Compact Rotary Actuator
Rack-and-Pinion Type/Sizes: 10, 15, 20, 30, 40
Series CRQ2
Compact Rotary Actuator  
Rack-and-Pinion Type/Sizes: 10, 15, 20, 30, 40

Series CRQ2

Piping can be installed from one end

Uses internal cushioning

10, 15: Rubber bumper
20, 30, 40: Air cushion

Body can be used as a flange

Compact design saves mounting space

10: 17mm
15: 20mm
20: 29mm
30: 33mm
40: 37mm

2 auto switches can be mounted on same side (both sides)

Angle adjustment bolts are standard

Use of double piston eliminates backlash

Easy alignment when mounting body

Body positioning pin holes

Use of double piston saves space

Single and double shaft types available in all sizes

Variations

<table>
<thead>
<tr>
<th>Rotation</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>30</th>
<th>40</th>
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<tbody>
<tr>
<td>80° to 100°</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>170° to 190°</td>
<td></td>
<td></td>
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<tr>
<td>Auto switches</td>
<td>☑</td>
<td>☑</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Air cushion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubber bumper</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single shaft type (S)</td>
<td>☑</td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double shaft type (W)</td>
<td></td>
<td></td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>

Miniature auto switches do not protrude from the body when installed and require no extra space.
## Compact Rotary Actuator
**Rack-and-Pinion Type**

### Series CRQ2

#### How to Order

<table>
<thead>
<tr>
<th>Standard type</th>
<th>CRQ2B</th>
<th>S</th>
<th>20</th>
<th>90</th>
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<tr>
<td>Shaft type</td>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>Double shaft</td>
<td>W</td>
<td></td>
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<table>
<thead>
<tr>
<th>With auto switch</th>
<th>CDRQ2B</th>
<th>S</th>
<th>20</th>
<th>90</th>
<th>A90</th>
<th>S</th>
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<tbody>
<tr>
<td>Built-in magnet</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Rotation</td>
<td>90</td>
<td>80° to 100°</td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td>180</td>
<td>170° to 190°</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Air cushion</td>
<td></td>
<td>Without Nil</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td>Nil</td>
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</table>

### Aplicable auto switches

<table>
<thead>
<tr>
<th>Type</th>
<th>Special function</th>
<th>Electrical entry</th>
<th>Indicator light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reed switch</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Solid state switch</td>
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<td>—</td>
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</table>

<table>
<thead>
<tr>
<th>Wiring (output)</th>
<th>DC</th>
<th>AC</th>
<th>Load voltage</th>
<th>Auto switch part no.</th>
<th>Lead wire length (m)*</th>
<th>Applicable loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 wire</td>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (NPN equiv.)</td>
<td>5V</td>
<td>—</td>
<td>A96V, A96</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9NV, F9N</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (NPN)</td>
<td>24V</td>
<td>12V</td>
<td>F9NVZ, F9NZ</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
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<td>12V</td>
<td>F9PV, F9P</td>
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<td>—</td>
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</tr>
<tr>
<td>2 wire</td>
<td></td>
<td></td>
<td>F9PVZ, F9PZ</td>
<td>—</td>
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</tr>
<tr>
<td>3 wire (NPN)</td>
<td>24V</td>
<td>5V, 12V</td>
<td>F9BV, F9B</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (NPN)</td>
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<td>12V</td>
<td>F9BVL, F9BL</td>
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</tr>
<tr>
<td>2 wire</td>
<td>24V</td>
<td>5V, 12V</td>
<td>F9BVZ, F9BZ</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (NPN)</td>
<td></td>
<td>12V</td>
<td>F9NVW, F9NW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9NVVL, F9NWL</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9NVWZ, F9NWZ</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 wire</td>
<td>24V</td>
<td>12V</td>
<td>F9PVW, F9PW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td>12V</td>
<td>F9PVVL, F9PWL</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9PVWZ, F9PWZ</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2 wire</td>
<td></td>
<td></td>
<td>F9BWW, F9BW</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9BWWL, F9BWL</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3 wire (PNP)</td>
<td></td>
<td></td>
<td>F9BWZ, F9BWZ</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

| Rotation         | 90     | 80° to 100° |
|                  | 180    | 170° to 190°|
| Air cushion      |        | Without Nil |
|                  |        | Nil |

### Number of auto switches

| Nil | 2 pcs. |
| 1 pc. |

### Lead wire length symbols

- 0.5m: L (Example) F9B
- 3m: L (Example) F9BL
- 5m: Z (Example) F9BZ

*Select applicable auto switch models from the table below.

### Special function

- Electrical entry: 3 wire (NPN equiv.), 2 wire
- Grommet: Yes, No
- Indicator light: —, —, —, —
- Diagnostic indication (2 color indicator): —, —, —, —
- Lead wire length (m)*: 0.5 (Nil), 3 (L), 5 (Z)

### Applicable loads

- IC circuit
- Relay, PLC

*Solid state auto switches marked with a ○ are produced upon receipt of order.

---

*Lead wire length symbols 0.5m . . . Nil (Example) F9B 3m … L (Example) F9BL 5m … Z (Example) F9BZ*
Specifications

<table>
<thead>
<tr>
<th>Size</th>
<th>Fluid</th>
<th>Maximum operating pressure</th>
<th>Minimum operating pressure</th>
<th>Ambient and fluid temperature</th>
<th>Cushion</th>
<th>Angle adjustment</th>
<th>Rotation</th>
<th>Port size</th>
<th>Mounting brackets</th>
<th>Output Nm*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Air (unlubricated)</td>
<td>0.7MPa</td>
<td>0.15MPa</td>
<td>0 to 60°C (with no freezing)</td>
<td>Rubber bumper</td>
<td>±5°</td>
<td>80° to 100°, 170° to 190°</td>
<td>M5 x 0.8</td>
<td>Basic type</td>
<td>0.3</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1.0MPa</td>
<td>0.1MPa</td>
<td></td>
<td>None, Air cushion</td>
<td></td>
<td></td>
<td>Rc1/8</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>1.0MPa</td>
<td>0.1MPa</td>
<td></td>
<td>None, Air cushion</td>
<td></td>
<td></td>
<td>Rc1/8</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>1.0MPa</td>
<td>0.1MPa</td>
<td></td>
<td>None, Air cushion</td>
<td></td>
<td></td>
<td>Rc1/8</td>
<td></td>
<td>3.1</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>1.0MPa</td>
<td>0.1MPa</td>
<td></td>
<td>None, Air cushion</td>
<td></td>
<td></td>
<td>Rc1/8</td>
<td></td>
<td>5.3</td>
</tr>
</tbody>
</table>

*) Indicates output with operating pressure at 0.5MPa. Refer to Page 14 for details.

