



Document No.:MSQB-OM00002

---

# Operation Manual

---

## Rotary Table

---

MSQB1, 2, 3, 7

---

---

---

---

---

---

---

- Please read this operation manual throughout before installing and operating this product.
- Please read a description on safety instructions with special care.
- Please keep this operation manual with you so that you can read it whenever you need it.



Series MSQB

## Safety Instructions

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



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



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



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



### Warning

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

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

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

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

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

1. Inspection and maintenance of machinery/equipment should only be performed after confirmation of safe locked-out control positions.
2. When equipment is to be removed, confirm the safety process as mentioned above. Then cut the supply pressure for this equipment and exhaust all residual compressed air in the system.
3. Before machinery/equipment is re-started, confirm if appropriate measures have been taken to prevent shooting out of cylinder piston rod.

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

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

## Precautions on 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 change that it will pose a hazard to humans, install a protective cover.**

If the moving portion of the product will pose a hazard to humans or damage the machinery of 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 There maybe cases in which a shock absorber is required.**

If the driven object moves at high speeds or has a large mass, there is a possibility that it might exceed allowable kinetic energy of rotary table. Therefore, provide an external shock absorber to dampen the shocks before reaching the rotation end. If these countermeasures are taken, make sure to take the rigidity of the mechanical equipment into consideration.

- 5 Consider the possibility of a reduction in the circuit air pressure that could be caused by power outages.**

When the product is used for a clamping, if the circuit air pressure is reduced due to a power outage, the clamping force could decrease, thus creating a hazardous situation in which the work piece is released. Therefore, make sure to integrate safety features that will prevent hazards to humans or damage to the equipment.

- 6 Consider possibility of power source related malfunction that could occur.**

On the pieces of equipment that rely on power sources such as compressed air, electricity, or hydraulic pressure, adopt a countermeasure that will prevent these pieces of equipment from causing hazards to humans or damage to the equipment in the event of a malfunction in these power sources.

- 7 If a speed controller is provided in the exhaust restrictor, implement a safety design taking the residual pressure into consideration.**

If air pressure is applied to the air supply side without residual pressure in the exhaust side, the rotary actuator will operate at abnormally high speeds, which could pose a hazard to humans and damage the machinery and equipment.

**8 Consider the behavior of the rotary table in the event of an emergency stop.**

Design a device that ensures safety so that the if a person engages the emergency stop, or if a safety device is tripped during a system malfunction such as a power outage, the halting of the machine will not cause the movement of the rotary table to pose a hazard to humans or damage the equipment

**9 Consider the behavior of the rotary table when restarting after an emergency stop.**

Design a device that ensures safety so that the restarting of the rotary table will not pose a hazard to humans or damage the equipment. If it is necessary to reset the rotary table to its starting position, make sure to provide a safe, manually operated control device.

**10 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 affected, which could pose a hazard to humans and damage the machinery and equipment.

<b>Selection</b>
------------------

 **Warning**

**1. Select a speed within the product's allowable energy value.**

If a product is used in a state in which the kinetic energy of the load exceeds the allowable value, it could damage the product, which could pose a hazard to humans and damage the machinery and equipment.

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

If the product is used in a state in which the kinetic energy exceeds the allowable value, it could damage the product, which could pose a hazard to humans and damage the machinery and equipment.

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

With the 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 equipment.



### **Caution**

**1. Do not operate the product in the low speed range below the speed adjustment range specified for the product.**

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

**2. Do not apply 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. 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 the product under hydraulic pressure.**

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

<b>Mounting</b>
-----------------



### **Warning**

**1. 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 posture of the equipment. As a result, it could pose a hazard to humans and damage the machinery and equipment.

2. **Do not loosen the angel adjustment screw beyond the allowable adjustment range.**

The angle adjustment screw could pull out if it is loosened beyond its allowable adjustment range, which could pose a hazard to humans and damage the machinery and equipment.

3. **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 table could operate suddenly, which could pose a hazard to humans and damage the machinery and equipment.

4. **Do not modify the product.**

By modifying the product, its strength could be affected, which could lead the product to break. As a result, it could pose a hazard to humans and damage the machinery and equipment.

5. **Do not enlarge the fixed throttle by modifying the pipe connectors.**

If the hole diameter is enlarged, the product's rotation speed increases, causing the shock force to increase and damage the product. As a result, it could pose a hazard to humans and damage the machinery and equipment.

6. **If shaft couplings are to be 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.



## Caution

1. **Do not hit the table by securing the body or hit the body by securing the table.**

These actions could damage the internal parts or bearing. When a load must be coupled to the table, do not secure the table.

2. **Do not place your foot directly on the load that is coupled to the table.**

Placing one's weight directly onto the table could cause the internal parts or bearing to become damaged.

3. **If a product is equipped with an angle adjustment function, use it within the specified adjustment range.**

If the product is used by outside the specified adjustment range, it could lead to equipment malfunction or product damage.

<b>Air supply</b>
-------------------



## Warning

1. **Use clean air.**

Do not use compressed air that contains synthetic oil, salt, and corrosive gases in which chemicals and organic solvents are present, because it could cause equipment damage or malfunction.



## Caution

- 1. Install an air filter.**  
Install an air filter upstream, near the valve. Select an air filter with an filtration degree of  $5\ \mu\text{m}$  or finer.
- 2. Take appropriate measures to ensure air quality, such as by providing an after cooler, air dryer, or drain catch.**  
Compressed air that contains a large amount of drainage could cause the rotary table or other types of pneumatic equipment to malfunction. Therefore, take appropriate measures to ensure air quality, such as by providing an after cooler, air dryer, or drain catch.
- 3. Ensure that the fluid and ambient temperature are within the specified range.**  
If the fluid temperature is below  $5^{\circ}\text{C}$ , the moisture in the circuit could freeze, causing damage to the seals and leading to equipment malfunction. Therefore, take appropriate measures to prevent freezing. For detailed information regarding the quality of the compressed air described above, refer to SMC's "Air Cleaning Systems".

## Environment



## Warning

- 1. Do not use the rotary table in an environment or location that poses the risk of corrosion.**  
Refer to the respective construction diagram for details on the materials used in the rotary table.
- 2. Do not use the rotary table in an area that contains a large amount of dust, or an area in which water or oil could be splashed on the rotary table.**

## Speed and Bumper 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

### **Caution**

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

## Maintenance

### **Warning**

1. **Follow the procedures given in the operation manual to perform a maintenance inspection**  
Improper handling could lead to malfunction or damage the machinery and equipment.
2. **During a maintenance inspection, do not disassemble the equipment with electrical power or an air supply applied.**
3. **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 type of grease that is used for the respective product.**  
The use of a non-designated lubricant could damage the seals.

## Auto switch precautions

## Design & selection

### **Warning**

1. **Confirm the specifications.**



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

**2. Take precautions when actuators are used close together.**

When multiple auto switch actuators are used in close proximity, magnetic field interference may cause the auto switches to malfunction. Maintain a minimum separation of 10mm.

**3. Wiring should be kept as short as possible.**

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

**4. Take precautions for the internal voltage drop of the auto switch.**

Generally, the internal voltage drop will be greater with a 2 wire solid state auto switch than with a lead switch. Also, note that a 12VDC relay is not applicable.

