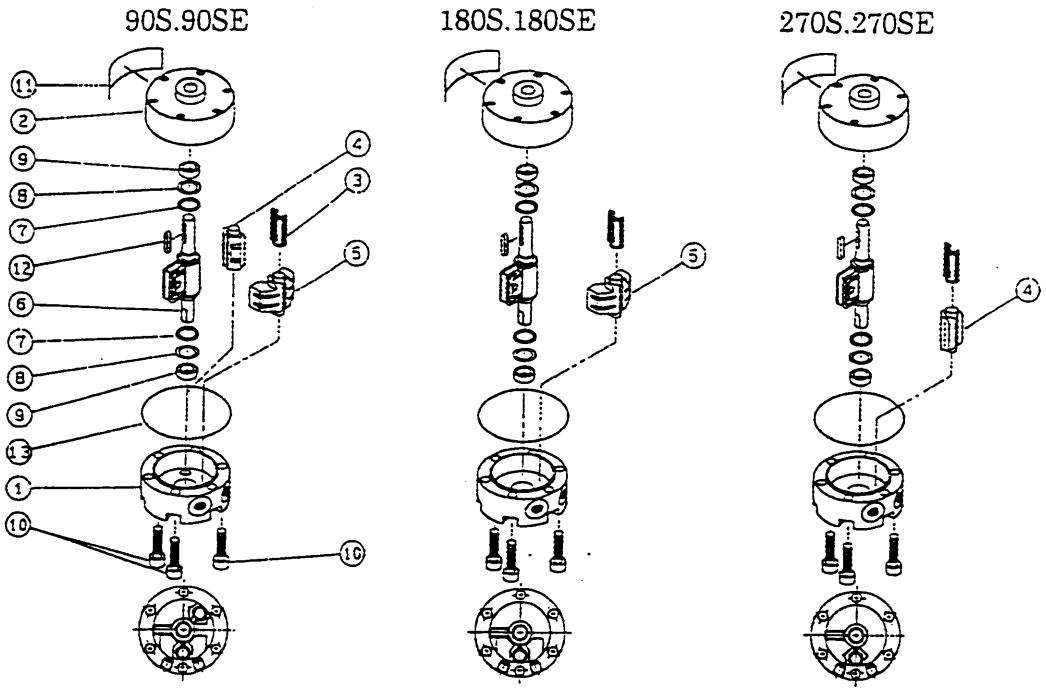


Figure 4

6. Maintenance and Check



- Be sure to install Air Filter to clean supply air.
- Do not disassemble the actuator. When disassembling it for unavoidable reason, follow the procedures below while preventing dust and/or foreign matter from entering. [Since increase in internal leakage causes malfunction in most cases, recheck speed controller. It is recommended to use stable speed adjusting range (refer to "Speed Adjusting Range" on page 1).]

CRB2BW40-90S, 90SE

[How To Disassemble]

① Remove Parallel Key ⑫.

② Remove Hexagon Socket Head Cap Screw ⑩.

③ Secure either Body (A)① or Body (B)② and push out Vane Shaft ⑥, then separate Body (A) from Body (B).

④ Remove Vane Shaft ⑥, Stoppers ④ and ⑤.

[How To Assemble]

① Mount O-ring ⑬ and Vane Shaft ⑥ to Body (B)②.

② Mount Stopper Packing ③ to Stopper ⑤.

③ Mount Stoppers ④ and ⑤ to Body (B)②. (Note: Be careful of stopper position)

④ Insert Body (A)① into Vane Shaft ⑥.

⑤ Tighten Body (A)① and Body (B)② with Hexagon Socket Head Cap Screw ⑩. (Tightening torque: 4 to 6 N•m)

[Notes]

① Since any product disassembled will not be guaranteed, fully understand the internal construction before disassembling.

② Exercise caution not to damage packing when reassembling.

③ Use caution to prevent damage to sliding surfaces of Body (A)①, Body (B)② and Vane Shaft ⑥.

④ Rubber of Vane Shaft ⑥ cannot be removed due to baking adhesion.

7. Troubleshooting

Failure	Cause	Countermeasure
Actuator does not operate. Adjust speed controller and check that rotation speed of Actuator is within the specified speed adjusting range.	Stable speed adjusting range is not satisfied.	Use the product within the specified speed adjusting range.
	Increase in internal leakage due to internal packing damage caused by foreign matter and/or oil.	Replace the vane shaft and stopper packing (In general, the product requires replacement).
	Sealing failure of internal packing or increase in internal resistance due to the use out of the specified operating temperature range (including freezing).	Use the product within the specified operating temperature range (In some cases of sealing failure, the vane shaft and stopper packing require replacement).
	Failure of peripheral components: a. Improper adjusting of speed controllers b. Malfunction of solenoid valves c. Air supply shortage due to clogging of air filter d. Decrease in pressure due to failure of regulator	Use special products (including measures against problems of pneumatic circuit).
Shaft breakage	Large load energy: a. Large load mass b. Fast operating speed c. Long rotation radius	Replace the shaft: a. Use the product within the allowable energy range. b. Install cushioning device and external stopper to absorb impact energy.
	External force other than load energy is applied.	Replace the shaft. Avoid excessive external force.
	Offset load due to de-centering	Replace the shaft.
Rotation angle failure	Breakage of the connection part of the rotation axis or internal stopper	Replace the connection part or product.
Bearing breakage	Overload (Loads in radial and thrust directions are too heavy)	Replace bearing: Make radial and thrust loads be within the allowable range.
	Offset load due to decentering	Replace bearing: Correct de-centering.
	Large vibration	Replace bearing: Absorb vibration.

External leakage	Sealing failure of O-ring due to bearing damage and/or shaft bending	Replace the bearing and/or shaft. Relieve external force.
	O-ring damage due to foreign matter and/or oil	Replace the O-ring.
Internal leakage (Excluding increase in internal leakage due to life)	Packing damage due to foreign matter and/or oil	Replace the vane shaft and stopper packing (In general, the product requires replacement). Prevent foreign matter and oil entrance.
	Sealing failure of packing due to the use out of the specified operating temperature range	Replace the vane shaft and stopper packing (The product requires replacement especially for the use at high temperature). Use the product within the specified operating temperature range.

Notice on Trouble and Troubleshooting

1. Life is excluded from the causes.
2. Consult SMC for any causes other than those in the table above (except life) since the product may require disassembling check.