Allowable Kinetic Energy and Rotation Time Adjustment Range

<table>
<thead>
<tr>
<th>Size</th>
<th>Allowable kinetic energy (J)</th>
<th>Cushion angle</th>
<th>Stable operational rotation time adjustment range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without cushion</td>
<td>Rubber bumper</td>
<td>With air cushion *</td>
</tr>
<tr>
<td>10</td>
<td>—</td>
<td>0.25 x 10^{-3}</td>
<td>—</td>
</tr>
<tr>
<td>15</td>
<td>—</td>
<td>0.39 x 10^{-3}</td>
<td>—</td>
</tr>
<tr>
<td>20</td>
<td>0.025</td>
<td>—</td>
<td>0.12</td>
</tr>
<tr>
<td>30</td>
<td>0.048</td>
<td>—</td>
<td>0.25</td>
</tr>
<tr>
<td>40</td>
<td>0.081</td>
<td>—</td>
<td>0.40</td>
</tr>
</tbody>
</table>

*) Allowable kinetic energy with cushion

Maximum energy absorption with optimal adjustment of cushion needle

Weight Table

<table>
<thead>
<tr>
<th>Size</th>
<th>Standard weight*</th>
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<tbody>
<tr>
<td></td>
<td>90°</td>
</tr>
<tr>
<td>10</td>
<td>120</td>
</tr>
<tr>
<td>15</td>
<td>220</td>
</tr>
<tr>
<td>20</td>
<td>600</td>
</tr>
<tr>
<td>30</td>
<td>900</td>
</tr>
<tr>
<td>40</td>
<td>1400</td>
</tr>
</tbody>
</table>

*) Value excluding the weight of auto switches.
Rotation Range

When pressure is applied to the port on the side with the arrow, the shaft rotates clockwise.

Sizes 10, 15

Sizes 20, 30, 40

Using the Body as a Flange

The body’s L dimensions are shown in the drawing on the right. When JIS standard hexagon socket head cap screws are used, the actuator grooves should be used to contain the heads of the screws.

<table>
<thead>
<tr>
<th>Size</th>
<th>L</th>
<th>Screw</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>13</td>
<td>M4</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>M4</td>
</tr>
<tr>
<td>20</td>
<td>22.5</td>
<td>M6</td>
</tr>
<tr>
<td>30</td>
<td>24.5</td>
<td>M8</td>
</tr>
<tr>
<td>40</td>
<td>28.5</td>
<td>M8</td>
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</tbody>
</table>
Series CRQ2

Construction

Standard type
Sizes 10, 15

Standard type
Sizes 20, 30, 40

Parts list

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Body</td>
<td>Aluminum alloy</td>
<td>Clear hard anodized</td>
</tr>
<tr>
<td>2</td>
<td>Cover</td>
<td>Aluminum alloy</td>
<td>Electroless nickel plated</td>
</tr>
<tr>
<td>3</td>
<td>Plate</td>
<td>Aluminum alloy</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>End cover</td>
<td>Aluminum alloy</td>
<td>Electroless nickel plated</td>
</tr>
<tr>
<td>5</td>
<td>Piston</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Shaft</td>
<td>Stainless steel</td>
<td>Sizes: 10, 15</td>
</tr>
<tr>
<td>7</td>
<td>Seal retainer</td>
<td>Aluminum alloy</td>
<td>Chromated</td>
</tr>
<tr>
<td>8</td>
<td>Bearing retainer</td>
<td>Aluminum alloy</td>
<td>Clear hard anodized</td>
</tr>
<tr>
<td>9</td>
<td>Wear ring</td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Hexagon socket cap screw</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Hexagon nut with flange</td>
<td>Steel wire</td>
<td>Electroless nickel plated</td>
</tr>
<tr>
<td>12</td>
<td>Round head No. 0 Phillips screw</td>
<td>Steel wire</td>
<td>Zinc chromated</td>
</tr>
<tr>
<td>13</td>
<td>Round head Phillips screw</td>
<td>Steel wire</td>
<td>10, 15 nickel plated</td>
</tr>
</tbody>
</table>

Parts list

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Material</th>
<th>Note</th>
</tr>
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<tbody>
<tr>
<td>14</td>
<td>Hexagon socket head set screw</td>
<td>Chromium molybdenum steel</td>
<td>Electroless nickel plated</td>
</tr>
<tr>
<td>15</td>
<td>Bearing</td>
<td>Bearing steel</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Parallel key</td>
<td>Carbon steel</td>
<td>20, 30, 40</td>
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<tr>
<td>17</td>
<td>Steel balls</td>
<td>Stainless steel</td>
<td>20, 30, 40</td>
</tr>
<tr>
<td>18</td>
<td>C S type snap ring</td>
<td>Stainless steel</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Seal</td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Gasket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Piston seal</td>
<td>20, 30, 40 with cushion</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Cushion seal</td>
<td>20, 30, 40 with cushion</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Seal washer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Magnet</td>
<td>Magnetic material</td>
<td>With auto switch</td>
</tr>
<tr>
<td>25</td>
<td>Cushion valve assembly</td>
<td>20, 30, 40 with cushion</td>
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</tr>
<tr>
<td>26</td>
<td>Cushion pad</td>
<td>Elastic material</td>
<td>10, 15</td>
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Replacement parts