**5. Pay attention to leakage current.**

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

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

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.**

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

**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.

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

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

## Mounting & Adjustment



### Warning

- 1. Do not drop or bump**  
Do not drop, bump or apply excessive impacts (1000m/s<sup>2</sup> or more for solid state switches) while handling. Although the body of the switch may not be damaged, the inside of the switch could be damaged and cause a malfunction.
- 2. Do not carry a rotary table by the auto switch lead wires.**  
Never carry a rotary table by its lead wires. This may not break the lead wires, but it may cause internal elements of the switch to be damaged by the stress.
- 3. Mount switches using the proper fastening torque.**

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

- 4. Mount a switch at the center of the operating range.**  
Adjust the mounting position of an auto switch so that the shaft stops at the center of the operating range (the range in which a switch in 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 border line of ON and OFF), operation will be unstable.

## Wiring



### Warning

- 1. Avoid repeatedly bending or stretching lead wires.**  
Broken lead wires will result from applying bending stress or stretching forces to the lead wires.
- 2. Be sure to connect the load before power is applied.**  
<2 wire type>  
If the power is turned ON when an auto switch is not connected to a load, the switch will be instantly damaged because of excess current.
- 3. Confirm proper insulation of wiring.**

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

- 4. Do not wire with power lines or high voltage lines.**  
Wire separately from power lines or high voltage lines, avoiding parallel wiring or wiring in the same conduit with these lines. Control circuits, including auto switches, may malfunction due to noise from these other lines.
- 5. Do not allow short circuit of loads.**

All models of PNP output switches do not have built-in short circuit prevention circuits. If loads are short circuited, the switches will be instantly damaged. Take special care to avoid reverse wiring with the brown (red) power supply line and the black (white) output line on 3 wire type switches.

**6. Avoid incorrect wiring.**

- 1) If connections are reversed on a 2 wire type switch, the switch will not be damaged if protected by a protection circuit, but the switch will always stay in an ON state. However, it is still necessary to avoid reversed connections, since the switch could be damaged by a load short circuit in this condition.
- 2) If connections are reversed (power supply line + and power supply line-) on a 3 wire type switch, the switch will be protected by a protection circuit. However, if the power supply line (+) is connected to the blue (black) wire and the power supply line (-) is connected to the black (white), the switch will be damaged.

<b>Operating environment</b>
------------------------------



**Warning**

**1. Never use in an atmosphere with explosive gases.**

The structure of auto switches is not designed 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 will become demagnetized. (Consult SMC regarding the availability of a magnetic field resistant auto switch.)

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

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

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

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

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

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

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

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

When there are units (solenoid lifter, high frequency induction furnace, motor, etc.) which generate a large amount of surge in the area around rotary table where solid state auto switches are mounted, this may deteriorate or damage to the switch. Avoid sources of surge generation and disorganized lines.

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

When a large amount of ferrous powder such as machining chips or spatter is accumulated, or a magnetic substance is brought into close proximity with an auto switch cylinder, it may cause the auto switch to malfunction due to a loss of the magnetic force inside the cylinder.

<b>Maintenance</b>
--------------------



**Warning**

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

- 1) Secure and tighten switch mounting screws. If screws become loose or the mounting position is dislocated, retighten them after readjusting the mounting position.
- 2) Confirm that there is no damage to lead wires. To prevent faulty insulation, replace switches or repair lead wires, etc., if damage is discovered.

<b>Other</b>
--------------



**Warning**

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

1. Model

1-1. How to order

Basic

M S Q B 1 A E - F9B S

Size
1
2
3
7

A With adjusting bolt

Connect port	
—	Side
E	Front

No. of auto switches	
—	2
S	1
n	n

Auto switch

— No auto switch (built in magnet)

See following table for applicable auto switch

Applicable auto switch

Type	Special function	Lead wire entry	Indicator	Wiring (Output)	Load voltage		Lead wire length(mm)	Auto switch part No.		Applicable load					
					DC	AC		Perpendicular	In-line						
Solid state switch	—	Grommet	Yes	3 wire (NPN)	24V	5V	—	0.5	F8N	F9N	IC circuit	Relay PLC			
						12V		3	F8NL	F9NL					
				3 wire (PNP)	—	—	0.5	F8P	F9P						
					—	—	3	F8PL	F9PL						
				2 wire	24V	12V	0.5	F8B	F9B						
						—	—	3	F8BL	F9BL					
	Diagnosis indicator (2 color)			3 wire (NPN)	5V	12V	—	—	0.5		F9NW			IC circuit	
									3		F9NWL				
				3 wire (PNP)	—	—	—	—	—	0.5			F9PW		
										3			F9PWL		
				2 wire	24V	12V	—	—	—	0.5			F9BW		
										3			F9BWL		
	NC (Normal Close)	3 wire (NPN)	24V	5V	12V	—	—	0.5		F9G	IC circuit				
								3		F9GL					
		3 wire (PNP)	—	—	—	—	—	0.5		F9GZ					
								3		F9HL					

## 2. Specification

### 2-1. Specification

Size	1	2	3	7
Operating Fluid	Air (Non-lube)			
Max. Operating Pressure	0.7MPa			
Min. Operating Pressure	0.1MPa			
Ambient and Fluid Temperature	0~60°C(No condensation)			
Cushion	No cushion		Lubber cushion	
Angle adjusting range	0~190°			
Max. rotation angle	190°			
Piston diameter	φ 6	φ 8	φ 10	φ 12
Port size	M3 × 0.5			M5 × 0.8

### 2-2. Allowable kinetic energy and rotation time regulation range

Size	Allowable kinetic energy(mJ)	Stable rotation time regulation range (s/90° )
1	1	0.2~0.7
2	1.5	
3	2	
7	6	0.2~1.0

Note 1) Please use within the stable rotation time regulation range, since low speed operation exceeding the range may lead stick-slip or stop of operation.

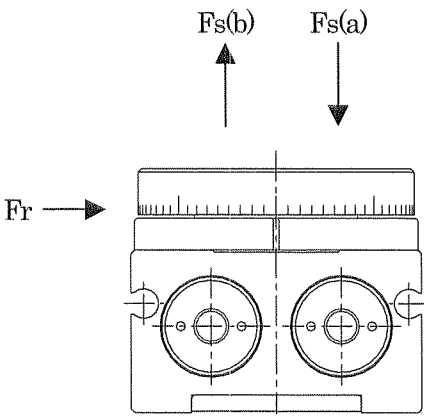
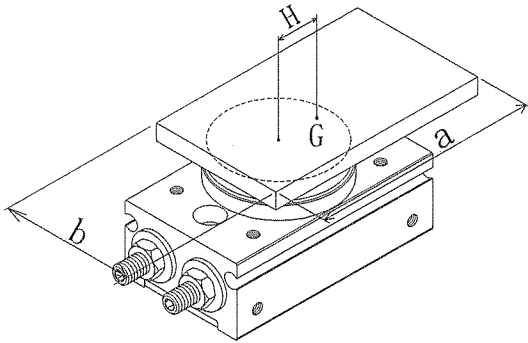
### 2-3. Weight

Size	1	2	3	7
Basic	75	105	150	250

g

### 3. Cautions on Model selection

Follow procedures below for selecting models.

Selection Procedure	Formula	Selection Example
<p>① Operating condition</p> <p>Enumerate operating condition according to mounting position.</p> 	<ul style="list-style-type: none"> <li>• Model</li> <li>• Operating pressure</li> <li>• Mounting posture</li> <li>• Type of load <ul style="list-style-type: none"> <li>Ts (N·m)</li> <li>Tf (N·m)</li> <li>Ta (N·m)</li> </ul> </li> <li>• Shape of load</li> <li>• Rotation time t(s)</li> <li>• Rotation angle</li> <li>• Mass of load m(kg)</li> <li>• Distance between shaft center and center of gravity H(mm)</li> <li>• Distance of mass point L(mm)</li> </ul>	 <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Rotary table : MSQB3A            Pressure : 0.4 MPa Mounting: Vertical            Type of load : Inertial load Ta            Shape of load 1 : 50mm × 30mm (Rectangular plate)            Rotation time t : 0.4 sec. Rotation angle : 90°            Mass m<sub>1</sub> of load 1: 0.06kg            Distance between shaft center and center of gravity H: 20mm</p> </div>
<p>② Required torque</p> <p>Check the load type below and select the actuator, which meets required torque.</p> <ul style="list-style-type: none"> <li>• Static load : Ts</li> <li>• Resistance load : Tf</li> <li>• Inertial load : Ta</li> </ul> <p style="text-align: right;"><b>Type of load</b></p>	<p>Effective torque <math>\geq Ts</math>            Effective torque <math>\geq (3\sim 5) \cdot Tf</math>            Effective torque <math>\geq 10 \cdot Ta</math></p> <p style="text-align: center;"><b>Effective torque</b></p>	<p>Inertia load</p> $10 \times Ta = 10 \times 1 \times \omega$ $= 10 \times 41.0 \times 10^{-6} \times (2 \times (\pi/2)/0.4^2)$ $= 0.0081 \text{ N} \cdot \text{m} < \text{Effective torque}$ <p style="text-align: center;"><b>OK</b></p> <p>Note : Input value of ⑤ moment of inertia for "I".</p>
<p>③ Rotation time</p> <p>Check if it is within the adjustable rotation time range.</p>	<p>0.2~0.7s/90° (Size 1, 2, 3)            0.2~1.0s/90° (Size 7)</p>	<p>0.4s/90° <b>OK</b></p>
<p>④ Allowable load</p> <p>Check if radial load and thrust load is within the allowable range.</p>	<p>Thrust load : <math>m \times 9.8 \leq \text{Allowable load}</math>            (Moment : <math>m \times 9.8 \times H \leq \text{Allowable Moment}</math>)</p> <p style="text-align: center;"><b>Allowable load</b></p>	<p><math>0.06 \times 9.8 = 0.59 \text{ N} &lt; \text{Allowable load}</math> <b>OK</b>  <math>0.06 \times 9.8 \times 0.02 = 0.0118 \text{ N} \cdot \text{m}</math>  <math>0.0118 \text{ N} \cdot \text{m} &lt; \text{Allowable moment}</math> <b>OK</b></p>
<p>⑤ Moment of inertia</p> <p>Calculate moment of inertia of load "I" to find out energy.</p>	$I = m \times (a^2 + b^2)/12 + m \times H^2$ <p style="text-align: center;"><b>Moment of inertia</b></p>	$I = 0.06 \times (0.05^2 + 0.03^2)/12 + 0.06 \times 0.02^2$ $= 41.0 \times 10^{-6} \text{ kg} \cdot \text{m}^2$
<p>⑥ Kinetic energy</p> <p>Check if kinetic energy of the load is within the allowable range.</p>	$1/2 \times I \times \omega^2 \leq \text{allowable energy}$ $\omega = 2\theta/t (\omega : \text{angle speed at the end})$ <p>θ : Rotation angle(rad)            t : Rotation time (s)</p> <p style="text-align: center;"><b>Kinetic energy/Rotation time</b></p>	$1/2 \times 41.0 \times 10^{-6} \times (2 \times (\pi/2)/0.4)^2$ $= 1.26 \text{ mJ} < \text{Allowable energy}$ <p style="text-align: center;"><b>OK</b></p>

### 3-1 Effective torque

#### Effective torque

- Calculate required torque for rotation, based on the object.

Static load :  $T_s$

Resistance load :  $(3\sim 5) \cdot T_f$

Inertia load :  $10 \cdot T_a$  or more

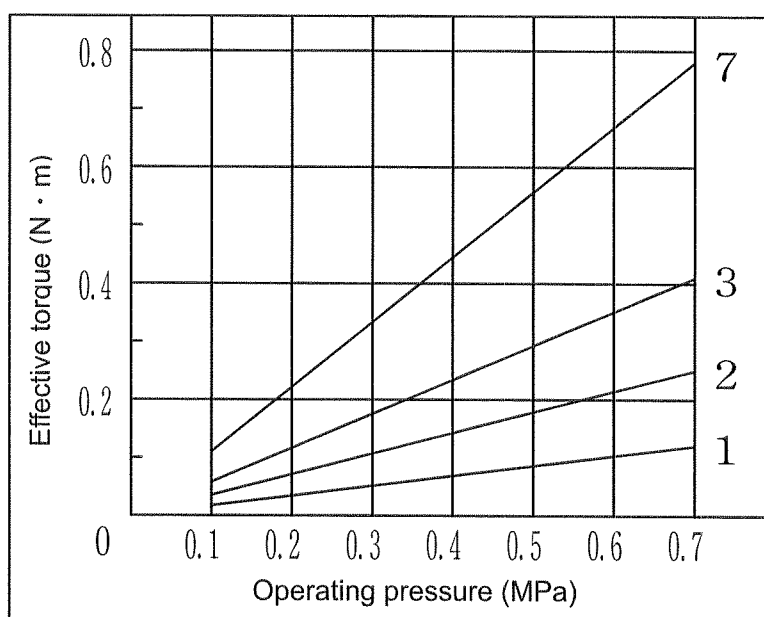
- Determine the operating pressure
- Determine appropriate size according to the table of effective torque.

Table 1. Effective torque

Unit :  $N \cdot m$

Size	Operating pressure (MPa)						
	0.1	0.2	0.3	0.4	0.5	0.6	0.7
1	0.017	0.035	0.052	0.070	0.087	0.10	0.12
2	0.035	0.071	0.11	0.14	0.18	0.21	0.25
3	0.058	0.12	0.17	0.23	0.29	0.35	0.41
7	0.11	0.22	0.33	0.45	0.56	0.67	0.78

Graph 1





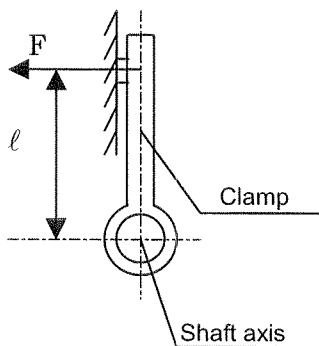
## Load type

### ● Static load: $T_s$

The load represented by the clamp which requires pressing force only.

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

(Example)



F: Pressing force

Static torque calculation

$$T_s = F \times l \text{ (N} \cdot \text{m)}$$

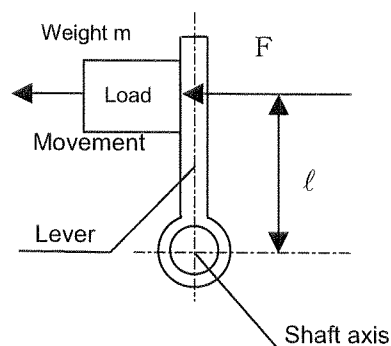
### ● Resistance load: $T_f$

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

\*Actuator effective torque  $\geq (3 \text{ to } 5) T_f$

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

(Example)



Friction coefficient  $\mu$

$$F = \mu mg$$

Static torque calculation

$$T_f = F \times l \text{ (N} \cdot \text{m)}$$

$$g = 9.8 \text{ m/s}^2$$

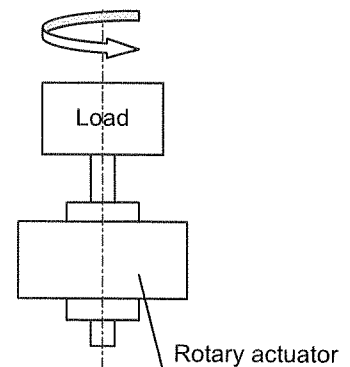
### ● Inertia load: $T_a$

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

\*Actuator effective torque  $\geq S \cdot T_a$

(S is 10 times or more.)