<table>
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<tr>
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<th>Kit number</th>
<th>Contents</th>
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<tr>
<td>Seal kit</td>
<td>P473010-1</td>
<td>19, 20, 21, 23</td>
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<tr>
<td></td>
<td>P473020-1</td>
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</tr>
<tr>
<td></td>
<td>P473030-1</td>
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</tr>
<tr>
<td></td>
<td>P473040-1</td>
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<tr>
<td></td>
<td>P473050-1</td>
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</table>
**Series CRQ2**

**Dimensions**

**Sizes 10, 15**

<table>
<thead>
<tr>
<th>Size</th>
<th>Rotation</th>
<th>A</th>
<th>AU*</th>
<th>B</th>
<th>BA</th>
<th>BB</th>
<th>BC</th>
<th>BD</th>
<th>BU</th>
<th>D (g6)</th>
<th>DD (h9)</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>90°, 180°</td>
<td>42</td>
<td>(8.5)</td>
<td>29</td>
<td>8.5</td>
<td>17</td>
<td>6.7</td>
<td>2.2</td>
<td>16.7</td>
<td>5</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>90°, 180°</td>
<td>53</td>
<td>(9.5)</td>
<td>31</td>
<td>9</td>
<td>26.4</td>
<td>10.6</td>
<td>–</td>
<td>23.1</td>
<td>6</td>
<td>14</td>
<td>20</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Size</th>
<th>Rotation</th>
<th>W</th>
<th>Q</th>
<th>S</th>
<th>US</th>
<th>UW</th>
<th>ab</th>
<th>M</th>
<th>TA</th>
<th>TC</th>
<th>TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>90°</td>
<td>4.5</td>
<td>17</td>
<td>56</td>
<td>69</td>
<td>35</td>
<td>6</td>
<td>9</td>
<td>15.5</td>
<td>8</td>
<td>15.4</td>
</tr>
<tr>
<td>15</td>
<td>90°</td>
<td>5.5</td>
<td>20</td>
<td>82</td>
<td>82</td>
<td>40</td>
<td>7</td>
<td>10</td>
<td>16</td>
<td>9</td>
<td>17.6</td>
</tr>
</tbody>
</table>

* Dimension AU does not indicate the dimension when shipped because of the adjustment section. S: Upper space 90°, Lower space 180°
Compact Rotary Actuator
Rack-and-Pinion Type
Series CRQ2

Sizes 20, 30, 40

<table>
<thead>
<tr>
<th>Size</th>
<th>Rotation</th>
<th>A</th>
<th>AU†</th>
<th>B</th>
<th>BA</th>
<th>BB</th>
<th>BC</th>
<th>BD</th>
<th>BE</th>
<th>BU</th>
<th>CA</th>
<th>CB</th>
<th>D (g6)</th>
<th>DD (h9)</th>
<th>F</th>
<th>H</th>
<th>J</th>
<th>JA</th>
<th>JB</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>90°, 180°</td>
<td>63</td>
<td>(11)</td>
<td>50</td>
<td>14</td>
<td>34</td>
<td>14.5</td>
<td>7</td>
<td>4.7</td>
<td>10</td>
<td>25</td>
<td>2.5</td>
<td>30 M8 x 1.25</td>
<td>11</td>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>90°, 180°</td>
<td>69</td>
<td>(11)</td>
<td>68</td>
<td>14</td>
<td>39</td>
<td>16.5</td>
<td>49</td>
<td>16</td>
<td>34.7</td>
<td>8.1</td>
<td>4.9</td>
<td>12</td>
<td>30</td>
<td>3</td>
<td>32</td>
<td>M10 x 1.5</td>
<td>14</td>
<td>8.5</td>
</tr>
<tr>
<td>40</td>
<td>90°, 180°</td>
<td>78</td>
<td>(13)</td>
<td>76</td>
<td>16</td>
<td>47</td>
<td>18.5</td>
<td>55</td>
<td>16</td>
<td>40.4</td>
<td>8.3</td>
<td>5.2</td>
<td>15</td>
<td>32</td>
<td>3</td>
<td>36</td>
<td>M10 x 1.5</td>
<td>14</td>
<td>8.6</td>
</tr>
</tbody>
</table>

* Dimension AU does not indicate the dimension when shipped because of the adjustment section.

S: Upper space 90°, Lower space 180°

With double shaft
## Series CRQ2
Auto Switch Specifications

### Reed Switches

<table>
<thead>
<tr>
<th>Auto switch part no.</th>
<th>Load voltage</th>
<th>Maximum load current or load current range</th>
<th>Internal voltage drop</th>
<th>Indicator light (lights when ON)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-A90 D-A90V</td>
<td>DC 24V or less</td>
<td>50mA</td>
<td>0</td>
<td>None</td>
<td>Relay, PLC, IC circuit</td>
</tr>
<tr>
<td></td>
<td>DC 48V or less</td>
<td>40mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DC 100V or less</td>
<td>20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-A93 D-A93V</td>
<td>24VDC</td>
<td>5 to 40mA</td>
<td>2.6V or less</td>
<td>⬤</td>
<td>Relay, PLC</td>
</tr>
<tr>
<td></td>
<td>100VAC</td>
<td>5 to 20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-A96 D-A96V</td>
<td>4 to 8VDC</td>
<td>20mA</td>
<td>0.8V or less</td>
<td>⬤</td>
<td>IC circuit</td>
</tr>
</tbody>
</table>

- Load wires: D-A90, A90V: Oil resistant heavy duty vinyl cord ø2.7. 0.18mm² x 2 wire (Brown, Blue, Red, Black) 0.5m
- D-A96: Oil resistant heavy duty vinyl cord ø2.7, 0.15mm² x 3 wire (Brown, Black, Blue, Red, White, Black) 0.5m
- Insulation resistance: 50MΩ or more at 50VDC (between lead wire and case)
- Withstand voltage: 1000VAC for 1 min. (between lead wire and case) 1.2ms
- Operation time: 1.2ms
- Ambient temperature: 10 to 60°C
- Impact resistance: 120m/s² (30.6G)
- Leakage current: 0
- Enclosure: IEC529 standard IP67 (JIS0920) watertight
- For a lead wire length of 3m, "L" is added to the end of the part number. Example) D-A90L