Accelerating torque calculation



$$T_a = I \cdot \dot{\omega} \text{ (N} \cdot \text{m)}$$

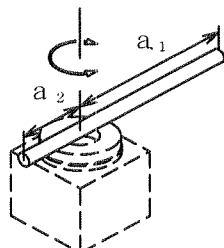
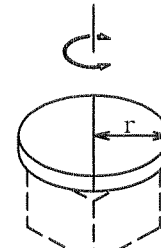
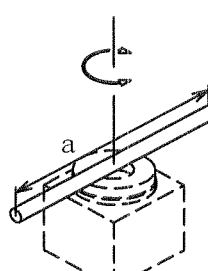
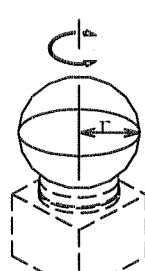
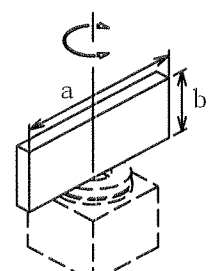
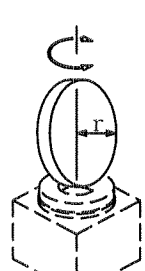
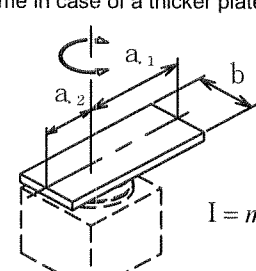
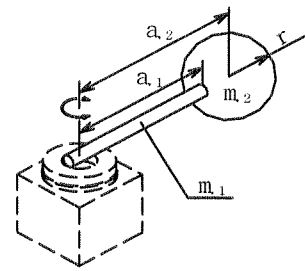
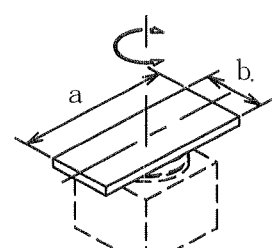
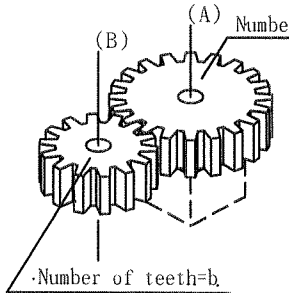
I : Moment of Inertia

$\dot{\omega}$  = Angular acceleration

$\theta$  = Rotation angle (rad)

t = Rotation time (s)

$$\dot{\omega} = \frac{2\theta}{t^2} \text{ (rad/s}^2\text{)}$$

<p>① Thin shaft</p> <p>Position of rotational axis: Perpendicular to the shaft through one end</p>  $I = m_1 \cdot \frac{a_1^2}{3} + m_2 \cdot \frac{a_2^2}{3}$	<p>⑥ Column(including thin round plate)</p> <p>Position of rotational axis: Central axis</p>  $I = m \cdot \frac{r^2}{2}$
<p>② Thin shaft</p> <p>Position of rotational axis: Through the shaft's center of gravity</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑦ Solid sphere</p> <p>Position of rotational axis: Diameter</p>  $I = m \cdot \frac{2r^2}{5}$
<p>③ Thin rectangular plate(rectangular parallelepiped)</p> <p>Position of rotational axis: Through the plate's center of gravity</p>  $I = m \cdot \frac{a^2}{12}$	<p>⑧ Thin round plate</p> <p>Position of rotational axis: Diameter</p>  $I = m \cdot \frac{r^2}{4}$
<p>④ Thin rectangular plate(rectangular parallelepiped)</p> <p>Position of rotational axis: Perpendicular to the shaft through one end (also the same in case of a thicker plate)</p>  $I = m_1 \cdot \frac{4a_1^2 + b^2}{12} + m_2 \cdot \frac{4a_2^2 + b^2}{12}$	<p>⑨ Load at end of lever</p>  $I = m_1 \cdot \frac{a_1^2}{3} + m_2 \cdot a_2^2 + K$ <p>(Example)When shape of m<sub>2</sub> is a sphere refer to 7 and K=m<sub>2</sub> · <math>\frac{2r^2}{5}</math></p>
<p>⑤ Thin rectangular plate(rectangular parallelepiped)</p> <p>Position of rotational axis:Through the center of gravity and perpendicular to the plate (also the same in case of a thicker plate)</p>  $I = m \cdot \frac{a^2 + b^2}{12}$	<p>⑩ Gear transmission</p>  <ol style="list-style-type: none"> <li>1. Find the moment of inertia <math>I_B</math> for the rotation of shaft (B).</li> <li>2.Next, <math>I_B</math> is entered to find <math>I_A</math> the moment of inertia for the rotation of shaft (A) as</li> </ol> $I_A = \left(\frac{a}{b}\right)^2 \cdot I_B$



There is a limitation of kinetic energy allowed by a rotary table, and the limit value of the rotation time can be found by calculating the moment of inertia. The moment of inertia indicates the difficulty of turning an object, or conversely, the difficulty of stopping an object which is turning and is calculated by size of the object, shape and weight.

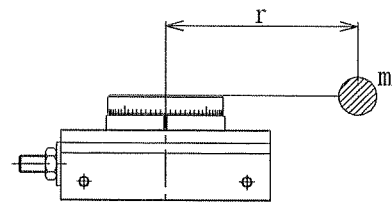
How to find the moment of inertia is explained below.

Basic formula of moment of inertia is indicated as

$$I = m \cdot r^2 \quad m : \text{mass } kg$$

This indicates the moment of inertia for rotation axis of an object with mass “m” which is a distance “r” from the rotation axis.

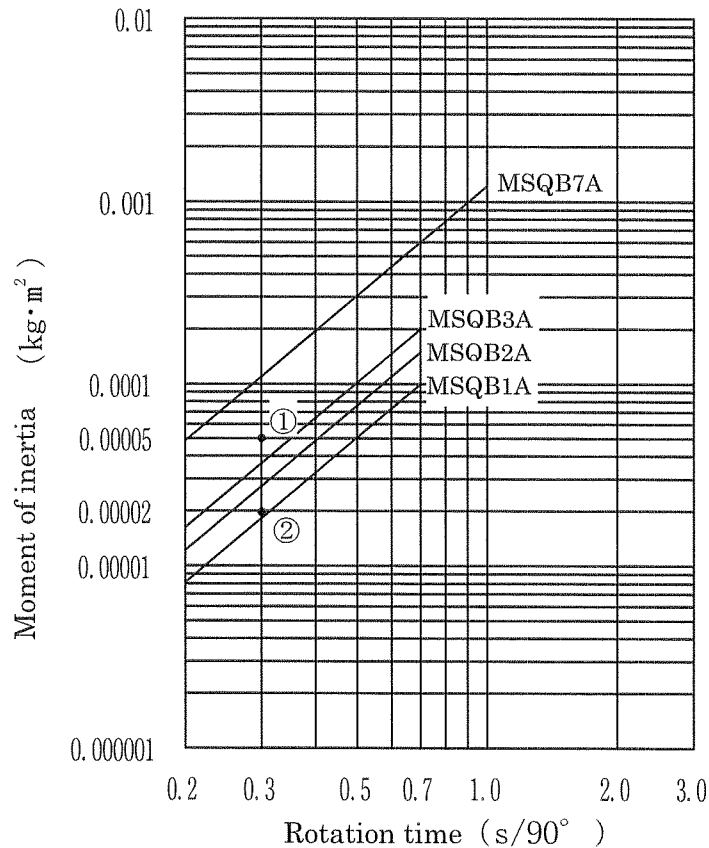
Formula of moment of inertia is subject to load shape. Document 2 shows formula to calculate moment of inertia for each shape.