### Solid State Switches

<table>
<thead>
<tr>
<th>Auto switch part no.</th>
<th>Output type</th>
<th>Power supply voltage</th>
<th>Current consumption</th>
<th>Load voltage</th>
<th>Max. load current or load current range</th>
<th>Internal voltage drop</th>
<th>Leakage current</th>
<th>Indicator light (lights when ON)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-F9N D-F9NV</td>
<td>NPN type</td>
<td>24VDC (10 to 25VDC)</td>
<td>8mA or less</td>
<td>24VDC</td>
<td>50mA or less</td>
<td>0.4V or less</td>
<td>10µA or less at 24VDC</td>
<td>Lights when ON</td>
<td>2 color indicator</td>
</tr>
<tr>
<td>D-F9NW D-F9NWW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Relay, PLC</td>
</tr>
<tr>
<td>D-F9P D-F9PV</td>
<td>PNP type</td>
<td>24VDC (10 to 25VDC)</td>
<td>10mA or less</td>
<td>24VDC</td>
<td>50mA or less</td>
<td>0.4V or less</td>
<td>15µA or less at 24VDC</td>
<td>Lights when ON</td>
<td>2 color indicator</td>
</tr>
<tr>
<td>D-F9PW D-F9PWW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-F9B D-F9BV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-F9BB D-F9BBWV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Lead wires: Oil resistant heavy duty vinyl cord ø2.7, 0.15mm² x 3 wire (Brown, Black, Blue, Red, White, Black) 0.5m, 0.18mm² x 2 wire (Brown, Blue, Red, Black) 0.5m
- Insulation resistance: 50MΩ or more at 50VDC (between lead wire and case)
- Withstand voltage: 1000VAC for 1 min. (between lead wire and case)
- Operation time: 1.2ms
- Ambient temperature: 10 to 60°C
- Impact resistance: 120m/s² (30.6G)
- Enclosure: IEC529 standard IP65 (JIS0920) splash proof
- For a lead wire length of 3m, "L" is added to the end of the part number. Example) D-F90NL
Auto Switch Internal Circuits

Reed switches
D-A90 (V)

Solid state switches
D-F9N (V)

D-F9NW (V)

D-F9P (V)

D-F9PW (V)

D-F9B (V)

D-F9BW (V)

Indicator light/Display method

Proper Auto Switch Mounting Positions

<table>
<thead>
<tr>
<th>Size</th>
<th>Rotation angle</th>
<th>Reed switches</th>
<th>Solid state switches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>Switch actuation range</td>
</tr>
<tr>
<td>10</td>
<td>90°</td>
<td>6.5</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>180°</td>
<td>9.5</td>
<td>18</td>
</tr>
<tr>
<td>15</td>
<td>90°</td>
<td>9.5</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>180°</td>
<td>13.5</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>90°</td>
<td>22</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>180°</td>
<td>28</td>
<td>34.5</td>
</tr>
<tr>
<td>30</td>
<td>90°</td>
<td>29</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>180°</td>
<td>37</td>
<td>45</td>
</tr>
<tr>
<td>40</td>
<td>90°</td>
<td>34</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>180°</td>
<td>43.5</td>
<td>53</td>
</tr>
</tbody>
</table>

Operation range θm: The value of the auto switch operating range Lm converted to the shaft rotation angle

Switch actuation range: The value of the auto switch hysteresis converted to an angle
Basic Wiring

**Solid state 3 wire, NPN**

- Source input specifications
  - 2 wire
- AND connection for NPN output (performed with switches only)
  - 2 wire

**Solid state 3 wire, PNP**

- Sink input specifications
  - 2 wire
- OR connection for NPN output
  - 2 wire

---

Examples of Connection to PLC

**Sink input specifications**

**3 wire, NPN**

- Switch
- COM
- Load

**Source input specifications**

**3 wire, NPN**

- Switch
- COM
- Load

**Connection Examples for AND (Series) and OR (Parallel)**

**3 wire**

- AND connection for NPN output (using relays)
  - Load
  - Relay
  - Switch 1
  - Switch 2
- OR connection for NPN output
  - Load

**2 wire**

- AND connection for NPN output (performed with switches only)
  - Load
  - Switch 1
  - Switch 2
- (Solid state)

**2 wire with 2 switch AND connection**

- When two switches are connected in series, a load may malfunction because the load voltage will decline when in the ON state.
- The indicator lights will light up if both of the switches are in the ON state.

**2 wire with 2 switch OR connection**

- (Solid state)
  - When two switches are connected in parallel, malfunction may occur because the load voltage will increase when in the OFF state.

---

**Load voltage at ON**

- Power supply voltage: 24V
- Residual voltage: 4V
- Example: Power supply is 24VDC

**Load voltage at OFF**

- Leakage current: 1mA
- Load impedance: 3kΩ
- Example: Load impedance is 3kΩ

---

Series CRQ2

Auto Switch Connections and Examples
Select the actuator torque.

1. Find the required turning torque for the intended objective.

<table>
<thead>
<tr>
<th>Work objective</th>
<th>Type of load</th>
<th>Required torque formula ( N \cdot m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static operation</td>
<td>Static load</td>
<td>( T_s )</td>
</tr>
<tr>
<td>Dynamic operation</td>
<td>Resistance load</td>
<td>((3 \text{ to } 5) \cdot T_f)</td>
</tr>
<tr>
<td>Dynamic operation</td>
<td>Inertial load</td>
<td>( S \cdot T_a ) or more</td>
</tr>
</tbody>
</table>

1. In the case of dynamic operation, there may be a combination of resistance and inertial loads.
2. Since it is also necessary to examine inertial load in selection step [2] in calculating the kinetic energy of the work piece, make the selections together.
3. Refer to load types below for details regarding the terms \( T_s \), \( T_f \), \( S \) and \( T_a \) in the table.

2. Determine the operating pressure
3. Determine the proper size from the effective torque table.

### Load Types

**Static load: \( T_s \)**

The load represented by the clamp which requires pressing force only

\[ T_s = F \times l \quad (N \cdot m) \]

*(Example)*

**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.

\[ T_s \leq (3 \text{ to } 5) \cdot T_f \]

*(Example)*

**Inertial load: \( T_a \)**

The load which must be rotated by the 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.

\[ T_s \leq S \cdot T_a \]

*(Example)*

**Accelerating torque calculation**

\[ Ta = I \cdot \omega \cdot \omega / 2 \quad (N \cdot m) \]

\( I \) : Moment of inertia
\( \omega \) : Angular acceleration
\( \omega \) : Angular acceleration
\( \theta \) : Rotation angle (rad)
\( t \) : Rotation time (S)
1. When an external stopper (shock absorber) is provided to absorb the impact, be sure to use one which has sufficient absorption capacity.

2. When relying on the actuator’s internal cushion without using a stopper, the model selection graphs consider the absorption capacity of the actuator’s internal cushion, making it possible to select a model from the rotation time within the speed adjustment range and the moment of inertia of the work piece.

1) Rubber bumper ... Kinetic energy is absorbed by placing an elastic body (rubber) at the end of the rotation.

2) Air cushion ........... The exhaust air is compressed shortly before the end of the rotation, and the load’s kinetic energy is absorbed by its repulsive force.

Find the air consumption necessary to calculate the running cost of the air supply. Refer to air consumption on page 18.
Effective Torque

Effective torque values are typical values and are not guaranteed. Use them as guide values in actual applications.

<table>
<thead>
<tr>
<th>Size</th>
<th>0.10</th>
<th>0.15</th>
<th>0.20</th>
<th>0.30</th>
<th>0.40</th>
<th>0.50</th>
<th>0.60</th>
<th>0.70</th>
<th>0.80</th>
<th>0.90</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.37</td>
<td>0.55</td>
<td>0.73</td>
<td>1.10</td>
<td>1.47</td>
<td>1.84</td>
<td>2.20</td>
<td>2.57</td>
<td>2.93</td>
<td>3.29</td>
<td>3.66</td>
</tr>
<tr>
<td>30</td>
<td>0.62</td>
<td>0.94</td>
<td>1.25</td>
<td>1.67</td>
<td>2.49</td>
<td>3.11</td>
<td>3.74</td>
<td>4.37</td>
<td>4.99</td>
<td>5.60</td>
<td>6.24</td>
</tr>
<tr>
<td>40</td>
<td>1.06</td>
<td>1.59</td>
<td>2.11</td>
<td>3.18</td>
<td>4.24</td>
<td>5.30</td>
<td>6.36</td>
<td>7.43</td>
<td>8.48</td>
<td>9.54</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Unit: N-m

Moment of Inertia

When an object (load) is moved by the actuator, inertial force (kinetic energy) is created in the object. Conversely, in order to stop the moving object, it is necessary to absorb the object's kinetic energy with a stopper or shock absorber, etc. When the load moves in a straight line (air cylinder) or turns (rotary actuator), the kinetic energies can be calculated with the formulas shown in Figures 1 and 2 respectively.

Air cylinder

\[ E = \frac{1}{2} \cdot m \cdot V^2 \]  
*Formula (1)*

- \( E \): Kinetic energy
- \( m \): Load mass
- \( V \): Speed

*Figure 1. Linear motion*

Rotary actuator

\[ E = \frac{1}{2} \cdot I \cdot \omega^2 = \frac{1}{2} \cdot m \cdot r^2 \cdot \omega^2 \]  
*Formula (2)*

- \( E \): Kinetic Energy
- \( I \): Moment of Inertia (= m \( \cdot \) r\(^2\))
- \( \omega \): Speed

*Figure 2. Turning motion*

In the case of linear motion, if the speed \( V \) from Formula (1) is constant, the kinetic energy \( E \) is readily determined by the mass \( m \). However, in the case of turning motion it is clear from Formula (2) that the kinetic energy \( E \) varies in proportion to the square of the turning radius \( r \), even if the angular speed \( \omega \) and mass \( m \) are constant. Thus, even if the mass is small, when \( r \) is large the resulting moment of inertia \( I = m \cdot r^2 \) is large, and since the kinetic energy \( E \) also becomes large, this may lead to damage of the shaft, etc. When a load is moved in this way by a rotary actuator, it is particularly necessary to exercise caution regarding the moment of inertia \( I = m \cdot r^2 \) of the load.

A 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. Since there is a limit to the kinetic energy allowed in a rotary actuator, the limit value of the rotation time can be found by finding the moment of inertia. How to find the moment of inertia is explained below.

The basic formula for moment of inertia is shown below.

\[ I = m \cdot r^2 \]

*However, the weight of the L section is ignored*

Concrete examples of how to calculate the moment of inertia are shown on the following pages.
1. Thin shaft  
Position of rotational axis: Perpendicular to the shaft through one end

\[ I = m \cdot \frac{a^2}{3} + m \cdot \frac{a_2^2}{3} \]

2. Thin shaft  
Position of rotational axis: Through the shaft's center of gravity

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

3. Thin rectangular plate (rectangular parallelepiped)  
Position of rotational axis: Through the plate's center of gravity

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

4. Thin rectangular plate (rectangular parallelepiped)  
Position of rotational axis: Perpendicular to the shaft through one end (also the same in case of a thicker plate)

\[ I = m \cdot \frac{4a^2 \cdot b^2}{12} + m \cdot \frac{4a_2^2 \cdot b^2}{12} \]