③ Selection of a model

Select a model by applying the calculated moment of inertia to the chart below. I.

Graph 2. Moment of inertia - Rotation time diagram



1 <How to read the diagram>

- Moment of inertia ... $0.05 \times 10^{-3}$
- Rotation time ... $0.3\text{s}/90^\circ$

In this case, MSQB7A is selected.

2 <Calculation>

Shape of load: Column with radius 0.02m, Weight 0.01

Rotation time:  $0.3\text{s}/90^\circ$

$$I = 0.01 \times \frac{0.02^2}{2} = 0.02 \times 10^{-3} \text{ kg} \cdot \text{m}^2$$

In the chart that depicts the moment of inertia and the rotation time, find the intersecting point of the lines that extend from the locations corresponding to  $0.004\text{kg}/\text{m}^2$  on the vertical axis (moment of inertia) and to  $0.9\text{s}/90^\circ$  on the horizontal axis (rotation time). Select MSQB2A because the intersecting point is found within the selection range for MSQB2A.

## 4. Setting

### 4-1. Limitation of load applied to table

Set the load to be applied to the table within the allowable values shown in the table below. (Values outside of limitations will cause excessive play, deteriorate accuracy, and shorten service life.)

Table 3. Allowable shaft load

Size	Allowable radial load (N)	Allowable thrust load(N)		Allowable moment (N · m)
		(a)	(b)	
1	31	41	41	0.56
2	32	45	45	0.82
3	33	48	48	1.1
7	54	71	71	1.5

In the condition where dynamic load does not generate, allowable radial and thrust load are acceptable, however, please avoid such usage that load is directly applied to the table, as much as possible. For better operating condition, it is advisable to use as following figures to avoid load to be applied directly to the table,

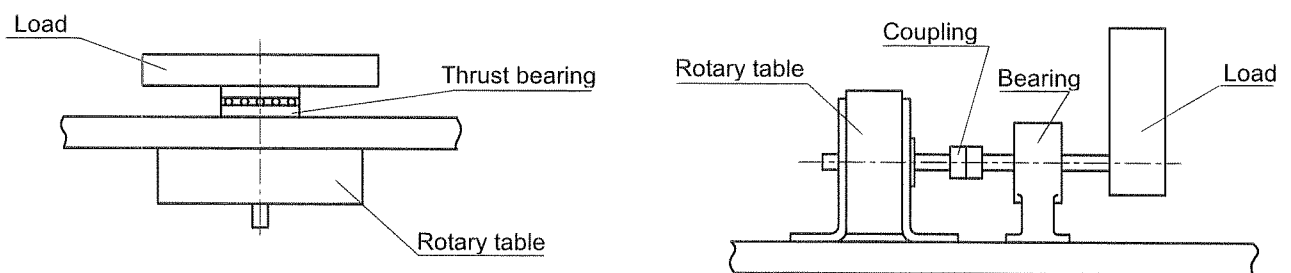


Figure 1

#### 4-2. Use of coupling

As shown in the figure 2, when shaft of rotary table is extended, centering of rotary table shaft and shaft of the other is necessary. In case used with decentered, load factor increases locally, causing excessive bending moment to be applied to the table. In such condition, stable operation cannot be acquired and breakage of the article may occur. In such case, it is required to use flexible coupling (such as Flexible shaft coupling, specified by JIS.)

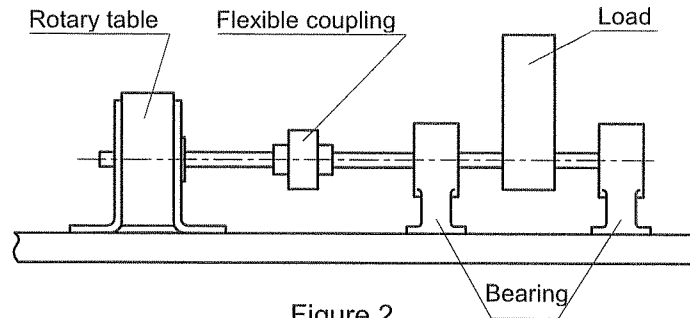
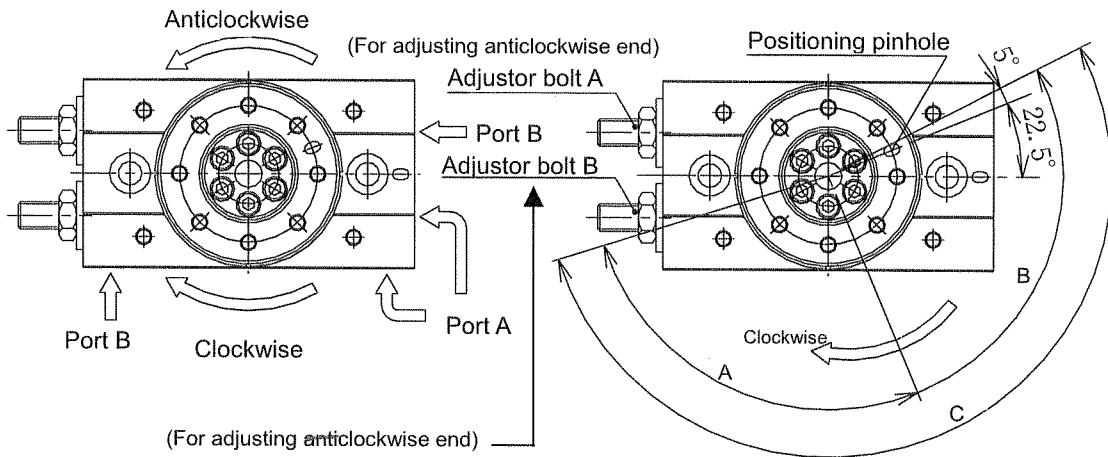


Figure 2

#### 4-3 Rotation direction and rotation angle

-When the pressurized from port A, the shaft rotates clockwise and to anticlockwise when pressurized from port B.

-To obtain the desired rotation angle, the rotation ends can be set within the range shown in the diagram by regulating the adjustment bolt.



- A. Clockwise rotation end adjustable range 95°
- B. Anticlockwise rotation end adjustable range 95°
- C. Max. rotation range 190°

#### Note)

- The figure shows rotation range of positioning pinhole.
- Position of pinhole in the figure shows anticlockwise rotation end when the rotation angle is set at 180° by equally tightening the adjusting bolts A and B.