5. Thin rectangular plate (rectangular parallelepiped)  
Position of rotational axis: Through the center of gravity and perpendicular to the plate (also the same in case of a thicker plate)

\[ I = m \cdot \frac{a^2 \cdot b^2}{12} \]

6. Column (including thin round plate)  
Position of rotational axis: Central axis

\[ I = m \cdot \frac{r^2}{2} \]

7. Solid sphere  
Position of rotational axis: Diameter

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

8. Thin round plate  
Position of rotational axis: Diameter

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

9. Load at end of lever

\[ I = m \cdot \frac{a^2}{3} + m \cdot a_2^2 + K \]  
(Example) When shape of \( m_2 \) is a sphere refer to 7 and \( K = m_2 \cdot \frac{2r^2}{5} \)

10. Gear transmission

1. Find the moment of inertia \( I_B \) for the rotation of shaft (B).
2. Next, \( I_B \) is entered to find \( I_A \) the moment of inertia for the rotation of shaft (A) as

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

Number of teeth = a

Number of teeth = b
### 1 Rotational Axis at Random Point in Load

**Example** When load is a rectangular shape as in technical data 5

Find the moment of inertia $I_1$ for rotation around the actual rotational axis with the mass of the load concentrated at the load's center of gravity.

$$ I_1 = m \left( \frac{a^2 + b^2}{12} \right) $$

kg m$^2$

Find the moment of inertia $I_2$ with the mass of the load concentrated at the load's center of gravity.

$$ I_2 = mL^2 $$

kg m$^2$

Find the actual moment of inertia $I$.

$$ I = I_1 + I_2 $$

Example calculation:

When $a = 0.2$m, $b = 0.1$m, $L = 0.05$m, $m = 1.5$kg

$$ I_1 = 1.5 \left( \frac{0.2^2 + 0.1^2}{12} \right) = 6.25 \times 10^{-3} $$

kg m$^2$

$$ I_2 = 1.5 \times 0.05^2 = 3.75 \times 10^{-3} $$

kg m$^2$

$$ I = (6.25 + 3.75) \times 10^{-3} = 0.01 $$

kg m$^2$

### 2 Load Divided into Multiple Parts

**Example** When load is divided into two columns such as shown in technical data 6

Find the moment of inertia $I_1$ with the load center of gravity at the tentative rotational axis.

$$ I_1 = m_1 \frac{r_1^2}{2} $$

kg m$^2$

Find the actual moment of inertia $I_1$.

$$ I_1 = m_1 \frac{r_1^2}{2} + m_1 L^2 $$

kg m$^2$

Example calculation:

When $m_1 = 2.5$kg, $m_2 = 0.5$kg, $r_1 = 0.1$m, $r_2 = 0.02$m, $L = 0.08$m

$$ I_1 = 2.5 \left( \frac{0.1^2}{2} \right) = 1.25 \times 10^{-2} $$

kg m$^2$

$$ I_2 = 0.5 \left( \frac{0.02^2}{2} \right) + 0.5 \times 0.08^2 = 0.33 \times 10^{-2} $$

kg m$^2$

$$ I = (1.25 + 0.33) \times 10^{-2} = 1.58 \times 10^{-2} $$

kg m$^2$
When \( L = 0.2 \text{m}, \ \varnothing D = 0.06 \text{m}, a = 0.06 \text{m}, b = 0.03 \text{m}, m_1 = 0.5 \text{kg}, m_2 = 0.4 \text{kg}, m_3 = 0.2 \text{kg}\)

\[\begin{align*}
I_1 &= 0.5 \times \frac{0.06^2}{3} = 0.67 \times 10^{-2} \text{kg} \cdot \text{m}^2 \\
I_2 &= 0.4 \times \frac{0.06^2}{8} + 0.4 \times 0.2^2 = 1.62 \times 10^{-2} \text{kg} \cdot \text{m}^2 \\
I_3 &= 0.2 \times \frac{0.03^2 + 0.04^2}{12} + 0.2 \times 0.2^2 = 0.81 \times 10^{-2} \text{kg} \cdot \text{m}^2 \\
I_A &= (1.04 + 1.25) \times 10^{-3} = 2.29 \times 10^{-3} \text{kg} \cdot \text{m}^2
\end{align*}\]
Air consumption is the volume of air which is expended by the rotary actuator's reciprocal operation inside the actuator and in the piping between the actuator and the switching valve, etc. This is necessary for selection of a compressor and for calculation of its running cost.

* The air consumption \( Q_{CR} \) required for one reciprocation of the rotary actuator alone is shown in the table below, and can be used to simplify the calculation.

\[
Q_{CR} = V \times \left( \frac{P + 0.1013}{0.1013} \right) \times 10^{-3} \quad \text{Formula (1)}
\]

\[
Q_{CR} = 2V \times \left( \frac{P + 0.1013}{0.1013} \right) \times 10^{-3} \quad \text{Formula (2)}
\]

\[
Q_{CP} = 2 \times a \times l \times \frac{P}{10^{-6}} \quad \text{Formula (3)}
\]

\[
Q_{C} = Q_{CR} + Q_{CP} \quad \text{Formula (4)}
\]

When selecting a compressor, it is necessary to choose one which has sufficient reserve for the total air consumption of pneumatic actuators downstream. This is affected by factors such as leakage in piping, consumption by drain valves and pilot valves, etc., and reduction of air volume due to drops in temperature.

Formula

\[
Q_{C} = Q_{C2} \times n \times \text{Number of actuators} \times \text{Reserve factor}
\]

**Rack-and-pinion type: Series CRQ2**

<table>
<thead>
<tr>
<th>Size</th>
<th>Rotation angle (°)</th>
<th>Internal volume V (cm³)</th>
<th>Operating pressure (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Air consumption of rotary actuator: \( Q_{C} \) (ANR)
Series CRQ2
Safety Instructions

These safety instructions are intended to prevent a hazardous situation and/or equipment damage. These instructions indicate the level of potential hazard by a label of "Caution", "Warning" or "Danger". To ensure safety, be sure to observe ISO 4414 Note 1), JIS B 8370 Note 2) 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.

Note 1) ISO 4414: Pneumatic fluid power - Recommendations for the application of equipment to transmission and control systems.

Note 2) JIS B 8370: General Rules for Pneumatic Equipment

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⚠️ 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 components 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. Cut the supply pressure for this equipment and exhaust all residual compressed air in the system.
   3. Before machinery/equipment is restarted, take measures to prevent shooting-out of cylinder piston rod, etc. (Bleed air into the system gradually to create back pressure.)

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 beverages, 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.
1. Keep the speed setting within the product's allowable energy value. If operated with the kinetic energy of the load exceeding the allowable value, this can cause damage to the product, leading to human injury as well as damage to equipment and machinery.

2. Provide a shock absorbing mechanism when kinetic energy applied to the product exceeds the allowable value. Operation exceeding the allowable kinetic energy can cause damage to the product and lead to human injury and damage to equipment and machinery.

3. Do not perform stops or holding operations by containing air pressure inside the product. If intermediate stops are performed by containing air with a directional control valve when the product does not have an external stop mechanism, the stopping position may not be held due to leakage, etc., and this can cause human injury and damage to equipment and machinery.

1. Do not operate the product at low speeds which are below the prescribed speed adjustment range. If operated at low speeds below the speed adjustment range, this may cause sticking and slipping or stopping of operation.

2. Do not apply external torque which exceeds the product's rated output. If external force is applied which exceeds the product's rated output, the product can be damaged.

3. Holding torque at end of rotation for double piston type
   In double piston type products, where the internal piston is stopped by contact with an angle adjustment screw or cover, the holding torque at the rotation end is one half the value of the effective output.

4. When repeatability of the rotation angle is required, the load should be directly stopped externally.
   The initial rotation angle may vary even in products equipped with angle adjustment.

5. Avoid operation with oil hydraulics.
   Operation with oil hydraulics can cause damage to the product.
Warning

1. When angle adjustment is performed while applying pressure, make advance preparations to keep equipment from rotating any more than necessary.

When adjustment is performed with pressure applied, there is a possibility of rotation and dropping during adjustment depending on the mounting position of the equipment, etc. This can cause human injury and damage to equipment and machinery.

2. Do not loosen the angle adjustment screw above the adjustment range.

If the angle adjustment screw is loosened above the adjustment range, it may come out causing human injury and damage to equipment and machinery.

3. Do not allow external magnetism close to the product.

Since the auto switches used are types sensitive to magnetism, external magnetism in close proximity to the product can cause malfunction leading to human injury and damage to equipment and machinery.

4. Do not perform additional machining on the product.

Additional machining of the product can result in insufficient strength and cause damage to human injury and damage to equipment and machinery.

5. Do not enlarge the fixed throttle on the piping port by reworking, etc.

If the bore is enlarged, rotation speed and impact force will increase, which can cause damage to the product leading to human injury and damage to equipment and machinery.

6. When using a shaft coupling, use one with a sufficient degree of freedom.

If a shaft coupling is used which does not have a sufficient degree of freedom, twisting will occur due to eccentricity, and this can cause malfunction and product damage leading to human injury and damage to equipment and machinery.

7. Do not apply loads to the shaft exceeding the values shown on page 13.

If loads exceeding the allowable values are applied to the product, this can cause malfunction and product damage leading to human injury and damage to equipment and machinery.

A load up to the allowable radial/thrust load can be applied provided that a dynamic load is not generated. However, applications which apply a load directly to the shaft should be avoided whenever possible. In order to further improve the operating conditions, a method such as that shown in the drawing below is recommended so that a direct load is not applied to the shaft.

8. Attach external stoppers away from the axis of rotation.

If the stopper is installed close to the axis of rotation, the reactive force operating on the stopper due to torque generated by the product itself will be applied to the shaft. This can cause damage to the shaft and bearing, leading to human injury and damage to equipment and machinery.

Caution

1. Do not wipe the model indications on labels, etc., with solutions such as organic solvents.

This will remove the indications.

2. Do not secure the body and strike the shaft, or secure the shaft and strike the body, etc.

This can bend the shaft and cause damage to the bearing. When installing a load, etc., on the shaft, secure the shaft.

3. Do not step directly on the shaft or the equipment installed on the shaft.

Stepping directly on the shaft can cause damage to the shaft and bearing, etc.

4. Operate products equipped with the angle adjustment function within the prescribed adjustment range.

Operation outside the adjustment range can cause malfunction and product damage. Refer to product specifications for the adjustment range of each product.
Series CRQ2
Rotary Actuator Precautions 3
Be sure to read before handling.

Air Supply

⚠️ Warning
1. Use clean air.
   - If compressed air includes chemicals, synthetic oils containing organic solvents, salt or corrosive gases, etc., it can cause damage or malfunction.

⚠️ Caution
1. Install air filters.
   - Install air filters at the upstream side of valves. The filtration degree should be 5µm or finer.
2. Install an after cooler, air dryer or Drain Catch, etc.
   - Air that includes excessive drainage may cause malfunction of rotary actuators and other pneumatic equipment. To prevent this, install an after cooler, air dryer or Drain Catch, etc.
3. Use the product within the specified range of fluid and ambient temperature.
   - Take measures to prevent freezing, since moisture in circuits may be frozen under 5°C, and this can cause damage to seals and lead to malfunction.
   - Refer to SMC’s “Air Cleaning Equipment” catalog for further details on compressed air quality.

Speed and Cushion Adjustment

⚠️ Warning
1. Perform speed adjustment gradually from the low speed side.
   - Speed adjustment from the high speed side can cause product damage leading to human injury and damage to equipment and machinery.
2. Since the cushion needle is not adjusted before shipment, perform adjustment for the applicable operation speed and load moment of inertia.
   - Absorption of kinetic energy by the cushion is accomplished by adjustment of the needle, and improper adjustment can cause product damage leading to human injury and damage to equipment and machinery.
3. Do not operate with the cushion needle fully closed.
   - This can cause seal damage leading to human injury and damage to equipment and machinery.
4. Do not loosen the cushion needle with excessive force.
   - The needle unit is provided with a stop to prevent it from coming out. Loosening it with excessive force can cause damage leading to human injury and damage to equipment and machinery.