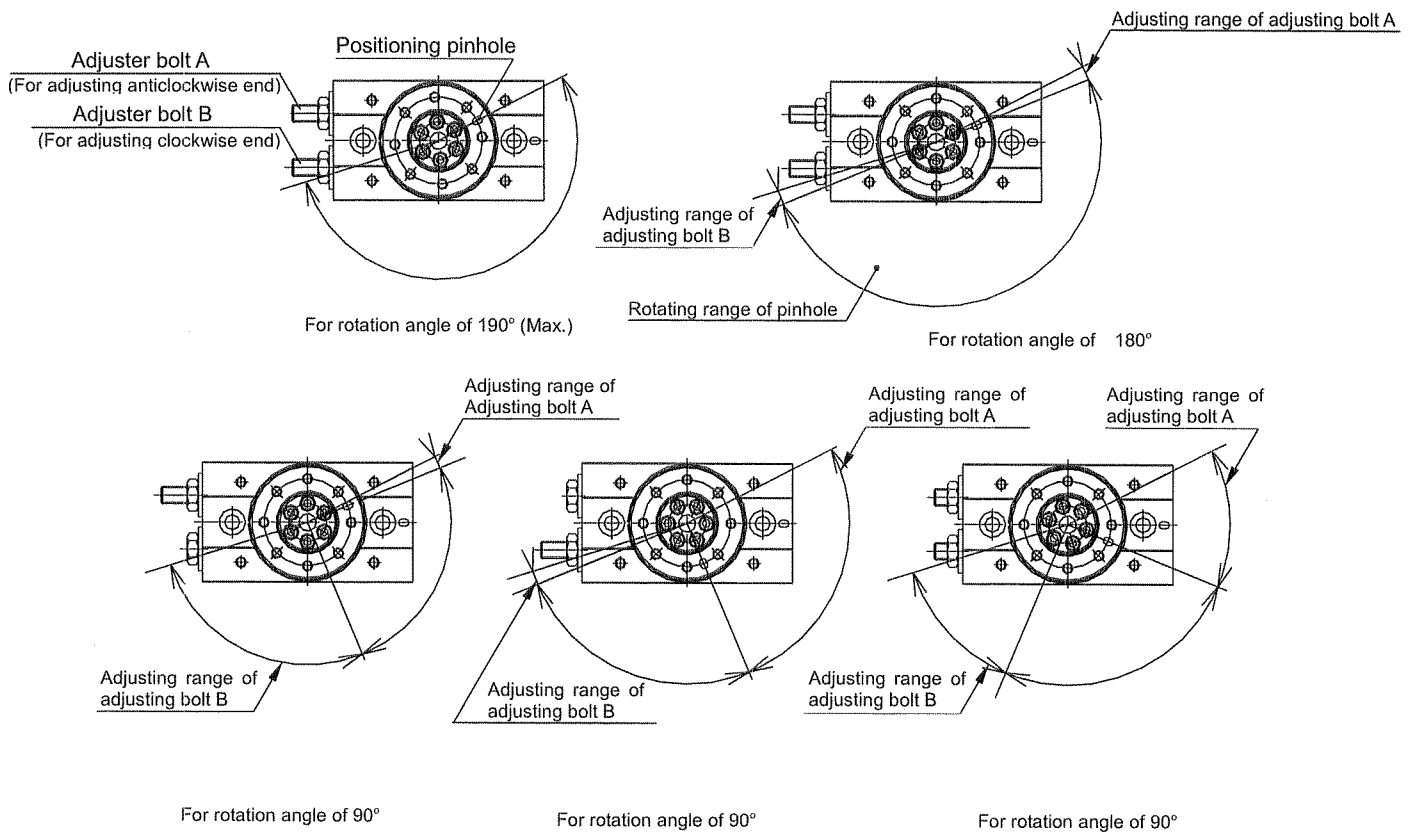


Figure 3. Rotation direction and rotation angle

- Rotation range can be set at variously as above figure, by adjusting adjuster bolt A and B.  
(The figure shows rotation range of positioning pinhole.)



4-4. When body is used as flange.

Rotary table can be mounted from three directions-Two side of axial direction and one side of lateral face.

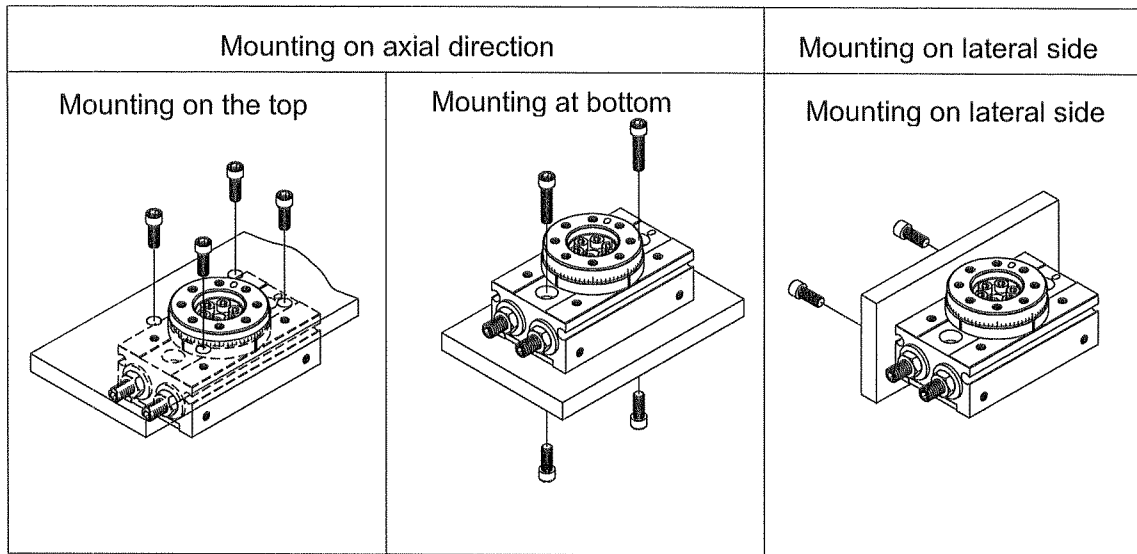


Table 2. Bolt size for mounting on axial direction

Size	Bolt			
	Mounting on the top		Mounting at bottom	
	Bolt	Tap depth	When using body tap	When using body through hole
1	M3×0.5	3.5	M4×0.7	M3
2				
3				
7	M4×0.7	4.5	M5×0.8	M4

Table 3. Mounting on lateral side

Size	Bolt	Tap depth
1	M4×0.7	4
2		
3		
7	M5×0.8	5

4-5. Piping

Figure 4 and table 4 shows position of piping port and size.

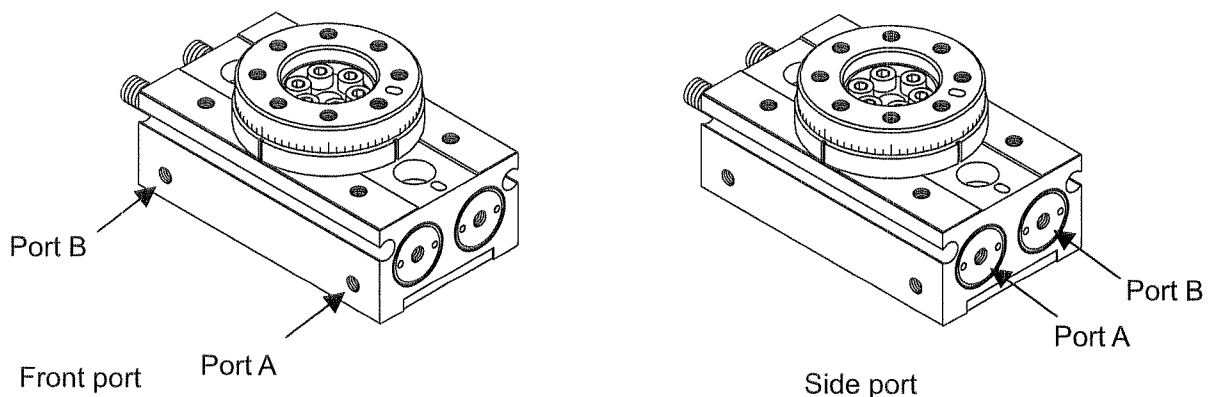


Figure 4 Port position

Table 4. Port size

Size	Port size	
	Front port	Side port
1	M3×0.5	
2		
3		
7	M5×0.8	

Take following measures before piping.

a) Dust or scale inside the piping and in front of the filter can be removed by the filter, however, it cannot be removed once it past the filter and contaminate into inside the solenoid valve or cylinder. As a result, it may cause operation failure or shorten service life. Thus, be sure to flush the piping thoroughly before connecting.

b) When connecting pipes and fittings, etc., be certain that cutting chips from the pipe threads and sealing material do not get inside the piping. Also, when sealant tape is used, leave 1.5 to 2 thread ridges exposed at the end of the pipe / fitting.