⚠️ Caution
1. Use this product without lubrication. It can be used with lubrication also, but this can cause problems such as sticking and slipping.

Lubrication

⚠️ Warning
1. Maintenance should be performed according to the procedure indicated in the instruction manual. Improper handling can cause damage and malfunction of equipment and machinery.
2. During maintenance, do not disassemble while the electric power and supply air are turned ON.
3. Conduct suitable function tests after the product has been disassembled for maintenance.
   - Failure to test functions can result in inability to satisfy the product specifications.

⚠️ Caution
1. For lubrication use the grease specified for each product.
   - Use of a lubricant other than that specified can cause damage to seals, etc.
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 switches to malfunction. Maintain a minimum actuator separation of 40mm. (When the allowable separation is indicated for each actuator series, use the specified value.)

3. 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:

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

4. 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) For an auto switch without a contact protection circuit, use a contact protection box when the wire length is 5m or longer.
2) Even if an auto switch has a built-in contact protection circuit, when the wiring is more than 30m 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 contact SMC in this case.

<Solid state switch>
3) Although wire length should not affect switch function, use wiring 100m or shorter.

5. Take precautions for the internal voltage drop of the switch.

<Reed switch>
1) Switches 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 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.

\[
\text{Load} \quad \text{Load} \quad \text{Load} \quad \text{Load} \quad \text{Load}
\]

<Solid state switch>

6. Pay attention to leakage current.

<Solid state switch>
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.

7. Do not use a load that generates surge voltage.

<Reed switch>
If driving a load such as a relay that generates a surge voltage, use a switch with a built-in contact protection circuit or use a contact protection box.

<Solid state switch>
Although a zener diode for surge protection is connected at the output side 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 type of switch with a built-in surge absorbing element.

8. 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.

9. Ensure sufficient clearance for maintenance activities.

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

1. Do not drop or bump.
   Do not drop, bump or apply excessive impacts (300m/s² or more for reed switches and 1000m/s² 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 actuator by the auto switch lead wires.
   Never carry a rotary actuator by its lead wires, as this may not only cause broken lead wires, but it may cause internal elements of the switch to be damaged by the stress.

3. Mount switches using the proper tightening torque.
   When a switch is tightened beyond the range of tightening torque, the mounting screws, mounting bracket or switch may be damaged. On the other hand, tightening below the range of tightening 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 piston stops at the center of the operating range (the range in which a switch is ON). (The mounting positions shown in the catalog indicate the optimum positions at stroke end.) If mounted at the end of the operating range (around the borderline of ON and OFF), operation may be unstable.

Warning

1. Avoid repeatedly bending or stretching lead wires.
   Broken lead wires will result from repeatedly applying bending stress or stretching force 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 containing auto switches may malfunction due to noise from these other lines.

Warning

5. Do not allow short circuit of loads.
   <Reed switch>
   If the power is turned ON with a load in a short circuit condition, the switch will be instantly damaged because of excess current flow into the switch.

   <Solid state switch>
   Model D-F9(C)(V), D-F9(W)(V) and all models of PNP output type switches do not have built-in short circuit protection circuits. As in the case of reed switches, 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.
   <Reed switch>
   A 24VDC switch with indicator light has polarity. The brown (red) lead wire or terminal 1 is (+), and the blue (black) lead wire or terminal 2 is (–).
   1) If connections are reversed, a switch will operate, however, the light emitting diode will not light up.
      Also note that a current greater than that specified will damage a light emitting diode and it will no longer operate.
      Applicable models: D-A93/A93V

   <Solid state switch>
   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 be in a normally 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) wire, the switch will be damaged.

Lead wire color changes

Lead wire colors of SMC switches and related products have been changed in order to meet NECA (Nippon Electric Control Equipment Industries Association) Standard 0402 for production beginning September, 1996 and thereafter. Please refer to the tables provided.

Special care should be taken regarding wire polarity during the time that the old colors still coexist with the new colors.

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<th>2 wire</th>
<th>3 wire</th>
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<tbody>
<tr>
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<tr>
<td><strong>Output (+)</strong></td>
<td><strong>Power supply</strong></td>
</tr>
<tr>
<td><strong>Output (–)</strong></td>
<td><strong>GND</strong></td>
</tr>
<tr>
<td><strong>Solid state with diagnostic output</strong></td>
<td><strong>Output</strong></td>
</tr>
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</tr>
</tbody>
</table>

* Lead wire color changes
Series CRQ2
Auto Switch Precautions 3
Be sure to read before handling.

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 actuators 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 some models, satisfy IEC standard IP67 construction (JIS C 0920: water tight 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 internally.

6. Do not use in an environment where there is excessive impact shock.
<Reed switch>
When excessive impact (300m/s² or more) is applied to a reed switch during operation, the contact point will malfunction and generate or cut off a signal momentarily (1ms or less). Consult SMC regarding the need to use a solid state switch depending upon the environment.

7. Do not use in an area where surges are generated.
<Solid state switch>
When there are units (solenoid type lifter, high frequency induction furnace, motor, etc.) which generate a large amount of surge in the area around actuators with solid state auto switches, this may cause deterioration or damage to the internal circuit elements of the switches. Avoid sources of surge generation and disorganized lines.

8. Avoid accumulation of iron debris or close contact with magnetic substances.
When a large amount of ferrous debris such as machining chips or welding spatter is accumulated, or a magnetic substance (something attracted by a magnet) is brought into close proximity to actuators with auto switches, it may cause the auto switches to malfunction due to a loss of the magnetic force inside the actuator.

Maintenance

⚠️ 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.

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

Other

⚠️ Warning

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