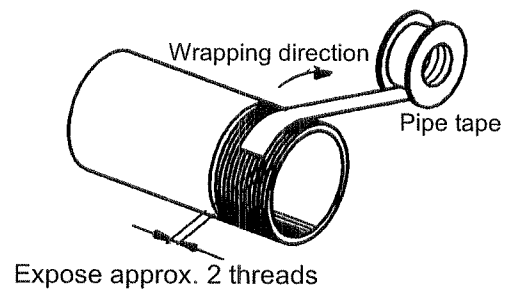
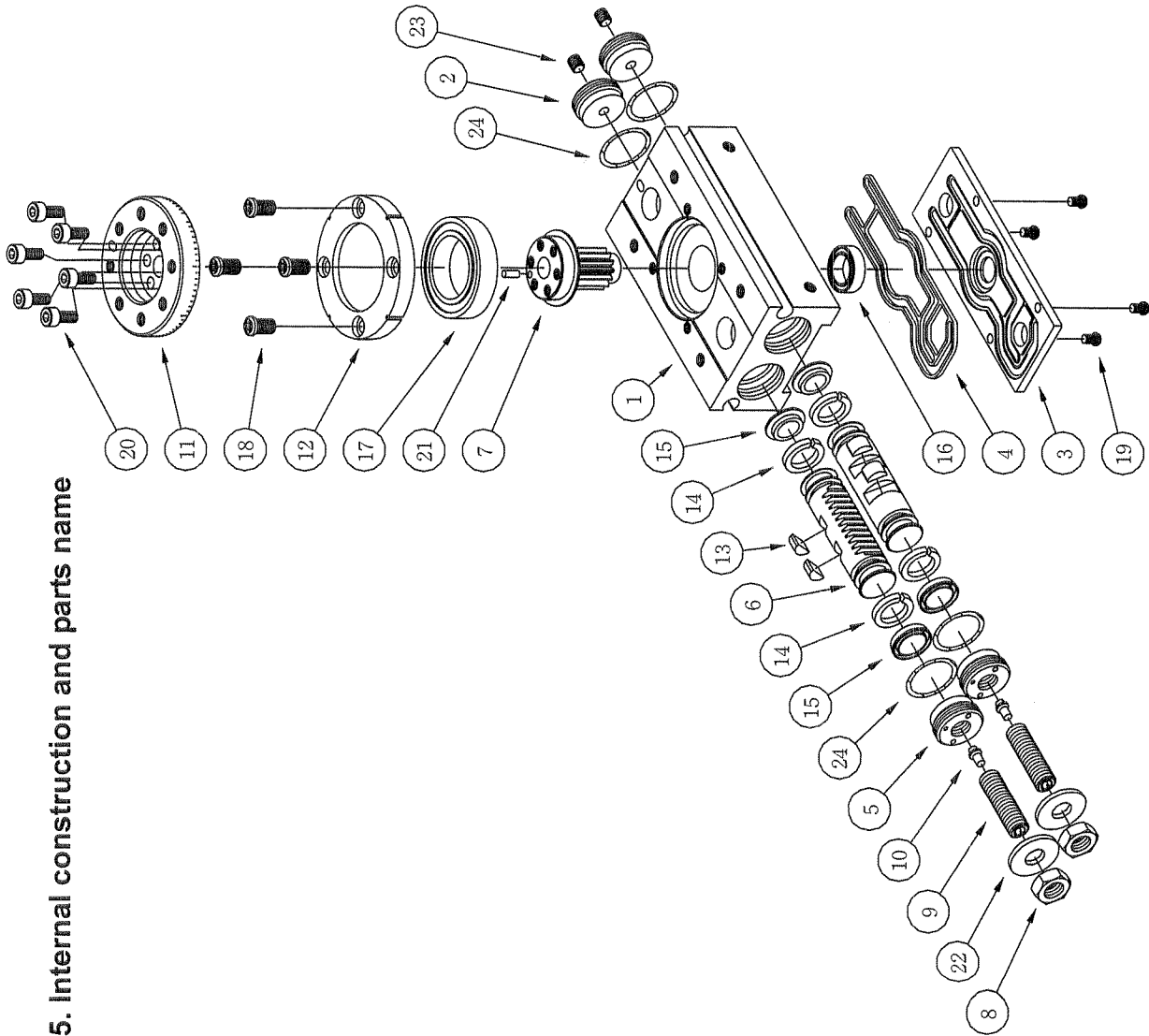


Figure 5

**5. Internal construction and parts name**



No.	Description	No. of item	Note
24	O ring	4	
23	Hexagon socket set screw	2	
22	Seal washer	2	
21	Parallel pin	1	
20	Hexagon socket head cap screw	Size 1, 2, 4 Size 3, 7 : 6	
19	Cross recessed No. 0 round head screw	4	
18	Size 1-3: Cross recessed No. 0 round head screw Size 7: Cross recessed round head screw	4	
17	Deep groove ball bearing	1	
16	Deep groove ball bearing	1	
15	Piston seal	4	
14	Wearing	4	
13	Magnet	4	
12	Bearing retainer	1	
11	Table	1	
10	Cushion pad	2	Size 3 and 7 only
9	Adjusting bolt	2	
8	Hexagon nut	2	
7	Pinion	1	
6	Piston	2	
5	End cover	2	
4	Seal	1	
3	Plate	1	
2	Cover	2	
1	Body	1	

## 6. Rotary table with auto switch

Rotary table with auto switch has magnet mounted on its piston and auto switch on outside the body to detect piston position (table position). Since piston stroke of rotary table is short, detection should be done at the stroke end.

### 6-1 Auto switch specification

Table 5. Solid state auto switch

Auto switch part no.	Output	Power voltage	Consumption current	Load voltage	Max. load current and load current range	Internal drop voltage	Leak current	Application
D-F9N D-F9NW	NPN type	DC24V (DC10 ~28V)	8mA or less	DC28V or less	50mA or less	0.4V	10 $\mu$ A or less at DC24V	Relay PLC
D-F9P D-F9PW	PNP type		12mA or less			10mA or less		
D-F9B				DC24V (DC10 ~28V)	5~30mA	4.5V or less	1mA or less at DC24V	IC circuit
D-F8N	NPN type	DC24V (DC10 ~28V)	8mA or less	DC28V or less	50mA or less	0.4V or less	10 $\mu$ A or less at DC24V	Relay PLC
D-F8P	PNP type		10mA or less			1.5V or less		
D-F8B				DC24V (DC10 ~28V)	5~30mA	4.5V or less	1mA or less at DC24V	IC circuit
D-F9G	NPN type	DC24V (DC10 ~28V)	8mA or less	DC28V or less	50mA or less	0.4V or less	10 $\mu$ A or less at DC24V	Relay PLC
D-F9H	PNP type		10mA or less			1.5V or less		

Operating time ...1ms or less

Operating temperature range...5~60°C

Shock proof...1000m/s<sup>2</sup>

6-2. Rotation range and switch actuation range for auto switches

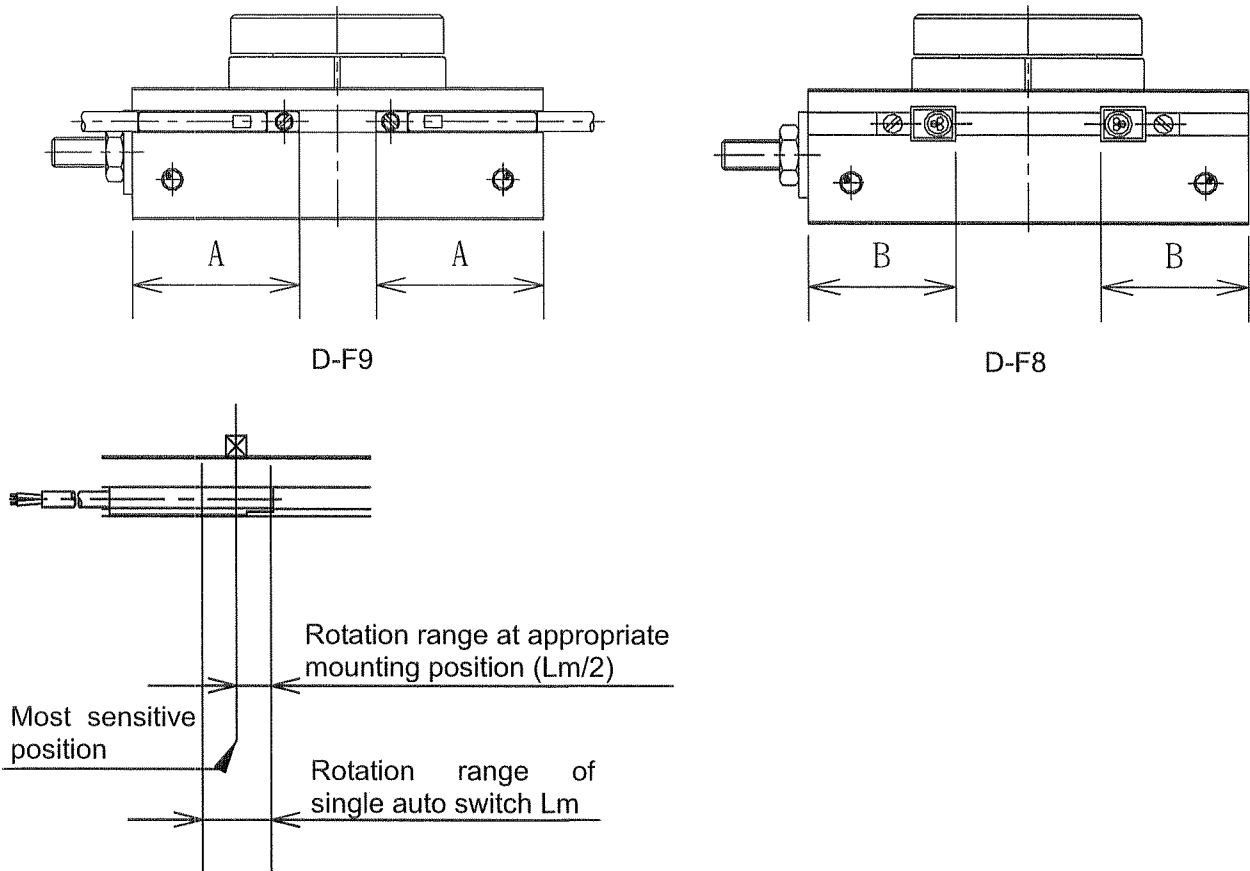


Figure 6

Table 6

Size	Rotation angle	Solid state auto switch					
		D-F9 Auto switch			D-F8 Auto switch		
		A	Rotation range $\theta_m$	Switch actuation range	B	Rotation range $\theta_m$	Switch actuation range
1	190°	20.9	40°	10°	16.9	20°	10°
2	190°	22.8	35°	10°	18.8	20°	10°
3	190°	24.4	30°	10°	20.4	15°	10°
7	190°	28.7	25°	10°	24.7	15°	10°

Rotation range  $\theta_m$ : The value which rotation range of single auto switch  $L_m$  is converted into rotating angle of axis.

Switch actuation range: The value, hysteresis of auto switch is converted into angle.

## 7. Maintenance / Inspection

### 7-1. Inspection

For most suitable use of actuator, regular inspection is required according to the operating condition.

#### (1) Check points

- ① Looseness of actuator mounting frame
- ② Check rotation operation
- ③ Check rotation angle and rotation position
- ④ External and internal leakage
- ⑤ Looseness of stopper bolt, which is fixed by nut
- ⑥ Check movement of switch ON/OFF

Check above points and if there is abnormality, please tight further or exchange maintenance parts or repair.

[Note: This item requires special tool for disassembling. Please contact SMC for maintenance.]

#### (2) Interval of inspection

To use rotary table series MSQ in the best condition, please check once or twice a year.

## 7-2. Troubleshooting

Breakage	Causes	Countermeasures
Actuator does not operate.	Supply pressure is not applied normally.	Adjust setting of regulator at supply pressure side correctly.
	Direction switch valve (solenoid valve, etc.) does not switch.	Correctly apply signal to direction switch valve (solenoid valve, etc.)
	Air leakage from piping.	Check the piping to stop leakage.
	Clogging of diaphragm inside the port.	Clean the diaphragm. Then take following measurements. 1) Flush piping again. 2) Check air filter.
Smooth operation cannot be achieved.	Local friction of load.	Alleviate friction resistance.
	Shaft of actuator and that of the load is not centered.	Use flexible fitting for joint part.
	Supply pressure is low and output is insufficient.	To achieve stable operation, adjust supply pressure so that load factor becomes 50% or less.
	Speed controller is narrowed down too much.	Readjust speed controller according to speed adjustment range of actuator.
Rotation angle changed extremely.	Breakage of internal parts.	Exchange to new actuator. Then take one of the following measurements. 1) Calculate kinetic energy applied to the actuator and adjust speed controller so that appropriate rotation time can be achieved. 2) Mount shock absorber externally to absorb shock. 3) Mount stopper externally to avoid shock to be applied to the actuator. In this case, allow flexibility to actuator stroke. External stopper adjusts the rotation angle.
Leakage from table part	Abrasion of piston seal.	Please request repair for SMC. Then take following measurement. 1) Calculate kinetic energy applied to the actuator and adjust speed controller so that appropriate rotation time can be achieved.

Breakage of gear	Excessive kinetic energy had applied to actuator and gear was damaged.	Please request repair for SMC. Then take one of the following measurements. 1) Calculate kinetic energy applied to the actuator and adjust speed controller so that appropriate rotation time can be achieved. 2) Mount shock absorber externally to absorb shock. 3) Mount stopper externally to avoid shock to be applied to the actuator. In this case, allow flexibility to actuator stroke. External stopper adjusts the rotation angle.
Rotation angle is not enough.	There is no extra in rotation angle is and position of the external stopper is not appropriate for rotation range of the actuator.	Remove external stopper and check whole rotation range of the actuator. Then mount external stopper at appropriate position.
Auto switch does not operate or glitch	Auto switch is not mounted on appropriate position.	Mount auto switch at appropriate position.
	Influence of external magnetic field.	Check that there is not strong magnetic field around the auto switch.
	Problem of electric circuit	Check that there is no problem with electric circuit.
	Problem of electric specification	Check that there is no problem with specification of voltage or current.

Notes for the breakage and measurement list

1. Life of the equipment is excluded from cause of breakage.
2. If the cause is due to factor other than in the table, disassembling of the article may be required. In that case, please contact SMC.